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Cruise Report of the Second Phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPNII) in 2016 (part I): Offshore component

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INTERNATIONAL WHALING COMMISSION

Cruise Report of the Second Phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPNII) in 2016 (part I) – Offshore component –

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ABSTRACT

The 15th and last cruise of the full-scale Second Phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPNII) -offshore component- was conducted in sub-areas 7, 8 and 9 of the western North Pacific. There were two main research components in the 2016 survey: whale sampling survey and dedicated sighting survey. A total of five research vessels was used: two sighting/sampling vessels (SSVs) (whale sampling survey component), one research base vessel (*Nisshin Maru, NM*) (whale sampling survey component) and two dedicated sighting vessels (SVs) (dedicated sighting survey component). The whale sampling survey was carried out from 13 May to 26 July 2016. A total of 2,662n.miles was surveyed in a period of 67 days by the SSVs. A total 444 sei, 104 Bryde's, of two common minke, 147 sperm, three blue, 15 fin and 26 humpback whales were sighted by the SSVs. A total of 90 sei and 25 Bryde's whale was sampled and biological surveys were conducted on board of *NM*. In May and June, sei whales fed mainly on mackerels followed by Japanese sardine, copepods and krill in sub-areas 8 and 9. Bryde's whales fed mainly on krill in sub-areas 8 and 9 in July. A dedicated sighting survey was carried out from 29 July to 6 September. A total of 3,185n.miles was surveyed during the survey by the two SVs. Data obtained during the JARPNII will be used in the elucidation of the role of whales in the marine ecosystem through the study of whale feeding ecology in the western North Pacific.

KEYWORDS: SCIENTIFIC PERMITS; BRYDE'S WHALE; SEI WHALE; FOOD/PREY; MONITORING

INTRODUCTION

After the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN) was completed in 1999, the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPNII) started in the 2000 summer season as a two-year feasibility study. Based on the success of the feasibility study (Government of Japan, 2002a), JARPNII started as a full-scale research program in 2002. The full-scale study aimed i) to examine feeding ecology for ecosystem studies, ii) to monitor environmental pollutants in cetaceans and the marine ecosystem and iii) to elucidate the stock structure (Government of Japan, 2002b).

The full-scale JARPNII plan involved two survey components: the 'offshore' survey, which was covered by the *Nisshin Maru* research unit and two 'coastal' surveys (Sanriku and Kushiro), which were covered by small type whaling catcher boats. The coastal component was necessary to cover the temporal and spatial gaps which could not be covered by the *Nisshin Maru* unit (Government of Japan, 2002b).

The research area of the offshore component was set in sub-areas 7, 8 and 9, and the target species and sample sizes for the lethal component of the research were set as follows: 100 common minke whales; 100 sei whales, 50 Bryde's whales and 10 sperm whales (Government of Japan, 2002b). The survey was composed of three main components: whale sampling survey, dedicated sighting survey and whale prey survey.

In January 2009, IWC/SC conducted an Expert Workshop to review the ongoing JARPNII Programme (IWC, 2010) for the first period (2002-2007) and the final review of the JARPNII was conducted in February 2016 (IWC, 2017). The results presented on the three main objectives of JARPNII were discussed by an Experts

Panel. Constructive discussions were conducted and some recommendations were offered by the Panel. Some of those recommendations had already been responded to by Japanese scientists (Pastene, *et al*., 2010; Tamura *et al*., 2016).

Following the March 31, 2014 Judgment of the International Court of Justice (ICJ) in the case Whaling in the Antarctic (Australia v. Japan: New Zealand intervening), the Government of Japan voluntarily reviewed the state of JARPNII. This voluntary review resulted in the reprioritization of the research focus as well as recalculation of sample sizes to be pursued during the 2014-2016 JARPNII surveys. The results of the three year's surveys were utilized for the establishment of a new research plan (IWC, 2015). Sampling of sperm and common minke whales in the offshore component was suspended because their role in the study of interactions between whales and fisheries seemed to be limited. Sei whale sample size of 100 (as in the original plan) of which 10 were studied using only non-lethal methods. Bryde's whale sample size of 50 (as in the original plan) of which 25 were studied using only non-lethal methods. A study for verifying the feasibility of using non-lethal methods is currently in progress and a part of the results have already been reported to the IWC/SC (Mogoe, *et al*., 2015, 2016; Yasunaga *et al*., 2017a).

This paper reports on the 15th and last cruise of the JARPNII conducted in the western North Pacific with the emphasis on the primary objective, feeding ecology of whale species. Results of pollution and stock structure studies will be presented separately.

MATERIALS AND METHODS

Whale sampling survey

Research area
Sub-areas 7, 8 and 9, excluding the EEZ zones of foreign countries, comprised the research area (Figure 1).

Research vessels
Three research vessels were used. The research base vessel *Nisshin Maru* (*NM*: 8,145GT) conducted the research and was the platform for biological examination of whale samples and processing of by-products. The *Yushin Maru* (*YS*1: 724GT) and *Yushin Maru* No.2 (*YS*2: 747GT) were used as the sighting/sampling vessels (SSVs), which conducted sighting activities, sampling of targeted whale species and various experiments and observations.

Methods for setting cruise track line and sighting procedure
Track lines and allocation of vessels were made as in previous JARPN and JARPNII surveys (Fujise *et al*., 1995, 1996, 1997, 2000, 2001, 2002, 2003; Ishikawa *et al*., 1997; Zenitani *et al*., 1999; Tamura *et al*., 2004, 2005, 2006, 2009a, 2009b, 2012, 2015; Bando *et al*., 2010, 2013, 2014, 2016a, 2016b, 2016c; Matsuoka *et al*., 2008; Yasunaga *et al*., 2011). The zigzag-shaped track line was established on an arbitrary basis in each sub-area. Furthermore, some 'special monitoring surveys' (SMS) were conducted in areas where the abundance of Bryde's and sei whales were expected to be high. Track line for the SMS were designed separately from the original track line. The research course for the SSVs consisted of one main track and one parallel track established 7n.miles apart from the main course. Two SSVs were allocated to these tracks with the allocation being changed every day.

Sighting procedure for the whale sampling survey was similar to the previous surveys of JARPN and JARPNII (Fujise *et al*., 1995, 1996, 1997, 2000, 2001, 2002, 2003; Ishikawa *et al*., 1997; Zenitani *et al*., 1999; Tamura *et al*., 2004, 2005, 2006, 2007, 2009a, 2009b, 2012, 2015; Bando *et al*., 2010, 2013, 2014, 2016a, 2016b, 2016c; Matsuoka *et al*., 2008; Yasunaga *et al*., 2011). In the research area, sighting survey was conducted mainly under closing mode. Furthermore two modalities of sighting in closing mode were adopted, *NSC* and *NSS modes*, by taking into consideration weather and sea conditions. The conditions 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 two n.miles or more and wind force of four or below). The *NSS mode* was used under bad weather conditions such as strong wind, heavy rain or fog but with the collection of whale samples still possible. These two modes for surveys were recorded separately for future analysis. Also an *ASP mode* was used (closing mode survey without sampling activities under normal sighting conditions). Closing was performed mainly on sightings of Bryde's and sei whales.

Furthermore closing was made on sightings of other large baleen whales, such as common minke, blue, fin, humpback, sperm and right whales. In these cases, closing was done in order to confirm species and school size and to conduct some experiments.

Sampling numbers and procedure of targeted whales
The target species and sample sizes in the 2016 JARPNII offshore component were set as follows: 90 sei whales and 25 Bryde's whales. Most of the whales sighted on the track line during the survey were approached for sampling. Furthermore sampling effort was applied outside the established research hours (main time: 06:00-18:00 (12 hrs) in local time), if collection of whale samples was considered possible. For schools consisting of two or more animals, all of the whales in the school were numbered to set the sampling order randomly in accordance with the table of random numbers (Kato *et al*., 1989). Cow and calf pairs were not targeted for sampling. Sampled whales were immediately transported to the research base vessel (*NM*), where biological examinations were carried out.

Experiments
The following experiments and observations were conducted by the SSVs:
1. Sighting distance and angle experiments to examine the precision of sighting data.
2. Biopsy sampling on gray, blue, fin, sei, Bryde's, common minke, humpback, right, bowhead and sperm whales.
3. Photographic records of natural marks on blue, humpback and right whales.
4. Observation of feeding behaviour on blue, fin, sei, Bryde's, common minke, humpback, right and sperm whales.
5. Observation of excretion and vomiting behaviour on sei, Bryde's and common minke whales.
6. Satellite tracking of sei whales.

Observation of marine debris
Observation of marine debris was conducted from the bridge of the research base vessel (*NM*) during transit between home port and research area. Marine debris was also investigated in the stomach contents of Bryde's and sei whales.

Dedicated Sighting survey

A report of the dedicated sighting surveys is presented by Matsuoka *et al*. (2017). Here just a brief outline is presented. One independent survey was conducted in this season.

Research area
Sub-area 7

Research vessel
The *YS1* and *YS2* were used as dedicated sighting vessels (SVs).

Methods for setting cruise track line and sighting procedure
An independent track line for the dedicated sighting survey was designed in the research area.

Experiments
The following experiments and observations were conducted by the SVs.
1. Sighting distance and angle experiments to examine the precision of sighting data.
2. Biopsy sampling on gray, blue, fin, sei, Bryde's, common minke, humpback, right, bowhead and sperm whales.
3. Photographic records of natural marks on blue, humpback and right whales.
4. Observation of excretion and vomiting behaviour on sei, Bryde's and common minke whales.

RESULTS

Whale sampling survey

Actual survey periods, track lines and searching distances
Cruise period: Between 13 May and 26 July (75 days)
Research period: Between 16 May and 21 July (67 days)
Track line: Track line set by the two SSVs is shown in Figure 2.
Searching distance: The total searching distance of two SSVs was 2,662n.miles

Sightings of sei, Bryde's, common minke and sperm whales
A total of 270 schools (444 individuals) of sei, 94 schools (104 individuals) of Bryde's, two schools (two individuals) of common minke and 56 schools (147 individuals) of sperm whales were sighted (Table 1, Figure 2).

Sightings of other large cetacean species
Table 1 also shows the number of sightings for other large whale species made by the SSVs, such as blue (three sch./three individuals), fin (13 schools./15 individuals) and humpback (21 schools/26 individuals) whales (Figure 2).

Sampling and biological examination on sei and Bryde's whales
A total of 90 sei whales (male: 38, female: 52 individuals) and 25 Bryde's whales (male: 11, female: 14 individuals) were sampled. Sighting position of sampled sei and Bryde's whales is shown in Figure 3. Sei whales were sampled in wide longitudinal area of sub-areas 8 and 9. Bryde's whales were mainly sampled in southern part of sub-areas 8 and 9. Struck and lost did not occur in this survey.

Table 2 summarizes the biological data and samples collected from whales. A total of 45 research items was covered. These items are related to the studies conducted under the three main objectives of the JARPNII. Composition of sex and sexual maturity status of sei and Bryde's whales are shown in Table 3. Statistics of body length of each whale species is shown in Table 4. Mean body length of sei whale was 13.24m and 13.87m for males and females, respectively. For Bryde's whales, those were 12.25m and 12.57m, respectively.

Food habits of whales
In this survey, dominant prey species of sei whales was Mackerels (*Scomber japonicus* and *S. australasicus*) (45.8%) followed by copepods (25.0%), and Japanese sardine (18.8%) (Table 5). For Bryde's whale, most of the stomach contents consisted of krill (77.8%) (Table 5).

Experiments
A detailed report of the progress of non-lethal research activity in 2014-2016 JARPNII is presented in Yasunaga *et al*. (2017a, b). In this section, the summary of the results is described.

Sighting distance and angle experiment
A sighting distance and angle experiment was performed on 21 June by *YS1* and *YS2*. The results of this experiment will be used in calculation of abundance estimates.

Photo-ID
Photo-ID was collected from four humpback whales.

Biopsy sampling
Biopsy samples were collected from 19 sei, 28 Bryde's, two common minke, two fin and four humpback whales using the Larsen system. Details of biopsy sampling efficiency is reported in Yasunaga *et al*. (2017a, b).

Feeding behaviour
No case of feeding was observed during the survey.

Excretion and vomiting behaviour

A total of two common minke, 440 sei and 103 Bryde's whales were observed. As a result, 11 cases of excretion behaviour were observed for sei whales but faeces samples were not collected. No case of vomiting was observed during the survey.

Observation of marine debris
No large debris was observed in the environment. A small piece of plastic was observed in each of the stomachs of three Bryde's and 46 sei whales. A small piece of wood was observed in one sei whale stomach. A small piece of net was observed in the stomach of five sei whales.

Satellite tracking of sei whales
Three satellite transmitters were successfully attached to three sei whales, however, location information could not be obtained from any of these.

Dedicated Sighting survey

Actual research periods and searching distance
Cruise period:
Between 29 July and 6 September (40 days; *YS1*, *YS2*)

Searching distance:
3,185 n.miles (*YS1*, *YS2*)

Sightings of Bryde's, sei, common minke, and sperm whales
Sighting number of large cetacean species during the survey is shown in Table 1. A total of 182 schools (225 individuals) of Bryde's, 12 schools (12 individuals) of common minke and 133 schools (544 individuals) of sperm whales were sighted.

Sightings of other large cetacean species
Large baleen whales such as fin (four schools/six individuals) and humpback (two schools/two individuals) whales were sighted (Table 1).

Experiments
Photo-ID
A total of one humpback and one Bryde's whales were photographed during the survey.

Biopsy sampling
Biopsy samples were collected from one fin and one humpback whales using the Larsen system.

Feeding behaviour
Feeding behaviour was not observed during the survey.

Excretion and vomiting behaviour
A total of 182 Bryde's and 12 common minke whales were observed. As a result, four cases of excretion behaviour by Bryde's whales were observed. No case of vomiting was observed during the survey.

DISCUSSION

The 15th and last cruise of JARPNII was conducted in early summer season (May-July). Prey species and food habits of sei and Bryde's whales in this survey are discussed below in the context of previous survey results.

Sei whale

From our research results of past JARPNII (2002 to 2015), drastic change of prey species was observed (Figure 4). At the early years of JARPNII, Japanese anchovy, copepod and krill were major prey species of sei whales. However, the proportion of Japanese anchovy decreased over the years and almost disappeared in recent years. On the other hand, mackerels first appeared as main prey species of sei whales in 2004 and since then, the proportion is gradually increased and became the most dominant prey species in 2013.

Furthermore, Japanese sardine first appeared in 2014, then increased suddenly and became the dominant prey species in 2015. In the 2016 survey, more than half of the sei whale stomachs contained mainly mackerels and Japanese sardine. These results indicate changes of dominant pelagic fish species and feeding habits of sei whales in the research area during the JARPNII period.

Bryde's whale

From our research results of past JARPNII (2000 to 2015), the dominant prey species of Bryde's whale were Japanese anchovy and krill (Figure 4). Seasonal change was observed for prey species of Bryde's whale in the sub-areas 7 and 8, with krill as the dominant prey in the early season (May and June) and Japanese anchovy in late season (July to September). In the south-eastern part of sub-area 9, mesopelagic fishes such as V*inciguerria nimbaria* or *Maurolicus japonicus* were also an important prey species in August. In the 2016 survey, most of the stomach contents of Bryde's whales sampled in sub-areas 8 and 9 contained mainly krill. The proportion of anchovy was very low in the recent two years, which might reflect recent changes of distribution or abundance of Japanese anchovy.

Summary of yearly change of prey species

In recent years, Japanese sardine increasingly appeared in the stomach contents of sei whales sampled offshore and common minke whales sampled in the Kushiro region (Kishiro *et al*., 2014, 2016; Yoshida *et al*., 2013, 2015, 2017). On the other hand, the proportion of Japanese anchovy as a prey species of baleen whales has decreased and completely disappeared in the present survey. This might indicate fish species replacement from Japanese anchovy to Japanese sardine/Mackerels occurred in the western North Pacific since early 2000's. These changes suggested sei and Bryde's whales changed their prey species in response to prey availability rather than preferred specific prey species.

Further surveys will be needed to detect possible ongoing changes of dominant pelagic fish species and changes of feeding strategy of baleen whales in the western North Pacific.

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Table 1. Whale species and number of sightings in the 2016 JARPNII offshore survey.

Whale sampling survey (*YS1* and *YS2*)

Species	Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Sei	133	213	137	231	270	444
Bryde's	57	63	37	41	94	104
Common minke	0	0	2	2	2	2
Sperm	36	105	20	42	56	147
Blue	1	1	2	2	3	3
Fin	8	10	5	5	13	15
Humpback	15	20	6	6	21	26

Dedicated sighting survey (*YS1 and YS2*)

Species	Primary		Secondary		Total	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Bryde's	180	222	2	3	182	225
Common minke	9	9	3	3	12	12
Sperm	131	540	2	4	133	544
Fin	4	6	0	0	4	6
Humpback	1	1	1	1	2	2

Table 2. Summary of biological data and samples collected during the 2016 JARPNII offshore survey.

Research items	Sei whale			Bryde's whale		
	M	F	T	M	F	T
Measurement of body length	38	52	90	11	14	25
Measurement of external body proportion	38	52	90	11	14	25
Photographic record of external characters	38	52	90	11	14	25
Record of Diatom film	38	52	90	11	14	25
Standard measurement of blubber thickness (five points)	37	52	89	11	13	24
Detailed measurement of blubber thickness (eleven points)	1	0	1	0	1	1
Measurement of body weight	38	52	90	11	14	25
Measurement of body weight by parts	1	0	1	0	1	1
Collection of earplug for age determination	38	52	90	11	14	25
Collection of eye lens for age determination	38	52	90	11	14	25
Collection of vertebral epiphyses for growth study	38	52	90	11	14	25
Measurement of skull length and breadth	38	51	89	10	13	23
Observation of lactation status	-	52	52	-	14	14
Measurement of mammary gland and collection of histological sample for reproductive study	-	52	52	-	14	14
Collection of endometrium histological sample for reproductive study	-	11	11	-	8	8
Collection of ovary	-	52	52	-	14	14
Photographic record of foetus	-	25	25	-	4	4
Identification of foetal sex	-	25	25	-	4	4
Measurement of foetal length and weight	-	25	25	-	4	4
Collection of foetal tissue for genetic study	-	25	25	-	4	4
Collection of foetal eye for age determination	-	25	25	-	4	4
Collection of testis histological sample for reproductive study	38	-	38	11	-	11
Measurement of testis weight	38	-	38	11	-	11
Collection of testis for epidemiological study	38	-	38	11	-	11
Photographic record of testis	38	-	38	11	-	11
Collection of plasma sample	38	51	89	11	14	25
Collection of skin tissue for genetic study	38	52	90	11	14	25
Collection of blubber, muscle, liver and kidney tissues for heavy metal analysis	38	52	90	11	14	25
Collection of blubber tissue for fatty acid analysis	38	52	90	11	14	25
Collection of blubber, muscle, liver tissues and stomach contents for stable isotope analysis	38	52	90	11	14	25
Collection of tissues for various analyses	38	52	90	11	14	25
Collection of lung tissue for pollutant analysis	10	-	10	5	-	5
Collection of blubber and muscle tissues for nutritional function analysis	2	3	5	2	3	5
Collection of blubber tissue for fat content analysis	38	52	90	11	14	25
Collecion of baleen plate for stable isotope analysis	7	12	19	3	6	9
Observation of stomach contents (conventional record)	38	52	90	11	14	25
Measurement of stomach content weight in each compartment	38	52	90	11	14	25
Collection of stomach contents for feeding study	25	36	61	5	10	15
Collection of stomach contents for various analyses	7	10	17	0	4	4
Measurement of stomach contents (prey length and weight)	7	11	18	0	0	0
Observation of appearance of marine debris in stomach	38	52	90	11	14	25
Collection of intestines contents for feeding study	38	52	90	11	14	25
Record of appearance of external parasites	38	52	90	11	14	25
Record of appearance of internal parasites	38	52	90	11	14	25
Collection of testis for sexual maturation study	-	-	0	1	0	1

Table 3. Sex and sexual maturity status composition of sei and Bryde's whales sampled during the 2016 JARPNII offshore survey.

Species	Sub area	Male			Female						Total
		Imm.	Mat.	Total	Imm.	Mat.				Total	
						Ovu.	Rest.	Preg.	Lact.	Total	
Sei	SA7	0	2	2	2	0	0	0	0	0	2	4
	SA8	6	3	9	5	0	1	7	4	12	17	26
	SA9	5	22	27	9	0	4	18	2	24	33	60
	Combined	11	27	38	16	0	5	25	6	36	52	90
Bryde's	SA7	-	-	-	-	-	-	-	-	-	-	-
	SA8	0	1	1	1	1	3	2	0	6	7	8
	SA9	1	9	10	1	0	4	2	0	6	7	17
	Combined	1	10	11	2	1	7	4	0	12	14	25

Table 4. Body length (m) of sei and Bryde's whales sampled during the 2016 JARPNII offshore survey.

Species	Sub area	Male					Female				
		n	mean	S.D.	min	max	n	mean	S.D.	min	max
Sei	SA7	2	13.71	0.64	13.25	14.16	2	12.70	0.68	12.22	13.18
	SA8	9	12.72	0.97	11.54	13.89	17	14.19	1.30	11.32	15.84
	SA9	27	13.38	0.97	10.99	14.65	33	13.78	1.02	11.86	15.29
	Combined	38	13.24	0.99	10.99	14.65	52	13.87	1.13	11.32	15.84
Bryde's	SA7	-	-	-	-	-	-	-	-	-	-
	SA8	1	13.04	-	13.04	13.04	7	12.72	1.28	10.21	13.61
	SA9	10	12.17	0.78	10.26	12.89	7	12.42	0.95	10.38	13.14
	Combined	11	12.25	0.79	10.26	13.04	14	12.57	1.10	10.21	13.61

Table 5. Prey species and stomach contents weight (1st. + 2nd. stomachs) in sei and Bryde's whales sampled during the 2016 JARPNII offshore survey.

Species	Dominant prey species		n	%	Range of weight (kg)
Sei					
	Krill		2	4.2	18.02 - 32.80
	Copepods	*Neocalanus* spp.	12	25.0	2.84 - 141.68
	Fish	Japanese anchovy	1	2.1	260.80
		Japanese sardine	9	18.8	5.52 - 478.73
		Mackerels	22	45.8	0.56 - 663.23
		Pacific saury	2	4.2	37.98 - 189.35
Bryde's					
	Krill		7	77.8	3.56 - 61.92
	Fish	Japanese anchovy	1	11.1	128.42
		Maurolicus japonicus	1	11.1	4.58

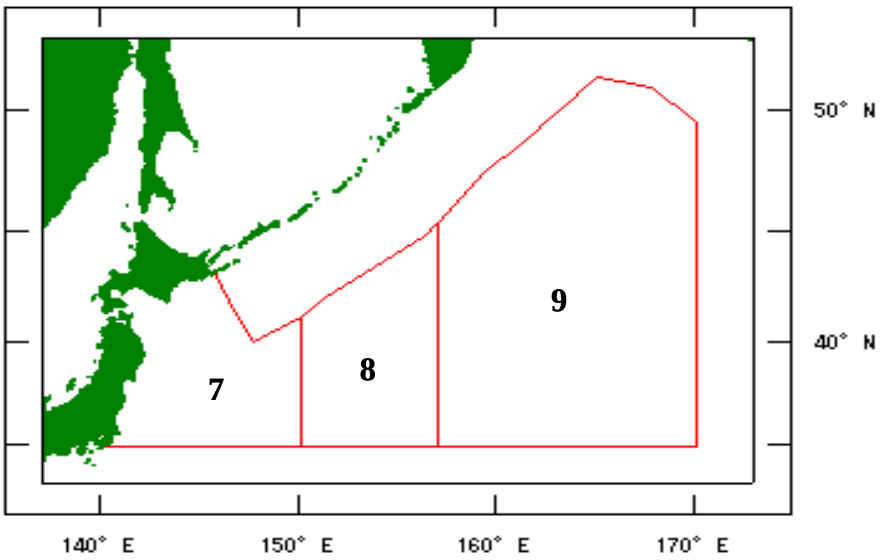

Figure 1. Research area of the JARPNII full-scale program.

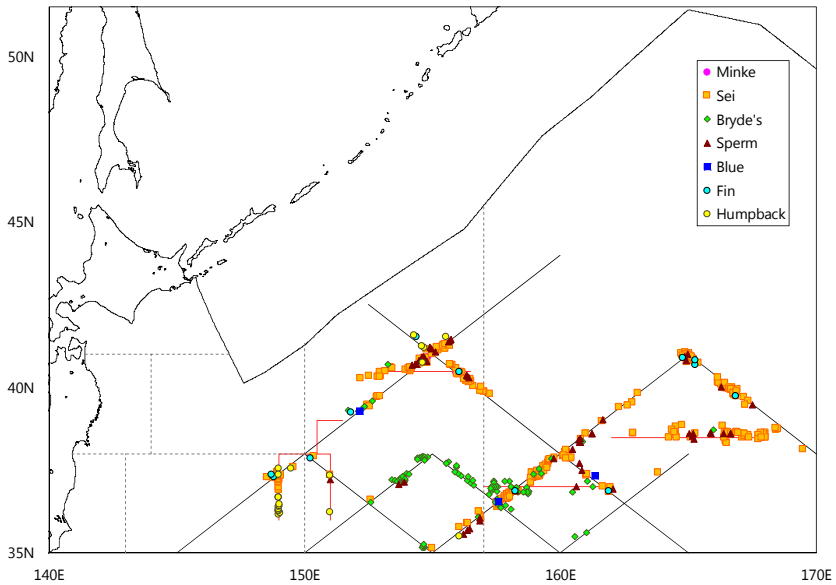

Figure 2. Track-lines and sighting positions of large whale species made by two sighting/sampling vessels (SSVs). Black line: Normal survey, Red line: SMS.

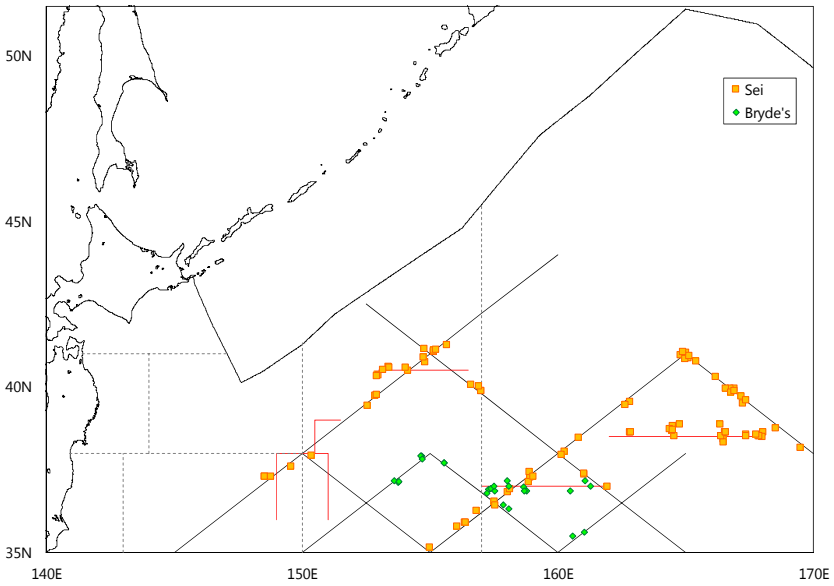

Figure 3. Sighting positions of sampled sei and Bryde's whales. Black line: Normal survey, Red line: SMS.

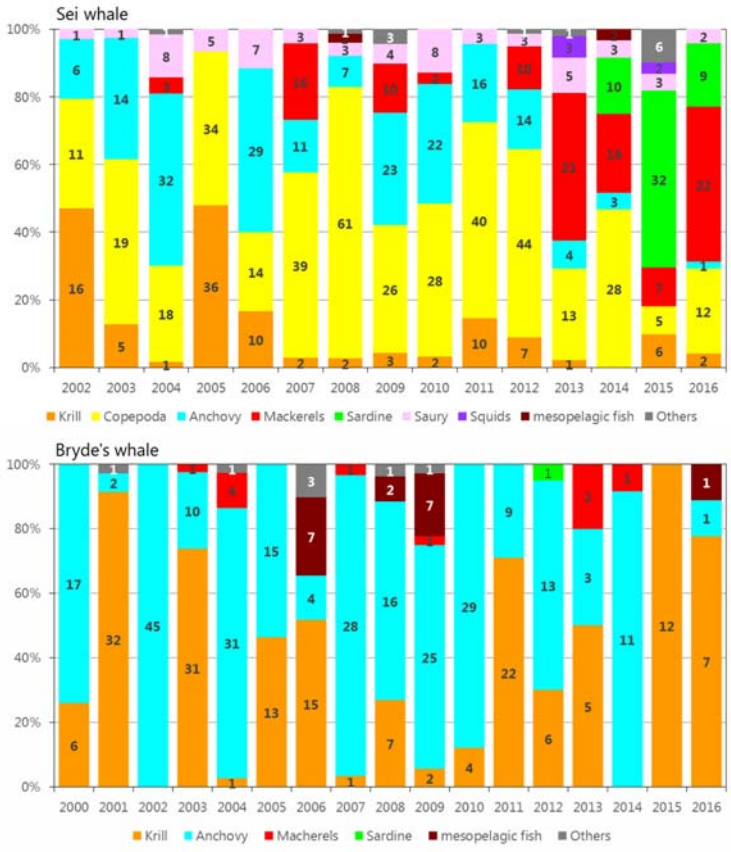

Figure 4. Composition of main prey species of sei (upper) and Bryde's (lower) whales sampled during the 2016 JARPNII offshore survey, with comparison to the previous surveys. The numbers in the graph show sample sizes.