Cruise report of the 2011 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER)

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ABSTRACT

The 2nd annual IWC-POWER (as a successor to the IWC/IDCR-SOWER cruises since 1978/79 in the Antarctic) was successfully conducted from 11 July to 8 September, 2011 in the eastern North Pacific (north of 40°N, south of the Alaskan Peninsula, between 170°W and 150°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 62nd IWC/SC meeting. Researchers from Japan and the US 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 (e.g. common minke 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. The survey effort was stratified into two zones: a northern stratum within the US Exclusive Economic Zone (US EEZ) and a southern stratum south of the US EEZ. Survey coverage was 58% in the northern stratum and 78% in the southern stratum. A total of 2,397.8 n.miles was surveyed in the research area in the Passing (NSP) with abeam closing (SSII) mode. Sightings of blue (10 schools / 10 individuals), fin (82/141), sei (58/95), common minke (2/2), humpback (76/133), sperm (95/119), killer (7/70), common dolphin (13/1,275), striped dolphin (2/55), Pacific white sided dolphin (9/373), northern right whale dolphin (5/290), Dall's porpoise (83/352), Mesoplodon spp. (7/26), Ziphiidae (14/23) and unidentified large whales (70/106) were made. Fin, humpback, sperm and sei whales were the most frequently sighted species. Blue whales were sighted in both the northern and southern strata. Fin whales were widely distributed in both strata. Sei whales were absent from the northern stratum and widely distributed in the southern stratum with some areas of concentration. Humpback whales were widely distributed in the northern stratum. Most sperm whales were solitary large males and were mainly distributed in the southern stratum in some areas of concentration. Killer whales were seen only in the northern stratum. Photo-identification data for 9 blue, 48 humpback, 27 sei and 18 killer whales were catalogued. A total of 48 biopsy samples from fast swimming whale species were successfully collected from 4 blue, 12 fin, 31 sei and 1 humpback whale using the Larsen-gun system. Marine debris of 132 objects were recorded. The Estimated Angle and Distance Training Exercise and Experiment were completed as in previous years. The planned sighting procedure was in accordance with the guideline agreed by the SC. 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. The 2nd cruise of this program was completed and provided information that various baleen whale species and other cetacean species were widely distributed in the research area where they were depleted in the past. 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, 2011a, 2011b and 2012; Matsuoka *et al*., 2011). The cruise plan was endorsed at the 62nd 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 (e.g. common minke 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, 2012).

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

The research area was set north of 40°N, south of Aleutian Islands including US EEZ between 170°W-150°W (Figure 1a). The survey area is divided into northern and southern stratum at the US EEZs. Outer limit of US EEZs is provided by NOAA Office of Coast Survey and the data are available from http://www.nauticalcharts.noaa.gov/csdl/docs/GIS_EEZ_Alaska.zip. A random start point for survey tracks was used as

same as 2010 IWC-POWER cruise 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 1b shows the cruise track design in the research area and Table 1a shows the planned waypoint (WP) for the pre-determined trackline. Research hours during the cruise will be the same as on recent SOWER cruises. The research day will begin 60 minutes after sunrise and end 60 minutes before sunset, with a maximum of a 12-hour research day. Time-zone changes will be in 30-minute intervals, coming into effect at midnight. Primary search effort is only conducted in acceptable weather conditions. The sighting survey will be conducted using Passing (NSP) with abeam closing mode (SS-II) based on the discussions at the Tromso SC meeting, recommendation from the 2010 cruise and suggestions from the SC members. The usual guidelines for acceptable conditions will apply, i.e. visibility is greater than 2.0 n.miles and wind speed is <21 knots; the sea state should be <Beaufort 6 as same as previous cruise. Two primary observers engaged the sighting survey from the barrel at all times in NSP mode (See Item 2 Survey Mode). Details of the sighting survey are given in the "Information for researchers" (Anon. 2011a). In the case of sightings of very rare species (e. g. blue and right whales), the ship may conduct a direct approach to the location of the sighting if there is a possibility that the group could be lost if closing were delayed. In the US EEZ, the research activities would be conducted under the ESA/MMPA permit held by AFSC and that no additional permit was required. Sally Mizroch (US researcher on board) was listed as a Co-Investigator on the AFSC permit.

As appropriate and decided by the Cruise Leader, research time was to be given for biopsy sampling of blue, right, North Pacific sei, common minke, fin, humpback, and sperm whales (Bryde's whales are unlikely to be seen north of 40°N), with higher priority given to the former four species in this cruise using the Larsen-gun system. Biopsy of killer whales will be attempted on an opportunistic basis. There are some discrepancies between Japan and the US in domestic legal systems regarding CITES/international trade and therefore neither side could accommodate the other side's requests related to issuing CITES permits/certificates necessary for: 1) bringing biopsy samples to be taken in the US EEZ out from there; and 2) bringing biopsy samples to be taken on the high seas into/out from the US EEZ. Consequently, there was no choice but to refrain from biopsy sampling when the *Yushin-Maru No.3* surveys within the US EEZ during the survey cruise as same as 2010 cruise. From view point of these permit issues, the *Yushin-Maru No.3* will survey the US EEZ first, and then (after completion of the survey within the US EEZ), she will survey the high sea area. Biopsy sampling will be conducted on the high seas only after *Yushin-Maru No.3* exits the US EEZ (i.e. no biopsy samples on board *Yushin-Maru No.3* at the time of exit of from the US EEZ).

Target species for photo-ID are blue, right and humpback whales. Photos of fin whales, sei whales, sperm whales and killer whales may also be obtained opportunistically.

2. SHORT NARRATIVE OF THE CRUISE

The 2011 cruise itinerary

Date	Event
10 July 2011	Pre-cruise meeting
11 July	Researchers on board. Vessel depart Shimonoseki, Japan
21 July	Vessel arrives in the research area to the starting point at 170°00'W
31 August	Vessel completes the research at 170°00'W (42 days in the research area).
8 September	Vessel arrives Hakodate, northern Japan (refuel, researchers got off)

Research vessel used

The *Yushin-Maru No.3* (742GT) was engaged for this cruise instead of *Kaiko-Maru* (860.25GT) in 2010 cruise. Detail of the photo, specification and list of crew of the vessel is shown in Appendix A.

Scientists present and responsibilities

For the cruise, two researchers were selected by the steering group of this cruise, Koji Matsuoka (Cruise leader, Institute of Cetacean Research, ICR, Japan), Sally Mizroch (photo-ID/biopsy, Alaskan Fisheries Science Center, AFSC, NOAA, USA).

Koji Matsuoka (Japan) - Cruise Leader, sighting/photo-ID
Sally Mizroch (USA) –biopsy/photo-ID
Reserve : -

Pre-cruise meeting

On 10 July, the pre-cruise meeting was held at the R/V *Yushin-Maru No.3* (YS3) under Kato (Convenor of this cruise). In the meeting, we discussed and confirmed on the priorities and strategies of the cruise based on the planning report (IWC, 2012), as well as the SC63 report (IWC, 2011b). Meeting participants were: Kato (TUMSAT, Chair), Miyashita (NRIFSF), Matsuoka (ICR, cruise leader), Mizroch (US, AFSC, researcher), Komiya (Captain), Oide (Chief Engineer), Iida (Chief Operater), Ohshima (Chief Officer), Ohmura (Bosun) and Noda (Kyodo-Senpaku). Report of this meeting was distributed to the steering group after review by the Chair (Anon. 2011b). On 10 July, all researchers and equipment were on board the YS3. One crossbow was provided by AFSC was brought to Japan by the US researcher.

Survey Mode

Activities aboard the ship are classified into two principal groups: On-effort and Off-effort. In the sightings survey portion of the research, On-effort activities are times when full search effort is being executed and conditions (such as weather and sea conditions) are within acceptable parameters to conduct research. Off-effort activities are all activities that are not On-effort. All sightings recorded while the ship is On-effort are classified as Primary sightings. All other sightings are Secondary sightings. Sighting effort is 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 (SS-II) Mode was used in this cruise. This is in effect Passing Mode. Two topmen are observing from the barrel at all times. There is open communication between the upper bridge and the barrel. The observers on the upper bridge should communicate with the topmen only to clarify information and should not direct the topmen to disrupt their normal search procedure unless directed to do so by the Cruise Leader (Anon. 2011a).

Immediately after a sighting is made from the barrel, the topman informs 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 does not change his normal searching pattern in order to keep contact with the sighting. The observers on the upper bridge must attempt to locate the sighting made by the topman and decide whether it is possible for them to confirm the species and number before the sighting passes abeam of the vessel. The topman gives 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 records the species and estimated number of whales in the school when the sighting passes abeam of the vessel, in consultation with other researchers. When the sighting passes abeam of the vessel, the ship then changes course to the appropriate heading to approach the whale, and vessel speed is increased to 15 knots to hasten the closure. Ship speed is decreased when the group is neared, usually at a distance of 0.2-0.4 n.miles from the initial sighting position. After the whale group has been approached, the species, number of animals in the group, estimated lengths, number of calves present, and behaviour are determined and recorded. After as many data as possible have been collected, other activities might take place, such as natural marking or biopsy experiments. Until the ship resumes the transect with full search effort, any whale sightings made after the initial sighting are classified as secondary sightings (Anon. 2011a).

Weather conditions and expected versus realised effort

In the northern stratum, there were some poor weather conditions (heavy winds or poor visibility) in the research area due to a strong low pressure system moving eastwards, especially in the western side of the northern stratum. On the contrary, weather conditions of the southern part of the southern stratum was good. Survey coverage was 58% in the northern stratum and 78% in the southern stratum. A total of 2,397.8 n.miles was surveyed in the research area in the Passing (NSP) with abeam closing (SSII) mode.

3. SUMMARY OF SIGHTINGS

3.1 Identification of species

The following guidelines based on the IWC-SOWER (Southern Ocean Whale and Ecosystem Research) and IWC-POWER cruises were used for classification of identification (Anon, 2011a):

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 Senior Scientist or other designated researcher. Probable identification of species was based on multiple cues, which are nevertheless insufficient to be absolutely confident in identification. This usually occurs when blows are seen, the surfacing pattern is correct, but the whale's body cannot be seen or clearly seen.

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, is determined are classified as confirmed schools. The data from the confirmed

schools are used in the analysis 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 should be 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 is 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).

3.3 Sighting summary in the research area

Tabulations of all searching effort and the sightings recorded in the northern and southern strata, by species and by effort mode are presented in Tables 1b, 2 and 3, respectively. List of all the sightings recorded in the research area, by species and by effort mode are presented in Table 4. Figure 2 illustrates the location of the searching effort. Figures 3a-3f illustrates the location of the sightings. Tables 5-6 lists the sightings observed during transits to and from the research area. Table 7 summarizes all the sightings observed during the entire cruise. Table 8 shows the sea surface temperatures (min. max. and range) for each species sighted in the research area. No sei whales were seen in the northern stratum and only two humpback whales were seen in the southern stratum. Figure 4 shows the breakdown of research time, in minutes with the strata of the research area.

Northern stratum (US EEZ)

Large whales species encountered within the northern stratum included one blue whale (photo-identified), 47 schools of fin whales (91 individual whales including 3 calves), one common minke whale, 74 schools of humpback whales (131 individuals including one calf, 47 photo-identified), 6 schools of sperm whales (10 individuals) and 6 killer whale pods (66 individuals including 2 calves, 18 individuals photo-identified from 5 different pods).

Survey coverage in the northern stratum varied by area. Survey effort was hampered on legs 1 and 2 because of high winds and heavy fog. On 22 July, the YS3 conducted a full survey day on effort and encountered a number of humpback whales including one mother and calf on the Aleutian Trench between latitudes 51˚00'N and 52˚20'N. A solitary blue whale was also sighted (51˚52'N 167˚24'W, sea temperature 9.5^{o}C) in this area. The blue whale and humpback whales were documented for photo-identification. Left and right dorsal fin photographs were obtained for the blue whale and tail flukes photographs and dorsal fin photos were obtained for 5 of the 7 humpback whales encountered.

From 25 to 27 July, the YS3 surveyed offshore area on the cruise track around boundary of the USEEZ, under the heavy fog intervals. Fin, humpback, sperm and killer whales were sighted and a number of photo-identification photographs were collected. High density areas of fin (8 schools and 16 individuals) were observed in the northern part of our transit around the west end of Kodiak and humpback (8 schools and 13 individuals) whales were observed off shore Alitak Bay. One solitary common minke whale was sighted west of Tugidak Island. On 31 July, the YS3 completed the detour around the Kodiak Islands and re-started the survey at WP109 (56˚56'N 153˚20'W) just south of Tugidak Island. Very high densities of humpback whales (31 schools and 72 individuals) were observed south of Tugidak Island within 7-10 miles of the coast. We observed a large feeding aggregation (shoal) and found that the changes in group composition made it hard to estimate group size for line transect surveys. Prey was observed on the sounder and the depth in this area was about 60 meters. Even higher densities (perhaps more than 40 individuals) were observed around WP109 on the cruise track around the Albatross bank southern coastal of Kodiak Island and we continued to survey those humpback whales in passing mode. While heading south toward WP110, a dead humpback whale (fairly fresh) was observed and photographed.

On 1 August, the YS3 surveyed the offshore area on the cruise track around the boundary of the USEEZ, under heavy fog intervals and completed the northern stratum (USEEZ). During the day, fin (2 schools 2 animals) and sperm (4 schools 8 animals) whales were sighted around the Marchand seamount (around 53˚N on the cruise track). The YS3 departed the USEEZ at 21:34 (53˚57'N 150˚12'W) on 1 August

Southern stratum

Large whales species encountered in the survey area south of the US EEZ included 8 schools of blue whales (8 individual whales 8 photo-identified, 4 biopsy samples), 33 schools of fin whale (48 individual whales, 25 photo-identified, 12 biopsy samples), 38 schools of sei whales (73 individual whales, 27 photo-identified, 31 biopsy samples), one common minke whale, 2 schools of humpback whales (2 individual whales, 2 photo-identified, 1 biopsy sample), and 51 schools of sperm whales (64 individual whales).

On 2 August, the YS3 started survey effort in the southern stratum at WP201 (53˚18'N 150˚00'W). From 2 to 4 August, a solitary blue (3 schools 3 animals), fin (5 schools 9 animals) and humpback (1 school 1 animal) whales were observed around the Gilbert seamount and the Woodworth seamount around WP201. On 5 August in the morning, the distance and

angle estimation experiment was successfully completed under good visibility condition. On 6 and 7 August, the YS3 encountered heavy fog and rain under the TD off effort steaming. One common minke and one fin whale were sighted while off effort.

On 8 and 9 August, the YS3 surveyed along the westernmost trackline of the southern stratum under heavy fog intervals. During on effort searching, fin whales (4 school / 5 animals) were sighted but there was no chance to collect biopsy samples. From 10 to 14 August, the YS3 continued the southward survey under good weather conditions. During these days, fin (4/5) and sei (4/7) whales were sighted and biopsy samples were collected from 3 fin whales and 3 sei whales. On 13 August, the YS3 turned to the northward survey at WP204 (40˚00'N 156˚55'W). Sperm whale, Ziphiidae, Mesoplodon spp., and mixed schools of common and striped dolphins were sighted in this region. There were no baleen whale sightings from south of 42˚N. On 14 August, the YS3 encountered a section of the trackline with a number of sightings of Ziphiidae, multiple groups of sperm whales and a mixed school of common and striped dolphins (at approx. 42˚30'N, 158˚ 40'W). As we transited further north (north of 43˚ 30'N), we encountered 2 separate fin whales and biopsied one individual.

On 15 August, the YS3 surveyed along the northwest trackline of the southern stratum under good weather condition. During on effort searching, a solitary blue whale was sighted (sea temperatures was 21.5˚C) and biopsy sampled and photographed. No survey was conducted on 16 August due to heavy fog. On 17 August, two solitary sei whales (sea temperatures were 18.2˚C and 18.7˚C, respectively) and a solitary fin whale (sea temperature was 18.2˚C) were sighted and biopsy sampled. On 18 August, YS3 encountered a high density area of fin (4/10) and sei (10/17) whales under good weather conditions. Biopsy samples were collected from 2 fin whales and 13 sei whales, including a mother and calf. No survey was conducted from 19 to 21 August due to heavy fog, high seas and high winds.

On 22 August, the YS3 surveyed along the northwest trackline of the southern stratum under good weather condition. During on-effort searching, 2 schools (2 individuals) of fin whales and 3 schools (11 individuals) of sei whales were sighted and biopsy sampled (2 fin and 4 sei). On 23 August, YS3 completed the northwest trackline and started the third (final) trackline (southwest) at WP207 (50˚28'N, 164˚37'W). 2 schools (3 individuals) of fin whales and 8 schools (21 individuals) of sei whales were sighted and biopsy sampled (3 sei). On 24 and 25 August, the YS3 surveyed under good weather condition. 3 schools (4 individuals) of fin whales, 6 schools (8 individuals) of sei whales and a solitary humpback whale were sighted and biopsy sampled (2 fin, 4 sei and 1 humpback). We obtained tail flukes and right dorsal fin photos of the humpback whale, as well as a biopsy sample. On 26 August, the YS3 surveyed under high wind condition and observed 1 group of fin whales (2 individuals), a solitary sei whale and 7 solitary sperm whales. We approached and biopsy sampled a mixed group of fin and sei whales (1 fin and 1 sei). No survey was conducted on 27 August due to high winds (over 30 knots). On 28 August, the YS3 surveyed under good weather conditions. A solitary blue whale and 2 groups (4 individuals) of sei whales were sighted. One group of sei whales included a mother and calf and the calf was biopsied sampled. We photographed the right lateral and dorsal fin of the blue whale.

Detailed sightings by each species as follows:

Blue whale

A total of 10 groups (10 individuals) of blue whales were observed in the entire cruise including a solitary blue whale during the transit survey from research area to Hakodate (Figure 3a). Sea temperatures ranged from 9.5˚C to 21.5˚C. All blue whales sighted were solitary. Blue whales were sighted in the first section of the northern stratum, and then again in all sectors of the southern stratum.

Blue whales are rarely seen in the North Pacific. The sightings data, biopsy samples and photo-identification data collected during this cruise will allow researchers to begin to assess abundance and study stock structure and movements of this species.

Fin whale

Fin whales were the most frequently encountered baleen whale species in the research area. The fin whales were widely distributed in the northern and southern strata and there were some concentrated areas in near western side of the Kodiak Island. A total of 80 schools (139 individuals including 4 calves) of fin whales were observed in the research area (Figure 2b). Sea temperatures ranged from 8.9˚C to 22.6˚C. Biopsy samples were obtained from 12 fin whales, including one calf.

Fin whales were observed as we headed north (14 schools and 32 individuals) past the Semidi Islands and Chirikof Island on the way to the west side of Kodiak Island. High density areas of fin whales were observed (16 schools and 31 individuals) around the western side of the Shelikof Strait. High density areas of fin (8 schools and 16 individuals) were observed in the northern part of our transit around the west end of Kodiak (Figure 3a).

Fin whale group sizes varied by strata: in the northern stratum, 43% (20 sightings) of fin whales were seen in groups of one and 34% (16 sightings) were seen in groups of two. In the southern stratum, 73% (24 sightings) of fin whales were seen in groups of 1 and 18% (6 sightings) were seen in groups of 2.

Sei whale

Although sei whales were the third most frequently encountered baleen whale species in the research area, all sei whale sightings were in the southern stratum. A total of 38 schools (73 individuals, including 2 calves) of sei whales were observed (Figure 3b). Biopsy samples were obtained from 31 individuals, including a mother/calf pair and a calf (the mother could not be sampled due to time constraints). Sei whales were seen mostly in groups of one (62%, 36 sightings) and groups of two (24%, 24 sightings). Sea temperatures ranged from 11.4 C to 22.4˚C.

Mixed groups of fin and sei whales

We encountered 5 different mixed groups of fin and sei whales (whales in close association surfacing in near synchrony). In the first two encounters (on 18 and 22 August), the groups were composed of one sei whale and one fin whale. We obtained a biopsy sample from the sei whale on 18 August (sample 11040120) and a biopsy sample from both the fin and the sei whale on 22 August (samples 11041029 and 11051030). In the next encounter (23 August), the group was composed of four sei whales and one fin whale and we were not able to obtain any biopsy samples from this group. In the next encounter (23 August), the group was composed of four sei whales and two fin whales and we obtained a biopsy sample from one of the sei whales. In the last encounter (26 August), the group was composed of one sei whale and two fin whales and we obtained a biopsy sample from one of the fin whales (11051043) and from the sei whale (11040144).

Common minke whale

A total of 2 schools (2 individuals) of common minke whales were observed. One solitary common minke whale was sighted near Kodiak Island west of Tugidak Island in the northern stratum and the other in the southern stratum on the westernmost leg as we transited toward waypoint 109 (Figure 3a). Minke whales were observed at sea temperature from 8.6˚C to 12.7˚C Because of difficulty in seeing their blow and small body, observations of this species were more difficult than in Antarctic waters. Common minke whales are hard to find within harsh sea surface conditions because their blows are not visible. In this survey, the Beaufort scale sea states were 4-5 in general. It is assumed that the sea condition was inadequate for common minke whale sightings.

Humpback whale

Humpback whales were the second most frequently encountered baleen whale species in the research area, but almost all of the sightings (all but two) were in the northern stratum. A total of 76 schools (133 individuals and one calf) were seen in the research area. Sea temperatures ranged from 8.2˚C to 13.7˚C. Humpback whales were seen in groups of 1 (61%, 46 sightings) and groups of two (20%, 15 sightings). The two sightings in the southern stratum were of solitary individuals. We obtained tail flukes photographs from both whales and a biopsy sample from the second whale. The humpback whale data collected on the cruise has already provided some information on humpback whale movements. Preliminary photo-identification analyses have shown that at least two of the humpback whales photographed in offshore waters of the US EEZ have prior sighting histories in offshore and mainland waters of Mexico.

A high density area of humpback whales was observed around Sirius seamount and Putnam seamount around waypoint 105 (51˚26'N 159˚42'W) (Figure 3b), as well as south of the Semidi Islands as we transited north toward waypoint 106. Numerous fish balls (dense concentrations of fish seen near the surface) were observed in that area and humpback whales were seen diving below and surfacing through fish balls. Humpback whales (8 schools and 13 individuals) whales were observed off shore Alitak Bay. Humpback whales were observed as we completed the detour around the Kodiak Islands and re-started the survey at WP109 (56˚56'N 153˚20'W) just south of Tugidak Island. Very high densities of humpback whales (31 schools and 72 individuals) were observed south of Tugidak Island within 7-10 miles of the coast. We observed a large feeding aggregation (shoal) and found that the changes in group composition made it hard to estimate group size for line transect surveys. Prey was observed on the sounder and the depth in this area was about 60 meters. Even higher densities (perhaps more than 40 individuals) were observed around WP109 on the cruise track around the Albatross bank southern coastal of Kodiak Island and we continued to survey those humpback whales in passing mode. While heading south toward WP110, a dead humpback whale (fairly fresh) was observed and photographed.

Sperm whale

A total of 57 sperm whale schools (74 individuals) were seen in the research area (sea temperature ranged from 9.1˚C to 24.7˚C) Sperm whales were the most frequently encountered toothed whale species in the research area (Figure 3c). Most sperm whales were solitary large males (97% of the schools) and were mainly distributed in the southern stratum in some concentrated areas. The concentration of sperm whales were observed on 12 August (10 schools 10 individuals) between 44°00'N and 45°07'N, 173°45'E and 175°00'E where the sea temperature ranged from 12.2˚C to 14.6˚C.

Ziphiidae and Mesoplodon spp.

A total of 12 schools (20 individuals) of *Ziphiidae* were observed in the research area (sea temperature ranged from 8.7˚C to 24.3˚C). A total of 6 schools (22 individuals) of *Mesoplodon* species were observed in the research area (sea temperature were from 9.4˚C to 24.7˚C). They were widely distributed throughout the research area (Figure 3d).

Killer whale

A total of 6 pods (66 individuals) of killer whales were observed in the research area (sea temperatures ranged from 9.4˚C to 11.6˚C) (Figure 3d). All killer whale sightings were in the northern stratrum. Photo-identification data were collected from 5 of the 6 pods observed and at least 18 individual killer whales were cataloged. Calves were observed and photo-identified in two different pods. .

Other species

Sightings of dolphin species such as short-beaked common dolphin (17 schools 1,196 individuals, mean school size was 70.3), Pacific white-sided dolphin (20 schools 1,341 individuals, mean school size was 67.1), Northern right whale dolphin (6 schools 750 individuals, mean school size was 125.0), Dall's porpoise (71 schools 391 individuals, including Unidentified type, mean school size was 5.5) were made. Dall's porpoise were the most frequently encountered dolphin species. This species was sighted throughout the research area. Pacific white-sided dolphins and Northern right whale dolphins were often observed in mixed schools.

A dolphin species spatial segregation was clearly observed (Figures 3e and 3f). Only short-beaked common dolphins were observed in the southern part of the survey area dominated by warm water. Conversely, Northern right whale dolphins, Pacific white sided dolphins and Dall's porpoise were observed in the northern part. Anomalous color patterns of Pacific white sided dolphins were occasionally observed during the survey. A very pale common dolphin and a dark color morph common dolphin were observed on 8 August (sighting no.004) at position 41°30'N 178°24'E in the southern stratum.

3.2 In transit

Sighting surveys were conducted during transit to and from the research area between 12 July (06:00) and 21 July (10:00) from Shimonoseki to research area and between 31 August (11:00) and 5 September (16:40) from research area to Hakodate (Table 1b). Sightings recorded in these transits sighting surveys, by species and by effort mode are presented in Tables 5 and 6, respectively.

4. BIOPSY SAMPLING

Biopsy sampling was attempted as often as possible in the southern stratum (Table 10). Biopsy samples were collected from 48 whales during 43 encounters (sightings). The minimum time to collect a biopsy sample was 4 minutes from the time when Larsen gun was set up on the bow deck to the time we got the sample. The maximum on-deck time to collect a sample was 1 hour, 46 minutes. Median sampling time was 19 minutes and 75% of our samples were collected within 35 minutes of setting up on deck (quartile 1: 13:07 minutes, quartile 2: 19:05 minutes, quartile 3: 35:24 minutes, quartile 4: 1:46:26, see Figure 5). For our 18 unsuccessful attempts, our minimum time on deck was 9 minutes, maximum 1 hour 12 minutes, median time was 27 minutes and 75% of our attempts took 42 minutes or less (Figure 5).

5. PHOTO-IDENTIFICATION

In the northern stratum, where biopsy sampling was not permitted, photo-identification data were collected for all blue whales and almost all humpback whales. Near Kodiak, a couple of dense aggregation of humpbacks were observed. We attempted photo ID in one and had to ignore the other.

In the southern stratum, photo-identification data were obtained opportunistically on blue whales as we attempted to biopsy them and opportunistically on fin and sei whales during biopsy attempts. We were able to obtain photo-identificaton data from both humpback whales we encountered in the southern stratum, the first as we attempted to biopsy the whale (unsuccessfully) and the second before we started our approaches for biopsy sampling.

Aside from a couple of close approaches early in our surveys of the northern stratum as we were calibrating our approach distances, most whales had no reactions to our photo-ID approaches. Because we were shooting using the RAW setting on our cameras and were using good, image-stabilized zoom telephoto lenses, we found that we could shoot at greater distances and still obtain good photos.

YS3 Whale ID numbers have been assigned to blue, humpback and sei whales. Biopsy sample numbers have been added to the whale ID numbers when a sampled whale was photo-identified. Temporary pod ID numbers have been assigned to killer whales. The fin whale photo data have been evaluated for photo-ID but not catalogued yet, so the fin whale ID numbers contain the biopsy sample number and an uppercase "X" in place of the catalogue number (Table 11).

6. VIDEO-RECORDING

No video recording was conducted in this cruise.

7. OTHER EXPERIMENTS

Estimated Angle and Distance Training Exercise

The Estimated Angle and Distance Training Exercise was conducted in the afternoon of 11 July for 1.95 hours. During the exercise the observers familiarized themselves with distance estimates from the TOP and Upper Bridge.

Estimated Angle and Distance Experiment

The Estimated Angle and Distance Experiment was conducted on 12 July for 4.08 hours. An Estimated Angle and Distance Training Exercise and Estimated Angle and Distance Experiment was performed using the same protocol as during recent cruises (Anon. 2010b).

Marine debris observation

Marine debris is an element of concern in all marine environments and could have an impact on the total ecosystem. During this cruise, we collected data on floating marine debris (mainly artificial materials which listed in the research manual, Anon, 2010b) to observe the type and extent of the marine debris in the North Pacific. Marine debris of 133 materials were recorded which were encountered during the research area and during transit are shown in Tables 9a and 9b.

We observed marine debris on 20 of 48 survey days. On 6 different days, we observed one item of debris each day. On 9 different days, we observed a range from 2-5 items. On four days, we transited areas which had very dense concentrations of debris. On 16 July, we recorded 21 items as we travelled from 44° 4' N 156° 46' E to 44° 28' N 158° 59' E. On 13 August, we recorded 27 items from 40° 05' N 156° 53' W to 41° 49' N 158° 09' W. On 2 and 3 September, we recorded 31 items the first day (from 43° 03' N 178° 25' E to 43° 44' N 168° 54' E) and 13 items the next day from 43° 36' N 171° 48' W to 43° 45' N 170° 1' E. Transit survey ended at 1300 on 3 September as we reached 170° E, so the debris numbers for 3 September represent only a partial day of surveys.

Note that in areas of high density of marine debris, it is impossible to record all items and also conduct the sighting survey, so our records will under-represent the extent of the debris in dense areas. We would suggest exploring alternative methods of recording debris in high density areas.

7. TECHNICAL MATTERS OF DATA AND RECOMMENDATIONS

Photography

All photographs were shot using the RAW format, which provides the best image possible from a given camera. Both researchers used "image-stabilized" lenses which are highly recommended for shooting moving objects (fast-swimming whales) from a moving object (fast traveling ship sometimes in heavy seas). Matsuoka photographed with a larger lens (100-400mm) and a standard camera. Mizroch photographed with a smaller lens (28-300) but used a camera with a full-frame sensor. Differences were noted during photo analysis. For medium shots and long distance shots in good lighting, the larger lens resulted in better focus. For long distance shots in poor lighting, the full-frame sensor provided better detail even though the lens had a smaller range. It is recommended that all future photographs be shot using RAW format, that researchers use long image-stabilized lenses (e.g., Canon 100-400, Nikon 80-400) and that researchers use full-frame cameras.

All photographs were geotagged. Mizroch's photographs were geotagged automatically using a GPS device attached to the camera. Matsuoka's photographs were geotagged each evening using the location data from the ship's automated data recording system and a geotagging software program (RoboGeo). The EXIF metadata fields in each image were used to label all photographs with an informative sighting number (Image Description: 2011_POWER_YS3_20110731_23) and all catalogued photographs were labelled with a 2011 YS3 ID number and the identifying part (e.g., LD for left dorsal).

Data forms

We attempted to collect photo-identification data as much as possible during surveys in the northern stratum and we also attempted to collect photo-identification data opportunistically during every biopsy attempt. Mizroch photographed from the bow deck and Matsuoka photographed from the barrel and we were also able to document almost every single biopsy hit. We collected photo-identification data during 86 sightings and recorded biopsy information during 71 sightings.

We strongly suggest integrating the biopsy and natural markings data forms and note that they contain much of the same information. We also suggest that they should be simplified. It should be sufficient to record the date, sighting number and start and end time of the experiment as well as the sample number and the whale ID number. Latitude and longitude are recorded by hand on the sighting sheets and electronically recorded at the time of each sighting and need not be written again on an integrated biopsy/natural marking sheet. The integrated biopsy/natural markings form can easily be linked to the sightings form using date/sighting number and start/end times.

8. CONCLUSIONS

The 2nd annual IWC-POWER (as a successor to the IWC/IDCR-SOWER cruises since 1978/79 in the Antarctic) was successfully conducted using the Japanese Research Vessel *Yushin-Maru No.3*. All equipments and the survey method were same as the past IWC international sighting surveys. The planned 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 6th December 2011. The 2nd cruise of this program was completed and provided information (sightings and photo-ID data, and biopsy samples) that various baleen whale species and other cetacean species were widely distributed in the research area where they were depleted in the past. These results will contribute to the above objectives for the IWC/SC.

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Table 1a. List of the Way Point (WP) for the 2011 IWC- POWER Cruise.

Northern stratum

WP	Latitude	Longitude
101	49°28'N	170°00'W
102	51°51'N	167°25'W
103	54°13'N	164°42'W
104	52°50'N	162°10'W
105	51°26'N	159°42'W
106	54°42'N	157°18'W
107	57°57'N	154°42'W
108	57°41'N	154°20'W
109	56°56'N	153°20'W
110	56°08'N	152°18'W
111	54°18'N	150°00'W

Southern stratum

WP	Latitude	Longitude
201	53°18'N	150°00'W
202	48°52'N	152°30'W
203	44°26'N	154°48'W
204	40°00'N	156°55'W
205	43°30'N	159°20'W
206	46°59'N	161°53'W
207	50°28'N	164°37'W
208	47°21'N	166°31'W
209	44°15'N	168°18'W
210	41°08'N	170°00'W

Table 1b. Summary of search effort (time and distance) and experimental time (hours) conducted during the 2011 IWC-POWER Cruise.

Area	Start	End	NSP with abeam closing (SSII)		Photo-ID, Biopsy	Estimated angle and distance training and experiment
	Date	Date	Time	Dist.	Time	Time
	Time	Time	(hours)	(n.m.)	(hours)	(hours)
Shimonoseki to research area	12-Jul. 6:00	21-Jul. 10:00	39:16	467.3	0:00	0:00
Northern stratum	21-Jul. 10:00	1-Aug. 18:00	62:23	723.8	11:11	2:09
Southern stratum	2-Aug. 6:00	31-Aug. 11:00	144:21	1,674.0	32:47	3:48
Research area to Hakodate	31-Aug. 11:00	5-Sep. 16:40	19:45	232.7	0:00	0:00
Total	12-Jul 6:00	5-Sep. 16:40	265:46	3,097.8	46:27	3:57

Table 2. Number of sightings for all species observed in the northern stratum (US EEZ) by effort mode (NSP: Normal Passing with abeam closing Mode; BX: Begin experiment; OE: Off effort). Parentheses indicate the number of calves observed.

Species	NSP		BX		OE		Total	
	Sch.	Ind	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Blue whale	1	1					1	1
Fin whale	45	88			2	3	47	91(3)
Common minke whale	1	1					1	1
Like minke whale	1	1					1	1
Humpback whale	60	113	4	4	10	14	74	131(1)
Sperm whale	5	8			1	2	6	10
Ziphiidae	1	1					1	1
Mesoplodon spp.					1	1	1	1
Killer whale	5	54			1	12	6	66(2)
Dalli-type Dall's porpoise	24	94			1	4	25	98
Truei-type Dall's porpoise	1	3			1	1	2	4
Unid. type Dall's porpoise	13	53					13	53
Unid. large whale	33	56	2	2			35	58
Unid. dolphin/porpoise	1	2					1	2
Unid. whale	1	1					1	1
Total	192	476	6	6	17	37	215	519(6)

Table 3. Number of sightings for all species observed in the southern stratum by effort mode (NSP: Normal Passing with abeam closing Mode; BX: Begin experiment; OE: Off effort). Parentheses indicate the number of calves observed.

Species	NSP		BX		OE		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Blue whale	8	8					8	8
Fin whale	30	41	1	5	2	2	33	48(1)
Sei whale	37	72			1	1	38	73(2)
Common minke whale					1	1	1	1
Like minke whale					1	1	1	1
Humpback whale	2	2					2	2
Sperm whale	50	63	1	1			51	64
Ziphiidae	11	19					11	19
Mesoplodon spp.	5	21					5	21
Common dolphin	10	1,155					10	1,155(100)
Striped dolphin	2	55					2	55(2)
Pacific white-sided dolphin	4	255			3	78	7	333
Northern right whale dolphin	3	230					3	230
Dalli-type Dall's porpoise	14	61	1	5	6	41	21	107
Truei-type Dall's porpoise	1	1					1	1
Unid. type Dall's porpoise	6	14			1	5	7	19
Unid. large whale	18	24	3	8	3	5	24	37
Unid. small whale	1	25					1	25
Unid. dolphin/porpoise	9	156					9	156
Unid. whale	2	2					2	2
Total	213	2,204	6	19	18	134	237	2,357(105)

Table 4. Number of sightings for all species observed in the entire research area (northern and southern strata) by effort mode (NSP: Normal Passing with abeam closing Mode; BX: Begin experiment; OE: Off effort). Parentheses indicate the number of calves observed.

Species	NSP		BX		OE		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Blue whale	9	9					9	9
Fin whale	75	129	1	5	4	5	80	139 (4)
Sei whale	37	72			1	1	38	73
Common minke whale	1	1			1	1	2	2 (2)
Like minke whale	1	1			1	1	2	2
Humpback whale	62	115	4	4	10	14	76	133 (1)
Sperm whale	55	71	1	1	1	2	57	74
Ziphiidae	12	20					12	20
Mesoplodon spp.	5	21			1	1	6	22
Killer whale	5	54			1	12	6	66 (2)
Common dolphin	10	1,155					10	1,155 (100)
Striped dolphin	2	55					2	55
Pacific white-sided dolphin	4	255			3	78	7	333 (2)
Northern right whale dolphin	3	230					3	230
Dalli-type Dall's porpoise	38	155	1	5	7	45	46	205
Truei-type Dall's porpoise	2	4			1	1	3	5
Unid. type Dall's porpoise	19	67			1	5	20	72
Unid. large whale	51	80	5	10	3	5	59	95
Unid. small whale	1	25					1	25
Unid. dolphin/porpoise	10	158					10	158
Unid. whale	3	3					3	3
Total	405	2,680	12	25	35	171	452	2,876

Table 5. Number of sightings for all species observed during transit to the research area from Shimonoseki by effort mode (NSP: Normal Passing with abeam closing Mode; OE: Off effort). No calves were observed.

Species	NSP		OE		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Fin whale	1	1			1	1
Sperm whale	23	23			23	23
Ziphiidae	1	2			1	2
Mesoplodon spp.	1	4			1	4
Killer whale			1	4	1	4
Dalli-type Dall's porpoise	6	25			6	25
Unid. type Dall's porpoise	7	25			7	25
Unid. large whale	1	1			1	1
Total	40	81	1	4	41	85

Table 6. Number of sightings for all species observed during transit to Hakodate from the research area by effort mode (NSP: Normal Passing with abeam closing Mode; OE: Off effort). Parentheses indicate the number of calves observed.

Species	NSP		OE		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Blue whale			1	1	1	1
Fin whale	1	1			1	1
Sei whale	20	22			20	22
Sperm whale	15	22			15	22
Ziphiidae	1	1			1	1
Common dolphin	1	30	2	90	3	120(7)
Pacific white-sided dolphin	2	40			2	40
Northern right whale dolphin	2	60			2	60
Unid. type Dall's porpoise	1	20			1	20
Unid. large whale	10	10			10	10
Unid. dolphin/porpoise	2	240			2	240
Total	55	446	3	91	58	537

Table 7. Number of sightings for all species observed in 2011, including sighting during transit and in the research area, by effort mode (NSP: Normal Passing with abeam closing Mode; BX: Begin experiment; OE: Off effort). Parentheses indicate the number of calves observed.

Species	NSP		BX		OE		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Blue whale	9	9			1	1	10	10
Fin whale	77	131	1	5	4	5	82	141 (4)
Sei whale	57	94			1	1	58	95 (2)
Common minke whale	1	1			1	1	2	2
Like minke whale	1	1			1	1	2	2
Humpback whale	62	115	4	4	10	14	76	133 (1)
Sperm whale	93	116	1	1	1	2	95	119
Ziphiidae	14	23					14	23
Mesoplodon spp.	6	25			1	1	7	26
Killer whale	5	54			2	16	7	70 (2)
Common dolphin	11	1,185			2	90	13	1,275 (107)
Striped dolphin	2	55					2	55 (2)
Pacific white-sided dolphin	6	295			3	78	9	373
Northern right whale dolphin	5	290					5	290
Dalli-type Dall's porpoise	44	180	1	5	7	45	52	230
Truei-type Dall's porpoise	2	4			1	1	3	5
Unid. type Dall's porpoise	27	112			1	5	28	117
Unid. large whale	62	91	5	10	3	5	70	106
Unid. small whale	1	25					1	25
Unid. dolphin/porpoise	12	398					12	398
Unid. whale	3	3					3	3
Total	50	3,207	12	25	39	266	551	3,498

Table 8. Sea surface temperatures (minimum, maximum and range) for each species sighted in the research area

Species	Minimum SST	Maximum SST	Temperature range
Blue whale	9.5	21.5	12
Fin whale	8.9	22.6	13.7
Sei whale	11.4	22.4	11
Common minke whale	8.6	12.7	4.1
Humpback whale	8.2	13.7	5.5
Sperm whale	9.1	24.7	15.6
Ziphiidae	8.7	24.3	15.6
Mesoplodon spp.	9.6	24.7	15.1
Killer whale	9.4	11.6	2.2
Common dolphin	18.6	24.7	6.1
Striped dolphin	22.3	24.7	2.4
Pacific white-sided dolphin	13.3	17.7	4.4
Northern right whale dolphin	16.7	17.7	1
Dalli-type Dall's porpoise	7.9	17.2	9.3
Truei-type Dall's porpoise	8.8	16.5	7.7
Unidentified type Dall's porpoise	9.6	16.4	6.8

Table 9a. Summary of the marine debris.

Code	Marine Debris Code Definitions	Count
134	Single fishing float	59
135	Clustered fishing floats (2-10 floats together)	13
136	Wood plank	13
140	Wood object, unidentified	10
146	Metal can, 250 or more litres	1
147	Styrofoam, unidentified	4
148	Styrofoam board, less than 1 square meter	1
149	Styrofoam board, 1-2 square meters	4
151	Styrofoam box (at least 2 sides)	1
153	Cardboard, less than 1 square meter	1
161	Plastic, unidentified	1
162	Plastic, less than 1 square meter	2
163	Plastic, 1-3 square meters	4
164	Plastic, greater than 3 square meters	1
199	Other	18

Table 9b. Summary of sightings of unusual objects (marine debris code 199)

Code	Notes	Count
199	White refrigerator	7
199	Tire and rim	2
199	Tire and rim, encrusted with barnacles	1
199	Small overturned boat, skiff	1
199	Other, single tatami	1
199	Orange rope	1
199	Large gray fender (over 10 meters)	1
199	Flat thin floating object	1
199	Empty life jacket	1
199	Bright yellow thin floating material, approx. 1 meter	1
199	2 large black rectangular objects, floating approx. a mile apart	1

Table 10. Summary of the biopsy experiment with accompanying photo-ID data. LD: Left dorsal; LL: Left lateral; RD: Right dorsal; RL: Right lateral

Common Name	Sighting Date	Sighting Number	Group size	Number of whales sampled	YS3WhaleID	Sample Number	Photo-ID result	Biopsy Result	Encounter Duration
Blue whale	02-Aug	3	1	1	Blue_2_11061001	11061001	LD, LL, RD, RL	2 shots, 2 hits	0:17
Blue whale	04-Aug	1	1	0	Blue_3		LD, LL, RL, RD	no chance to shoot	0:30
Blue whale	04-Aug	5	1	1	Blue_4_11061003	11061003	LL	2 shots	0:06
Blue whale	15-Aug	1	1	1	Blue_5_11061010	11061010	LL, RL, RD	2 shots , 2 hits	0:49
Blue whale	28-Aug	8	1		Blue_6		RD, RL	no chance to shoot	1:22
Blue whale	29-Aug	3	1	0	Blue_7		LD, LL	2 shots, no hits	0:56
Blue whale	30-Aug	1	1	1	Blue_8_11061046	11061046	LD,RD,RL	2 shots, 2 hits	0:53
Blue whale	30-Aug	3	1		Blue_9		LD, LL, Back	no chance to shoot	0:43
Fin whale	02-Aug	2	1	0				no chance to shoot	0:15
Fin whale	02-Aug	5	1	0			LD	no chance to shoot	0:14
Fin whale	04-Aug	3	2	1		11051002	LD	two shots	0:12
Fin whale	04-Aug	6	1	0				no chance to shoot	0:49
Fin whale	09-Aug	14	2	0	014_Bp1, 014_Bp_2		LD, RD	2 approaches, 3 shots, no hits	0:28
Fin whale	09-Aug	15	1	0				no chance to shoot	0:09
Fin whale	10-Aug	1	1	0				no chance to shoot	0:42
Fin whale	10-Aug	3	2	1		11051004	LD of biopsied whale	3 shots, 1 hit	0:25
Fin whale	11-Aug	1	1	0			LD	1 shot, no hits	0:25
Fin whale	12-Aug	1	1	1		11051008		2 shots, 1 hit	0:14
Fin whale	14-Aug	17	1	0				1 shot, no hits	0:13
Fin whale	14-Aug	18	1	1		11051009		2 shots, 2 hits	0:12
Fin whale	17-Aug	4	1	1	Bp_X_11041013	11041013	RD	2 shots, 2 hits	0:33
Fin whale	18-Aug	9	1					no chance to shoot	0:30
Fin whale	18-Aug	13	3	1	Bp_X_11051018, 013_Bp_2, 013_Bp_3	11051018	RD of biopsied whale, RD of others	2 shots, 2 hits	0:10
Fin whale	18-Aug	26	5	1		11051026		2 shots, 2 hits	0:04
Fin whale	22-Aug	2	1	1		11051027		2 shots, 1 hit	0:18
Fin whale	22-Aug	7	1	1	Bp_X_11051030	11051030	RD, LD	2 shots, 2 hits	0:35
Fin whale	22-Aug	7	1	1	Bp_X_11051030	11051030	RD, LD	2 shots, 2 hits	0:35
Fin whale	23-Aug	7	1		007_008_Bp_1		LD,RD	no chance to shoot	0:16
Fin whale	23-Aug	7	1		007_008_Bp_1		LD,RD	no chance to shoot	0:16
Fin whale	23-Aug	13	2		012_013_Bp_1		LD	no shots	0:33
Fin whale	23-Aug	13	2		012_013_Bp_1		LD	no shots	0:33
Fin whale	24-Aug	16	2	1	Bp_X_11051037 (calf)	11051037		2 shots, 2 hits	0:08
Fin whale	25-Aug	4	1	1		11051039		2 shots, 2 hits	0:35
Fin whale	25-Aug	8	1					2 shots, no hits. Wave hit second shot.	0:40
Fin whale	26-Aug	3	2	1	Bp_X_11051043	11051043	LD, RD	1 shot, 1 hit	0:13
Fin whale	26-Aug	3	2	1	Bp_X_11051043	11051043	LD, RD	1 shot, 1 hit	0:13

Common Name	Sighting Date	Sighting Number	Group size	Number of whales sampled	YS3WhaleID	Sample Number	Photo-ID result	Biopsy Result	Encounter Duration
Fin whale	29-Aug	4	1					no chance to shoot	0:45
Fin whale	29-Aug	6	1					no chance to shoot	0:28
Fin whale	29-Aug	10	1				LD	no chance to shoot	0:47
Humpback whale	02-Aug	4	1	0	Mn_47		Tail, LD	2 shot, no hitss	0:40
Humpback whale	24-Aug	18	1	1	Mn_48_11071038	11071038	Tail, RD	4 shots, 2 hits	0:51
Sei whale	10-Aug	4	2	1	Sei_X_11041005	11041005		2 shots, 1 hit	1:12
Sei whale	11-Aug	4	1	1	Sei_X_11041006	11041006		5 shots, 2 hits	0:13
Sei whale	11-Aug	6	2	1	Sei_1_11041007	11041007	RD of biopsied whale	4 shots, 1 hit	0:12
Sei whale	17-Aug	1	1	1	Sei_2_11041011	11041011	LD, RD	2 shots, 1 hit	0:35
Sei whale	17-Aug	3	1	1	Sei_3_11041012	11041012	LD	2 shots, 1 hit	0:14
Sei whale	18-Aug	6	2	2	Sei_X_calf_11041014;Sei_X_mother_11041015	1104101415		calf: 2 shots, 1 hit; mother:2 shots, 2 hits	0:21
Sei whale	18-Aug	7	2	2	Sei_X_11041016, Sei_4_11041017	1104101617	LD, RD of Sei_4_11041017	4 shots, 2 hits, maybe 2 whales	0:44
Sei whale	18-Aug	16	1	1	Sei_5_11041019	11041019	RD	2 shots, 1 hit	0:04
Sei whale	18-Aug	17	1	1	Sei_6_11041020	11041020	LD, RD	2 shots, 1 hit	0:12
Sei whale	18-Aug	19	1	1	Sei_7_11041021, Sei_8	11041021	LD, RD of the biopsied whale, LD of a different whale	2 shots, 1 hit	0:27
Sei whale	18-Aug	20	3	1	Sei_X_11041022	11041022		2 shots, 1 hit	0:11
Sei whale	18-Aug	22	2	2		1104102324		whale 1: 1 shot, 1 hit; whale 2: 2 shots, 2 hits	0:13
Sei whale	18-Aug	23	2		Sei_9		LD, RD one whale	2 shots, no hits	0:15
Sei whale	18-Aug	25	2	1	Sei_X_11041025	11041025		2 shots, 2 hits	0:07
Sei whale	18-Aug	30	1	0				2 shots, no hits	1:12
Sei whale	22-Aug	3	2	1	Sei_10_11041028	11041028	LD, RD of biopsied whale	8 shots, 1 hit	1:46
Sei whale	22-Aug	6	1	1	Sei_11_11041029	11041029	RD, LD	4 shots, 2 hits	0:35
Sei whale	22-Aug	6	1	1	Sei_11_11041029	11041029	RD, LD	4 shots, 2 hits	0:35
Sei whale	22-Aug	8	8	2	Sei_12_11041032, Sei_13, Sei_14	1104103132	LD of Sei_12_11041032, RD, LD of another whale, LD of another	2 shots, 2 hits	0:19
Sei whale	23-Aug	2	3	1	Sei_15_11041033	11041033	LD of biopsied whale	1 shot, 1 hit	0:32
Sei whale	23-Aug	4	3	1	Sei_16_11041034	11041034	LD of biopsied whale	3 shots, 1 hit	0:47
Sei whale	23-Aug	6	4	0	Sei_17, Sei_18,Sei_19		RD of both whales, probably LD of Sei_18	3 shots, no hits	0:16
Sei whale	23-Aug	6	4	0	Sei_17, Sei_18,Sei_19		RD of both whales, probably LD of Sei_18	3 shots, no hits	0:16
Sei whale	23-Aug	9	2	0				no chance to shoot	0:44
Sei whale	23-Aug	12	4	1	Sei_20, Sei_21_11041035	11041035	LD of the biopsied whale plus one other	1 shot, 1 hit	0:33
Sei whale	23-Aug	12	4	1	Sei_20, Sei_21_11041035	11041035	LD of the biopsied whale plus one other	1 shot, 1 hit	0:33
Sei whale	24-Aug	2	1	0				no chance to shoot	0:20
Sei whale	24-Aug	3	2	1	Sei_22_11041036, Sei_23	11041036	LD, RD of biopsied whale, RD of other	2 shots, 1 hit	0:28
Sei whale	25-Aug	2	1	0				no chance to shoot	0:09

Common Name	Sighting Date	Sighting Number	Group size	Number of whales sampled	YS3WhaleID	Sample Number	Photo-ID result	Biopsy Result	Encounter Duration
Sei whale	25-Aug	6	1	1	Sei_X_11041040	11041040		3 shots, 1 hit	0:36
Sei whale	25-Aug	7	2	2	Sei_24_11041041, Sei_X_11041042	1104104142	RD of first biopsied whale (Sei_24_11041041), no ID for 2nd whale	3 shots, 3 hits (1 shot, Sei_24_11041041 1; 2 shots, Sei_X_11041042)	0:43
Sei whale	26-Aug	2	1	1	Sei_X_11041044	11041044		1 shot, 1 hit	0:13
Sei whale	26-Aug	2	1	1	Sei_X_11041044	11041044		1 shot, 1 hit	0:13
Sei whale	28-Aug	2	1	0				no chance to shoot	0:15
Sei whale	28-Aug	4	3	1	Sei_25_11041045 (calf), Sei_26, Sei_27	11041045	LD, LL, RD,RL of Sei_25_11041045 (calf), LD, RD, and RL of Sei_26 (mother), LD, LL, RD of Sei_27	4 shots, 1 hit (1+1+2)	1:08
Sei whale	30-Aug	6	1	1	Sei_X_11041047	11041047		2 shots, 1 hit	0:14
Sei whale	30-Aug	7	1	1	Sei_X_11041048	11041048		2 shots, 1 hit	0:15
Unidentified large whale	10-Aug	6	1	0				no chance to shoot	0:35

Table 11. Summary of the photo-identification experiment with accompanying photo-ID data. LD: Left dorsal; LL: Left lateral; RD: Right dorsal; RL: Right lateral. YS3 Whale ID numbers have been assigned to blue, humpback and sei whales. Biopsy sample numbers have been added to the whale ID numbers when a sampled whale was photo-identified. Temporary pod ID numbers have been assigned to killer whales. The fin whale photo data have been evaluated for photo-ID but not catalogued yet, so the fin whale ID numbers contain the biopsy sample number and an uppercase "X" in place of the catalogue number.

Common Name	Sighting Date	Sighting Number	Group size	Number of individuals photographed	YS3 Whale ID	Photo-ID result	Encounter Duration
Blue whale	22-Jul	13	1	1	Blue_1	LD, RD	0:27
Blue whale	02-Aug	3	1	1	Blue_2_11061001	LD, LL, RD, RL	0:17
Blue whale	04-Aug	1	1	1	Blue_3	LD, LL, RL, RD	0:30
Blue whale	04-Aug	5	1	1	Blue_4_11061003	LL	0:06
Blue whale	15-Aug	1	1	1	Blue_5_11061010	LL, RL, RD	0:49
Blue whale	28-Aug	8	1	1	Blue_6	RD, RL	1:22
Blue whale	29-Aug	3	1	1	Blue_7	LD, LL	0:56
Blue whale	30-Aug	1	1	1	Blue_8_11061046	LD,RD,RL	0:53
Blue whale	30-Aug	3	1	1	Blue_9	LD, LL, Back	0:43
Fin whale	16-Jul	4	1	1		LD, RD, Head	0:01
Fin whale	28-Jul	6	5	2		RD	0:01
Fin whale	28-Jul	12	1	1		LD	0:09
Fin whale	28-Jul	22	2	1		RD	0:09
Fin whale	28-Jul	26	4	2		RD of both whales	0:03
Fin whale	29-Jul	9	2	2		RD	0:13
Fin whale	29-Jul	24	4	1		RD	0:07
Fin whale	30-Jul	4	2	1		LD	0:01
Fin whale	02-Aug	5	1	1		LD	0:14
Fin whale	09-Aug	14	2	2	014_Bp1, 014_Bp_2	LD, RD	0:28
Fin whale	10-Aug	3	2	1		LD of biopsied whale	0:25
Fin whale	11-Aug	1	1	1		LD	0:25
Fin whale	17-Aug	4	1	1	Bp_X_11041013	RD	0:33
Fin whale	18-Aug	13	3	3	Bp_X_11051018, 013_Bp_2, 013_Bp_3	RD of biopsied whale, RD of others	0:10
Fin whale	22-Aug	7	1	1	Bp_X_11051030	RD, LD	0:35
Fin whale	22-Aug	7	1	1	Bp_X_11051030	RD, LD	0:35
Fin whale	23-Aug	7	1	1	007_008_Bp_1	LD,RD	0:16
Fin whale	23-Aug	7	1	1	007_008_Bp_1	LD,RD	0:16
Fin whale	23-Aug	13	2	1	012_013_Bp_1	LD	0:33

Common Name	Sighting Date	Sighting Number	Group size	Number of individuals photographed	YS3 Whale ID	Photo-ID result	Encounter Duration
Fin whale	23-Aug	13	2	1	012_013_Bp_1	LD	0:33
Fin whale	26-Aug	3	2	1	Bp_X_11051043	LD, RD	0:13
Fin whale	29-Aug	10	1	1		LD	0:47
Humpback whale	22-Jul	2	1	1	Mn_1	Tail, LD, RD	0:18
Humpback whale	22-Jul	5	1	1	Mn_2	LD, RD	0:21
Humpback whale	22-Jul	6	1	1	Mn_3	RD	0:05
Humpback whale	22-Jul	8	1	1	Mn_4	Tail, RD	0:02
Humpback whale	22-Jul	10	1	1	Mn_5	Tail, LD	0:18
Humpback whale	22-Jul	11	1	1	Mn_6	Tail, LD, RD	0:10
Humpback whale	22-Jul	15	2	2	Mn_7 and Mn_8	LD, RD (Mn_7 and Mn_8)	0:17
Humpback whale	26-Jul	3	2	2	Mn_9 and Mn_10	LD (Mn_9); LD, RD (Mn_10)	0:07
Humpback whale	26-Jul	4	1	1	Mn_11	Tail, LD	0:04
Humpback whale	26-Jul	5	1	1	Mn_12	Tail, LD	0:00
Humpback whale	26-Jul	6	1	1	Mn_13	Tail, LD, RD	0:03
Humpback whale	26-Jul	7	1	1	Mn_14	LD	0:07
Humpback whale	26-Jul	9	1	1	Mn_15	Tail, RD	0:10
Humpback whale	26-Jul	10	1	1	Mn_16	Tail, LD	0:06
Humpback whale	26-Jul	12	3	3	Mn_17, Mn_18, Mn_19	Tail, LD, RD (dorsals not linked to tails)	0:07
Humpback whale	26-Jul	15	1	1	Mn_20	Tail	0:02
Humpback whale	28-Jul	5	1	1	Mn_21	LD, RD	0:27
Humpback whale	28-Jul	9	2	2	Mn_22 and Mn_23	RD	0:11
Humpback whale	29-Jul	28	3	3	Mn_24, Mn_25, Mn_26	Tail, RD	0:01
Humpback whale	30-Jul	9	1	1	Mn_27	Tail, RD	0:03
Humpback whale	30-Jul	11	2	2	Mn_28 and Mn_29	Tail, LD	0:03
Humpback whale	30-Jul	14	1	1	Mn_30	RD	0:00
Humpback whale	30-Jul	21	4	3	Mn_31, Mn_32, Mn_33	Tail, RD	0:09
Humpback whale	30-Jul	23	1	1	Mn_34	Tail	0:07
Humpback whale	31-Jul	1	1	1	Mn_35	Tail	0:13
Humpback whale	31-Jul	2	1	1	Mn_36	Tail	0:00
Humpback whale	31-Jul	3	1	1	Mn_37	Tail	0:10
Humpback whale	31-Jul	6	3	2	Mn_38, Mn_39	Tail	0:13

Common Name	Sighting Date	Sighting Number	Group size	Number of individuals photographed	YS3 Whale ID	Photo-ID result	Encounter Duration
Humpback whale	31-Jul	7	5	1	Mn_40	Tail, RD	0:13
Humpback whale	31-Jul	8	5	2	Mn_41, Mn_42	Tail, LD both, RD Mn_41	0:02
Humpback whale	31-Jul	10	2	2	Mn_43, Mn_44	Tail (Mn_43), LD, RD both, caudal peduncle both	0:18
Humpback whale	31-Jul	11	1	1	Mn_45	Tail	0:05
Humpback whale	31-Jul	23	3	1	Mn_46	Tail, RD	0:18
Humpback whale	02-Aug	4	1	1	Mn_47	Tail, LD	0:40
Humpback whale	24-Aug	18	1	1	Mn_48_11071038	Tail, RD	0:51
Killer whale	26-Jul	8	2	2	008_KW_1 and 008_KW_2	RD of each	0:06
Killer whale	28-Jul	4	7	2	004_KW_1 and 004_KW_2	RD	0:14
Killer whale	28-Jul	29	35	5	029_KW_1,029_KW_2,029_KW_3,029_KW_4, 029_KW_5	LD, 1 RD	0:16
Killer whale	28-Jul	36	5	5	036_KW_1, 036_KW_2,036_KW_RD1,036_KW_RD2	3 LD, 2 RD	0:07
Killer whale	29-Jul	20	5	5	020_KW_1,020_KW_2,020_KW_3(calf),020_KW_4,020_KW_5 (mother)	LD	0:15
Sei whale	11-Aug	6	2	1	Sei_1_11041007	RD of biopsied whale	0:12
Sei whale	17-Aug	1	1	1	Sei_2_11041011	LD, RD	0:35
Sei whale	17-Aug	3	1	1	Sei_3_11041012	LD	0:14
Sei whale	18-Aug	7	2	1	Sei_X_11041016, Sei_4_11041017	LD, RD of Sei_4_11041017	0:44
Sei whale	18-Aug	16	1	1	Sei_5_11041019	RD	0:04
Sei whale	18-Aug	17	1	1	Sei_6_11041020	LD, RD	0:12
Sei whale	18-Aug	19	1	2	Sei_7_11041021, Sei_8	LD, RD of the biopsied whale, LD of a different whale	0:27
Sei whale	18-Aug	23	2	1	Sei_9	LD, RD one whale	0:15
Sei whale	22-Aug	3	2	1	Sei_10_11041028	LD, RD of biopsied whale	1:46
Sei whale	22-Aug	6	1	1	Sei_11_11041029	RD, LD	0:35
Sei whale	22-Aug	6	1	1	Sei_11_11041029	RD, LD	0:35
Sei whale	22-Aug	8	8	3	Sei_12_11041032, Sei_13, Sei_14	LD of Sei_12_11041032, RD, LD of another whale, LD of another	0:19
Sei whale	23-Aug	2	3	1	Sei_15_11041033	LD of biopsied whale	0:32

Common Name	Sighting Date	Sighting Number	Group size	Number of individuals photographed	YS3 Whale ID	Photo-ID result	Encounter Duration
Sei whale	23-Aug	4	3	1	Sei_16_11041034	LD of biopsied whale	0:47
Sei whale	23-Aug	6	4	3	Sei_17, Sei_18,Sei_19	RD of both whales, probably LD of Sei_18	0:16
Sei whale	23-Aug	6	4	3	Sei_17, Sei_18,Sei_19	RD of both whales, probably LD of Sei_18	0:16
Sei whale	23-Aug	12	4	2	Sei_20, Sei_21_11041035	LD of the biopsied whale plus one other	0:33
Sei whale	23-Aug	12	4	2	Sei_20, Sei_21_11041035	LD of the biopsied whale plus one other	0:33
Sei whale	24-Aug	3	2	2	Sei_22_11041036, Sei_23	LD, RD of biopsied whale, RD of other	0:28
Sei whale	25-Aug	7	2	1	Sei_24_11041041, Sei_X_11041042	RD of first biopsied whale (Sei_24_11041041), no ID for 2nd whale	0:43
Sei whale	28-Aug	4	3	3	Sei_25_11041045 (calf), Sei_26, Sei_27	LD, LL, RD,RL of Sei_25_11041045 (calf), LD, RD, and RL of Sei_26 (mother), LD, LL, RD of Sei_27	1:08

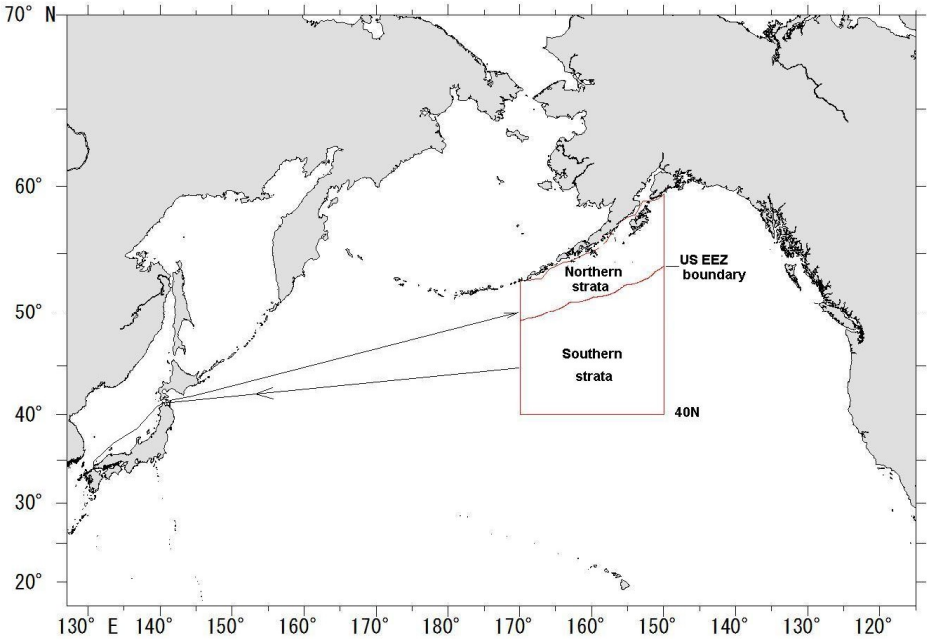

Figure 1a. Research area of the 2011 IWC-POWER cruise. The survey area is divided into northern and southern stratum at US EEZ line. Outer limit of US EEZ is provided by NOAA Office of Coast Survey and the data are available from http://www.nauticalcharts.noaa.gov/csdl/docs/GIS_EEZ_Alaska.zip.

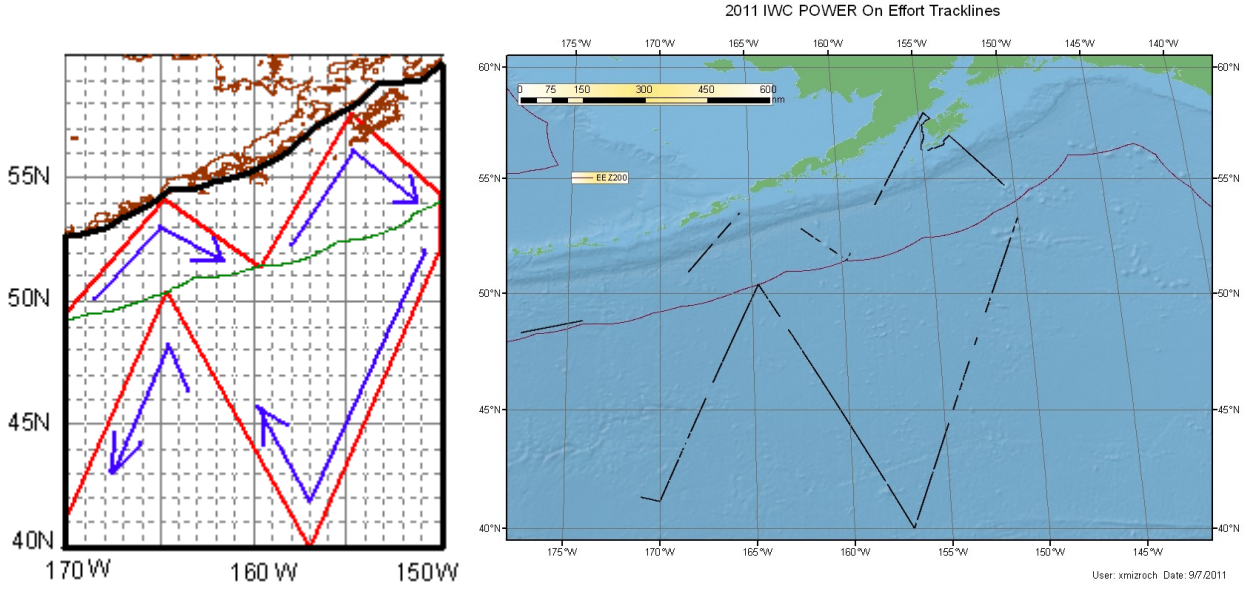

Figure 1b (left). The trackline design for this cruise (red line). The survey area is divided into northern and southern stratum at USEEZ. Green line represents the boundaries for the US EEZs. The starting points of transect lines within the study area were randomized following IWC/SC guidelines (Hammond and Donovan, 2004).

Figure 2 (right). The searching effort of the 2011 IWC-POWER cruise (black line).

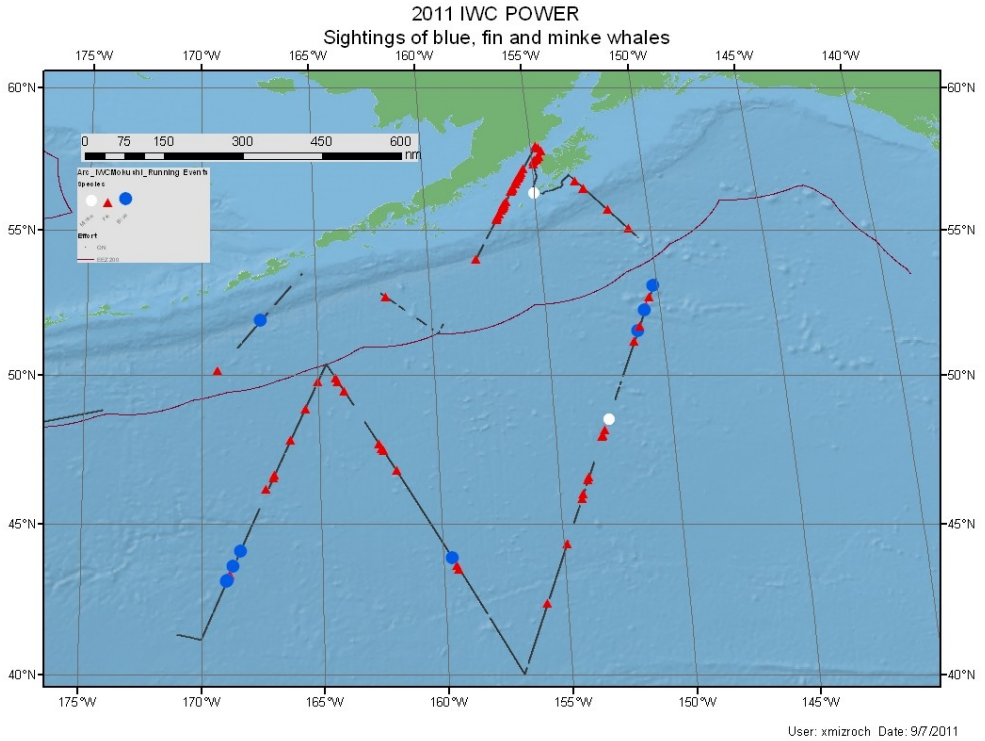

Figure 3a. Positions of blue (blue circle), fin (red diamond) and common minke (white circle) observed in the research area.

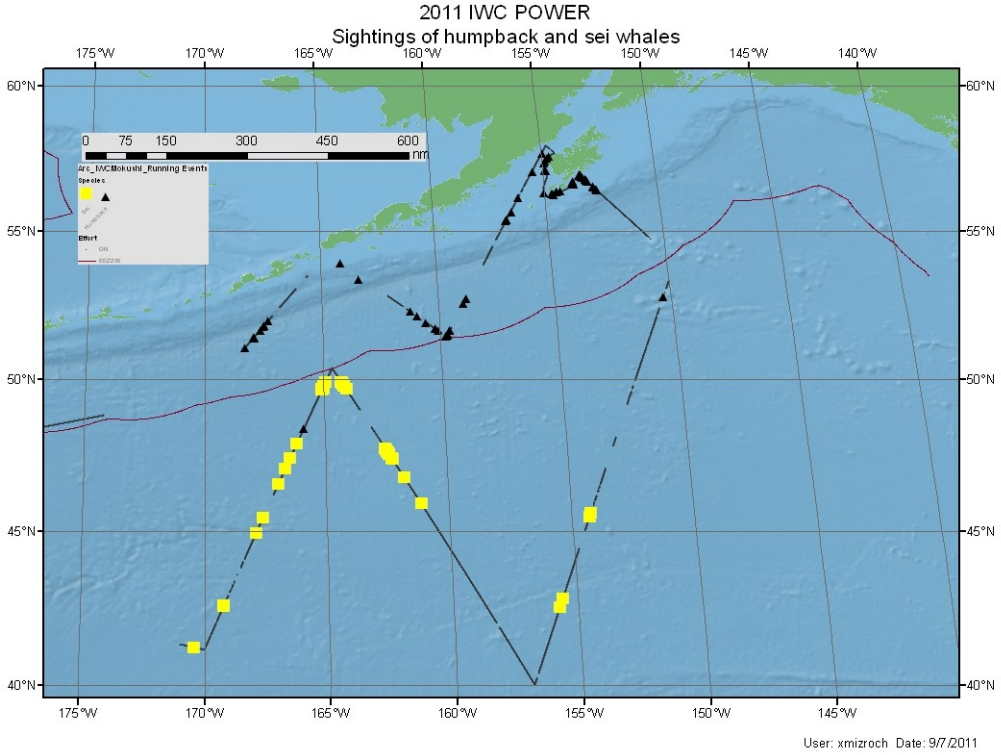

Figure 3b. Positions of sei (yellow square) and humpback (black triangle) whales observed in the research area.

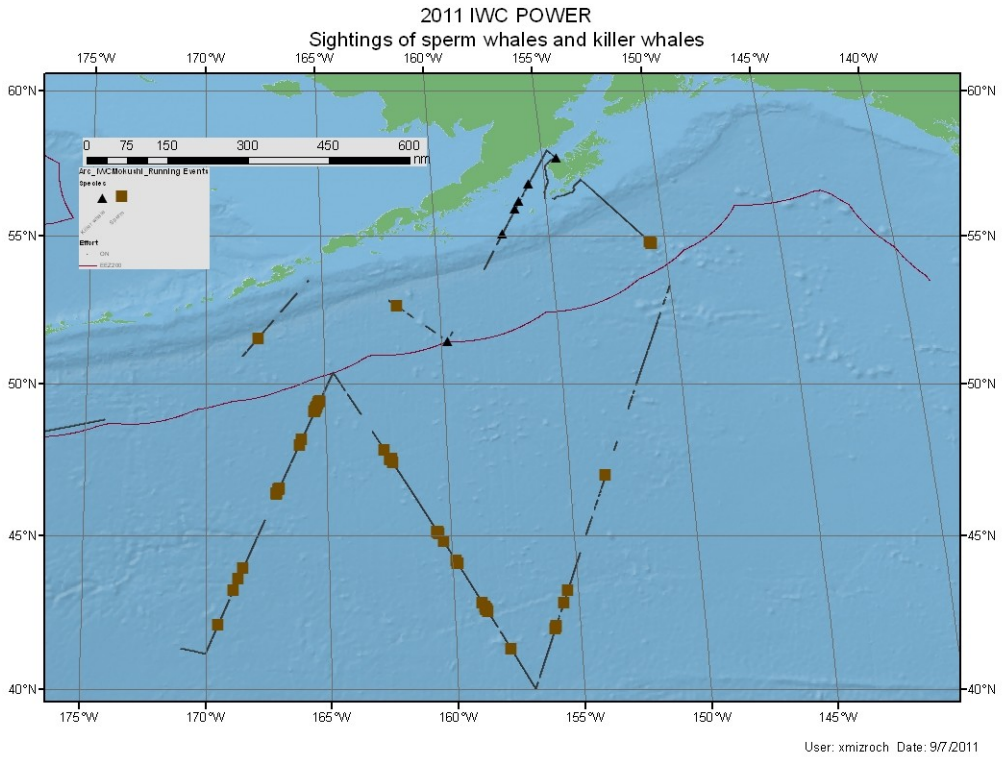

Figure 3c. Positions of sperm (brown square) and killer (black triangle) whales observed in the research area.

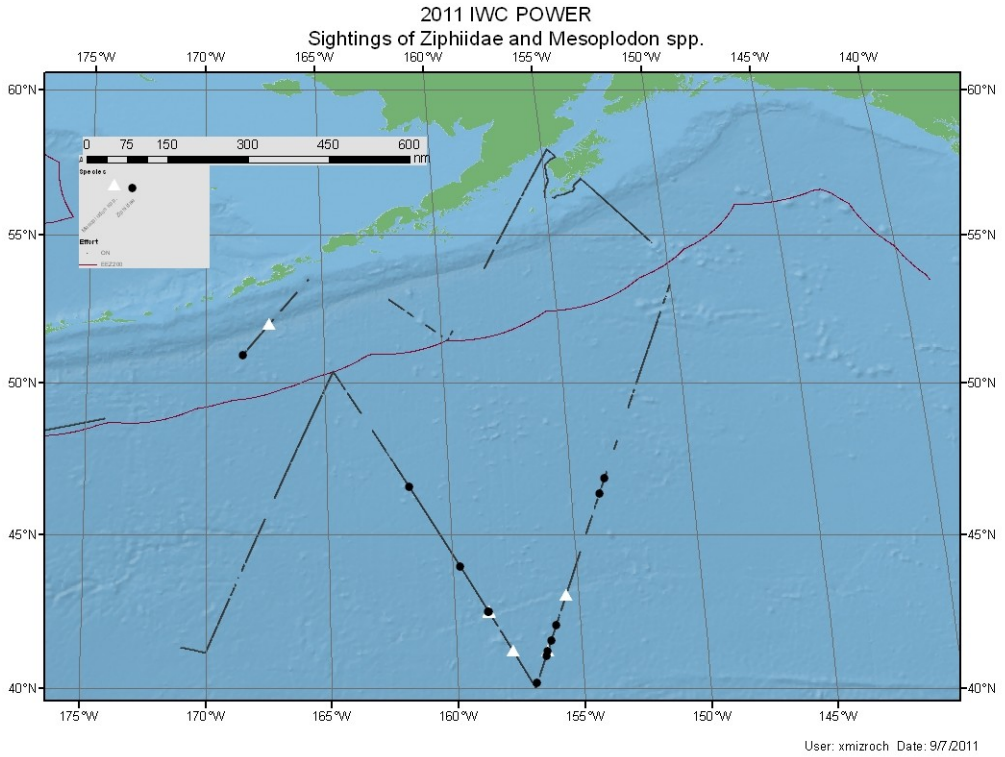

Figure 3d. Positions of Ziphiidae (black circle) and Mesoplodon spp.(white triangle) observed in the research area.

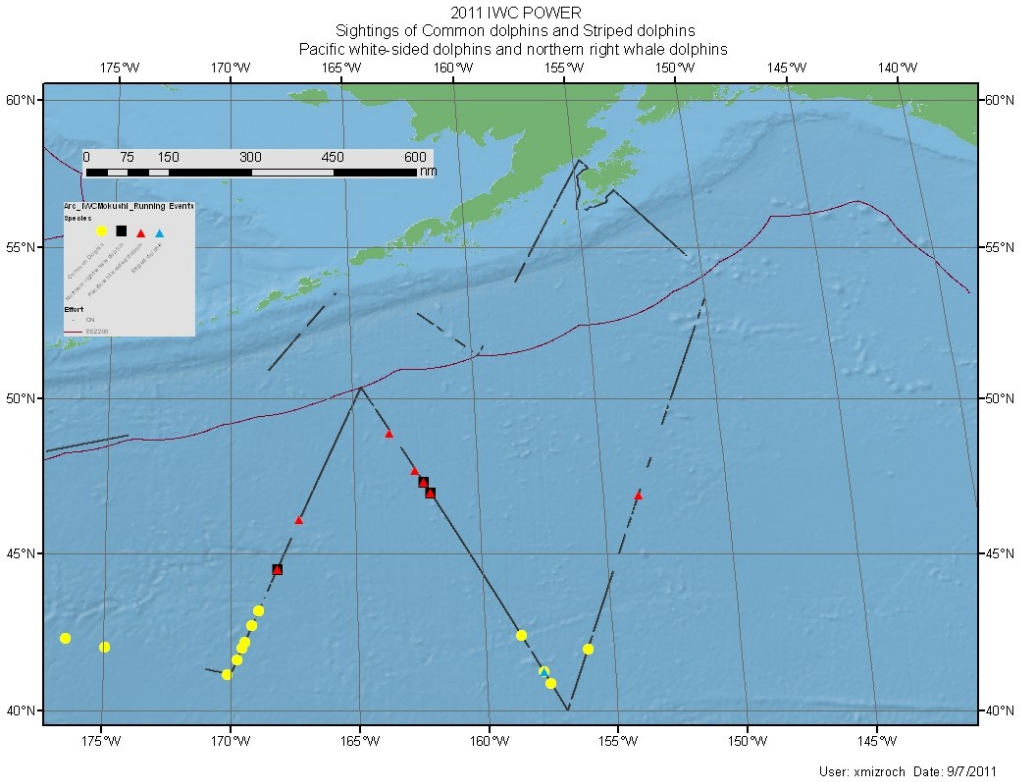

Figure 3e. Positions of common dolphin (yellow circle), striped dolphin (blue triangle), Pacific white-sided dolphin (red triangle) and Northern right whale dolphin (black square) observed in the research area.

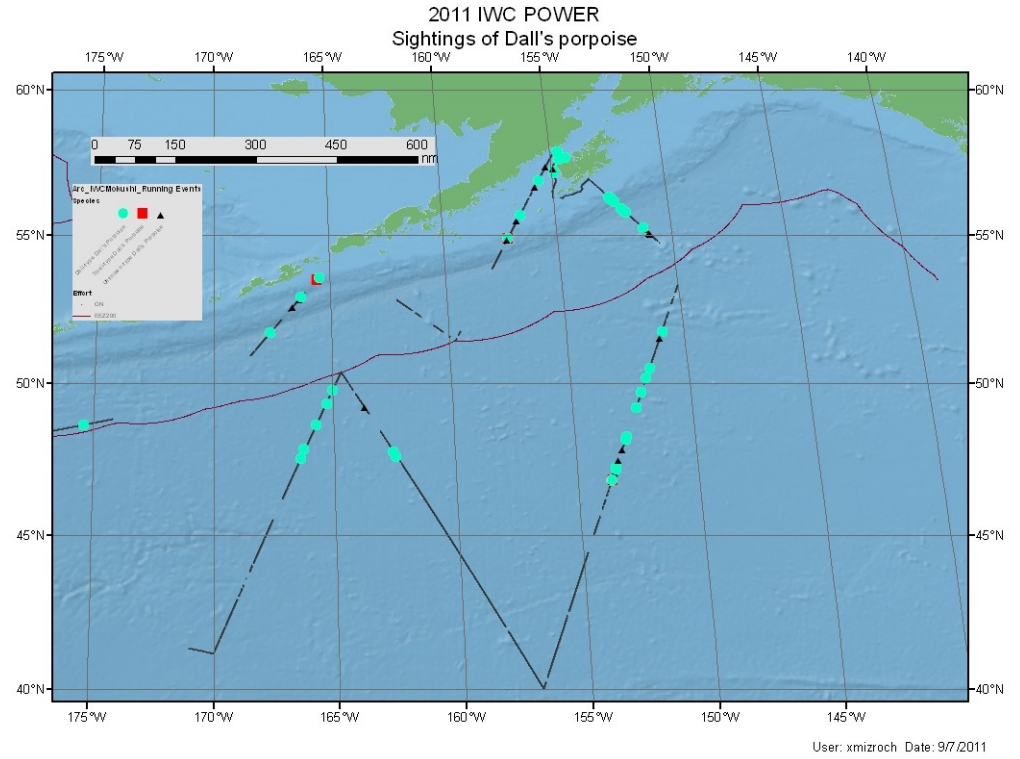

Figure 3f. Positions of Dalli type Dall's porpoise (green circle), Truei type Dall's porpoise (red square) and unidentified type Dall's porpoise (black triangle) observed in the research area.

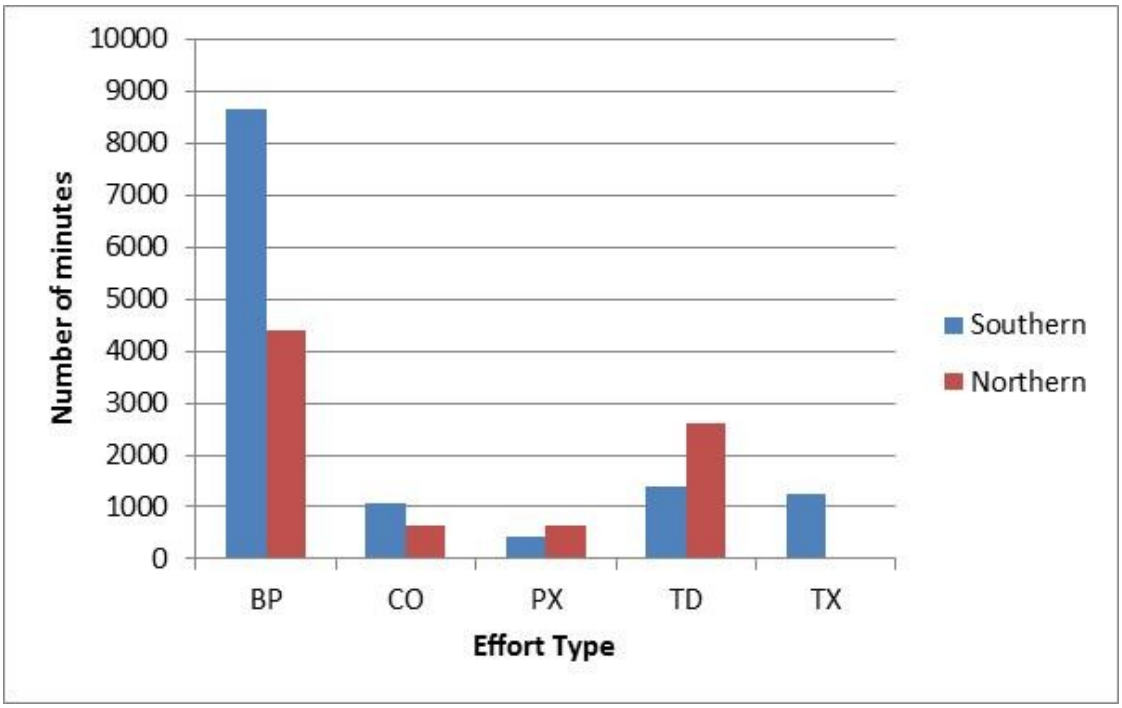

Figure 4. Breakdown of research time, in minutes, by effort mode within the strata of the research area. Right side bar in each mode indicates the northern stratum. BP: Passing mode searching, CO: Confirmation of school, PX: Photo-ID experiment, TD: Top down steaming (off effort), TX: Biopsy experiment.

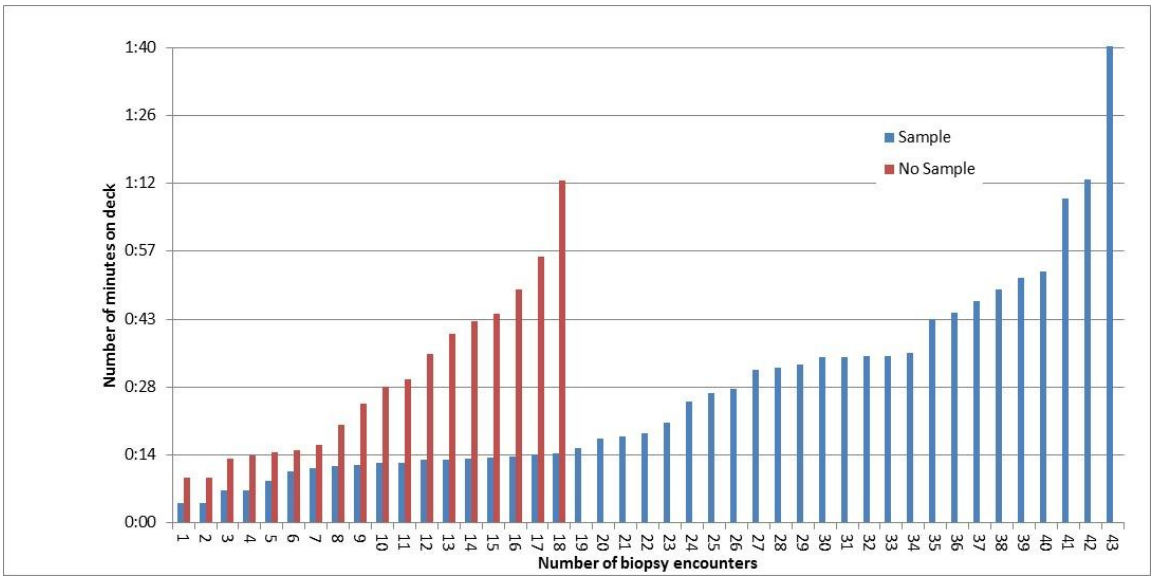

Figure 5. Biopsy encounter duration. Right side bar in each number of biopsy encounters indicates the "no sample".

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	H. Komiya
Chief Officer	T. Ohshima
Second Officer	R. Moriyama
Chief Engineer	A. Oide
First Engineer	T. Miura
Second Engineer	K. Kawamoto
Third Engineer	M.Masuya
Chief Operator	F. Iida
Second Operator	T. Koyanagi
Boatswain	T. Ohmura
Quartermaster	K. Sugiyama
Quartermaster	H. Honma
Quartermaster	Y. Sekine
Sailor	A. Tsuji
Sailor	K. Murakami
Sailor	T. Okita
Chief Steward	H. Hodokuma
Steward	M. Saito