Methodology and survey procedure under the JARPN II - offshore component- with special emphasis on whale sampling procedures

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Abstract

The Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN II) was conducted every year from 2000 to 2007 season. After two years of feasibility research（2000 and 2001）, the full-scale research started in 2002. The research area was divided into nine strata taking into account of the distributions of different prey species, and density and distribution of whales targeted and oceanographic conditions. The research period ranged from the May to September. The research was conducted alternately in the early season (May-August) and the late season (June-September). The research has three components. 1）whale sampling survey, 2) co-operative whale sampling survey and acoustic / trawl prey survey and 3) whale sighting survey. In the whale sampling survey, three sighting/sampling vessels (SSVs) conducted sighting and whale sampling survey on the predetermined track line with parallel sub track lines. The zigzag-shaped track line was set based on sub areas and research period, reflecting previous sighting information of targeted whales and sea conditions. Furthermore, Special Monitoring Surveys (SMS) were conducted in areas where the numbers of targeted whales were expected to be large. Track line in the SMS was designed independently from the original track line. The common minke, Bryde's, sei and sperm whales were sampled. Individuals to be sampled in a school were chosen by a researcher on board using a series of tables of random sampling numbers (TRS), which were prepared according the size of the schools. In the 2000 and 2001 feasibility surveys, a maximum of 100 common whales, 50 Bryde's whales and 10 sperm whales were taken from sub-areas 7, 8 and 9. 50 sei whales were added beginning with the 2002 season which was increased to a maximum of 100 beginning with the 2004 season. Biological sampling was conducted on the research base vessel for all the whales sampled. For the co-operative whale sampling survey and acoustic / trawl prey survey, some special blocks were set except for the 2006 season. The whale sighting survey by one sighting vessel (SV) was conducted beginning from the 2002 season. The JARPN II is therefore a comprehensive research program involving the collection of several kinds of data and samples, which has been useful for the management of whale resources through the IWC's RMP a single-species management procedure for commercial whaling, as well for the development of multi-species, ecosystem-based management procedures for commercial fisheries.

1. Background

The survey of the second phase of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN II) was conducted every year from 2000 to 2007 season. In compliance with Article VIII of the International Convention for the Regulation of Whaling, JARPN II was authorized by the Government of Japan and planned and conducted by the Institute of Cetacean Research (ICR). After two seasons of feasibility research in 2000 and 2001, the full-scale research started in 2002 season. The full-scale study was aimed at i) feeding ecology and ecosystem, ii) monitoring of environmental pollutants in cetaceans and the marine ecosystem and iii) to elucidate the stock structure (Government of Japan, 2002).

In order to achieve these objectives, it was necessary to obtain a wide variety of data representing ecosystem in the research area. Therefore, JARPN II was characterized by combination of sighting and sampling of whale survey. This paper reviews the survey procedure of JARPN II with special reference to methodology of sampling of whales.

2. General methodology

JARPN II has been conducted under the consistent research methods during survey period. Table 1 shows an outline of all JARPN II cruises from 2000 to 2007 season.

2.1 Research area and season

Main research area of JARPN II was the western North Pacific. Sub-areas 7, 8 and 9, excluding the EEZ zones of foreign countries, were surveyed (Fig. 1). These sub areas were further divided as follows:

Sub-area 7: Five small blocks (7N, 7MI, 7MO, 7SI, 7SO stratified for taking into account satellite information on water temperature.

Sub-areas 8, 9: Four small blocks (8N, 8S, 9N and 9S) were divided at 40ºN.

The research area is the Western Subarctic Gyre region in the North Pacific (Favorite *et al*., 1976). The Western Subarctic Gyre region is known as an area of high production capacity. The Oyashio, which is the Western Boundary Current of the gyre, flows into the sea east of Honshu and sustains the high productivity there.

Except for the feasibility researches, the entire research area has been tried to be covered every year. The research season extended from spring to autumn season. Although the whole research period ranged from the May to September, the regular research was concentrated from June to August. The researches conducted alternately in early season (May-August) and late season (June-September) due to logistical reason.

2.2 Research vessels

Following vessels were used for JARPN II (Table 1).

1) Research base vessel (RB)
Nisshin-maru (NM ; Gross tonnage was increased from 7,575 to 8,030)・・・2000 – 2007 season

2) Sighting and Sampling vessels (SSVs)
Toshi-maru No.25 (T25; 739.92GT) ・・・2000 – 2002 season

Kyo-maru No.1 (K01; 812.08GT) ・・・2000 – 2007 season

Yushin-maru (YS1; 720GT) ・・・2000 – 2007 season

Yushin-maru No.2 (YS2; 747GT)・・・2003 – 2007 season

3) Scientific echo sounder survey vessel (ESV)
Kyoshin-maru No.2 (KS2; from 368 to 372GT) ・・・2000 – 2007 season

Ø This vessel also conducted as a dedicated sighting survey vessel (SV).

4) Dedicated sighting survey vessel (SV)
Syounan maru (SM1; 712GT) ・・・2003 season

Kyoshin-maru No.2 (KS2; from 368 to 372GT) ・・・2000 – 2007 season

5) Trawl survey vessel (TSV)
Syunyou maru (SYO; 396GT) ・・・2000 season

Torishima (TOR; 426GT) ・・・2001 season

New Syunyou maru (SYO; 887GT) ・・・2002 – 2005 season

Kaikou maru (KK1; 860.25GT)・・・2007 season

Ø *New Syunyou maru* and *Kaikou maru* also conducted as scientific echo sounder survey vessels.

2.3 Research component

JARPN II has three components. 1） whale sampling survey, 2) co-operative survey of whale sampling survey and acoustic / trawl prey survey and 3) whale sighting survey.

2.3.1 Whale sampling survey

1) Objective

The whale sampling surveys have been conducted under the consistent research methods during survey period. The objective was sampling of whales for collecting data and samples for objectives of JARPN II. Biological survey conducted all the whales sampled on the research base vessel.

2) Research vessels

Three sighting/sampling vessels and one research base vessel. (NM)

3) Design of track line

In the whale survey, the track line and the allocation of vessels was set in similar manner as in previous JARPN survey (Fujise *et al*., 1995, 1996, 1997; Ishikawa *et al*., 1997; Zenitani *et al*., 1999). The order of sub area / strata was chosen based on seasonal distribution of whales and logistics, and zigzag-shaped track lines were set in each sub area and research period, reflecting the available information such as sea conditions. The research course consisted of one main track line and two parallel track lines established in six or seven n.miles apart from main course. Furthermore, in order to secure enough number of samples, Special Monitoring Survey (SMS) was conducted in areas where the numbers of targeted whales were expected to be large in the whale sampling surveys. Track lines in the SMS were designed independently from the original track lines. Whenever SMS was adapted, the research course consisted of one main track line and two parallel track lines established in four to seven n.miles apart from main course.

4) Sighting methods

Sighting procedures were similar as in the previous surveys of JARPN (Fujise *et al*., 1995, 1996, 1997, 2000; Ishikawa *et al*., 1997; Zenitani *et al*., 1998). JARPN II also kept its consistent sighting and sampling method during all surveys. In order to obtain biological samples representing whole population in the research area, random sampling method under the line transect sighting survey was adopted.
Sighting was conducted under closing mode (*NSC mode* and *NSS mode*). Two modalities of sighting in closing mode were adopted, *NSC* and *NSS modes* for taking account for weather and sea conditions in the research. The condition to conduct surveys under *NSC mode* were similar to those established in Japanese sighting surveys conducted by the National Research Institute of Far Seas Fisheries (*i.e.* visibility of 2 n.miles or more and wind speed of 4 or below). The *NSS mode* was used under worse weather and sea condition, though the sampling of whales was possible. These two survey modes were recorded separately for future analysis. Also, an *ASP mode* was used. This mode was the closing mode survey without sampling activities under normal sighting condition. During transit, the *NSP mode* was adopted. This mode was passing mode without sampling activities under normal sighting condition.

Basically, each of the SSVs changed the track line orderly among three days to avoid possible sighting bias by the fixed position. Starting position of the day was set at a point where one of the SSVs ended survey in the previous day in the most advanced position. Other SSVs moved to the starting position of next day after the end of the daily survey. These daily arrangements of SSVs were determined by a cruise leader on the research base vessel. The survey conducted at a speed of 10.5 knots from 30 minutes after sunrise to 30 minutes before sunset (or maximum from 06:00 to 19:00), with two top man assigned at the barrel.

Sightings of whales were classified into primary and secondary sightings. The primary sightings were those seen in normal searching mode (three observers searched from the top barrel of the vessel on the predetermined track-line). The secondary sightings were those seen in out of normal searching mode (e.g. during confirming or chasing whales, no observer in the top barrel or the vessel engages in other work).

A researcher on board recorded all the sightings of whales. The sighting record includes date and time of the sighting, position of the vessel, classification of the survey mode and the sightings (primary or secondary), angle and distance from the vessel, species and school size, estimated body length, and etc.

5) Sampling methods

All common minke, Bryde's, sei and sperm whales of primary and secondary sighting were targeted for sampling. The order of individuals to be sampled in a school were chosen by a researcher on board using a series of tables of random sampling numbers (TRS), which were prepared according the size of the schools. When the sighting of the common minke, Bryde's, sei and sperm whales was occurred, the SSV approached to the school of whales within 0.2n.miles. Observers on the top barrel counted a number of whales and estimated body length of each animal. If a sighting was solitary whale, it was sampled immediately after the body length estimation. If a school was consisted of two or more animals, the researcher assigned a serial number to each individual, ranging from left to right. The first target whale was chosen using the TRS specific to the school size. When two whales should be sampled from a school, the second target was selected by the same manner after the first animal was sampled. In this case, the remaining individuals were renumbered according to the latest position in the school and TRS was used for the original school size minus one.

In addition to the sightings of common minke, sei, Bryde's and sperm whales or whales suspected to be these whales, the SSV approached large baleen whales such as blue whale *Balaenoptera musculus*, right whale *Eubalaena glacialis* and humpback whale *Megaptera novaeangliae* for conducting some experiments (see section 2.5).

2.3.2 Co-operative survey of whale sampling survey and acoustic / trawl prey survey

1) Objective

The Co-operative survey of whale sampling survey and acoustic / trawl prey survey has two research units, whale sampling unit and prey survey unit. These researches were conducted in the same limited blocks, concurrently. The objective was collected data such as stomach contents of whales and biomass of their prey species in the field for estimating the prey preferences of whales.

2) Research area and design of track line

In the co-operative survey on ecosystem research, small block was defined using satellite information on surface temperature. The zigzag-shaped track lines were set in each small block, and the whale samplings were conducted.

3) Whale sampling unit

It was consist of three sighting/sampling vessels and one research base vessel. This unit was apart from that of whale sampling survey. The some track lines were set in limited small block, and the whale samplings were conducted.

4) Prey survey unit

The prey survey unit involved echo sounder survey and a trawl survey. The some track lines were set in limited small block, and the echo sounder survey and a trawl survey were conducted.
1) Hydro-acoustic survey used a passive acoustic system (EK500 38kHz, 120kHz and 200kHz, SIMRAD, Norway; in 2000 and 2001 season; EK60 38kHz, 70kHz and 120kHz, SIMRAD, Norway; during 2002 and 2005 season) to elucidate distribution and abundance of prey species of baleen whales (from 2000 season), 2) Surface and mid water trawling, used mid-water trawl net, IKMT, MOCNESS (Multiple Opening and Closing Nets Environmental Sampling System) and NORPAC and 3) XCTD and CTD survey.

In 2000 and from 2002 to 2005 seasons, SYO, a research vessel of Japanese Fisheries Agency conducted cooperative survey with JARPN II on prey species of whales and oceanography in the western North Pacific. In 2007 season, KK1 conducted cooperative survey on prey species of whales and oceanography in the western North Pacific. These surveys were described in detail by Murase *et al*. (Murase *et al*., 2009).

2.3.3 Whale sighting survey

A dedicated sighting vessel (SV: KS2 and/or SM1) introduced whale sighting survey independently from whale sampling survey. The sighting survey by the SV was conducted under limited closing mode (*ASP mod*) and passing mode (*NSP mode*; even if sighting was made on the predetermined track line, the vessel did not approach the whale directly and searching from the barrel was uninterrupted). Track line in the SV was designed independently from the SSV's track line. A researcher on board recorded all the sightings of cetaceans. The sighting record includes date and time of the sighting, position of the vessel, classification of survey mode and sighting (primary or secondary), distance and angle from the vessel, species and school size, estimated body length, and etc.

KS2 also conducted the following survey; 1) consecutive measuring of surface water temperature, conductivity, surface chlorophyll, dissolved oxygen and surface particle by Electric Particle Counting and Sizing System (EPCS, from 2000 season), and 2) XCTD and CTD survey.

2.4 Biological survey

All the whales sampled were used for biological survey on the research base vessel. Table 2 summarizes data and samples collected. These data and samples were analyzed for the objectives of JARPN II and some were used for collaborative studies in various fields such as histology, physiology, embryology, pharmacology, pathology and reproductive physiology.

2.5 Non-lethal survey

Besides the sighting survey, a variety of non-lethal survey was conducted mainly on SV. These surveys especially contributed to study on large baleen whales, prey species and oceanography. These surveys were described in detail by Kiwada *et al*. (Kiwada et al. 2009).

2.6 Observation of marine debris

Drifting marine debris was recorded from port to the research area and from research area to port by the research base vessel. In addition, on the deck of research base vessel, we recorded the marine debris in the stomach of common minke whales, Bryde's whales, sei whales and sperm whales, and recorded the materials and number of the marine debris.

3 Outline of the research cruises

Table 1 summarizes yearly cruises of JARPN II. Followings are summary of research procedure and results in each cruise. Details of each cruise are described in cruise reports of JARPN II (see References). Distributions of common minke whales, Bryde's whales, Sei whales and sperm whales sampled by JARPN II in each cruise are shown in Figs.2-7.

3.1. 2002 season (Fig. 2)

The first full scale research was conducted in sub area 7, 8 and 9 from 29 June to 23 September 2002 (87 days including transit), using three SSVs, one SV, one PSV and one RB. Sampling of 100 minke whales, 50 sei whales, 50 Bryde's whales and 10 sperm whales were planed to sample in this season. In addition 50 minke whales to be taken by small-type whaling catcher boats in the coastal area. Sei whale is newly selected as a target species as they feed on fisheries resources such as common squid and the estimated biomass is larger than that of Bryde's and minke whales. The additional 50 minke whales will provide more coverage of the spring and autumn seasons in coastal waters where the competition between cetaceans and fisheries is likely to be substantial. Research period was carried from 5 July to 18 September 2002 (76 days). The total searching effort by three SSVs was 11,497.3 n. miles during which 141 common minke whales, 129 Bryde's whales, 207 sei whales and 556 sperm whales were sighted. The number of individuals sampled was 100 common minke whales, 50 Bryde's whale, 39 sei whales and five sperm whales.

The dedicated sighting survey was conducted in sub area 7, 8 and 9 from 5 June to 8 September 2002 (96 days including co-operative survey), using one SV (KS2). Total searching effort by SV was 3,443.9 n. miles during

which 9 common minke whales (6 schools), 69 Bryde's whales (54 schools), 81 sei whales (46 schools) and 61 sperm whales (48 schools) were sighted.

The co-operative survey on the prey species and whale sampling, two special blocks were settled. First period was between 18 July and 1 August in sub areas 8 and 9 and second period was between 7 and 17 August excluding 13 and 14 August in sub area 7 (Fujise *et al*., 2003).

3.2. 2003 season (Fig. 3)

The second full scale research was conducted in sub area 7, 8 and 9 from 13 May to 13 August 2003 (93 days including transit), using three SSVs, one SV, one PSV and one RB. Research period was carried from 17 May to 8 August 2003 (84 days). The total searching effort by three SSVs was 11,903.0 n. miles during which 125 common minke whales, 193 Bryde's whales, 236 sei whales and 935 sperm whales were sighted. The number of individuals sampled was 100 common minke whales, 50 Bryde's whale, 50 sei whales and 10 sperm whales.

The dedicated sighting surveys were conducted in sub area 7, 8 and 9, using two SVs (SM1 and KS2). The survey by SM was conducted from 30 April to 18 May (20 days) in sub area 8. Total searching effort by SV was 1,044.5 n. miles during which 4 common minke whales (4 schools), 3 sei whales (2 schools) and 58 sperm whales (29 schools) were sighted. The survey by KS2 was conducted from 14 May to 5 September (115 days including co-operative survey) in sub areas 7, 8 and 9. Total searching effort by SV was 5,662.3 n. miles during which 87 common minke whales (79 schools), 79 sei whales (47 schools) and 315 sperm whales (185 schools) were sighted.

The co-operative survey on the prey species and whale sampling, two special blocks were settled. First period was between 10 and 26 June in sub areas 8 and 9 and second period was between 26 June and 7 July excluding 30 June in sub area 7 (Tamura *et al*., 2004).

3.3. 2004 season (Fig. 4)

The third full scale research was conducted in sub area 7, 8 and 9 from 10 June to 24 September 2004 (107 days including transit), using three SSVs, one SV, one PSV and one RB. The sample size of the sei whales modified from 50 to 100 individuals since the 2004 season, because the new calculation showed that at least 100 sei whales per year were required for estimating prey consumption with sufficient precision (Government of Japan, 2005). Research period was from 15 June to 18 September 2004 (96 days). The total searching effort by three SSVs was 10,695.4 n. miles during which 119 common minke whales, 180 Bryde's whales, 385 sei whales and 523 sperm whales were sighted. The number of individuals sampled was 100 common minke whales, 50 Bryde's whale, 100 sei whales and three sperm whales.

The dedicated sighting survey was conducted in sub area 7, 8 and 9 from 14 May to 5 September 2004 (115 days including co-operative survey), using one SV (KS2). Total searching effort by SV was 3,943.8 n. miles during which 33 common minke whales (29 schools), 44 Bryde's whales (35 schools), 80 sei whales (53 schools) and 239 sperm whales (102 schools) were sighted.

The co-operative survey on the prey species and whale sampling, one special block was settled. The period was between 15 and 17 September (Tamura *et al*., 2005).

3.4. 2005 season (Fig. 5)

The forth full scale research was conducted in sub area 7, 8 and 9 from 13 May to 19 August 2006 (99 days including transit), using three SSVs, one SV, one PSV and one RB. The total searching effort by three SSVs was 12.697.4 n. miles during which 114 common minke, 110 Bryde's, 503 sei and 337 sperm whales were sighted. The number of individuals sampled was 100 common minke whales, 50 Bryde's whale, 39 sei whales and five sperm whales.

The dedicated sighting survey was conducted in sub area 7, 8 and 9 from 15 May to 24 August 2005 (113 days including co-operative survey), using one SV (KS2). Total searching effort by SV was 5,078.7 n. miles during which 21 common minke whales (20 schools), 15 Bryde's whales (12 schools), 360 sei whales (181 schools) and 210 sperm whales (79 schools) were sighted.

The co-operative survey on the prey species and whale sampling, two special blocks were settled. First period was between 8 and 15 July in sub area 7 and second period was between 25 July and 4 August in sub areas 8 and 9 (Tamura *et al*., 2006).

3.5. 2006 season (Fig. 6)

The fifth full scale research was conducted in sub area 7, 8 and 9 from 23 May to 21 August 2006 (91 days including transit), using three SSVs, one SV, and one RB. Research period was carried from 24 May to 16 August 2006 (85 days). The total searching effort by three SSVs was 12,245.3 n. miles during which 134 common minke, 172 Bryde's, 326 sei and 330 sperm whales were sighted. The number of individuals sampled was 100 common minke whales, 50 Bryde's whale, 100 sei whales and six sperm whales.

The dedicated sighting survey was conducted in sub area 7, 8 and 9 from 15 May to 30 August 2006 (108 days including co-operative survey), using one SV (KS2). Total searching effort by SV was 5,541.7 n. miles during which 54 common minke whales (46 schools), 15 Bryde's whales (10 schools), 244 sei whales (137 schools) and 220 sperm whales (118 schools) were sighted.

The co-operative survey on the prey species and whale sampling did not conducted in this season due to logistics reason. One Bryde's whale was tracked by satellite tag in the western North Pacific during July. The satellite tracking data was received for two weeks (Tamura *et al*., 2007).

3.6. 2007 season (Fig. 7)

The sixth full scale research was conducted in sub area 7, 8 and 9 from 11 May to 18 August 2007 (100 days including transit), using three SSVs, one SV, and one RB. Research period was carried from 18 May to 13 August 2006 (87 days). The total searching effort by three SSVs was 11,416.4 n. miles during which 146 common minke, 376 Bryde's, 548 sei and 620 sperm whales were sighted. The number of individuals sampled was 100 common minke whales, 50 Bryde's whale, 100 sei whales and three sperm whales.

The dedicated sighting survey was conducted in sub area 7, 8 and 9 from 11 May to 1 August 2007 (83 days including transit), using one SV (KS2). Total searching effort by SV was 4,042.5 n. miles during which 9 common minke whales (9 schools), 235 Bryde's whales (152 schools), 52 sei whales (35 schools) and 264 sperm whales (101 schools) were sighted.

At the same time with the whale sighting, prey species survey was conducted in sub area 7, 8 and 9 from 4 July to 6 September 2007 (65days including transit), using one TSV (KK1).

The co-operative survey on the prey species and whale sampling, three special blocks were settled. First period was between 9 and 22 July, and second period was between 3 and 5 August in sub areas 8 and 9. Third period was 11 and 13 August in sub areas 7 and 8 (Matsuoka *et al*., 2008).

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Table 1. Outline of research between 2000 and 2007 JARPN II.

Seasons	Research periods	Research area			Research periods (days)	Research vessels					Sampling number			
		7	8	9		RBV	SSV	SV	PSV	TSV	Mi	Br	Sei	Sperm
2000	Feasibility	○	-	○	Aug. 1 - Sept. 16 (47)	NM	YS1, K01, T25	KS2	SHU		40	43	-	5
2001	Feasibility	○	○	○	May 14 - Aug. 3 (82)	NM	YS1, K01, T25	KS2	TOR		100	50	-	8
2002	Entire	○	○	○	July 5 - Sept. 18 (76)	NM	YS1, K01, T25	KS2	SHU		100	50	39	5
2003	Entire	○	○	○	May 17 - Aug. 8 (84)	NM	YS1, YS2, K01	KS2, SM1	SHU		100	50	50	10
2004	Entire	○	○	○	June 15 - Sept. 18 (96)	NM	YS1, YS2, K01	KS2	SHU		100	50	100	3
2005	Entire	○	○	○	May 16 - Aug. 16 (93)	NM	YS1, YS2, K01	KS2	SHU		100	50	100	5
2006	Entire	○	○	○	May 24 - Aug. 16 (88)	NM	YS1, YS2, K01	KS2	-		100	50	100	6
2007	Entire	○	○	○	May 18 - Aug. 14 (94)	NM	YS1, YS2, K01	KS2	-	KK1	100	50	100	3
Total											**740**	**393**	**489**	**45**

Table 2. Sampling numbers of whales in each sub area between 2000 and 2007 JARPN II.

Seasons	Month	Minke				Bryde's				Sei				Sperm			
		Area 7	Area 8	Area 9	Total	Area 7	Area 8	Area 9	Total	Area 7	Area 8	Area 9	Total	Area 7	Area 8	Area 9	Total
2000		24	-	16	40	43	-	-	43	-	-	-	-	5	-	-	5
2001		50	21	29	100	50	-	-	50	-	-	-	-	8	-	-	8
2002		60	11	29	100	8	36	6	50	-	7	32	39	5	-	-	5
2003		24	37	39	100	27	14	9	50	4	19	27	50	4	3	3	10
2004		16	-	84	100	-	12	38	50	-	2	98	100	-	-	3	3
2005		32	14	54	100	39	8	3	50	-	31	69	100	1	2	2	5
2006		38	38	24	100	5	11	34	50	5	48	47	100	-	2	4	6
2007		79	15	6	100	10	30	10	50	6	24	70	100	0	0	3	3
Total		323	136	281	740	182	111	100	393	15	131	343	489	23	7	15	45
Avg.		40	17	35	93	23	14	13	49	3	22	57	82	3	1	2	6

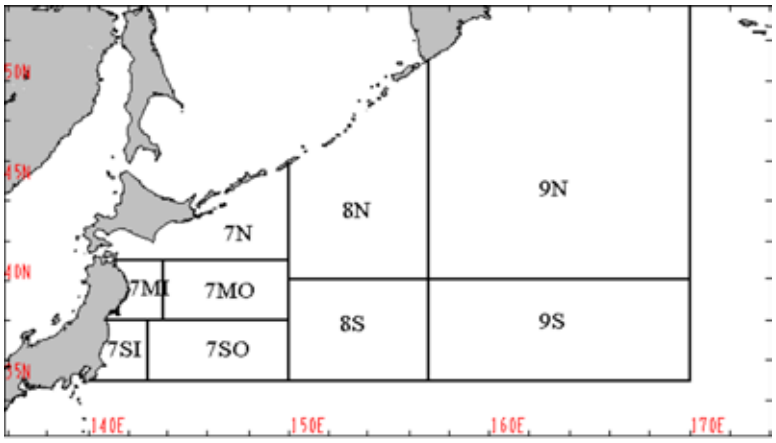
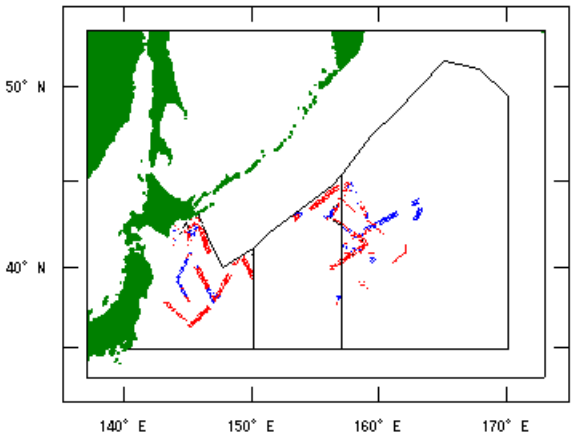
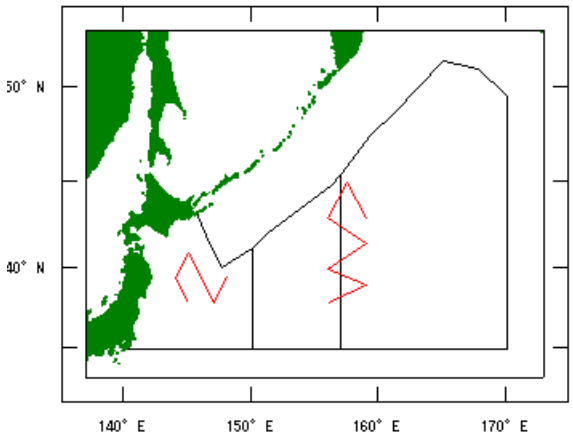


Fig. 1. Map showing the research area and strata of the JARPN II.

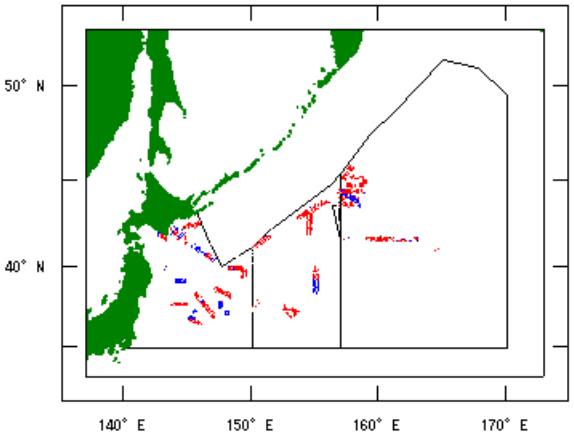
Whale survey



Co-operative survey



Special monitoring survey



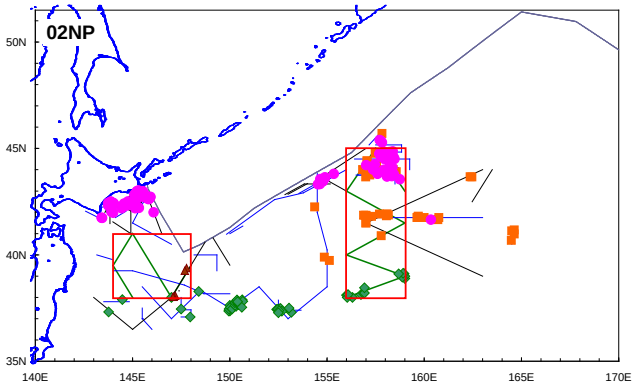
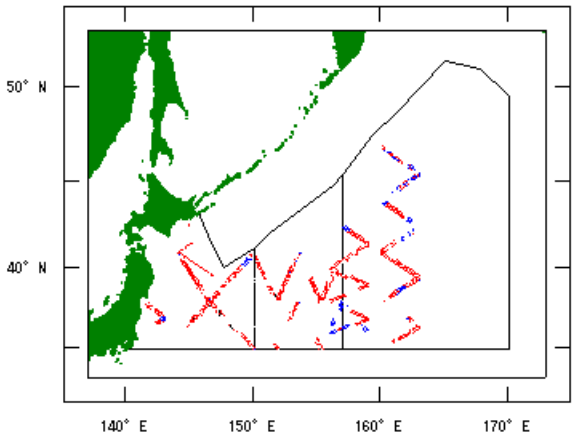


Fig. 2. Outline of the cruise track-line in each survey design in the 2002 JARPN II cruise

Red line: BC mode; Blue line: BS mode

Sighting position of whales sampled (●: minke whale, ■: Sei whale, ◆: Bryde's whale, ▲: sperm whale)

Whale survey



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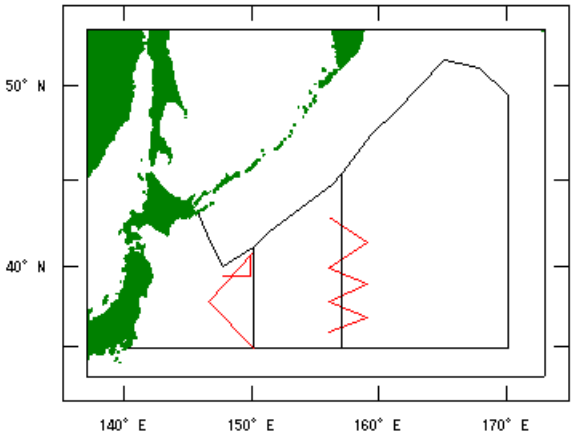

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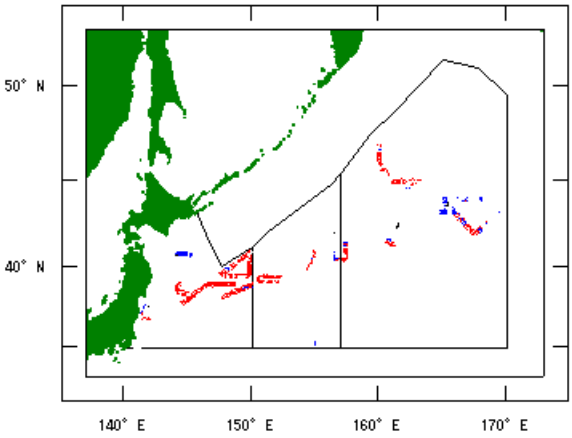


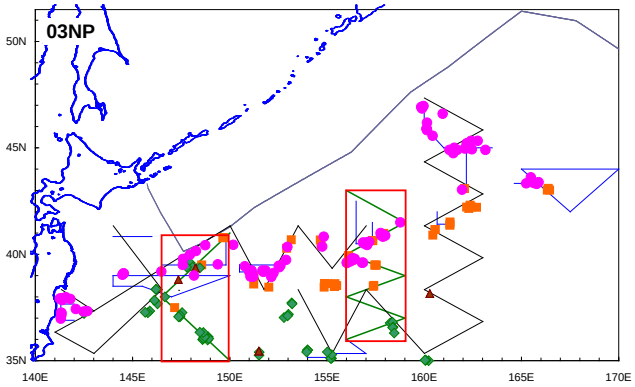
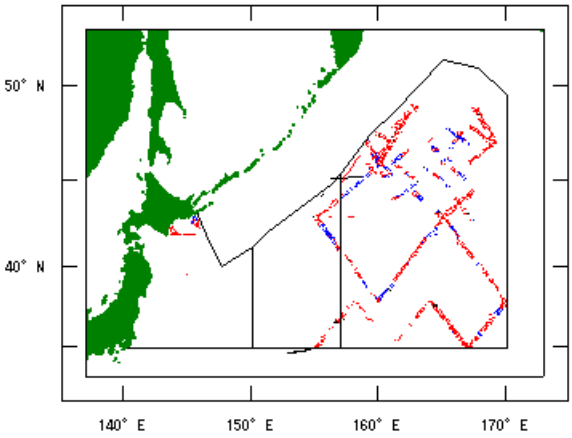


Fig. 3. Outline of the cruise track-line in each survey design in the 2003 JARPN II cruise

Red line: BC mode; Blue line: BS mode

Sighting position of whales sampled (●: minke whale, ■: Sei whale, ◆: Bryde's whale, ▲: sperm whale)

Whale survey



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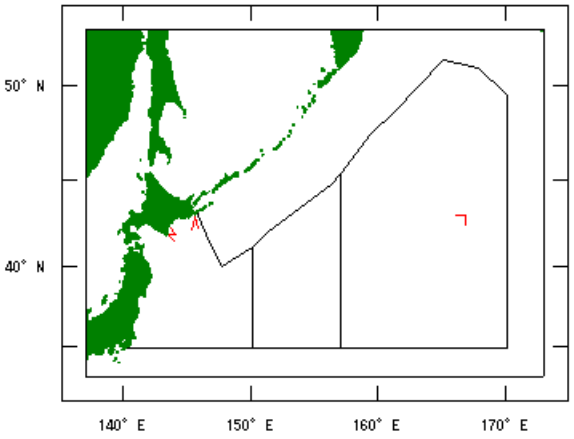

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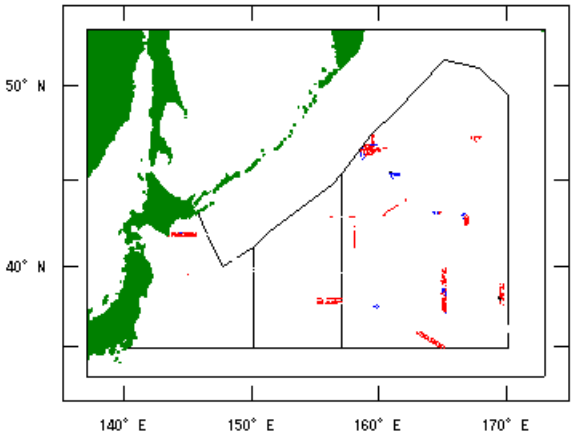


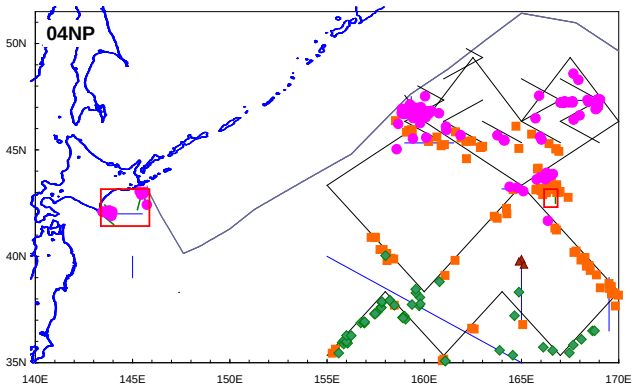
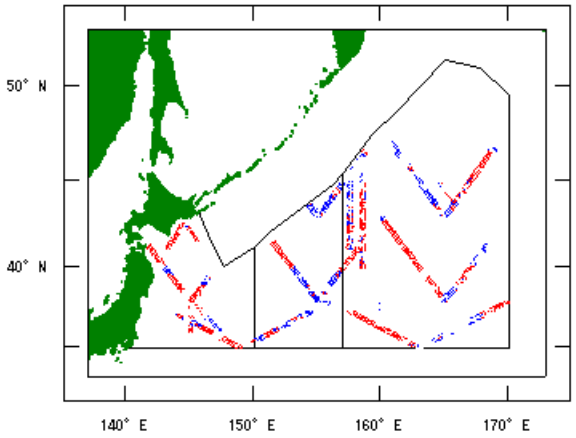


Fig. 4. Outline of the cruise track-line in each survey design in the 2004 JARPN II cruise

Red line: BC mode; Blue line: BS mode

Sighting position of whales sampled (●: minke whale, ■: Sei whale, ◆: Bryde's whale, ▲: sperm whale)

Whale survey



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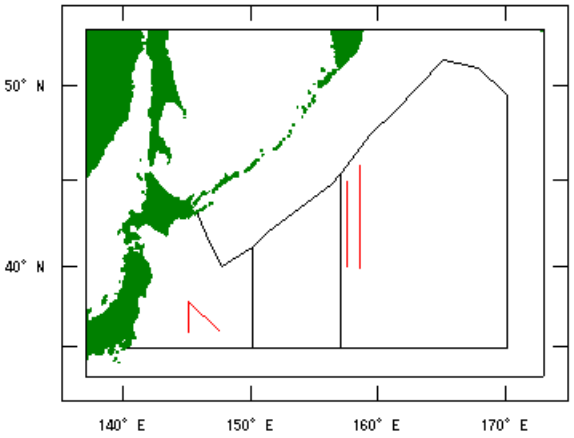

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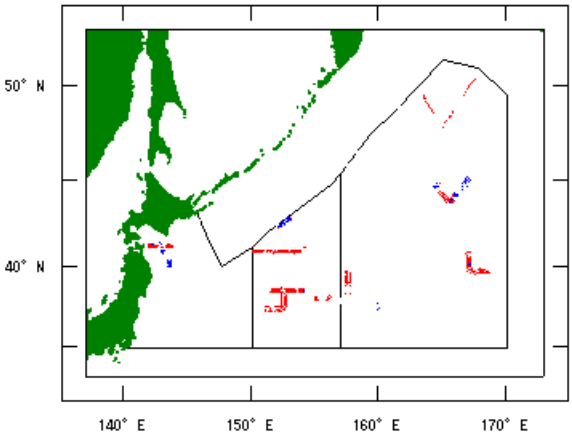


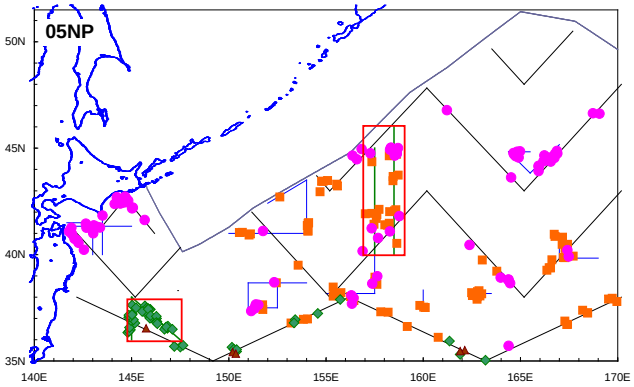
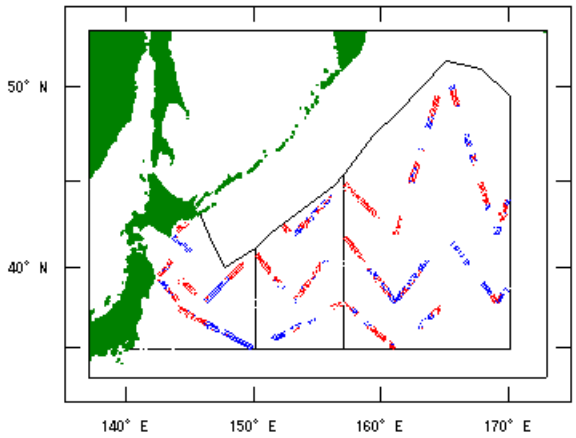


Fig. 5. Outline of the cruise track-line in each survey design in the 2005 JARPN II cruise

Red line: BC mode; Blue line: BS mode

Sighting position of whales sampled (●: minke whale, ■: Sei whale, ◆: Bryde's whale, ▲: sperm whale)

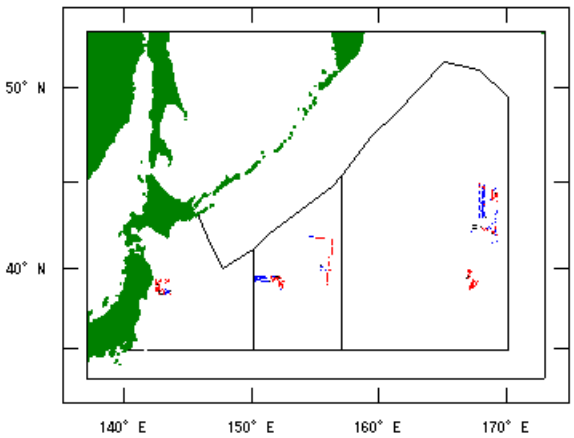
Whale survey



Co-operative survey

No survey

Special monitoring survey



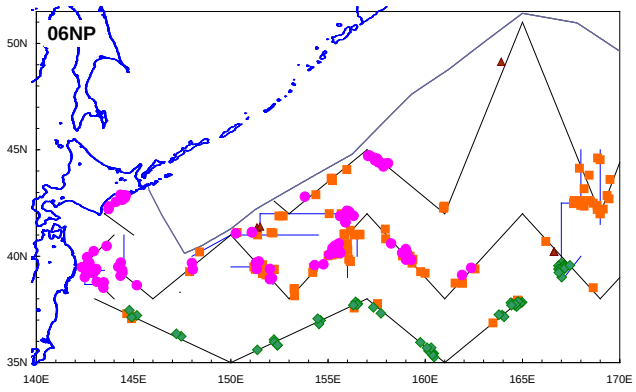
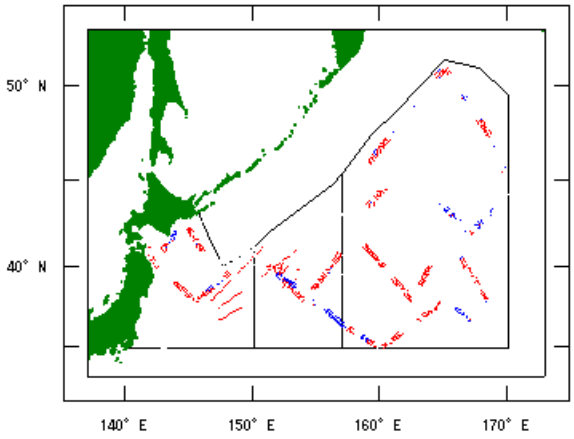


Fig. 6. Outline of the cruise track-line in each survey design in the 2006 JARPN II cruise

Red line: BC mode; Blue line: BS mode

Sighting position of whales sampled (●: minke whale, ■: Sei whale, ◆: Bryde's whale, ▲: sperm whale)

Whale survey



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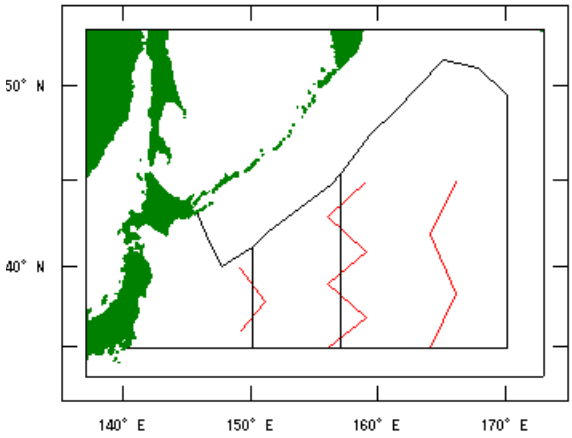
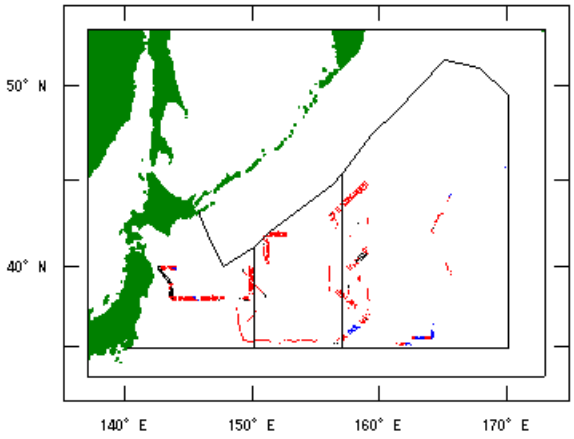


Special monitoring survey



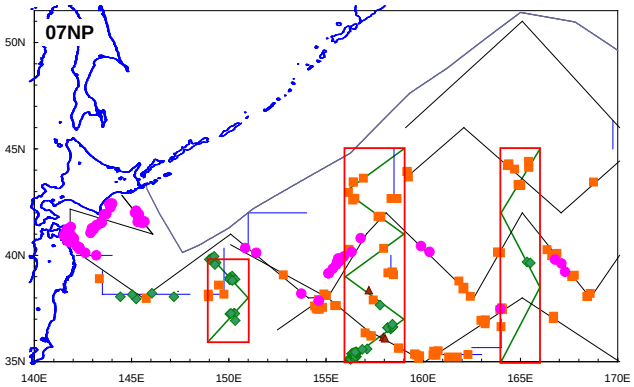


Fig. 7. Outline of the cruise track-line in each survey design in the 2007 JARPN II cruise

Red line: BC mode; Blue line: BS mode

Sighting position of whales sampled (●: minke whale, ■: Sei whale, ◆: Bryde's whale, ▲: sperm whale)