

Cruise report of the 2016 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 7th annual IWC-POWER cruise was successfully conducted between 02 July to 30 August, 2016 in the central North Pacific (with the dedicated research area located between 20°N-30°N Latitude and between 135°W - 160°W Longitude). Areas of the US EEZ were included within this research area. The survey was conducted aboard the Japanese R/V *Yushin-Maru No.3*. The cruise was organized as a joint project between the IWC and Japan. The cruise plan was endorsed at the 66a IWC/Scientific Committee (IWC/SC) meeting. Researchers from Japan, the US and Republic of Korea participated in the survey. The cruise had five main objectives: (a) provide information for the proposed future in-depth assessment of sei whales in terms of both abundance and stock structure; (b) provide information relevant to the *Implementation Reviews* of whales in terms of both abundance and stock structure (e.g. Bryde's whales); (c) provide baseline information on distribution and abundance for an area of the North Pacific not recently and systematically surveyed for several large whale species/populations, including those that were known to have been depleted in the past, but whose status is unclear; (d) provide biopsy samples and photo-identification data to contribute to discussions of stock structure for several large whale species/populations, including those that were known to have been depleted in the past but whose status is unclear, and; (e) provide essential information for the intersessional workshop to plan for a medium to long term international programme in the North Pacific. At the pre-cruise meeting, the Captain and crew of the vessel and international researchers agreed on the procedures and objectives of the survey. The survey was conducted using methods based on the guidelines of the IWC/SC. The predetermined transect lines were completed within the anticipated time schedule. Survey track line coverage was 97.2% within the designated survey area and a total of 2,237.5 n.miles was surveyed in the Passing with abeam closing mode (NSP) and the Independent Observer passing mode (IO). Additionally, 626.2 and 580.1 n.miles were surveyed during transit to and from the research area respectively. Sightings of: Blue (1 school / 1 individual), sei (1/1), Bryde's (28/32), sperm (32/125), Cuvier's beaked (2/5), *Mesoplodon* spp. (2/3), *Ziphiidae* (7/11), short finned pilot (2/31), pygmy killer (1/16) whales; Risso's (2/19), bottlenose (1/37), common (8/217), striped (5/378) and spotted (1/133) dolphins were observed during the cruise. Bryde's and sperm whales were the most frequently sighted large whale species. The Estimated Angle and Distance Training Exercises and Experiments were completed with improvements following SC suggestions. Photo-identification data for 12 Bryde's whales, 2 sperm whales were collected. A total of 23 biopsy (skin and blubber) samples was collected from 1 blue, 1 sei, 16 Bryde's whales and 5 sperm whales using the Larsen biopsy rifle/darts system. In the case of Bryde's whale, 3 samples (individuals) were collected from Sub-area 1 (west of 180°E) and 13 samples from Sub-area 2 (east of 180°E). These biopsy samples will enable genetic studies on stock structure to be conducted in contribution to the North Pacific Bryde's whale *Implementation Review* to be held at the 2017 SC meeting. A total of 153 objects of marine debris were observed. All survey procedures were in accordance with the guidelines set forth and agreed upon by the SC. The 7th annual cruise of the IWC-POWER programme was completed and provided important information on cetacean distribution in an area where no survey had been conducted in recent decades. These results will contribute to the aforementioned objectives of the IWC/SC.

KEY WORD: BLUE WHALE, BRYDE'S WHALE, SPERM WHALES, SURVEY VESSEL, NORTH PACIFIC, IWC-POWER

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, 2014a, 2014b, 2015a, 2015b; Kato *et al.*, 2011, Matsuoka *et al.*, 2011, 2012, 2013, 2014, 2015). The 2016 cruise plan was endorsed at the 66a IWC/Scientific Committee (IWC/SC) meeting. The cruise had five main objectives: (a) provide information for the proposed future in-depth assessment of sei whales in terms of both abundance and stock structure; (b) provide information relevant to the *Implementation Reviews* of whales in terms of both abundance and stock structure; (c) provide baseline information on distribution 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); (d) provide biopsy samples and photo-identification data to contribute to discussions of stock structure for several large whale species/populations and (e) provide essential information for the intersessional workshop to plan for a medium to long term international research programme in the North Pacific (IWC, 2016b).

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

The research area was set north of 20°N, south of 30°N between 160°W and 135°W, including areas of the US EEZ (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” (Thomas *et al.*, 2010). Figure 1b shows the cruise track design in the designated research area and Table 1a 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 (nmi), wind speed <21 knots and sea state <Beaufort 6. The sighting survey was conducted using Passing with abeam closing mode (NSP) and the Independent Observer passing mode (IO) based on discussions and suggestions from the Technical Advisory Group (TAG) of IWC/SC members (IWC, 2013, 2016a). Two primary observers were in the TOP barrel throughout periods of NSP and IO modes (see section 2.5). Sighting survey procedures are detailed in “Information for Researchers” (Anon. 2016a). For encounters of rare species (e.g. blue and right whales), it was decided that the vessel would approach whales immediately in order to avoid losing the sighting due to a delay in closing.

The R/V *Yushin-Maru No.3* (YS3) was used during this cruise, which included transits between Japan and the research area located adjacent to the Hawaiian Islands. Research time was allocated for biopsy sampling of blue, fin, sei, Bryde’s, common minke, North Pacific right, humpback, sperm and killer whales, with higher priority given to the former seven species. The Larsen system was used to collect samples. Priority species for photo-ID were blue, North Pacific right and humpback whales, although photos of all other species, including fin, sei, Bryde’s, sperm and killer whales would be obtained opportunistically.

2. SHORT NARRATIVE OF THE CRUISE

2.1 The 2016 cruise itinerary

Date	Event
1 July 2016	Pre-cruise meeting
2 July	Researchers board the <i>Yushin-Maru No. 3</i> . Vessel departed the port of Shiogama, Miyagi Prefecture, Japan
4 July	Started transit survey
19 July	Vessel started survey in the research area at 135°00’W (29 days in the research area)
14 August	Vessel entered the US EEZ (16:35 at 25°-29.9’N, 158°-47.1’W)
16 August	Vessel completed survey in the research area at 160°00’W and begins return transit.
21 August	Vessel left the US EEZ (15:13 at 31°-45.4’N, 178°-34.2’W)
28 August	Finished transit survey, Post-cruise meeting
30 August	Vessel arrived at the port of Shiogama, Miyagi, Prefecture, Japan

2.2 Research vessel

The R/V *Yushin-Maru No.3* (742GT) was contracted for this cruise. The vessel was also contracted in previous years; 2011, 2012, 2013, 2014 and 2015. 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 Koji Matsuoka (The Institute of Cetacean Research, ICR, Cruise Leader), James Gilpatrick (US National

Oceanic and Atmospheric Administration (NOAA), Southwest Fisheries Science Center (SWFSC), Ji Hye Kim (Cetacean Research Institute, Republic of Korea), and Isamu Yoshimura (IWC-nominated researcher, Japan).

Koji Matsuoka (Japan) - Cruise Leader /Chief Scientist, sighting, photo-ID
 James Gilpatrick (USA) - sighting, photo-ID and photo database, biopsy
 JiHye Kim (Republic of Korea) – biopsy and marine debris /video
 Isamu Yoshimura (Japan) – sighting data management, biopsy

2.4 Pre-cruise meeting

On 1 July, a pre-cruise meeting was held at the Tohoku Dock yard Shiogama, chaired by the cruise leader. Meeting participants were: Miyashita (National Research Institute of Far Seas Fisheries, NRIFSF), Matsuoka, Gilpatrick, Yoshimura, Kim, Eguchi (Captain), Tanno (Chief Engineer), Tsuda (Chief Operator), Kasai (Chief Officer), Omura (Bosun) and Kuroki (Quartermaster). The meeting discussed and confirmed priorities and strategies for the cruise based on the IWC Scientific Committee's planning report (IWC, 2016b), and IWC research manual (Anon, 2016a). The pre-cruise meeting report (Anon, 2016b) was distributed to the steering group after reviewing by the Convenor. On 2 July, researchers boarded the YS3 with all of the necessary equipment and departed from the port of Shiogama.

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 (approximately 06:00-18:00). 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 Cruise Leader. In such cases, there were an allocation of equivalent time-off on the following day for crew and scientist aboard the vessel. Time-zone changes were made in 30-minute intervals, effective from 01:00 hrs. Work schedules adhered to local ship time which ranged between +9 and +14.5 GMT (depending on the ships geographic location) throughout the cruise. Data collected during the cruise and all associated reporting were reported according to the local ship time.

Sighting activities aboard the ship were classified into two principal types: On-effort and Off-effort. In the sightings survey portion of the research, 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 (e.g. during drifting, during the Top down (TD) steaming on the trackline due to bad weather condition; there are no primary observers on the TOP barrel). All sightings recorded during On-effort were classified as Primary sightings. All other sightings were considered to be Secondary sightings. Sighting effort was conducted by the bos'un and topmen from the TOP barrel (crow's nest: always two primary observers) and the upper bridge where the helmsman, captain or officer-on-watch, four researchers, and the chief engineer or deputy were also present (always two primary observers and 5 secondary observers).

Following advice from the Scientific Committee and the Technical Advisory Group (TAG) (IWC, 2016a), the 2016 survey alternated between NSP and IO modes (Highest priority for IO mode (suggested that at least 75% of effort include the IO mode)).

Passing with abeam closing mode (NSP): This was in effect Passing Mode. Two topmen were on effort from 06:00-19:00 (at time a 30 minutes allocated break time for lunch and supper meals) 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 Cruise Leader (CL) (Anon. 2016a).

Independent Observer Mode (IO): This is also in effect Passing Mode. Two topmen were observing from the barrel at all times and two observers were also observing from the IO barrel as recommended by the TAG (IWC, 2016a). Research hours were the same as NSP mode. Communications were essentially one-directional, with the topmen reporting information to the upper bridge observers. In general, no sighting information was exchanged between the barrel observers and the independent 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 (based on time allowed and at the discretion of the CL), such as photography for natural marking (Photo-ID) studies and biopsy 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 (Anon. 2016a).

2.6 Weather conditions and expected versus realised effort

In the research area, sea surface conditions were generally rough due to prevalent trade winds from the northeast. A total of 446.5 n. miles and 1,791.0 n.miles were surveyed in the research area in NSP mode and IO mode respectively. In the research area, 97.2% of the planned track-line distance (of 2,302.7 n.miles) was surveyed. 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.

All research activities (i.e., the approach of cetaceans for species identification, school size estimates, digital photography, and tissue biopsy samples) that were carried out within the Exclusive Economic Zone of the United States (US EEZ, along the NW Hawaiian Island Chain) were permitted under U.S. National Marine Fisheries Service (NMFS) Permit nos. 14097-06 (issued to the SWFSC). Researcher James Gilpatrick (US, SWFSC) was listed as the co-investigator (CI) aboard the research vessel under the Permits.

Cetacean tissue biopsy samples obtained within the US EEZ (i.e, 7 Bryde's whale and 4 sperm Whale specimens) were legally exported to Japan under the CITES (Convention on International Trade in Endangered Species) U.S. Management Authority (U.S. Fish and Wildlife Service) Permit no. 16US95839B/9. The biopsy samples were then imported to Japan under the CITES Japan Management Authority i.e., the Office of Trade Licensing for Wild Animals and Plants, Ministry of Economy, Trade and Industry (METI): Permit/Cert. No. 16JP000003/TI.

Cetacean research activities conducted on the high seas in international waters by Japanese researchers aboard the YS3 were authorized under permit SUIKAN 28-561 issued by Fisheries Agency, Government of Japan. A summary of research effort in the US EEZ is provided in Appendix C.

2.8 Data entry system and analysis

Research data collected during the survey (weather, effort, sighting and distance experiments data) were entered by researchers using the 'onboard data collecting system' (ICR, 2013).

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 (Anon, 2016a):

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 Cruise leader 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. 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 'Information for Researchers' (Anon, 2016a).

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 believed to be confirmed for school size are approached to within 1 n. mile for large whales and to within 0.3 n. miles for minke whales. Allowing for context-

specific differences (i.e. environmental conditions and animal behaviour), every effort was made to be consistent with regard to the maximum time spent on identification of species and confirmation of numbers. Normally, if the sighting was thought to be minke whales, no more than 20 minutes (after closure has been completed) will be spent on confirmation, this reduces the potential for confusion with other whale sightings in the vicinity (Anon, 2016a). 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

Tabulations of all track line WPs, the searching effort and the sightings recorded in the research area, by species and by survey modes are presented in Tables 1a, 1b, 2a and 2b, respectively. Table 2c summarises all sightings observed throughout the cruise including those recorded during transit to and from the research area. Table 2d shows the identification of duplicate sightings observed during survey in the 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. Figure 1a illustrates the research area and transit course between Japan and research area. Figure 1b illustrates the pre-determined track line design and the succession of tracklines followed during the survey. Figures 2a through 2d illustrate locations of the main species sightings and search effort in the research area. Recorded sea surface temperature (SST) ranged from 24.7 to 31.4°C during sightings observed in the research area (Table 3). Figure 3 shows the breakdown of research time, in hours by effort code in the research area. Appendix B show the comparison of weather conditions (wind speed / visibility) in the research area among past cruises.

Transit survey to the research area

The YS3 departed the port of Shiogama on schedule (at 09:00 hrs, 02 July 2016) and conducted the transit survey to the research area from 4 July (06:00) to 18 July (17:30) using NSP and IO modes. A safety instruction meeting and an emergency abandon ship drill were conducted on 3 July. Whale biopsy collection training using the Larsen rifle/darts system was conducted on 4 July. YS3 arrived at the research area at Waypoint (WP) 101 (24°-48.0N, 135°-00.0W) on 19 July at 6:00. Weather conditions were good, with occasional intervals of rain. Distance and angle estimation exercises were conducted on 14 July.

Total searching distance was 626.2 n. miles (249.2 n.miles by NSP mode and 377.0 n.miles by IO mode). Total transit sightings included Blue (1 school/ 1 individual), sei (1/1), Bryde's (14/18), like Bryde's (2/2), sperm whales (2/3), Risso's dolphins (2/19), common (8/217) and striped (2/251) dolphins (Table 2c). Biopsy samples were successfully collected for 1 blue, 1 sei and 5 Bryde's whales (Tables 4a and 4c).

The research area

The YS3 finished the transit survey and started the research area survey at Waypoint 101 (Table 1a) position 24°48.0'N 135°00.0'W, on 19 July 06:00. The research vessel followed a north-west course (324°) towards latitude 30°N, with a south-west course change (216°) towards latitude 20 °N under acceptable searching conditions. The vessel. The YS3 entered in US EEZ at waypoint 126 (25°-29.9'N, 158°-47.1'W) on 16:36 on 14 August. The YS3 arrived at the most easterly WP (WP128), position 23°57.0'N 160°00'W, on 16 July 07:37 and finished the research area survey almost on schedule.

Generally, weather conditions were narrowly good for the sighting survey allowing for a good portion of searching. Low pressure weather systems are influencing or research operations at present with trade winds up to 20 kts and swells up to 2.0 meters. Wind speed generally ranged between 15 to 20 knots and visibility was usually over 7.0 n.miles (Appendix B). There were no strong ocean currents in the research area or during the research period.

A total of 2,237.5 n. miles was surveyed in the research area (original trackline) with 2,126.1 n.miles (high sea) and 111.4 n.miles (USEEZ) in the Passing with abeam closing (NSP) mode and Independent Observer (IO) mode, respectively (Table 1b). Survey coverage (searching distance/planned distance (2,302.7 n.miles)) was 97.2% in the research area. Sightings recorded in the research area by species, by survey mode, are presented in Tables 2a and 2b.

The large whale species sighted in the research area were Bryde's (1 school/ 1 individual) and sperm (6/30) whales. Total sightings of other species sighted in the research area include: Cuvier's beaked (2/5), *Mesoplodon* (2/3), *Ziphiidae* (2/2), pygmy killer (1/16), southern-form short finned pilot (2/31) whales; and striped (2/67) dolphins.

Details of sightings by each species; results of photo-identification and biopsy experiments; and marine debris observations are provided in the following paragraphs (Tables 2a, 2b, 4a, 4b and 4c).

Transit survey to Shioyama

In the US EEZ, the YS3 departed the research area (07:37, 16 August) and started the transit survey to Japan (the port of Shioyama) using the IO mode. The YS3 departed US EEZ (15:13, 21 August at 31°-45.4'N, 178°-34.2'W) and continued the transit survey until 28 August (12:00) under intervals of heavy wind and/or rain (Table 1b). The searching distance in the US EEZ and high sea during transit were 505.2 n.miles and 74.9 n.miles, respectively and total searching distance was 580.1 n. miles. Sightings recorded during the transit sighting survey, by species are presented in Table 2c. Three Bryde's whale biopsy samples were collected in international waters of the high seas on 23 August (Table 4c).

Detailed sightings by each species are as follows:

(Note: Table 3 shows the summary data on sea surface temperatures, SST by each species in the research area)

Blue whale (*Balaenoptera musculus* spp.)

A solitary blue whale was sighted during the transit survey from Japan to the research area. The sighting occurred on 9 July at 38°02.2'N, 179°15.2'E (Figure 2a). The blue whale appeared to be healthy (body appeared robust) and many cookie-cutter shark bites were observed on the dorsal and lateral surfaces. Its body length was estimated to be 19.8 m. A biopsy sample was collected and photo-identification photos were taken. SST in the vicinity of the whale was 20.2 °C (Tables 3).

Sei whale (*Balaenoptera borealis*)

One sei whale was sighted during the transit survey from Japan to the research area on 8 July at 38°37.8'N, 176°36.5'E (Figure 2a). Its body length was estimated to be 13.4 m. Sea surface temperature in the vicinity of the sei whale was 19.8 °C (Tables 3).

Bryde's whale (*Balaenoptera edeni*)

Bryde's whales were the most frequently encountered whale species during the survey with 28 sightings; a total of 32 individuals were counted including 2 mother/calf pairs (Figure 2a). All Bryde's whales were approached close enough so that physical identification features (i.e., overall dark coloration and three prominent longitudinal rostral ridges) could be confirmed by the observers. Fourteen of these school sightings (18 individuals including 2 calves) were made during the survey transit from Japan to the main research area. Only one sighting (1 individual) was made within the research area and geographically this sighting represented the most easterly Bryde's whale sighting during the survey. The whale was sighted at 28°-51.3'N, 138°-13.4'W, SST was 21.2°C. Photo-ID photographs and a skin biopsy sample were collected for this whale. Nine sighting (9 individuals) were recorded during the return transit survey in the USEEZ from research area to Japan, and four sightings (4 individuals) were recorded during the return transit survey in the international waters of the high sea from the research area to Japan (Table 2c).

Biopsy samples were obtained from 16 Bryde's whales throughout the cruise. Within the research area, one biopsy sample was obtained from a Bryde's whale. The whale was located in international waters of the high seas. Biopsy samples were collected from 15 Bryde's whales outside of the main research area (7 samples within the US EEZ and 8 samples were taken in international waters on the high sea) (Table 4c). One mother/calf pair was biopsied during the transit survey from Japan to the designated research area.

With the exception of one whale (sighted within the designated survey box area), Bryde's whales were sighted along the transit trackline between Japan and the designated survey area. Sightings were located north of 26°N Latitude and west of the 165°W Longitude line (Figure 2a). Bryde's whales were found in SST ranging between 18.6°- 26.9°C with most whales sighted in SST ranging between 22.2°-26.1°C (using 25th to 75th quartiles of the observed SST data for this species).

Sperm whale (*Physeter macrocephalus*)

Sperm whales were the most frequently encountered toothed whale sighted during the survey with 32 sperm whale sightings comprised of 125 whales (including 5 calves). Two sperm whale sightings were recorded during the transit to the survey area (3 whales) and 6 other sightings comprised of 30 individuals (including 1 calf) were recorded in the main research area. 24 sighting (82 individuals, including 4 calves) were recorded during the return transit survey in the USEEZ from research area to Japan, and no sightings were recorded during the return transit survey in the international waters of the high sea from the research area to Japan (Table 2c). Sightings were located over a relatively wide area with most sightings occurring north of 23°N Latitude and west of 150°W Longitude (Figure 2c).

Sperm whales were recorded in waters with SST ranging from 22.5°- 26.9°C with most individuals found in SST waters between 26.1-26.5°C (using 25th to 75th quartiles of the SST data observed for this species) (Table 3).

Cuvier's beaked whale (*Ziphius cavirostris*)

There were 2 Cuvier's beaked whale sightings (5 individuals) during the survey. Both sightings were recorded in international of the high sea in the research area (Figure 2d). Cuvier's beaked whales occurred in SST ranging between 24.6°-24.9°C.

Mesoplodon spp.

Two sightings of *Mesoplodon spp.* beaked whales (not identified to species; 3 individuals) were recorded. Both sightings were recorded in international of the high sea in the research area (Figure 2d), in SST ranging between 25.8°-25.9°C.

Ziphiidae

Seven sightings of beaked whales (11 individuals; no calves observed) belonging to the Family *Ziphiidae* were recorded (Figure 2d). SST ranged between 25.6°-26.1°C.

Short-finned pilot whale (*Globicephala macrorhynchus*)

Two sightings of the southern form of the short-finned pilot whale were observed during the survey (31 individuals including 6 calves). These pilot whales recorded along the transit line were located in SST of 26.1°C.

Pygmy killer whale (*Feresa attenuata*)

One pygmy killer whale school (16 individuals) was observed within the research area. The SST at the time of the sighting was 21.7° C.

Risso's dolphin (*Grampus griseus*)

Two schools of Risso's dolphins (19 individuals including 1 calf) were observe in the research area in areas with SST ranging between 18.9°- 23.2°C.

Bottlenosed dolphin (*Tursiops truncatus*)

One school of bottlenosed dolphins (37 individuals including 2 calves) was observed during the transit survey between the designated research area and the coast of Japan. The sighting was associated topographically with a sea mount; approx. water depth above the sea mount was recorded at between 35-100 m. This school was found in SST 25.3°C.

Striped dolphin (*Stenella coeruleoalba*)

Five schools of striped dolphins (378 individuals including 35 calves) were observed during the survey with SST ranging between 19.0°- 25.8°C.

3.4 Resighting During IO Mode

Resighting data were recorded for a total of 15 sightings during IO Mode. Table 2d shows the identification of duplicate sightings observed during survey in IO Mode.

4. PHOTOGRAPHIC DATABASE

Ten different species were photographed during the 2016 IWC-POWER cruise: Blue (1 school / 1 individual), Sei (1/1), Bryde's (18/20), sperm (5/43), Cuvier's beaked (2/4), Short-finned pilot (2/31), Pygmy killer (1/16) whales; bottlenose (1/37), spotted (1/133) and striped (3/175) dolphins (Table 4a). Note that numbers are given for total individuals in photographed schools, not all individuals were photographed.

Images collected during the 2016 IWC-POWER cruise were uploaded to the SOWER-POWER IWC Lightroom (LR) database. Preliminary coding was completed for all images, including the allocation of species, sighting number and school size. A more thorough photo analysis was conducted for Bryde's, sperm and beaked whale sightings. Time permitting, various health, behaviour and unique identification parameters were coded when evident in images. The majority of small odontocete images were marked for coding at a later date. Images of non-cetaceans were archived.

4.1 Individual Identification

Photo-identification results are **preliminary** and subject to change at the discretion of catalogue curators. Images useful for individual identification were collected for blue, sei, Bryde's, sperm whales and some dolphin species.

Individuals provisionally identified include 12 Bryde's and two sperm whales. Of the total 28 sightings of 32 individual Bryde's whales sighted during this, 18 sightings were photo-documented and 12 individuals were photo-identified (Table 4b). The sperm whales were also photo-identified. Images will be available for incorporation into their respective catalogues.

5. BIOPSY SAMPLING

Overall, biopsy samples were collected for 23 individual whales. These whales included 1 blue, 1 sei, 16 Bryde's and 5 sperm whales (Table 4a). Every biopsy encounter was documented photographically. All biopsy samples were catalogued and stored frozen; samples will be used for molecular genetics analyses. All biopsy samples will be sent to NRIFS post cruise upon arrival to the Port of Shioyama, Japan. So that replicate genetic analyses can take place for the biopsy collection (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 Japanese Fisheries Agency at the NRIFS laboratory), all individual biopsies will be cut in half (at the NRIFS). This will provide two equivalent biological samples to be analysed separately at the respective laboratories noted above. Samples are to be divided in half, with one half of the sample for IWC and the other half for Japan. Summary of number of Bryde's whale biopsied individuals during this cruise is shown in Table 4c.

In the case of Bryde's whales, biopsy samples from 5 individuals were collected from sub-area 1 (west of 180°E) and biopsy samples were collected from 11 Bryde's whales located in sub-area 2 (east of 180°E).

These biopsy samples will enable genetic studies on stock structure to be conducted and results from these studies will be submitted in support of the North Pacific Bryde's whale *Implementation Review* to be held at the 2017 IWC SC meeting.

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 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 (Table 4a). Biopsy success rate when approaching Bryde's whales for sampling was very high and similar to the success rate since the 2014 cruise. Of the 23, encounters with Bryde's whales where biopsy sampling was attempted, a sample was obtained in 16 of those encounters (70.0% success rate). Median time from setup to sample retrieval when sampling single Bryde's whales was 20.5 minutes. When sampling groups of 2 Bryde's whales (mothers and calves), the median time from setup to sample retrieval was 16.5 minutes.

Five biopsy samples were collected for sperm whales; including one mother/calf pair. This pair were originally found within a group of 16 sperm whales (biopsy effort duration: 18 minutes). Biopsy specimens were collected from one blue and sei whales (both solitary animal) and average time for the encounter and collection of the samples was 16.5 minutes. During the six encounters with Bryde's whales where the biopsy experiment was initiated but samples were not collected, the whales were surfacing in erratic (not predictable) patterns and the whales exhibited exceptional speed in staying ahead of the research vessel (Median time of biopsy effort duration: 32.0 minutes). Biopsy sampling was attempted as often as permitted under acceptable environmental conditions.

6. VIDEO-RECORDING

A digital video camera recorder, Sony NEX-VG30, AVCHD progressive was used to conduct opportunistic video recording. 64 separate video clips (13 schools) were recorded. And 8 clips (8 schools) were selected, for a total time of 00:07:34, including 00:00:38 of blue whale surfacing, 00:00:24 of Bryde's whale biopsy event, 00:01:49 of striped dolphin large group, 00:04:43 of sperm whale mother and calf surfacing.

7. OTHER EXPERIMENTS

7.1 Estimated Angle and Distance Training Exercise

The Estimated Angle and Distance Training Exercises were conducted on the afternoon of 9 July for 2 hour 54 minutes. During the exercise observers familiarised themselves with distance estimates from the top barrel and upper bridge. Following advice from the Scientific Committee and the TAG, the 2016 survey conducted several improvements for this experiment (IWC, 2016a). 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 recommended buoy (to simulate a whale's body rather than the blow) had provided on the vessel.

7.2 Estimated Angle and Distance Experiment

The Estimated Angle and Distance Experiments were conducted on 3 August for 7 hours 38 minutes during the latter half of the research period whilst in the research area. A total of 60 trials were conducted for each platform (top and IO barrels and upper bridge). Both of the estimated Angle and Distance Training Exercises and Estimated Angle and Distance Experiments were performed using the improved protocol (IWC, 2016b). Details of the results will be analysed and reported to the TAG after the conclusion of the cruise.

7.3 Marine debris observations

During this cruise as in past years, data on floating marine debris were collected to document type and extent of marine debris presence in the North Pacific. As agreed during the pre-cruise meeting in Shioyama, 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. Photographed items were archived and will be available to those interested in these data.

Marine debris was sparsely distributed during this cruise, unlike during the 2012 POWER cruise (Matsuoka *et al.* 2013) and especially during the 2013 POWER cruise (Matsuoka *et al.* 2014). In 2016 cruise, a total of 153 marine debris objects were observed, of which 150 were recorded "on effort" (i.e., during the first 15 minutes of each hour) (Table 5). A total of 22 objects were recorded in the US EEZ (Appendix Table C7). A total of 74 objects were photographed.

8. TECHNICAL MATTERS OF DATA AND RECOMMENDATIONS

8.1 Photographic database processing in Lightroom

Images collected during the cruise were uploaded to the Adobe Lightroom (LR) software program and preliminarily coded were added. 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. It is **recommended** that researchers on future cruises continue the Adobe Lightroom processing to make the photographic database a more valuable and readily available resource. A guidance document specific for photo-processing procedures to be followed during the cruise have been developed and the IWC LR Photographic Database Manual will be made available during the cruise. It is also **recommended** that hard copies of this document and the LR IWC Photographic Database Manual be made available during the cruise. For upcoming cruises, it is **recommended** that two newer laptops (i.e., with fast processors, high resolution wide screens and with ample memory and drive storage) be available for digital photography processing. One of the laptops should be reserved as a back-up computer in case a technical failure occurs with the primary laptop. A large capacity external drive for digital image and program backup is also recommended. Both computers should contain the latest version of the Adobe Lightroom (LR) program.

8.2 Large-whale Entanglement cases

There were no entanglement whales during this cruise. It is **recommended** that specific protocols, data forms and data submission for cases of entanglement (and carcasses if sighted) be agreed upon.

9. CONCLUSIONS

The 7th annual IWC-POWER cruise was successfully conducted using the Japanese R/V *Yushin-Maru No.3*. 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, 2005). 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 photographic, sighting records, biopsy samples and video data, already submitted to the IWC secretariat by the cruise leader and confirmed on 28 April 2017. The 7th cruise of this programme provides critical information on the distribution, abundance and stock structure of baleen whale species, in particular the Bryde's whale, in a poorly-known area. Additional information on other cetacean species in particular the sperm whale found to be widely distributed in the 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 IWC/SC.

ACKNOWLEDGEMENTS

We acknowledge the Governments of the US, Republic of Korea and Japan for their assistance in the research permit and funding for this cruise. We acknowledge Greg Donovan of the Secretariat of the IWC, the steering group of this cruise (Hidehiro Kato (Convener), Robert Brownell, Phillip Clapham, Paul Ensor, Hyun Woo Kim, Tomio Miyashita, Hiroto Murase, Luis Pastene and Lars Walloe), the Technical advisory group of this cruise (Debra Palka, Toshihide Kitakado, Sharon Hedley, Mark Bravington, and Natalie Kelly) and the staff of the Institute of Cetacean Research (Tokyo) and Kyodo Senpaku Co. LTD. for their arrangements and support for this cruise. We also thank the Captain, his officers and crew of the R/V *Yushin-Maru No.3* for their hard work and dedication. Cetacean Research Institute loaned equipment of video camera for the photo-ID. Hideyoshi Yoshida, the National Research Institute of Far Seas Fisheries (Yokohama) arranged biopsy CITES permit issues and loaned materials for biopsy processing and storage.

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TABLES AND FIGURES

Table 1a. Way Points (WP) and each survey mode in the research area. The planned original cruise track line distance in the research area was 2,302.7 n.miles (except a modified course to avoid the PMNM, see Figure 1b).

WP	Latitude	Longitude	Co.	Distance	Mode	WP	Latitude	Longitude	Co.	Distance	Mode
101	24°48.0'N	135°00.0'W	324°	95.3	IO	115	22°30.1'N	149°06.1'W	324°	92.3	IO
102	26°06.0'N	136°01.3'W	324°	95.4	IO	116	23°45.1'N	150°05.1'W	324°	92.3	IO
103	27°24.0'N	137°03.3'W	324°	95.4	NSP	117	25°00.1'N	151°04.7'W	324°	92.3	NSP
104	28°42.0'N	138°06.0'W	324°	95.4	IO	118	26°15.1'N	152°04.9'W	324°	92.3	IO
105	30°00.0'N	139°09.6'W	216°	92.4	NSP	119	27°30.1'N	153°05.8'W	324°	92.2	IO
106	28°45.0'N	140°11.9'W	216°	92.3	IO	120	28°45.0'N	154°07.3'W	324°	92.3	IO
107	27°30.0'N	141°13.4'W	216°	92.3	IO	121	30°00.0'N	155°09.6'W	216°	74.0	IO
108	26°15.1'N	142°14.3'W	216°	92.3	IO	122	28°59.6'N	155°59.1'W	216°	74.1	IO
109	25°00.1'N	143°14.5'W	216°	92.2	NSP	123	27°59.1'N	156°48.1'W	216°	74.1	IO
110	23°45.1'N	144°14.0'W	216°	92.3	IO	124	26°58.6'N	157°36.7'W	216°	74.0	NSP
111	22°30.1'N	145°13.1'W	216°	92.3	IO	125	25°58.1'N	158°24.8'W	216°	34.5	IO
112	21°15.1'N	146°11.6'W	216°	92.3	IO	126	25°29.9'N	158°47.1'W	216°	39.5	IO
113	20°00.0'N	147°09.6'W	324°	92.3	NSP	127	24°57.6'N	159°12.6'W	216°	74.2	IO
114	21°15.0'N	148°07.6'W	324°	92.4	IO	128	23°57.0'N	160°00.0'W	-	-	-

Table 1b. Summary of the searching effort (time and distance) and experimental time (hours) by each survey with the area code conducted during 2016 Cruise.

Survey (area code)	Start	End	NSP		IO		NSP+IO		Photo-ID, Biopsy	Estimated angle and distance training / experiment
	Date	Date	Time	Dist. (n.m.)	Time	Dist. (n.m.)	Time	Dist. (n.m.)	Time	Time
	Time	Time								
Shiogama to research area (1)	4-Jul.	18-Jul.	21:43:45	249.20	32:56:57	377.02	54:40:42	626.22	5:01:29	5:17:14
	6:00	17:30								
Research area (High Sea) (65)	19-Jul.	14-Aug.	38:40:43	446.47	145:51:25	1,679.65	184:32:08	2,126.12	0:34:42	7:11:51
	6:00	16:35								
Research area (US EEZ) (66)	14-Aug.	16-Aug.	0:00:00	0.00	9:37:59	111.37	9:37:59	111.37	1:15:28	0:00:00
	16:35	7:37								
Research area to Shiogama (US EEZ) (67)	16-Aug.	21-Aug.	0:00:00	0.00	42:08:10	505.18	42:08:10	505.18	4:54:18	0:00:00
	7:37	15:13								
Research area to Shiogama (High Sea) (68)	21-Aug.	28-Aug.	0:00:00	0.00	6:13:56	74.90	6:13:56	74.90	1:11:27	0:00:00
	15:13	12:00								
Total	4-Jul	28-Aug.	60:24:28	695.67	236:48:27	2,748.12	297:12:55	3,443.79	12:57:24	12:29:05
	6:00	12:00								

Table 2a. Number of sightings for all species observed in the research area (Original trackline) 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 are included the number of calves.

Species	NSP			IO			OE			Total		
	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf
Bryde's whale	0	0	0	1	1	0	0	0	0	1	1	0
Sperm whale	0	0	0	6	30	1	0	0	0	6	30	1
Cuvier's beaked whale	0	0	0	2	5	0	0	0	0	2	5	0
<i>Mesoplodon</i> spp.	1	2	0	1	1	0	0	0	0	2	3	0
<i>Ziphiidae</i>	0	0	0	2	2	0	0	0	0	2	2	0
Pygmy killer whale	0	0	0	1	16	2	0	0	0	1	16	2
Short-finned pilot whale	0	0	0	2	31	6	0	0	0	2	31	6
Striped dolphin	0	0	0	2	67	4	0	0	0	2	67	4
Unidentified small cetacean	0	0	0	3	55	0	0	0	0	3	55	0
Unidentified dolphin	0	0	0	1	6	0	0	0	0	1	6	0
Unidentified cetacean	0	0	0	4	4	0	0	0	0	4	4	0
Total	1	2	0	25	218	13	0	0	0	26	220	13

Table 2b. Number of sightings for all species observed in the research area (by high sea and US EEZ). Numbers of Individuals include number of calves.

Species	Research area (high sea), (area code 65)			Research Area (US EEZ) (area code 66)			Research area Total		
	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf
Bryde's whale	1	1	0	0	0	0	1	1	0
Sperm whale	3	19	0	3	11	1	6	30	1
Cuvier's beaked whale	2	5	0	0	0	0	2	5	0
<i>Mesoplodon</i> spp.	2	3	0	0	0	0	2	3	0
<i>Ziphiidae</i>	1	1	0	1	1	0	2	2	0
Short-finned pilot whale	0	0	0	2	31	6	2	31	6
Pygmy killer whale	1	16	2	0	0	0	1	16	2
Striped dolphin	2	67	4	0	0	0	2	67	4
Unidentified small cetacean	3	55	0	0	0	0	3	55	0
Unidentified dolphin	1	6	0	0	0	0	1	6	0
Unid. cetacean	4	4	0	0	0	0	4	4	0
Total	20	177	6	6	43	7	26	220	13

Table 2c. Number of all sightings observed during 2016 POWER cruise. S: Number of schools, I: Number of individuals, C: Number of calves.

Species	Transit to research area (area code 1)			Research area (High Sea , area code 65)			Research area (US EEZ, area code 66)			Transit to Shiogama (US EEZ, area code 67)			Transit to Shiogama (High Sea, area code 2)			Total		
	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf
Blue whale	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Sei whale	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Bryde's whale	14	18	2	1	1	0	0	0	0	9	9	0	4	4	0	28	32	2
Like Bryde's	2	2	0	0	0	0	0	0	0	5	5	0	1	1	0	8	8	0
Sperm whale	2	3	0	3	19	0	3	11	1	24	82	4	0	0	0	32	115	5
Cuvier's beaked whale	0	0	0	2	5	0	0	0	0	0	0	0	0	0	0	2	5	0
<i>Mesoplodon</i> spp.	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	2	3	0
<i>Ziphiidae</i>	0	0	0	1	1	0	1	1	0	2	4	0	3	5	0	7	11	0
Short-fin pilot whale	0	0	0	0	0	0	2	31	6	0	0	0	0	0	0	2	31	6
Pygmy killer whale	0	0	0	1	16	2	0	0	0	0	0	0	0	0	0	1	16	2
Risso's dolphin	2	19	1	0	0	0	0	0	0	0	0	0	0	0	0	2	19	1
Bottlenose dolphin	0	0	0	0	0	0	0	0	0	0	0	0	1	37	2	1	37	2
Spotted dolphin	0	0	0	0	0	0	0	0	0	0	0	0	1	133	11	1	133	11
Striped dolphin	2	251	25	2	67	4	0	0	0	1	60	6	0	0	0	5	378	35
Common dolphin	8	217	25	0	0	0	0	0	0	0	0	0	0	0	0	8	217	25
Unid. large baleen	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Unid. small cetacean	0	0	0	3	55	0	0	0	0	0	0	0	0	0	0	3	55	0
Unid. dolphin	3	141	0	1	6	0	0	0	0	0	0	0	0	0	0	4	147	0
Unid. cetacean	3	3	0	4	4	0	0	0	0	0	0	0	0	0	0	7	7	0
Total	39	657	53	20	177	6	6	43	7	41	160	10	10	180	13	116	1,217	89

Table 2d. Identification of duplicate sightings observed during survey in Independent Observer (IO) mode. 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
Bryde's whale	20	8	6	0	0	2
Like Bryde's whale	5	2	0	0	0	2
Sperm whale	30	12	8	0	0	4
<i>Ziphiidae</i>	6	2	1	0	0	1
Short-finned pilot whale	2	1	0	0	0	2
Pygmy killer whale	1	1	0	0	0	1
Risso's dolphin	1	1	0	0	0	1
Spotted dolphin	1	1	0	0	0	1
Unidentified small cetacean	3	1	0	0	0	1
Unidentified cetacean	6	3	0	0	0	3

Table 3. Minimum, maximum and range of sea surface temperatures in degrees Celsius for each species sighted during the whole cruise (including during the transit survey to the designated research area). Also noted are the number of sightings for each species. Range of 25th to 75th quartiles are presented for our most frequently encountered cetaceans.

Species	Number of sightings	Minimum SST	Maximum SST	Temperature range	25 th to 75 th Quartile
Blue whale	1	20.2	-	-	-
Sei whale	1	19.8	-	-	-
Bryde's whale	28	18.6	26.9	8.3	22.2-26.1
Sperm whale	32	22.5	26.9	4.4	26.1-26.5
Cuvier's beaked whale	2	24.6	24.9	0.3	-
<i>Mesoplodon spp.</i>	2	25.8	25.9	0.1	-
<i>Ziphiidae</i>	7	24.9	27.4	2.5	25.6-26.1
Short-finned pilot whale	2	26.1	26.1	0.0	-
Pygmy killer whale	1	21.7	-	-	-
Risso's dolphin	2	18.9	23.2	4.3	-
Common dolphin	8	18.6	18.8	0.2	18.7-18.8
Striped dolphin	5	18.8	26.7	7.9	19.0-25.8
Spotted dolphin	1	25.7	-	-	-
Bottlenose dolphin	1	25.3	-	-	-

Table 4a. Summary of Photographed Sightings with Photo-ID and Biopsy results. For species where biopsy / photo-ID is not attempted Whale ID and Biopsy Sample No. are blank (-). All Bryde's whale images were assessed for photo-ID. When images were not sufficient for unique identification, Whale ID states 'No ID'. For all Bryde's whale sightings that were not sampled, Biopsy Sample No. states 'No Sample', this includes sightings where attempts were unsuccessful and sightings where no biopsy attempt was made. For sightings where no biopsy attempt was made Encounter duration is blank (-). Biopsy sampling encounter duration was calculated using effort code "BX" (standby the equipment) and "EX" (darts collected time).

Sighting Date (D/M/Y) (SMT)	Sight No.	Species	School Size	Number Photo-ID'd	Number Biopsied	Nat Mark Form No.	Whale ID	Biopsy Sample No.	Biopsy Form No.	Encounter duration (min)	Notes
08/07/2016	2	Bryde's whale	2	1	2	ID001	ID001_A	16031001	BY001	18	
08/07/2016	2	Bryde's whale	2	1	2	ID001	-	16031002	BY001	15	
08/07/2016	4	Sei whale	1	1	1	ID002	ID002_A	16041003	BY002	25	
09/07/2016	2	Blue whale	1	1	1	ID003	ID003_A	16061004	BY003	50	Video taken
10/07/2016	2	Bryde's whale	2	2	1	ID004	ID004_B	16031005	BY004	13	
10/07/2016	2	Bryde's whale	2	2	0	ID004	ID004_A	-	BY004	42	
10/07/2016	3	Bryde's whale	1	0	0	ID005	-	-	-	32	
10/07/2016	4	Bryde's whale	1	0	0	ID006	-	-	-	32	
10/07/2016	9	Bryde's whale	1	1	1	ID007	ID007_A	16031006	BY005	31	
11/07/2016	4	Bryde's whale	1	0	1	ID008	-	16031007	BY006	14	
21/07/2016	1	Bryde's whale	1	1	1	ID009	ID009_A	16031008	BY007	10	
21/07/2016	2	Pygmy killer whale	16	0	0	ID010	-	-	-	-	
01/08/2016	1	Striped dolphin	12	0	0	ID011	-	-	-	-	Video taken
09/08/2016	2	Cuvier's beaked whale	3	2	0	ID012	ID012_A	-	-	-	
09/08/2016	2	Cuvier's beaked whale	3	2	0	ID012	ID012_B	-	-	-	
09/08/2016	4	Sperm whale	7	0	1	ID013	-	16101009	BY008	17	Video taken

Table 4a (continued).

Sighting Date	Sight No.	Species	School Size	Number Photo-ID'd	Number Biopsied	Nat Mark Form No.	Whale ID	Biopsy Sample No.	Biopsy Form No.	Encounter duration (min)	Notes
(D/M/Y)											
(SMT)											
10/08/2016	1	Striped dolphin	55	0	0	ID014	-	-	-	-	
15/08/2016	1	Sperm whale	5	1	1	ID015	ID015_A	16101010	BY009	70	Video taken
15/08/2016	7	Short-finned pilot whale	11	3	0	ID016	ID016_A	-	-	-	
15/08/2016	7	Short-finned pilot whale	11	3	0	ID016	ID016_B	-	-	-	
15/08/2016	7	Short-finned pilot whale	11	3	0	ID016	ID016_C	-	-	-	
15/08/2016	8	Short-finned pilot whale	20	0	0	ID017	-	-	-	-	
17/08/2016	1	Cuvier's beaked whale	1	1	0	ID018	ID018_A	-	-	-	
19/08/2016	3	Bryde's whale	1	0	1	ID019	-	16031011	BY010	7	Video taken
19/08/2016	4	Bryde's whale	1	1	1	ID020	ID020_A	16031012	BY011	29	Video taken
19/08/2016	12	Sperm whale	12	1	0	ID021	ID021_A	-	-	20	Video taken
20/08/2016	5	Bryde's whale	1	0	1	ID022	-	16031013	BY012	29	
20/08/2016	13	Striped dolphin	60	2	0	ID023	ID023_A	-	-	-	Video taken
20/08/2016	8	Striped dolphin	60	2	0	ID023	ID023_B	-	-	-	Video taken
20/08/2016	15	Sperm whale	3	0	0	ID024	-	16101014	BY013	14	Video taken
21/08/2016	1	Bryde's whale	1	1	1	ID025	ID025_A	16031015	BY014	40	Video taken
21/08/2016	4	Bryde's whale	1	1	1	ID026	ID026_A	16031016	BY015	49	Video taken
21/08/2016	5	Sperm whale	16	0	1	ID027	-	16101017	BY016	18	Video taken
21/08/2016	5	Sperm whale	16	0	1	ID027	-	16101018	BY016	18	
21/08/2016	9	Bryde's whale	1	1	1	ID028	ID028_A	16031019	BY017	14	Video taken
21/08/2016	13	Bryde's whale	1	1	1	ID029	ID029_A	-	-	26	
21/08/2016	17	Bryde's whale	1	1	1	ID030	ID030_A	16031020	BY018	14	
23/08/2016	2	Bottlenose dolphin	37	0	0	ID031	-	-	-	-	Video taken
23/08/2016	3	Bryde's whale	1	0	1	ID032	-	16031021	BY019	12	Video taken
23/08/2016	8	Bryde's whale	1	0	1	ID033	-	16031022	BY020	28	Video taken
23/08/2016	10	Bryde's whale	1	1	1	ID034	ID034_A	16031023	BY021	23	Video taken
23/08/2016	12	Spotted dolphin	133	0	0	ID035	-	-	-	-	

Table 4b. Summary of Bryde's whale sightings, photography and biopsy effort during the cruise. R.A.: Research Area. Parentheses indicate the number of calves. Ind.Photo-ID'd column indicates the number of whales photographed that displayed physical characteristics (i.e., dorsal fin nick or scarring) that would, potentially, be useful in future photo-identification and mark-recapture studies.

Bryde's whale	Total Sightings		Ind. Biopsy	Sch. Photo-graphed	Ind. Photo-graphed	Ind. Photo-ID'd
	Sch.	ind.				
Transit to R.A. (High Sea)	14	18 (2)	5 (1)	6	8 (2)	4
RA. (High Sea)	1	1	1	1	1	1
R.A. (US EEZ)	0	0	0	0	0	0
Transit to Shiogama (US EEZ)	9	9	7	8	8	6
Transit to Shiogama (High Sea)	4	4	3	3	3	1
Total	28	32	16	18	20	12

Table 4c. Summary of the number of biopsy samples collected by each species. *: including both samples from a mother and calf. In the case of Bryde's whales, biopsy samples from 5 individuals were collected from sub-area 1 (west of 180°E) and from 11 Bryde's whales located in sub-area 2 (east of 180°E).

Biopsy samples	Blue	Sei	Bryde's	Sperm	Total
Transit to R.A	1	1	5*	0	7
RA (High Sea)	0	0	1	1	2
RA (US EEZ)	0	0	0	1	1
Transit to Shiogama (US EEZ)	0	0	7	3	10
Transit to Shiogama (High Sea)	0	0	3	0	3
Total	1	1	16	5	23

Table 5. Summary of marine debris observations during whole cruise. On-effort observations were during the first 15 minutes each hour while on survey. Off-effort observations were strictly opportunistic.

IWC code	Item	ON Effort	OFF Effort	Total
121	Trawl net, large mesh, large piece	1	-	1
123	Unidentified net	3	-	3
124	Unidentified net, small mesh, large piece	2	-	2
125	Unidentified net, medium mesh, small fragment	1	-	1
126	Unidentified net, medium mesh, large piece	2	-	2
129	Unidentified net, large mesh, large piece	1	-	1
134	Long line, small piece	74	-	74
135	Long line, large piece	5	1	6
139	Single fishing float	1	-	1
147	Clustered fishing floats(2-10 floats together)	9	-	9
148	Wood plank	4	-	4
149	Wood crate, 1 side only	2	-	2
151	Wood structure	1	-	1
154	Metal can, 50-150 litres	1	-	1
161	Styrofoam, unidentified	9	-	9
162	Styrofoam board, less than 1 square metre	21	-	21
163	Styrofoam board, 1-3 square metres	5	-	5
199	Styrofoam box (at least 2 sides)	8	2	10
Total		150	3	153

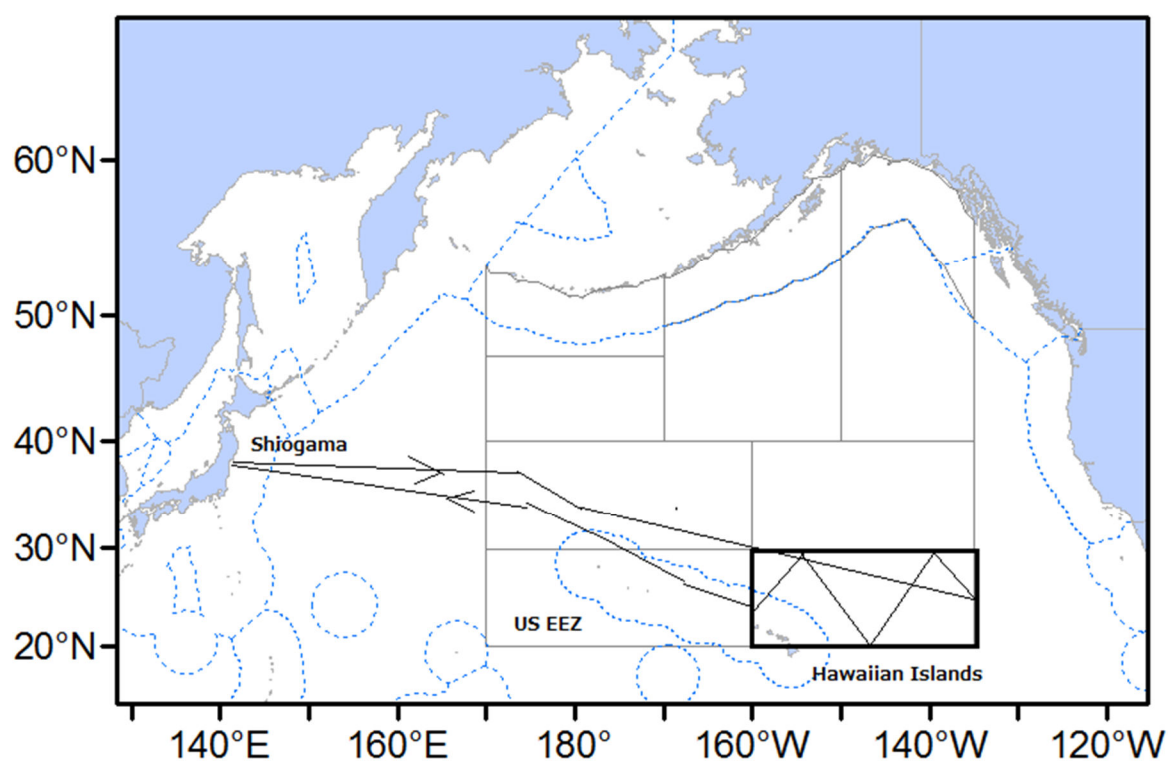


Figure 1a. Research area, transit and survey track lines for the 2016 IWC-POWER cruise.

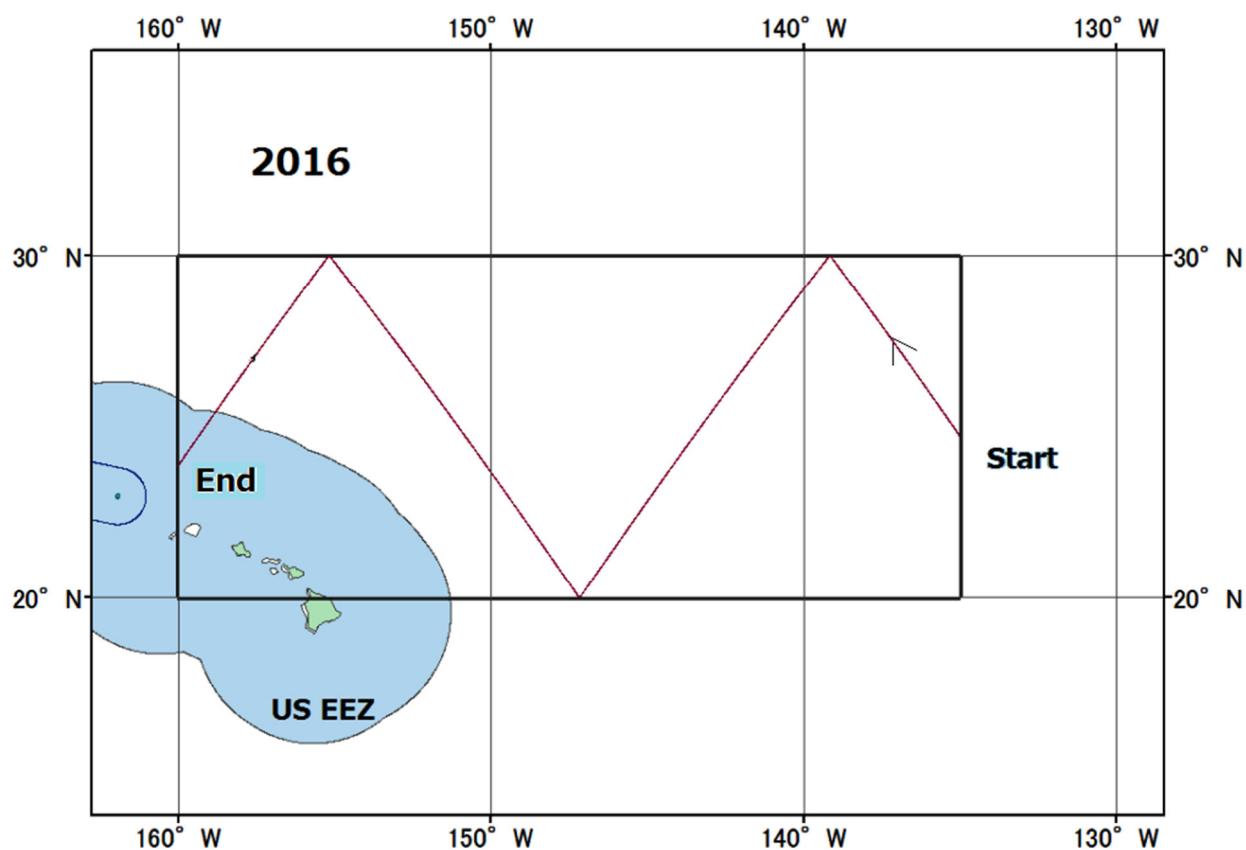


Figure 1b. Predetermined cruise track lines and course directions taken within the main survey area for the 2016 IWC POWER cruise survey.

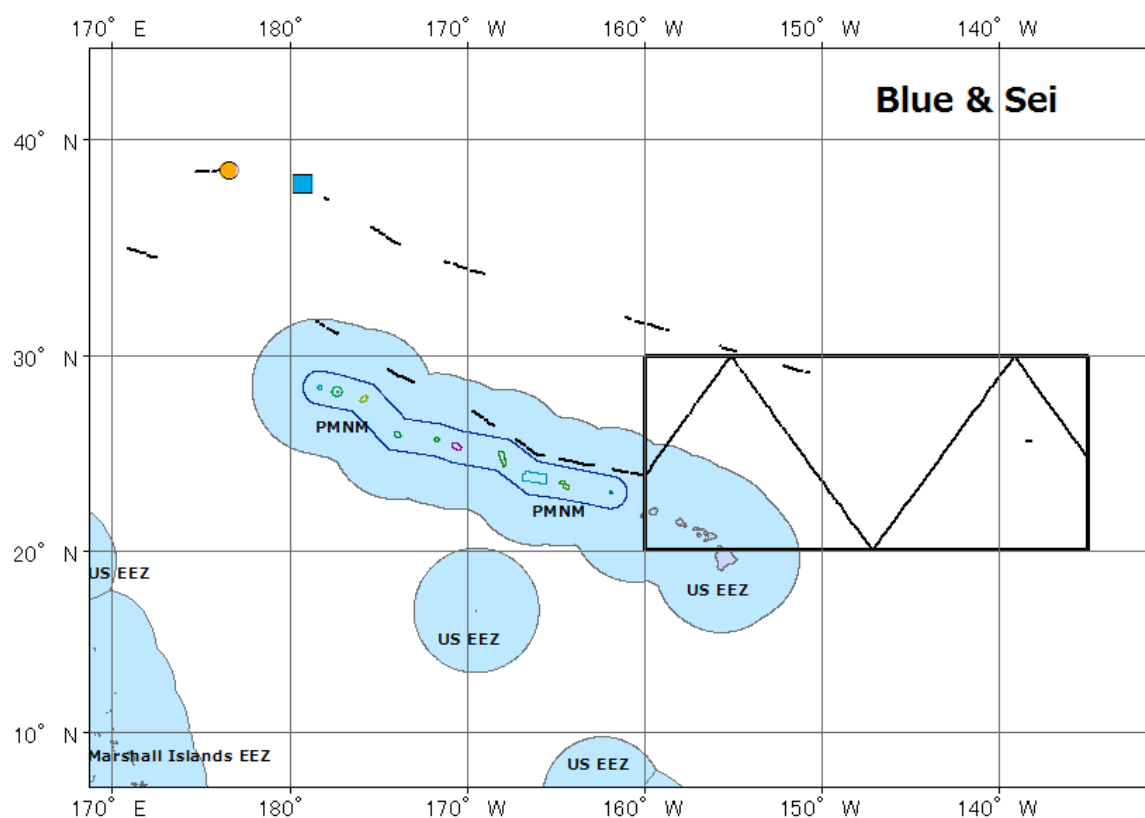


Figure 2a. The searching effort (thin line) and sighting positions of blue whale (blue square) and sei (yellow triangle) during the 2016 POWER cruise.

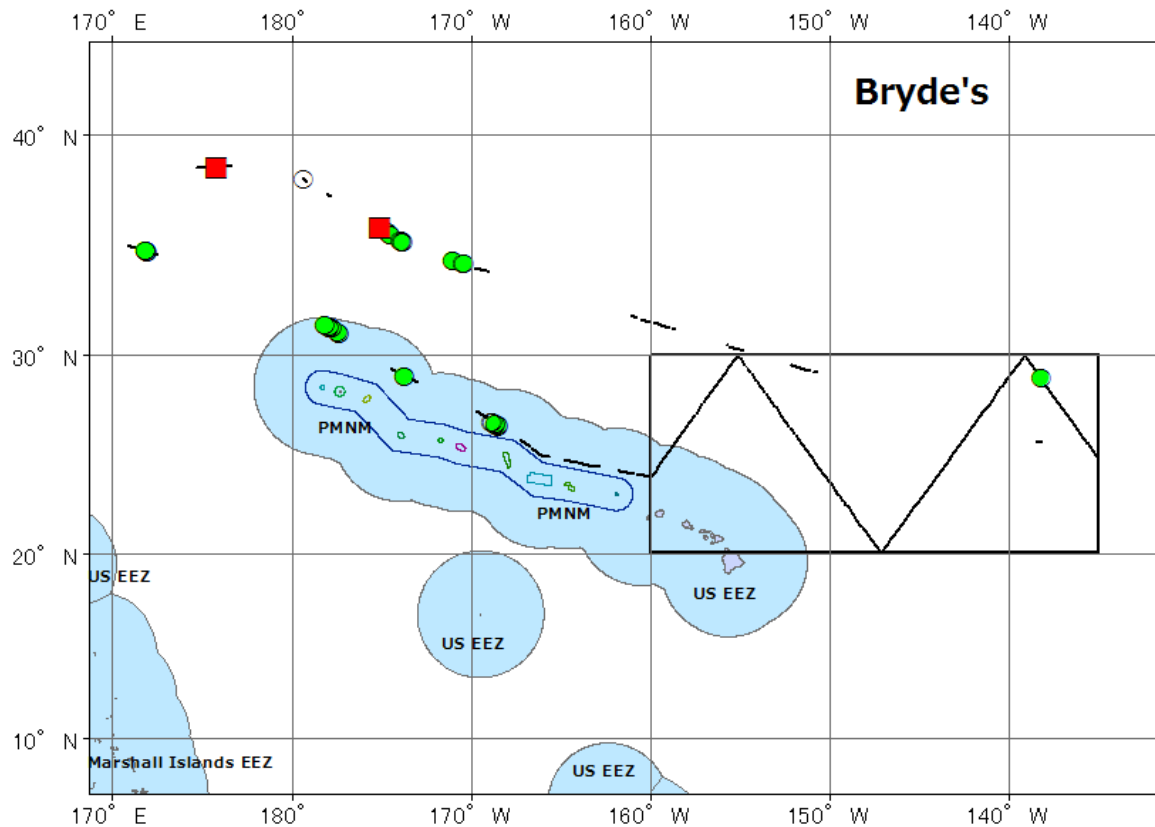


Figure 2b. The searching effort (thin line) and sighting positions of Bryde's whales (green circle), like Bryde's (white circle) including two mother and calf pairs (red Square) during the 2016 POWER cruise.

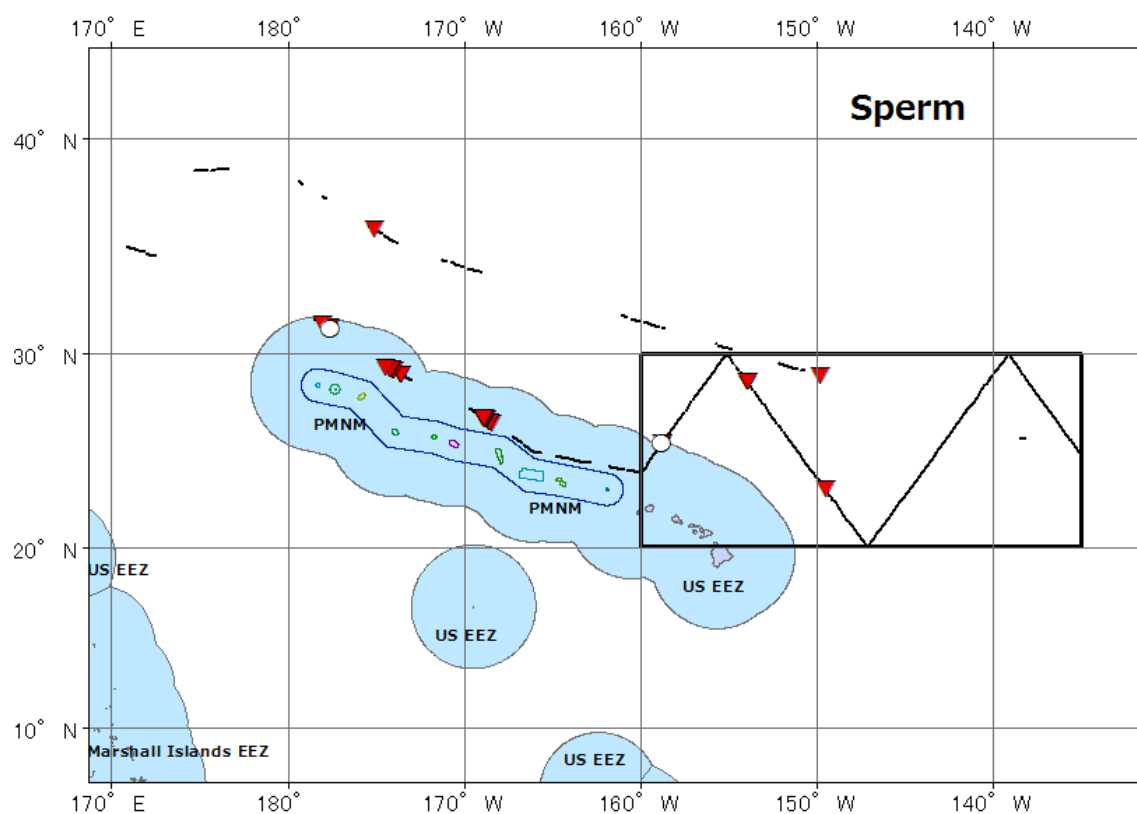


Figure 2c. The searching effort (black line) and sighting positions of sperm whales (red triangle) including mother and calf pairs (white circle) during the 2016 POWER cruise.

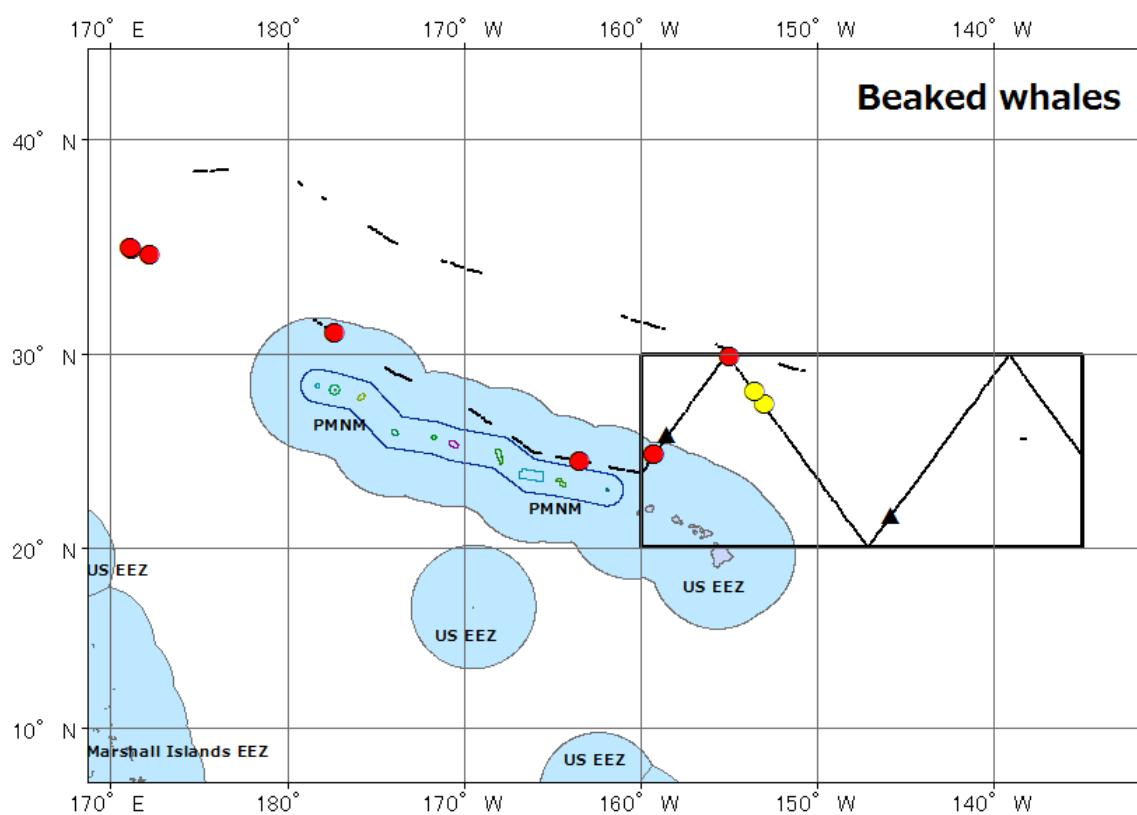


Figure 2d. The searching effort (thin line) and sighting positions of beaked whales. Cuvier's beaked whale (yellow circle), unidentified *Mesoplodon* (black triangle) and unidentified *Ziphiidae* (red circle) during the 2016 POWER cruise.

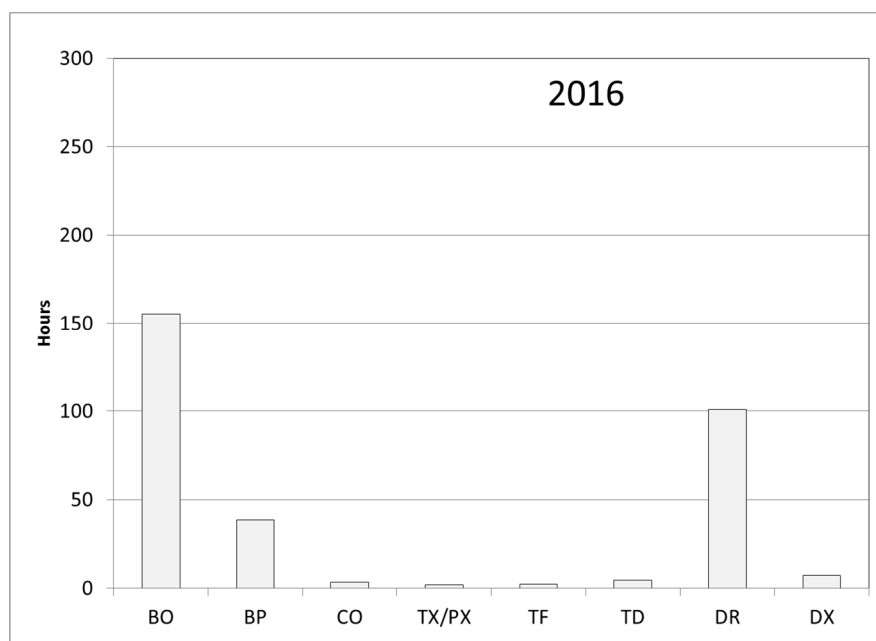


Figure 3. Breakdown of research time in hours, by effort code in the research area during the 2016 POWER cruise. BP: Passing mode searching, BO: Independent Observer mode, CO: Confirmation of school, TX/PX: Biopsy / Photo-ID experiments, TF: Time back to trackline, TD: Top down steaming, DR: Drifting, DX: Distance and angle estimate experiment.

APPENDICES

Appendix A. Ship specifications and crew list of *Yushin-Maru No.3*.

Ship photo:



Ship specifications:

	<i>Yushin-Maru No.3</i>
Call sign	7JCH
Length overall [m]	69.61
Molded breadth [m]	10.80
Gross tonnage (GT)	742
Barrel height [m]	19.5
Upper bridge height [m]	11.5
Bow height [m]	6.5
Engine power [PS / kW]	5280 / 3900

Crew list:

Title	<i>Yushin-Maru No.3</i>
Captain	Hiroshi Eguchi
Chief Officer	Hidenori Kasai
Second Officer	Hideto Honma
Chief Engineer	Hiroshi Tanno
First Engineer	Yoshihiro Ooura
Second Engineer	Keisuke Mizobuchi
Third Engineer	Yoshiaki Taketomi
Chief Operator/Purser	Yasunari Tsuda
Boatswain	Takao Ohmura
Quartermaster	Takashi Kuroki
Quartermaster	Kazumitsu Kurisu
Sailor	Akihiko Tsuji
Sailor	Kohsuke Matsuguchi
Sailor	Atsuo Yamasaki
Sailor	Masanori Tashima
Chief Steward	Kenichi Yasunaga
Steward	Kanji Mae

Appendix B. Comparison of weather conditions (wind speed / visibility) among past cruises (2010-2016).

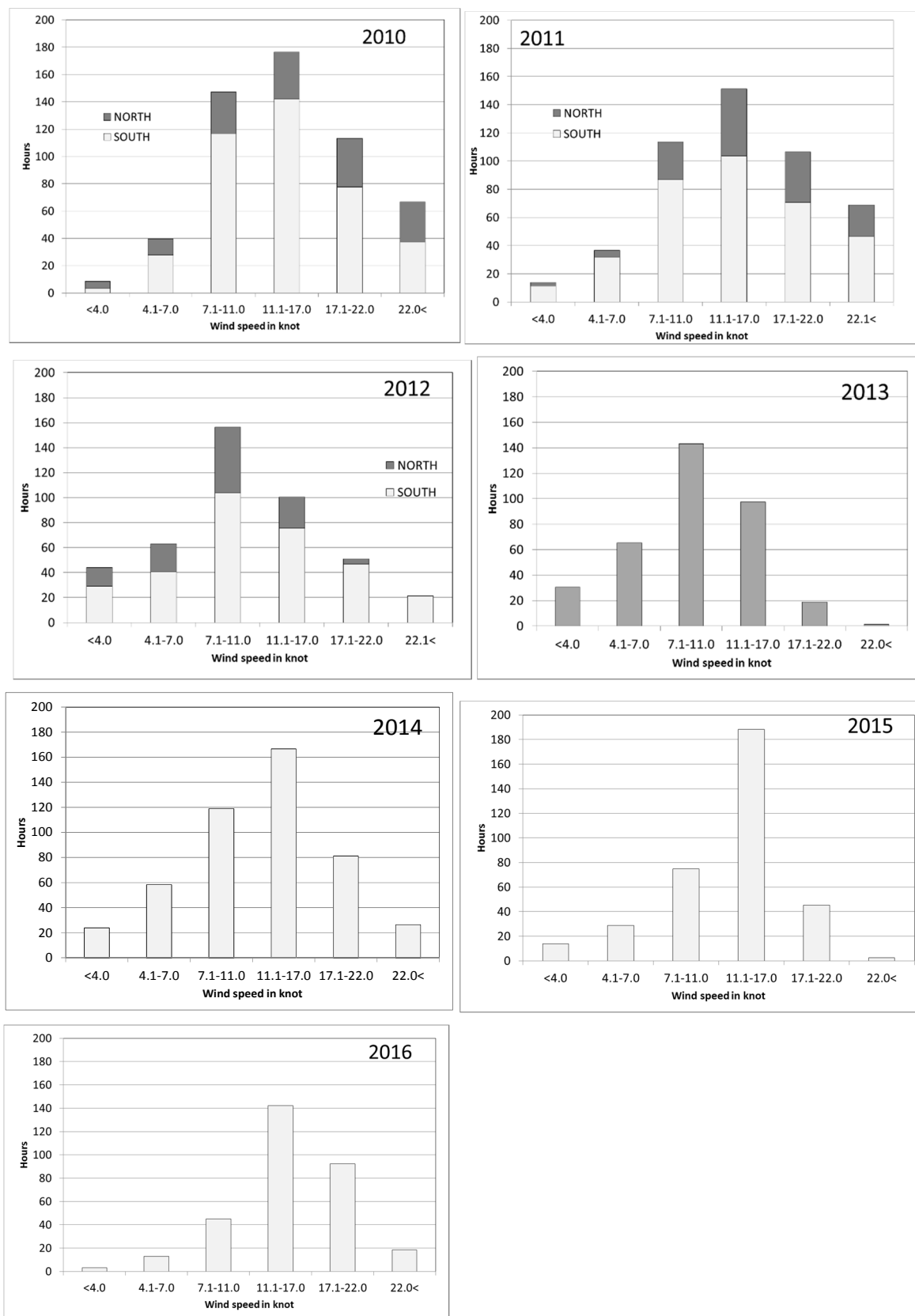


Figure B1. Breakdown of research time in hours during 2010 to 2016 surveys in research area by wind speed.

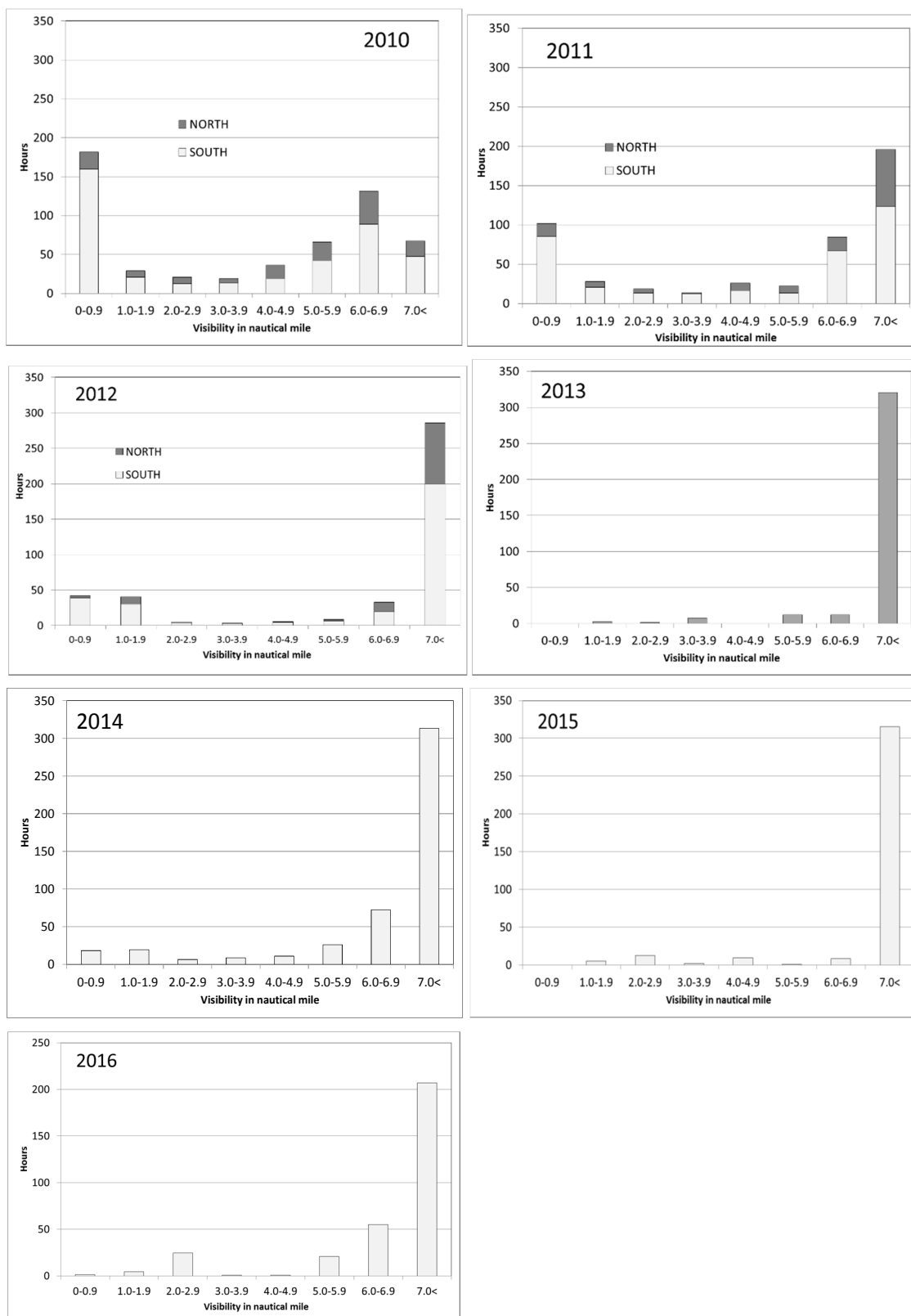


Figure B2. Breakdown of research time in hours during 2010 to 2016 surveys in research area by visibility in nautical mile.

Appendix C. Sightings in the US EEZ

1. Dates and Locations of Survey Effort in US waters

The ship first entered the US EEZ at location 25°-29.9'N, 158°-47.1'W on 14 August 2016 at 16:35 (SMT: GMT+12.5 hours) and final departure from the US EEZ was at location 31°-45.4'N, 178°-34.2'W, on 21 August 2016 at 15:13 (SMT: GMT+11.5 hours). Total searching distance in the US EEZ was 616.6 n. miles.

Appendix Table C1. Summary of searching effort by each survey mode in the US EEZ.

Area	Start	End	NSP		IO		NSP+IO		Photo-ID, Biopsy
	Date	Date	Time	Dist. (n.m.)	Time	Dist. (n.m.)	Time	Dist. (n.m.)	Time
	Time	Time							
US-EEZ (in the research area)	14-Aug.	16-Aug.	0:00:00	0.00	9:37:59	111.37	9:37:59	111.37	1:15:28
	16:35	7:37							
US-EEZ (transit to Shiogama)	16-Aug.	21-Aug.	0:00:00	0.00	42:08:10	505.18	42:08:10	505.18	4:54:18
	7:37	15:13							
Total	14-Aug.	21-Aug.	0:00:00	0.00	51:46:09	616.55	51:46:09	616.55	6:09:46
	16:35	15:13							

2. Sightings

Appendix Table C2 shows total sightings in the US EEZ. All Bryde's and killer whales sighted were approached for species confirmation and biopsy sampling. The group of sperm, beaked whales and dolphins were approached briefly to within 0.1 miles for long distance species confirmation.

Appendix Table C2. Summary of all sightings in the US-EEZ.

Species	Research area (US-EEZ)			Transit to Shiogama (US-EEZ)			Total		
	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf
Bryde's whale	0	0	0	9	9	0	9	9	0
Like Bryde's whale	0	0	0	5	5	0	5	5	0
Sperm whale	3	11	1	24	82	4	27	93	5
<i>Ziphiidae</i>	1	1	0	2	4	0	3	5	0
Southern form short-finned pilot whale	2	31	6	0	0	0	2	31	6
Striped dolphin	0	0	0	1	60	6	1	60	6
Total	6	43	7	41	160	10	47	203	17

Appendix Table C3. Sightings in the US-EEZ with locations and sea surface temperature (SST).

Date (y/m/d)	Sighting No.	Species	School size	Calf	Lat.	Long.	S.Temp. (°C)
2016/8/15	001	Sperm whale	5	1	25°28.3'N	158°48.4'W	25.8
2016/8/15	002	Sperm whale	4	0	25°28.3'N	158°48.4'W	25.8
2016/8/15	004	Sperm whale	2	0	25°28.1'N	158°48.5'W	25.8
2016/8/15	007	Southern form short-finned pilot whale	11	2	24°57.2'N	159°13.0'W	26.1
2016/8/15	008	Southern form short-finned pilot whale	20	4	24°53.4'N	159°16.0'W	26.1
2016/8/15	009	<i>Ziphiidae</i>	1	0	24°53.2'N	159°16.1'W	26.1
2016/8/17	001	<i>Ziphiidae</i>	1	0	24°34.1'N	163°31.2'W	27.4
2016/8/19	001	Sperm whale	1	0	26°30.6'N	168°29.9'W	26.1
2016/8/19	002	Bryde's whale	1	0	26°30.9'N	168°30.4'W	26.1
2016/8/19	003	Bryde's whale	1	0	26°31.1'N	168°30.8'W	26.1
2016/8/19	004	Bryde's whale	1	0	26°32.6'N	168°36.7'W	26.1
2016/8/19	005	Sperm whale	3	0	26°33.8'N	168°38.2'W	26.1
2016/8/19	007	Sperm whale	3	0	26°34.7'N	168°39.4'W	26.1
2016/8/19	009	Like Bryde's whale	1	0	26°40.0'N	168°48.8'W	26.3
2016/8/19	010	Sperm whale	6	0	26°40.7'N	168°49.5'W	26.3
2016/8/19	011	Sperm whale	4	0	26°41.6'N	168°50.6'W	26.2
2016/8/19	012	Sperm whale	12	0	26°41.9'N	168°50.9'W	26.2
2016/8/19	013	Like Bryde's whale	1	0	26°41.9'N	168°50.9'W	26.3
2016/8/19	015	Sperm whale	6	0	26°42.0'N	168°51.0'W	26.3
2016/8/19	016	Sperm whale	3	0	26°42.1'N	168°51.2'W	26.3
2016/8/19	018	Sperm whale	1	0	26°45.3'N	168°54.3'W	26.4
2016/8/19	019	Sperm whale	1	0	26°46.5'N	168°56.4'W	26.4
2016/8/19	022	Sperm whale	1	0	26°47.3'N	168°57.8'W	26.3
2016/8/19	023	Sperm whale	1	0	26°47.6'N	168°58.2'W	26.3
2016/8/19	024	Sperm whale	1	0	26°47.8'N	168°58.7'W	26.3
2016/8/20	001	Sperm whale	7	0	28°56.0'N	173°36.5'W	26.5
2016/8/20	003	Sperm whale	1	0	28°55.8'N	173°39.3'W	26.5
2016/8/20	005	Bryde's whale	1	0	28°58.4'N	173°43.9'W	26.5
2016/8/20	007	Sperm whale	2	0	29°08.3'N	174°04.4'W	26.8
2016/8/20	009	Sperm whale	1	0	29°12.0'N	174°13.4'W	26.8
2016/8/20	010	Sperm whale	2	0	29°12.1'N	174°13.6'W	26.8
2016/8/20	013	Striped dolphin	60	6	29°13.5'N	174°15.9'W	26.7
2016/8/20	015	Sperm whale	3	0	29°19.9'N	174°32.2'W	26.6
2016/8/21	001	Bryde's whale	1	0	31°01.8'N	177°21.2'W	26.1
2016/8/21	002	<i>Ziphiidae</i>	3	0	31°02.3'N	177°20.5'W	26.1
2016/8/21	003	Like Bryde's whale	1	0	31°02.4'N	177°20.4'W	26.1
2016/8/21	004	Bryde's whale	1	0	31°07.1'N	177°27.4'W	26.0
2016/8/21	005	Sperm whale	16	4	31°11.6'N	177°36.4'W	26.4
2016/8/21	007	Sperm whale	1	0	31°15.4'N	177°39.8'W	26.7
2016/8/21	009	Bryde's whale	1	0	31°17.6'N	177°44.4'W	26.7
2016/8/21	011	Sperm whale	2	0	31°17.9'N	177°46.4'W	26.9
2016/8/21	012	Sperm whale	2	0	31°17.9'N	177°51.9'W	26.8
2016/8/21	013	Bryde's whale	1	0	31°19.3'N	177°53.7'W	26.7
2016/8/21	014	Like Bryde's whale	1	0	31°20.2'N	177°54.9'W	26.8
2016/8/21	015	Sperm whale	2	0	31°26.7'N	178°07.4'W	26.9
2016/8/21	016	Like Bryde's whale	1	0	31°27.2'N	178°07.9'W	27.0
2016/8/21	017	Bryde's whale	1	0	31°27.5'N	178°08.3'W	26.9

3. Photo-ID

Sufficient photographs for assigning photo-ID catalogue numbers were collected for 6 individual Bryde's whales. In addition, 2 sperm whales, 3 pilot whales, 1 Ziphiidae and 2 striped dolphins were sufficiently photographed for individual identification (Appendix Table C5).

Appendix Table C4. Summary of Photo-ID effort in the US EEZ by Sighting.

Sighting Date (SMT)	Sight. No.	Species	School Size	Number Photo-ID'd	Number Biopsied	Whale ID / Nat. Mark. Form No.	Biopsy Sample No.	Biopsy Form No.	Encounter Duration (min)	Notes
15/08/2016	001	Sperm whale	5	1	1	ID015	16101010	BY009	12	
15/08/2016	007	Short-finned pilot	11	3	0	ID016	-		21	
15/08/2016	008	Short-finned pilot	20	0	0	ID017	-	-	15	
17/08/2016	001	Ziphiidae	1	1	0	ID018			10	
19/08/2016	003	Bryde's whale	1	0	1	ID019	16031011	BY010	22	
19/08/2016	004	Bryde's whale	1	1	1	ID020	16031012	BY011	25	
19/08/2016	012	Sperm whale	12	1	0	ID021	-	-	18	
20/08/2016	005	Bryde's whale	1	0	1	ID022	16031013	BY012	25	
20/08/2016	013	Striped dolphin	60	2	0	ID023	-	-	20	
20/08/2016	015	Sperm whale	3	0	1	ID024	16101014	BY013	18	
21/08/2016	001	Bryde's whale	1	1	1	ID025	160331015	BY014	25	
21/08/2016	004	Bryde's whale	1	1	1	ID026	16031016	BY015	27	
21/08/2016	005	Sperm whale	16	0	2	ID027	16101017-18	BY016	35	Cow and Calf Biopsied
21/08/2016	009	Bryde's whale	1	1	1	ID028	16031019	BY017	22	
21/08/2016	013	Bryde's whale	1	1		ID029			20	
21/08/2016	017	Bryde's whale	1	1	1	ID030	16031020	BY018	15	

Appendix Table C5. Summary of photo-ID effort in the US EEZ by Species.

Species Photographed	Total Sightings		Photo-ID		
	Sch.	Ind.	Sch. Photo'd	No. images useful for Photo-ID ¹	Ind. Photo-ID'd
Bryde's whale	9	9	7	36	6
Sperm whale	22	93	3	5	2
Short-finned pilot whale	2	31	2	59	3
Striped dolphin	4	191	1	6	2
Total	37	581	13	106	12

4. Biopsy

Biopsy samples were collected from 11 Bryde's whales within the boundaries of the US EEZ, including samples from two mother-calf pairs. In addition, biopsy samples were collected from 2 killer whales within the US EEZ (Appendix Table C4).

Appendix Table C6. Summary of biopsy samples in the US EEZ.

Sighting Date	Species	Sighting No.	School Size	Biopsy Sample No.*	Natural Markings Form No.**	Whale No.***	Photo ID	Remarks
15-Aug-16	Sperm whale	001	5	16101010	ID015	A	Yes	US EEZ
19-Aug-16	Bryde's whale	003	1	16031011	ID019	A	No	US EEZ
19-Aug-16	Bryde's whale	004	1	16031012	ID020	A	Yes	US EEZ
20-Aug-16	Bryde's whale	005	1	16031013	ID022	A	No	US EEZ
20-Aug-16	Sperm whale	015	3	16101014	ID024	A	No	US-EEZ,
21-Aug-16	Bryde's whale	001	1	16031015	ID025	A	Yes	US-EEZ,
21-Aug-16	Bryde's whale	004	1	16031016	ID026	A	Yes	US-EEZ,

¹ Images useful for photo-ID may not be sufficient to catalogue the individual, but show useful identification characteristics such as dorsal fin shape, nick in dorsal, scars etc. These images are coded Green in the IWC Lightroom database.

Sighting Date	Species	Sighting No.	School Size	Biopsy Sample No.*	Natural Markings Form No.**	Whale No.***	Photo ID	Remarks
21-Aug-16	Sperm whale	005	16	16101017	ID027	A	No	US-EEZ, Mother.
21-Aug-16	Sperm whale	005	16	16101018	ID027	B	No	US-EEZ, Calf.
21-Aug-16	Bryde's whale	009	1	16031019	ID028	A	Yes	US EEZ
21-Aug-16	Bryde's whale	017	1	16031020	ID030	A	Yes	US EEZ
23-Aug-16	Bryde's whale	003	1	16031021	ID032	A	No	US EEZ,
23-Aug-16	Bryde's whale	008	1	16031022	ID033	A	No	US EEZ
23-Aug-16	Bryde's whale	010	1	16031023	ID034	A	Yes	US EEZ

* Sample Number = Year (16) | Species code (e.g. Bryde's 03) | Boat code (1) | Serial number (consecutive number for all samples throughout the cruise starting at 001)

** A natural marking record sheet is completed for every school photographed. Forms are numbered consecutively throughout the cruise starting at ID001.

*** Each individual in a school is designated a letter starting with 'A'. Mother within a cow/calf pair is 'A', calf is 'B'

5. Marine Debris

A total of 22 objects of marine debris were recorded during surveys in the US EEZ (Appendix Table C7) and 2 of those were photographed.

Appendix Table C7. Summary of all marine debris observations in the US EEZ.

IWC code	Item	Remarks	Number
134	Single fishing float	Diameter:0.5m×7, 0.6m×2, 0.8m×1	10
147	Styrofoam, unidentified	Styrofoam buoy×2(0.8m×0.5)(0.6m×0.4m), unkown×2(0.8×0.5×0.5)(0.2×0.1)	4
162	Plastic, less than 1 square metre	Plastic grid×3(10m)(0.4m×0.3m)(0.08m×0.25m), Plastic box×1(0.6m×0.4)	4
163	Plastic, 1-3 square metres	Plastic sheet×1(3m×3m)	1
199	Other	Large buoy from Japan(1.5m×1,5m)	1
199	Other	Large flat buoy(2m)	1
199	Other	Radio buoy(0.8m)	1
Total			22

END