Technical Reports of the Institute of Cetacean Research (2020) pp. 23–34

Technical Report (not peer reviewed)

An outline of the IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER) including results of the 2019 survey

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ABSTRACT

This paper outlines the objectives, research area and general methodology of the International Whaling Commission-Pacific Ocean Whale and Ecosystem Research Program (IWC-POWER). It also provides the main results of the 2019 survey conducted under this research program. The IWC-POWER is designed and implemented by the IWC Scientific Committee (SC) in special partnership with the Government of Japan. The long-term objective of the IWC-POWER is to 'provide information to allow determination of the status of populations (and thus stock structure is inherently important) of large whales that are found in the North Pacific waters and provide the necessary scientific background for appropriate conservation and management actions'. To fulfill this objective, the IWC-POWER originally identified short and medium-term activities and priorities. The IWC-POWER is close to successfully completing its first-phase (2010–2021) related to the short-term priorities, and the IWC SC will start organizing the second phase (from 2022 onward). It has also updated the medium-term priorities for this second phase. The 2019 survey was conducted successfully between 3 July and 25 September 2019 in the Gulf of Alaska, within the U.S. Exclusive Economic Zone by the Japanese R/V *Yushin Maru* No. 2. Blue (17 schools/19 individuals), fin (266/458), sei (9/20), common minke (5/5), humpback (173/402), gray (6/15), sperm (20/20), Baird's beaked (2/37), Cuvier's beaked (3/5) and killer (53/264) whales were observed during the survey. Photo-identification data were collected from 16 blue, 51 fin, 30 humpback, 6 gray and 19 killer whales. A total of 75 biopsy samples were collected from 12 blue, 45 fin, 4 sei, 12 humpback and 2 gray whales. A total of 229 sonobuoys were deployed, for a total of over 820 monitoring hours. The main species detected by the acoustic survey included fin, sperm, killer, blue, humpback, North Pacific right and sei whales. A total of 42 objects of marine debris were also observed.

INTRODUCTION

The International Whaling Commission-Pacific Ocean Whale and Ecosystem Research (IWC-POWER) program is an international research effort in the North Pacific coordinated by the IWC and designed by the IWC Scientific Committee (SC) in special partnership with the Government of Japan. Scientists from the Institute of Cetacean Research (ICR) participate regularly in the IWC-POWER program, both in designing and implementing the surveys. The IWC-POWER in the North Pacific follows the series of IWC International Decade for Cetacean Research/Southern Ocean Whale and Ecosystem Research (IDCR/SOWER) surveys that had been conducted in the Antarctic since 1978.

The long-term objective of the IWC-POWER is to 'provide information to allow determination of the status of populations (and thus stock structure is inherently important) of large whales that are found in the North Pacific waters and provide the necessary scientific background for appropriate conservation and management actions'. The first survey of this program was conducted in 2010 and subsequent surveys have taken place on an annual basis.

The IWC SC is close to completing the first phase of the IWC-POWER, which is related to the short-term priorities, and now is preparing for the second phase related to medium term priorities, based on the results of the first phase.

The objectives of this document are: i) to present an outline of the IWC-POWER program including its objectives, research area, and general methodology; and ii) to present the results of the 2019 IWC-POWER survey based on Matsuoka *et al*. (2020).

OUTLINE OF THE IWC-POWER

Objectives

The IWC-POWER has the following long-term objective:

'Provide information to allow determination of the status of populations (and thus stock structure is inherently important) of large whales that are found in North Pacific waters and provide the necessary scientific background for appropriate conservation and management actions. The programme will primarily contribute information on abundance and trends in abundance of populations of large whales and try to identify the causes of any trends should these occur. The programme will learn from both the successes and weaknesses of past national and international programmes and cruises, including the IDCR/SOWER programme'. (IWC, 2011).

To attain this long-term objective, the IWC-POWER has utilized short and medium-term activities and priorities. The short-term priorities involved the definition and implementation of surveys in areas of the Central and Eastern North Pacific (east of 170°E) (see section on research area below). This region had not been surveyed since the time of commercial whaling in the 1970's (see Annex D of IWC, 2012). After reviewing current knowledge of the region, a list of medium-term priorities by species for the program was agreed to by the IWC SC (see Table 1 of IWC, 2013). This list was updated recently in view of the preparation of the second phase of IWC-POWER (see section 'WHAT NEXT?').

Research area for the short-term priorities

The research area was comprised between north of 20°N and south of the Bering Sea, and between 170°E and 135°W, including the Exclusive Economic Zone (EEZ) of the United States (U.S. EEZ) and Canada (Canadian EEZ).

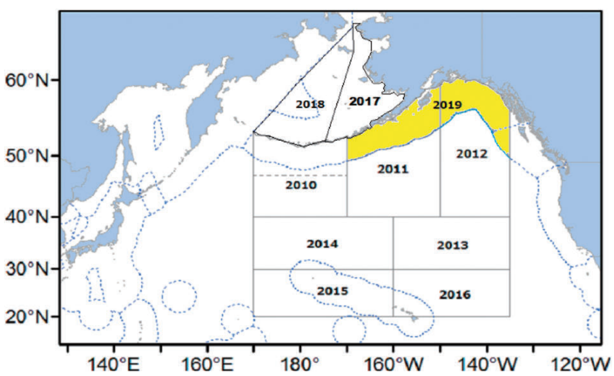

Figure 1. The research areas covered by IWC-POWER in 2010–2019 (EEZs are shown by blue dotted line). The yellow indicates the most recently surveyed area.

Figure 1 shows a map of the survey areas covered since 2010.

Survey season and research vessels

To collect consistent seasonal sighting data, the annual surveys were conducted in the middle of summer, during July to September (e.g., Matsuoka *et al.*, 2011). The following research vessels were engaged in the annual survey:

Kaiko Maru (860.25 GT) in 2010;
Yushin Maru No. 3 (742 GT) from 2011–2016; and
Yushin Maru No. 2 (747 GT) from 2017–2019.

These vessels were prepared with specialized equipment and personnel for visual survey of cetaceans.

Sighting survey procedure

Survey time

Research effort began 60 minutes after sunrise and ended 60 minutes before sunset, with a maximum of 12-hour research day (maximum 06:00–19:00, including 30 minutes for meal time for lunch and supper, when surveying in IO mode; see below).

Number of primary observers

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

Survey modes

Passing with abeam closing mode (NSP): Two topmen were on effort from the TOP barrel at all times. There was open communication between the upper bridge and the barrel. The observers on the upper bridge communicated with the topmen only to clarify sighting information. The upper bridge observers did not distract the topmen from their normal search procedure unless they were directed to do so by the cruise leader (IWC, 2020a).

Independent Observer Mode (IO): This is also in effect Passing Mode. Two topmen were observing from the TOP barrel and two from the IO barrel at all times. Communications were essentially one-way, with topmen from the TOP and IO platforms reporting information to the upper bridge in isolation from each other to ensure that no sighting information was exchanged between the TOP and IO barrel observers. The observers on the upper bridge would communicate with the topmen only to clarify sighting information and would not direct the topmen to disrupt their normal search procedure unless directed to do so by the cruise leader. Immediately after a sighting was detected from the barrel, the topman relayed information to observers on the upper bridge. After the sighting information was relayed to the upper bridge observers, the topman responsible for the sighting continued his normal searching pattern. Observers on the upper bridge located the sighting made by the topman and decided whether it would be possible to confirm species and conduct a school size count before the sighted whale(s) passed abeam of the vessel. The topmen gave no further information to the upper bridge unless the whale school resurfaced within their normal searching area. A designated researcher on the upper bridge recorded the species and estimated number of whales in the school when the sighting passed abeam of the vessel. This was done in consultation with other upper bridge observers/researchers (Anon, 2019a).

Approach to the whale schools

During both NSP or IO modes, and at the abeam time, the vessel altered the course to approach the whale(s), and the speed was increased to 15 knots to hasten the closure. Vessel speed was decreased when the school was close, usually within 0.2 to 0.4 n.miles from the initial sighting position. After the school was approached, the species, number of animals in the school, estimated body length(s), number of calves present, and behaviour were determined and recorded. Following this, other activities would normally be conducted (time allowing and at the discretion of the cruise leader), such as photography for natural marking (Photo-ID) studies and biopsy sampling. All sightings detected during these activities were classified as secondary sightings (Anon, 2019a).

Species identification

Species identification was based on agreed guidelines (IWC, 2020a). Positive identification of species was based on multiple cues and usually required clear observation of the whale′s body. Occasionally, repeated observations of the shape of the blow, surfacing and other behavioural patterns were sufficient to identify whales. This judgement was made only by the cruise leader or other designated researcher. Identification of species was recorded as ′probable′ where multiple cues were insufficient to be absolutely confident of identification (recorded as ′like′). This usually occurred when blows and surfacing patterns could be confirmed, but the whale′s body could not be clearly seen. Details of recording procedures during sightings can be found in Anon (2019a).

School size determination

Schools where the number of animals, or an accurate estimated range of the number of animals was determined, were classified as confirmed schools. Data from the confirmed schools can be used to determine a mean school size. Normally, schools believed to be confirmed for school size were approached to within 1 n.mile for large whales and to within 0.3 n.miles for common minke whales. Allowing for context-specific differences (i.e., environmental conditions and animal behaviour), every effort was made to be consistent with regard to the maximum time spent on identification of species and confirmation of numbers. Normally, if the sighting was thought to be common minke whales, no more than 20 minutes (after closure has been completed) was spent on confirmation. This reduces the potential for confusion with other whale sightings in the vicinity (IWC, 2020a).

Estimated Distance and angle experiments

This experiment has been conducted every year since 2010. The experiment is designed to calibrate and identify any biases in individual observers′ estimation of angle and distance. The experiment should be conducted during weather and sea conditions representative of the conditions encountered during the survey. In 2015, a major improvement was made increasing the number of target buoys to improve accuracy of the observer′s estimates (IWC, 2020b).

Photo-ID data collection

This experiment has been conducted since 2010. As appropriate and decided by the cruise leader, research time is allocated for photo-identification and/or video recording of large whales. The priority species were North Pacific right (highest priority), gray, blue and sei whales. Medium-priority species included fin, Bryde′s, common minke, sperm and killer whales. Generally, large whales were approached within 15–20 m. Adults, juveniles, and females accompanied by calves were approached for photo-identification. Photo-ID experiments involved a minimum of one photographer and a maximum of three on the bow, with additional photographers in the TOP barrel and IO barrel or upper bridge (Anon, 2019a).

Biopsy sampling

This experiment has been conducted since 2010 to analyze stock structure and movement for each species. The priority species for biopsy sampling were the same as for photo-identification (see above). The Larsen sampling system was used to collect samples within approximately 5 to 30 m of the bow of the vessel (Larsen, 1998).

Acoustic monitoring

Passive acoustics monitoring using sonobuoys were introduced to detect North Pacific right whales′ calls in the Bering Sea and a part of the Gulf of Alaska, and was conducted successfully from 2017 to 2019. A sonobuoy is a free-floating, expendable, short-term passive acoustic listening device that transmits signals in real time via VHF radio waves to a receiver on a vessel. Sonobuoys were deployed approximately every 2–2.5 hours, or approximately every 20–25 n.miles, from 06:00 to 18:00 (ship time) to obtain an evenly-sampled cross-survey census of marine mammal vocalizations. Sonobuoys were monitored in real-time by the acoustician, and presence of species-specific call types was noted (Crance *et al.*, 2017).

Marine debris observation

This observation has been conducted since 2010. Data on floating marine debris were observed and recorded. Observation of marine debris was limited to the first 15 minutes of each hour, as time permitted (so as not to interfere with marine mammal observations). In addition, marine debris were photographed if items were particularly large and/or could potentially lead to large whale entanglements. For all recorded marine debris items, observers recorded angle, distance and time of initial sighting, IWC code and a description. Photographs of items were archived and are available to interested scientists.

Data recording and format

Research data collected during the survey (weather, effort, sighting and distance experiment data) were entered by researchers using the ′onboard data collecting system′ developed by ICR (ICR, 2013). An English language version is now available.

RESULTS OF THE 2019 IWC-POWER SURVEY

In this section, the main results of the 2019 IWC POWER survey are summarized, based on Matsuoka *et al.* (2020).

Itinerary

The survey was conducted between 3 July and 25 September, 2019 in the Gulf of Alaska, within the U.S. Exclusive Economic Zone. The itinerary is shown in Table 1.

Table 1
The 2019 survey itinerary.

Date	Event
5-Jul	Pre-cruise meeting at Shiogama, Japan
6-Jul	Vessel departed Shiogama
6-Jul	Started transit survey to Dutch Harbor (D.H.)
11-Jul	Vessel enter U.S. EEZ (14:53, 48°08.3′N, 177°53.3′E)
11-Jul	Passed the dateline at 48-57.0N (23:03)
14-Jul	Vessel arrived at D.H., Alaska, USA
16-Jul	Pre-cruise meeting at D.H.
17-Jul	Vessel left D.H. and started transit survey to the start point of Western stratum
18-Jul	Vessel started surveying the Western stratum
12-Aug	Vessel finished surveying the Western stratum and moved to the starting point of the Eastern stratum
14-Aug	Vessel started the survey of Eastern stratum
8-Sep	Vessel completed the Eastern stratum and started transit survey back to Kodiak (via NPRW Critical Habitat)
12-Sep	Vessel completed transit survey
14-Sep	Vessel arrived Kodiak, Alaska, USA
16-Sep	Post-cruise meeting
16-Sep	Vessel left Kodiak and started the transit survey to Shiogama
26-Sep	Vessel completed the transit survey
28-Sep	Vessel arrived Shiogama, Japan

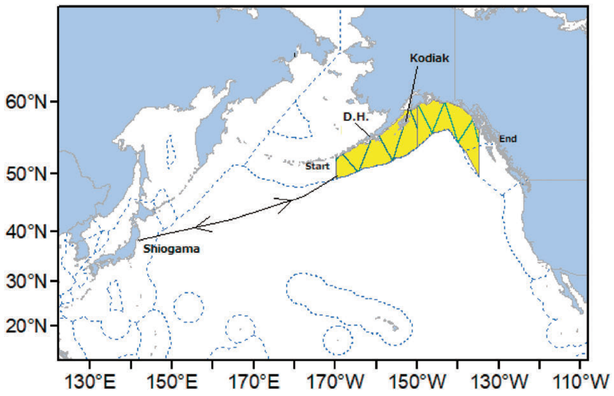

Figure 2. Research area, transit and survey track lines with start and end points for the 2019 IWC-POWER cruise. D.H.: Dutch Harbor.

Figure 3. Photography of the R/V *Yushin Maru* No. 2.

Table 2
Specifications of the R/V *Yushin Maru* No. 2.

Call sign	JPPV
Length overall [m]	69.61
Molded breadth [m]	11.5
Gross tonnage (GT)	747
Barrel height [m]	19.5
IO barrel height [m]	13.5
Upper bridge height [m]	11.5
Bow height [m]	6.5
Engine power [PS/kW]	5303/3900

Research area

The research area was the northern Gulf of Alaska, between 170°W and 135°W, and comprised the U.S. EEZ (Figure 2).

Research vessel and scientific personnel

The R/V *Yushin Maru* No. 2 was used for this survey. The vessel is shown in Figure 3 and its specifications in Table 2.

Four international researchers were nominated by the IWC SC for this survey:

Koji Matsuoka (Japan)–Cruise Leader/Chief Scientist, sighting, photo-ID;

Jessica Crance (USA)–acoustics, photo-ID;

James Gilpatrik (USA)–sighting, photo-ID data management, marine debris;

Isamu Yoshimura (Japan)–sighting data, marine debris and biopsy sample managements.

Searching effort

A total of 1,030.7 n.miles (NSP: 534.0 n.miles, IO: 496.7 n.miles) and 1,088.1 n.miles (NSP: 557.4 n.miles, IO: 530.7 n.miles) were surveyed in the western and eastern strata, respectively. A total of 420.0 n.miles was surveyed during transit surveys (e.g., transit from Dutch Harbor to the most western point and transit between the end and start points around Kodiak Island). The effort (time and distance) spent on sighting and several experiments are shown in Table 3.

Sighting summary

In the research area, blue (17 schools/19 individuals), fin (266/458), sei (9/20), common minke (5/5), humpback (173/402), gray (6/15), sperm (20/20), Baird's beaked (2/37), Cuvier's beaked (3/5) and killer (53/264) whales were sighted. Several dolphin species were also sighted (Table 4).

<u>Gray whale</u> (*Eschrichtius robustus*)

A total of 6 schools (15 individuals) were sighted in the Western stratum, south of Kodiak Island (5 to 10 n.miles off Dangerous Cape, south of Ugak Island, water depth between 60 m and 80 m) (Figure 4a, b). Several gray whales were feeding (mud trails were seen). No mother and calf pairs were seen. Sea temperatures ranged from 12.9°C to 15.7°C.

<u>Blue whale</u> (*Balaenoptera musculus*)

Blue whales were widely distributed in the offshore part of the Western and Eastern strata near EEZ border (Figure 5a, b). A total of 17 schools (19 individuals, including two mother and calf pairs) were sighted (Table 4). All blue whales were sighted in deep water of depths over 1,000 m. Sea surface temperatures of the sighting positions were between 10.9°C and 15.6°C.

<u>Fin whale</u> (*Balaenoptera physalus*)

Fin whales were the most frequently encountered baleen whale species in the research area, and they were widely distributed throughout both the Western and Eastern strata. Several high-density fin whale areas were observed, around Kodiak Island as well as the eastern part of the Eastern stratum (Figure 6). A total of 266

Table 3
Summary of the searching effort (time and distance) and experimental time (hours) by each survey with the area code conducted during 2019 survey. Dutch Harbor (D.H.), High Sea (H.S.), Research Area (R.A.).

Area	Area Code	Leg No. Start/End	Start Date/Time	End Date/Time	NSP Time	NSP Dist. (n.m.)	IO Time	IO Dist. (n.m.)	NSP+IO Time	NSP+IO Dist. (n.m.)	Photo-ID, Biopsy Time	Estimated angle and distance training/experiment Time
Shiogama to D.H.	1 H.S.	1 —	6 Jul. 6:00	11 Jul. 14:53	0:00:00	0	26:35:14	322.32	26:35:14	322.32	0:00:00	0:00:00
Shiogama to D.H.	11 U.S. EEZ	1 —	11 Jul. 14:53	13 Jul. 18:00	0:00:00	0	0:00:00	0	0:00:00	0	0:00:00	0:00:00
D.H. to R.A	78 U.S. EEZ	841 —	18-Jul. 7:20	18-Jul. 12:00	0:00:00	0	0:00:00	0	0:00:00	0	0:00:00	2:43:00
Western stratum	76 U.S. EEZ	101 114	18-Jul. 12:00	26-Jul. 13:13	20:02:43	228.61	19:35:18	224.71	39:38:01	453.32	10:08:11	0:00:00
Detour Shumagin Island	80 U.S. EEZ	844 —	26-Jul. 13:13	27-Jul. 8:13	1:19:22	15.3	0:00:00	0	1:19:22	15.3	0:00:00	0:00:00
Western stratum	76 U.S. EEZ	116 126	27-Jul. 8:13	8-Aug. 8:52	21:16:38	243.97	17:25:52	199.16	38:42:30	443.13	14:14:47	0:00:00
Detour Kodiak Island	80 U.S. EEZ	846 —	8-Aug. 8:52	8-Aug. 10:22	1:01:16	11.64	0:00:00	0	1:01:16	11.64	0:00:00	0:00:00
NPRW Critical Habitat	80 U.S. EEZ	847 —	8-Aug. 10:22	9-Aug. 10:38	9:24:46	106.28	0:00:00	0	9:24:46	106.28	0:36:39	0:00:00
Detour Kodiak Island	80 U.S. EEZ	846 —	9-Aug. 10:38	10 Aug. 8:59	7:02:32	80.2	0:00:00	0	7:02:32	80.2	0:33:50	0:00:00
Western stratum	76 U.S. EEZ	128 134	10 Aug. 8:59	12 Aug. 13:31	5:23:11	61.45	6:22:33	72.78	11:45:44	134.23	2:23:12	0:00:00
W. to E. Stratum	81 U.S. EEZ	849 —	12 Aug. 13:31	14 Aug. 7:42	8:57:11	100.98	0:00:00	0	8:57:11	100.98	1:45:04	0:00:00
Eastern stratum	77 U.S. EEZ	201 224	14 Aug. 7:42	8-Sep. 10:01	49:00:30	557.35	46:33:50	530.73	95:34:20	1,088.08	25:33:44	7:06:35
R.A to Kodiak	79 U.S. EEZ	854 —	8-Sep. 10:01	10-Sep. 13:22	0:00:00	0	0:00:00	0	0:00:00	0	0:00:00	0:00:00
NPRW Critical Habitat	79 U.S. EEZ	855 —	10-Sep. 13:22	12-Sep. 18:00	9:21:39	105.56	0:00:00	0	9:21:39	105.56	0:00:00	0:00:00
R.A to Kodiak	79 U.S. EEZ	854 —	12-Sep. 18:00	13-Sep. 18:00	0:00:00	0	0:00:00	0	0:00:00	0	0:00:00	0:00:00
Kodiak to Shiogama	12 U.S. EEZ	2 —	18-Sep. 7:55	22-Sep. 16:25	0:00:00	0	0:00:00	0	0:00:00	0	0:00:00	0:00:00
Kodiak to Shiogama	2 H.S.	2 —	23-Sep. 6:00	26-Sep. 12:00	0:00:00	0	9:23:32	115.03	9:23:32	115.03	0:00:00	0:00:00
Total			6-Jul. 6:00	26-Sep. 12:00	132:49:48	1,511.30	125:56:19	1,464.70	258:46:07	2,976.10	55:15:27	9:49:35

Table 4
Number of sightings for all species observed in the research area (Original trackline and transit tracklines) by effort mode. NSP: Normal Passing with abeam closing Mode; IO: Independent Observer Mode (IO), OE: Top down (TD) and drifting (DR). Numbers of Individuals includes the number of calves.

Species	NSP			IO			OE			Total		
	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf
Blue whale	5	6	1	9	10	1	3	3	0	17	19	2
Fin whale	145	260	0	112	186	0	9	12	0	266	458	0
Like fin	6	11	0	13	17	0	1	2	0	20	30	0
Sei whale	3	4	0	6	16	0	0	0	0	9	20	0
Like sei	0	0	0	1	2	0	0	0	0	1	2	0
Common minke whale	3	3	0	2	2	0	0	0	0	5	5	0
Humpback whale	116	234	0	49	132	0	8	36	0	173	402	0
Like humpback	1	1	0	6	14	0	0	0	0	7	15	0
Gray whale	6	15	0	0	0	0	0	0	0	6	15	0
Sperm whale	8	8	0	12	12	0	0	0	0	20	20	0
Baird′s beaked whale	2	37	2	0	0	0	0	0	0	2	37	2
Cuvier′s beaked whale	1	1	0	2	4	0	0	0	0	3	5	0
Ziphiidae	2	4	0	3	3	0	0	0	0	5	7	0
Killer whale	36	156	9	17	108	5	0	0	0	53	264	14
Pacific white-sided dolphin	0	0	0	0	0	0	1	4	0	1	4	0
Habour porpoise	1	1	0	0	0	0	0	0	0	1	1	0
Dalli type Dall′s porpoise	50	277	1	34	196	5	2	32	4	86	505	10
Unid. type Dall′s porpoise	3	13	0	1	4	0	0	0	0	4	17	0
Unid. small cetacean	1	3	0	0	0	0	0	0	0	1	3	0

schools (458 individuals) of fin whales were observed in the research area. No mother and calf pairs were observed. A total of 20 schools and 30 individuals of "Like fin" were recorded; these looked like fin whale blows but could not be confirmed (Table 4). Most fin whales were sighted in deep water of depths over 1,000 m (Figure 6). Sea temperatures ranged from 9.9°C to 16.7°C.

Sei whale (*Balaenoptera borealis*)

A total of 9 schools (20 individuals) of sei whales were observed (Table 4). Observed mean school size was 2.22. Although sei whales were the third most frequently encountered baleen whale species through the surveys, almost all sei whale sightings were in the southern part of the Western stratum. There was a notable lack of sei whales in the Eastern stratum (Figure 7). This is similar to results seen during a previous POWER survey in 2012, where no sei whales were sighted in the U.S. EEZ (Eastern Stratum of current survey). Sea surface temperatures ranged from 11.2°C to 13.0°C, which was lower than the range for fin whales.

Common minke whale (*Balaenoptera acutorostrata*)

Common minke whales were the rarest baleen whale species in the research area, and were only sighted very close to shore (Figure 8). A total of 5 schools (5 individuals, all solitary schools) were observed (Table 4). Sea temperature at sighting locations ranged from 10.8°C to 16.9°C. Because of the difficulty in seeing their blow and small body, observations of this species were more difficult than in Antarctic waters. Common minke whale blows are very small and are difficult to spot in rough sea surface conditions (e.g., wind speed over 12 knots). During this survey, sea states averaged 4–5 on the Beaufort scale, which is assumed to be too rough for sighting common minke whales.

Humpback whale (*Megaptera novaeangliae*)

Humpback whales were the second most frequently encountered baleen whale species in the research area, primarily in the Western stratum. High-density areas of this species were observed in waters north-east and south-east of Kodiak Island, and along the most eastern trackline along the continental shelf (near 135°W). There was a lack of sightings between 150°W and 138°W in the Eastern stratum (Figure 9). A total of 173 schools (402 individuals) were observed in the research area. There were no mother and calf pairs. In some cases, red colored fecal matter was observed indicating that the whales were feeding on krill. Sea temperatures ranged from 10.0°C to 15.7°C.

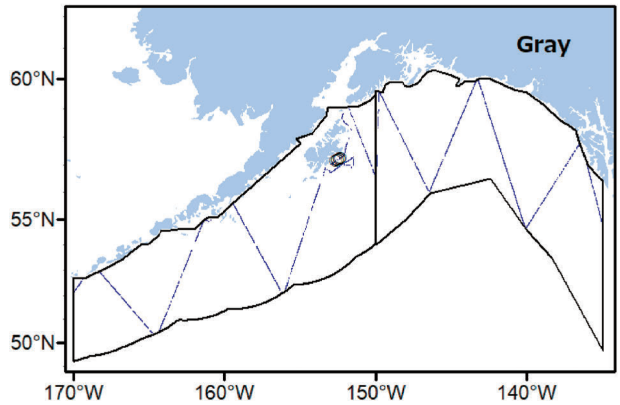

Figure 4a. The searching effort (thin line) and sighting positions (white circles) of gray whales during the 2019 IWC-POWER cruise.

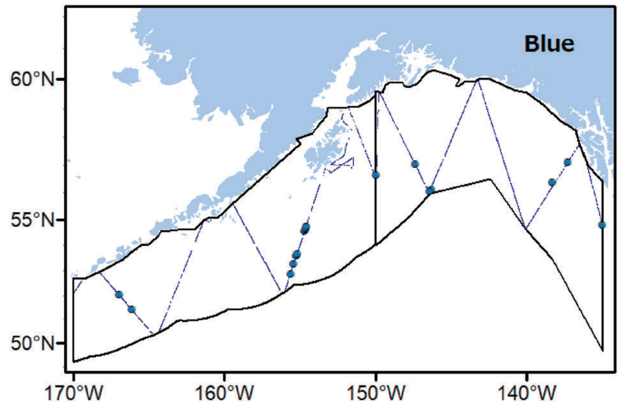

Figure 5a. The searching effort (thin line) and sighting positions (blue circles) of blue whales during the 2019 IWC-POWER cruise.

Figure 4b. Three gray whales observed during the 2019 IWC-POWER survey.

Figure 5b. Two blue whales observed during the 2019 IWC POWER survey.

<u>Sperm whale</u> (*Physeter macrocephalus*)

Sperm whales were widely distributed throughout the Western and Eastern strata where the water depth was over 1,000 m (Figure 10). A total of 20 schools (20 individuals) were sighted (Table 4). All schools observed were solitary individuals (probably large male). Sperm whales were recorded in waters with SST ranging from 10.9°C to 16.7°C.

<u>Baird's beaked whale</u> (*Berardius bairdii*)

A total of 2 schools (37 individuals) were sighted (Table 4). Both Baird's beaked whale schools were sighted along the most eastern trackline in the Eastern stratum along the continental slope off Prince of Wales Island (water depths over 1,000 m). Sea temperatures ranged from 13.9°C to 14.4°C.

<u>Killer whale</u> (*Orcinus Orca*)

Killer whales were mainly sighted in the Western stratum (Figure 11). A total of 50 schools (248 individuals, including 13 calves) were sighted (Table 4). They were sighted in waters with SST ranging from 10.9°C to 16.2°C.

Identification of duplicated sightings

A total of 154 resightings (duplicates) was made during IO Mode. Of these, for fin whales, there were 60 'Definite duplicates,' 1 'probable duplicate' and 13 'Not duplicates.' For sei whales, there were 12 'Definite duplicates' and 4 'Not duplicates.' For humpback whales, there were 34 'Definite duplicates' and 8 'Not duplicates.'

Photo-ID photographs

Photo-identified species included: blue (15 schools/16 individuals), fin (64/51), humpback (25/30), gray (2/6) and killer (8/19) whales (Table 5). Baird's beaked whales (20 individuals) and Dall's (24) porpoises were also photographed. Images collected during the cruise were uploaded to the IWC/ICR master photographic database in Adobe Lightroom (LR) (Anon, 2019b). Preliminary coding was completed for all cetacean images (7,762), including the allocation of species name, sighting number, school size and biopsy effort.

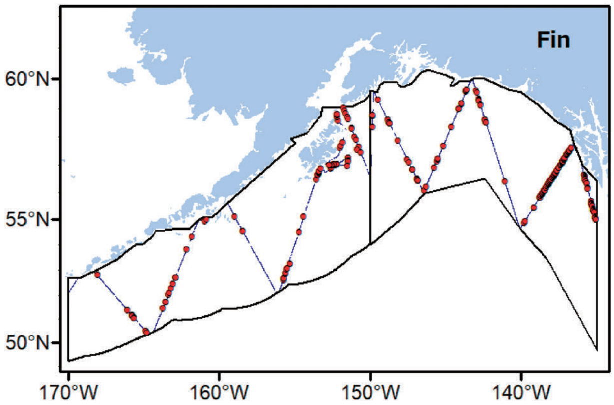

Figure 6. The searching effort (thin line) and sighting positions (red circles) of fin whales during the 2019 IWC-POWER cruise.

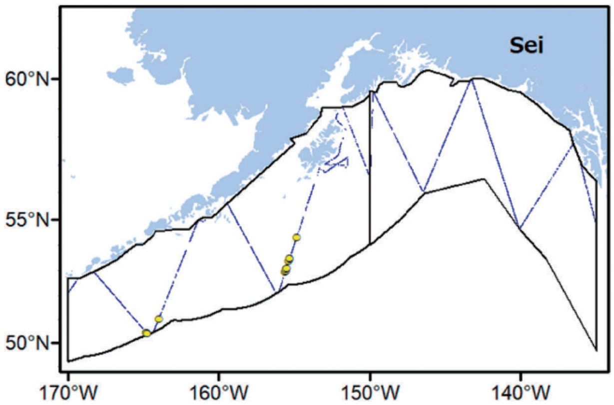

Figure 7. The searching effort (thin line) and sighting positions (yellow circles) of sei whales during the 2019 IWC-POWER cruise.

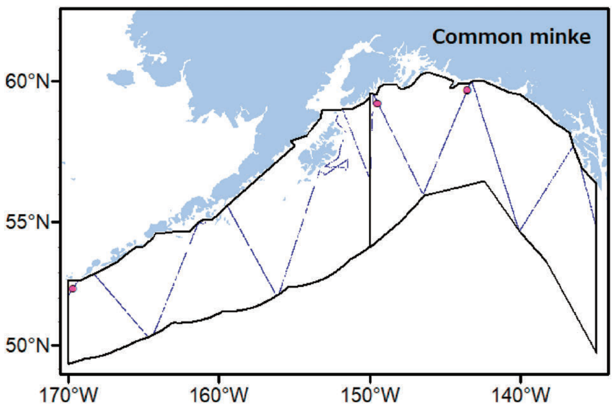

Figure 8. The searching effort (thin line) and sighting positions (pink circles) of common minke whales during the 2019 IWC-POWER cruise.

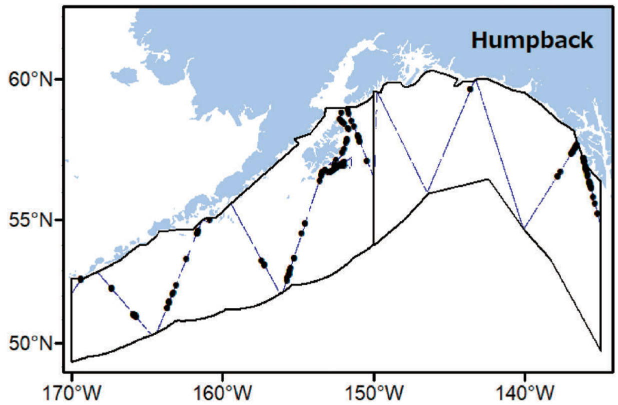

Figure 9. The searching effort (thin line) and sighting positions (black circles) of humpback whales during the 2019 IWC-POWER cruise.

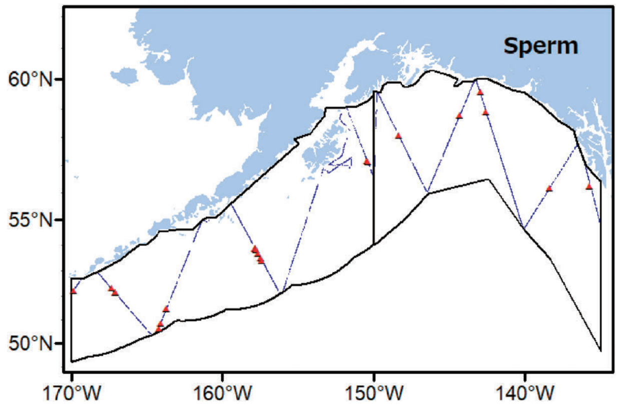

Figure 10. The searching effort (thin line) and sighting positions (red triangles) of sperm whales during the 2019 IWC-POWER cruise.

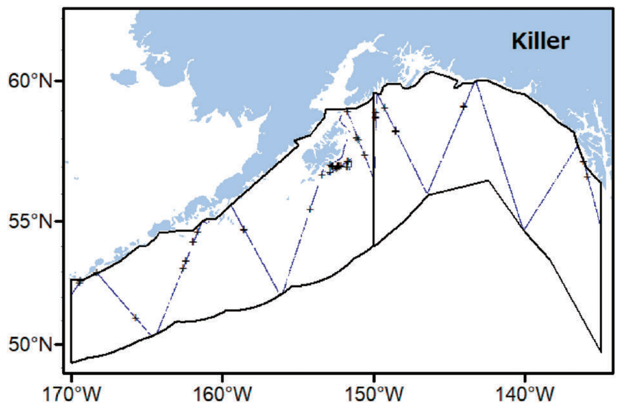

Figure 11. The searching effort (thin line) and sighting positions (black cross) of killer whales during the 2019 IWC-POWER cruise.

Biopsy sampling

Biopsy samples were collected from 75 individual whales: 12 blue, 45 fin, 4 sei, 12 humpback, 2 gray whales (Table 6). Every biopsy encounter was documented photographically. All biopsy samples were catalogued and stored in cryo-vials frozen at a temperature of −30°C on the vessel. These samples will be used for molecular genetics analyses. Figure 12 shows an event of biopsy sampling.

Table 5
Summary of the number of Photo-ID'd individuals by each species.

	Blue	Fin	Humpback	Gray	Killer	Total
Western Stratum	9	16	20	6	5	56
Eastern Stratum	7	35	10	0	14	66
Sub-total (US-EEZ)	**16**	**51**	**30**	**6**	**19**	**122**
Sub-total (High Sea)	**0**	**0**	**0**	**0**	**0**	**0**
Total	**16**	**51**	**30**	**6**	**19**	**122**

Table 6
Summary of the number of biopsy samples collected by each species.

	Blue*	Fin	Sei	Humpback	Gray	Total
Western Stratum	6	12	4	10	2	34
Eastern Stratum	6	33	0	2	0	41
Sub-total (U.S. EEZ)	**12**	**45**	**4**	**12**	**2**	**75**
Sub-total (High Sea)	**0**	**0**	**0**	**0**	**0**	**0**
Total	**12**	**45**	**4**	**12**	**2**	**75**

Blue* Including one mother and calf pair.

Figure 12. Biopsy sampling for sei whale during the IWC-POWER survey.

Acoustic monitoring

A total of 229 sonobuoys were deployed for a total of over 820 monitoring hours. Species detected included fin (119 buoys, 56.1% detection), sperm (112, 52.8%), killer (76, 35.8%), blue (54, 25.5%), humpback (47, 22.2%), North Pacific right (10, 4.7%), and sei (4, 1.9%) whales. Other species/events detected included Baird's beaked whales (3, 1.4%), Pacific white-sided dolphins (3, 1.4%), earthquakes (33, 15.6%), and unknown calls/signals (12, 5.7%).

Marine debris observation

A total of 42 marine debris objects were observed including 9 single fishing floats. A total of 41 items were recorded 'on effort' (i.e., during the first 15 minutes of each hour) and 1 item was recorded during 'off effort.'

WHAT NEXT?

The following tasks are identified for the immediate future of IWC-POWER.

Completion of the short-term priorities

To complete the short-term priorities, the IWC SC reiterated the importance of completing the Bering Sea survey areas. However, given the difficulties previously experienced, it was important to consider a backup plan for the 2020 cruise. If the Russian area cannot be covered in 2020, then every effort should be made to cover this in 2021, given its importance to meeting the objectives of the IWC-POWER program (IWC, 2020c). Also, several analytical tasks based on data collected in the first phase under the short-term priorities were recommended.

Design of the next phase

The IWC SC agreed on revised priorities for the medium-term (Table 7). To develop a detailed plan for the second phase of IWC-POWER, it is important to complete the analyses of the data collected during the first phase (short-term).

The IWC SC will hold a pre-meeting just before the 2021 Scientific Committee Meeting in order to develop a detailed proposal for a workshop to design the next

Table 7

Suggestions for updated medium-term priorities based upon results from Phase 1 for IWC-POWER (*refers to likelihood of obtaining an abundance estimate at least in some areas **refers to likelihood of obtaining biopsy and/or photo-ID data from encountered schools) (IWC, 2020c).

Initial priority/feasibility	Rationale/comments
Blue whale (High) Medium direct*, high opportunistic**	•Depletion level (i.e. highly depleted based on catch history) •Initial abundance estimates from IWC-POWER (still being finalised) suggest it remains heavily depleted. •Results of analyses of existing samples (27 IWC-POWER samples available) in conjunction with other samples (e.g. samples collected under Japanese national programmes) important in addressing population structure in context of idea/scope of occasional focussed cruises, especially samples from the west (see (4) below). •Potential for some blue whale focussed cruises in specific areas (including directional acoustics) should be considered (e.g. Gulf of Alaska) as well as continuing opportunistic studies. •Continued collaboration with existing photo-id work e.g. US and Japanese national programmes is important (42 individuals available from IWC-POWER)–and Japan west existing samples. •Consider telemetry studies
Fin whale (High) High direct*, high opportunistic**	•Depletion level (i.e. high based upon catch history) •Initial abundance estimates from IWC-POWER (still being finalised) suggest some recovery •Results of genetic analyses important to contribute to future survey strategy and future Comprehensive Assessment (e.g. is there evidence of more than one stock from the existing 124 biopsy samples that cover waters from 170°E to 135°W?). •Work in Russian Federation waters provided appropriate permits can be obtained is important •Co-ordination with national programmes in Japan, Korea and USA needed including existing samples
Right whale (High) Medium direct*, high opportunistic**	•Depletion level: (i.e. highly depleted based on catch history) •Still critically low numbers in east (from US studies and IWC-POWER) •Feasibility of collecting biopsy and photo-ID data high if targeted and using acoustics •Feasibility of obtaining abundance in east from line-transect low given such small numbers; may be much higher in west e.g. Sea of Okhotsk and southeast of Kamchatka Peninsula where population is at least 10X larger or more •Although new area, consideration should be given to a targeted survey in Sea of Okhotsk-high feasibility and priority to obtain good abundance, photo-id and biopsy data provided appropriate permits can be obtained from the Russian Federation.
Sei whale (Medium) High direct*, high opportunistic**	•Depletion level: (i.e. high based on catch history) •Initial abundance estimates from IWC-POWER (still being finalised) and Japan suggest some recovery •IWC-POWER has provided valuable information for the ongoing Comprehensive Assessment (the 2020 backup cruise will provide biopsy samples from a poorly covered area) •Results of that CA will help focus future IWC-POWER medium-term strategy and priority for this species-e.g. (a) possible focussed biopsy sampling in postulated coastal stock areas and (b) frequency and scope dedicated abundance surveys in 'pelagic' area to examine trends
Humpback whale (Medium) High direct*, high opportunistic**	•Good information already available from SPLASH and national programmes suggests overall high abundance (genetic and photo-ID mark-recapture) hence medium priority •Continue to contribute to existing genetic and photo-ID databases. •Ongoing Comprehensive Assessment will assess status and potential depletion of [sub-] populations. •Abundance estimates from IWC-POWER (still being finalised) can provide interesting 'snapshot' estimates to compare with mark-recapture estimates by population/feeding aggregation •The results of the CA will assist in developing medium-term strategy and priority for this species within IWC-POWER
Sperm whale (Medium) Medium direct* and medium opportunistic**	•Depletion level: (unknown but possibly high given catch history) •Lack of good information on population structure and status at present although good distributional data from IWC-POWER •Obtaining abundance estimates from visual surveys can be problematic due to long dive times and other issues •Combined acoustic (towed array)/visual surveys have been successful for sperm whales however feasibility in the context of IWC-POWER depends on availability of equipment and practicality in light of other priorities •Possibility of using towed acoustic arrays in some years should be considered
Gray whale (Medium) Low direct*, high opportunistic**	•There are ASW hunts but that primary data sources to evaluate those are from other visual, genetic and photo-ID programmes (e.g. US, Mexico, Sakhalin Island)–hence medium priority •Main IWC-POWER contribution is in obtaining biopsy/photo-ID in areas outside those programmes for comparison and information on population structure •Sharing of data with other programmes should continue
Bryde's whale (Medium) High direct*, high opportunistic**	•Suggest low priority for first six or so years of next phase of POWER because: •Recently completed IR shows good population status and apparently low level of threats •Removing from target species allows a great reduction in size of priority research area to north of 40°N •If required, a targeted survey or surveys could be designed towards end of 10-year period (e.g. from 2027)
Common minke whale (Low) Suggest only opportunistic	•Depletion level (probably low east/central based upon catch history) and in west dealt with by national programmes •However, if Okhotsk Sea is able to be covered for high priority species (e.g. right whales) then would provide valuable information incl. biopsy samples •If permission granted by Russian Federation then consider modifying present 'acceptable' conditions as at the present high range they are unsuitable for estimating abundance for this species

phase of the IWC-POWER program. The emphasis will be on participation from all range states and the availability of analyses/data. The workshop should include consideration of more methodologically focused cruises in designated years (e.g., use of towed acoustic arrays, telemetry work, use of SeaGlider, etc.).

The ICR scientists will participate actively in the discussions regarding the second phase of IWC-POWER. This research program has contributed and will continue to contribute important information relevant for the conservation and management of large whales in the North Pacific.

ACKNOWLEDGEMENTS

I thank all international researchers for their hard work during the IWC-POWER cruises. Thanks also to the crews of the respective vessels that participated in the annual surveys for their effort and assistance. I also thank scientists of the IWC-POWER Steering Group for planning and designing the cruises and for their technical support. My gratitude to the IWC and the Governments of Japan and the USA for financial support. Acknowledgement to Luis A. Pastene (ICR) for his assistance in the preparation of this document.

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