Cruise report of the 2013 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER)

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ABSTRACT

The 4th annual IWC-POWER (as a successor to the IWC/IDCR-SOWER cruises since 1978/79 in the Antarctic) was successfully conducted from 12 July to 9 September, 2013 in the eastern North Pacific (north of 30°N, south of 40°N, between 160°W and 135°W) using the Japanese Research Vessel *Yushin-Maru No.3*. The cruise was organized as a joint project between the IWC and Japan. The cruise plan was endorsed at the 64th IWC/SC meeting. Researchers from Japan, Korea and México 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 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 photos 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; (e) provide essential information for the intersessional workshop to plan for a medium-long term international programme in the North Pacific. The sighting survey was conducted under the methods based on the guidelines of the IWC/SC and the predetermined transect lines were completed. Survey coverage was 93.9% and a total of 3,035.9 n.miles was surveyed in the research area in the Passing (NSP) with abeam closing mode. Totals of 854.9 and 451.4 n.miles were also surveyed during transit to and from the research area. Sightings of fin (3 schools / 3 individuals), sei (4/4), Bryde's (54/64), common minke (1/1), sperm (67/99), dwarf sperm (1/2), Cuvier's beaked (2/6), Stejneger's beaked (1/4), *Mesoplodon* spp. (9/22), Ziphiidae (36/71), short-finned pilot (1/1) whales, Risso's (9/208), rough-toothed (2/62), bottlenose (1/7), spotted (6/455), striped (16/1,395), short-beaked common dolphin (3/175), Pacific white-sided (5/68), northern right whale (2/21) dolphins, Dall's porpoise (11/38) and unidentified large whales (39/43) were made during whole cruise. Sperm and Bryde's whales were the most frequently sighted large species. All solitary Bryde's and fin whales were sighted in the west of 148°W in the research area. Sperm and beaked whales were widely distributed in the research area. The Estimated Angle and Distance Training Exercise and Experiment were completed as in previous years. There were no high priority sightings of photo-ID species (blue, humpback and North Pacific right whales) during the cruise. Photo-identification data for 3 fin, 2 sei and 6 Bryde's whales were collected. A total of 8 biopsies (skin samples) were successfully collected from 1 fin, 1 sei and 6 Bryde's whales using the Larsen-gun system. The research area of this cruise was within an area so called 'Great Pacific Garbage Patch'. 1,508 records of marine debris were observed including 10 overturned small boats and 2 other items, possibly related to the Japan Tsunami-2011. The planned survey procedure was in accordance with the guidelines agreed by the SC. At the pre-cruise meeting, Captain and crew of the vessel, and international researchers fully agreed on the objectives of the survey and procedures. The 4th cruise of POWER program was completed and provided important information on the cetacean distributions in the area where no survey had been conducted in the recent decades. These results will contribute to the above objectives for the IWC/SC.

1. INTRODUCTION

1.1 Research objective

The cruise was organized as a joint project between the IWC and Japan (IWC, 2012a, 2012b, 2012c, 2013; Kato *et al*., 2011, Matsuoka *et al*., 2011, 2012, 2013). The 2013 cruise plan was endorsed at the 64th 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 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 photos 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; (e) provide essential information for the intersessional workshop to plan for a medium-long term international programme in the North Pacific (IWC, 2013).

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

The research area was set north of 30°N, south of 40°N between 160°W-135°W where the longer transit distance from Japan than previous cruises (Figure 1a). The survey area was not divided into northern and southern strata. A random start point for survey tracks was used as same as 2010, 2011 and 2012 IWC-POWER cruises based on the IWC/SC survey guidelines (IWC, 2005). Every location within the study area has an equal probability of being sampled which is calculated by the software "DISTANCE" (Thomas *et al*., 2010). Figure 1a shows the cruise track design in the research area and Table 1a shows Waypoints (WP) for the pre-determined tracklines. Research hours during the cruise were the same as in SOWER cruises. The research day began 60 minutes after sunrise and ended 60 minutes before sunset, with a maximum of a 12-hour research day (7:00-19:00 for 2013 cruise). Time-zone changes were in 30-minute or 60-minute intervals, coming into effect at midnight. Primary search effort was conducted only in acceptable weather conditions. The sighting survey was conducted using Passing (NSP) with abeam closing mode based on the discussions at the Tromsø SC meeting, recommendations based on the 2010 cruise and suggestions from the Technical Advisory Group (TAG) of SC members (IWC, 2013). The usual guidelines for acceptable conditions applied, i.e. visibility greater than 2.0 n. miles and wind speed is <21 knots; the sea state should be <Beaufort 6 as same as previous cruises. Two primary observers were in the barrel throughout in NSP mode (See Item 2 Survey Mode). Details of the sighting survey are given in the "Information for researchers" (Anon. 2013a). At the sightings of very rare species (e. g. blue and right whales), the vessel approached to whales to avoid losing them due to the delay of closing.

The R/V *Yushin-Maru No.3* (YS3) surveyed the high seas area in this cruise including transits between Japan and research area. Research time was given 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 in this cruise using the Larsen-gun system. Target species for photo-ID were blue, North Pacific right and humpback whales. Photos of fin whales, sei whales, Bryde's, sperm whales were also obtained opportunistically.

2. SHORT NARRATIVE OF THE CRUISE

2.1 The 2013 cruise itinerary

Date	**Event**
11 July 2013	Pre-cruise meeting
12 July	Vessel departed Shiogama, Japan
23 July	Vessel arrived at the starting point at 160°00'W in the research area
23 August	Vessel completed the research at 135°00'W (32 days in the research area).
7 September	Post-cruise meeting
9 September	Vessel arrived Shiogama, Japan

2.2 Research vessel used

The R/V *Yushin-Maru No.3* (742GT) was engaged for this cruise as in 2011 and 2012 cruises. Ship specifications, photo, and a crew list are shown in Appendix A.

2.3 **Scientists present and responsibilities**

Four international researchers were nominated by the steering group of POWER programm: Koji Matsuoka (Cruise leader), Hyun Woo Kim (photo-ID/video), Sergio Martínez Aguilar (biopsy and marine debris), Saeko Kumagai (sighting data management).

Koji Matsuoka (Japan) - Cruise Leader, sighting/photo-ID
Hyun Woo Kim (Republic of Korea) - photo-ID and video
Sergio Martínez-Aguilar (México) - biopsy and marine debris data managements
Saeko Kumagai (Japan) – sighting and data management
Reserve : -

2.4 Pre-cruise meeting

On 11 July, a pre-cruise meeting was held on the R/V *Yushin-Maru No.3* (YS3) under Kato (Convenor of this cruise). The meeting discussed and confirmed the priorities and strategies of the cruise based on the planning report (IWC, 2013) as well as research manual (Anon, 2013a). Meeting participants were: Kato (TUMSAT, Chair), Miyashita (NRIFSF), Matsuoka (ICR, cruise leader), Kim (Republic of Korea, CRI, researcher), Martínez (Mexico, PRIMMA-UABCS, researcher), Kumagai (researcher), Sasaki (Captain), Abe (Chief Engineer), Iida (Chief Operater), Takamatsu (Chief Officer), Wakatsuki (Bosun) and Mori (Kyodo-Senpaku). Report of this meeting was distributed to the steering group after review by the Chair (Anon, 2013b). On 12 July, all researchers and equipment were on board the YS3.

2.5 Research hour, the survey mode and the number of observers on effort

Research hours during the cruise were the same as on recent SOWER and POWER cruises. The research day began 60 minutes after sunrise and ended 60 minutes before sunset, with a maximum of a 12-hour research day (07:00-19:00). Time-zone changes were in 30-60 minute intervals, coming into effect at midnight.

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 is being executed and conditions (such as weather and sea conditions) were within acceptable parameters to conduct research. Off-effort activities were all activities that were not On-effort. All sightings recorded while the ship was On-effort were classified as Primary sightings. All other sightings are considered to be Secondary sightings. Sighting effort was conducted by the bosun and topmen from the barrel (crow's nest) and the upper bridge where the helmsman, captain or officer-on-watch, researchers, and the chief engineer or deputy are also present. Passing with abeam closing Mode (NSP) was used during this cruise. This was in effect Passing Mode. Two topmen were observing from the barrel at all times (07:00-19:00). There was open communication between the upper bridge and the barrel. The observers on the upper bridge communicated with the topmen only to clarify information and did not direct the topmen to disrupt their normal search procedure unless they were directed to do so by the Cruise Leader (Anon. 2013a).

Immediately after a sighting was made from the barrel, the topman informed the upper bridge of his estimate of the distance and angle to the sighting (and also, if possible, the species and number of animals present), but did not change his normal searching pattern in order to keep contact with the sighting. The observers on the upper bridge attempted to locate the sighting made by the topman and decided whether it was possible for them to confirm the species and number before the sighting passes abeam of the vessel. The topman gave no further information to the upper bridge unless the whale group happens to surface again within the normal searching pattern of the topman. 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, in consultation with other researchers. When the sighting location was abeam of the vessel, the ship changed course to the appropriate heading to approach the whale, and vessel speed was increased to 15 knots to hasten the closure. Ship speed was decreased when the group was neared, usually at a distance of 0.2-0.4 n. miles from the initial sighting position. After the whale group was approached, the species, number of animals in the group, estimated lengths, number of calves present, and behaviour were determined and recorded. After as much data as possible have been collected, other activities might take place, such as natural marking or biopsy experiments. Until the ship resumed the transect with full search effort, any whale sightings made after the initial sighting were classified as secondary sightings (Anon. 2013a).

2.6 Weather conditions and expected versus realised effort

Weather conditions were different and better than in the previous three cruises. In the research area, general weather conditions were good due to a strong high pressure system and high sea surface temperature from the south. A total of 3,035.7 n. miles was surveyed in the research area in the Passing (NSP) with abeam closing mode. Survey coverage (searching distance / planned distance (3,233.9 n.miles)) was 93.9% in the research area.

3. SUMMARY OF SIGHTINGS

3.1 Identification of species

Guidelines for species identification were based on the IWC-SOWER (Southern Ocean Whale and Ecosystem Research) and IWC-POWER methods for classification of identification (Anon, 2013a):

Positive identification of species was based on multiple cues and usually required the clear observation of the whale's body. Occasionally, repeated observations of the shape of the blow, surfacing and other behavioural patterns were also sufficient; this judgement was made only by the Cruise leader or other designated researcher. Probable identification of species was based on multiple cues, which were nevertheless insufficient to be absolutely confident in identification. This usually occurred when blows are seen, the surfacing pattern is correct, but the whale's body could not be seen or clearly seen. Details of the sighting record were shown in the 'Information for researcher' (Anon, 2013a).

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. The data from the confirmed schools can be used to determine a mean school size. Therefore it is critical that the schools that are confirmed are representative in size of the schools that are in the survey area. Normally, schools believed to be confirmed for school size are approached to within 1n. mile for large whales and to within 0.3 n. miles for minke whales. Obviously, there are differences in the environmental conditions and behavior of the animals for every sighting; however, (with particular reference to minke whale sightings) every effort was made to be as consistent as possible in 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) should be spent trying to complete these tasks. (Otherwise there is the potential for confusion with other sightings in the vicinity) (Anon, 2013a).

3.3 Sighting summary

Tabulations of all waypoint (WP) of the track line, the searching effort and the sightings recorded in the research area, by species and by effort mode are presented in Tables 1a, 1b and 2a, respectively. Table 2b summarizes all the sightings observed during the entire cruise including transit to and from the research area. Table 3 shows the sea surface temperatures (min. max. and range) for each frequently sighted species in the research area and provides quartile analysis for a few of the major species observed. Figure 1a and 1b illustrated the research area and the track line design and location of the searching effort, respectively. Figures 2a, 2b, 2c, 2d and 2e illustrate the location of the sightings. Figure 3a shows the breakdown of research time, in hours by effort codes in the research area. Figure 3b and 3c show the breakdown of research time, in hours by wind speed and visibility in the research area, respectively.

Comparison of weather conditions (wind speed and visibility) among past cruises (2010-2012) are shown in Appendix B. It is appeared that wind speed of this cruise was generally low rather than 2010 and 2011 cruises.

Transit survey to the research area

The YS3 departed Shiogama port on schedule (10:55, 12 July) and started transit survey using the passing mode between 14 July (07:00) and 22 July (18:20) from Shiogama to the research area under good weather or intervals of rain conditions. The safety instruction meeting and emergency drill were conducted on 13 July. The exercise “experiment of distance & angle estimation” and “test of Larsen-gun” were conducted on 16 July. No biopsy experiment was conducted due to time limitation during the transit survey.

A number of Bryde’s whales were sighted in the both sides of the Emperor Sea mount chain (32˚N-35˚N, between 160˚E and 180˚E) during 16 to 19 July (Figures 2a and 2f). Total searching distance was 854.9 n. miles. Total sightings included Bryde’s (48 schools / 58 individuals), sperm (21/23), *Mesoplodon* spp. (1/2), Ziphiidae (4/10), Risso’s (1/14), rough-toothed (1/60), spotted (1/55), striped (1/80), short-beaked common (2/95) dolphins were made. Sightings recorded in the transit sighting survey, by species are presented in Tables 2b.

The research area

The YS3 finished the transit survey and started the research area survey at Waypoint 101 (WP, see Table 1a) position 32˚22’N 160˚00’W, on 23 July 07:00 on a southeast course under acceptable searching conditions. The YS3 arrived at the most east WP (WP131) position 37˚38’N 135˚00’W on 23 August 13:13 almost on schedule (Table 2b).

Generally, weather condition was good for the sighting survey under the strong high pressure which located in the western side of the research area. Wind speed was generally ranged 7-15 knots and visibility was almost over 7.0 n.miles (Figures 3b and 3c). There was no strong ocean current in the research area.

A total of 3,035.9 n. miles was surveyed in the research area in the Passing (NSP) with abeam closing mode. Survey coverage (searching distance / planned distance (3,233.9 n.miles)) was 93.9% in the research area. The most dominant large whale species in the research area were sperm (33 schools / 50 individuals) and Bryde’s (6/6) whales. Total sightings of other species including fin (1 school / 1 individual), dwarf sperm (1/2), Cuvier’s beaked (2/6), Stejneger’s beaked (1/4), *Mesoplodon* spp. (8/20), Ziphiidae (other than beaked whale) (28/51), short-finned pilot (1/1) whales, Risso’s (7/169, including 21 calves), rough-toothed (1/2), bottlenose (1/7), spotted (5/400, incl. 61 calves), striped (14/1,275 incl. 87 calves) dolphins and unidentified large whales (8/8) were made in the research area. All Bryde’s and fin whales were sighted in western side of the research area (Figures 2a and 2b). Sperm and beaked whales were widely distributed in the research area (Figures 2b and 2c). Sightings recorded in the research area by species, by modes are presented in Table 2a.

The Estimated Angle and Distance Training Exercise and Experiment were completed on 17 August in the research area as in previous years. Results of the Photo-identification, biopsy experiments and the marine debris observation were shown following paragraphs.

Transit survey to Shiogama

The YS3 departed the research area (13:13, 23 August) and started transit survey using the passing mode between 23 August (07:00) and 7 September (12:00) to Shiogama port under heavy wind or fog intervals of rain conditions (Table 1b). Total searching distance was 451.4 n. miles. Total sightings included fin (2 schools / 2 individuals), sei (4/4), common minke (1/1), sperm (13/26) whales, Ziphiidae (4/10), Risso's (1/25), striped (1/40), short-beaked common (1/80), Pacific white-sided (5/68), northern right whale (2/21), dolphins and Dall's porpoise (11/38). Sightings recorded in the transit sighting survey, by species are presented in Tables 2b.

Detailed sightings by each species as follows:

Fin whale

A solitary fin whale was sighted in the western side of the research area (Figure 2a). Sea surface temperature was at 22.1˚C. Skin sample was collected from this animal. From photos, many parasites were observed on their skin. Two solitary fin whales were also sighted during transit to Japan. Sea surface temperatures during this transit were from 16.5˚C to 19.8˚C (Figure 2f).

Sei whale

Sei whale was not sighted in the research area. They were sighted only during transit to Japan (4 schools / 4 individuals) (Figure 2f). Sea surface temperatures were from 13.9˚C to 17.0˚C. One skin sample was collected from one animal.

Bryde's whale

Bryde's whales were the most frequently encountered baleen whale species in the research area (6 schools / 6 individuals). They were distributed in the western side of the research area between 156°W-148°W (Figure 2a). Sea surface temperatures ranged from 21.9 °C to 24.9˚C. Skin samples were collected from all individuals.

During transit to the research area, they distributed western north Pacific until longitude 180˚. A total of 48 schools (58 individuals) were sighted during this transit. A number of Bryde's whales (32 schools 39 individuals) were sighted in the both sides of the Emperor Sea mount chain (32˚N-35˚N, between 160˚E and 180˚) during 16 to 19 July (Figures 2a and 2f).

Sperm whale

A total of 33 sperm whale schools (50 individuals) were seen in the research area (Table 2a and Figure 2b). 20schools were consisted of a solitary large animal. They were observed at sea surface temperature ranges from 22.0˚C to 25.5˚C and the 25th to 75th quartile range was 22.8-24.1˚C (Table 3). Sperm whales were the most frequently encountered toothed whale species in the research area. Most sperm whales were solitary and were widely distributed in the research area between 160˚W and 142˚W. They were not sighted in the eastern side of 140˚W. Some of individuals were photographed. Two different dead sperm whales were observed on 18 July at 34˚18'N, 173˚24'E (during transit to research area) and 2nd August at 33˚11'N, 150˚21'W in the research area and both photographed.

Ziphiidae and *Mesoplodon* spp.

Ziphiidae and *Mesoplodon* spp. were widely distributed throughout the research area (Figure 2c). In the research area, two schools (6 individuals) of Cuvier's beaked whales, one school (4 individuals) of Stejneger's beaked whale, 8 schools (20 individuals) of *Mesoplodon* spp. and 28 schools (51 individuals) of Ziphiidae (other than beaked whales) were sighted (Table 2a). Sea surface temperature of all beaked whales ranged from 21.6 to 26.3˚C. One school of Cuvier's beaked whale and one school of Stejneger's beaked whales (one breaching animal) were photographed on 19 August at 30˚13'N, 138˚42'W and 21 August at 33˚22'N, 137˚10'W.

Other species

A solitary short-finned pilot whale was sighted in the research area (sea surface temperature was 24.5˚C). It was a mixed school of Risso's dolphin and rough-toothed dolphin on 7th August at 34˚47'N, 146˚28'W in the research area.

Sightings of dolphin species of striped dolphin (14 schools 1,275 individuals, including 87 calves), spotted dolphin (5/400, including 61 calves), Risso's dolphin (1/169, including 21 calves), rough-toothed dolphin (1/2), bottlenose dolphin (1/7), unidentified dolphin/porpoise (14/1,255) were made in the research area. Striped dolphin was the most frequently encountered dolphin species. This species was sighted throughout the research area between 157˚W and 140˚W (Figure 2e). Some bow- riding behaviors were observed of dolphins in the research area.

During transit to Japan, sightings of dolphin species such as short-beaked common dolphin (1 school 80 individuals), striped dolphin (1/40), Pacific white-sided dolphin (5/68), northern right whale dolphin (2/21), Risso's dolphin (1/25),

Dalli type Dall's porpoise (7/21), unidentified type Dall's porpoise (4/17) were made. Short-beaked common dolphins were the most frequently encountered dolphin species (Figure 2f). A mixed school of striped (1/40) and short-beaked common dolphins (1/80) was observed on 24 August at 39˚31'N, 139˚37'W. And also a mixed school of Pacific white-sided dolphin (35 individuals) and northern right whale dolphin (6 individuals) was observed on 1st September at 45˚50'N, 173˚41'E.

4. PHOTO-IDENTIFICATION

There were no high priority species sightings (blue, humpback and North Pacific right whales) in the whole cruise. A total of 6 Bryde's whales, 3 fin whales and 2 sei whales were photo-identified during the 2013 IWC-POWER cruise (Table 4). Catalogue numbers were assigned to all species.

In the survey area, photo-identification data were collected for six Bryde's whales and one fin whale. During the research area to transit, photo-identification data were collected for two fin whale and two sei whales.

The photo-identification data analysis was attempted to confirm feasibility of photo-identification for the observed baleen whales. Distinctive natural markings were found from dorsal fin of two Bryde's whales among 11 photo-identified animals. Many scars caused by cookie cutter shark were seen on the head and dorsal part on Bryde's whales. However, the permanent existence of the scar as natural marker was not figured out from the analysis.

5. BIOPSY SAMPLING

A total of 8 skin tissue samples were collected, including 6 Bryde's whale, 1 fin whales, 1 sei whale, (Table 5). Every biopsy trial/experiment was documented photographically.

5.1 Biopsy data management

Biopsy darts were numbered and color-coded and each biopsy shooter used either red or black labeled darts. During setup for each biopsy sampling encounter, photos were taken of each dart before it was loaded into the Larsen gun. After a sample was collected, photos were taken of each dart with the sample. This allowed us to track which whale was sampled. The biopsy time was recorded for each sighting by the researcher on the upper bridge.

Each evening, the photos were evaluated to confirm which whale had been biopsied. After analysis of the photographs, biopsy sample numbers were assigned and simultaneously linked to photo-ID data were possible. Information about each encounter was entered into the PhotoID_Biopsy database. Sighting number, photo-ID and biopsy data were recorded in each photo's EXIF metadata fields.

After sample numbers were assigned, data were double-checked with the sightings records to confirm sighting numbers and biopsy hit times, and then biopsy data sheets were given to the biopsy sample manager for sample processing.

Times of biopsy start (setup on bow deck, document biopsy darts before approach), hitting, retrieval (photo of dart with sample) and/or finish (no hit or no shot) were recorded in the "PhotoID_Biopsy database" based on time of the effort record.

5.2 Biopsy efficiency

Biopsy experiment/trial was attempted in the research area. Table 5 shows the summary of biopsy experiment. There were 11 sightings where biopsy sampling was attempted. Of those, 8 encounters resulted in a successful hit. For 2 encounters, shots were fired but no whales were sampled. For 1 encounter, the biopsy team was ready on the bow deck but no shots were fired.

In 25 % of the 8 successful biopsy encounters, the first hit occurred in less than 13 minutes from biopsy setup. The fastest time to first hit was less than 11 minutes. For encounters where no shots were fired, 100 % of encounters ended in less than 14 minutes. Where shots were fired but no samples obtained, the average time was 37 minutes.

Some of the encounters of very short duration occurred under ideal sighting conditions, i.e., good lighting and calm seas, where the topmen could track the whales underwater as we approached. Most of the encounters where no shots were fired were approaches to whales which were surfacing in erratic (not predictable patterns) under less than ideal lighting conditions.

6. VIDEO-RECORDING

Video recording was opportunistically conducted in this cruise. Video of the main sightings were recorded for the behavioral studies of cetacean animals and the backup data for school size estimation or photo-id studies. The digital video camera recorder (Sony HDR-PJ760) was used for the video recording. Video recording took place at the bow deck and top barrel during the photo-identification or biopsy.

Generally, several video clip files were made for each sighting because the camera was turned on and off repeatedly due to the diving behaviors of the animals. Therefore, the original video clips need amount of data storage. After recording, the original clips of a sighting were edited with useful parts which the animals featured in and saved as a WMV (Windows Media Video) format in order to reduce the data storage and to provide easy access to the scenes of the animals.

During the survey period, 37.7 minutes of video recordings for 12 sightings of 8 species were made. 7.0 minutes from three Bryde's whales, 7.8 minutes from two fin whales, 6.7 minutes from three striped, 9.0 minutes from two spotted, 3.5 minutes from two Risso's, 0.5 minutes from one common, 0.7 minutes from one Pacific white-sided dolphin and 2.5 minutes from one Dall's porpoise sightings were video-recorded.

7. OTHER EXPERIMENTS

7.1 Estimated Angle and Distance Training Exercise

The Estimated Angle and Distance Training Exercise were conducted in the afternoon of 16 July for 1 hour 32 minutes. During the exercise the observers familiarized themselves with distance estimates from the TOP barrel and Upper Bridge.

7.2 Estimated Angle and Distance Experiment

The Estimated Angle and Distance Experiment were conducted on 17 August for 3 hours 30 minutes in the later of the research period in the research area. An Estimated Angle and Distance Training Exercise and Estimated Angle and Distance Experiment were performed using the same protocol as recent cruises (Anon. 2013a).

7.3 Marine debris observation

Research area of this cruise was a part of the hot spot of marine debris which located the centre of the North Pacific Gyre, so called 'Great Pacific Garbage Patch; 35 ˚ N- 42 ˚ N, between 155 ˚ W and 135 ˚ W' (Day *et al*., 1988). During this cruise, marine debris data were collected to document the type and distribution of marine debris in the eastern North Pacific. These data were collected between July 14 to September 4th, with a total of 46 days. In the same way than in 2012, special consideration was taken to try to evaluate whether any observed debris could be related to the Japan Tsunami. From July 14 to August 5th, marine debris data were collected for every single sighting during the effort time, but because of the fact that we found too much marine debris, we started collecting information just for the first 15 minutes after each hour, beginning on August 6th (32° 14' N and 147° 45' W), as discussed the pre-cruise meeting.

A total of 1,508 marine debris items were observed, 72 during transit from Japan to survey area, with an average of 8 per day and within the research area we registered 1,347 items with an average of 44.9 per day and finally during transit from survey area to Japan, we observed 89 items with an average of 12.7 per day. Main observations of marine debris, including 789 single fishing float, 340 miscellaneous pieces of plastic and 151 pieces of rope and net (Table 6a). There were 10 overturned small boats and 2 other items of the marine debris that seemed possibly to be related to the Japan Tsunami 2011 (Table 6b). Fifty photographs from most representative and important items were taken and link with data base was made.

On August 2nd, we registered 86 items in just one day, between 34°23'N / 150°56'W and 32°38'N / 150°03'W and in spite of we reduce the time of marine debris data collect, the number of marine debris sighting didn't decrease, and the date and area with the highest number of records after we reduced the marine debris effort time was, on August 11 between 38°34'N / 144°34'W and 39°35'N / 143°35'W with a total of 82 items. Throughout the cruise, weekly summaries of marine debris observations were provided to IWC scientific committee.

8. TECHNICAL MATTERS OF DATA AND RECOMMENDATIONS

8.1 Whale ID numbering protocol for the IWC-POWER cruises

YS3 Whale ID numbers were assigned whales identified during the 2013 IWC-POWER cruise. This year, the YS3 whale ID numbers have the prefix 2013. Once all 2013 photos are compared to the 2011 and 2012 YS3 catalogs, permanent IWC-POWER whale ID numbers will be assigned, sequentially using the 2011 and 2012 YS3 ID numbers as the catalog starting numbers. When photos from the 2010 IWC-POWER are cataloged, they will also be integrated into the IWC-POWER catalog.

Biopsy sample numbers have been added to the whale ID numbers when a sampled whale was photo-identified, e.g., 2013_Sei_1_13041001. For whales which have been cataloged, such as sei whales, if the whale was biopsied but not photo-identified, the whale ID number is the species, the letter "X" in place of the whale ID number, and the biopsy sample number. E.g., Sei_X_13041023. The prefix "2013" is not used in this case because the coding for the biopsy sample number includes the year "13" as part of the biopsy sample numbering protocol.

9. CONCLUSIONS

The 4th annual IWC-POWER cruise was successfully conducted using the Japanese Research Vessel *Yushin-Maru No.3*. All equipment and the survey method were same as the past IWC international sighting surveys. The sighting procedure was in accordance with the guideline agreed by the SC (IWC, 2005). As explained the objectives of the survey and its procedure to the vessel, the Captain, officers, crew and international researchers fully understood the objectives and methods for operating the survey properly before starting the survey. (Sighting data was already sent to the IWC secretary and confirmed at 2nd December 2013). The 4th cruise of this program was completed and provided information that some baleen whale species and other cetacean species were widely distributed in the research area where there were not surveyed in the recent decades. These results will contribute to the above objectives for the IWC/SC.

ACKNOWLEDGEMENTS

We acknowledge the Governments of the 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, Tomio Miyashita, Hiroto Murase, Luis Pastene and Lars Walloe), the Technical advisory group of this cruise (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 supports for the cruise. We also thank the Captain, his officers and crew of the R/V *Yushin-Maru No.3* for their hard work and dedication. The National Research Institute of Far Seas Fisheries (Yokohama) loaned equipment for the cruise, including video camera and items for biopsy processing and storage. The Cetacean Research Institute (CRI) also loaned camera and video camera for the experiments. Quartermasters K. Kurisu and T. Nagai assisted with collection of biopsy.

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Table 1a. Way Points (WP) in the research area.

WP	Latitude	Longitude
101	32˚22.0'N	160˚00.0'W
102	30˚00.0'N	158˚49.0'W
103	31˚40.0'N	158˚01.4'W
104	33˚20.0'N	157˚13.0'W
105	35˚00.0'N	156˚23.4'W
106	36˚40.0'N	155˚33.2W
107	38˚19.9'N	154˚41.7'W
108	40˚00.0'N	153˚49.0'W
109	38˚20.1'N	152˚56.3'W
110	36˚40.2'N	152˚04.8'W
111	35˚00.2'N	151˚14.4'W
112	33˚20.2'N	150˚25.0'W
113	31˚40.2'N	149˚36.6'W
114	30˚00.0'N	148˚49.0'W
115	31˚40.0'N	148˚01.4'W

WP	Latitude	Longitude
116	33˚20.0'N	147˚13.0'W
117	35˚00.0'N	146˚23.6'W
118	36˚40.0'N	145˚33.2'W
119	38˚19.9'N	144˚41.7'W
120	40˚00.0'N	143˚49.0'W
121	38˚20.1'N	142˚56.3'W
122	36˚40.2'N	142˚04.8'W
123	35˚00.2'N	141˚14.4'W
124	33˚20.2'N	140˚25.0'W
125	31˚40.2'N	139˚36.6'W
126	30˚00.0'N	138˚49.0W
127	31˚31.6'N	138˚04.8'W
128	33˚03.1'N	137˚19.9'W
129	34˚34.6'N	136˚34.2'W
130	36˚06.1'N	135˚47.7'W
131	37˚38.0'N	135˚00.0'W

Table 1b. Summary of search effort (time and distance) and experimental time (hours) conducted during the 2013 IWC- POWER Cruise.

Area	Start	End	NSP with abeam closing		Photo-ID, Biopsy	Estimated angle and distance training / experiment
	Date	Date	Time	Dist.	Time	Time
	Time	Time		(n.m.)		
Shiogama to research area	14-Jul. 7:00	22-Jul. 18:20	72:49	854.92	0:00	1:32
Research area	23-Jul. 7:00	23-Aug. 13:12	268:36	3,035.93	1:56	3:30
Research area to Shiogama	23-Aug. 13:13	7-Sep. 12:00	40:55	451.36	1:44	0:00
Total	14-Jul 7:00	7-Sep. 12:00	382:21	4,342.21	3:40	5:02

Table 2a. Number of sightings for all species observed in the research area by effort mode (NSP: Normal Passing with abeam closing Mode; OE: (TD: topdown and DR: drifting). Parentheses indicate the number of calves observed.

Species	NSP		OE		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Fin whale	1	1	0	0	1	1
Bryde's whale	6	6	0	0	6	6
Sperm whale	32	47	1	3	33	50
Dwarf sperm whale	1	2	0	0	1	2
Cuvier's beaked whale	2	6	0	0	2	6
Stejneger's beaked whale	1	4	0	0	1	4
Mesoplodon spp.	8	20	0	0	8	20
Ziphiidae	27	50	1	1	28	51
Short-finned pilot whale	1	1	0	0	1	1
Risso's dolphin	7	169(21)	0	0	7	169(21)
Rough-toothed dolphin	1	2	0	0	1	2
Bottlenose dolphin	1	7	0	0	1	7
Spotted dolphin	5	400(61)	0	0	5	400(61)
Striped dolphin	14	1,275(87)	0	0	14	1,275(87)
Unid. large whale	8	8	0	0	8	8
Unid. small whale	5	9	0	0	5	9
Unid. dolphin/porpoise	28	1,255	0	0	28	1,255
Unid. whale	7	62	0	0	7	62
Total	155	3,324 (169)	2	4	157	3,328 (169)

Table 2b. Number of sightings for all species observed in 2013, including sighting during transits and in the research area (R.A.). Parentheses indicate the number of calves observed.

Species	Transit to R.A.		Research Area (R.A.)		Transit from R.A.		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Fin whale	0	0	1	1	2	2	3	3
Sei whale	0	0	0	0	4	4	4	4
Bryde's whale	48	58(5)	6	6	0	0	54	64(5)
Common minke whale	0	0	0	0	1	1	1	1
Sperm whale	21	23	33	50	13	26(2)	67	99(2)
Dwarf sperm whale	0	0	1	2	0	0	1	2
Cuvier's beaked whale	0	0	2	6	0	0	2	6
Stejneger's beaked whale	0	0	1	4	0	0	1	4
Mesoplodon spp.	1	2	8	20	0	0	9	22
Ziphiidae	4	10	28	51	4	10	36	71
Short-finned pilot whale	0	0	1	1	0	0	1	1
Risso's dolphin	1	14(4)	7	169(21)	1	25	9	208(25)
Rough-toothed dolphin	1	60(3)	1	2	0	0	2	62(3)
Bottlenose dolphin	0	0	1	7	0	0	1	7
Short-beaked Common dolphin	2	95	0	0	1	80(10)	3	175(10)
Spotted dolphin	1	55	5	400(61)	0	0	6	455(61)
Striped dolphin	1	80	14	1,275(87)	1	40	16	1,395(87)
Pacific white-sided dolphin	0	0	0	0	5	68	5	68
Northern right whale dolphin	0	0	0	0	2	21	2	21
Dalli-type Dall's porpoise	0	0	0	0	7	21	7	21
Unid. Type Dall's porpoise	0	0	0	0	4	17	4	17
Unid. large whale	28	32(1)	8	8	3	3	39	43(1)
Unid. small whale	1	8	5	9	1	1	7	18
Unid. dolphin/porpoise	11	446	28	1,255	0	0	39	1,701
Unid. whale	3	3	7	62	1	1	11	66
Total	123	886 (13)	157	3,328 (169)	50	320 (12)	330	4,534 (194)

Table 3. Minimum, maximum and range of sea surface temperatures in degrees Celsius for each species sighted in the research area, sorted in order of frequency of sightings. Range of 25th to 75th quartiles are presented for sperm whales, Ziphiidae, and striped dolphins. See text for details.

Species	Number of sightings	Minimum SST	Maximum SST	Temperature range	25th to 75th Quartile
Sperm whale	33	22.0	25.5	3.5	22.8-24.1
Ziphiidae	28	21.6	25.2	3.6	22.5-24.2
Striped dolphin	14	21.9	23.9	2.0	22.3-23.4
Mesoplodon spp.	8	22.4	26.3	3.9	-
Risso's dolphin	7	21.8	24.5	2.7	-
Bryde's whale	6	21.9	24.9	3.0	-
Spotted dolphin	5	23.2	26.3	3.1	-
Cuvier's beaked whale	2	23.7	23.7	-	-
Fin whale	1	22.1	-	-	-
Stejneger's beaked whale	1	22.6	-	-	-
Rough-toothed dolphin	1	24.5	-	-	-
Bottlenose dolphin	1	22.0	-	-	-
Short-finned pilot whale	1	24.5	-	-	-
Dwarf sperm whale	1	25.6	-	-	-

Table 4. Summary of the photo-identification experiment with accompanying photo-ID data. LD: Left dorsal; RD: Right dorsal. YS3 Whale ID numbers have been assigned to Bryde's, fin and sei whales. Biopsy sample numbers have been added to the whale ID numbers when a sampled whale was photo-identified.

NDNM; No distinctive natural marking. *: Videotaped.

Species	Sighting Date	Sighting Number	Group size	Number of individuals photographed	YS3 Whale ID	Photo-ID result	Remarks	Experiment duration
Bryde's whale	27-Jul-13	010	1	1	2013_Bryde's_1_13031001	LD	Distinctive notch, Biopsied.	0:07:58
Bryde's whale	28-Jul-13	007	1	1	2013_Bryde's_2_13031002	LD	NDNM, Biopsied.	0:10:25
Bryde's whale	29-Jul-13	002	1	1	2013_Bryde's_3_13031003	LD, RD	NDNM, Biopsied.	0:03:16
Fin whale	29-Jul-13	003	1	1	2013_Fin_1_13051004	LD, RD	NDNM, Biopsied. *	0:10:01
Bryde's whale	3-Aug-13	002	1	1	2013_Bryde's_4_13031005	LD, RD	Distinctive notch, Biopsied. *	0:16:38
Bryde's whale	3-Aug-13	003	1	1	2013_Bryde's_5_13031006	RD	NDNM, Biopsied. *	0:11:20
Bryde's whale	5-Aug-13	003	1	1	2013_Bryde's_6_13031007	LD, RD	NDNM, Biopsied. *	0:27:47
Fin whale	27-Aug-13	002	1	1	2013_Fin_2	LD	NDNM. *	0:33:20
Sei whale	29-Aug-13	001	1	1	2013_Sei_1_13041008	LD	NDNM, Biopsied.	0:18:25
Fin whale	30-Aug-13	004	1	1	2013_Fin_3	LD	NDNM.	0:01:23
Sei whale	3-Sep-13	007	1	1	2013_Sei_2	LD	NDNM.	0:07:41

Table 5. Summary of the biopsy experiment.

Species	Date	Sighting No	YS3WhaleID	Sample Number	Number of samples	Number of shots	Number of hits	Encounter duration (min)
Bryde's whale	27-Jul-13	010	Bryde's_1_13031001	13031001	2	3	2	22
Bryde's whale	28-Jul-13	007	Bryde's_2_13031002	13031002	1	2	1	10
Bryde's whale	29-Jul-13	002	Bryde's_3_13031003	13031003	2	2	2	21
Fin whale	29-Jul-13	003	Fin_1_13051004	13051004	1	2	1	14
Bryde's whale	03-aug-13	002	Bryde's_4_13031005	13031005	1	1	1	18
Bryde's whale	03-aug-13	003	Bryde's_5_13031006	13031006	1	2	1	17
Bryde's whale	05-aug-13	003	Bryde's_6_13031007	13031007	1	2	1	10
Fin whale	27-aug-13	002	-	-	0	2	0	38
Sei whale	29-aug-13	001	Sei_1_13041008	13041008	2	5	2	20
Sei whale	30-aug-13	001	-	-	0	2	0	36
Fin whale	30-aug-13	004	-	-	0	0	0	13

Table 6a. Summary of marine debris observations sorted by frequency of occurrence. Some new descriptive codes were developed based on the types of debris observed during the 2011 and 2012 POWER cruises.

IWC code	YS3 code	Marine Debris IWC / YS3 Code Definitions	Transit to Research area	Research area	Transit to Japan	Total
101	101	Gillnet, small mesh, small fragment	3	3	0	6
108	108	Gillnet, large mesh, 1-10 tans	0	1	0	1
111	111	Trawl net, small mesh, small fragment	0	2	0	2
112	112	Trawl net, small mesh, medium size	0	1	0	1
116	116	Trawl net, medium mesh, large piece	0	1	0	1
120	120	Unidentified net	1	24	1	26
121	121	Unidentified net, small mesh, small fragment	0	5	0	5
122	122	Unidentified net, small mesh, medium size	0	6	0	6
126	126	Unidentified net, medium mesh, large piece	0	2	0	2
129	129	Unidentified net, large mesh, large piece	0	2	0	2
130	130	Longline, small piece	0	88	2	90
131	131	Longline, medium piece	0	6	0	6
132	132	Longline, large piece	1	2	0	3
134	134	Single fishing float	32	711	46	789
135	135	Clustered fishing floats (2-10 floats together)	1	19	0	20
137	137	Wood crate, 1 side only	0	3	0	3
139	139	Wood structure	0	6	0	6
140	140	Wood object, unidentified	0	7	0	7
140	801	Wooden log	3	4	3	10
143	901	Metal can 1-50 litres / metal container	0	2	0	2
147	147	Styrofoam, unidentified	3	40	6	49
148	148	Styrofoam board, less than 1 square metre	1	16	0	17
161/162	606	Plastic, unidentified	3	79	7	89
161	606	Plastic, unidentified /plastic container	2	27	1	30
162	601	Plastic, less than 1 square metre / plastic bottle	4	47	5	56
162	602	Plastic, less than 1 square metre / plastic box	9	37	1	47
162	606	Plastic, less than 1 square metre / plastic lid, bag, bucket and sheet	5	49	5	59
162	610	Plastic, less than 1 square metre / plastic basket	0	43	6	49
164	164	Plastic, greater than 3 square metres / plastic board	1	2	0	3
165	165	Plastic bag, small	1	6	0	7
168	168	Garbage, unidentified	0	17	1	18
199	199	Overturned boat	0	10	0	10
199	301	Buoy with antenna	1	5	0	6
199	401	Glass ball	0	6	2	8
199	701	Tire with or without rim	0	11	0	11
199	199	Sponge	0	45	3	48
199	199	Refrigerator	0	2	0	2
199	199	Other	1	10	0	11
		Total	72	1,347	89	1,508
		Number of days	9	30	7	46
		Average per day	8.0	44.9	12.7	32.8

Table 6b. Summary of marine debris observations of 2013 cruise possibly related to the Japan Tsunami 2011.

No.	Items	Date	position	notes
1	Half stern of ship	29-07-2013	39° 18’ N / 153° 27’ W	Estimated 5 m, without name and engine
2	Overturned small boat	03-08-2013	31° 11’ N / 149° 23’ W	Estimated 5 m, without name and engine
3	Overturned small boat	03-08-2013	31° 06’ N / 149° 20’ W	Estimated 7 m with engine, and name
4	Overturned small boat	04-08-2013	30° 30’ N / 149° 02’ W	Estimated 6 m, without engine and name
5	Overturned small boat	07-08-2013	34° 04’ N / 146° 49’ W	Estimated 7m, with name, number and province
6	Stern of overturned boat	09-08-2013	36° 00’ N / 145° 53’ W	Piece of 2.5 m of 5 m boat
7	Overturned small boat	13-08-2013	37° 39’ N / 142° 37’ W	Estimated 7 m
8	Overturned small boat	15-08-2013	35° 27’ N / 141° 28’ W	Estimated 7 m without name
9	Overturned small boat	15-08-2013	34° 51’ N / 141° 10’ W	Not approached, less than 10 m.
10	Overturned small boat	17-08-2013	31° 56’ N / 139° 44’ W	Estimated 6 m without name
11	A moored buoy	31-07-2013	37° 18’ N / 152° 24’ W	Estimated 3 m diameter
12	Net with more than 130 floats	10-08-2013	37° 29’ N / 145° 38’ W	50 floats of 1.5 m and more than 80 floats of 0.6 m

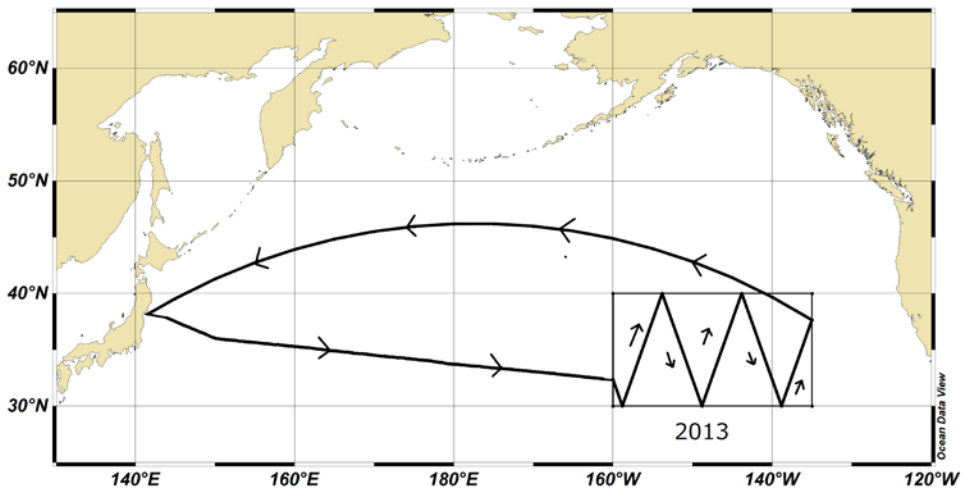

Figure 1. Research area and the trackline design of the 2013 IWC-POWER cruise. The starting points of transect lines within the study area were randomized following IWC/SC guidelines (IWC, 2005).

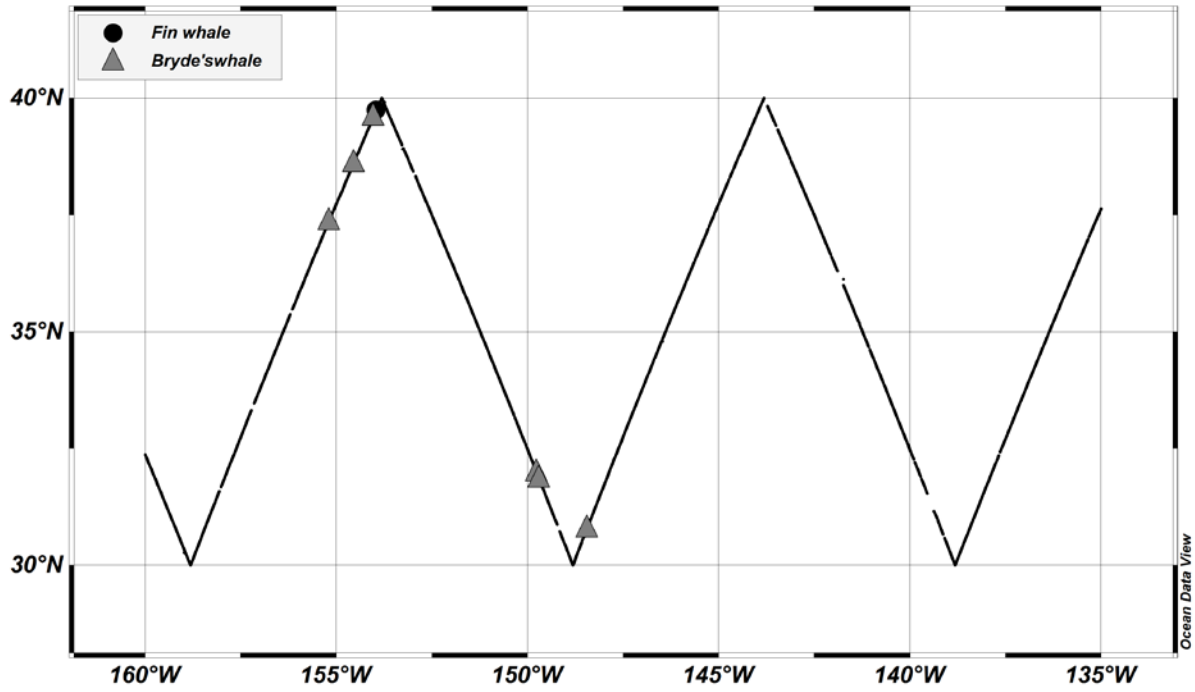

Figure 2a. The searching effort (black line) and sighting positions of fin (circle) and Bryde's whale (triangle) in the research area.

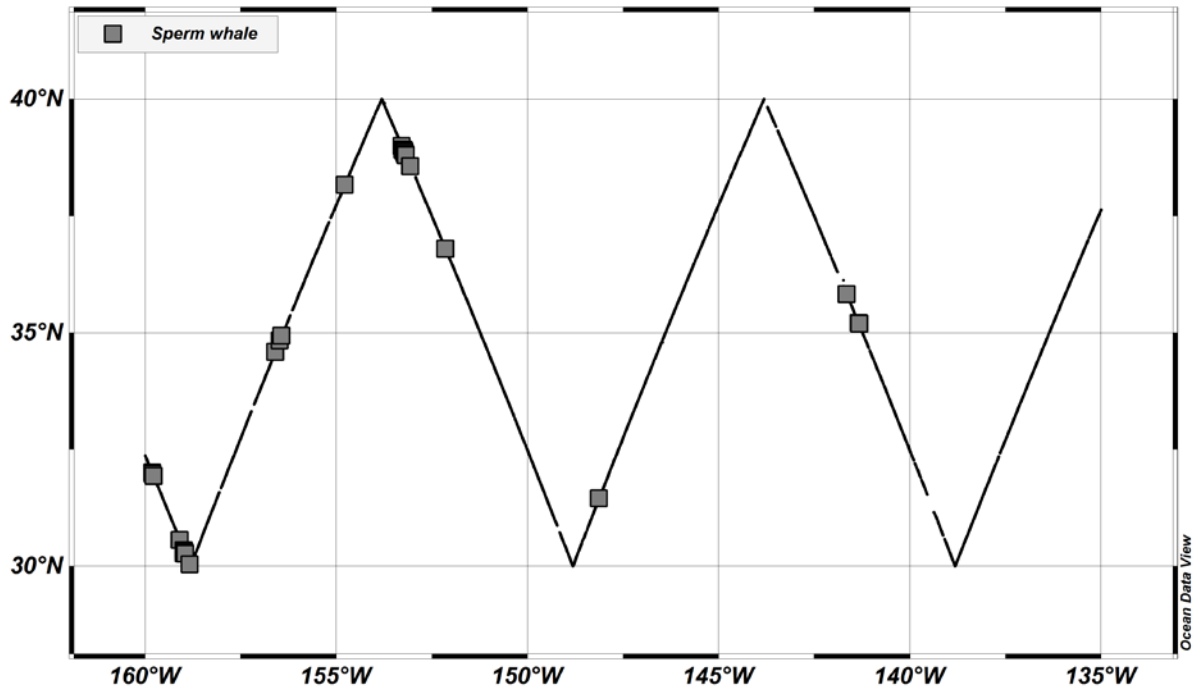

Figure 2b. The searching effort (black line) and sighting positions of sperm whales (square) in the research area.

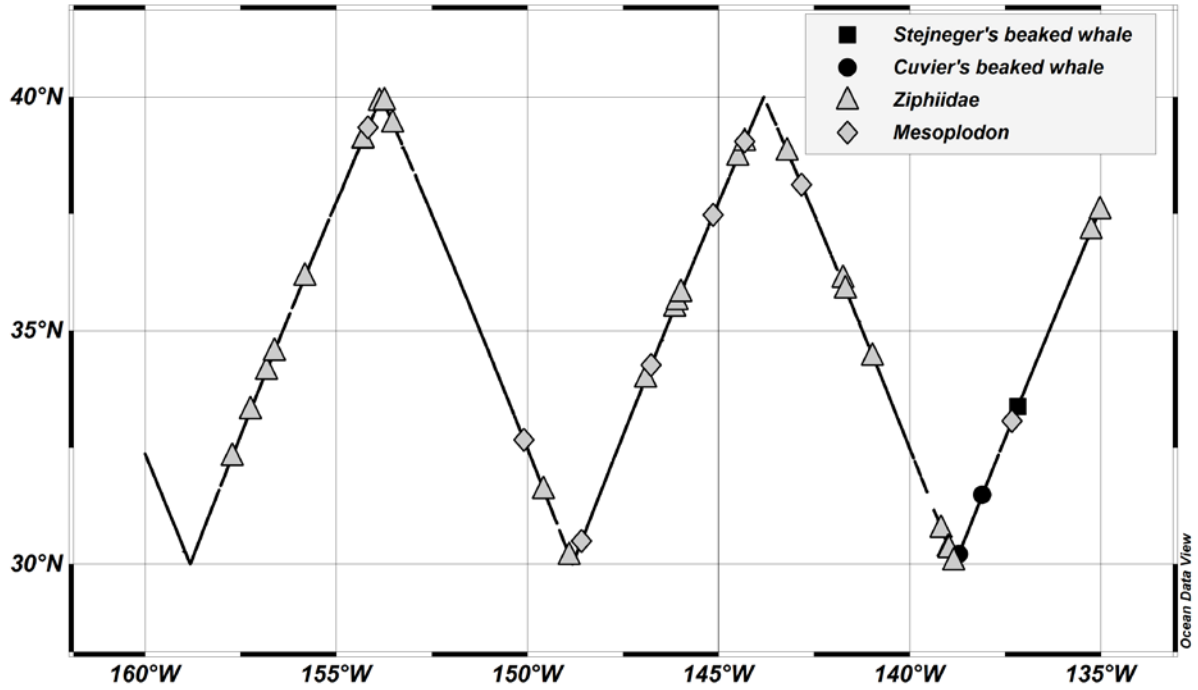

Figure 2c. The searching effort (black line) and sighting positions of Stejneger's beaked whale (black square), Cuvier's beaked whale (black circle), Ziphiidae (triangle) and *Mesoplodon* spp. (diamond) in the research area.

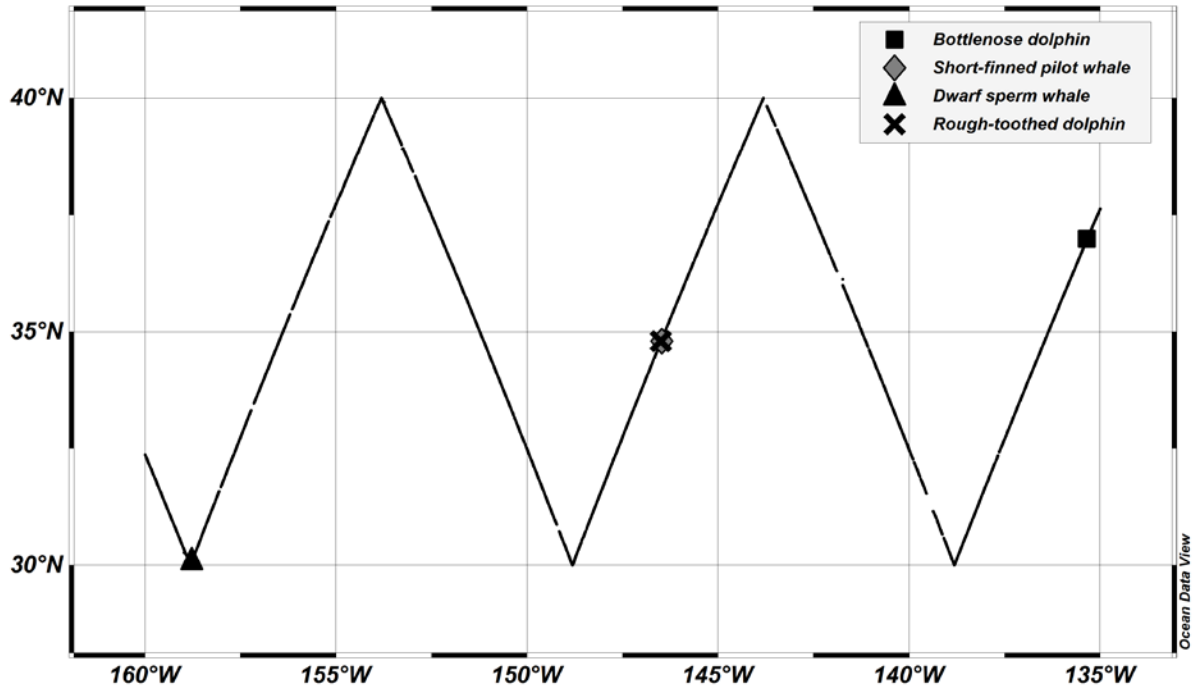

Figure 2d. The searching effort (black line) and sighting positions of bottlenose dolphin (black square), dwarf sperm whale (black triangle), Short-finned pilot whale (diamond), and rough-toothed dolphin (X) in the research area.

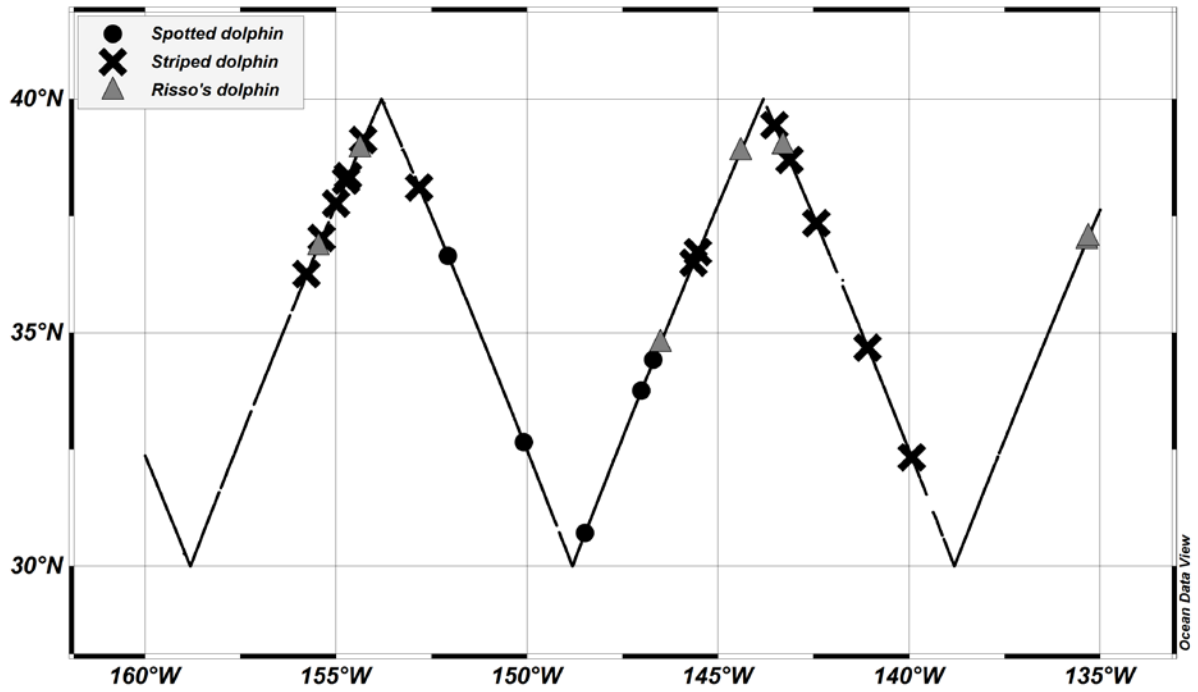

Figure 2e. The searching effort (black line) and sighting positions of spotted (black circle), striped (X), and Risso's (triangle) dolphins in the research area.

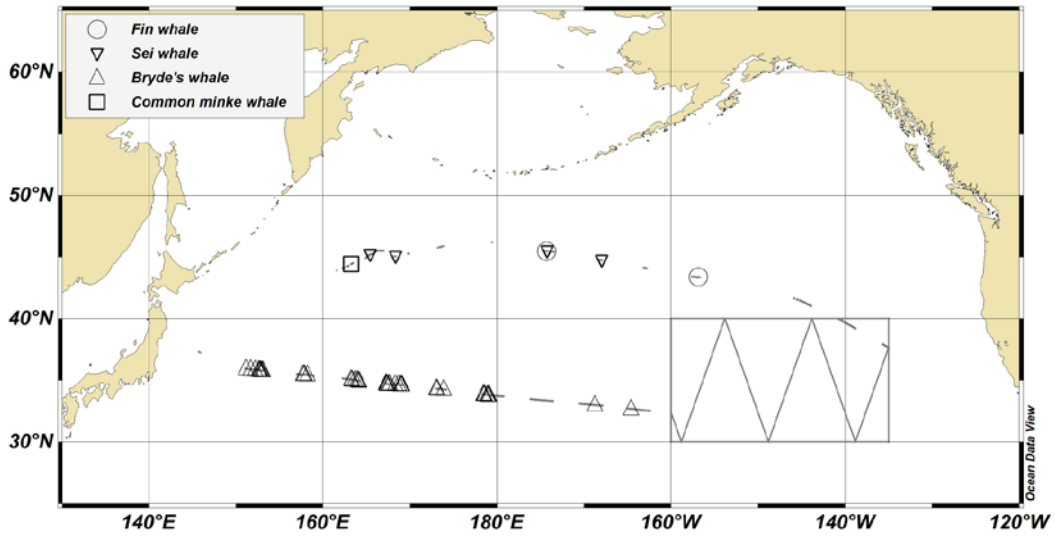

Figure 2f. The searching effort (black line) and sighting positions of fin, sei, Bryde's and common minke whales during transit surveys from and to Japan.

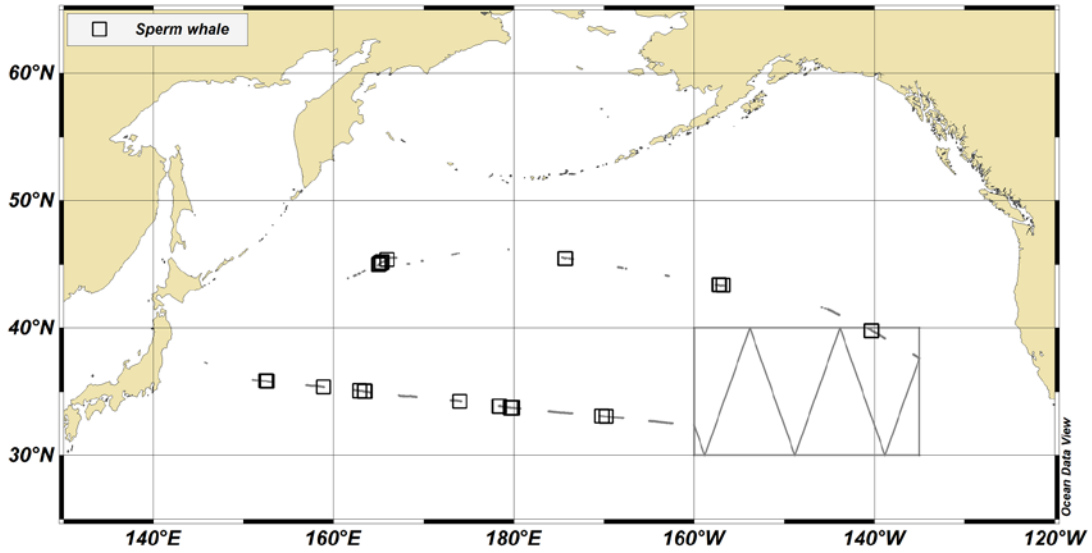

Figure 2g. The searching effort (black line) and sighting positions of sperm whale during transit surveys from and to Japan.

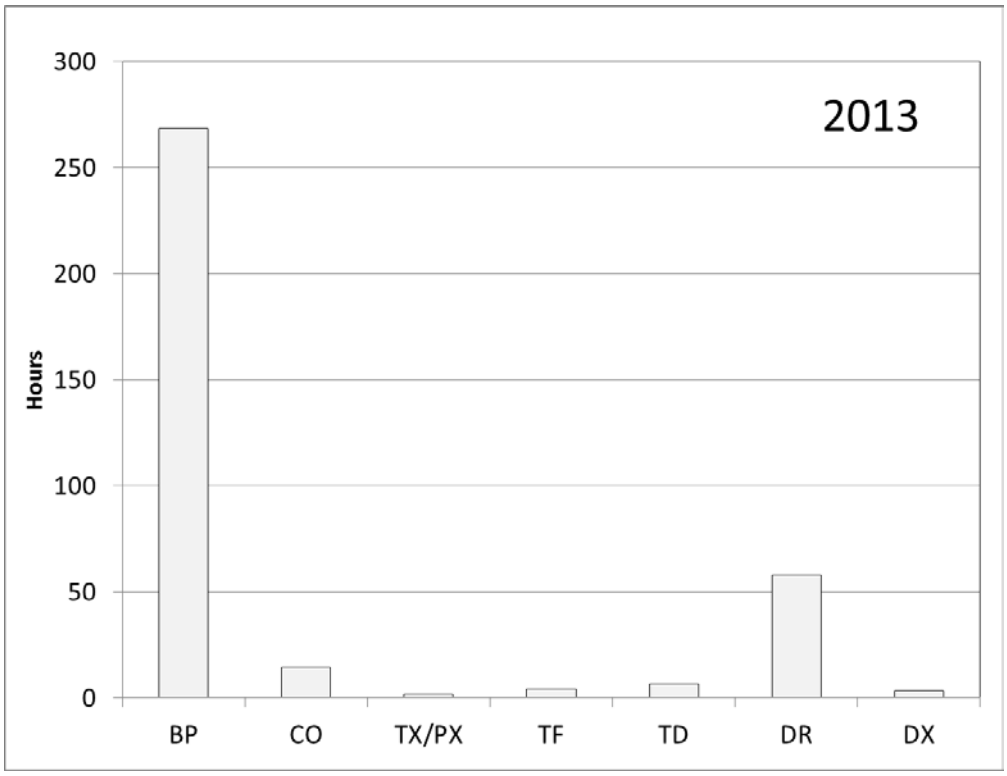

Figure 3a. Breakdown of research time in hours, by effort code in the research area during 2013 cruise. BP: Passing mode searching, CO: Confirmation of school, TX/PX: Biopsy experiment, TF: Time back to trackline, TD: Top down steaming, DR: Drifting , DX: Distance and angle estimate experiment.

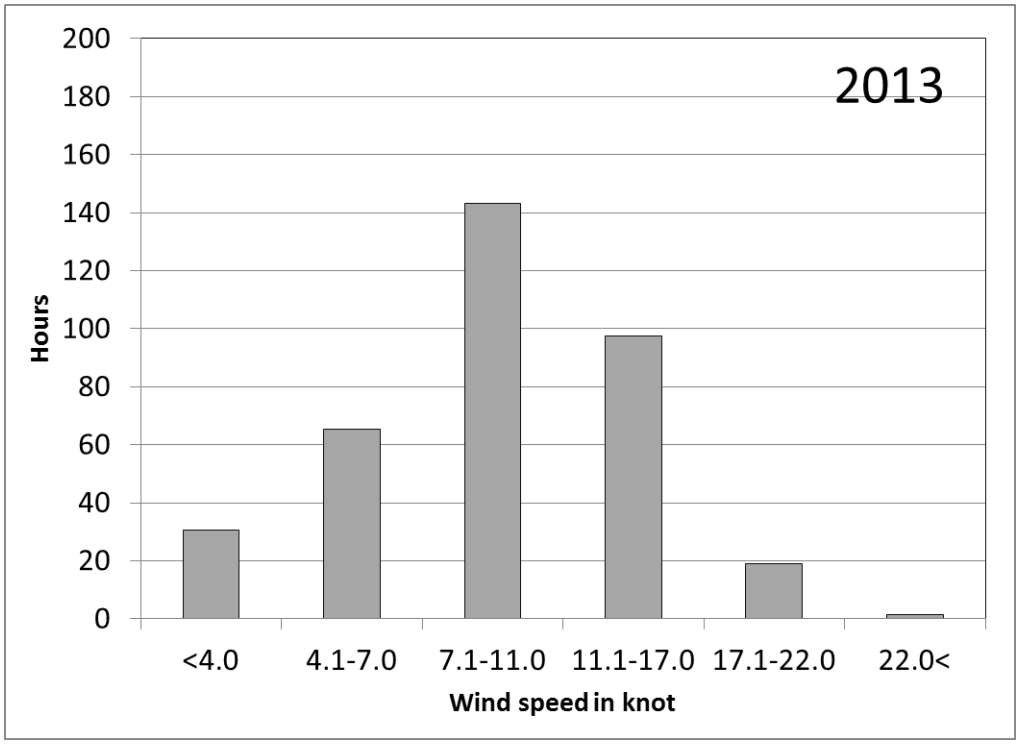

Figure 3b. Breakdown of research time in hours during 2013 survey in research area, by wind speed in knot.

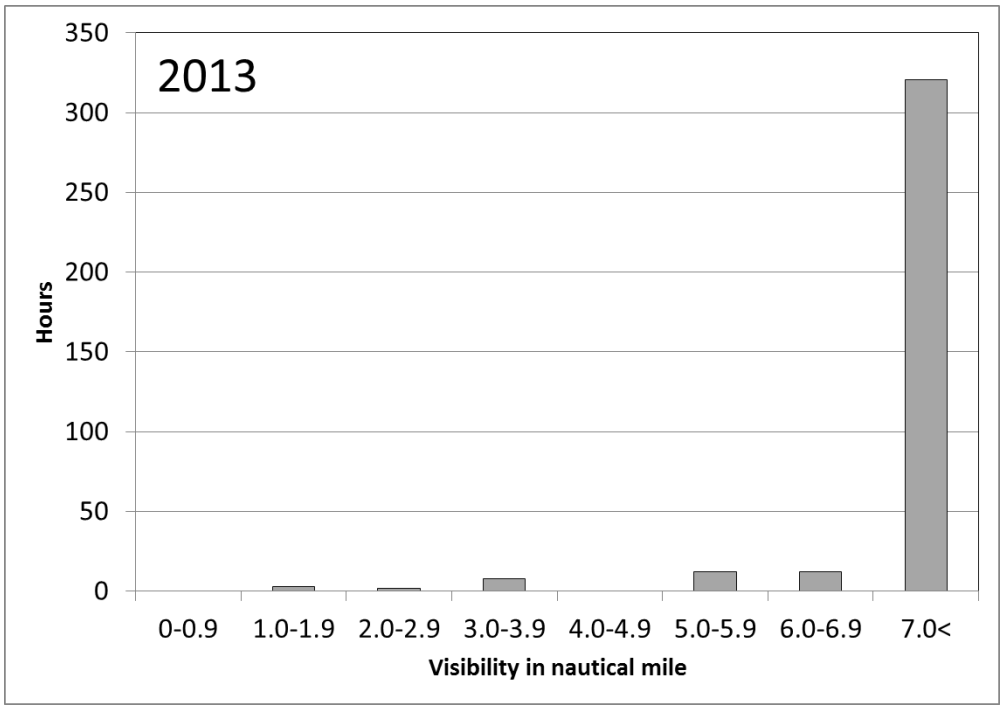

Figure 3c. Breakdown of research time in hours during 2013 survey in research area, by visibility in nautical mile.

Appendix A

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

Ship photo:

Ship specifications:

	Yushin-Maru No.3
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:

	Yushin-Maru No.3
Captain	Yasuaki Sasaki
Chief Officer	Tohru Takamatsu
Second Officer	Shinya Kawabe
Chief Engineer	Shoetsu Abe
First Engineer	Yoshihiro Ooura
Second Engineer	Kazuhito Abe
Third Engineer	Yasuhisa Nitta
Chief Operator	Fumio Iida
Boatswain	Kenji Wakatsuki
Quartermaster	Kazuyuki Sugiyama
Quartermaster	Kazumitsu Kurisu
Quartermaster	Takahiro Nagai
Sailor	Kohsuke Matsuguchi
Sailor	Naoto Nomakawauchi
Oiler	Mao Karizuka
Chief Steward	Hironobu Hodokuma
Steward	Kanji Mae

Appendix B

Comparison of weather conditions (wind speed and visibility) among past cruises (2010-2012).

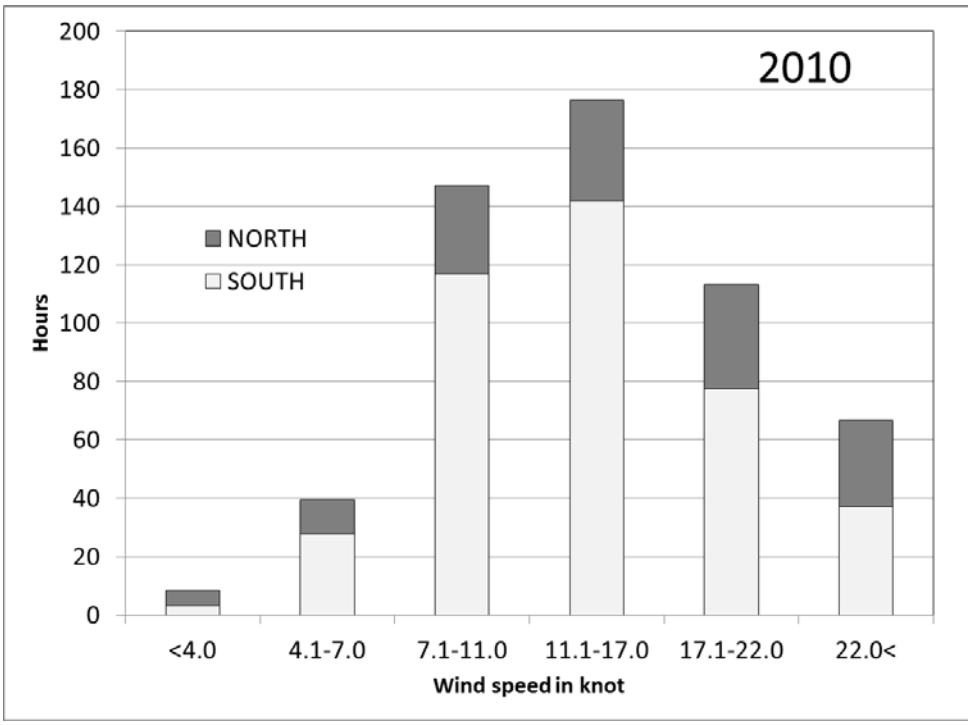

Figure 1a. Breakdown of research time in hours during 2010 survey in research area by wind speed in knot.

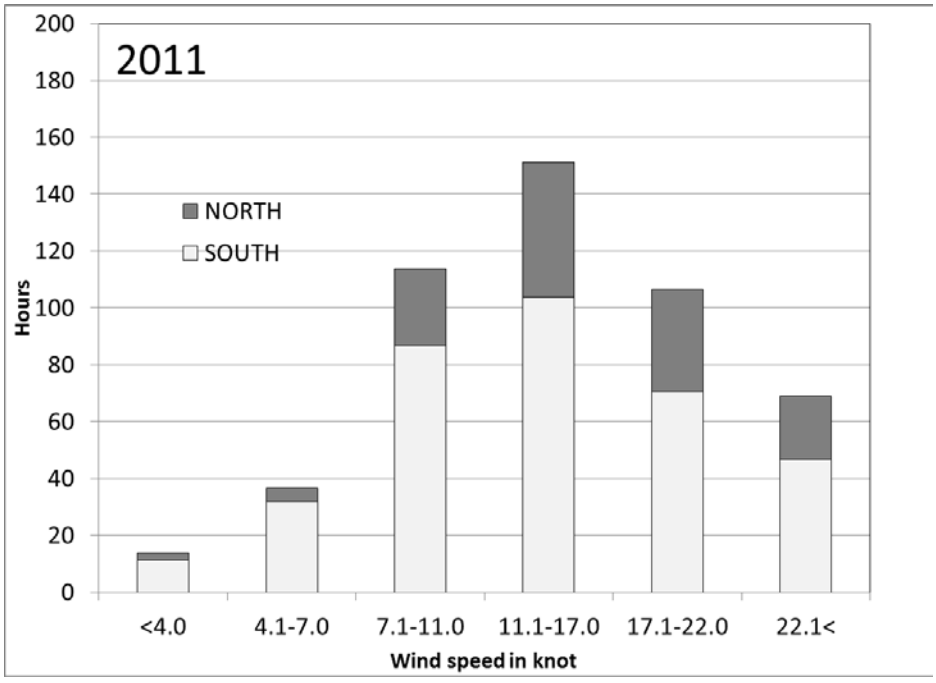

Figure 1b. Breakdown of research time in hours during 2011 survey in research area by wind speed in knot.

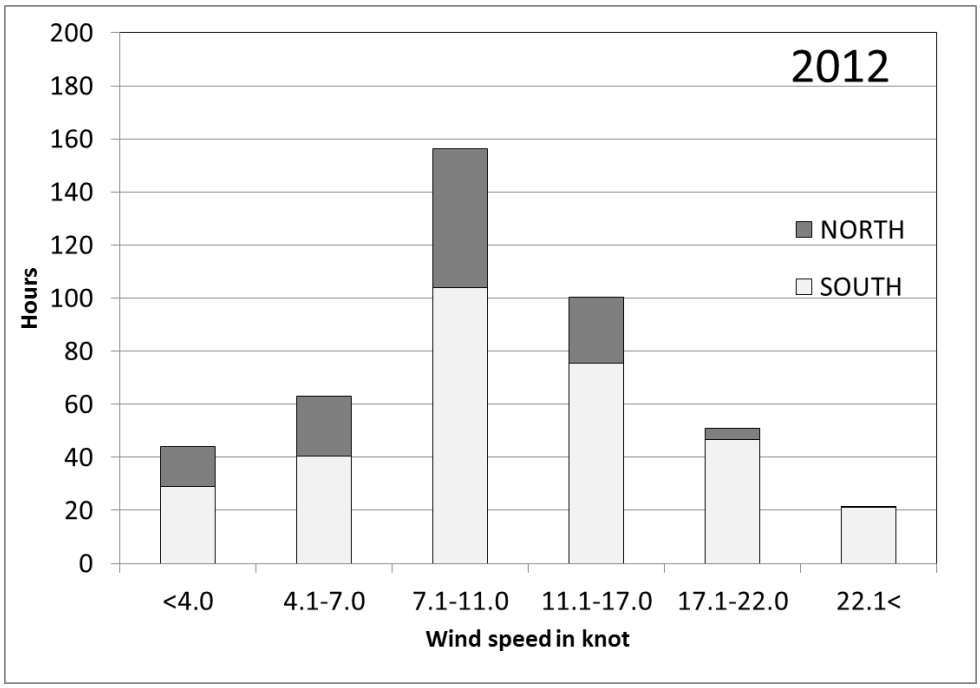

Figure 1c. Breakdown of research time in hours during 2012 survey in research area by wind speed in knot.

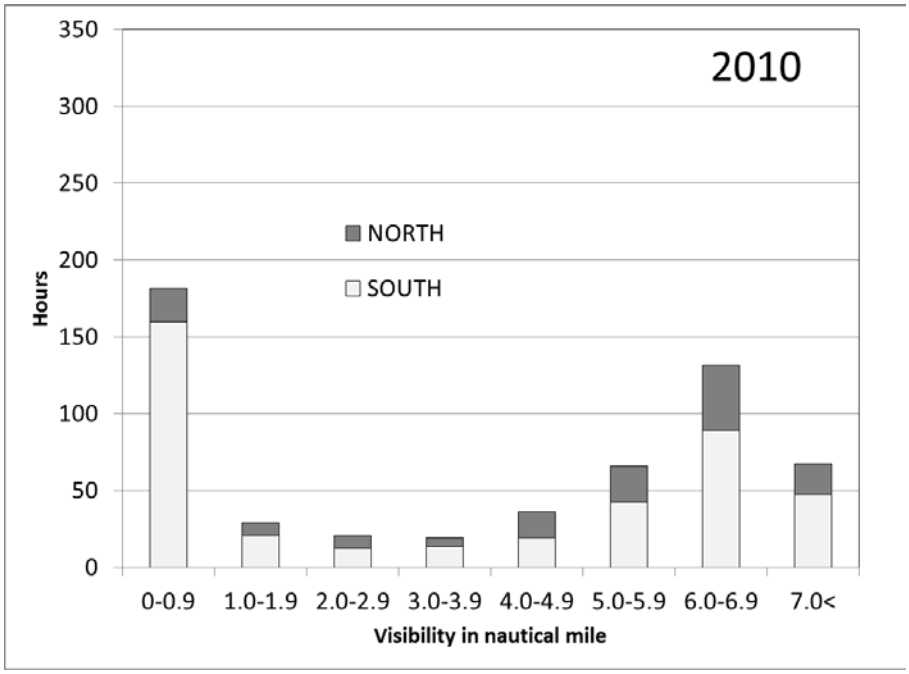

Figure 2a. Breakdown of research time in hours during 2010 survey in research area by visibility in nautical mile.

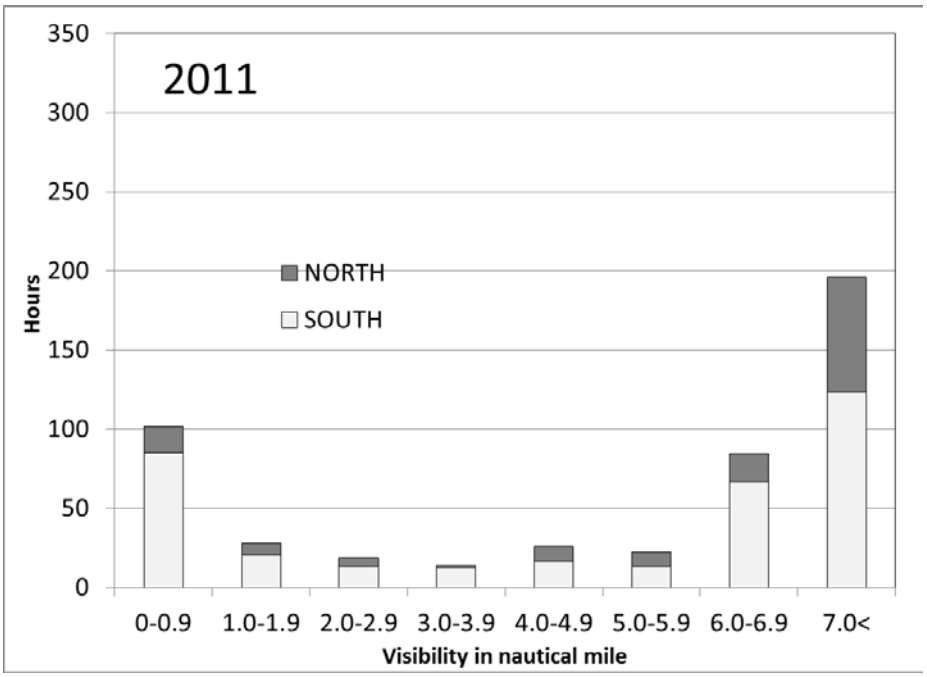

Figure 2b. Breakdown of research time in hours during 2011 survey in research area by visibility in nautical mile.

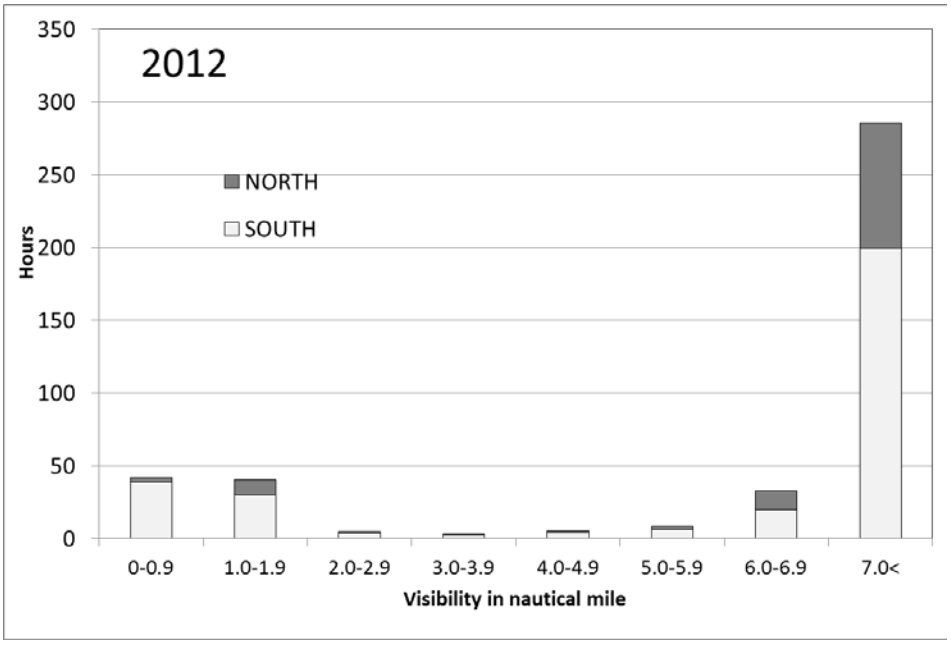

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Figure 2c. Breakdown of research time in hours during 2012 survey in research area by visibility in nautical mile.