TEREP-ICR

TECHNICAL REPORTS OF THE INSTITUTE OF CETACEAN RESEARCH

ICR

No. 6

December 2022

TEREP-ICR is published annually by the Institute of Cetacean Research.
ISSN: 2433-6084

Citation

Entire issue:

Institute of Cetacean Research. 2022. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)* No. 6. The Institute of Cetacean Research, Tokyo, Japan, 86 pp.

Individual reports:

'Author Name'. 2022. 'Report title'. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)* No. 6: 'pp'-'pp'.

Editorial correspondence should be sent to:
Editor, TEREP-ICR
The Institute of Cetacean Research,
4-5 Toyomi-cho, Chuo-ku, Tokyo 104-0055, Japan
Phone: +81(3) 3536 6521
Fax: +81(3) 3536 6522
E-mail: webmaster@icrwhale.org
TEREP-ICR is available online at www.icrwhale.org/TEREP-ICR.html

Cover photo: Fin whales against the background of the Hokkaido coast (top and middle); a common minke whale near the Japanese coast (bottom).

TECHNICAL REPORTS OF THE INSTITUTE OF CETACEAN RESEARCH

TEREP-ICR
No. 6

The Institute of Cetacean Research (ICR)
Tokyo, 2022

Foreword

It is a pleasure for me to introduce the sixth issue of the Technical Reports of the Institute of Cetacean Research (TEREP-ICR-6). Consistent with its stated objectives, TEREP-ICR describes and reports on the process, progress, and results of technical or scientific research, as well as the state of technical or scientific research programs conducted by the ICR, including those commenced recently as is the case of the Japanese Abundance and Stock structure Surveys in the Antarctic (JASS-A).

The Covid-19 pandemic has continued affecting the ways of conducting scientific research at the ICR. Despite the difficulties, inconveniences and limitations derived from the pandemic, during 2022 the ICR has been able to safely and successfully conducts field surveys, conducts laboratory works and analyses, and participates in national and international meetings. These efforts enabled the ICR to make significant progress on several research works during 2022 as shown in this issue of TEREP-ICR.

Similar as in previous TEREP-ICR issues, TEREP-ICR-5 was widely distributed in Japan and in foreign countries. Notwithstanding the challenges imposed by the pandemic, TEREP-ICR is on course towards achieving its objectives. At the same time, it has been a good opportunity for our scientists to compile and summarize their research conducted over the years, as a precursor to submitting their works for peer review publications.

I sincerely hope that this sixth issue of the TEREP-ICR will contribute further to an increased understanding among national and international scientific communities of the technical and research activities conducted by the ICR.

Dr. Yoshihiro Fujise
Director General
Institute of Cetacean Research
Tokyo, December 2022

Editorial

Welcome to the sixth issue of the Technical Reports of the Institute of Cetacean Research (TEREP-ICR-6).

This issue contains seven technical reports and one commentary article. In TEREP-ICR-6, we started with the series of reports summarizing the research findings on whales and the ecosystem in the western North Pacific Ocean.

Regarding the research findings in the western North Pacific, Taguchi and colleagues (Part 1) focused on the studies on stock structure in large baleen whale species. These studies have been possible because the ICR holds one of largest collection of genetic samples in this oceanic basin, which derived from both past whale research programs under special permit and biopsy samples collected during dedicated sighting surveys. Takahashi and colleagues (Part 2) focused on the results of abundance estimates of baleen whale species based on sighting data collected systematically during dedicated sighting surveys. Bando and colleagues (Part 3) focused on the results of biological parameters in baleen whale species based on samples and data collected during past whale research programs under special permits.

Results of three important dedicated sighting surveys are summarized in this issue: Isoda and colleagues summarized the results of the 2021/22 austral summer season survey of the Japanese Abundance and Stock structure Surveys in the Antarctic (JASS-A); Katsumata and Matsuoka summarized the results of surveys conducted in the North Pacific Ocean in 2021; and Murase summarized the results of the 2021 International Whaling Commission-Pacific Ocean Whale and Ecosystem Research (IWC-POWER) survey.

Konishi and Isoda summarized the results of the long-term track movement of Antarctic minke whales revealed by satellite-monitored tagging experiments conducted by the ICR, and examined these preliminary results in the context of the available stock structure hypothesis derived from genetic analyses.

In the commentary article, Gómez Díaz presented his view on the development and relevance of the ICR in the context of recent whaling events in Japan and the world.

TEREP-ICR-6 issue also includes sections that outline the contribution of ICR scientists to international and national meetings in 2022, as well as their contribution in terms of peer-reviewed publications up to December 2022.

We trust that you will find this sixth issue informative and useful.

Dr. Luis A. Pastene
Dr. Satoko Inoue
Editorial Team, TEREP-ICR
Tokyo, December 2022

Contents

Technical Reports of the Institute of Cetacean Research (2022) pp. 1–10

Technical Report

What do we know about whales and ecosystem in the western North Pacific Ocean? Part 1: summary of results on stock structure in baleen whale species

Mioko TAGUCHI*, Mutsuo GOTO and Luis A. PASTENE

Institute of Cetacean Research, 4–5 Toyomi-cho, Chuo-ku, Tokyo 104–0055, Japan

**Contact e-mail: taguchi@cetacean.jp*

ABSTRACT

Identification of biological stocks within a species is fundamental to appropriately interpret demographic parameters. Information on the temporal-spatial stock structure is crucial in establishing effective management and conservation strategies of marine living resources. This paper summarizes the recent genetic studies on stock structure of four baleen whale species in the North Pacific: right, sei, Bryde′s and common minke whales. These studies used a large number of genetic samples collected mainly in surveys conducted by the Institute of Cetacean Research since 1994. Results of the studies revealed novel stock structures, and this information is contributing to stock assessments and conservation of each whale species in the North Pacific.

INTRODUCTION

Different biological stocks could have different demographic characteristics and respond in different ways to environmental stress. For this reason, the identification of stocks in a species is fundamental for the appropriate interpretation of abundance estimation and other demographic parameters. Information on the temporal-spatial stock structure is thus crucial in establishing effective management and conservation strategies. In this regard, Moritz (1994) defined management units (MUs) as historically isolated sets of populations and suggested that genetic markers be used to define management units within species: populations with a significant divergence of allele frequencies at nuclear or mitochondrial loci, regardless of the phylogenetic distinctiveness of the alleles.

This paper describes the outline of the recent studies which examine genetic diversities and stock structure based on the MUs defined by Moritz (1994) for the four North Pacific whale species: right (*Eubalaena japonica*), sei (*Balaenoptera borealis*), Bryde′s (*B. brydei*) and common minke whales (*B. acutorostrata*).

BACKGROUND ON GENETIC STUDIES ON STOCK STRUCTURE IN NORTH PACIFIC BALEEN WHALES

North Pacific right whales

LeDuc *et al.* (2012) was the first study that focused on North Pacific right whale′s stock structure and genetic diversity. The study using the mitochondrial DNA (mtDNA) control region and six microsatellite DNA (msDNA) loci, mainly showed the potential parentage and genetic diversity in 24 individual whales (23 from the eastern North Pacific and one from the western North Pacific). Their results inferred that North Pacific right whales could be isolated to some degree between the western and eastern regions based on paternity analysis. However, it was noted that the relationship of the eastern North Pacific right whales to those in the western North Pacific was largely unexamined.

Sei whales

A pioneering work on stock structure of North Pacific sei whales was carried out on the feeding grounds by Wada and Numachi (1991) using three polymorphic allozyme loci, which suggested a single stock in the area east of 160°E. The most comprehensive genetic study was performed by Kanda *et al.* (2009c) using msDNA genotypes at 17 loci and mtDNA control region sequences from a total of 790 specimens collected on the feeding grounds between 140°E and 135°W during 1972–1973 and 2002–2007. The study also showed no evidence of genetic heterogeneity in the research area. Kanda *et al.* (2013) subsequently examined genetic differences of this species both spatially and temporally. The results of the study were consistent with those found by Kanda *et al.* (2009). In addition, Kanda *et al.* (2015) examined spatial genetic differentiation using genotypes at 16 msDNA loci by only using samples collected during the summers in 2010, 2011 and 2012 in order to eliminate temporal negative biases. The study again did not find evidence of multiple stocks of sei whales in the North Pacific.

Bryde′s whales

A series of allozyme studies (Wada and Numachi, 1991; Wada, 1996) were conducted using Bryde′s whale samples collected between 150°E and 160°W, on the North Pacific feeding grounds. These studies did not find evidence of genetic heterogeneity in the research area. A subsequent RFLP analyses investigated the pattern of genetic variations of Bryde′s whales at intra- and inter-oceanic levels for mtDNA control region in specimens from four locations: western North Pacific, western South Pacific, eastern South Pacific and eastern Indian Oceans (Pastene *et al.*, 1997). The study showed significant genetic differences among the four regions, but did not reveal any significant genetic differences within the western North Pacific Ocean. The most recent population genetic study was performed by Kanda *et al.* (2007), using msDNA genotypes at 17 loci and mtDNA control region sequences in a sample set used by Pastene *et al.* (1997), as well as additional samples from the western North Pacific feeding grounds. The study confirmed significant genetic differentiations among oceanic regions, but not within the western North Pacific.

Common minke whales

At least two stocks of the common minke whales have been historically recognized in the western North Pacific, namely the Okhotsk Sea–West Pacific (known as the O-stock) and the Sea of Japan–Yellow Sea–East China Sea (known as the J-stock). These two stocks are differentiated morphologically, reproductively (Omura and Sakiura, 1956; Kato, 1992) and genetically (Wada and Numachi, 1991; Goto and Pastene, 1997), which suggests their reproductive isolation.

Kanda *et al.* (2009a; b) examined genetic variations at 16 msDNA loci in a total of 2,542 genetic samples collected in the waters around Japan and pelagic areas of the western North Pacific during 1994–2007, and succeeded in the assignment of individual to stocks using a Bayesian clustering approach, i.e. STRUCTURE analysis. The study presented the highest likelihood probability at $K=2$, which indicated that the samples came from two genetically distinct populations, i.e. O- and J-stocks.

Pastene *et al.* (2016a) updated these studies by increasing sample sizes, and showed a finer spatial distribution of each stock (Figure 1): J-stock whales mainly distributed in the Sea of Japan (sub-areas 6E and 10E), O-stock whales mainly distributed in the offshore North Pacific (east of sub-area 7WR). Both stocks occur along the Pacific coast of Japan (sub-areas 7CN, 7CS and 2C) and in the southern Okhotsk Sea (sub-area 11) but sub-area 2C is mainly occupied by the J-stock whales. Furthermore, the study showed the temporal distribution of the O- and J-stock whales on the Pacific side of Japan (sub-areas 2C, 7CN and 7CS) as shown in Figure 2: J-stock whales are predominant throughout the year in sub-area 2C, while the proportion of the J-stock whales increases in autumn/winter and decreases in spring/summer in sub-areas 7CS and 7CN. The reverse is true for O-stock.

A subsequent study by Pastene *et al.* (2016b) investigated the possibility of additional structure within O-stock using hypothesis testing and the discriminant analysis of principal component (DAPC) approach. A simulation exercise showed that the statistical power of

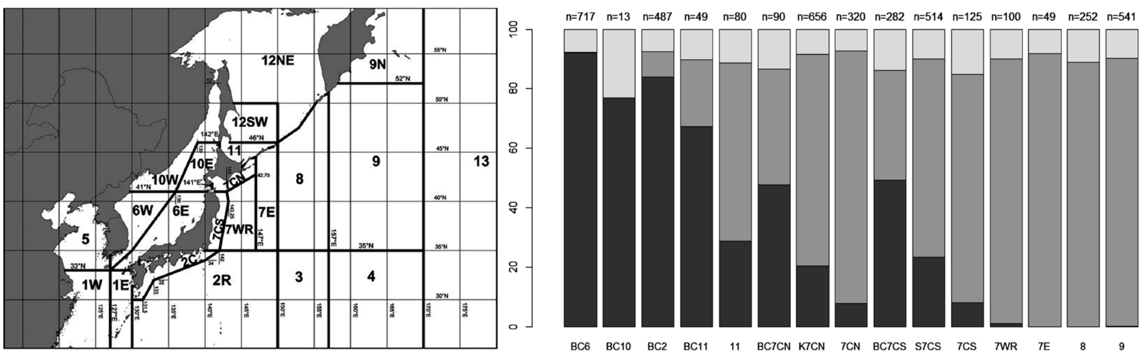


Figure 1. Management sub-areas defined by the IWC for the western North Pacific common minke whales (left), and spatial occurrence of O- and J-stocks in sub-areas (right: BC2, BC6, BC7CS, BC7CN, BC10, BC11=bycatches from the respective areas; K7CN=coastal JARPNII surveys at Kushiro; S7CS=coastal JARPNII surveys at Sanriku; 7CS, 7CN, 7WR, 7E, 8, 9 and 11=offshore JARPN/JARPNII surveys). Sample sizes are at the top of each bar. Color indicates stock assignment by STRUCTURE analysis (gray=O-stock, dark gray=J-stock, light gray=unassigned).

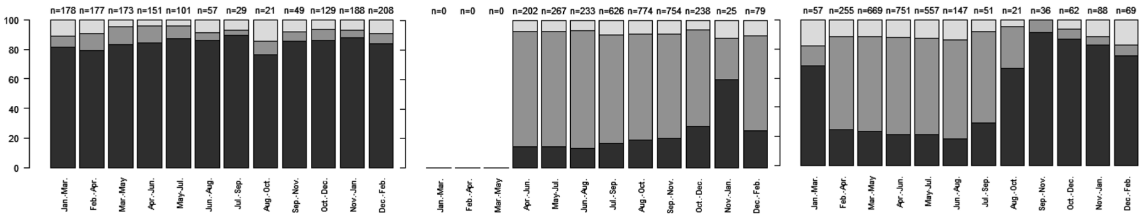


Figure 2. Monthly occurrence of J- and O-stocks in sub-areas 2C (left), 7CN (middle) and 7CS (left). Each bar is expressed as three months moving average. Sample sizes are on the top of each bar. Samples from sub-area 2C and subareas 7CN and 7CS were collected during 2001–2014 and 1994–2014, respectively. Color indicates stock assignment by STRUCTURE analysis (dark gray=J-stock, gray=O-stock, light gray=unassigned).

the hypothesis testing was high. Both analyses showed no evidence of sub-structuring within O-stock.

Tiedemann *et al.* (2017) developed a new maximum likelihood-based approach to infer Parent–Offspring (P–O) relationships using full msDNA data at 16 loci in a total of 4,554 western North Pacific common minke whales including fetuses. The study identified a total of 49 validated P–O pairs (excluding mother-fetus pairs) across sub-areas, with J-stock pairs on both sides of Japan closer to the coast, while O-stock pairs were mostly located to the east of Japan, both close to the coast as well as far offshore. The study provided no evidence for further stock structure other than O- and J-stocks.

RECENT GENETIC STUDIES ON STOCK STRUCTURE IN THE NORTH PACIFIC

Basic laboratory procedures

DNA extraction

Total genomic DNA was extracted from 0.05 g of a tissue sample using either the standard phenol-chloroform method (Sambrook *et al.*, 1989) or Gentra Puregene kits (QIAGEN) and stored in TE buffer (10 mM Tris-HCl, 1 mM EDTA, pH 8.0).

mtDNA

Approximately 500 base pairs of a variable part of the mtDNA control region were amplified by PCR using primers MT4 (Árnason *et al.*, 1993) and Dlp5R (5′-CCA TCG AGA TGT CTT ATT TAA GGG GAA C-3′; Pastene *et al.*, 2022). PCR amplification was carried out in 25 µl reaction mixtures containing 10–100 ng of template DNA, 0.1 µM of each primer, 0.5 units of *Ex Taq* DNA polymerase (Takara Bio Inc., Shiga, Japan), 0.2 mM of dNTPs, and 1× *Ex Taq* buffer. Each reaction was performed with an initial denaturation step at 95°C for 5 min, followed by 30 cycles of 30 s at 94°C, 30 s at 50°C and 30 s at 72°C, with a final extension step at 72°C for 10 min. PCR products were purified using MicroSpin S-400HR Columns (GE Healthcare, Illinois, USA). Cycle sequencing was performed using BigDye terminator cycle sequence Kit (Applied Biosystems Inc., Massachusetts, USA), following the manufacturer's instructions. The cycle sequencing products were purified using AutoSeq G-50 spin Columns (GE Healthcare). The labeled sequencing fragments were resolved by ABI genetic analyzers (Applied Biosystems Inc.) for Sanger sequencing by capillary electrophoresis. Both strands of all samples were sequenced using the primers used for amplification. The nucleotide sequences obtained were aligned by using the program MUSCLE implemented in MEGA ver. 10.0.5 (Kumar *et al.*, 2018) or the program Sequence Navigator.

msDNA

Different nuclear msDNA loci were genotyped according to the whale species (Table 1). The polymerase chain reaction (PCR) amplifications were performed in 15 µl reaction mixtures containing 10–100 ng of DNA, 0.25 µM of each primer, 0.35 units of *Ex Taq* DNA polymerase (Takara Bio Inc.), 0.2 mM of dNTPs, and 1× *Ex Taq* buffer, with 94°C for 2 min, followed by 30 cycles at 94°C for 20 s/54–61°C for 45 s/72°C for 1 min, and a post-cycling extension at 72°C for 10 min. Negative and positive control samples, one of each, were run in parallel with all PCR amplifications. The PCR products were run on a BaseStation100 DNA fragment analyzer (Bio-Rad, California, USA) with an internal size standard (GENESCAN400HD, Applied Biosystems Inc.), or on an ABI 3500 DNA Analyzer (Applied Biosystems Inc.) with a 600 LIZ size standard (Applied Biosystems Inc.). In the former platform, alleles were visualized using Cartographer software specifically designed for the BaseStation, and the fragment sizes were determined manually in relation to the internal size standard and a positive control sample of known size that were run on each gel. In the other platform, each allele was determined by automated binning and assigned to allelic bins predefined in GeneMapper v. 4.0 (Applied Biosystems Inc.). Any misassigned scores were corrected by hand. If msDNA scores generated from both platforms were

Table 1
msDNA markers used in the recent studies on four North Pacific baleen whales.

Norht Pacific right whale	Sei whale	Bryde's whale	Common minke whale
EV1	EV94	DlrFCB14	EV1
EV14	EV1	EV1	EV14
EV21	GT211	EV104	EV21
EV37	EV14	EV14	EV37
EV94	EV21	EV21	EV94
GT023	GGAA520	EV94	GATA28
GT211	GATA53	GATA28	GATA98
GT310	GT23	GATA417	GATA417
GATA028	GT575	GATA53	TAA31
DlrFCB17	GATA417	GATA98	GT23
TR3G2	GT310	GGAA520	GT195
TR2G5	EV104	GT011	GT211
TR3F2	GATA28	GT23	GT310
	GT271	GT310	GT509
	GT011	GT575	GT575
	DlrFCB17	TAA31	DlrFCB14
	GATA98		

Table 2
Genetic analyses used in the recent studies on four North Pacific baleen whales.

Analysis	North Pacific right whale		Sei whale		Bryde's whale		Common minke whale	
	mtDNA	msDNA	mtDNA	msDNA	mtDNA	msDNA	mtDNA	msDNA
Genetic diversity indices	●	●	●	●	●	●	●	●
HWE test	●	●	●	●	●	●	●	●
Hypothesis test	●		●	●	●	●	●	●
F_{ST} estimates	●		●	●	●	●	●	●
G'_{ST} estimates						●		
AMOVA			●	●	●	●		
Mantel test						●		
STRUCTURE				●				●
DAPC						●		●
sPCA								●
GENELAND								●
BAPS								●
TESS								●
Phylogenetic analyses	●				●			
PO analysis								●

contained in a single dataset, then all msDNA scores generated by the ABI 3500 DNA Analyzer were standardized to those by the BaseStation100 DNA fragment analyzer.

Basic analytical procedures

The analytical procedures used in the recent genetic studies on population structure are shown in Table 2 for each whale species.

This section briefly explains these analytical procedures.

Genetic diversity indices

mtDNA haplotype (h) and nucleotide (π) diversities (Nei, 1987) were estimated with sample standard deviations. The number of alleles (A), inbreeding coefficient (F_{IS}) and expected heterozygosity (H_E) were estimated per msDNA locus and across loci. The departure from Hardy–Weinberg equilibrium (*HWE*) was also tested for each msDNA locus and across loci.

Genetic differentiation

The genetic difference between populations was examined by several statistical tests for differences in allele/haplotype frequencies between populations, as well as by pairwise F_{ST} estimates and G'_{ST} values (Hedrick, 2005). The Analysis of Molecular Variance (AMOVA) (Excoffier *et al.*, 1992) was used to examine the hierarchical genetic structure. A Mantel test was performed between a matrix of pairwise Edward's genetic distances and a matrix of Euclidian geographic distances to examine the pattern of isolation by distance (IBD).

Genetic clustering and stock assignment approaches

Estimation of the most likely number of clusters and/or individual-based stock assignment were performed using a Bayesian clustering analysis with an admixture model assuming correlated allele frequencies implemented in STRUCTURE program (Pritchard *et al.*, 2000).

To identify and describe clusters of genetically related individuals, a Discriminant Analysis of Principal Components (DAPC; Jombart *et al.*, 2010), which relies on data transformation using Principal Components Analysis as a prior step to discriminant analysis, was performed with or without *a priori* group assignments for msDNA genotype set. *A priori* group was determined based on geographic sampling site.

The spatially explicit clustering approaches, e.g. spatial Analysis of Principal Components (sPCA; Jombart *et al.*, 2008), GENELAND (Guillot *et al.*, 2005), TESS (François *et al.*, 2006; Chen *et al.*, 2007) and BAPS (Corander *et al.*, 2008), have been also used to investigate genetic structure and stock assignment.

Phylogeographic analysis

A statistical parsimony network (Clement *et al.*, 2000) was generated to infer the phylogenetic relationships among mtDNA haplotypes.

Parent–offspring analysis

Parent–Offspring (P–O) relationships were inferred based on a maximum-likelihood approach (Tiedemann *et al.*, 2017). mtDNA haplotypes and biological information, e.g. sex, sexual maturity and sampling position, were used to interpret the inferred P–O pairs. The geographical distribution of the pairs was discussed from the view point of stock structure.

Main results

North Pacific right whales

Dataset

Pastene *et al.* (2022) summarized and analyzed all available genetic data for North Pacific right whales. After removing all duplicates (i.e. samples that were collected from the same individual) and one sample from each mother and calf pair, a single dataset was generated for the mtDNA statistical analyses, which consisted of 30 samples each in the western North Pacific (WNP: 27 new samples, one from LeDuc *et al.* [2012] and two historical baleen samples) and the eastern North Pacific (ENP: 21 samples from LeDuc *et al.* [2012], three historical baleen samples and six new samples), respectively (Figure 3); the sample size for the msDNA analysis was 19 whales for WNP.

Main results and discussion

The study found a total of 16 haplotypes among 60 individual whales. Only four haplotypes were shared between WNP and ENP right whales. The F_{ST} between WNP and ENP right whales was high (0.128) and statistically significant, and the heterogeneity test resulted in statisti-

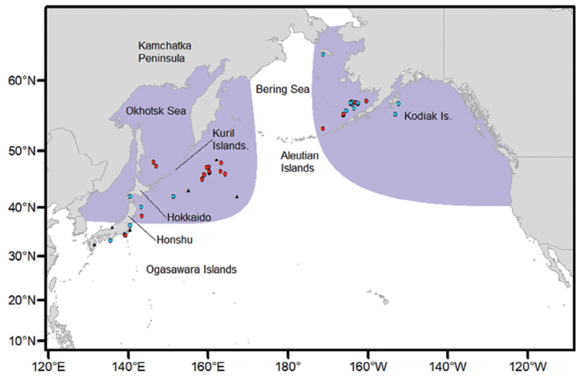


Figure 3. Approximate core distribution of North Pacific right whales in summer (July–August) based on 19th century whaling records and 20th century sighting and whaling catch data compiled by Clapham *et al.* (2004). The pattern of distribution shows high density in the western and eastern sides of the North Pacific (purple) and low density in the central area (white). The monthly plots of right whale sightings and catches by Clapham *et al.* (2004) suggested a pattern of south–north migratory movement in spring (March–May) to summer (June–August) on both sides of the North Pacific. The figure also shows the distribution of genetic samples examined in the recent study (Pastene *et al.*, 2022). Most of the samples from the eastern side are from LeDuc *et al.* (2012). Symbol color indicates sexes (red=female, blue=male, black=unidentified).

cally significant differences between whales on both sides of the North Pacific; however, there was no concordance between geography and haplotype network pattern.

The number of msDNA alleles per locus ranged from 2 to 7 (4.08 on average), and the H_E ranged from 0.285 to 0.787 (0.593 on average). The F_{IS} in each locus ranged from 0.045 to 0.350 with 0.032 on average. The study found no significant deviations from *HWE* across loci.

The mtDNA results, suggesting some degree of population structuring, were consistent with the pattern of catch and sighting data showing higher densities on either side of the North Pacific, but little in between as shown in Figure 3 (Clapham *et al.*, 2004). These findings support the hypothesis of different populations occurring in the eastern and western sides of the North Pacific. The authors also suggested the possibility of incomplete lineage sorting of ancestral polymorphisms from a lack of structure in haplotype network.

An alternative interpretation on these results was that there is a single interbreeding population in the North Pacific that is exhibiting mtDNA structuring as a result of matrilineally driven seasonal site fidelity. Although the authors could not rule out the alternative interpretation, they considered, as the more plausible, the hypothesis of two discrete breeding populations of right whales on both sides of the North Pacific since such hypothesis is supported also by the pattern of catches and sighting distribution, and different catch and recovery histories (Brownell *et al.*, 2001; Clapham *et al.*, 2004).

Sei whales

Dataset

A single dataset consisting of mtDNA control region sequences (n=1,733) and msDNA genotypes at 17 loci (n=1,729) was generated from specimens of sei whales collected from different sources (Figure 3: Appendix 7 in Tamura *et al.*, 2019). The genetic data generated from these samples were divided into three areas for the purpose of data analyses (Figure 4).

Main results and discussion

Pairwise F_{ST} estimates between areas showed no evidence of genetic heterogeneity in North Pacific sei whales for both genetic markers. These results were also supported by AMOVA and STRUCTURE analyses, which showed a lack of genetic structuring of this species in the oceanic areas of the North Pacific. These findings were also consistent with results of comparable genetic diversities among areas as well as the results from the tests of *HWE* and F_{IS} estimates. Overall, the recent refined analyses supported a single stock hypothesis as suggested

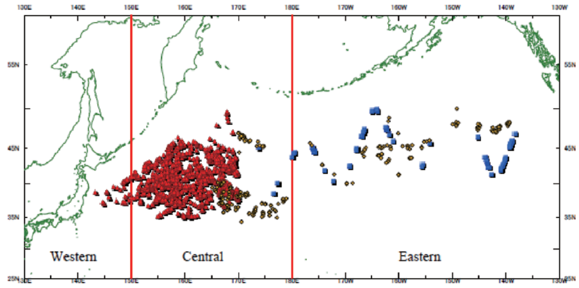


Figure 4. Sampling position of sei whales used in the recent genetic analyses (Appendix 7 in Tamura *et al.*, 2019). Color indicates sample source; yellow: historical commercial whaling during 1972–1973, red: JARPNII during 2002–2016, and blue: POWER during 2010–2013. Solid red line shows subareas. The genetic data was stratified according to the three areas, i.e. western, central and eastern, for data analyses.

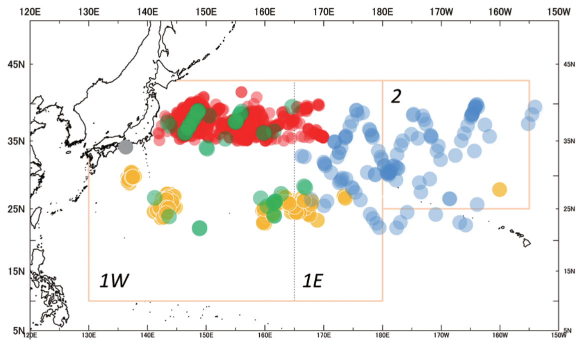


Figure 5. Sampling position of Bryde's whales used in the genetic analysis in Taguchi *et al.* (in press). Color indicates sample source; yellow: historical commercial whaling operated in 1979 and 1983–1984, red: JARPNII during 2000–2016, blue: POWER during 2013–2016, green: dedicated sighting survey in 2012 and 2014, and gray: bycatch in 2010. Areas enclosed by solid and dashed lines are sample stratification according to management areas for the western North Pacific Bryde's whales defined by the IWC scientific committee (IWC, 2008; 2018). Multiple genetic samples that were collected outside of these areas were assigned to the longitudinally closest area, i.e. area 2.

previously.

Bryde's whales

Dataset

In the most recent study (Taguchi *et al.*, in press), a total of 1,182 msDNA genotype sets at 17 loci and 1,195 mtDNA control region sequences were analyzed (Figure 5). These data were divided into the three management areas for the purpose of data analyses (Figure 5).

Main results and discussion

According to Taguchi *et al.* (in press), genetic diversities were similar among areas and a haplotype network did not show any geographic structure. However, an AMOVA found evidence of genetic structure in this species. Pairwise F_{ST} and G'_{ST} estimates, as well as heterogeneity tests, attributed this genetic structure to weak, but significant differentiation between areas 1W and 2. Furthermore, a Mantel test and a high-resolution analysis of genetic diversity statistics showed a weak spatial cline of genetic differentiation.

Given that this study focused on whales in their feeding grounds, these findings could be reconciled by two possible scenarios: (1) the occurrence of a single population with kin-association being responsible for feeding ground preference, and (2) the occurrence of two populations, with feeding ground preference for either area 1W or area 2; both populations mix geographically through area 1E. The results from the DAPC were not inconsistent with these scenarios. Given an estimated dispersal rate of less than 2% between areas 1W and 2, which indicates some demographic independency among whales in these two areas, both scenarios should be considered based on the precautionary principle in stock assessments.

Common minke whales

Recent genetic works have focused on refining the two-stock hypothesis, O- and J-stocks, as well as investigating whether additional structure exists within each stock.

Dataset

Recent studies have been based on mtDNA control region sequences (n=4,706) and msDNA genotype sets at 16 loci (n=4,707). The genetic samples were collected during the Japanese Whale Research Programs under Special Permit in the western North Pacific, Phases I and II (JARPN/JARPNII) conducted systematically in the western North Pacific during spring–summer from 1994 to 2016, as well as from bycatches which occurred along the Japanese coast from 2001 to 2016.

Main results and discussion

P–O inferences and their geographical distribution

Goto *et al.* (2019) updated the analysis by Tiedemann *et al.* (2017), and identified a total of 40 and 13 P–O pairs for O- and J-stocks, respectively. The O-stock pairs were found between coastal and offshore waters, while J-stock pairs were distributed within and between the Sea of Japan and the Pacific side of Japan (Figure 6). These results provided no evidence for further stock structure other than O- and J-stocks.

Spatially explicit clustering analyses

The results of sPCA in conjunction with those of DPAC suggested the occurrence of the O- and J-stocks but provided no evidence for additional structure in each stock (Taguchi *et al.*, 2019a), which was also supported by the mtDNA analyses. These findings indicated a low possibility that multiple stocks exist (other than the J- and O-stocks) in the study area with overlapping geographic ranges.

A study by de Jong and Hoelzel (2019) using three other spatially explicit clustering tools including GENELAND, TESS and BAPS showed different patterns of clustering, and the authors stated that the most informative approach was GENELAND using the mixture model with correlated allele frequency model which supported K=4. However, an additional work subsequently undertaken by Taguchi *et al.* (2019b) examined the correspondence of the four clusters by GENELAND with the available genetic and non-genetic information, and concluded that the

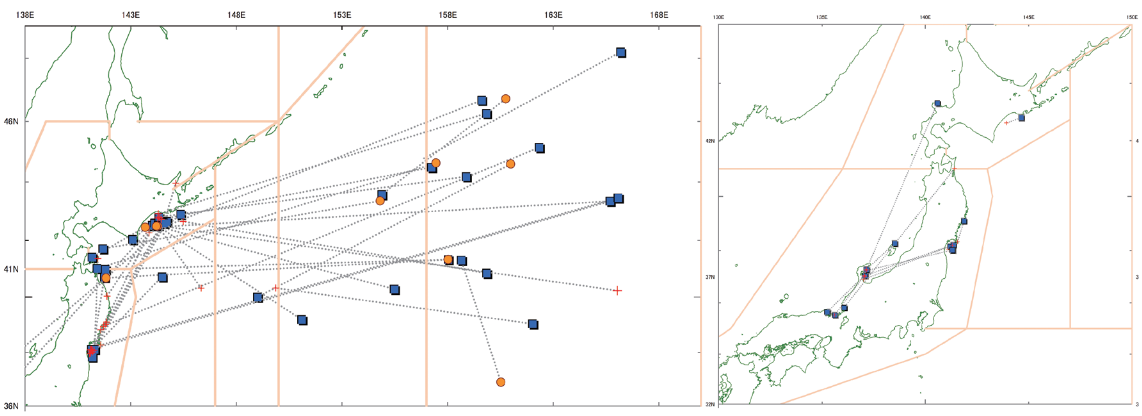


Figure 6. Distribution of parent–offspring pairs of O- (left) and J-stocks (right) in western North Pacific common minke whale (blue square: parent, orange circle: mature offspring, red cross: immature or unknown offspring).

most plausible scenario was for two populations (O- and J-stocks) with complex spatial and temporal mixing along the Pacific coast of Japan. de Jong and Hoelzel (2019) further noted that some of the analyses conducted were consistent with a scenario of coastal areas containing genetically admixed individuals, and recommended further analyses under the GENELAND as well under the TESS and BAPS.

CONCLUDING REMARKS

Over the last two decades, many genetic studies focused on stock identification and structure in western North Pacific baleen whales have been undertaken. The driving force behind these analyses was to obtain information to assist in determining effective conservation and management. Of necessity, these studies were based on genetic samples collected on feeding grounds and migratory corridors. In this context, they are based on the concept of MUs described by Moritz (1994). The recent studies summarized in this paper used several increasingly sophisticated clustering approaches for the purpose of identifying stocks, which showed statistical results consistent with this criterion for defining stocks and contributed to their stock assessment. It is also important to make effort to investigate the stock structure of baleen whales distributed in unsurveyed areas including breeding grounds, and the genetic relationship of them with whales distributed around Japan.

FUTURE WORKS

Genetic samples for other baleen whale species in the western North Pacific (i.e. humpback whales, fin whales and blue whales) are also available at the ICR. The genetic data generated from these samples will be analyzed in the near future to investigate their stock structure.

The development of a new genetic marker, which is less error-prone than msDNA, i.e. SNP (Single Nucleotide Polymorphism) is on-going at the ICR. This marker will be used to perform the genetic analyses for all whale species of interest. Such analyses will aid in a better understanding of stock structure of baleen whales in the western North Pacific.

ACKNOWLEDGEMENTS

We thank all of the whalers and researchers who contributed to the collection of samples. We are grateful to all technicians for their laboratory works at the ICR. We would also like to thank Naohisa Kanda who organized most of the msDNA data used in the studies summarized in this paper. We thank the Editorial Team of TEREP-ICR for the editorial work on this manuscript.

REFERENCES

Árnason, Ú., Gullberg, A. and Widegren, B. 1993. Cetacean mitochondrial DNA control region: sequences of all extant baleen whales and two sperm whale species. *Molecular Biology and Evolution* 10 (5): 960–970.

Brownell, R.L., Clapham, P.J., Miyashita, T. and Kasuya, T. 2001. Conservation status of North Pacific right whales. *J. Cetacean Res. Manage.* (special issue) 2: 269–286.

Chen, C., Durand, E., Forbes, F. and François, O. 2007. Bayesian clustering algorithms ascertaining spatial population structure: A new computer program and a comparison study. *Molecular Ecology Notes* 7 (5): 747–756.

Clapham, P.J., Good, C., Quinn, S.E., Reeves, R.R., Scarff, J.E. and Brownell Jr, R.L. 2004. Distribution of North Pacific right whales (*Eubalaena japonica*) as shown by 19th and 20th century whaling catch and sighting records. *J. Cetacean Res. Manage.* 6: 1–6.

Clement, M., Posada, D. and Crandall, K.A. 2000. TCS: A computer program to estimate gene genealogies. *Molecular Ecology* 9 (10): 1657–1659.

Corander, J., Marttinen, P., Sirén, J. and Tang, J. 2008. Enhanced Bayesian modelling in BAPS software for learning genetic structures of populations. *BMC Bioinformatics* 9: 539.

Excoffier, L., Smouse, P.E. and Quattro, J.M. 1992. Analysis of molecular variance inferred from metric distances among DNA haplotypes: Application to human mitochondrial DNA restriction data. *Genetics* 131 (2): 479–491.

François, O., Ancelet, S. and Guillot, G. 2006. Bayesian clustering using hidden Markov random fields in spatial population genetics. *Genetics* 174 (2): 805–816.

Goto, M. and Pastene, L.A. 1997. Population structure of the western North Pacific minke whale based on an RFLP analysis of the mtDNA control region. *Rep. int. Whal. Commn* 47: 531–537.

Goto, M., Taguchi, M. and Pastene, L.A. 2019. A note with an update of the parent–offspring genetic analyses in the western North Pacific common minke whales. Paper SC/F19/WNPM/03 presented to the First Intersessional Workshop on the Implementation Review for western North Pacific minke whales, February 2019 (unpublished). 5 pp. [Available from the IWC Secretariat].

Guillot, G., Mortier, F. and Estoup, A. 2005. GENELAND: A computer package for landscape genetics. *Molecular Ecology Notes* 5 (3): 712–715.

Hedrick, P.W. 2005. A standardized genetic differentiation measure. *Evolution* 59 (8): 1633–1638.

International Whaling Commission. 2008. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure (RMP). *J. Cetacean Res. Manage*. (Suppl.) 10: 90–120.

International Whaling Commission. 2018. Report of the workshop on the Implementation Review of western North Pacific Bryde′s whales. *J. Cetacean Res. Manage.* (Suppl.) 19: 561–593.

Jombart, T., Devillard, S., Dufour, A.-B. and Pontier, D. 2008. Revealing cryptic spatial patterns in genetic variability by a new multivariate method. *Heredity* 101: 92–103.

Jombart, T., Devillard, S. and Balloux, F. 2010. Discriminant analysis of principal components: A new method for the analysis of genetically structured populations. *BMC Genet.* 11 (1): 1–15.

de Jong, M. and Hoelzel, R.A. 2019. Collaborative analysis of WNP minke whale stock structure using Japanese microsatellite DNA database and spatially explicit population structure analyses. Paper SC/F19/WNPM/02 presented to the First Intersessional Workshop on the Implementation Review for western North Pacific minke whales, February 2019 (unpublished). 25 pp. [Available from the IWC Secretariat].

Kanda, N., Goto, M., Kato, H., McPhee, M.V. and Pastene, L.A. 2007. Population genetic structure of Bryde′s whales (*Balaenoptera brydei*) at the inter-oceanic and trans-equatorial levels. *Conserv. Genet.* 8 (4): 853–864.

Kanda, N., Goto, M., Kishiro, T., Yoshida, H., Kato, H. and Pastene, L.A. 2009a. Individual identification and mixing of the J and O stocks around Japanese waters examined by microsatellite analysis. Paper SC/J09/JR26 presented to the JARPNII Review Workshop, January 2009 (unpublished). 9 pp. [Available from the IWC Secretariat].

Kanda, N., Goto, M., Kishiro, T., Yoshida, H., Kato, H. and Pastene, L.A. 2009b. Update of the analyses on individual identification and mixing of the J and O stocks around Japanese waters examined by microsatellite analysis. Paper SC/61/JR5 presented to the IWC Scientific Committee, May 2009 (unpublished). 14 pp. [Available from the IWC Secretariat].

Kanda, N., Yoshida, H., Goto, M. and Pastene, L.A. 2009c. Stock structure of sei whales in the North Pacific as revealed by microsatellite and mitochondrial DNA analyses. Paper SC/J09/JR32 presented to the JARPNII Review Workshop, January 2009 (unpublished). 14 pp. [Available from the IWC Secretariat].

Kanda, N., Matsuoka, K., Yoshida, H. and Pastene, L.A. 2013. Microsatellite DNA analysis of sei whales obtained from the 2010–2012 IWC-POWER. Paper SC/65a/IA05 presented to the IWC Scientific Committee, June 2013 (unpublished). 6 pp. [Available from the IWC Secretariat].

Kanda, N., Matsuoka, K., Goto, M. and Pastene, L.A. 2015. Genetic study on JARPNII and IWC-POWER samples of sei whales collected widely from the North Pacific at the same time of the year. Paper SC/66A/IA/08 presented to the IWC Scientific Committee, May 2015 (unpublished). 7 pp. [Available from the IWC Secretariat].

Kato, H. 1992. Body length, reproduction and stock separation of minke whales off northern Japan. *Rep. int. Whal. Commn* 42: 443–453.

Kumar, S., Stecher, G., Li, M., Knyaz, C. and Tamura, K. 2018. MEGA X: Molecular evolutionary genetics analysis across computing platforms. *Mol. Biol. Evol.* 35 (6): 1547–1549.

LeDuc, R.G., Taylor, B.L., Martien, K.K., Robertson, K.M., Pitman, R.L., Salinas, J.C., Burdin, A.M., Kennedy, A.S., Wade, P.R., Clapham, P.J. and Brownell, J.L. 2012. Genetic analysis of right whales in the eastern North Pacific confirms severe extirpation risk. *Endang Species Res* 18 (2): 163–167.

Moritz, C. 1994. Defining ʻEvolutionarily Significant Unitsʼ for conservation. *Trends Ecol. Evol.* 9 (10): 373–375.

Nei, M. 1987. *Molecular Evolutionary Genetics*. Columbia Univ. Press, New York. 512 pp.

Omura, H. and Sakiura, H. 1956. Studies on the little piked whale from the coast of Japan. *Sci. Rep. Whales Res. Inst.* 11: 1–37.

Pastene, L.A., Goto, M., Itoh, S., Wada, S. and Kato, H. 1997. Intra- and inter-oceanic patterns of mitochondrial DNA variation in the Bryde′s whales, *Balaenoptera edeni*. *Rep. int. Whal. Commn* 47: 569–574.

Pastene, L.A., Goto, M., Taguchi, M. and Kitakado, T. 2016a. Temporal and spatial distribution of the "J" and "O" stocks of common minke whale in waters around Japan based on microsatellite DNA. Paper SC/F16/JR38 presented to the JARPNII special permit expert panel review workshop, February 2016 (unpublished). 14 pp. [Available from the IWC Secretariat].

Pastene, L.A., Goto, M., Taguchi, M. and Kitakado, T. 2016b. Updated genetic analyses based on mitochondrial and microsatellite DNA indicated no sub-structuring of the "O" stock common minke whale in the western North Pacific. Paper SC/F16/JR40 presented to the JARPNII special permit expert panel review workshop, February 2016 (unpublished). 19 pp. [Available from the IWC Secretariat].

Pastene, L.A., Taguchi, M., Lang, A., Goto, M. and Matsuoka, K. 2022. Population genetic structure of North Pacific right whales. *Marine Mammal Science* 38: 1249–1261.

Pritchard, J.K., Stephens, M. and Donnelly, P. 2000. Inference of population structure using multilocus genotype data. *Genetics* 155 (2): 945.

Sambrook, J., Fritsch, E.F. and Maniatis, T. 1989. *Molecular Cloning: a Laboratory Manual*, 2nd edition. Cold Spring Harbor Laboratory Press, New York. 1546 pp.

Taguchi, M., Goto, M. and Pastene, L.A. 2019a. Results of Discriminant Analysis of Principal Component (DAPC) and Spatial Analysis of Principal Component (sPCA) and implications for the stock structure of western North Pacific common minke whale. Paper SC/F19/WNPM/04 presented to the First Intersessional Workshop on the Implementation Review for western North Pacific minke whales, February 2019 (unpublished). 16 pp. [Available from the IWC Secretariat].

Taguchi, M., Goto, M. and Pastene, L.A. 2019b. Genetic and non-genetic evidences suggest a low plausibility for western North Pacific common minke whale stock structure hypothesis E. Paper SC/68a/SDDNA02 presented to the IWC Scientific Committee, May 2019 (unpublished). 22 pp. [Available from the IWC Secretariat].

Taguchi, M., Goto, M., Matsuoka, K., Tiedemann, R. and Pastene, L.A. (in press). Population genetic structure of Bryde′s whales (*Balaenoptera brydei*) on the central and western North Pacific feeding grounds. *Can. J. Fish. Aquat. Sci.*

Tamura, T., Yoshida, H., Yasunaga, G., Goto, M. and Pastene, L.A. 2019. Final conclusions of the JARPNII research based on refined analyses and additional samples. Paper SC/68A/SP/05 presented to the IWC Scientific Committee, May 2019 (unpublished). 135 pp. [Available from the IWC Secretariat].

Tiedemann, R., Goto, M., Taguchi, M. and Pastene, L.A. 2017. Finding parent–offspring pairs among western North Pacific common minke whale. Paper SC/67a/SDDNA/01 presented to the IWC Scientific Committee, May 2017 (unpublished). 17 pp. [Available from the IWC Secretariat].

Wada, S. 1996. The stability of Got-1f frequencies of the western North Pacific stock of Bryde′s whales. *Rep. int. Whal. Commn* 46: 459–460.

Wada, S. and Numachi, K. 1991. Allozyme analyses of genetic differentiation among the popultions and species of the *Balaenoptera*. *Rep. int. Whal. Commn* (special Issue) 13: 125–154.

Technical Reports of the Institute of Cetacean Research (2022) pp. 11–18

Technical Report

What do we know about whales and ecosystem in the western North Pacific Ocean? Part 2: summary of results on abundance estimates in baleen whale species

Megumi TAKAHASHI*, Takashi HAKAMADA and Koji MATSUOKA

Institute of Cetacean Research, 4–5 Toyomi-cho, Chuo-ku, Tokyo 104–0055, Japan

**Contact e-mail: takahashi@cetacean.jp*

ABSTRACT

The Institute of Cetacean Research (ICR) has been conducting whale sighting surveys in the western North Pacific Ocean for more than 25 years. The main purpose of these surveys is the collection of sighting data required for abundance estimation of baleen whale species in this oceanic basin. Results of the analyses of the data collected have revealed the pattern of distribution and abundance estimates of each whale species in different years and in different periods within a year. Abundance estimates have been used for management purposes (e.g. calculation of catch limits for sustainable commercial whaling) in the case of some species. This paper presents a brief outline of the survey design and analytical procedures used, and of the main results obtained so far.

INTRODUCTION

Information regarding the distribution and abundance of whale species is essential in understanding the role and impact of whales in the ecosystem. Abundance is also an important piece of information required for establishing policy of management of whales. For example, a time series of estimates of absolute abundance derived from sighting surveys is required under the Revised Management Procedure (RMP) for setting safe catch limits of commercial whaling. The RMP is the management procedure developed by the International Whaling Commission's Scientific Committee (IWC SC) for baleen whale species.

One of the most common approaches for collecting sighting data for abundance estimation purposes is the vessel-based survey using the Line Transect (LT) method. Japan through the Institute of Cetacean Research (ICR) has conducted systematic research on whales in the western North Pacific for more than 25 years. The first one was the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN, 1994–1999), which was followed by the second phase of this program (JARPNII, 2000–2016). Subsequently, the New Scientific Whale Research Program in the western North Pacific (NEWREP-NP) was designed and implemented between 2017–2019. All these three research programs (JARPN, JARPNII, NEWREP-NP) had an important sighting survey component based on the LT method. Abundance estimates based on sighting data collected by this survey component have been crucial in the context of some of the objectives of those programs, e.g. the estimation of prey consumption by whale species. As noted above, abundance estimates are key information for calculating catch limit for commercial whaling on some species.

The objective of this paper is to presents a brief outline of the survey design and analytical procedures used by the ICR sighting surveys in the western North Pacific, and to present the main results obtained so far.

RESEARCH AREA

The research area for the sighting surveys comprises the Pacific side of Japan, north of 35°N, the Sea of Japan, and Okhotsk Sea (see Figure 1). Each of these research areas were divided into smaller strata, and the surveys were conducted in spring (mainly May to June) and summer (mainly August to September) seasons to investigate whale distribution and abundance in each season.

VESSEL USED

Specialized vessels which have three observation platforms were used in the surveys (Figure 2). Observers collected whale sighting data from the platforms using binoculars in the time period between sunrise and sunset.

SURVEY METHODOLOGY

Sighting surveys were conducted by the LT method. The survey protocols followed the IWC SC's Requirements and Guidelines for Conducting Surveys and Analyzing Data within the Revised Management Scheme (IWC, 2012a). Under the LT method, vessels move on pre-determined zigzag track lines, which cover the entire or a part of a management area (Figure 3A). The start point is randomly selected for each survey. The design of track lines does not follow physical features such as isobaths which may be correlated with whale distribution and their migration.

Observers search for whales from each platform on the research vessels. When a whale school is detected, the distance between observers and whales and the angle from the track line to whales were recorded (Figure 3B) together with the position of the research vessel and time of the sighting.

ANALYTICAL PROCEDURES

Abundance estimation using sighting data is made using distance sampling calculation (Buckland *et al.*, 2001). The methodology involves two main components. The first component involves fitting the detection function to sighting data. Initially it is assumed that whales are uniformly distributed and that they have the same probability to be detected. However, searching activity is affected by environmental factors (e.g. glare, fog, sea state), and whales occurring far from the vessel are more difficult to detect (Figure 4). Therefore, detection function (e.g. Half-normal function and Hazard-rate function) should be examined, and the best model is selected using the Akaike Information Criterion (AIC) values.

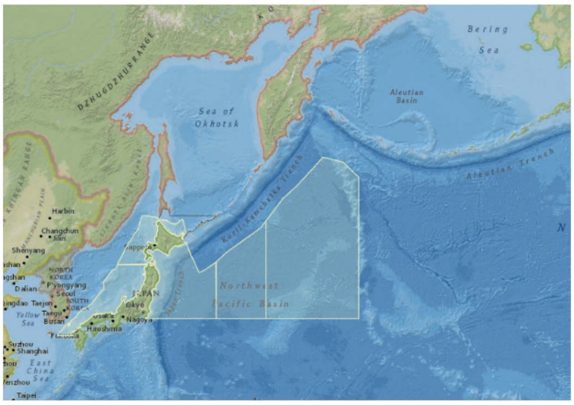


Figure 1. Research area on the Pacific side of Japan, southern Okhotsk Sea and Sea of Japan, covered by Japanese sighting surveys.

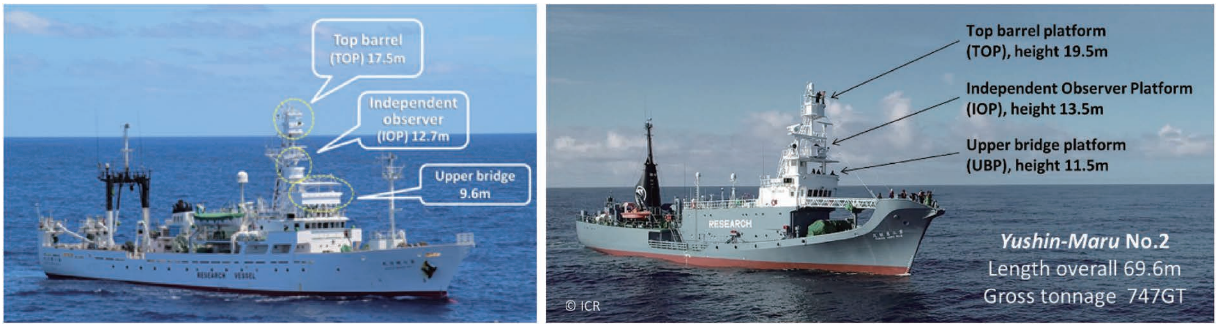


Figure 2. Specialized research vessels used for sighting surveys (left: *Kaiyo-Maru* No.7, right: *Yushin-Maru* No.2). The figures show the observation platforms (taken from Takahashi [2020] and Isoda *et al.* [2021]).

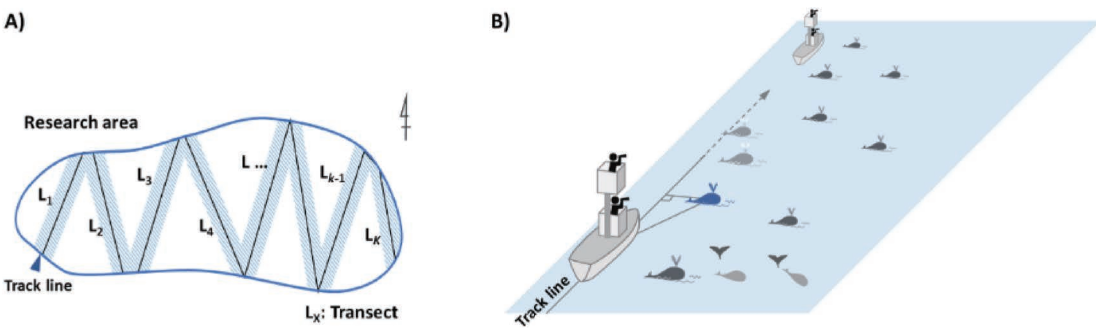


Figure 3. Diagrams showing the zigzag track lines for a research area under the LT survey (A); and the whale observation from different platforms (B).

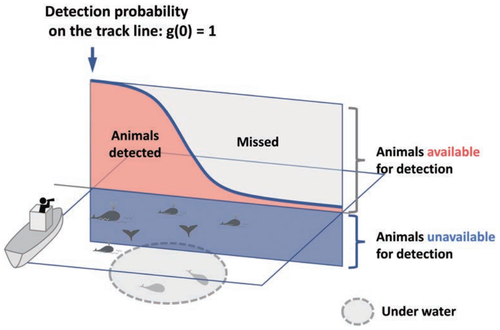


Figure 4. Diagram showing the detection probability assuming $g(0)=1$. The probability of detection decreases with distance from the vessel.

$$\text{Half-normal: } f(x,\boldsymbol{z}) = \exp\left(-\frac{x^2}{2\sigma^2}\right)$$

$$\text{Hazard-rate: } f(x,\boldsymbol{z}) = 1-\exp\left[\left(\frac{-x}{a\sigma}\right)^{-b}\right],$$

where x is perpendicular distance, $\boldsymbol{z}$ is vector of several covariates; and σ represents scale parameter for incorporating the covariates in the detection function and a and b are parameters of each key function.

The second component is for estimating abundance using the detection probability derived from the detection function. The Horvitz–Thompson-like estimator is one of the most frequently used methods. The principle of the estimator is that the total number of whales present are estimated from the proportion of the abundance in the area surveyed (the covered area) to the entire survey area. To do this the abundance in the area surveyed is calculated using the detection probability. The detection function models are denoted $f(x;$ _) where x is perpendicular distance (from the track line to whales) and $\boldsymbol{\theta}$ is a vector of parameters of the key function to be estimated.

$$\hat{N}_{covered} = \sum_{i=1}^{n} \frac{s_i}{\int_0^w \frac{1}{w} f(\widehat{x,\boldsymbol{z}_i;\boldsymbol{\theta}})dx},$$

where w is truncation distance from the track line, s_i is size of i^{th} detected cluster ($I=1, \cdots, n$).

Then, it is scaled up to the full study area by multiplying it by the ratio of covered area to study area. Here, $A/2wL$ represents proportion of entire research area to area searched:

$$\hat{N} = \frac{A}{2wL}\widehat{N_{covered}}$$

In reality, because of diving behavior, not all animals are available for detection even when they are near the vessel and/or on the track line. Therefore, this bias should also be considered in the abundance estimation process. This bias is known as availability bias and is different from perception bias caused by human error under different environmental conditions.

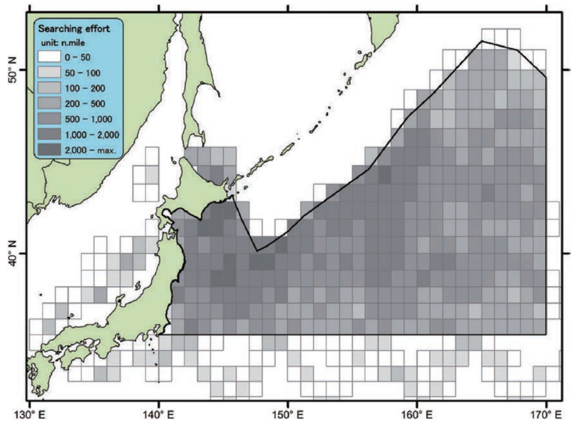


Figure 5. The searching effort by each Lat. 1°×Long. 1° grid square covered by JARPN and JARPNII surveys during 1994 to 2014 (Matsuoka and Hakamada, 2019). The gray scale shows the degree of searching effort.

RESULTS ON DISTRIBUTION AND ABUNDANCE

Figure 5 shows the main research area and the total primary searching effort by each Lat. 1°×Long. 1° grid square during 1994 to 2014 under JARPN and JARPNII surveys.

Table 1 shows the abundance estimates for each whale species. The numbers of whales distributed in the JARPNII survey area were estimated in the early and late seasons (see Hakamada and Matsuoka, 2016a; 2016b).

Blue whales

The main distribution area for blue whales moved northward from 35°N–40°N to north of 40°N during the spring (May to June) to summer (August to September) seasons (Matsuoka *et al.*, 2016) (Figure 6). In the late 20th century, they had never been observed in this area in June, but this could have been caused by the difference in regulations of the whaling operations for coastal and offshore whaling. In the late season, blue whales were more frequently sighted north of 40°N (Figure 6), and the abundance estimate was 958 animals (CV=0.461) (Table 1).

Fin whales

Fin whales were observed mainly in the Pacific side of Japan but also occurred in the Okhotsk Sea and Sea of Japan (Matsuoka *et al.*, 2016). The main distribution area was north of 37°N, and the highest density area was north of 45°N. Fin whales were widely distributed across the western North Pacific in the spring season, but they

Table 1
Abundance estimates for several large baleen whale species. All estimates assumed $g(0)=1$, except for common minke whales in which $g(0)=0.798$ (CV=0.134).

Species	Spring season		Summer season	References
	2009	2011+2012	2008	
Blue whale	38 (0.977)	161 (0.474)	958 (0.461)	Hakamada and Matsuoka (2016b)
Fin whale	413 (0.569)	1,369 (0.295)	3,958 (0.425)	Hakamada and Matsuoka (2016b)
Sei whale	4,734 (0.177)	2,988 (0.304)	5,086 (0.378)	Hakamada and Matsuoka (2016a)
Bryde's whale	2,957 (0.394)	1,851 (0.413)	13,306 (0.251)	Hakamada and Matsuoka (2016a)
Humpback whale	1,136 (0.438)	1,921 (0.318)	392 (0.877)	Hakamada and Matsuoka (2016b)
North Pacific right whale	0 (—)	1,147 (0.434)	416 (0.653)	Hakamada and Matsuoka (2016b)
Common minke whale	3,629 (0.586)	2,122 (0.371)	3,080 (0.677)	Hakamada and Matsuoka (2016a)

Spring season: May to June, Summer season: August to September.

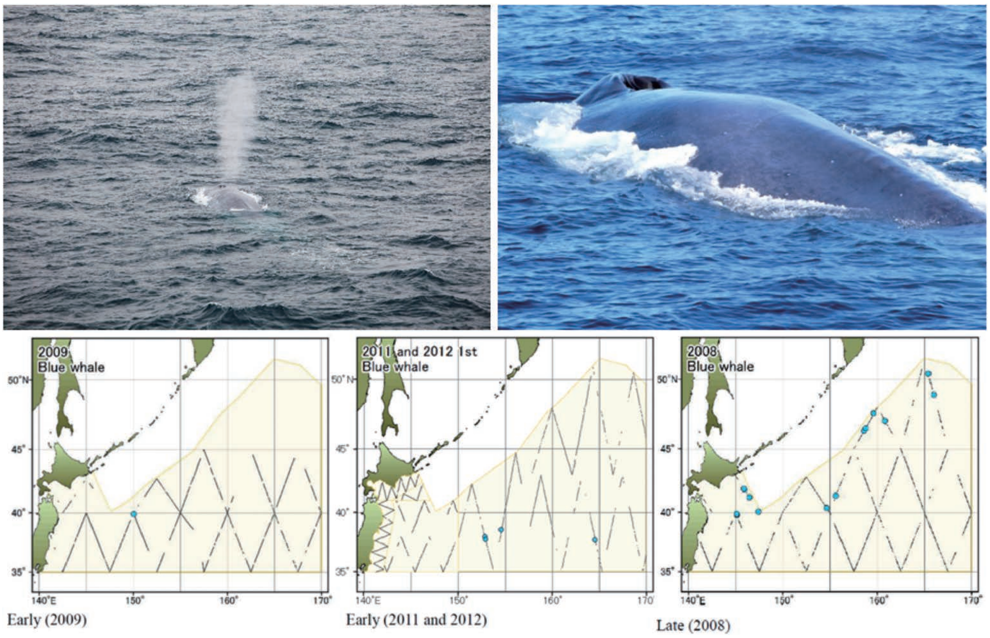


Figure 6. Blue whales observed during the surveys (top). Sighting positions of blue whales (blue circles) on the track lines, by survey period (bottom).

were more frequently sighted north of 40°N in the summer season (Figure 7), and the abundance was estimated at 3,958 animals (CV=0.425) in this season (Table 1).

Humpback whales

The main distribution area of humpback whales was north of 37°N from May to September (Matsuoka *et al.*, 2016). The highest density area was observed north of 35°N (west of 158°E) and north of 45°N (east of 158°E). They moved northward from 37°N to 43°N in the inshore area of Japan during May to June, and to further north of 45°N during July to August (Figure 8). The abundance estimates were 1,136 (CV=0.438) to 1,921 (CV=0.318) in the early seasons. Despite the surveys covering the entire western North Pacific in the summer season, sightings of this species were not frequent in this season (Table 1).

North Pacific right whales

During the survey programs, 48 schools (68 individuals) were observed north of 37°N from May to September (Matsuoka *et al.*, 2016) (Figure 9). The total abundance was estimated to be 1,147 animals (CV=0.434) based on the JARPNII data in the spring season of 2011/12 (Table 1).

Sei whales

The main distribution area of sei whales shifted northward during spring to summer seasons (Murase *et al.*, 2016; Figure 10). The abundance estimate in the summer season was higher than that in the spring season

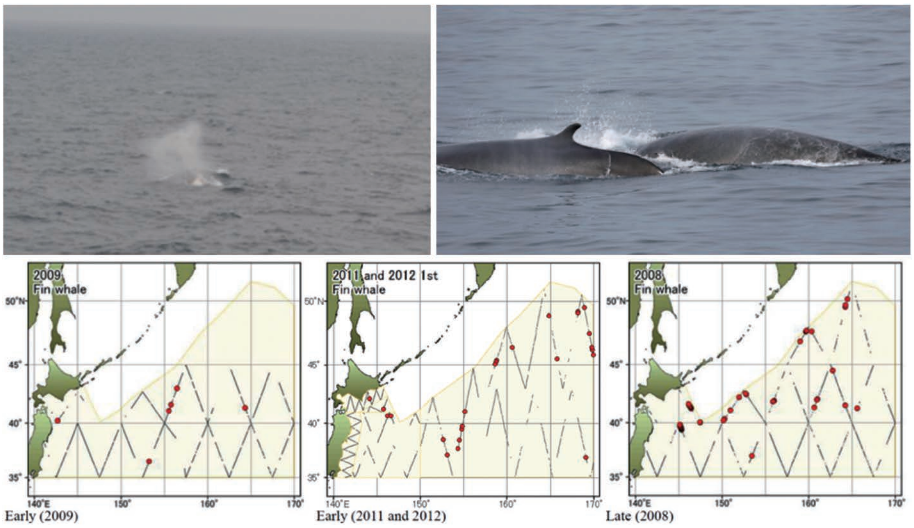


Figure 7. Fin whales observed during the surveys (top). Sighting positions of fin whales (red circles) on the track lines, by survey period (bottom).

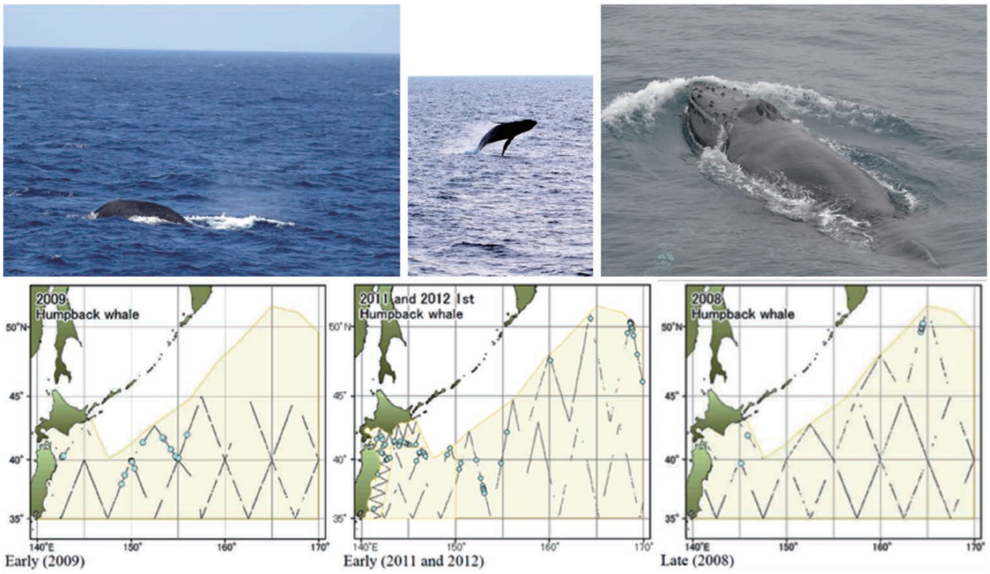


Figure 8. Humpback whales observed during the surveys (top). Sighting positions of humpback whales (light blue circles) on the track lines, by survey period (bottom).

(Table 1). The estimates should be considered as a part of the total stock number of this species (see Taguchi *et al.*, this issue).

Bryde's whales

The main distribution of Bryde's whale shifted northward during the spring to summer season (Hakamada *et al.*, 2009). Their distribution was in lower latitudes compared to other large baleen whale species (Figure 9). Table 1 shows the abundance estimates for Bryde's whales in the spring and summer (July to September) seasons in this JARPNII area.

Common minke whales

Common minke whales are known to migrate further north of the JARPNII survey area through early season to late season (Hakamada *et al.*, 2009) (Figure 12). Common minke whales distribute primarily in the Sea of Okhotsk and in the waters east of the Kamchatka Peninsula and the Kuril Islands in August and September (Buckland *et al*, 1992; Miyashita, 2019). The estimated numbers distributed in the survey area were 3,629 (CV=0.586) and 2,122 (CV=0.371) in the spring season and 3,080 (CV=0.677) in the summer season (Table 1).

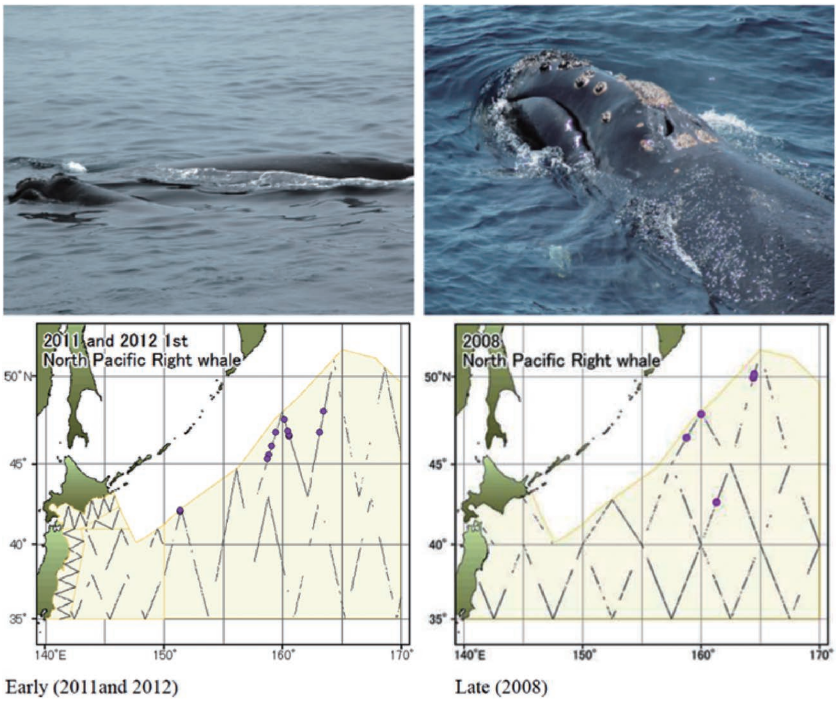


Figure 9. North Pacific right whales observed during the surveys (top). Sighting positions of North Pacific right whales (purple circles) on the track lines, by survey period (bottom).

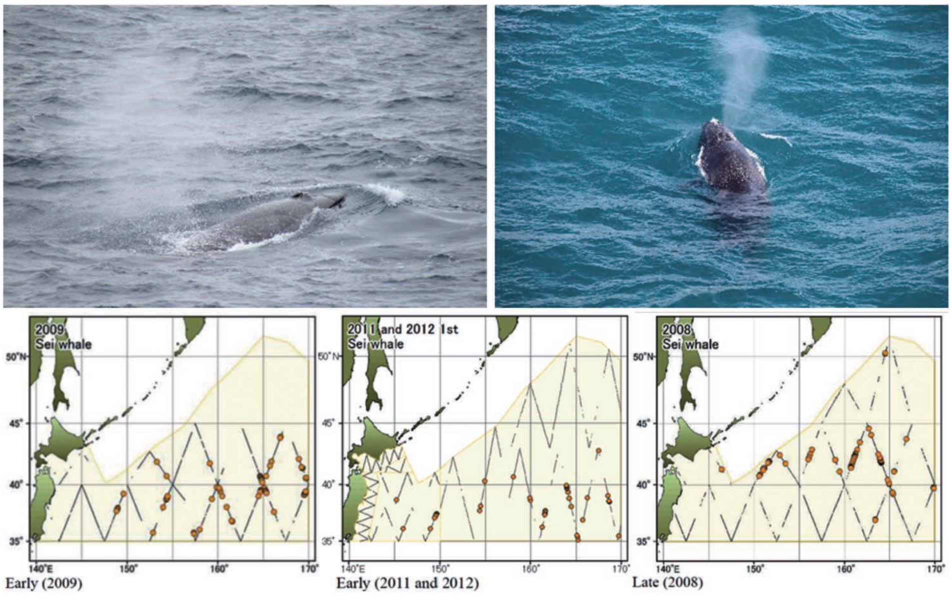


Figure 10. Sei whales observed during the surveys (top). Sighting positions of sei whales (orange circles) on the track lines, by survey period (bottom).

USE OF THE ABUNDANCE ESTIMATES FOR MANAGEMENT PURPOSES

Japan resumed commercial whaling of North Pacific sei, Bryde's and western North Pacific common minke whales in July 2019. Catch limits for each species were set in line with the RMP (IWC, 2012b). The core component of the RMP is the Catch Limit Algorithm (CLA) (Aldrin and Huseby, 2007; Aldrin *et al.*, 2008), which is a feedback control algorithm that sets baleen whale harvest levels based on catch histories and a time series of estimates of absolute abundance derived from sighting surveys. *Implementation Simulation Trials* (*ISTs*) are conducted to assess uncertainties for several parameters in the case of multi-stock scenarios.

Abundance estimates from ICR sighting surveys have been fundamental in the process of applying the CLA and *ISTs* to the three North Pacific baleen whale species.

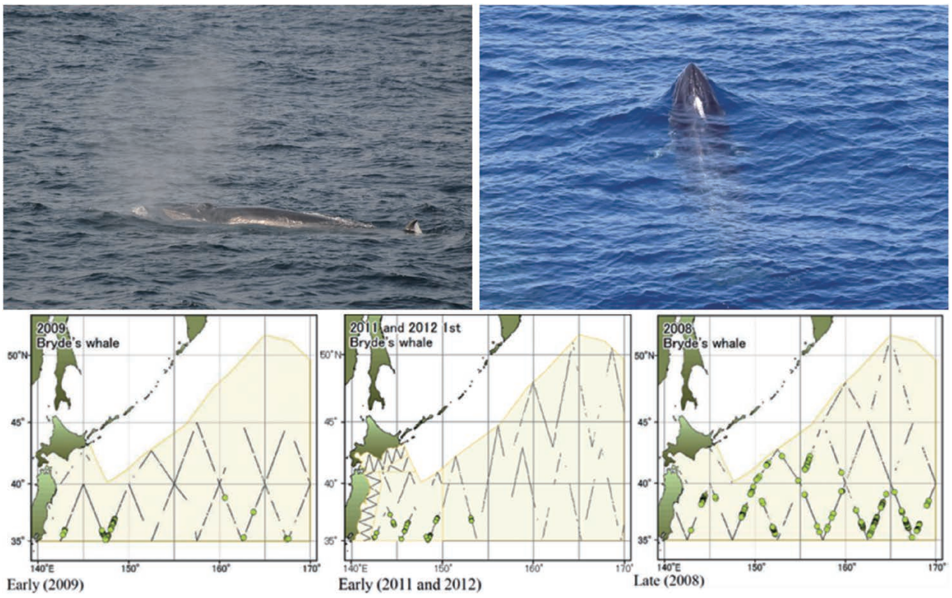


Figure 11. Bryde′s whales observed during the surveys (top). Sighting positions of Bryde′s whales (green circles) on the track lines, by survey period (bottom).

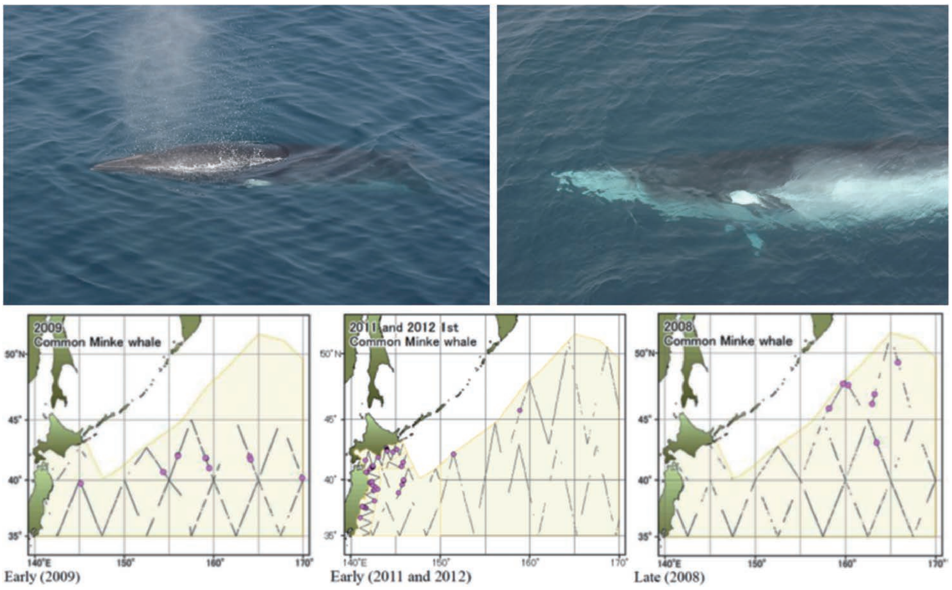


Figure 12. Common minke whales observed during the surveys (top). Sighting positions of common minke whales (purple circles) on the track lines, by survey period (bottom).

For species like the sei and Bryde′s whales, total stock abundances have been obtained by combining the ICR estimates in the western North Pacific with estimates from other surveys in the central and eastern North Pacific.

See details of the process for catch limit calculation in Japan′s RMP Team (2019).

FINAL REMARKS

The ICR has conducted sighting surveys for more than 25 years, in collaboration with other institutions, using a systematic survey procedure. The surveys revealed the distribution and abundance of several large baleen whale species in the western North Pacific Ocean. Moreover, abundance estimates from the ICR surveys contributed to the process for calculating catch limits for sustainable commercial whaling of sei, Bryde′s and common minke whales. There are several aspects that could improve the abundance estimates in the future. Among them are the estimates of *g*(0) for all species, evaluation of additional variance for multi-year surveys and the use of model-based approaches.

ACKNOWLEDGEMENTS

We thank all researchers and crew members who participated in the ICR sighting surveys for their hard work in collecting data in the field. Our thanks are also extended to all researchers who assisted in the analyses. We are grateful to the Fisheries Agency of Japan for providing funds for the surveys. Our gratitude to Luis A. Pastene (ICR) for his assistance in preparing this manuscript. We also thank the Editorial Team of TEREP-ICR for the editorial work on this manuscript.

REFERENCES

Aldrin, M. and Huseby, R.B. 2007. Simulation trials 2007 for a retuned Catch Limit Algorithm. Paper SC/59/RMP4 presented to the IWC Scientific Committee, May 2007 (unpublished). 143 pp. [Available from the IWC Secretariat].

Aldrin, M., Huseby, R.B. and Schweder, T. 2008. A note on tuning the Catch Limit Algorithm for commercial baleen whaling. *J. Cetacean Res. Manage.* 10 (3): 191–194.

Buckland, S.T., Cattanash, K.L. and Miyashita, T. 1992. Minke whale abundance in the northwest Pacific and the Okhotsk Sea, estimated from 1989 and 1990 sighting surveys. *Rep. int. Whal. Commn* 42: 387–392.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L. 2001. *Introduction to Distance Sampling*. Oxford University Press, Oxford. 595 pp.

Hakamada, T., Matsuoka, K. and Miyashita, T. 2009. Distribution and the number of western North Pacific common minke, Bryde's, sei and sperm whales distributed in JARPNII Offshore component survey area. Paper SC/J09/JR15 presented to the JARPNII Review Meeting, January 2009 (unpublished). 18 pp. [Available from the IWC Secretariat].

Hakamada, T. and Matsuoka, K. 2016a. The number of western North Pacific common minke, Bryde's and sei whales distributed in JARPNII Offshore survey area. Paper SC/F16/JR12 presented to the JARPNII Review Meeting, February 2016 (unpublished). 14 pp. [Available from the IWC Secretariat].

Hakamada, T. and Matsuoka, K. 2016b. The number of blue, fin, humpback, and North Pacific right whales in the western North Pacific in the JARPNII Offshore survey area. Paper SC/F16/JR13 presented to the JARPNII Review Meeting, February 2016 (unpublished). 14 pp. [Available from the IWC Secretariat].

Matsuoka, K. and Hakamada, T. 2019. Distribution of blue, fin, humpback and North Pacific right whales in the western North Pacific based on JARPN and JARPNII surveys (1994–2014). *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)* No.3: 41–51.

International Whaling Commission. 2012a. Requirements and guidelines for conducting surveys and analysing data within the revised management scheme. *J. Cetacean Res. Manage*. (Suppl.) 13: 509–517.

International Whaling Commission. 2012b. Requirements and guidelines for *Implementations* under the Revised Management Procedure (RMP). *J. Cetacean Res. Manage.* (Suppl.) 13: 497–505.

Isoda, T., Katsumata, T. and Matsuoka, K. 2021. Results of the dedicated sighting survey under the Japanese Abundance and Stock structure Surveys in the Antarctic (JASS-A) in the western part of Area III in the 2020/21 austral summer season. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)* No.5: 7–15.

Japan's RMP Team. 2019. Catch limits for western North Pacific sei, Bryde's and common minke whales calculated in line with the IWC's Revised Management Procedure (RMP). https://www.jfa.maff.go.jp/j/whale/attach/pdf/index-63.pdf.

Matsuoka, K., Hakamada, T. and Miyashita, T. 2016. Distribution of blue (*Balaenoptera musculus*), fin (*B. physalus*), humpback (*Megaptera novaeangliae*) and north pacific right (*Eubalaena japonica*) whales in the western North Pacific based on JARPN and JARPNII surveys (1994 to 2014). Paper SC/F16/JR9 presented to the JARPNII Review Meeting, February 2016 (unpublished). 12 pp. [Available from the IWC Secretariat].

Miyashita, T. 2019. Abundance estimate of common minke whales in sub-areas 11, 10E and 7CN in 2014. Paper SC/68A/ASI15 presented to the IWC Scientific Committee, May 2019 (unpublished). 3 pp. [Available from the IWC Secretariat].

Murase, H., Hakamada, T., Sasaki, H., Matsuoka, K. and Kitakado, T. 2016. Seasonal spatial distributions of common minke, sei and Bryde's whales in the JARPNII survey area from 2002 to 2013. Paper SC/F16/JR7 presented to the JARPNII Review Meeting, February 2016 (unpublished). 17 pp. [Available from the IWC Secretariat].

Takahashi, M. 2020. A note on $g(0)$ estimates derived from vessel-based sighting surveys. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)* No.3: 14–20.

Technical Reports of the Institute of Cetacean Research (2022) pp. 19–24

Technical Report (not peer reviewed)

What do we know about whales and ecosystem in the western North Pacific Ocean? Part 3: summary of results on biological parameters in baleen whale species

Takeharu BANDO[1,*], Hikari MAEDA[2], Satoko INOUE[1] and Tomoe KUNO[1]

[1] *Institute of Cetacean Research, 4–5 Toyomi-cho, Chuo-ku, Tokyo 104–0055, Japan*

[2] *Fisheries Resources Institute, Japan Fisheries Research and Education Agency, 2–12–4 Fukuura, Kanazawa-ku, Yokohama-shi, Kanagawa 236–8648, Japan*

**Contact e-mail: bando@cetacean.jp*

ABSTRACT

Three baleen whale species, sei, Bryde's and common minke whales were surveyed during the former Japanese scientific whaling programs in the western North Pacific Ocean conducted from 1994 to 2019. This paper summarizes some life history-related biological parameters estimated for the three species, based on data and samples collected during the research programs. These biological parameters are important as input data for models aimed at studying the population dynamics of the species. Results therefore will contribute to the management of these whale species in the western North Pacific.

INTRODUCTION

Three baleen whale species, sei (*Balaenoptera borealis*), Bryde's (*B. edeni brydei*) and common minke (*B. acutorostrata scammoni*) whales were surveyed by former Japanese scientific whaling program in the western North Pacific conducted by the Institute of Cetacean Research (ICR). The target species for the Japanese Whale Research Program under Special Permit in the North Pacific (JARPN) (1994–1999) was the common minke whales (GOJ, 1994). The second phase of this program (JARPNII) (2000–2016) targeted Bryde's, common minke and sei whales. The latter was added as a target species in 2002 (GOJ, 2000; 2002).

After the completion of the JARPNII, the New Scientific Whale Research Program in the western North Pacific (NEWREP-NP) commenced in 2017 and lasted until 2019 (GOJ, 2017). The target species were sei and common minke whales. Figure 1 shows the baleen whale species targeted by the former Japanese scientific whaling programs in the western North Pacific.

During these research programs, systematic biological sampling was conducted on the whales taken. These included earplugs for age determination, testes and ovaries for determination of sexual maturity and estimation of reproductive history, fetus for reproductive studies and body length for growth studies. Some life history-related biological parameters, which are important as input data for population dynamics models, were estimated for the three whale species based on data and samples collected during the research programs.

This paper summarizes the results of biological parameter estimations in sei, Bryde's and common minke whales in the western North Pacific. It follows more detailed analyses presented previously in Bando (2017; 2018), Bando and Maeda (2020) and Maeda *et al.* (2017).

SUMMARY OF BIOLOGICAL PARAMETERS IN THREE BALEEN WHALE SPECIES

Laboratory and analytical procedures to estimate biological parameters in baleen whales were explained in previous articles (Bando, 2017; 2018; Bando and Maeda, 2020; Maeda *et al.*, 2017). Details of these approaches are not repeated here for brevity. The results of biological parameter estimations for the three species in the western North Pacific are presented in this section.

Earplug age readability

In many baleen whale species, ages are estimated by counting the number of growth layers accumulated in the earplugs which are formed in the external auditory meatus (Lockyer, 1984a). During the scientific whaling programs, earplug age readability had improved compared to the reading based on earplug collected from past commercial whaling. This was due to careful sampling

Figure 1. Baleen whale species targeted by the former Japanese scientific whaling programs in the western North Pacific: sei whale (upper left); Bryde's whale (upper right); and common minke whale (lower).

of earplugs by experienced researchers and introduction of a new gelatinized extraction method during the scientific whaling programs (Bando, 2021; Bando and Maeda, 2020; Maeda, *et al.*, 2013).

Sei whales

Bando and Maeda (2020) reported earplug age readability of immature sei whales as 55.9% and 48.9% for males and females, respectively. Readability in sexually mature animals was higher. The values were 72.5% and 67.4% for males and females, respectively.

Bryde's whales

Similar readability values were reported for Bryde's whales. They were 43.8% and 40.8% for immature males and females, respectively, and 74.0% and 76.4% for mature males and females, respectively (Bando, 2021).

Common minke whales

In the case of common minke whale, the readability was somewhat lower. They were 35.4% and 34.7% for immature males and females, respectively, and 49.2% and 59.0% for mature males and females, respectively (Maeda *et al.*, 2016).

Growth curve

The growth curve of each whale species was estimated by fitting the von Bertalanffy growth model to body length and age.

Sei whales

The growth curve of sei whales was estimated as L_t=14.14$(1-e^{-0.174(t+6.650)})$ for males, and L_t=15.17$(1-e^{-0.150(t+7.407)})$ for females (Bando and Maeda, 2020).

Bryde's whales

The asymptotic length of Bryde's whales was slightly smaller than that of sei whale. The growth curve was estimated as L_t=12.65$(1-e^{-0.189(t+5.250)})$ for males, and L_t=13.30$(1-e^{-0.170(t+4.929)})$ for females (Bando, 2021).

Common minke whales

The asymptotic length of common minke whales was much smaller than the other two species. The growth curve was estimated as L_t=7.49$(1-e^{-0.41(t+0.90)})$ for males, and L_t=8.66$(1-e^{-0.11(t+7.60)})$ for females (Maeda, 2012).

In the three whale species, the asymptotic length was greater in females than in males.

Maximum life span

Sei whales

Bando and Maeda (2020) reported the maximum age of sei whales (estimated from earplug reading) as 54 years for males and 43 years for females.

Bryde's whales
Bando (2021) reported the maximum age of Bryde's whales as 51 and 56 years for males and females, respectively.

Common minke whales
Maeda *et al.* (2016) reported maximum age of male and female common minke whales as 49 and 41 years, respectively.

Age at sexual maturity
There are several methods to estimate age at sexual maturity of baleen whales (Lockyer, 1984b). Age at 50% sexual maturity (*tm50%*) is estimated by calculating the ratio of immature and mature whales in each age. Age at first ovulation (*tmov*) is estimated by mean age of whales with one corpus luteum and no corpus albicans in both ovaries. It is generally known that the transition phase in earplugs of large baleen whales indicates sexual maturity (Lockyer, 1972; Masaki, 1979; Kato, 1983; Ohsumi, 1986) and age at sexual maturity (*tmp*) is estimated by mean age of whales when the transition phase is formed.

Sei whales
Bando and Maeda (2020) estimated *tm50%* of sei whales as 6.7 (SE=0.29) years for males and 6.9 (SE=0.27) years for females, respectively. *Tmov* was estimated as 8.6 (SD=3.14) years (Bando, 2017).

Bryde's whales
For Bryde's whales, *tm50%* were estimated as 7.72 (SE=0.49) and 8.56 (SE=0.39) years for males and females, respectively (Bando, 2021). *Tmov* was estimated as 10.1 (SD=1.13) years (Bando, 2017).

Common minke whales
Tmp was estimated as 7.68 (SD=1.81) years for males and 7.82 (SD=1.58) years for females (Maeda *et al*, 2017). *Tmov* was estimated as 8.75 (SD=1.5) years (Maeda *et al*, 2017).

Body length at sexual maturity
Body length at 50% sexual maturity (*Lm50%*) and first ovulation (*Lmov*) are estimated in the same manner as the age at 50% sexual maturity (*tm50%*) and age at first ovulation (*tmov*). *Lm50%* is estimated by calculating the ratio of immature and mature whales in each body length class. *Lmov* is estimated by mean body length of whales with one corpus luteum and no corpus albicans in both ovaries.

Sei whales
Lm50% of sei whales was estimated as 12.72 m (SE=0.12) for males and 13.31 m (SE=0.12) for females (Bando and Maeda, 2020). *Lmov* was estimated as 13.70 m (SD=0.47) (Bando, 2017).

Bryde's whales
Lm50% of Bryde's whales was slightly smaller than that of sei whale, 11.41 m (SE=0.25) for males and 11.75 m (SE=0.23) for females (Bando, 2021). *Lmov* was estimated as 12.13 m (SD=0.62) (Bando, 2017).

Common minke whales
There are no available estimates of *Lm50%* and *Lmov* for common minke whales. Common minke whales are known to segregate in the western North Pacific by sex and sexual maturity status (Zenitani *et al.*, 2000a; 2000b). This fact will bias the estimate of length at sexual maturity.

Pregnancy rate
Pregnancy rates are usually calculated as the proportion of pregnant females among captured mature females. However, in some cases, this value may differ from the true pregnancy rate due to biases such as segregation and the effect of mother and calf pair's occurrence.

Sei and Bryde's whales
Most sei and Bryde's whales are thought to give birth every two or more years. Females accompanied by calf are considered to have a low pregnancy rate because they were pregnant in the previous year. If females with calf were excluded from samples, pregnancy rate may be overestimated. Bando (2017) estimated pregnancy rate of sei and Bryde's whales with correction of the effect of mother and calf pair (which were not targeted for sampling in most years) as 0.650 and 0.491, respectively.

Common minke whales
Pregnancy rates of common minke whale have not been estimated due to the small number of mature female samples. Most of the mature females distribute outside of the research area (Hatanaka and Miyashita, 1997; Wada, 1989).

Conception Date
In baleen whales, growth of fetus after the early stage of development is considered to be linear with time, and methods for estimating conception date from foetal length and date of capture has been developed (Huggett and Widdas, 1951; Kato and Miyashita, 1991; Lockyer, 1984b).

Table 1
Summary of biological parameters of three baleen whale species in the western North Pacific.

		Sei whale		Bryde's whale		Common minke whale	
		Male	Female	Male	Female	Male	Female
Age reading							
Earplug readability	Immature	55.9% (n=152)	48.9% (n=174)	43.8% (n=105)	40.8% (n=120)	35.4% (n=548)	34.7% (n=501)
	Mature	72.5% (n=466)	67.4% (n=562)	74.0% (n=208)	76.4% (n=296)	49.2% (n=1,340)	59.0% (n=183)
	Total	68.4% (n=618)	63.0% (n=736)	63.9% (n=313)	66.1% (n=416)	45.2% (n=1,888)	41.2% (n=684)
Growth							
Growth curve		$L_t=14.14(1-e^{-0.174(t+6.650)})$	$L_t=15.17(1-e^{-0.150(t+7.407)})$	$L_t=12.65(1-e^{-0.189(t+5.250)})$	$L_t=13.30(1-e^{-0.170(t+4.929)})$	$L_t=7.49(1-e^{-0.41(t+0.90)})$	$L_t=8.66(1-e^{-0.11(t+7.60)})$
Maximum life span		54 years	43 years	51 years	56 years	49 years	41 years
Sexual maturity							
Age at sexual maturity	*tmov*		8.6 years		10.1 years		8.75 years
	tm50%	6.7 years	6.9 years	7.72 years	8.56 years	—	—
	tmp	—	—	—	—	7.68 years	7.82 years
Body length at sexual maturity	*Lmov*		13.70 m		12.13 m	—	—
	Lm50%	12.72 m	13.31 m	11.41 m	11.75 m	—	—
Reproductive characteristics							
Pregnancy rate			0.650		0.491		—
Conception date		Peak from December to February		Year round with peak from October to May		Peak from autum to winter (J-stock) One peak in winter (O-stock)	
Annual ovulation rate			0.744/year		0.526/year		—
Foetal sex ratio		0.519	0.481	0.533	0.467	—	—
Litter size			1.007		1.011		—
References		Bando (2017) Bando and Maeda (2020)		Bando (2017); (2018); (2021)		Bando *et al.* (2010) Goto *et al.* (2021) Maeda (2012) Maeda *et al.* (2016); (2017)	

Sei and Bryde′s whales
Bando (2017) calculated conception dates based on the analysis of fetuses from 414 sei and 177 Bryde′s whales. He reported that the conception season of sei whales lasts from November to March, with a peak from December to February, and that of Bryde′s whales is year-round, with a moderate peak from October to May.

Common minke whales
As for minke whales, two biological stocks are known to exist in the western North Pacific, the J and O stocks (see reviews in Goto *et al.*, 2017; 2021). Both stocks are reported to have different conception seasons, the O-stock from November to June with a single winter peak, and the J-stock from August to March with a peak from autumn to winter (Bando *et al.*, 2010, Goto *et al.*, 2021).

Annual ovulation rate
Annual ovulation rate was estimated from regression of age and number of corpora in the ovaries.

Sei and Bryde′s whales
Annual ovulation rate was estimated as 0.744/year for sei whales and 0.526/year for Bryde′s whales, respectively (Bando and Maeda, 2020; Bando, 2021).

Common minke whales
There is no estimate available for common minke whales.

Foetal sex ratio
Sei and Bryde′s whales
Bando (2017) reported foetal sex ratio (male ratio) of sei whales as 51.9% (n=418) and that of Brydes′s whales as 53.3% (n=169). No significant difference from parity was detected for sei and Bryde′s whales.

Common minke whales
There are no estimates available for common minke whales.

Litter size
In baleen whale species, the number of fetuses is usually one. However, multiple fetuses (twins in most cases) are observed occasionally (Kimura, 1957; Lockyer, 1984b).

Sei and Bryde′s whales
Litter sizes were estimated as 1.007 for sei whales (n=420), and 1.011 for Bryde′s whale (n=177) (Bando, 2017).

Common minke whales
There are no estimates available for common minke whales.

Table 1 summarizes the estimates of life history-related biological parameters in sei, Bryde′s and common minke whales in the western North Pacific.

CONCLUDING REMARKS

Several biological parameters of three baleen whale species were estimated from the samples collected by scientific whaling programs conducted by the ICR. During these surveys, a wide range of whale samples, from young to old, were collected by random sampling method which led to a more accurate estimation of biological parameters than that estimated from past commercial whaling data. Some biological parameters respond to changes in their environment such as food availability or fecundity, which will affect the status of whale stocks. Biological parameters are also important as input data for models aimed at studying the population dynamics of the species. The estimated biological parameters will contribute to the management of these whale species in the western North Pacific Ocean.

ACKNOWLEDGEMENTS

Our sincere thanks to all researchers and crews who collected data and samples during the JARPN, JARPNII and NEWREP-NP surveys. We thank the members of the Institute of Cetacean Research (ICR) and Japan Fisheries Research and Education Agency for their useful suggestions and assistance in the laboratory work. We also thank Luis A. Pastene (ICR) for his assistance in preparing this report. We also thank the Editorial Team of TEREP-ICR for the editorial work on this manuscript.

REFERENCES

Bando, T. 2017. Comparison of the morphological and biological characters of Bryde′s whale *Balaenoptera edeni brydei* and sei whale *B. borealis* in the western North Pacific. Doctoral thesis, Tokyo University of Marine Science and Technology. 147 pp. (in Japanese).

Bando, T. 2018. Earplug-based age determination and estimation of biological parameters in North Pacific Bryde′s whales based on samples collected by JARPNII. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)* No. 2: 32–37.

Bando, T. 2021. Improved estimates of some life-history parameters of the pelagic subspecies of Bryde′s whale in the western North Pacific. *Cetacean Population Studies* 3: 239–245.

Bando, T. and Maeda, H. 2020. Progress in the research on earplug-based age determination and biological parameters of North Pacific sei whales at the Institute of Cetacean Research.

Technical Reports of the Institute of Cetacean Research (TEREP-ICR) No. 4: 48–53.

Bando, T., Miyashita, T., Kishiro, T., Yoshida, H. and Hatanaka, H. 2010. An analysis of conception date of common minke whales sampled by JARPN and JARPNII in the context of stock structure hypotheses. Paper SC/S10/NPM10 presented to the Preparatory Meeting for the First Intersessional Workshop for the Western North Pacific Common Minke Whale *Implementation Review*, September 2010 (unpublished). 5 pp. [Available from the IWC Secretariat].

Goto, M., Taguchi, M. and Pastene, L.A. 2017. Distribution and movement of 'O' and 'J' stock common minke whales in waters around Japan based on genetic assignment methods. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)* No. 1: 37–43.

Goto, M., Tamura, T., Bando, T. and Yasunaga, G. 2021. Review of biological information of the J stock common minke whale based on genetically identified individuals. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)* No. 5: 49–57.

Government of Japan. 1994. Research plan for clarification of minke whale stock structure in the northwestern part of the North Pacific. Paper SC/46/NP1 presented to the IWC Scientific Committee, May 1994 (unpublished). 13 pp. + Appendix I–II. [Available from the IWC Secretariat].

Government of Japan. 2000. Research plan for cetacean studies in the western North Pacific under special permit (JARPNII) (feasibility study plan for 2000 and 2001). Paper SC/52/O1 presented to the IWC Scientific Committee, June 2000 (unpublished). 68 pp. [Available from the IWC Secretariat].

Government of Japan. 2002. Research plan for cetacean studies in the western North Pacific under special permit (JARPNII). Paper SC/54/O2 presented to the IWC Scientific Committee, April 2002 (unpublished). 115 pp. [Available from the IWC Secretariat].

Government of Japan. 2017. Revised research plan for New Scientific whale Research Program in the western North Pacific (NEWREP-NP). Paper SC/67a/SCSP10 presented to the IWC Scientific Committee, May 2017 (unpublished). 147 pp. [Available from the IWC Secretariat].

Hatanaka, H. and Miyashita, T. 1997. On the feeding migration of Okhotsk Sea–West Pacific stock of minke whales, estimates based on length composition data. *Rep. int. Whal. Commn* 47: 557–564.

Huggett, A.G. and Widdas, W.F. 1951. The relationship between mammalian foetal weight and conception age. *J. Physiol.* 114: 306–317.

Kato, H. 1983. Relation of earplug growth and skull growth in the Antarctic minke whale. Paper SC/A83/AW5 presented to the IWC Minke Whale Ageing Workshop, April 1983 (unpublished). 6 pp. [Available from the IWC Secretariat].

Kato, H. and Miyashita, T. 1991. Migration strategy of southern minke whales in relation to reproductive cycle estimated from foetal length. *Rep. int. Whal. Commn* 41: 363–369.

Kimura, S. 1957. The twinning in southern fin whales. *Sci. Rep. Whales Res. Inst.* 12: 103–125.

Lockyer, C. 1972. The age at sexual maturity of southern fin whale (*Balaenoptera physalus*) using annual layer counts in the earplug. *ICES Journal of Marine Science* 34: 276–294.

Lockyer, C. 1984a. Age determination by means of the earplug in baleen whales. *Rep. int. Whal. Commn* 34: 692–696.

Lockyer, C. 1984b. Review of baleen whale (Mysticeti) reproduction and implications for management. *Rep. int. Whal. Commn* (special issue) 6: 27–50.

Maeda, H., 2012. Investigation of the earplug in common minke whales as age characters and their age dynamics. Doctoral thesis, Tokyo University of Marine Science and Technology. 122 pp. (in Japanese).

Maeda, H., Kawamoto, T. and Kato, H. 2013. A study on the improvement of age estimation in common minke whales using the method of gelatinized extraction of earplug. *NAMMCO Scientific Publications* 10: 17 pp.

Maeda, H., Bando, T., Kishiro, T., Kitakado, T. and Kato, H. 2016. Basic information of earplug as age character of common minke whales in western North Pacific. Paper SC/F16/JR53 presented to the JARPNII special permit expert panel review workshop, Tokyo, February 2016 (unpublished). 10 pp. [Available from the IWC Secretariat].

Maeda, H., Fujise, Y., Kishiro, T. and Kato, H. 2017. Utility of the transition phase in earplugs of the North Pacific common minke whale as an indicator of age at sexual maturity. *Open Journal of Animal Sciences* 7: 414–424.

Masaki, Y. 1979. Yearly change of the biological parameters for the Antarctic minke whale. *Rep. int. Whal. Commn* 29: 375–395.

Ohsumi, S. 1986. Earplug transition phase as an indicator of sexual maturity in female Antarctic minke whales. *Sci. Rep. Whales Res. Inst*. 37: 17–30.

Wada, S. 1989. Latitudinal segregation of the Okhotsk Sea – West Pacific stock of minke whales. *Rep. int. Whal. Commn* 39: 229–233.

Zenitani, R., Fujise, Y. and Kato, H. 2000a. Some analyses on biological parameters of western North Pacific minke whales, from a viewpoint of stock identification. Paper SC/F2K/J13 presented to the IWC Scientific Committee Workshop to Review the Japanese Whale Research Programme under Special Permit for North Pacific minke whales (JARPN), February 2000 (unpublished). 18 pp. [Available from the IWC Secretariat].

Zenitani, R., Fujise, Y., Okamura, H. and Kato, H. 2000b. Further examination of the distribution of western North Pacific minke whales applying a logistic regression analysis for reproductive data collected by the JARPN surveys. Paper SC/52/RMP17 presented to the IWC Scientific Committee, May 2000 (unpublished). 8 pp. [Available from the IWC Secretariat].

Technical Reports of the Institute of Cetacean Research (2022) pp. 25–35

Technical Report (not peer reviewed)

Results of the dedicated sighting survey under the Japanese Abundance and Stock structure Surveys in the Antarctic (JASS-A) in the eastern part of Area VI in the 2021/2022 austral summer season

Tatsuya ISODA*, Taiki KATSUMATA and Koji MATSUOKA

Institute of Cetacean Research, 4–5 Toyomi-cho, Chuo-ku, Tokyo 104–0055, Japan

**Contact e-mail: isoda@cetacean.jp*

ABSTRACT

The results of the sighting survey of the Japanese Abundance and Stock structure Surveys in the Antarctic (JASS-A) in the 2021/2022 austral summer season are reported. A dedicated sighting vessel was engaged in the line transect method survey in the eastern part of Antarctic Area VI East (130°W–120°W) for 33 days, from 11 January to 12 February 2022. For the survey, the research area was divided into northern and southern strata. In addition, surveys were conducted successfully in coastal ice-free waters, south of 72°S, an area that is normally covered by pack-ice and difficult for vessels to access. The total searching distance in the research area was 1,333.5 n.miles (2,469.6 km). Four baleen whale species and at least four toothed whale species were sighted in the research area. Other research activities such as biopsy sampling, photo-ID, satellite tagging, and oceanographic observations were also conducted. The data and samples collected are required for the main and secondary research objectives of JASS-A.

INTRODUCTION

Long-term systematic surveys on whales and the ecosystem in the Antarctic, such as the JARPA/JARPAII[1], NEWREP-A[2], and IDCR/SOWER[3], obtained important data pertaining to the study of abundance and abundance trends of large whales and their biology as well as the role of whales in the Antarctic ecosystem. All these research programs have been terminated. The last NEWREP-A survey was carried out in the 2018/2019 austral summer season.

The Japanese Abundance and Stock structure Surveys in the Antarctic (JASS-A) commenced in the 2019/2020 austral summer season because it was considered important to continue with the whale and ecosystem surveys in the Indo-Pacific region of the Antarctic Ocean through dedicated sighting surveys and other non-lethal research techniques. JASS-A has two main research objectives, i) the study of the abundance and abundance trends of large whale species, and ii) the study of the distribution, movement, and stock structure of large whale species. JASS-A also has several secondary research objectives related to oceanography, marine debris, genetic data to estimate abundance, whale biology, and study on the utility of Unmanned Aerial Vehicle (UAV). The JASS-A program was presented to the 2019 meeting of IWC SC[4] (GOJ, 2019a), the 2019 meeting of CCAMLR-EMM[5] (GOJ, 2019b), and the 2019 meeting of NAMMCO SC[6] (GOJ, 2019c).

The approach of JASS-A is systematic vessel-based sighting surveys utilizing the 'line transect method'. Surveys are designed and conducted following the protocols included in the 'Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme' (IWC, 2012). Sighting protocols are the same as those used in the former IDCR/SOWER surveys (Matsuoka *et al.*, 2003). The JASS-A surveys are conducted alternatively in IWC Management Areas III, IV, V, and VI by one or two specialized vessels, over a tentative period of eight austral summer seasons.

[1] Japanese Whale Research Programs under Special Permit in the Antarctic, Phases I and II

[2] New Scientific Whale Research Program in the Antarctic Ocean

[3] International Decade for Cetacean Research/Southern Ocean Whale and Ecosystem Research

[4] International Whaling Commission-Scientific Committee

[5] Commission for the Conservation of Antarctic Marine Living Resources-Working Group on Ecosystem Monitoring and Management

[6] North Atlantic Marine Mammal Commission-Scientific Committee

The first and second JASS-A surveys were carried out in the 2019/2020 and 2020/2021 austral summer seasons and covered the sector 000°–035°E of Antarctic Area III West. The third survey was carried out during the 2021/2022 season and covered the sector 130°W–120°W of Antarctic Area VI East. This paper presents a summary of the 2021/2022 JASS-A survey results. The Appendix shows photographs of whales, experiments and Antarctic environment taken during the 2021/2022 survey.

SURVEY DESIGN

Research area

The research area of JASS-A is comprised of IWC Management Areas III, IV, V, and VI, south of 60°S (Figure 1). The research area in the 2021/2022 season was the eastern part of Antarctic Area VI East (130°W–120°W), south of 60°S (Figure 1). The area was divided into northern and southern strata. The boundary between these strata was defined by a line 45 n.miles from the northern edge of the pack-ice (Figure 2). In addition, an area of ice-free waters (polynya) was formed between the southern edge of the pack-ice and the ice shelf, south of 72°S in early January (Figure 2). Details of the ice configuration are shown in Figure 3. The ice-free waters (in the range of 125°W to 110°W) became accessible to the vessel in early February.

Research vessel

The dedicated sighting vessel *Yushin-Maru* No. 2 (*YS2)* was engaged in the survey. Its specifications are indicated in Figure 4. Three Japanese researchers participated in the survey. They had experience in conducting line transect surveys, biopsy sampling, photo-identification (photo-ID), satellite tagging, and oceanographic survey in the Antarctic through the previous JARPA/JARPAII and NEWREP-A programs.

Sighting procedures, mode and experiments

See Isoda *et al.* (2022) for details of the procedures used for sighting surveys and other research activities such as sighting distance and angle experiment, photo-ID, biopsy sampling, satellite tagging, oceanographic survey, marine debris observation, and survey using UAV.

RESULTS OF THE SURVEY

Narrative of the survey

Table 1 shows the itinerary of the survey. The duration of this cruise was 109 days. The *YS2* departed Shiogama, Japan on 3 December 2021, arriving back at the home port on 20 December 2021. The *YS2* started the sighting survey in Antarctic Area VI East at 68°37'S; 120°00'W on 11 January. The survey was completed at 73°51'S; 120°00'W on 12 February. The *YS2* arrived back at the home port on 1 March and in Japan on 21 March.

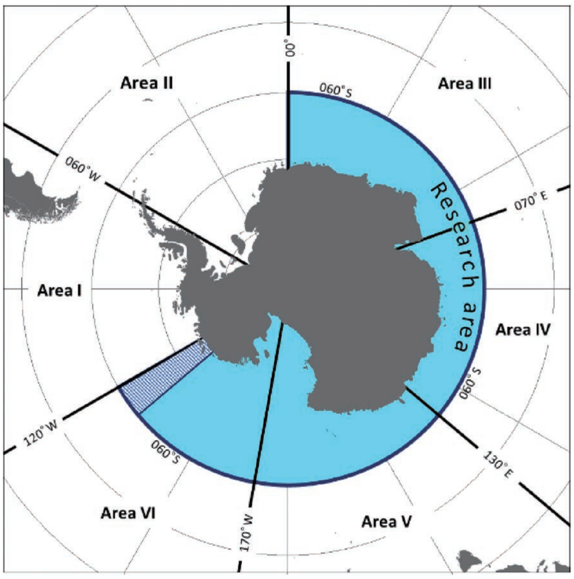


Figure 1. Research area of JASS-A. The shaded area (130°W–120°W) indicates the surveyed area in the 2021/2022 austral summer season.

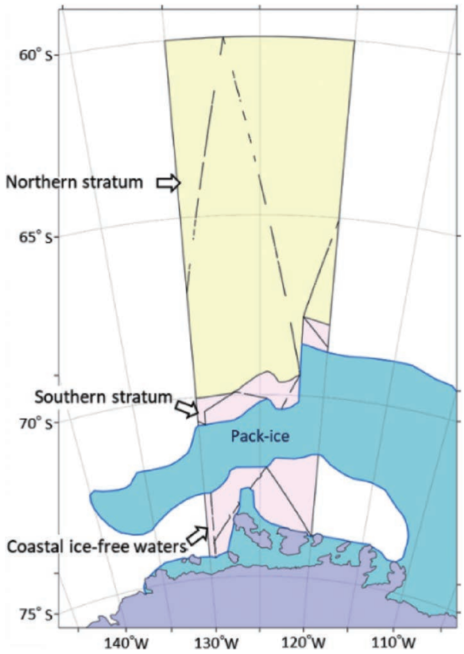


Figure 2. Research area (130°W–120°W) indicating northern and southern strata, and searching efforts (black lines) of the JASS-A survey in 2021/2022 austral summer season. The research commenced at 68°37'S; 120°00'W and ended at 73°51'S; 120°00'W. Note the ice-free waters south of 72°S.

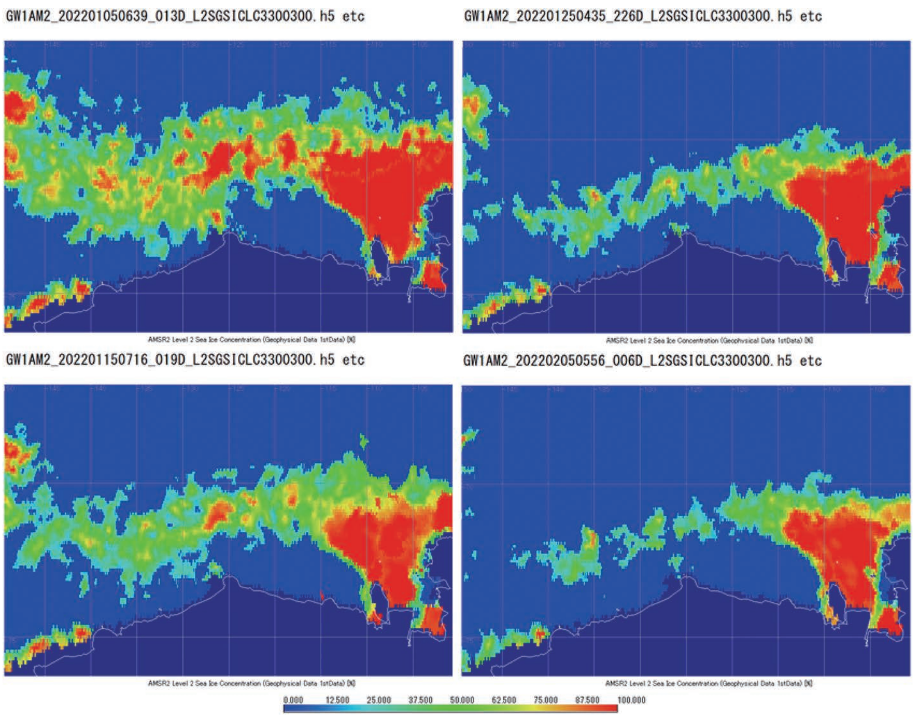


Figure 3. Maps of the pack-ice distributions in the research area for dates 5 January (upper left), 15 January (lower left), 25 January (upper right) and 5 February (lower right) 2022, constructed by Japan Aerospace Exploration Agency (JAXA), based on observational data acquired by the Advanced Microwave Scanning Radiometer 2 (AMSR2). Note that the ice-free waters became accessible to the vessel in early February.

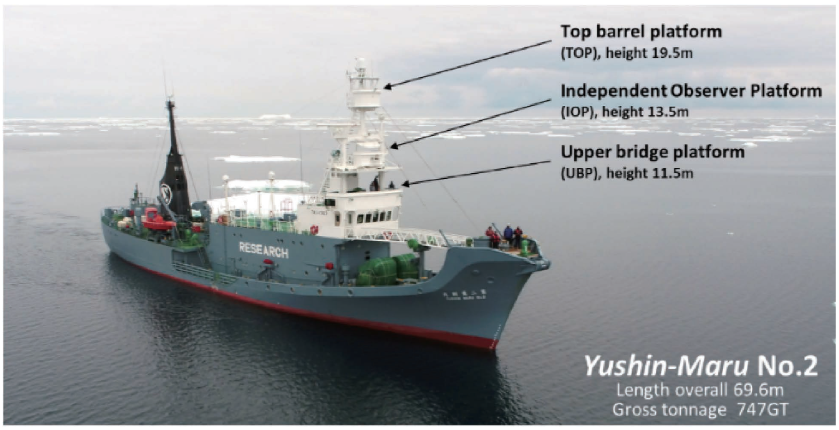


Figure 4. The dedicated sighting vessel *Yushin-Maru* No. 2 and its three observation platforms: top barrel platform (TOP), Independent Observer Platform (IOP) and Upper Bridge Platform (UBP).

Research effort in the research area

Table 2 shows a summary of the searching effort spent during the survey. The *YS2* was engaged in the research for 33 days, from 11 January to 12 February 2022. The total searching effort was 1,333.5 n.miles (2,469.6 km); 659.0 n.miles in NSP mode during 60 hour 27 minutes of research and 674.4 n.miles in IO mode during 62 hour 21 minutes of research. In the northern stratum, the total searching effort was 731.2 n.miles (NSP: 322.7 n.miles; IO: 408.5 n.miles), and the searching effort coverage was 62%. In the southern stratum, the total searching effort was 254.6 n.miles (NSP: 145.8 n.miles; IO: 108.8 n.miles), and the searching effort coverage was 92%. In the coastal ice-free waters, the total searching effort was 347.7 n.miles (NSP: 190.5 n.miles; IO: 157.2 n.miles), and the searching effort coverage was 83%.

Therefore, a good distribution of effort within both strata and survey mode was achieved. The total experimental time for photo-ID, biopsy sampling, tagging, and distance and angle experiment was 22 hours 00 minutes.

Table 1
Itinerary of the 2021/2022 JASS-A dedicated sighting survey.

Date (y/m/d)	Event
2021/11/16	Planning meeting at Tokyo, Japan
2021/12/2	Pre-cruise meeting in Shiogama, Japan
2021/12/3	*YS2* departed Shiogama, Japan
2021/12/13	Transit survey started at 0°00'; 163°00'E
2021/12/20	*YS2* arrive at the home port
2022/1/11	Transit survey finished and survey started in the research area at 68°37'S; 120°00'W
2022/2/12	Survey completed in the research area (33 days) and transit survey start at 73°51'S; 120°00'W
2022/3/1	*YS2* arrive at the home port
2022/3/9	Transit survey completed at 0°00'; 163°00'E
2022/3/21	*YS2* arrived in Japan and post cruise meeting carried out in Shiogama, Japan

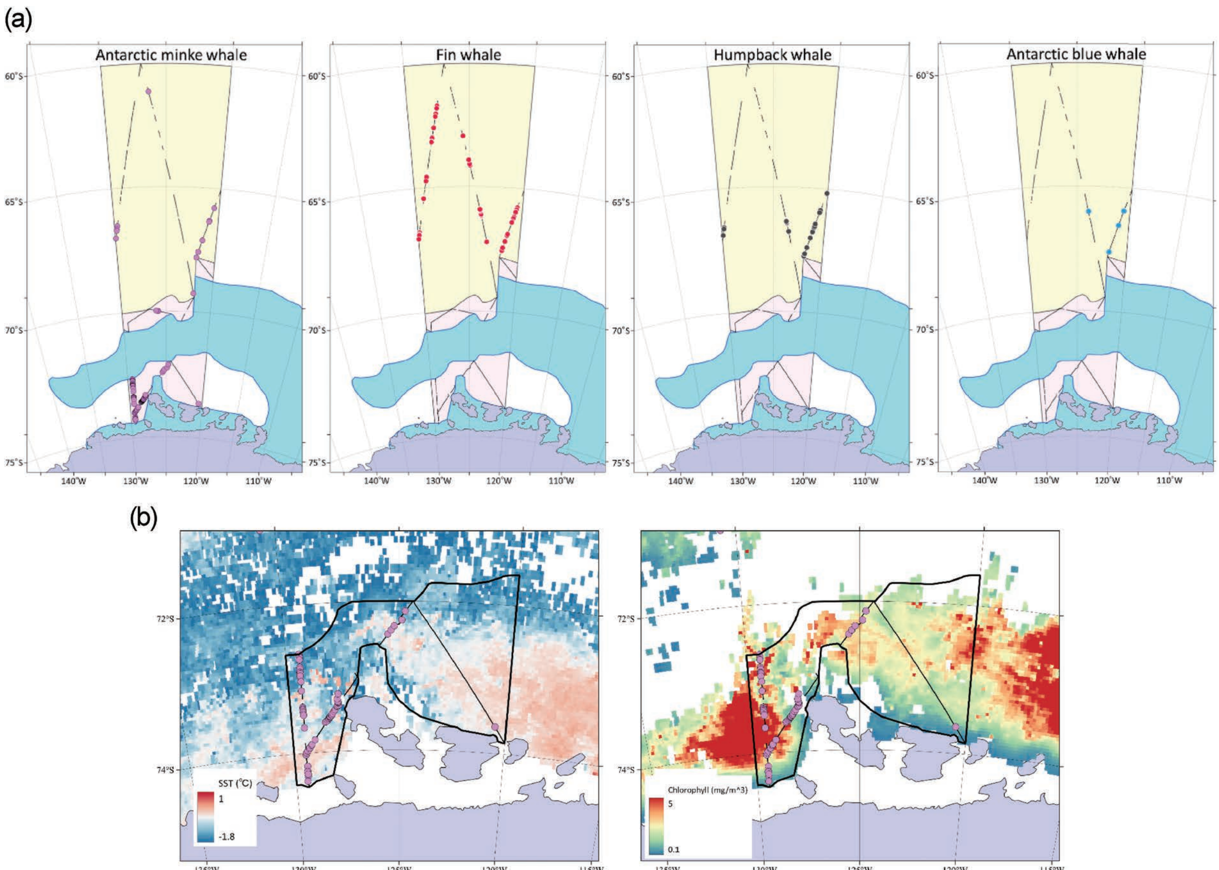


Figure 5 (a) Geographical distribution of primary sightings of Antarctic minke, fin, humpback, and Antarctic blue whales. (b) The distribution of Antarctic minke whales (pink circle) in the ice-free waters. Rolling 32 days average sea surface temperature (left) and chlorophyll concentration (right) from 17 January to 17 February 2022 were observed by MODIS-Aqua and MODIS-Terra (Original data: Ocean colour web, from https://oceancolor.gsfc.nasa.gov/ (Accessed 2022-7-30)). Note that sea surface temperature was lower and chlorophyll concentration was higher in the western part, where the density of Antarctic minke whales was high.

Whale sightings in the research area

Four baleen whale species and at least four toothed whale species were sighted in the research area. The dominant whale species in the research area was the Antarctic minke whale (83 schools/142 individuals) followed by the fin whale (44/64). Sightings of other species were as follows: humpback (26/36), Antarctic blue (5/6), sperm (9/10), Arnoux's beaked (1/8), southern bottlenose (1/1), killer (5/71, include Types B, C and undetermined type) and Ziphiidae (4/6) whales (Table 3).

Table 2
Summary of searching effort (time and distance) and time (hours) spent during the 2021/2022 JASS-A survey.

Survey Sections	Date and time		Searching effort (distance [n.miles] and time [hours:minutes:seconds])				Experiment time [hours:minutes:seconds]	
	Start	End	NSP		IO		Photo-ID, Biopsy, Satellite tag experiment	Estimated angle and distance training/ experiment
Transit survey (0°00–Entering foreign countries EEZ)	2021/12/13 14:59	2021/12/18 18:00	124.2	10:44:29	—	—	0:14:08	—
Transit survey (Leaving foreign countries EEZ–Research area)	2021/12/26 8:35	2022/1/11 9:02	579.9	50:46:32	—	—	2:55:24	1:40:57
Research area (Area VIE 130°W–120°W)	2022/1/11 9:02	2022/2/1 18:08	468.5	43:18:40	517.2	47:36:56	13:18:08	3:44:27
Navigation/transit survey to the coastal ice-free waters, south of 72°S	2022/2/1 18:08	2022/2/8 14:06	—	—	—	—	3:56:13	—
Coastal ice-free waters, south of 72°S (130°W–120°W)	2022/2/8 14:06	2022/2/12 10:03	190.5	17:08:29	157.2	14:44:45	1:02:08	—
Transit survey (Research area–Entering foreign countries EEZ)	2022/2/12 10:03	2022/2/22 17:05	782.2	67:39:37	—	—	6:20:12	—
Transit survey (Leaving foreign countries EEZ–0°00)	2022/3/8 6:30	2022/3/9 12:05	177.9	14:45:22	—	—	—	—
Total	2021/12/13 14:59	2022/3/9 12:05	2323.2	204:23:09	674.4	62:21:41	27:46:13	5:25:24

Table 3
Number of sightings made during the 2021/22 JASS-A survey in the research area, by stratum and species.

Species	Eastern part of Area VIE (130°W–120°W)												Sub-total				Total	
	Southern stratum				Northern stratum				Coastal ice-free waters, south of 72°S									
	Prim.		Second.		Prim.		Second.		Prim.		Second.		Prim.		Second.			
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Antarctic blue whale	0	0	0	0	4	5	1	1	0	0	0	0	4	5	1	1	5	6
Fin whale	0	0	0	0	41	60	3	4	0	0	0	0	41	60	3	4	44	64
Like fin	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	1	1
Antarctic minke whale	4	6	0	0	11	13	1	1	64	119	3	3	79	138	4	4	83	142
Like minke	0	0	0	0	0	0	0	0	2	2	1	2	2	2	1	2	3	4
Humpback whale	0	0	0	0	18	24	8	12	0	0	0	0	18	24	8	12	26	36
Like humpback	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	0	2	2
Baleen whale	1	1	0	0	2	2	0	0	0	0	0	0	3	3	0	0	3	3
Sperm whale	5	5	0	0	3	4	1	1	0	0	0	0	8	9	1	1	9	10
Southern bottlenose whale	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Arnoux's beaked whale	0	0	0	0	0	0	0	0	1	8	0	0	1	8	0	0	1	8
Killer whale (undetermined type)	0	0	0	0	0	0	0	0	3	44	0	0	3	44	0	0	3	44
Killer whale (type B)	1	21	0	0	0	0	0	0	0	0	0	0	1	21	0	0	1	21
Killer whale (type C)	0	0	0	0	0	0	0	0	1	6	0	0	1	6	0	0	1	6
Ziphiidae	1	1	0	0	2	3	1	2	0	0	0	0	3	4	1	2	4	6
Unidentified whale	0	0	0	0	3	3	0	0	0	0	0	0	3	3	0	0	3	3

Prim.: primary sighting, Second.: secondary sighting, Sch.: school, Ind.: individual.

Table 4
Summary of the results of experiments conducted during the 2021/2022 JASS-A survey.

Experiments	Results and descriptions
Sighting distance and angle experiment	128 trials completed by 30 January
Photo-ID	Obtained from 7 Antarctic blue, 9 humpback and 10 killer whales
Biopsy sampling	Collected from 2 Antarctic blue, 12 fin, 15 Antarctic minke, 11 humpback, 1 Bryde's whales and 2 killer whales
Satellite tagging	Deployed on 9 fin and 15 Antarctic minke whales
Oceanographic survey	116 XCTD casts
Marine debris observation	A fishing buoy was observed in the research area
UAV	Aerial images collected from 2 Antarctic blue, 6 Antarctic minke and 3 humpback whales

Antarctic minke whales
Antarctic minke whales were widely distributed in the research area (Figure 5a). It was the only species sighted in the ice-free waters with high density. This observation is consistent with the interpretation of Fujise and Pastene (2021) that larger numbers of this species are being distributed in polynyas within the pack-ice in recent years, possibly in search of alternative feeding areas in response to the increase in abundance and geographical expansion of other large whale species (e.g. humpback and fin whales). A sighting survey using an icebreaker vessel (Ainley *et al.*, 2007) found no Antarctic minke whales within coastal polynyas in an area similar to that surveyed in the present survey. However, this earlier survey was conducted in 1994 and the distribution of this species in polynyas is postulated for recent years.

The density of Antarctic minke whales in ice-free waters was generally high. However, the number of sightings east of 125°W (eastern side) was noticeably lower. The sea surface temperature (SST) map shows that the SST in the eastern side was relatively high and the chlorophyll concentration was relatively low compared to the western side (Figure 5b). In addition, the water colour in the eastern side was clear, while the colour in the western side was brownish and muddy suggesting waters with higher productivity. Therefore, a possible explanation for the lower whale density on the eastern side is that waters on this side are less productive, as suggested by low chlorophyll concentration, which could be translated into less phytoplankton and less krill for the whales to feed. Future detailed analysis of the XCTD observation data will lead to a better understanding of environmental factors affecting the Antarctic minke whale distribution in ice-free waters.

Fin whales
Fin whales were widely distributed only in the northern stratum (Figure 5a). The density was higher than that in the previous 2000/2001 SOWER survey in the same sector (Ensor *et al.*, 2001). The abundance of this species appears to be increasing, as suggested for Antarctic Areas V+VI West (Matsuoka and Hakamada, 2014).

Humpback whales
Humpback whales were widely distributed in the northern stratum with higher concentrations observed in the southern part of this stratum (Figure 5a). The density was higher than that in the 2000/2001 SOWER cruise in the same sector (Ensor *et al.*, 2001), confirming the view that this species is increasing in this area.

Antarctic blue whales
All Antarctic blue whales were observed in the northern stratum (Figure 5a). The density was a little higher than in the 2000/2001 SOWER cruise in the same sector (Ensor *et al.*, 2001).

Duplicate sightings
Duplicates sightings were those sightings made concurrently by both the IOP and TOP barrel observers during the IO mode survey. These data will be used to estimate $\boldsymbol{g}(0)$, which in turn will be used to adjust estimates of abundance. There was a total of 31 duplicates involving several whale species.

Other research activities
Table 4 shows a summary of results of different experiments.

Sighting distance and angle experiment
The sighting distance and angle experiment was conducted in order to evaluate the accuracy of sighting distance and angle provided by primary observers. The results of

this experiment will be used for the calculation of abundance estimates. A training for this experiment was conducted on 7 January. The actual experiments, comprising 128 trials, were successfully completed on 30 January.

Photo-ID

Photo-ID data is used for individual matching exercise to investigate distribution and movement of large whales. A total of 7 Antarctic blue, 9 humpback and 10 killer whales were successfully photo-identified during the entire survey. These data will be registered into the Institute of Cetacean Research (ICR) database (see Matsuoka and Pastene, 2014).

Biopsy sampling for large whales

Biopsy samples are used for genetic studies on stock structure of large whales and for other feasibility studies related to the specific objectives of the JASS-A. For the entire survey, a total of 43 biopsy samples were collected from 2 Antarctic blue, 12 fin, 15 Antarctic minke, 11 humpback, 1 Bryde's (in transit area), and 2 killer whales, using the Larsen system (Larsen, 1998). Biopsy samples were stored at −20°C.

Satellite tagging

Satellite tagging is used for the study of movement, distribution and stock structure of whales. The satellite-monitored tags (SPOT and SPLASH-types, Wildlife Computers, Redmond, Washington, USA) were deployed with the Air Rocket Transmitter System (ARTS) (LK-ARTS, Skutvik, Norway). The detail of deployment system and protocols, and research results to date were described in Konishi *et al.* (2020). In the research area, 9 and 15 satellite tags were deployed on fin and Antarctic minke whales respectively.

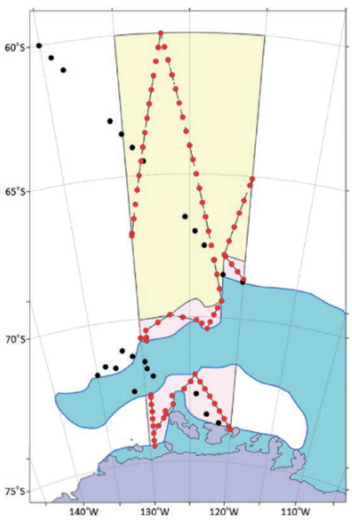


Figure 6. Oceanographic stations (XCTD casting points). Red circle: research area; black circle: transit.

Oceanographic survey

Oceanographic observations are important to understand the relationship of whales and the physical environment. The vertical distribution of water temperature and salinity were recorded from sea surface to 1,850 m water depth using XCTD system (eXpendable Conductivity, Temperature and Depth profiler, Tsurumi-Seiki Co., Ltd., Yokohama, Japan; probe type: XCTD-4 and XCTD-4N) with Digital Converter MK-150P at 116 stations along the survey track lines (Figure 6). Oceanographic data will be analysed to study the oceanographic structure of the research area and the relationship with whale distribution.

Marine debris observation

Studies on marine debris in the Antarctic are very scarce. It is therefore important to continue with this kind of survey in order to monitor future trends in the occurrence of marine debris. One fishing buoy was observed in the research area. These data will be registered into the ICR database and reported in the future (e.g. Isoda *et al.*, 2021).

Feasibility study on the utility of UAV

This technique will be used to refine observations related with whale abundance and distribution, e.g. determine the number of individuals in the schools. The technique can be used also for photogrammetry studies. Aerial images were collected for a total of two Antarctic blue, six Antarctic minke and three humpback whales using small UAV, Inspire 2 Pro and DJI phantom 4 Pro (video clips can be accessed at https://www.youtube.com/channel/UCz3c9IIMiQPVeryAogmJIig). These data will be registered into the photo-ID catalogue of ICR.

Sighting survey in low-middle latitude area

Sighting survey was conducted between the equator and the research area (includes transit to the starting point within the research area), excluding areas of the foreign countries' EEZs. The searching effort was 704.1 n.miles and the total sightings included fin (4/4), Antarctic minke (4/5), and humpback (1/2), Bryde's (1/1) and sperm (4/4) whales.

During the transit survey from the Antarctic research area to the equator (includes transit from the ending point within the research area), the searching effort was 960.1 n.miles and the total sightings included fin (10/24), Antarctic minke (2/2), humpback (8/15), sperm (1/1) and Arnoux's beaked (1/3) whales.

During the transit surveys, biopsy samples were collected from five fin, two Antarctic minke, seven humpback, and one Bryde's whales.

HIGHLIGHTS OF THE SURVEY

The 2021/2022 JASS-A survey covered the eastern part of Area VI East (130°W–120°W) and succeeded in collecting sighting data necessary for the abundance estimation of cetaceans in this area. Of particular importance was the survey conducted in ice-free waters south of 72°S. Several other data necessary for understanding stock structure, movement and the environment of whales were collected during the survey. The data collected through the JASS-A will be analysed in conjunction with the data collected by the previous JARPA/JARPA, NEWREP-A and IDCR/SOWER surveys in the same region so that the analyses can be based on a long and consistent data set.

ACKNOWLEDGEMENTS

We thank the captain, crew members and researchers who participated in the 2021/2022 JASS-A survey for their effort in the collection of data and samples. We also thank the Fisheries Agency of Japan for the funding and logistic support for the JASS-A program. We appreciate Yoshihiro Fujise, Tsutomu Tamura (ICR), Hiroto Murase (Tokyo University of Marine Science and Technology), Takashi Hakamada, Mioko Taguchi (ICR) and the steering group of JASS-A for their guidance in the design and implementation of the research. Kyodo Senpaku Co. Ltd. is acknowledged for their arrangements and support for this cruise. We thank Kenji Konishi (ICR) for preparing the satellite tagging, Takashi Yoshida (ICR) for compiling the sea ice information, and Toshihiro Mogoe (ICR) for drawing the figures for the pack-ice distribution. We are grateful to Luis A. Pastene (ICR) for his assistance in preparing this report. We also thank the Editorial Team of TEREP-ICR for the editorial work on this manuscript. Finally, we acknowledge all of those who helped during the implementation of the survey despite the very difficult situations caused by the COVID-19 pandemic.

REFERENCES

Ainley, D.G., Dugger, K.M., Toniolo, V. and Gaffney, I. 2007. Cetacean occurrence patterns in the Amundsen and southern Bellingshausen Sea sector, Southern Ocean. *Marine Mammal Science* 23 (2): 287–305.

Ensor, P., Matsuoka, K., Marques, F., Miura, T., Murase, H., Pitman, R., Sakai, K. and Van Waerebeek, K. 2001. 2000–2001 International Whaling Commission-Southern Ocean Whale and Ecosystem Research (IWC-SOWER) circumpolar cruise, Areas V, VI and I. Paper SC/53/IA5 presented to the IWC Scientific Committee, July 2001 (unpublished). 56 pp. [Available from the IWC Secretariat].

Fujise, Y. and Pastene, L.A. 2021. Whales as indicators of historical and current changes in the marine ecosystem of the Indo-Pacific sector of the Antarctic. pp. 84–104. *In*: M. Kanao, D. Godone and N. Dematteis (eds.). *Glaciers and Polar Environment.* IntechOpen. 200 pp.

Government of Japan. 2019a. Outline of a research program to investigate the abundance, abundance trends and stock structure of large whales in the Indo-Pacific region of the Antarctic, including a survey plan for the 2019/20 austral summer season. Paper SC/68a/ASI8 presented to the IWC Scientific Committee, May 2019 (unpublished). 16 pp. [Available from the IWC Secretariat].

Government of Japan. 2019b. Outline of a research program to investigate the abundance, abundance trends and stock structure of large whales in the Indo-Pacific region of the Antarctic, including a survey plan for the 2019/20 austral summer season. Paper WG-EMM-2019/68 presented to CCAMLR meeting of Working Group on Ecosystem Monitoring and Management, June–July 2019 (unpublished). 16 pp.

Government of Japan. 2019c. Outline of a research program to investigate the abundance, abundance trends and stock structure of large whales in the Indo-Pacific region of the Antarctic, including a survey plan for the 2019/20 austral summer season (revised version of document SC/68a/ASI08 presented to the IWC SC 2019 meeting). Paper SC/26/NPR-JP presented to the 26th meeting of the NAMMCO Scientific Committee, October–November 2019 (unpublished). 16 pp.

International Whaling Commission. 2012. Requirements and guidelines for conducting surveys and analysing data within the Revised Management Scheme. *J. Cetacean Res. Manage.* (Suppl.) 13: 509–517.

Isoda, T., Matsuoka, K., Tamura, T. and Pastene, L.A. 2021. Spatial and temporal distribution of floating marine macro debris in the Indo-Pacific region of the Antarctic. *Cetacean Population Studies* 3: 198–211.

Isoda, T., Katsumata, T., Ueta, E., Kasai, H. and Matsuoka, K. 2022. Results of the Japanese Abundance and Stock structure Survey in the Antarctic (JASS-A) during the 2021/2022 austral summer season. Paper SC/68D/ASI/10 presented to the IWC Scientific Committee, April–May 2022 (unpublished). 28 pp. [Available from the IWC Secretariat].

Konishi, K., Isoda, T., Bando, T., Minamikawa, S. and Kleivane, L. 2020. Antarctic minke whales find ice gaps along the ice edge in foraging grounds of the Indo-Pacific sector (60°E and 140°E) of the Southern Ocean. *Polar Biol* 43 (4): 343–357.

Larsen, F. 1998. Development of a biopsy system primarily for use on large cetaceans. Paper SC/50/O15 presented to the IWC Scientific Committee, May 1998 (unpublished). 8 pp. [Available from the IWC Secretariat].

Matsuoka, K., Ensor, P., Hakamada, T., Shimada, H., Nishiwaki, S., Kasamatsu, F. and Kato, H. 2003. Overview of minke whale sightings surveys conducted on IWC/IDCR and SOWER Antarctic cruises from 1978/79 to 2000/01. *J. Cetacean Res. Manage.* 5 (2): 173–201.

Matsuoka, K. and Hakamada, T. 2014. Estimates of abundance and abundance trend of the blue, fin and southern right whales in the Antarctic Areas IIIE–VIW, south of 60°S, based on JARPA and JARPAII sighting data (1989/90–2008/09). Paper SC/F14/J05 presented to the IWC Scientific Committee, February 2014 (unpublished). 27 pp. [Available from the IWC Secretariat].

Matsuoka, K. and Pastene, L.A. 2014. Summary of photo-identification information of blue, southern right and humpback whales collected by JARPA/JARPAII. Paper SC/F14/J34 presented to the IWC Scientific Committee, February 2014 (unpublished). 11 pp. [Available from the IWC Secretariat].

Appendix 1.

Photographs from 2021/2022 JASS-A survey

Photo 1. Antarctic minke whale.

Photo 2. Antarctic minke whale within the pack ice.

Photo 3. Antarctic blue whale.

Photo 4. Fin whale.

Photo 5. Humpback whale.

Photo 6. Killer whale.

Photo 7. Navigating within the pack-ice.

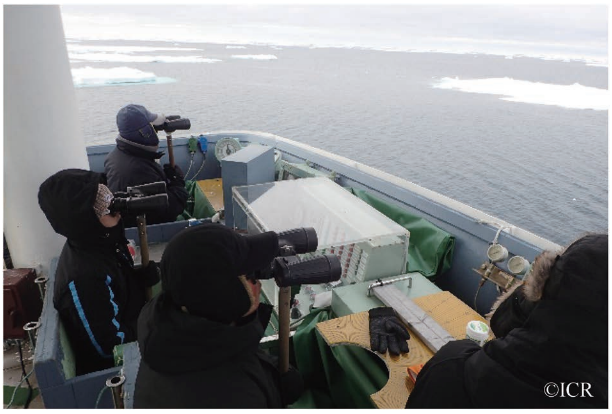


Photo 8. Sighting activity at the Upper Bridge Platform.

Photo 9. Sighting activity near an iceberg.

Photo 10. Buoy used in the angle and distance experiment.

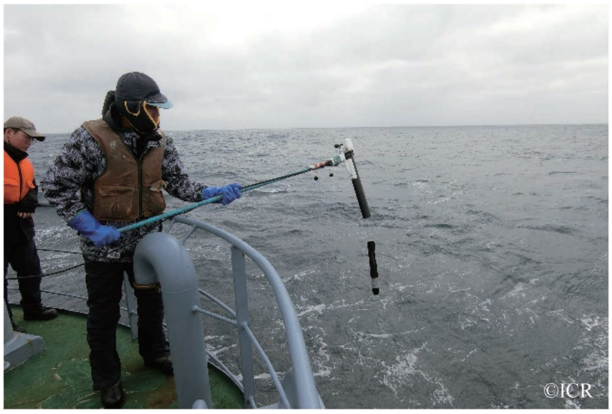


Photo 11. Oceanographic observation using XCTD.

Photo 12. Biopsy sampling on humpback whale.

Technical Report (not peer reviewed)

Report and highlights of the dedicated sighting surveys in the western North Pacific Ocean in 2021

Taiki KATSUMATA* and Koji MATSUOKA

Institute of Cetacean Research, 4–5 Toyomi-cho, Chuo-ku, Tokyo 104–0055, Japan

**Contact e-mail: katsumata@cetacean.jp*

ABSTRACT

Vessel-based sighting surveys were conducted in 2021 by the Institute of Cetacean Research to examine the distribution and abundance of whales in the western North Pacific Ocean. The research area was between 30°N–53°N and 150°E–155°W. The surveys were conducted between 4 August and 30 September, and two research vessels, *Yushin-Maru* and *Kaiyo-Maru* No.7, were engaged in the surveys. A total of 3,713.8 n.miles was searched by the passing mode in the research area. Coverage of the searching efforts on the planned cruise track line was 70.4%. In total, seven large whale species, including blue (17 schools/20 individuals), fin (78/124), sei (102/156), Bryde′s (57/72), common minke (1/1), humpback (13/16) and sperm (94/193) whales were sighted during the research period. Photo-ID images were collected from blue (12 individuals), humpback (5 individuals) and sperm (1 individual) whales. Biopsy skin samples using a Larsen system were collected from blue (n=1), fin (n=5), sei (n=15) and humpback (n=3) whales. The density indices of blue and fin whales have increased notably since the last survey in the same research area 10 years ago. Furthermore, Bryde's and humpback whales, which were not detected in the previous surveys, were sighted in the 2021 surveys.

INTRODUCTION

Dedicated cetacean sighting surveys in the western North Pacific have been conducted in the summer season since 1995, as a part of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN/JARPNII) and the New Scientific Whale Research Program in the western North Pacific (NEWREP-NP), based on the survey procedures of the International Whaling Commission/Southern Ocean Whale and Ecosystem Research (IWC/SOWER) (Anon, 2008). Based on the data collected from those surveys, the distribution patterns of large whales such as blue, fin, sei, Bryde's, common minke, humpback, North Pacific right and sperm whales, and abundance estimates of common minke, sei, and Bryde's whales were investigated and reported to the IWC Scientific Committee (SC) (IWC, 2001; 2010; 2016).

The Fisheries Resources Institute (FRI) has also conducted dedicated sighting surveys for cetaceans in the North Pacific Ocean since the 1980s (Buckland *et al.*, 1992; Miyashita *et al.*, 1995; Miyashita and Kato, 2004; Shimada, 2004; Kanaji *et al.*, 2012). In 2019, the Government of Japan decided to continue the sighting surveys in the North Pacific (IWC, 2019) under the rationale that the collection of sighting data to estimate abundance and biopsy/photo-identification data to examine stock structure have contributed in the past to the work on the management and conservation of large whales by the IWC SC (IWC, 2016).

This paper reports the results of the latest Japanese dedicated sighting surveys conducted by the Institute of Cetacean Research (ICR) between 4 August and 30 September 2021.

SURVEY DESIGN

Research vessels

The surveys in 2021 were conducted by the research vessels *Kaiyo-Maru* No.7 (*KY7*) and *Yushin-Maru* (*YS1*). The vessels were equipped with a top barrel platform (TOP), IO barrel platform (IOP) and upper bridge. Specifications of these vessels are shown in Figure 1.

Research period and area

In 2021, surveys were conducted in late summer (August to September), and the research areas were between 30°N–40°N and 150°E–180°for *KY7*, and between 40°N–53°N and 180°–155°W for *YS1* (Figure 2).

Track line design

The pre-determined track lines in the research area are

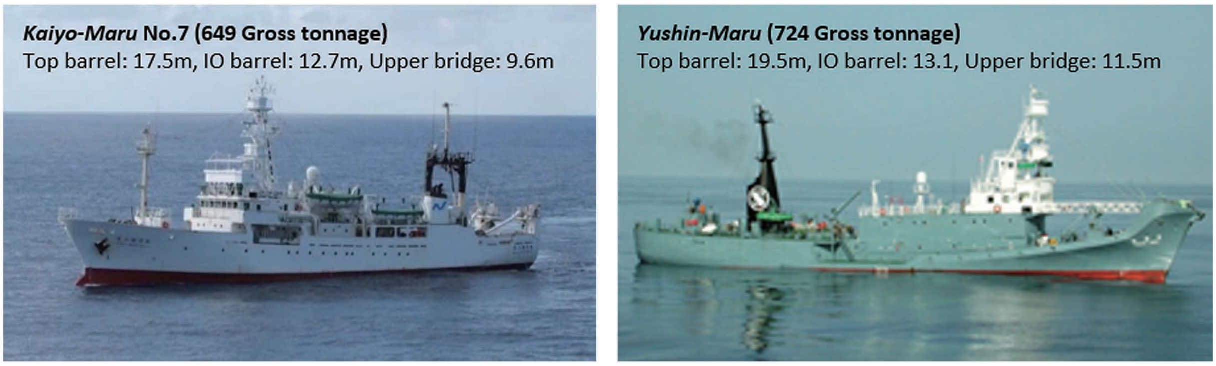


Figure 1. Research vessels *Kaiyo-Maru* No.7 (*KY7*) (left) and *Yushin-Maru* (*YS1*) (right).

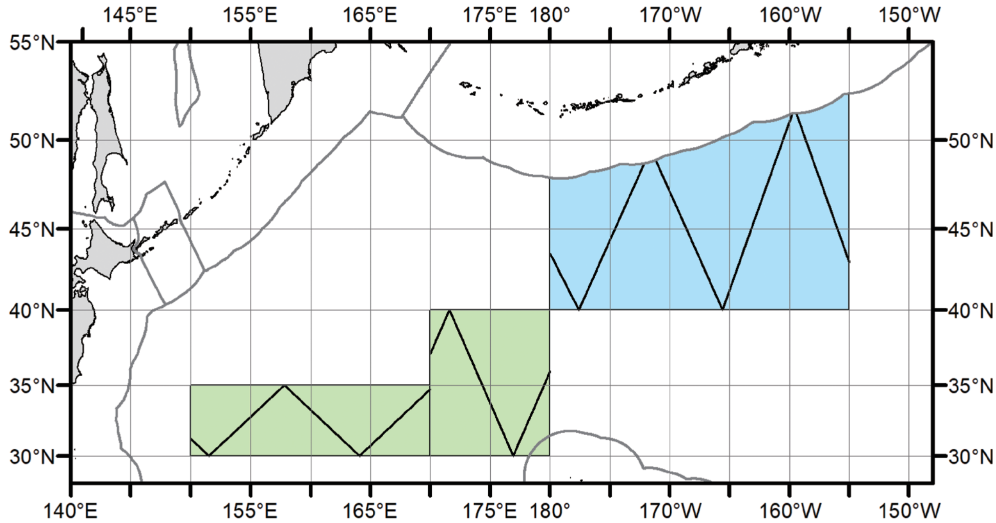


Figure 2. Research areas of the 2021 sighting survey held from August to September. *KY7* covered the green area, and *YS1* covered the blue area.

shown in Figure 2. The start point of the track lines were decided randomly using the "Distance program ver. 7.0" (Thomas *et al.*, 2010), and the number of the line transects was decided by considering the research schedule and based on the IWC survey guidelines (IWC, 2012).

Sighting procedures

The sighting survey was conducted using (1) Normal Passing mode (NSP) and (2) Passing with Independent Observer mode (IO). Data obtained under the IO mode are useful for future estimations of *g*(0). Both survey modes followed the protocol endorsed for the SOWER surveys (e.g. Matsuoka *et al.*, 2003; Anon, 2008; IWC, 2012).

For NSP mode, there were two primary observers on the top barrel platform (TOP) and two (captain and helmsman) on the upper bridge. All primary observers engaged in the searching activity for cetaceans by using angle board and scaled binoculars (7×).

For IO mode, there were two primary observers on the TOP and two on the IO barrel platform (IOP). These observers conducted the searching activity for cetaceans by using angle board and scaled binoculars (7×). There was no open communication between the IOP and the TOP. The observers and researchers on the upper bridge communicated to the TOP (or IOP) independently only to clarify information, and did not distract the top-men from their normal searching procedure. These primary observers report sighting-information to researchers and other observers on the upper bridge for data recording.

The sighting survey effort began 60 minutes after sunrise and ended 60 minutes before sunset, with a maximum of 12 hours per day when the weather conditions were acceptable for observations: visibility better than 2.0 n.miles and wind speed less than 21 knots. The searching speed was planned to be 10.5 to 11.5 knots with slight adjustments to avoid vibration of the vessel.

Experiments

Distance and angle experiments were conducted in the middle of the survey period. The experiment was conducted to evaluate measurement error, and followed the protocol of the IWC/SOWER and IWC-POWER surveys

Table 1
Summary of the survey periods and searching effort in each research area.

Vessel	Research period	Planned cruise track (n.miles)	Searching effort NSP (n.miles)	Searching effort IO (n.miles)	Searching effort Total (n.miles)	Coverage of effort (%)
KY7	2021/08/11–08/21	1,226.1	455.1	470.7	925.8	75.5
	2021/08/30–09/09	1,392.5	533.1	534.4	1,067.5	76.7
YS1	2021/08/18–09/20	2,658.6	752.3	968.2	1,720.5	64.7
Total	–	5,277.2	1,740.5	1,973.3	3,713.8	70.4

Table 2
Numbers of sightings of large cetaceans, by species and research vessel in the 2021 surveys.

Vessel	Transit (Including both vessels)				*KY7* (150°E–180°)				*YS1* (180°–155°W)				Total			
Species	Prim.		Second.		Prim.		Second.		Prim.		Second.		Prim.		Second.	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Blue whale	0	0	0	0	0	0	0	0	17	20	0	0	17	20	0	0
Fin whale	8	13	0	0	1	1	0	0	66	107	3	3	75	121	3	3
Sei whale	1	1	0	0	0	0	0	0	98	146	3	9	99	147	3	9
Bryde's whale	12	20	1	1	20	25	0	0	24	26	0	0	56	71	1	1
Common minke whale	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0
Humpback whale	0	0	0	0	0	0	0	0	11	13	2	3	11	13	2	3
Sperm whale	32	72	3	5	34	90	0	0	24	25	1	1	90	187	4	6

Prim.: primary sighting, Second.: secondary sighting, Sch.: school, Ind.: individual.

(IWC, 2012).

When large cetaceans such as blue and humpback whales were found, photo-ID images were obtained using Canon EOS 7D Mark II (with 100–400 mm lens) from the bow or upper deck. Further, biopsy skin sampling using the Larsen system (Larsen, 1998) was conducted when blue, fin, sei, humpback whales were sighted. A satellite tagging experiment using the Air Rocket Transmitter System (LK-ARTS) was also conducted for fin and sei whales.

RESULTS

Brief narrative of the surveys

KY7 departed Shiogama, Miyagi, Japan on 4 August, and started the transit survey on 5 August. *KY7* began the survey in the research area from the east on 11 August. *KY7* paused the survey at 170°E on 21 August for a scheduled port call, and entered Kushiro, Hokkaido, Japan, on 26 August for refueling and disembarkation of researchers. On 27 August, *KY7* departed Kushiro, and reached the resume point at 170°E on 30 August. The survey was completed on 9 September. *KY7* arrived in Shiogama, Miyagi on 17 September.

YS1 departed Shimonoseki, Yamaguchi, Japan on 4 August, and started the transit survey on 6 August. On 18 August, *YS1* reached the start point at 155°W, and completed the survey on 20 September. *YS1* and arrived in Shiogama, Miyagi, on 30 September.

Searching effort

A summary of searching effort and coverage by each research vessel is shown in Table 1. A total of 3,713.8 n.miles (6,878.0 km) were searched. The total searching effort by *KY7* was 925.8 n.miles (1,714.6 km) (75.5% coverage) in the eastern part, and 1,067.5 n.miles (1,977.0 km) (76.7% coverage) in the western part. The total searching effort by *YS1* was 1,720.5 n.miles (3,186.4 km) (64.7% coverage).

Sightings

Overall

Sightings were summarized by each research vessel in Table 2 for large cetaceans and in Table 3 for small cetaceans.

There was a total of 349 schools sighted of seven large whale species, involving 560 individual whales. The largest number of sightings was for sperm whales (in terms of

Table 3
Numbers of sightings of small cetaceans, by species and research vessel in the 2021 surveys.

Vessel	Transit (Including both vessels)				*KY7* (150°E–180°)				*YS1* (180°–155°W)				Total			
Species	Prim.		Second.		Prim.		Second.		Prim.		Second.		Prim.		Second.	
	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.	Sch.	Ind.
Killer whale	0	0	0	0	0	0	0	0	7	18	0	0	7	18	0	0
Melon-headed whale	0	0	0	0	1	105	0	0	0	0	0	0	1	105	0	0
Risso's dolphin	3	45	0	0	3	21	0	0	1	3	0	0	7	69	0	0
Striped dolphin	11	1,549	0	0	3	225	0	0	0	0	0	0	14	1,774	0	0
Common dolphin	0	0	0	0	1	6	0	0	7	288	0	0	8	294	0	0
Pacific white-sided dolphin	1	12	0	0	0	0	0	0	14	392	1	13	15	404	1	13
Northern right whale dolphin	3	14	0	0	0	0	0	0	2	223	0	0	5	237	0	0
True type Dall's porpoise	0	0	0	0	0	0	0	0	2	4	0	0	2	4	0	0
Dalli type Dall's porpoise	0	0	0	0	0	0	0	0	11	74	0	0	11	74	0	0
Unid. type Dall's porpoise	0	0	0	0	0	0	0	0	7	27	0	0	7	27	0	0
Ziphiidae	4	16	0	0	21	44	0	0	3	4	0	0	28	64	0	0
Mesoplodon spp.	1	1	0	0	2	3	0	0	1	3	0	0	4	7	0	0

Prim.: primary sighting, Second.: secondary sighting, Sch.: school, Ind.: individual.

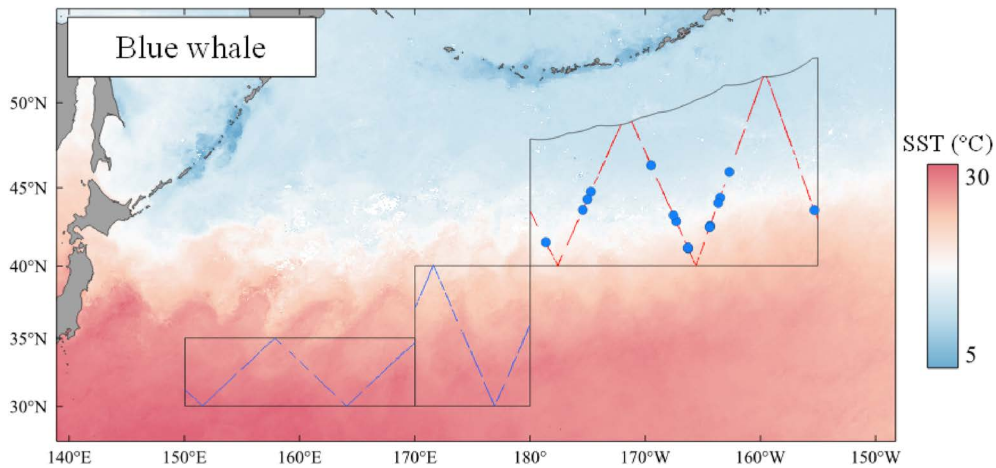


Figure 3. The sighting distribution of blue whales (blue circle) with the searching track of *KY7* (blue line) and *YS1* (red line). Rolling 32 days average sea surface temperature from 13 August to 13 September 2021 was observed by MODIS-Aqua (Original data: Ocean color web, from https://oceancolor.gsfc.nasa.gov/ (Accessed 2022-7-18)).

number of individuals) and the smallest was for common minke whales. The largest number of sightings in baleen whales was for sei whales (Table 2).

In terms of small cetaceans, seven species were identified in the family Delphinidae, and one species was identified in the family Phocoenidae. No species were identified in the family Ziphiidae because of their elusive behavior. The most common species sighted were striped dolphins (14/1,774), followed by Pacific white-sided dolphins (16/417) (Table 3).

Geographical distribution of sightings by cetacean species

Blue whale

The geographical distribution of the sightings is shown in Figure 3 together with sea surface temperature. In total, one mother and calf pair was sighted at position 44°45′N, 174°43′W. The mean school size was 1.2 and the range of sea surface temperature (SST) at the sighting positions was 11.5–19.7°C (mean SST: 16.3°C).

The density index (DI: schools sighted/100 n.miles searching distance) based on primary sightings in the research area for *YS1* was 0.99. The DIs were 0.15 and 0.48

in the 2010 and 2011 IWC-POWER cruises, respectively, which were conducted north of 40°N. The longitudinal ranges of those cruises were 170°E–170°W and 170°W–150°W, respectively (Matsuoka *et al.*, 2011; 2012). It should be noted that the survey period in 2021 was about one month later than in the previous IWC-POWER surveys. The DIs suggest that the population of blue whales in the North Pacific is increasing. A photograph of a blue whale is shown in Figure 4.

Figure 4. A blue whale observed in the research area on 10 September 2021.

Fin whale

The geographical distribution of the sightings is shown in Figure 5 together with sea surface temperature. In total, one mother and calf pair was sighted at position 45°53’N, 174°00'W. Fin whales were distributed mainly throughout the research area surveyed by the *YS1*. The observed mean school size was 1.6 and the range of SST at the sighting positions was 11.0–20.3°C (mean SST: 14.9°C).

The DI of *YS1* was 3.84. The DI in the previous 2010 and 2011 IWC-POWER surveys were 0.53 and 1.79, respectively (Matsuoka *et al.*, 2011; 2012). As in the case of blue whales, the DIs suggest that the fin whale population in the North Pacific is increasing.

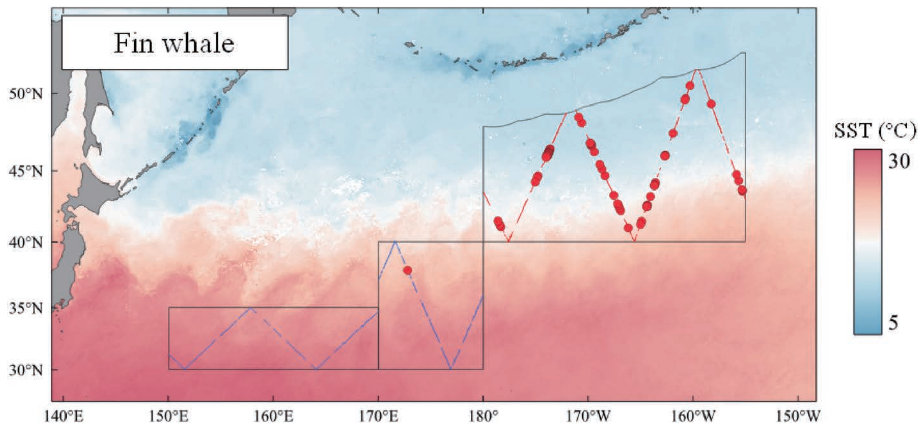


Figure 5. The sighting distribution of fin whales (red circle) with the searching track of *KY7* (blue line) and *YS1* (red line). Rolling 32 days average sea surface temperature from 13 August to 13 September 2021 was observed by MODIS-Aqua.

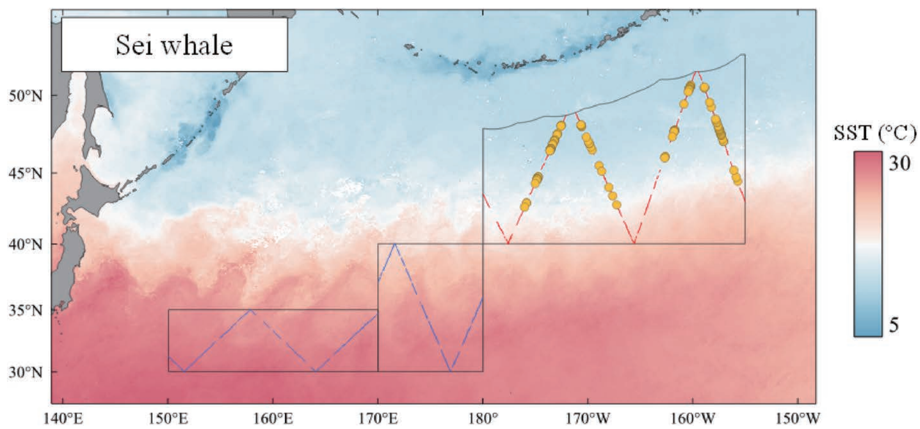


Figure 6. The sighting distribution of sei whales (orange circle) with the searching track of *KY7* (blue line) and *YS1* (red line). Rolling 32 days average sea surface temperature from 13 August to 13 September 2021 was observed by MODIS-Aqua.

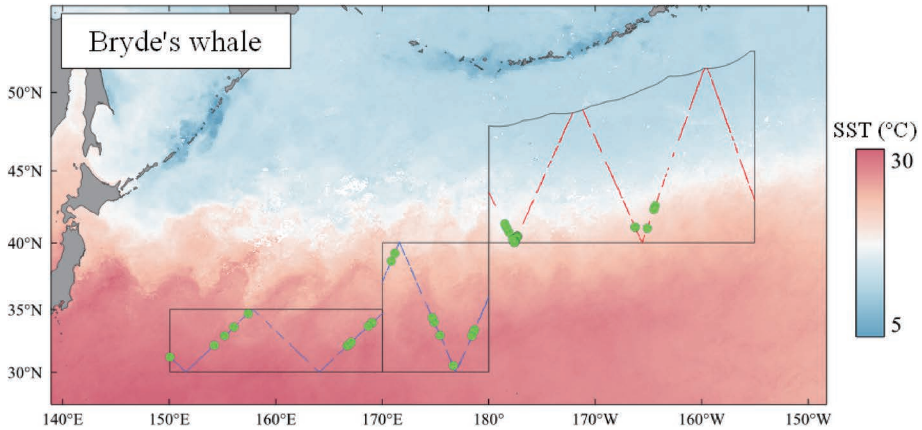


Figure 7. The sighting distribution of Bryde's whales (green circle) with the searching track of *KY7* (blue line) and *YS1* (red line). Rolling 32 days average sea surface temperature from 13 August to 13 September 2021 was observed by MODIS-Aqua.

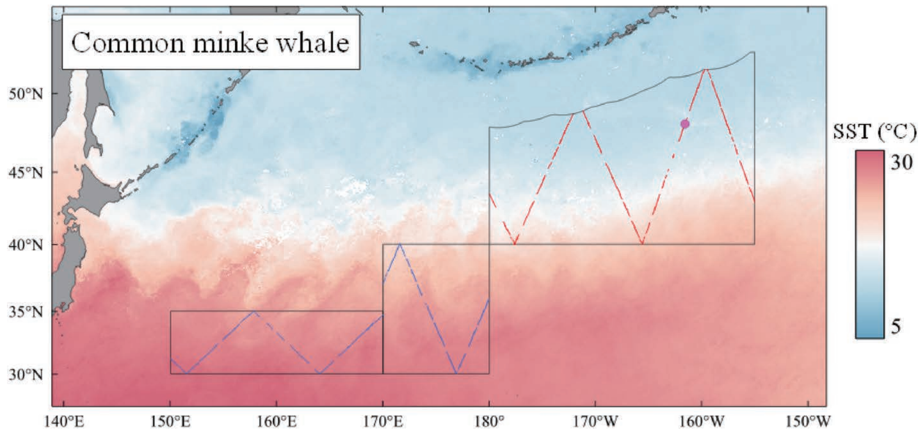


Figure 8. The sighting distribution of common minke whales (pink circle) with the searching track of *KY7* (blue line) and *YS1* (red line). Rolling 32 days average sea surface temperature from 13 August to 13 September 2021 was observed by MODIS-Aqua.

Sei whale

The geographical distribution of the sightings is shown in Figure 6 together with sea surface temperature. This species was sighted north of 42°N in the survey area of the *YS1*. No mother and calf pairs were observed. High density was observed in the latitudinal band between 47°N and 49°N (Figure 6). The observed mean school size was 1.5 and the range of SST at the sighting positions was 10.9–17.4°C (mean SST: 12.6°C).

The DI of *YS1* was 5.70. The DIs of the 2010 and 2011 IWC-POWER surveys were 3.55 and 2.21, respectively (Matsuoka *et al.*, 2011; 2012). These values were smaller than those found in the 2021 surveys.

Bryde's whale

The geographical distribution of the sightings is shown in Figure 7 together with sea surface temperature. One mother and calf pair was observed at position 41°03'N, 178°18'W. Bryde's whales were widely distributed longitudinally north of 30°N, which is similar to the pattern found in previous surveys (Shimada, 2004; Hakamada *et al.*, 2017). Based on sighting data by *KY7*, the observed mean school size was 1.3, and the range of SST at the sighting positions was 21.4–29.7°C (mean SST: 27.2°C). Based on sighting data by *YS1*, the observed mean school size was 1.1, and the range of SST at the sighting positions was 17.5–20.7°C (mean SST: 20.1°C).

The DIs were 1.00 and 1.39 by the *KY7* and *YS1*, respectively. Bryde's whales were not sighted north of 40°N in the previous IWC-POWER surveys (Matsuoka *et al.*, 2011; 2012), however in the 2021 surveys some sightings were made north of that latitude (Figure 7) The northern most sighting position in these surveys was 42°36'N.

Common minke whale

The geographical distribution of the sightings is shown in Figure 8 together with sea surface temperature. Only one school (one individual) was sighted at 48°07'N, 161°34'W

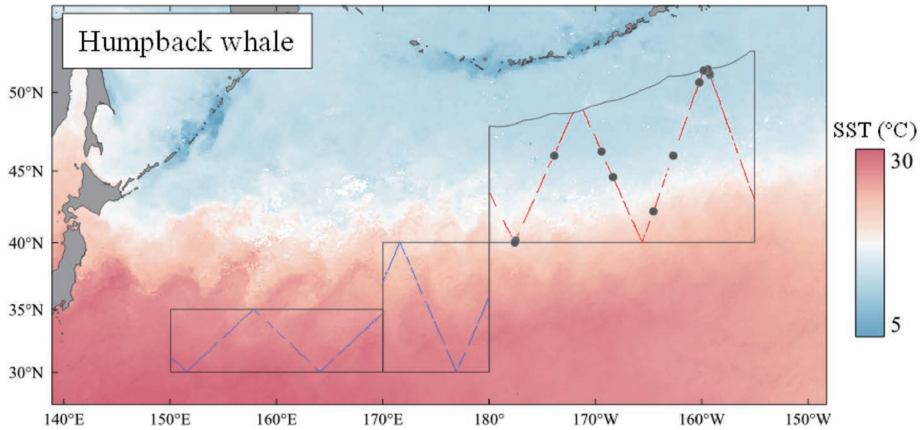


Figure 9. The sighting distribution of humpback whales (black circle) with the searching track of *KY7* (blue line) and *YS1* (red line). Rolling 32 days average sea surface temperature from 13 August to 13 September 2021 was observed by MODIS-Aqua.

Figure 10. A humpback whale sighted at 40°N on 18 September, 2021.

in calm weather conditions. The SST at the sighting position was 12.5°C. Common minke whales are hard to find under harsh sea surface conditions because their small blows are difficult to detect in such conditions.

Humpback whale

The geographical distribution of the sightings is shown in Figure 9 together with sea surface temperature. No mother and calf pair of this species were sighted. Sightings were made north of 40°N only in the area surveyed by *YS1* (Figure 9). The range of SST at the sighting positions was 10.7–20.7°C (mean SST: 13.8°C).

The DI based on primary sightings of *YS1* was 0.64. In previous surveys, humpback whales were not sighted south of 47°N (Matsuoka *et al.*, 2011; 2012). In the 2021 surveys, two schools were sighted around 40°N, and one individual was photographed (Figure 10). A biopsy sample was collected from this individual.

Sperm whale

The geographical distribution of the sightings is shown in Figure 11 together with sea surface temperature. This species was distributed widely in the research areas (Figure 11). The observed mean school size differed markedly between the research areas covered by the two vessels: 2.6 in the area covered by *KY7* and 1.0 by the area covered by *YS1*.

Small cetaceans

The geographical distribution of the sightings of small cetaceans is shown in Figures 12a and 12b together with sea surface temperature. Killer whales, Pacific white-sided dolphins and Dall's porpoises were mainly sighted north of 42°N, while common dolphins were sighted primarily in the 40°N–42°N latitudinal band. Striped dolphins were not sighted north of 40°N. These distribution patterns of small cetaceans were consistent with those found in the previous IWC-POWER surveys conducted ten years ago (Matsuoka *et al.*, 2011; 2012).

Duplicate sightings

A total of 31 and 96 duplicates of large cetaceans were recorded during IO mode surveys by *KY7* and *YS1*, respectively.

Experiments

Sighting distance and angle experiment

The Estimated Angle and Distance Training Exercise was conducted during the surveys using a buoy that resembles a blow with a reflector. During the exercise, the observers familiarized themselves with distance estimates from the TOP, IO and Upper Bridge. The Estimated Angle and Distance Experiment was conducted on 23 September by *YS1* on 14 August by *KY7*. The results of this experiment will be used for the calculation of abundance estimates.

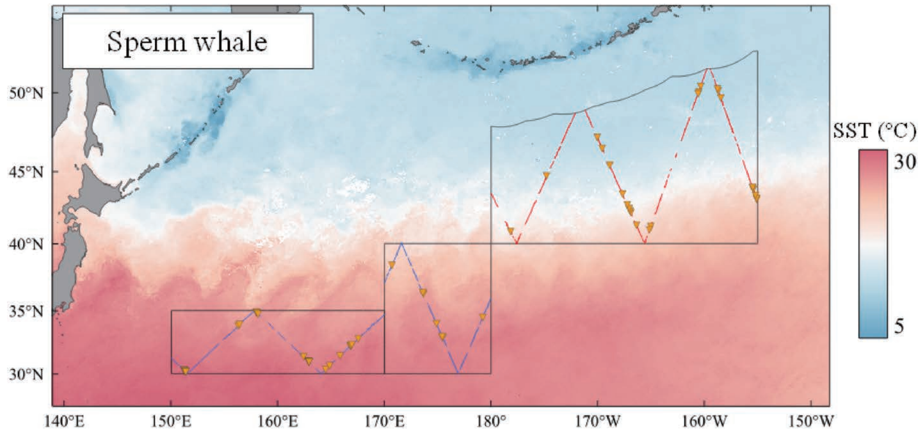


Figure 11. The sighting distribution of sperm whales (inverted brown triangle) with the searching track of *KY7* (blue line) and *YS1* (red line). Rolling 32 days average sea surface temperature from 13 August to 13 September 2021 was observed by MODIS-Aqua.

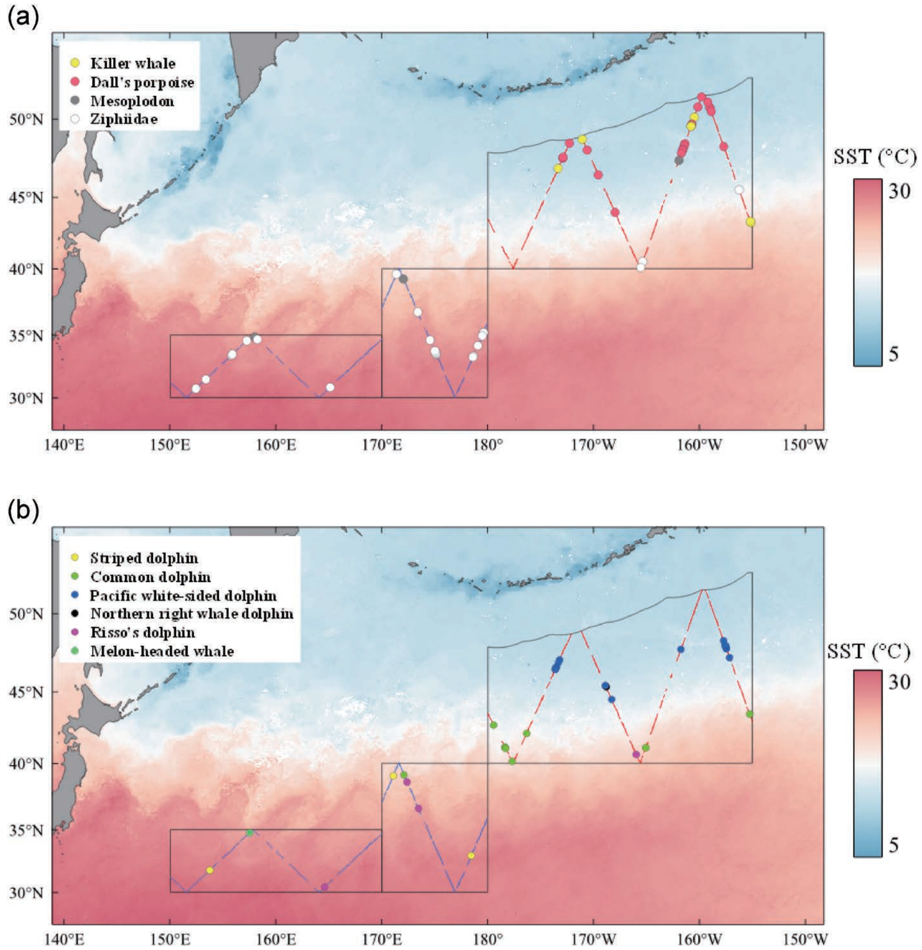


Figure 12. (a) The sighting distribution of killer whales, Dall's porpoise, unidentified *Mesoplodon* spp., and Ziphiidae with the searching track of *KY7* (blue line) and *YS1* (red line). Rolling 32 days average sea surface temperature from 13 August to 13 September 2021 was observed by MODIS-Aqua. (b) The sighting distribution of striped, common, Pacific white-sided, northern right whale, Risso's dolphin and melon-headed whale with the searching track of *KY7* (blue line) and *YS1* (red line). Rolling 32 days average sea surface temperature from 13 August to 13 September 2021 was observed by MODIS-Aqua.

Photo-ID

Photographs were taken of blue (n=12), humpback (n=5) and sperm (n=1) whales. All photographs were stored in the ICR catalog and will be used for investigating stock structure and movement of these species in the future.

Biopsy sampling

A total of 24 biopsy samples were collected from blue (n=1), fin (n=5), sei (n=15) and humpback (n=3) whales. All samples were stored at the ICR laboratory and will be used in genetic analyses to investigate stock structure of these species in the future.

Satellite tagging

Two fin and nine sei whales were successfully tagged and tracked. Results of this experiment are shown in Konishi and Isoda (2022).

HIGHLIGHTS OF THE SURVEY

The sighting surveys conducted in 2021 were completed successfully. They provided unique data for summer months, as information on cetacean distribution and abundance during summer have been very scarce. Some main characteristics of the surveys are summarized below.

The surveys in August–September covered the northern part of the central Pacific, and provided important summer sighting data for, fin, sei, Bryde's and sperm whales. These data will be used for the abundance estimation of those species. At the same time, it was confirmed that blue, humpback and common minke whales were also distributed in these areas, although in small numbers.

The DI of blue, fin and sei whales increased significantly compared with previous IWC-POWER surveys conducted ten years ago. The distribution pattern of these three species overlapped in terms of the latitudinal band and SSTs (Figures 3, 5 and 6). The distribution pattern of these three species were consistent with those in the previous surveys from ten years ago. On the other hand, the distribution of Bryde's and humpback whales were different. Ten years ago, Bryde's whales were not sighted and humpback whales were sighted only north of 47°N. The result of the 2021 surveys showed that Bryde's whale distribution either expanded or shifted northward, and humpback whale distribution expanded or shifted southward.

As with the previous surveys, the 2021 surveys collected data on small cetaceans in the same way as large cetaceans. The analyses of these data will provide valuable information on the distribution and abundance of small cetaceans in different seasons.

ACKNOWLEDGEMENTS

We thank Captains Chikamasa Okoshi, Yasuaki Sasaki, and their officers and crew of the *Yushin-Maru* and *Kaiyo-Maru* No.7 for their hard work and dedication that led to the successful implementation of these surveys. We express our gratitude to Takashi Hakamada and Megumi Takahashi (ICR) for their assistance in survey design. We thank Yoshihiro Fujise and Tsutomu Tamura and the staff of the ICR and Kyodo Senpaku Co. Ltd. for their arrangements and support for the survey. We also thank Kenji Konishi (ICR) for satellite tagging and Mioko Taguchi (ICR) for the management of biopsy samples. We thank Luis A. Pastene (ICR) for his assistance in preparing this report. We also thank the Editorial Team of TEREP-ICR for the editorial work on this manuscript.

REFERENCES

Anon. 2008. IWC SOWER Cruise 2008/09, Information for Researchers. https://iwc.int/private/downloads/-m4RVc06JhBVw3ymd3oPcw/Guide%20%20for%20Researchers%202008-09.pdf.

Buckland, S.T., Cattanach, K.L. and Miyashita, T. 1992. Minke whale abundance in the northwest Pacific and the Okhotsk Sea, estimated from 1989 and 1990 sighting surveys. *Rep. int. Whal. Commn* 42: 387–392.

Hakamada, T., Takahashi, M., Matsuoka, K. and Miyashita, T. 2017. Abundance estimate for western North Pacific Bryde's whale by sub-areas based on IWC-POWER and JARPNII sighting surveys. Paper SC/M17/RMP2 presented to the Workshop on the Implementation Review of western North Pacific Bryde's whales, March 2017 (unpublished). 11 pp. [Available from the IWC Secretariat].

International Whaling Commission. 2001. Report of the Workshop to Review the Japanese Whale Research Program under Special Permit for North Pacific minke whales (JARPN). *J. Cetacean Res. Manage.* (Suppl.) 3: 377–413.

International Whaling Commission. 2010. Report of the Expert Workshop to review the ongoing JARPNII programme. *J. Cetacean Res. Manage.* (Suppl.) 11 (2): 405–450.

International Whaling Commission. 2012. Requirements and guidelines for conducting surveys and analyzing data within the revised management scheme. *J. Cetacean Res. Manage.* (Suppl.) 13: 509–517.

International Whaling Commission. 2016. Report of the Expert Panel of the final review on the western North Pacific Japanese Special Permit Programme (JARPNII). Paper SC/66b/REP/06 presented to the IWC Scientific Committee, June 2016 (unpublished). 96 pp. [Available from the IWC Secretariat].

International Whaling Commission. 2019. Report of the

Scientific Committee. Annex Q. *J. Cetacean Res. Manage*. (Suppl.) 20: 394–412.

Kanaji, Y., Iwasaki, T., Kishiro, T. and Miyashita, T. 2012. Cruise report of the sighting and satellite tagging survey for common minke whales in the sub-area 7 in 2011. Paper SC/64/O9 presented to the IWC Scientific Committee, June 2012 (unpublished). 10 pp. [Available from the IWC Secretariat].

Konishi, K. and Isoda, T. 2022. Results of the Japanese dedicated cetacean sighting survey in the North Pacific in 2021 summer season. Appendix B. Results of the satellite-monitored tracking experiment during the summer survey cruises in 2021. Paper SC/68D/ASI06 presented to the IWC Scientific Committee, April–May 2022 (unpublished). 2 pp. [Available from the IWC Secretariat].

Larsen, F. 1998. Development of a biopsy system primarily for use on large cetaceans. Paper SC/50/O15 presented to the IWC Scientific Committee, May 1998 (unpublished). 8 pp. [Available from the IWC Secretariat].

Matsuoka, K., Ensor, P., Hakamada, T., Shimada, H., Nishiwaki, S., Kasamatsu, F. and Kato, H. 2003. Overview of minke whale sightings surveys conducted on IWC/IDCR and SOWER Antarctic cruises from 1978/79 to 2000/01. *J. Cetacean Res. Manage*. 5 (2): 173–201.

Matsuoka, K., Hakala. S., Kim, H.W., Aki, M. and Shinyasiki, Y. 2011. 2010 IWC/Japan joint cetacean sighting survey cruise in the North Pacific. Paper SC/63/O5 presented to the IWC Scientific Committee, May–June 2011 (unpublished). 40 pp. [Available from the IWC Secretariat].

Matsuoka, K., Mizroch, S. and Komiya, H. 2012. Cruise report of the 2011 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER). Paper SC/64/IA5 presented to the IWC Scientific Committee, June 2012 (unpublished). 27 pp. [Available from the IWC Secretariat].

Miyashita, T., Kato, H. and Kasuya, T. (eds.) 1995. *Worldwide Map of Cetacean Distribution based on Japanese Sighting Data (Volume 1)*. National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka, Japan. 140 pp.

Miyashita, T. and Kato, H. 2004. Plan for the North Pacific minke whale sighting surveys in 2004. Paper SC/56/RMP3 presented to the IWC Scientific Committee, June 2004 (unpublished). 3 pp. [Available from the IWC Secretariat].

Shimada, H. 2004. Abundance estimate of the western North Pacific stock of Bryde's whales using sighting data from 1998 to 2002. Paper SC/56/PFI6 presented to the IWC Scientific Committee, June 2004 (unpublished). 8 pp. [Available from the IWC Secretariat].

Thomas, L., Buckland, S.T., Rexstad, E.A., Laake, J.L., Strindberg, S., Hedley, S.L., Bishop, J.R.B., Marques, T.A. and Burnham, K.P. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47 (1): 5–14.

Technical Reports of the Institute of Cetacean Research (2022) pp. 46–51

Technical Report (not peer reviewed)

Results of the IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER) dedicated sighting survey in 2021—An overview—

Hiroto MURASE*

Tokyo University of Marine Science and Technology, 4–5–7 Konan, Minato-ku, Tokyo 108–8477, Japan

Contact e-mail: hmuras0@kaiyodai.ac.jp

ABSTRACT

This paper outlines the main results of the 2021 dedicated sighting survey of the International Whaling Commission-Pacific Ocean Whale and Ecosystem Research (IWC-POWER). The IWC-POWER surveys are designed and implemented by the IWC Scientific Committee, in special partnership with the Government of Japan. The surveys have been conducted since 2010 as the first phase with the long-term objective: ʻ(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 actionsʼ. The 2021 survey was conducted successfully between 2 August and 30 September 2021 in the eastern North Pacific by the Japanese R/V *Yushin-Maru* No. 2. The following whale species were sighted in the survey area: blue (6 schools / 7 individuals), fin (77/113), sei (23/37), Brydeʼs (20/22), sperm (14/14) and killer (1/4) whales. Photo-identification data were collected from 7 blue, 31 fin, 15 sei 13 Brydeʼs and 3 killer whales. A total of 19 biopsy samples were collected from 3 blue, 9 fin, 4 sei, 2 Brydeʼs and 1 killer whales. A total of 88 objects of marine debris were observed and recorded. Data collected during this survey will be used mainly for abundance estimation and stock structure purposes.

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 and cooperating institutes such as Tokyo University of Marine Science and Technology participate regularly in the IWC-POWER program, both in designing and implementing the surveys. The IWC-POWER surveys in the North Pacific follow the series of IWC International Decade for Cetacean Research/Southern Ocean Whale and Ecosystem Research (IDCR/SOWER) surveys conducted in the Antarctic since 1978.

The long-term objective of the IWC-POWER is to ʻprovide 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.ʼ The first survey of this program was conducted in 2010 and the most recent one in 2021 as the first phase (IWC, 2021).

The IWC SC is close to completing the first phase of the IWC-POWER, which is related to its short-term priorities. The IWC SC is preparing for the second phase related to medium-term priorities, based on the results of the first phase (see Matsuoka, 2020).

Originally, the 2021 IWC-POWER was planned to be conducted in the region east of the Kuril archipelago within the Russian EEZ, and Japan submitted the research application to the Russian Federation. However, Russia sent a note verbale to Japan stating that the government could not accept the application. No reason was given. As a result, the 2021 IWC-POWER was conducted following the back-up plan in the eastern North Pacific waters.

The objective of this document is to present an overview of the results of the 2021 IWC-POWER survey. Details can be found in Murase *et al.* (2022). For general background of the IWC-POWER including objectives, research area and general methodology, see Matsuoka (2020).

RESULTS OF THE 2021 IWC-POWER SURVEY

The main results of the 2021 IWC-POWER survey are summarized here based on Murase *et al.* (2022).

Table 1
The 2021 IWC-POWER survey itinerary.

Date	Event
1 August 2021	Pre-cruise meeting in Shiogama
2 August	Vessel departs Shiogama
17 August	Vessel starts the survey in the research area
18 September	Vessel completes the survey in the research area
30 September	Vessel arrives in Shiogama
1 October	Post-cruise meeting in Shiogama

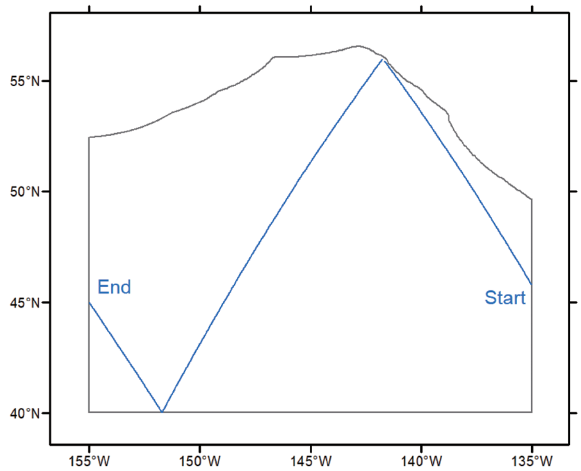


Figure 1. Research area and survey track lines with start and end points for the 2021 IWC-POWER survey.

Figure 2. Photograph of the R/V *Yushin-Maru* No. 2 used in the 2021 IWC-POWER survey.

Itinerary

The survey was conducted between 2 August and 30 September 2021 by the Japanese R/V *Yushin-Maru* No. 2. The itinerary is shown in Table 1.

Table 2
Specifications of the R/V *Yushin-Maru* No. 2 used in the 2021 IWC-POWER survey.

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 between 40°00′N and US and Canadian EEZ boundaries, between 135°00′W and 155°00′W, comprised entirely of the high seas (Figure 1). The areas between 150°00′W and 155°00′W, and between 135°00′W and 150°00′W were surveyed in the 2011 and 2012 POWER surveys, respectively, although the timing of the surveys were different from the 2021 POWER survey.

Research vessel and scientific personnel

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

Three international researchers were nominated by the IWC SC for this survey:
Hiroto Murase (Japan)—Cruise Leader (CL)/Chief Scientist
James W. Gilpatrick, Jr. (US)—Photo-ID
Isamu Yoshimura (Japan)—sighting data, marine debris and biopsy sample management

Searching effort

Survey trackline coverage in the research area was 77.2% (1,562.5 n.miles of a planned distance of 2,022.4 n.miles), with a total of 833.7 n.miles in Passing with abeam closing mode (NSP) and 728.8 n.miles in Independent Observer passing mode (IO). The effort spent in sighting and several experiments are shown in Table 3.

Summary of the sightings

During the survey in the research area, the following sightings were made: blue (6 schools / 7 individuals), fin (77/113), sei (23/37), Bryde's (20/22), sperm (14/14) and killer (1/4) whales (Table 4). These data will be used to estimate abundance of several species.

Table 3
Summary of the searching effort (time and distance) and experimental time (hours) in the survey area of the 2021 IWC-POWER survey.

Area	Leg No.	Start	End	NSP		IO		NSP+IO		Photo-ID, Biopsy, TDR tag	Estimated angle and distance training/ experiment
	Start	Date	Date	Time	Dist. (n.m.)	Time	Dist. (n.m.)	Time	Dist. (n.m.)	Time	Time
	End	Time	Time								
Research Area (between 150°W and 135°W)	101	17-Aug.	11-Sep.	59:04:25	624.30	52:33:36	552.83	111:38:01	1177.13	14:08:44	6:40:47
	121	12:43	14:27								
Research Area (between 155°W and 150°W)	121	11-Sep.	16-Sep.	19:45:13	209.44	16:26:07	175.99	36:11:20	385.43	0:24:46	0:00:00
	127	14:27	13:54								

Table 4
Number of sightings for all species observed in the research area during the 2021 IWC-POWER survey (original track lines), by effort mode. NSP: Normal Passing with abeam closing mode; IO: Independent Observer mode, OE: Top down (TD) and drifting (DR). Numbers of Individuals include the number of calves.

Species	NSP			IO			OE			Total		
	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf	Sch.	Ind.	Calf
Blue whale	2	3	0	4	4	0	0	0	0	6	7	0
Fin whale	39	58	1	37	54	3	1	1	0	77	113	4
Like fin whale	0	0	0	1	1	0	0	0	0	1	1	0
Sei whale	14	26	0	8	10	0	1	1	0	23	37	0
Like sei whale	1	2	0	0	0	0	0	0	0	1	2	0
Bryde's whale	11	13	1	9	9	0	0	0	0	20	22	1
Sperm whale	9	9	0	5	5	0	0	0	0	14	14	0
Baird's beaked whale	1	3	0	0	0	0	0	0	0	1	3	0
Ziphiidae	1	2	0	3	6	0	0	0	0	4	8	0
Killer whale	1	4	0	0	0	0	0	0	0	1	4	0
Striped dolphin	0	0	0	1	74	0	0	0	0	1	74	0
Common dolphin	1	84	2	3	410	8	0	0	0	4	494	10
Pacific white-sided dolphin	3	85	3	1	157	7	0	0	0	4	242	10
Northern right whale dolphin	1	107	4	0	0	0	0	0	0	1	107	4
Dalli type Dall's porpoise	10	55	0	5	42	0	0	0	0	15	97	0
Unid. type Dall's porpoise	3	11	0	2	2	0	0	0	0	5	13	0
Unid. dolphin	2	13	0	0	0	0	0	0	0	2	13	0
Unid. small cetacean	1	1	0	1	1	0	0	0	0	2	2	0
Unid. cetacean	2	2	0	3	3	0	0	0	0	5	5	0
Unid. large baleen whale	7	7	0	5	6	0	0	0	0	12	13	0

Geographical distribution by species

Blue whale (Balaenoptera musculus)

Blue whales were mainly distributed in the northern part of the research area (Figure 3). Sea surface temperatures at the sighting positions were between 12.7°C and 13.6°C.

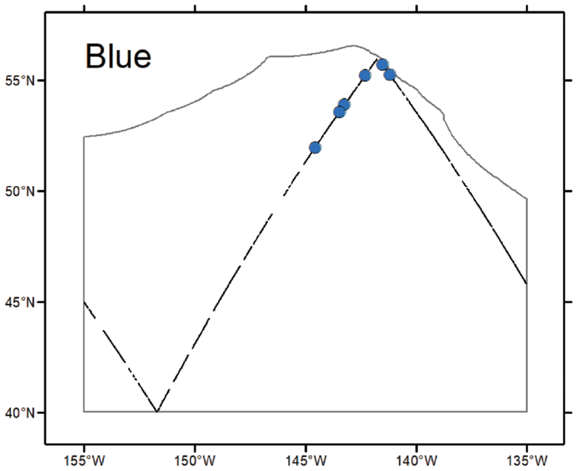


Figure 3. The searching effort (black line) and sighting positions (blue circles) of blue whales during the 2021 IWC-POWER survey.

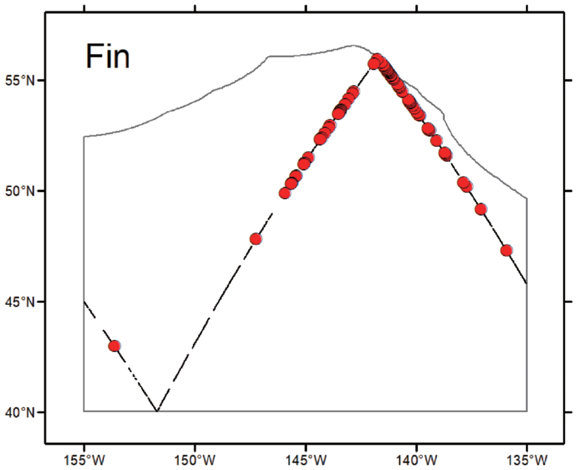


Figure 4. The searching effort (black line) and sighting positions (red circles) of fin whales during the 2021 IWC-POWER survey.

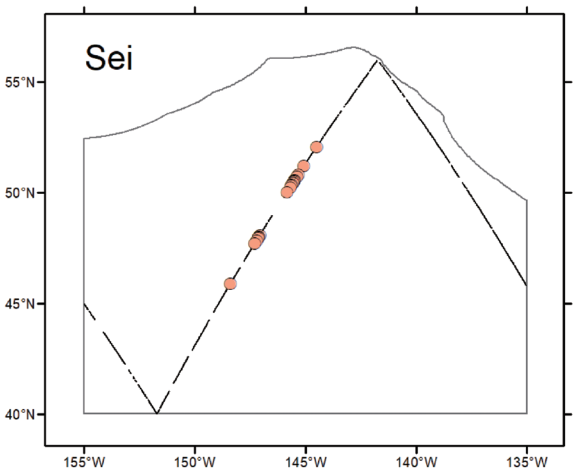


Figure 5. The searching effort (black line) and sighting positions (orange circles) of sei whales during the 2021 IWC-POWER survey.

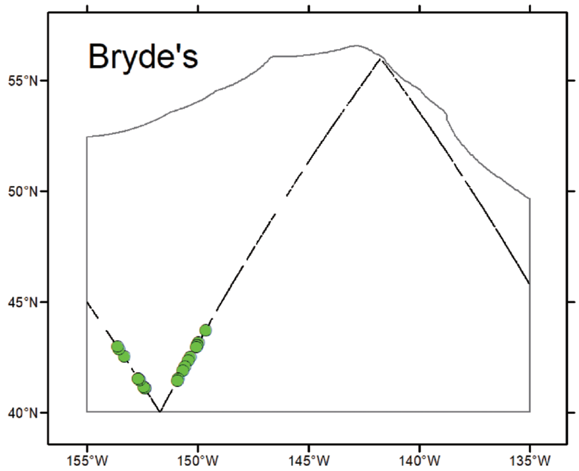


Figure 6. The searching effort (black line) and sighting positions (green circles) of Bryde's whales during the 2021 IWC-POWER survey.

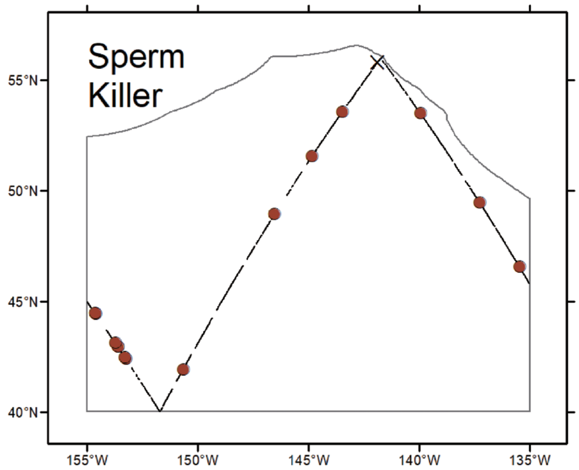


Figure 7. The searching effort (black line) and sighting positions of sperm and killer whales (brown circles and black cross, respectively) during the 2021 IWC-POWER survey.

Fin whale (Balaenoptera physalus)

Fin whales were mainly distributed in the northern part of the research area (Figure 4). Sea surface temperatures at the sighting positions were between 12.7°C and 19.7°C.

Sei whale (Balaenoptera borealis)

Sei whales were distributed in mid-latitudes of the research area (Figure 5). Sea surface temperatures at the sighting positions were between 13.0°C and 16.1°C.

Bryde's whale (Balaenoptera edeni brydei)

Bryde's whales were distributed in the southern part of the research area (Figure 6). Sea surface temperatures at the sighting positions were between 17.4°C and 21.3°C.

Table 5
Summary of the Photo-ID experiments for each species conducted in the 2021 IWC-POWER research area.

Photo-ID	Blue	Fin	Sei	Bryde's	Killer	Total
Between longitude 150°W and 135°W	7	31	15	2	3	58
Between longitude 155°W and 150°W	0	0	0	11	0	11

Table 6
Summary of the number of species-specific biopsy samples collected in the 2021 IWC-POWER research area.

Biopsy samples	Blue	Fin	Sei	Bryde's	Killer	Total
Between longitude 150°W and 135°W	3	9	4	1	1	18
Between longitude 155°W and 150°W	0	0	0	1	0	1

Figure 8. Researchers and crew of the 2021 IWC-POWER survey with the *Yushin-Maru* No. 2 in the background. The picture was taken at the end of the cruise in Shiogama.

Sperm (Physeter macrocephalus) and killer whales (Orcinus Orca)

Sperm whales were widely distributed in the research area (Figure 7). Sea surface temperatures at the sighting positions were between 12.7°C and 20.0°C. A total of 1 school (4 individuals) of killer whales was sighted in the northern part of the research area where the sea surface temperature was 13.1°C.

Identification of duplicated sightings

Resight data were recorded for a total of 108 sightings during IO Mode involving several baleen whale species. These data will be used to estimate $g(0)$, which in turn will be used to adjust abundance estimates.

Photo-ID experiments

Photo-ID data were obtained for a total of 69 whales: blue (7 individuals), fin (31), sei (15) Bryde's (13) and killer (3) whales (Table 5). Images collected during the survey were uploaded to the IWC master photographic database in Adobe Lightroom (LR) (Anon, 2020). Photo-ID data will be used to study movement, distribution and stock structure of the species involved.

Biopsy sampling

Biopsy samples were collected using the Larsen sampling system from 19 individual whales: 3 blue, 9 fin, 4 sei, 2 Bryde's and 1 killer whales (Table 6). Every biopsy sampling 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 on stock identification.

Marine macro debris observation

During the survey, a total of 88 marine macro debris objects were observed. All items were recorded 'on effort' (i.e. during the first 15 minutes of each hour).

Feasibility experiment of dive behavior tagging

During the survey, satellite linked dive behavior tags were experimentally deployed as a feasibility study at the discretion of Japan. The tags were attached to 2 fin and 3 sei whales and the data were obtained via satellite. Detailed analysis will be conducted by Japanese scientists and the results will be reported to relevant scientific communities.

HIGHLIGHTS OF THE SURVEY

It is concluded that the 2021 IWC-POWER survey was completed successfully by a group of international scientists (Figure 8) and that valuable data were collected for several cetacean species. Such data will allow for studies on distribution, abundance and stock structure of large cetaceans in this particular area of the North Pacific.

There are two aspects of this survey that should be highlighted. The first aspect is a seasonal change in the distribution of baleen whales. Although the 2021 POWER survey area was covered by the 2011 and 2012 POWER surveys, the survey timing in 2021 was approximately a month later than the previous two surveys. From the results, it appeared that the distribution of baleen whales has shifted northward. For instance, the Bryde's whale, a tropical species, was sighted in the southern part of the 2021 survey area while none was sighted in the previous two surveys. Such a change will be investigated in future studies.

The second aspect is the success of the feasibility experiment of dive behavior tagging. This was the first attempt of this kind of experiment in the IWC-POWER surveys. The obtained data could be used to correct availability bias in future abundance estimation work.

Although the IWC-POWER survey within the Russian EEZ has not been completed, it is anticipated that the IWC-POWER program will move toward its second phase, which will be designed after examining in details the results from the first phase between 2010 and 2021.

ACKNOWLEDGEMENTS

I am grateful to the Governments of the United States (NOAA Fisheries) and Japan (Fisheries Agency of Japan) for funding this cruise. I also acknowledge the Government of Japan for their assistance in arranging the research permit. I extend my thanks to Iain Staniland and the Secretariat of the IWC for their support and funding for this cruise. I appreciate the ongoing support by the POWER Steering Group and the Technical Advisory Group (TAG). I thank Takashi Hakamada, Megumi Takahashi and Mioko Taguchi from the Institute of Cetacean Research and the staff of Kyodo Senpaku Co. Ltd. for making arrangements and supporting the cruise. I also wish to express my gratitude to the crew of the R/V *Yushin-Maru* No.2 for their hard work and dedication. I thank the Editorial Team of TEREP-ICR for the editorial work on this manuscript.

REFERENCES

Anon. 2020. IWC's IDCR/SOWER and POWER cruise photographic database manual. 21 pp. [Available from the IWC Secretariat].

International Whaling Commission. 2021. Report of the Meeting of the IWC-POWER Technical Advisory Group (TAG) and 2021 Planning Meeting: November 2020. Paper SC/68C/REP/01Rev01 presented to the IWC Scientific Committee, April–May 2021 (unpublished). 24 pp. [Available from the IWC Secretariat].

Matsuoka, K. 2020. An outline of the IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER) including results of the 2019 survey. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)* No. 4: 23–34.

Murase, H., Gilpatrick, J.W. Jr., Yoshimura, I. and Eguchi, H. 2022. Cruise report of the 2021 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER). Paper SC/68D/ASI/03 presented to the IWC Scientific Committee, May 2022 (unpublished). 34 pp. [Available from the IWC Secretariat].

Technical Reports of the Institute of Cetacean Research (2022) pp. 52–55

Technical Report (not peer reviewed)

Long-term track movement of Antarctic minke whales revealed by satellite-monitored tag experiments conducted by the Institute of Cetacean Research

Kenji KONISHI* and Tatsuya ISODA

Institute of Cetacean Research, 4–5 Toyomi-cho, Chuo-ku, Tokyo 104–0055, Japan

**Contact e-mail: konishi@cetacean.jp*

ABSTRACT

This paper presents progress of the work on long-term track movement of Antarctic minke whales based on satellite tagging experiments conducted by the Institute of Cetacean Research. In particular, the experiments focused on investigating the migratory links between whales in the feeding and breeding areas. Five examples of northward tracks from Antarctic feeding areas in the Indo-Pacific sector of the Antarctic to lower latitudes areas are presented. The five tracks suggested some migration patterns in the Indian and Pacific Oceans. These results showed that tracking of Antarctic minke whales by satellite-monitored tags provides precise and direct evidence of migratory links. This work should be continued and the number of whales tagged should be increased. This information will greatly assist the interpretation of the stock structure hypothesis of Antarctic minke whales derived from genetic and sighting data analyses.

INTRODUCTION

Understanding the stock structure of whales is crucial for assessment and management purposes. The Antarctic minke whale *Balaenoptera bonaerensis* (hereafter AMW) is one of the most abundant species in the Southern Hemisphere, and its abundance exceeds 500,000 animals (IWC, 2012). As in the case of other rorqual whales, the AMW is assumed to migrate between winter tropical and sub-tropical breeding areas and summer Antarctic feeding areas (Kasamatsu *et al.*, 1995). However, evidences of direct links are scarce. Only three Discovery tag-marked AMWs were recovered at lower latitude areas, showing movements from feeding to breeding areas. An AMW marked at 35°W (east of Antarctic Peninsula) and two AMWs marked at 19°E were recaptured off Brazil at latitude 6°S–7°S in the Atlantic Ocean (Buckland and Duff, 1989). These were the only cases showing direct evidence of links between breeding and feeding grounds for this species.

The Institute of Cetacean Research (ICR) has conducted detailed research of the AMW and its ecosystem in the Indo-Pacific sector of the Antarctic in austral summer, through the former programs JARPA (Japanese Whale Research Program under Special Permit in the Antarctic), JARPAII (the second phase of JARPA) and the NEWREP-A (New Scientific Whale Research Program in the Antarctic Ocean). A summary of the biological and ecological research outputs from these programs is available in Murase *et al.* (2020). In the austral summer 2019/20 the ICR commenced a new non-lethal research program in the Indo-Pacific sector of the Antarctic called JASS-A (Japanese Abundance and Stock-structure Surveys in the Antarctic). The main objective of the JASS-A is the estimation of the abundance and abundance trends of the AMW and other large whale species. Research on the stock structure of large whales is the other main objective of the JASS-A, which is essential for appropriately interpreting the results of abundance estimates.

A review of the stock structure studies on the AMW in the Indo-Pacific sector was provided by Murase *et al.* (2020). The current stock structure hypothesis of the AMW in the Indo-Pacific sector of the Antarctic involves the occurrence of at least two stocks, the eastern Indian Ocean stock (I-stock) and the western South Pacific stock (P-stock) (IWC, 2008; Pastene and Goto, 2016; Kitakado *et al.*, 2014; Murase *et al.*, 2020). These stocks are presumed to be related to the breeding areas for this species suggested by Kasamatsu *et al.* (1995) based on sighting density indices. Figure 1 shows a schematic representation of the distribution of the I- and P-stocks in the Antarctic feeding grounds and the geographical locations of the low latitude breeding areas suggested by Kasamatsu *et al.* (1995).

One of the important aspects to be investigated is the

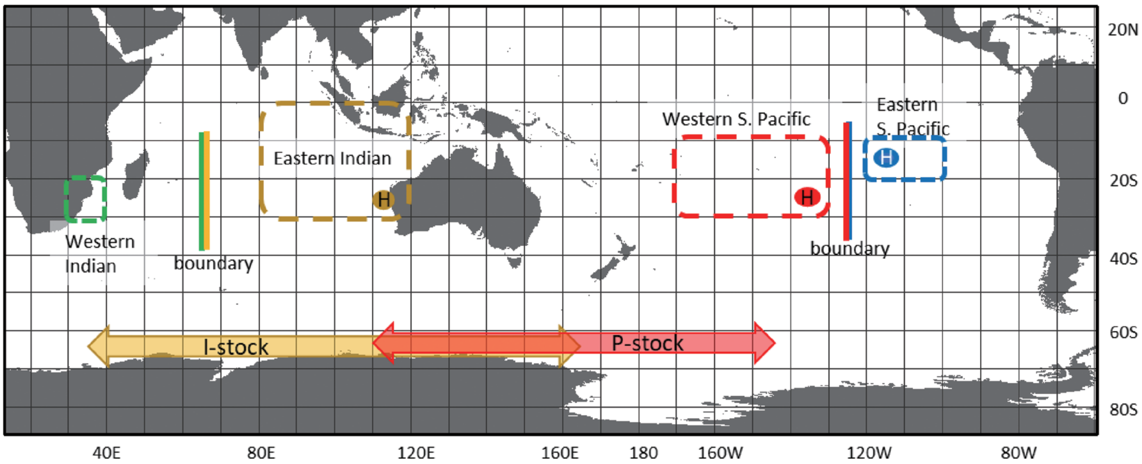


Figure 1. Hypothesis on stock structure of Antarctic minke whales in the feeding grounds of the Indo-Pacific sector of the Antarctic derived from genetic analyses (I- and P- stocks) (IWC, 2008; Pastene and Goto, 2016; Kitakado *et al.*, 2014) and location of breeding areas of this species suggested by the sighting records (Kasamatsu *et al.*, 1995). The figure shows the distribution of the eastern Indian Ocean stock (I-stock) and western South Pacific stock (P-stock) (Pastene and Goto, 2016), and an overlap sector (Kitakado *et al.*, 2014). The four breeding areas suggested by sighting density indices (Kasamatsu *et al.*, 1995) are also shown with dashes-line, and the highest density parts are marked with the letter "H". Vertical bars represent possible boundaries (Kasamatsu *et al.*, 1995).

links between the hypothesized stocks in the feeding areas and breeding areas. Satellite tracking of whales can be useful for this purpose. Long-term tracking of AMWs were previously reported (Lee *et al.*, 2017; Konishi *et al.*, 2020). However only a few tracks showed evidence of northward migration pattern from the Antarctic Peninsula (Lee *et al.*, 2017).

This paper presents the progress on the work of long-term track movement of AMWs based on satellite tagging experiments conducted by the ICR. Information on the link between whales in the feeding and breeding areas will greatly assist the interpretation of the stock structure hypothesis in the feeding ground based on genetic analyses.

TAGGING EXPERIMENTS ON ANTARCTIC MINKE WHALES BY THE ICR

In this report, tagging results using SPOT6-type tags, which are designed to investigate horizontal movement, are presented (Wildlife Computers Inc.; Figure 2). The tags were deployed using an air compressed launcher LK-ARTS (Figure 3), fired from the research vessel *Yushin-Maru* No.2 (Konishi *et al.*, 2020). Five tracking records with clear northward migration movements were selected for this paper.

Long-term track movement of AMWs

The five northward tracking movements of AMWs are shown in Figure 4 and the relevant data are presented in Table 1. The tag deployments were made in the sector 10°E–30°E (west of Indian Ocean Sector) and in the sector 170°W–140°W (Pacific Sector), south of 60°S. These records indicated that the western and eastern movements seem to be closely related to the direction of westward Antarctic Coastal Current and eastward Circumpolar Current, respectively (see Nicol *et al.*, 2000).

Figure 2. SPOT6-type tags (Wildlife Computers Inc.) connected to ICR's ISOD-type anchor and LK-Carrier.

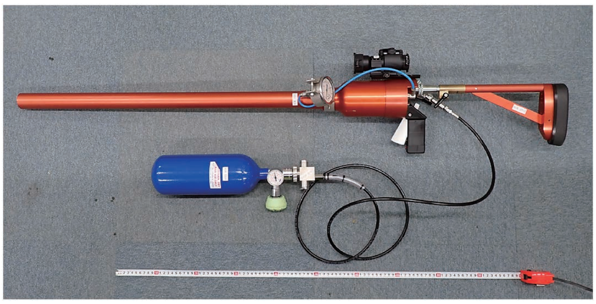


Figure 3. Whale tagger LK-ARTS used during the NEWREP-A and JASS-A tagging experiments.

Two AMWs in the Indian Ocean Sector were tagged in

Figure 4. Five cases of northward tracking movement of Antarctic minke whales tagged during the NEWREP-A and JASS-A programs. All deployments were conducted during the austral summer on the feeding ground. Two former whaling locations in South Africa and Brazil are also shown.

Table 1
Relevant data of five satellite-tracked Antarctic minke whales in Figure 4 during the NEWREP-A and JASS-A programs.

Tracking colour	Tracking periods	Locations of deployments	Location of last transmission
Green	2 Feb. 2020–2 Sept. 2020	68.5°S; 14.6°E	30.5°S; 35.1°E
Blue	28 Jan. 2021–1 Jul. 2021	69.2°S; 19.4°E	40.2°S; 67.5°E
Red	27 Feb. 2018–3 Jun. 2018	76.7°S; 163.9°W	46.7°S; 140.7°W
Purple	6 Feb. 2022–6 Aug. 2022	71.5°S; 133.4°W	15.9°S; 109.2°W
Yellow	28 Jan. 2022–1 Jul. 2022	66.6°S; 129.8°W	59.9°S; 104.3°W

a similar longitudinal sector, however they showed different movement patterns. One animal moved eastward and started migrating to the north around 70°E (blue in Figure 4). The other animal showed a westward movement along the Antarctic coast, then changed its course to the east at 45°W in the offshore area, then started migrating in the northeast direction. This animal finally arrived at the area off the coast of Durban, South Africa, in September (green in Figure 4).

In the Pacific Sector, AMWs moved into the Ross Sea at first, then one whale started migrating to the east (yellow in Figure 4). Two others moved first to the east and then to the north (red and purple in Figure 4). The longest tracked animal showed northward migration and finally arrived at 16°S; 109°W in August.

In the previous study by Lee *et al.* (2017), two AMWs tagged in the west of the Antarctic Peninsula showed northward migration at different longitudinal bands in the Pacific Sector, while another one moved into the Atlantic Sector.

Interpretation of movements in the context of stock structure

The five cases of tracking AMWs presented in this paper demonstrated that their longitudinal range of movement at the feeding area are wider than previously reported (up to 80°). On the other hand, the migratory corridors to breeding areas involve a wide longitudinal range. In addition, AMWs appear to move in the northeast direction when they start the migration to the breeding areas. These latitudinal movement patterns will assist the interpretation of the stock structure hypothesis of this species in the Indo-Pacific sector of the Antarctic derived from genetic analyses.

As indicated earlier, the current hypothesis on stock structure by genetic evidence in the Indo-Pacific sector of the Antarctic feeding grounds involves at least two stocks, the I-stock and the P-stock (Pastene and Goto, 2016) (Figure 1). These authors suggested that the former could be related to the breeding area in the eastern Indian Ocean while the latter could be related to the breeding area in the western South Pacific suggested by sighting density indices examined by Kasamatsu *et al.* (1995). It is important to note that no genetic analysis has been conducted on whales in the hypothesized breeding areas at lower latitudes and that the genetic relationship among the proposed breeding areas remains unknown.

Indian Ocean sector

One of the whales tagged in the Indian Ocean Sector of the Antarctic reached the coast of Durban, in South Africa (Figure 4). This location corresponds to the western Indian

Ocean breeding area proposed by Kasamatsu *et al.* (1995) and Best (1982). This is a critical piece of evidence on movement from the tagging program conducted by the ICR. The migratory track of the second whale tagged in the Indian Ocean sector of the Antarctic is not complete therefore the migratory destination of this whale in the Indian Ocean is unknown. It should be noted that the two tracked AMWs were both at 0–10°E in the feeding ground.

Pacific sector

The migratory patterns of the three AMWs tagged in the Pacific sector of the Antarctic (Ross Sea) to lower latitudes were different from each other, however, they all moved in a northeast direction (Figure 4). The whale with the longest tracking record arrived at latitudes<20°S, in the eastern Pacific Ocean breeding area proposed by Kasamatsu *et al.* (1995). The final migratory destinations of the other two whales are unknown. However, the incomplete movement pattern, in particular that of the 'yellow' whale, suggests that it is unlikely that they reached the western South Pacific breeding area (Figures 1 and 4).

The three whales were tagged initially in the Antarctic in a sector corresponding to the P-stock (Figure 1). Assuming that whales in the proposed breeding areas of the western and eastern South Pacific Ocean are differentiated genetically, the tagging data are consistent with the notion that whales from genetically differentiated breeding stocks mix spatially in the feeding grounds, in this case in the Ross Sea. Mark-recovery tags in the past showed that AMWs marked in the Atlantic feeding ground at 35°W were recovered in the breeding area off Costinha, Brazil in the Atlantic Ocean (Buckland and Duff, 1989), suggesting that whales from a breeding ground (Brazil) could be distributed in a very distant feeding ground.

Future works

The number of tagged whales should be increased in the Indo-Pacific sector of the Antarctic. In particular, Antarctic minke whales in the core areas of distribution of the hypothesized I- and P- stocks should be targeted in the future. Technological improvement of the satellite tagging is also required in order to increase the duration of tracking whales.

ACKNOWLEDGEMENTS

The authors would like to thank the vessel crews and ICR members involved in the tagging experiments in the field. We also thank Mutsuo Goto and Mioko Taguchi (ICR) for providing explanation of the current stock structure hypothesis of AMWs in the Indo-Pacific sector of the Antarctic. Our gratitude to Luis A. Pastene (ICR) for his input in the interpretation of the tagging data in the context of the stock structure and for his assistance in preparing this manuscript. Finally, we thank the Editorial Team of TEREP-ICR for the editorial work on this manuscript

REFERENCES

Best, P. 1982. Seasonal abundance, feeding, reproduction, age and growth in minke whales off Durban. *Rep. int. Whal. Commn* 32: 759–786.

Buckland, S.T. and Duff, E.I. 1989. Analysis of the Southern Hemisphere minke whale mark-recovery data. *Rep. int. Whal. Commn* (special issue) 11: 121–143.

International Whaling Commission. 2008. Report of the Intersessional Workshop to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic, Tokyo, 4–8 December 2006. *J. Cetacean Res. Manage*. (Suppl.) 10: 411–445.

International Whaling Commission. 2012. Report of the Scientific Committee. *J. Cetacean Res. Manage.* (Suppl.) 14: 1–468.

Kasamatsu, F., Nishiwaki, S. and Ishikawa, H. 1995. Breeding areas and southbound migrations of southern minke whales *Balaenoptera acutorostrata*. *Mar. Ecol. Prog. Ser*. 119: 1–10.

Kitakado, T., Schweder, T., Kanda, N., Pastene, L.A. and Walløe, L. 2014. Dynamic population segregation by genetics and morphometrics in Antarctic minke whales. Paper SC/F14/J29 presented to the IWC Scientific Committee JARPA review meeting, February 2014 (unpublished). 20 pp. [Available from the IWC Secretariat].

Konishi, K., Isoda, T., Bando, T., Minamikawa, S. and Kleivane, L. 2020. Antarctic minke whales find ice gaps along the ice edge in foraging grounds of the Indo-Pacific sector (60°E and 140°E) of the Southern Ocean. *Polar Biol* 43: 343–357.

Lee, J.F., Friedlaender, A.S., Oliver, M.J. and DeLiberty, T.L. 2017. Behavior of satellite-tracked Antarctic minke whales (*Balaenoptera bonaerensis*) in relation to environmental factors around the western Antarctic Peninsula. *Anim Biotelemetry* 5: 23.

Murase, H., Palka, D., Punt, A.E., Pastene, L.A., Kitakado, T., Matsuoka, K., Hakamada, T., Okamura, H., Bando, T., Tamura, T., Konishi, K., Yasunaga, G., Isoda, T. and Kato, H. 2020. Review of the assessment of two stocks of Antarctic minke whales (eastern Indian Ocean and western South Pacific). *J. Cetacean Res. Manage.* 21: 95–122.

Nicol, S., Pauly, T., Bindoff, N.L., Wright, S., Thiele, D., Hosie, G.W., Strutton, P.G. and Woehler, E. 2000. Ocean circulation off east Antarctica affects ecosystem structure and sea-ice extent. *Nature* 406: 504–507.

Pastene, L.A. and Goto, M. 2016. Genetic characterization and population genetic structure of the Antarctic minke whale *Balaenoptera bonaerensis* in the Indo-Pacific region of the Southern Ocean. *Fish Sci* 82: 873–886.

Technical Reports of the Institute of Cetacean Research (2022) pp. 56–58

Commentary

The views expressed here are those of the author and do not necessarily reflect the views of the Institute of Cetacean Research

Some thoughts about the Institute of Cetacean Research

Gabriel Gómez Díaz

Institute of Cetacean Research, 4–5 Toyomi-cho, Chuo-ku, Tokyo 104–0055, Japan

After the establishment of the International Whaling Commission (IWC) moratorium on commercial whaling and the following start of Japan's whale research program in the Antarctic Ocean (the JARPA program), the Institute of Cetacean Research (ICR) became the focus of attention and repeated publicity stunts by protest extremist groups reacting to the lethal component, one of many elements forming part of the research program. Over the years, that undeserved attention mainly aimed to diminish the importance and significance of ICR research activities, was often accompanied by seemingly endless hype directed to an uninformed public and stirred up in great part by western mainstream media. An often-seen cliché was the allegation that, in spite of long years of research activities in the Antarctic, the ICR had only managed to produce a single scientific publication. Apparently, all that criticism was just a flank of a nefarious, systematic and sustained effort deployed over the years by a huge variety of actors to isolate and stigmatize Japan for its whaling policies, as exposed in detail in a paper titled "*International pressure and Japanese withdrawal from the International Whaling Commission: when shaming fails*" (Kolmaš, 2020). In fact, the ICR's research programs have produced a large amount of scientific information required for conservation and management of large whales (see list of peer-reviewed publications in this issue).

Since the 2019 resumption of commercial whaling following its withdrawal from the International Convention for the Regulation of Whaling (ICRW), most of that cacophony has subsided. For a brief time soon after this decision was taken by the Government of Japan, the ICR got a few calls and email queries from the general public and the media wanting to know whether ICR's role and reason to exist had abruptly come to an end. Although some pundits may disagree, the scientific data produced over the years through ICR research programs and Japan's contribution have been and continues to be of paramount importance to part of the work and discussions of the IWC and other international organizations. Soon after Japan's expression of intention to withdraw from the ICRW, the IWC unequivocally stated that 'for many years Japan has played an active and integral role in both the Commission and its Scientific Committee' (IWC, 2019). So, the answer to those queries is no, the role and mission of ICR presumably will continue as far as Japan remains committed to the realization of sustainable use of whale resources.

Japan withdrew from the ICRW in 2019 after careful considering that the IWC had walked away from its original objective of promoting sustainable use of whale resources, namely maintaining a commercial whaling moratorium without any scientific justification. Enacted in 1972, the U.S. Marine Mammal Protection Act (MPA), 'is celebrating this year 50 years of marine mammal science, conservation, and recovery' (NOAA, 2022a). The MPA was coincidentally created the same year when, according to mainstream media, a recommendation for a 10-year moratorium on commercial whaling was approved overwhelmingly at the United Nations Conference on the Human Environment in Stockholm (New York Times, 1972). Ten years later, the IWC decided that there should be a pause (a zero-quota regulation) in commercial hunting on all species and populations of whales from the 1985/1986 season onwards. This purportedly temporary pause, which became to be known as the IWC commercial whaling moratorium didn't last for 10 years as originally intended, and, although it went remarkably unnoticed by the media, in July 2022 a few anti-whaling groups celebrated in Brighton, UK, its 40th anniversary. Brighton was the venue of the 34th IWC Annual Meeting where the principal stated goal of the United States was to gain an indefinite moratorium on commercial killing of whales.

This outcome was summarized as the conservationist countries achieving an outstanding victory for whale protection, although they had yet to close the book on the history of commercial whaling (U.S. GPO, 1982). Another, less often quoted, major achievement by the United States at that meeting was the IWC's agreement to create a new management scheme for aboriginal/subsistence whaling. This decision established a Technical Subcommittee to consider subsistence, nutritional and cultural requirements of aboriginal peoples and advise the Committee in much the same way as the Scientific Committee does (U.S. GPO, 1982).

It is noteworthy that in spite of the 40-year-old moratorium, commercial whaling, an economic activity not much different from other fisheries, is now being conducted sustainably by two IWC member countries (Norway and Iceland) and one ex-member country (Japan) (IWC, 2022). Remarkably enough, consumption for food of some 87 species of cetaceans and other marine mammals has been reported in at least 114 countries (Robards and Reeves, 2011), while the UN Organization for Food and Agriculture (FAO) has yet to include marine mammals as a source of food in its statistics and reports (FAO, 2022).

Current sustainable whaling does not produce a negative effect on the exploited stocks. Meanwhile, due to different causes other than whaling, at present two iconic cetacean species, the North Atlantic right whale (*Eubalaena glacialis*) (NOAA, 2022b) and the vaquita (*Phocoena sinus*) (CEMDA, 2021) are facing imminent extinction. Further, more than 500,000 cetaceans are being killed worldwide annually, by fishing gear bycatch and other human activities (FAO, 2021).

The ICR 1987 inception as a general incorporated foundation came as a direct result of the moratorium establishment. However, the history of our institution goes further back in time: ICR is, in reality, older than the 40-year IWC moratorium. The introduction of the moratorium brought an abrupt halt to Japan′s commercial coastal and high seas whaling. The 1987 reorganization of our institution was a direct result of the moratorium establishment and the proactive measures by Japan to undertake a research program in the Antarctic to systematically collect scientific data necessary for the resumption of that activity, ideally under the aegis of the IWC.

Harking back to the time when Japan′s whaling in the Antarctic resumed after the WWII, a firsthand witness wrote the following: ′*A unique thing is happening in Japan today. (...) Their islands do not have space to devote to growing food for domestic animals. Hence their meat must come largely from the sea. (...) When General MacArthur authorized two whaling fleets to operate in Antarctic waters during 1946–47, he undoubtedly expected objections to be raised by competitor whaling nations. But his reason was partly humanitarian. Japan needed the proteins and fats (...) of whale meat and blubber. (...) No one can deny that Japan utilizes the whale more than other nations do—they actually eat the meat and blubber, which is more than anyone else does, except the Eskimos.*′ (McCracken, 1948). It seems several countries protested then against Japan′s vessels going to the Antarctic, because of the postwar turmoil and political situation. The ICR′s origins go back to such times. The Institute was born at a time of need for food, while the world′s whaling industry was competing for increasingly dwindling resources. Whaling was for oil as a resource, but some countries, as is the case today, were pursuing this activity for food. Such was the case of Japan then, as it is now.

What was then the need for establishing an institution specialized in whale research, several decades before the moratorium? The parent institution, or the originator of ICR was the Nakabe Institute of Science, founded in 1941. In 1942 it became an incorporated foundation with the first approval from the Planning Agency. After the end of the war, the facilities and researchers of the Nakabe Institute of Science had not been dispersed and were still available. According to one of the founders, if there had been no war, the Nakabe Institute of Science would have continued to exist and perform the activities of its future successor, the Whales Research Institute (WRI) (Maruyama, 1959).

In 1946, the year following the end of WWII, with the momentum of two of the three authorized whaling fleets actually going out to the Southern Ocean to help overcome the food shortage, a plan was made to establish an institution specializing in whale research, and on August 20, 1947, the Ministry of Agriculture and Forestry Order No. 22-4014 authorized the establishment of the WRI (Ikeda, 1988). Ever since, until the 1987 inception of the present ICR, our institution was a rare, world-renowned private biological research institute in the fishery industry, with an already long history of 40 years and outstanding scientific achievements contributing to cetology and whale resource management worldwide (Ikeda, 1988). Without taking account of this historical fact, criticism against ICR scientific activities would lack solid ground. The charter of the WRI emphasized the importance of the whaling industry, the efficiency of whale fishing and processing technology, and the necessity of thorough utilization of whale products. It called for the expansion of research and the implementation of systematic and comprehensive research on whale stocks, and the application of the results for the public benefit (Ikeda, 1988), while the stated purpose of establishment of ICR is ′to contribute to the proper management and utilization of fishery resources by conducting research on cetaceans and other marine mammals, as well as studies on related international matters.′

One may argue that the prestige gained then by the WRI and later ICR, was due in part to the long-year prolific inventive and strenuous efforts of its outstanding researchers, but it is also due to the fact that since its origins, the institute has had an established system to reach out and publicize its activities. The publication of the *Geiken Tsushin* newsletter continues even today, and was planned at the same time as the publication of the English-language *The Scientific Reports of the Whales Research Institute (SRWRI)*, first published in 1948 (Maruyama, 1959). Although the SRWRI journal had to be discontinued when the moratorium introduction made mandatory for all ICR research staff to apply and devote themselves to scientific production oriented to discussions at the IWC Scientific Committee, the edition of the now five-year old *Technical Reports of the Institute of Cetacean Research* (TEREP-ICR) may be considered part of these agelong efforts to reach both to the public and scholars.

While institutional introspection is always necessary, in particular for a highly specialized and small organization as the ICR, perhaps a renewed appraisal about the institute′s nature, its background, origins and achievements thus far, is in order. Hopefully more and more people would understand better Japan′s attitude towards whales and whaling, and perhaps bear in mind the unchanging importance, both domestic and international, of the present and future role of our institute.

REFERENCES

Centro Mexicano de Derecho Ambiental. 2021. *Estrategias de Conservación de la Vaquita Marina*. Propuestas en la Administración Federal 2018–2024, Análisis de contexto, Julio, 2020. Centro Mexicano de Derecho Ambiental, Cuauhtémoc, Mexico. 29 pp. https://www.cemda.org.mx/wp-content/uploads/2021/03/CEM-informe-vaquitamarina.pdf.

Food and Agriculture Organization. 2021. *Fishing Operations. Guidelines to Prevent and Reduce Bycatch of Marine Mammals in Capture Fisheries*. FAO Technical Guidelines for Responsible Fisheries No. 1, Suppl. 4. Food and Agriculture Organization, Rome, Italy. 118 pp. https://doi.org/10.4060/cb2887en.

Food and Agriculture Organization. 2022. *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation*. Food and Agriculture Organization, Rome, Italy. 266 pp. https://doi.org/10.4060/cc0461en.

Ikeda, I. 1988. Zaidan Houjin Nihon Geirui Kenkyusho no hossoku ni saishite. *Geiken Tsushin* 372: 1–5.

International Whaling Commission. 2019. Statement on Government of Japan withdrawal from the IWC. https://iwc.int/resources/media-resources/news/statement-on-government-of-japan-withdrawal. (Accessed on 22 August 2022).

International Whaling Commission. 2022. Commercial whaling. https://iwc.int/management-and-conservation/whaling/commercial. (Accessed on 31 August 2022).

Kolmaš M. 2020. International pressure and the Japanese withdrawal from the International Whaling Commission: When shaming fails. *Australian Journal of International Affairs* 75 (2): 197–216.

Maruyama, T. 1959. Geiken Tsushin no omoide. *Geiken Tsushin* 100: 1–3.

McCracken, D.R. 1948. *Four Months on a Jap Whaler*. First Edition. Robert M. Mc Bride & Co., New York, USA. 228 pp.

National Oceanic and Atmospheric Administration. 2022a. Celebrating 50 Years of the Marine Mammal Protection Act. *News*, 30 July 2022. https://www.fisheries.noaa.gov/feature-story/celebrating-50-years-marine-mammal-protection-act. (Accessed on 31 August 2022).

National Oceanic and Atmospheric Administration. 2022b. North Atlantic Right Whale. *Species Directory*, 16 September 2022. https://www.fisheries.noaa.gov/species/north-atlantic-right-whale#overview. (Accessed on 27 September 2022).

New York Times. 1972. Whaling halt urged in Stockholm. *The New York Times*, 10 June 1972. https://www.nytimes.com/1972/06/10/archives/whaling-halt-urged-in-stockholm.html. (Accessed on 31 August 2022).

Robards, M.D. and Reeves, R.R. 2011. The global extent and character of marine mammal consumption by humans: 1970–2009. *Biological Conservation* 144: 2770–2786.

U.S. Government Printing Office. 1982. *Review of the 34th International Whaling Commission Meeting: Hearing Before the Subcommittee on Human Rights and International Organizations of the Committee of Foreign Affairs, House of Representatives, Ninety-seventh Congress, second session, September 16, 1982*. U.S. Government Printing Office, Washington, USA. 100 pp.

National meetings

Participation of scientists from the Institute of Cetacean Research in National Meetings in 2022

Seminar of the research group on the North Pacific Marine Ecosystem, Maritime Order and Diplomatic Security System

The Kajima Institute of International Peace was founded in July 1966. The purpose of this institute is to promote research and studies to promote international peace. From its inception, the institute has attempted, on the initiative of the founder, to design itself as a forum for experienced public figures in politics, civil service and the business world, by providing them with opportunities to exchange views on important issues of international concern. This research group was started from 2019 as one of their activities.

The 5th meeting of this research group was held online on 22 October 2021 and was focused on whales and ecosystem. Two scientists from the Institute of Cetacean Research (ICR) (Pastene and Tamura) participated in the meeting by making a presentation entitled ʻWhales and ecosystem studies at the Institute of Cetacean Research (ICR)ʼ.

The 2022 meeting of the Japanese Society of Fisheries Science (JSFS)

The Japanese Society of Fisheries Science (JSFS) was established in 1932. It is a non-profit, registered society dedicated to the promotion of all aspects of fisheries science. The society fulfills its global commitment by promoting science, striving to achieve sustainable development in the field of fisheries, while recognizing the crucial need to preserve the natural aquatic resources. It also strives to forge relationships with the fishing industry, comprising both capture and culture fisheries. The main events organized by the society are the biannual meetings held in spring and autumn in one of the main cities of Japan. This forum is where members present their research activities, exchange information, and foster collaborative research in areas of common interest.

The 2022 spring meeting of the JSFS was held online from 26 to 29 March. Three scientists from the ICR (Katsumata, Yoshida and Matsuoka) contributed to the meeting with the presentation entitled ʻDeveloping new technology UAV – Development of VTOL-UAV ʻAsukaʼʼ.

The 2022 meeting of the Mammal Society of Japan (MSJ)

The Mammal Society of Japan (MSJ) was established in 1987 by uniting two academic organizations, the Mammalogical Society of Japan and the Research Group of Mammalogists, which were founded in 1949 and 1955, respectively. The mission of the MSJ is not only to promote the global advance of mammalogy, but also to encourage social interactions among its members. The MSJ convenes an annual meeting, which consists of academic sessions (symposia, oral presentations, and poster presentations). Members of the MSJ always give great importance to social problem related with mammals.

The annual meeting of the MSJ was held online from 26 to 29 August 2022. Taguchi, Katsumata and Goto from the ICR were co-authors of a presentation to the meeting entitled ʻPreliminary population genetic analyses of humpback whales from Hachijo Islandʼ.

The 165th meeting of the Japanese Society of Veterinary Science (JSVS)

The Japanese Society of Veterinary Science (JSVS) has its origin in the Greater Japan Veterinary Society, which was founded in 1885. The focus of this society is veterinary science from basic research to applied science and clinical research. The JSVS held an annual academic meeting in autumn.

The annual meeting was held at Azabu University, Kanagawa from 6 to 8 September 2022. Tamura and Bando from the ICR were co-authors of an oral presentation to the meeting entitled ʻDiscovery of new molecules as stimulators for gonadotrophs in whale brains: possible mechanisms for long term lifespan and fertility of whales compared to bovinesʼ.

The 27th Annual Meeting of the Association of Wildlife and Human Society (AWHS)

The Association of Wildlife and Human Society (AWHS) was established in 1994. The Society aims to serve as a platform for a wide range of academic fields that deal with the diverse relationships between wildlife and humans. The role of the AWHS is to promptly present the results of academic research, practical knowledge and discussions to not only the academic world but to the society at large. The AWHS held annual academic meetings.

The 27th Annual Meeting of the AWHS was held at Rakuno Gakuen University, Hokkaido from 28 to 30 October 2022. Konishi from the ICR was a co-author of two oral presentations to the meeting entitled 'Habitat use pattern of fin whales off Abashiri, Hokkaido, Japan' and 'Possibility of individual identification based on photo identification of areas around the dorsal fin of fin whales off Abashiri, Hokkaido'.

The 60th Anniversary Conference of the Japanese Society of Fisheries Oceanography (JSFO)

The Japanese Society of Fisheries Oceanography (JSFO) was established in 1962. Its aim is to identify scientific issues of local fisheries, and to promote studies in cooperation with local scientists and fishermen in order to address such issues. Recent field research activities in JSFO include, for example, the study on the relationship between marine organism distributions and oceanographic conditions, acoustic assessment of fish abundance, oceanographic approach using satellite image, population dynamics, modeling approaches. The research activities of the JSFO are within the framework of the fisheries oceanography definition, which is 'the study of oceanic processes affecting marine ecosystems and the relationship of these ecosystems to the abundance and availability of fish'.

The 60th Anniversary Conference of the JSFO was held at the Yokohama field station of the Fisheries Resources Institute from 3 to 6 November 2022. Hakamada and Matsuoka from the ICR were co-authors of an oral presentation to the meeting entitled 'Development of a comprehensive app for cetacean species distribution modeling in the North Pacific Ocean'.

Technical Reports of the Institute of Cetacean Research (2022) pp. 61–65

International meetings

Participation of scientists from the Institute of Cetacean Research in International Meetings in 2022

Annual meeting of the International Whaling Commission Scientific Committee (IWC SC)

The International Whaling Commission (IWC) is an international body set up by the terms of the International Convention for the Regulation of Whaling (ICRW), which was signed in Washington, D.C., United States, on 2 December 1946, to 'provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry'. One of the important subsidiary bodies of the IWC is its Scientific Committee (SC), which meets annually.

The 2022 meeting of the IWC SC was carried out through a series of virtual sessions from 25 April to 13 May (SC68D). A total of twelve scientists from the Institute of Cetacean Research (ICR) participated in the meetings (Fujise, Kato, Pastene, Tamura, Matsuoka, Hakamada, Taguchi, Konishi, Goto, Isoda, Takahashi and Katsumata). They presented a total of 10 documents: six documents at the Standing Working Group on Abundance Estimates, Stock Status and International Cruises (ASI), one document at the Working Group on Stock Definition and DNA testing (SDDNA), one document at the Sub-Committee on Conservation Management Plans (CMP) and two general documents (O: PICES Observer Report and Japan's Scientific Progress Reports).

Observers from Japan participating in the online 2022 IWC Scientific Committee meeting at the ICR meeting room.

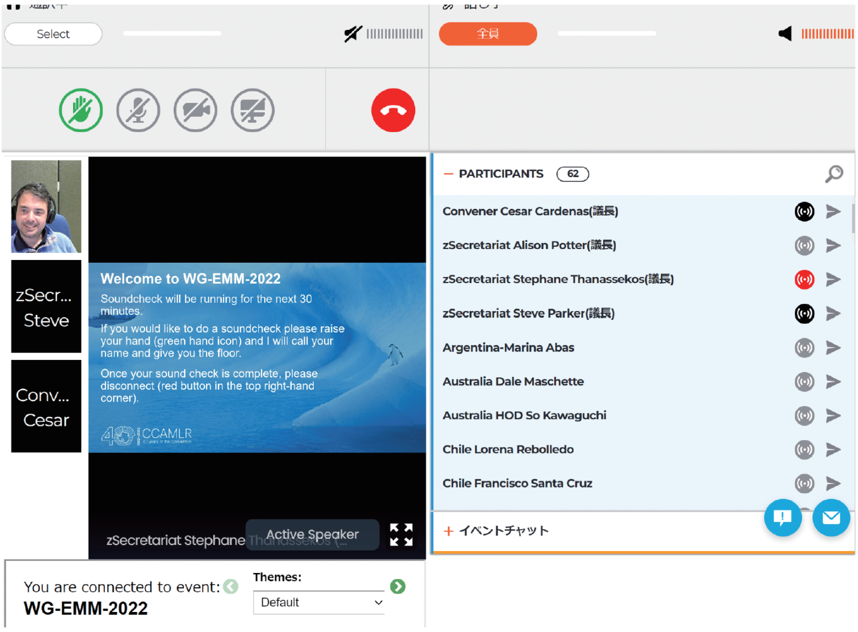
The report of the IWC SC meeting can be found on the website of the IWC (https://iwc.int/events-and-workshops/sc68d-2022).

IWC's Workshop of the Technical Adviser Group (TAG) and 2023 cruise planning meeting for the IWC-POWER program

IWC-POWER (Pacific Ocean Whale and Ecosystem Research) is a large international research program aimed to study the abundance and abundance trend of large whales in the North Pacific through annual dedicated sighting surveys. The program is designated and implemented by the Scientific Committee of the IWC through a Steering Group, which in turn count with a Technical Adviser Group (TAG). The TAG usually meets once a year. The IWC-POWER program has carried out surveys with the participation of scientists from Japan, USA, Russian Federation, Republic of Korea and Mexico.

The TAG and the 2023 cruise planning meetings were

Scientists participating in the 2022 IWC's TAG and 2023 cruise planning meeting for the IWC-POWER program.



2022 online meeting of the CCAMLR-EMM Working Group.

held from 6 to 10 September 2022 at the Fisheries Agency's Crew house, Tokyo. The TAG meeting was co-chaired by Matsuoka of the ICR, who also chaired the planning meeting. In addition, Pastene, Taguchi and Isoda from the ICR participated in the meetings. A total of 10 primary documents were presented.

The report of the meetings can be found on the website of the IWC (https://iwc.int/events-and-workshops).

68th Meeting of the International Whaling Commission

The plenary sessions of the 68th meeting of the IWC was carried out between 17 and 21 October 2022 at the Grand Hotel Bernardin and Conference Centre, Portoroz, Slovenia. Among the main items in the meeting agenda were: the Scientific Committee presentation of four consecutive meetings; discussion on finance and administrative issues; proposals to amend the *Schedule*; discussion on proposed resolutions; and aboriginal subsistence whaling. Fujise and Ohmagari from the ICR participated in the meeting. The next meeting of the IWC will be held in Lima, Peru in 2024.

68th meeting of the International Whaling Commission.

Annual meeting of the Convention on the Conservation of Antarctic Marine Living Resources–Working Group on Ecosystem Monitoring and Management (CCAMLR-EMM)

The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) is part of the Antarctic Treaty System. The Convention was opened for signature on 1 August 1980 and entered into force on 7 April 1982, thereby establishing the Commission for the Conservation of Antarctic Marine Living Resources. Its goal is to preserve marine life and environmental integrity in and near Antarctica. It was established in large part in response to concerns that an increase in krill catches in the Southern Ocean could have a serious impact on populations of other marine life, which are dependent upon krill for food. The CCAMLR has a Scientific Committee and several Working Groups. One of these is the Working Group on Ecosystem Monitoring and Management (EMM), which meets annually.

The online meeting of the EMM Working Group was held from 4 to 11 July 2022. The main items on the meeting agenda were: krill management including risk analyses, spatial management and climate change. Under the risk analyses approach, several papers on distribution, abundance and prey consumption of whales in western

Antarctic were presented. Three scientists from the ICR participated in the meeting (Tamura, Isoda and Katsumata).

The report of the meeting can be found on the website of the CCAMLR (https://meetings.ccamlr.org/en/wg-emm-2022).

Annual meeting of the North Atlantic Marine Mammal Commission (NAMMCO) Scientific Committee (SC)

The North Atlantic Marine Mammal Commission (NAMMCO) is an international body for cooperation on the conservation, management and study of marine mammals in the North Atlantic. The NAMMCO Agreement was signed in Nuuk, Greenland on 9 April 1992 by Norway, Iceland, Greenland and the Faroe Islands, and entered into force on 8 July 1992. The agreement focuses on modern approaches to the study of the marine ecosystem as a whole, and to better understanding the role of marine mammals in the ecosystem. NAMMCO has a Scientific Committee (SC), which meets annually.

The 2022 NAMMCO SC (SC28) meeting was held online from 24 to 28 January 2022. Five scientists from the ICR participated in the meeting (Pastene, Tamura, Konishi, Hakamada and Takahashi) as observers from Japan. They presented the following documents: '2020–2021 Japan progress report on large cetacean research', '2019–2020 Japan progress report on small cetacean research', 'Outline of the process to calculate a catch limit for North Pacific common minke whale', and '2020–2021 report on satellite tagging experiments at the Institute of Cetacean Research'.

The report of the meeting can be found on the website of NAMMCO (https://nammco.no/wp-content/uploads/2022/06/final_report-sc28-2022.pdf).

Scientists participating in the 28th online meeting of the NAMMCO Scientific Committee.

Meetings of the Steering Committee of the NAMMCO-Japan MINTAG project

The essence of the Miniature-Tag project (MINTAG project) is the development of smaller and lighter satellite transmitter tagging systems than the ones existing on the market today. The objective is to develop a tag (MINTAG) adapted to the study of the lesser-known fast swimming baleen whales such as fin, common minke, sei and Bryde's whales, as well as pilot whales. The project is a cooperation between the four NAMMCO member countries (see above) and Japan. MINTAG is led by a Steering Group, which meets regularly. Pastene and Konishi from the ICR are members of the Steering Group. An outline of the MINTAG project can be found at the NAMMCO homepage.

Fourth online meeting of the Steering Group of the NAMMCO-Japan MINTAG project.

In 2022 several meetings of the Steering Group have been carried out. The fourth meeting of the Steering Group was held online on 9 September 2022. The main objectives of the meeting were to review of summer test shooting, tag design and meeting with Wildlife Computers, project website, plan and schedule for 2023, data depository and budget.

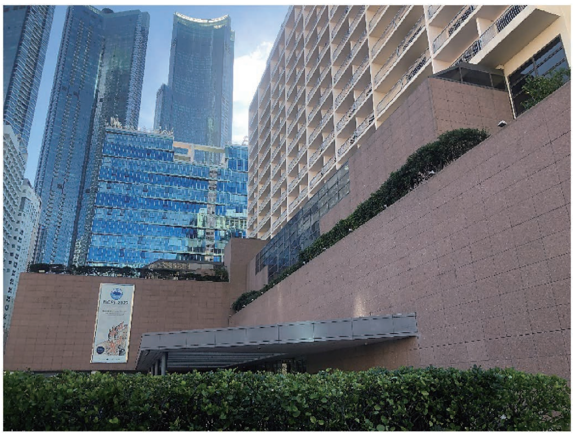
29th Annual Meeting of the NAMMCO Council

The 29th NAMMCO Council meeting was held at the Grand Hotel, Oslo, from 13 to 15 September 2022. Pastene from the ICR participated in the meeting as member of the observer delegation from Japan composed by the Fisheries Agency and the Ministry of Foreign Affairs (MOFA) members. The Council meeting was carried out concurrently with the meeting of the Management Committee.

Observers from Japan to the 29th Annual Meeting of the NAMMCO Council.

Annual meeting of the North Pacific Marine Science Organization (PICES)

The North Pacific Marine Science Organization (PICES) is an intergovernmental science organization established in 1992. It aims to promote and coordinate marine scientific research in the North Pacific Ocean and its adjacent seas, and to provide a mechanism for information and data exchange among scientists in its member countries. Its present members are Canada, Japan, People's Republic of China, Republic of Korea, the Russian Federation, and the United States of America.



Hotel Paradise Busan, the venue of the PICES-2022 meeting.

The 2022 meeting of the PICES was held at the Hotel Paradise Busan, Busan, Korea. The business meeting of the Marine Bird and Mammals (S-MBM) group was held on 24 September 2022. One scientist from the ICR participated in the meeting (Tamura) introducing the observer report of the 2022 IWC-SC meeting. The report of the PICES meeting can be found on the website of PICES (https://meetings.pices.int/).

Workshop of the project Basin-scale Events to Coastal Impacts (BECI)

The Basin-scale Events to Coastal Impacts (BECI) is an approved UN Decade of Ocean Science (UNDOS) project supported by the North Pacific Anadromous Fish Commission (NPAFC) and the North Pacific Marine Science Organization (PICES). The objective of BECI is, over the course of the UN Decade (2021–2030), to develop and implement an international ocean intelligence system of monitoring, research and analytical approaches that will provide timely knowledge and advice to decision makers regarding the impact of current and future ocean conditions from the high seas to coastal socio-ecological systems. In order to develop a high-level science plan for BECI, a series of workshops are carried out to assemble experts to advise on the state of climate and ocean models, knowledge of the current and projected conditions of climate and ocean in the North Pacific and their likely effects on biological production including fishery resources and emerging tools and technology that can be used to effectively monitor and study the connection between fish and the ecosystem.

The Workshop 3 of the BECI ('Technology and tools for monitoring and synthesis') was held online from 13 to 14 June 2022. Katsumata from the ICR participated in this workshop by presenting the study entitled 'Progress in the development of a long-range flying VTOL-UAV 'ASUKA''. Presentations made at the Workshop 3 can be found at https://beci.info/workshop_3/.

Presentation by an ICR scientist at the Workshop 3 of the BECI.

24th Biennial Conference of the Society for Marine Mammalogy (SMM)

The Society for Marine Mammalogy (SMM) was founded in 1981 and is the largest international association of marine mammal scientists in the world. The mission of the SMM is to promote the global advancement of marine mammal science and contribute to its relevance and impact in education, conservation and management. The SMM held conferences every two years.

The 24th biennial conference of the SMM was held at Palm Beach, Florida, USA from 1 to 5 August 2022. This was the first fully hybrid, live-virtual conference of the SMM. Kim, Bando, Fujise and Kato from the ICR were co-authors of a poster presentation entitled ʻPrenatal development stages of the Antarctic minke whaleʼ, presented to the conference.

2022 Conference of the Spanish Cetacean Society (SEC)

The Spanish Cetacean Society (SEC) was founded in April of 1999 during the XIII Annual Conference of the European Cetacean Society held in Valencia. The SEC was created with the global goals of promoting and coordinating the co-operation between people and institutions dedicated to research and conservation of marine mammals in Spain and to reinforce the link between researchers and the relevant authorities in order to integrate research efforts in the framework of the regional, national and international biodiversity conservation strategies. The SEC held annual conferences.

The 2022 annual conference of the SEC was held in Ibiza, Spain from 27 to 30 October. Pastene, Konishi and Nakai from the ICR were co-authors of an oral presentation entitled ʻLa distribution especial del epibionte *Xenobalanus globicipitis* como indicador de diferencias morfocinematicas entre cetaceosʼ.

Peer-reviewed publications

List of peer-reviewed publications based on the Institute of Cetacean Research (ICR)'s surveys up to 2022

This section presents a list of peer-reviewed publications based on data collected by surveys conducted under former special scientific permit programs (JARPA/JARPAII/NEWREP-A and JARPN/JARPNII/NEWREP-NP), including both lethal and non-lethal techniques. Peer-reviewed publications based on these surveys are focused mainly on topics related to assessment and management of large whales. However samples and data collected by the surveys have also been useful to carry out studies of a more academic-oriented nature. Publications based on such studies are also listed here.

This section also includes a list of peer-reviewed publications resulting from other surveys and research activities, different from special scientific permit surveys.

Publications having as a first author a non-ICR scientist commonly followed a data request or collaboration research agreement with ICR. In a few cases, external scientists used published data from ICR surveys in their analyses and publications, without a formal agreement with ICR. These cases are indicated by an asterisk (*).

JARPA/JARPAII/NEWREP-A surveys

1989 (2)

Kato, H., Hiroyama, H., Fujise, Y. and Ono, K. 1989. Preliminary report of the 1987/88 Japanese feasibility study of the special permit proposal for Southern Hemisphere minke whales. *Rep. int. Whal. Commn* 39: 235–248.

Nakamura, T., Ohnishi, S. and Matsumiya, Y. 1989. A Bayesian cohort model for catch-at-age data obtained from research takes of whales. *Rep. int. Whal. Commn* 39: 375–382.

1990 (8)

Butterworth, D.S. and Punt, A.E. 1990. Some preliminary examinations of the potential information content of age-structure data from Antarctic minke whale research catches. *Rep. int. Whal. Commn* 40: 301–315.

Ichii, T. 1990. Distribution of Antarctic krill concentrations exploited by Japanese krill trawlers and minke whales. *Proc. NIPR Symp. Polar Biol* 3: 36–56.

Itoh, S., Takenaga, F. and Tsuyuki, H. 1990. Studies on lipids of the Antarctic minke whale. I. The fatty acid compositions of the minke whale blubber oils caught on 1987/88 season. *Yukagaku* 39 (7): 486–490 (in Japanese).

Kasamatsu, F., Kishino, H. and Hiroyama, H. 1990. Estimation of the number of minke whale (*Balaenoptera acutorostrata*) schools and individuals based on the 1987/88 Japanese feasibility study data. *Rep. int. Whal. Commn* 40: 239–247.

Kato, H., Fujise, Y., Yoshida, H., Nakagawa, S., Ishida, M. and Tanifuji, S. 1990. Cruise report and preliminary analysis of the 1988/89 Japanese feasibility study of the special permit proposal for southern hemisphere minke whales. *Rep. int. Whal. Commn* 40: 289–300.

Kato, H., Kishino, H. and Fujise, Y. 1990. Some analyses on age composition and segregation of southern minke whales using samples obtained by the Japanese feasibility study in 1987/88. *Rep. int. Whal. Commn* 40: 249–256.

Nagasaki, F. 1990. The Case for Scientific Whaling. *Nature* 334: 189–190.

Tanaka, S. 1990. Estimation of natural mortality coefficient of whales from the estimates of abundance and age composition data obtained from research catches. *Rep. int. Whal. Commn* 40: 531–536.

1991 (9)

Bergh, M.O., Butterworth, D.S. and Punt, A.E. 1991. Further examination of the potential information content of age-structure data from Antarctic minke whale research catches. *Rep. int. Whal. Commn* 41: 349–361.

Ichii, T. and Kato, H. 1991. Food and daily food consumption of southern minke whales in the Antarctic. *Polar Biol* 11 (7): 479–487.

Kasamatsu, F., Kishino, H. and Taga, Y. 1991. Estimation of southern minke whale abundance and school size composition based on the 1988/89 Japanese feasibility study data. *Rep. int. Whal. Commn* 41: 293–301.

Kato, H., Fujise, Y. and Kishino, H. 1991. Age structure and segregation of southern minke whales by the data obtained during Japanese research take in 1988/89. *Rep. int. Whal. Commn* 41: 287–292.

Kato, H. and Miyashita, T. 1991. Migration strategy of southern minke whales in relation to reproductive cycles estimated from foetal lengths. *Rep. int. Whal. Commn* 41: 363–369.

Kato, H., Zenitani, R. and Nakamura, T. 1991. Inter-reader calibration in age readings of earplugs from southern minke whale, with some notes of age readability. *Rep. int. Whal. Commn* 41: 339–343.

Kishino, H., Kato, H., Kasamatsu, F. and Fujise, Y. 1991. Detection of heterogeneity and estimation of population characteristics from the field survey data: 1987/88 Japanese feasibility study of the Southern Hemisphere minke whales. *Ann. Inst. Statist. Math.* 43 (3): 435–453.

Nakamura, T. 1991. A new look at a Bayesian cohort model for time-series data obtained from research takes of whales. *Rep. int. Whal. Commn* 41: 345–348.

Wada, S., Kobayashi, T. and Numachi, K. 1991. Genetic variability and differentiation of mitochondrial DNA in minke whales. *Rep. int. Whal. Commn* (special issue) 13: 203–215.

1992 (2)

Nakamura, T. 1992. Simulation trials of a Bayesian cohort model for time-series data obtained from research takes of whales. *Rep. int. Whal. Commn* 42: 421–427.

Tanaka, S., Kasamatsu, F. and Fujise, Y. 1992. Likely precision of estimates of natural mortality rates from Japanese research data for Southern Hemisphere minke whales. *Rep. int. Whal. Commn* 42: 413–420.

1993 (7)

Fujise, Y., Ishikawa, H., Saino, S., Nagano, M., Ishii, K., Kawaguchi, S., Tanifuji, S., Kawashima, S. and Miyakoshi H. 1993. Cruise report of the 1991/92 Japanese research in Area IV under the special permit for Southern Hemisphere minke whales. *Rep. int. Whal. Commn* 43: 357–371.

Hasunuma, R., Ogawa, T., Fujise, Y. and Kawanishi, Y. 1993. Analysis of selenium metabolites in urine samples of minke whale (*Balaenoptera acutorostrata*) using ion exchange chromatography. *Comp. Biochem. Physiol.* 104C (1): 87–89.

Itoh, S., Takenaga, F. and Tsuyuki, H. 1993. Studies on lipids of the Antarctic minke whale. II. The fatty acid compositions of the blubber oils of minke whale and dwarf minke whale caught on 1988/89 and 1989/90 seasons. *Yukagaku* 42 (12): 1007–1011 (in Japanese).

Iwata, H., Tanabe, S., Sakai, N. and Tatsukawa, R. 1993. Distribution of persistent organochlorines in the oceanic air and surface seawater and the role of ocean on their global transport and fate. *Environ. Sci. Technol.* 27: 1080–1098.

Kasamatsu, F., Yamamoto, Y., Zenitani, R., Ishikawa, H., Ishibashi, T., Sato, H., Takashima, K. and Tanifuji, S. 1993. Report of the 1990/91 southern minke whale research cruise under scientific permit in Area V. *Rep. int. Whal. Commn* 43: 505–522.

Nakamura, T. 1993. Two-stage Bayesian cohort model for time-series data to reduce bias in the estimate of mean natural mortality rate. *Rep. int. Whal. Commn* 43: 343–348.

Pastene, L.A., Kobayashi, T., Fujise, Y. and Numachi, K. 1993. Mitochondrial DNA differentiation in Antarctic minke whales. *Rep. int. Whal. Commn* 43: 349–355.

1994 (3)

Kimoto, H., Endo, Y. and Fujimoto, K. 1994. Influence of interesterification on the oxidative stability of marine oil triacylglycerols. *JAOCS* 71 (5): 469–473.

Pastene, L.A., Fujise, Y. and Numachi, K. 1994. Differentiation of mitochondrial DNA between ordinary and dwarf forms of southern minke whale. *Rep. int. Whal. Commn* 44: 277–281.

Yoshioka, M., Okumura, T., Aida, K. and Fujise, Y. 1994. A proposed technique for quantifying muscle progesterone content in the minke whales (*Balaenoptera acutorostrata*). *Can. J. Zool.* 72 (2): 368–370.

1995 (3)

Fukui, Y., Mogoe, T., Terawaki, Y., Ishikawa, H., Fujise, Y. and Ohsumi, S. 1995. Relationship between physiological status and serum constituent values in minke whales (*Balaenoptera acutorostrata*). *Journal of Reproduction and Development* 41 (3): 203–208.

Ishikawa, H. and Amasaki, H. 1995. Development and physiological degradation of tooth buds and development of rudiment of baleen plate in Southern minke whale, *Balaenoptera acutorostrata*. *J. Vet. Med. Sci.* 57 (4): 665–670.

Kasamatsu, F., Nishiwaki, S. and Ishikawa, H. 1995. Breeding areas and southbound migrations of southern minke whales *Balaenoptera acutorostrata*. *Mar. Ecol. Prog. Ser.* 119: 1–10.

1996 (7)

Bakke, I., Johansen, S., Bakke, O. and El-Gewely, M.R. 1996. Lack of population subdivision among the minke whales (*Balaenoptera acutorostrata*) from Icelandic and Norwegian waters based on mitochondrial DNA sequences. *Marine Biology* 125: 1–9.

Butterworth, D.S. and Geromont, H.F. 1996. On the provision of advice on the effect on stock(s) of scientific permit catches, with particular reference to proposed research catches of minke whales from Antarctic Area IV. *Rep. int. Whal. Commn* 46: 653–655.

Butterworth, D.S., Punt, A.E., Geromont, H.F., Kato, H. and

Miyashita, T. 1996. An ADAPT approach to the analysis of catch-at-age information for Southern Hemisphere minke whales. *Rep. int. Whal. Commn* 46: 349–359.

Fukui, Y., Mogoe, T., Jung, Y.G., Terawaki, Y., Miyamoto, A., Ishikawa, H., Fujise, Y. and Ohsumi, S. 1996. Relationships among morphological status, steroid hormones, and post-thawing viability of frozen spermatozoa of male minke whales (*Balaenoptera acutorostrata*). *Marine Mammal Science* 12 (1): 28–37.

Iga, K., Fukui, Y., Miyamoto, A., Ishikawa, H. and Ohsumi, S. 1996. Endocrinological observations of female minke whales (*Balaenoptera acutorostrata*). *Marine Mammal Science* 12 (2): 296–301.

Matsuoka, K., Fujise, Y. and Pastene, L.A. 1996. A sighting of a large school of the pygmy right whale, *Caperea marginata* in the southeast Indian Ocean. *Marine Mammal Science* 12 (4): 594–597.

Pastene, L.A., Goto, M., Itoh, S. and Numachi, K. 1996. Spatial and temporal patterns of mitochondrial DNA variation in minke whale from Antarctic Areas IV and V. *Rep. int. Whal. Commn* 46: 305–314.

1997 (3)

Aono, S., Tanabe, S., Fujise, Y., Kato, H. and Tatsukawa, R. 1997. Persistent organochlorines in minke whale (*Balaenoptera acutorostrata*) and their prey species from the Antarctic and the North Pacific. *Environmental Pollution* 98: 81–89.

Fukui, Y., Mogoe, T., Ishikawa, H. and Ohsumi, S. 1997a. Factors affecting *in vitro* maturation of minke whale (*Balaenoptera acutorostrata*) follicular oocytes. *Biology of Reproduction* 56: 523–528.

Fukui, Y., Mogoe, T., Ishikawa, H. and Ohsumi, S. 1997b. *In vitro* fertilization of *in vitro* matured minke whale (*Balaenoptera acutorostrata*) follicular oocytes. *Marine Mammal Science* 13 (3): 395–404.

1998 (7)

Ichii, T., Shinohara, N., Fujise, Y., Nishiwaki, S. and Matsuoka, K. 1998. Interannual changes in body fat condition index of minke whales in the Antarctic. *Mar. Ecol. Prog. Ser.* 175: 1–12.

Ito, S., Takenaga, F. and Tsuyuki, H. 1998. Lipids in Antarctic minke whales III. Site and sexual differences of muscle lipids. *J. Jpn. Oil Chem. Soc.* 47 (2): 191–194 (in Japanese).

Kida, M.Y. 1998. Morphology of the tracheobronchial tree and the route of the pulmonary artery in the fetal minke whale (*Balaenoptera acutorostrata*). *Okajimas Folia Anat. Jpn.*75 (5): 251–258.

Mogoe, T., Fukui, Y., Ishikawa, H. and Ohsumi, S. 1998a. Morphological observations of frozen-thawed spermatozoa of Southern minke whales (*Balaenoptera acutorostrata*). *Journal of Reproduction and Development* 44 (1): 95–100.

Mogoe, T., Fukui, Y., Ishikawa, H. and Ohsumi, S. 1998b. Effects of diluent composition and temperature on motility and viability after liquid storage and cryopreservation of minke whale (*Balaenoptera acutorostrata*) spermatozoa. *Marine Mammal Science* 14 (4): 854–860.

Nagasawa, K., Yamada, T.K. and Ishikawa, H. 1998. Measurements of the skeleton of a minke whale (*Balaenoptera acutorostrata*) from the Antarctic Ocean. *Bulletin of the Yamagata Prefectural Museum* 20: 1–19.

Terabayashi, T. and Kawanishi, Y. 1998. Naturally occurring ganglioside lactones in minke whale brain. *Carbohydrate Research* 307 (3): 281–290.

1999 (4)

Bannister, J.L., Pastene, L.A. and Burnell, S.R. 1999. First record of movement of a southern right whale (*Eubalaena australis*) between warm water breeding grounds and the Antarctic Ocean, South of 60°S. *Marine Mammal Science* 15 (4): 1337–1342.

Butterworth, D.S., Punt, A.E. Geromont, H.F., Kato, H. and Fujise, Y. 1999. Inferences on the dynamics of Southern Hemisphere minke whales from ADAPT analyses of catch-at-age information. *J. Cetacean Res. Manage.* 1 (1): 11–32.

Ishikawa, H., Amasaki, H., Dohguchi, H., Furuya, A. and Suzuki, K. 1999. Immunohistological distributions of fibronectin, tenascin, type I, III and IV collagens, and laminin during tooth development and degeneration in fetuses of minke whale, *Balaenoptera acutorostrata*. *J. Vet. Med. Sci.* 61 (3): 227–232.

Thomson, R.B., Butterworth, D.S. and Kato, H. 1999. Has the age at transition of southern hemisphere minke whales declined over recent decades? *Marine Mammal Science* 15 (3): 661–682.

2000 (5)

Asada, M., Horii, M., Mogoe, T., Fukui, Y., Ishikawa, H. and Ohsumi, S. 2000. *In vitro* maturation and ultrastructural observation of cryopreserved minke whale (*Balaenoptera acutorostrata*) follicular oocytes. *Biology of Reproduction* 62 (2): 253–259.

Kasamatsu, F., Matsuoka, K. and Hakamada, T. 2000. Interspecific relationships in density among the whale community in the Antarctic. *Polar Biol* 23 (7): 466–473.

Mogoe, T., Suzuki, T., Asada, M., Fukui, Y., Ishikawa, H. and Ohsumi, S. 2000. Functional reduction of the Southern minke whale (*Balaenoptera acutorostrata*) testis during the feeding season. *Marine Mammal Science* 16 (3): 559–569.

Rosenbaum, H.C., Brownell, R.L., Brown, M.W., Schaeff, C., Portway, V., White, B.N., Malik, S., Pastene, L.A., Pateneude, N.J., Baker, C.S., Goto, M., Best, P.B., Clapham, P.J., Hamilton, P., Moore, M., Payne, R., Rowntree, V., Tynan, C.T., Bannister, J.L. and DeSalle, R. 2000. World-wide genetic differentiation of *Eubalaena*: questioning the number of right whale species. *Molecular Ecology* 9: 1793–1802.

Wei, H. and Fukui, Y. 2000. Fertilizability of ovine, bovine or minke whale (*Balaenoptera acutorostrata*) spermatozoa intracytoplasmically injected into bovine oocytes. *Zygote* 8 (3): 267–274.

2001 (3)

Asada, M., Tetsuka, M., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2001. Improvement on *in vitro* maturation, fertilization and development of minke whale (*Balaenoptera acutorostrata*) oocytes. *Theriogenology* 56 (4): 521–533.

Asada, M., Wei, H., Nagayama, R., Tetsuka, M., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2001. An attempt at intracytoplasmic sperm injection of frozen-thawed minke whale (*Balaenoptera bonaerensis*) oocytes. *Zygote* 9 (3): 299–307.

Suzuki, T., Mogoe, T., Asada, M., Miyamoto, A., Tetsuka, M., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2001. Plasma and pituitary concentrations of gonadotropins (FSH and LH) in minke whales (*Balaenoptera acutorostrata*) during the feeding season. *Theriogenology* 55 (5): 1127–1141.

2002 (6)

Abe, H. and Goto, M. 2002. The application of microsatellite DNA for determining population structure of minke whale. pp. 109–113. *In*: A. Nishimura (Ed.). *Technical Reports of the Hokkaido National Fisheries Research Institute No.5*. Hokkaido National Fisheries Research Institute, Hokkaido.

Kunito, T., Watanabe, I., Yasunaga, G., Fujise, Y. and Tanabe, S. 2002. Using trace elements in skin to discriminate the populations of minke whale in southern hemisphere. *Marine Environmental Research* 53: 175–197.

Murase, H., Matsuoka, K., Ichii, T. and Nishiwaki, S. 2002. Relationship between the distribution of euphausiids and baleen whales in the Antarctic (35°E–145°W). *Polar Biol* 25 (2): 135–145.

Pastene, L.A., Goto, M. and Kanda, N. 2002. The utility of DNA analysis for the management and conservation of large whales. *Fish Sci* 68 (Suppl. I): 286–289.

Suzuki, M., Ishikawa, H., Otani, S., Tobayama, T., Katsumata, E., Ueda, K., Uchida, S., Yoshioka, M. and Aida, K. 2002. The characteristics of adrenal glands and its hormones in cetacean. *Fish Sci* 68 (Suppl. I): 272–275.

Urashima, T., Sato, H., Munakata, J., Nakamura, T., Arai, I., Saito, T., Tetsuka, M., Fukui, Y., Ishikawa, H., Lyndersen, C. and Kovacs, K.M. 2002. Chemical characterization of the oligosaccharides in beluga (*Delphinapterus leucas*) and minke whale (*Balaenoptera acutorostrata*) milk. *Comparative Biochemistry and Physiology, Part B* 132: 611–624.

2003 (5)

Hayashi, K., Nishida, S., Yoshida, H., Goto, M., Pastene, L.A. and Koike, H. 2003. Sequence variation of the *DQB* allele in the cetacean MHC. *Mammal Study* 28 (2): 89–96.

Matsuoka, K., Watanabe, T., Ichii, T., Shimada, H. and Nishiwaki, S. 2003. Large whale distributions (south of 60°S, 35°E–130°E) in relation to the Southern Boundary of the Antarctic Circumpolar Current. pp. 26–30. *In*: *Antarctic Biology in a Global Context.* Proceedings of the VIIIth SCAR International Biology Symposium, 27 August-1 September 2001. Vriji Universiteit, Amsterdam, The Netherlands, Backhuys Publisheres, Leiden.

Nishida, S., Hayashi, K., Pastene, L.A., Goto, M., Kanda, N. and Koike, H. 2003. Polymorphic analysis of cetacean MHC—A case study on the minke whales—. *Mammalian Science* (Suppl.) 3: 75–78 (in Japanese).

Nishida, S., Pastene, L.A., Goto, M. and Kanda, N. 2003. SRY gene structure and phylogeny in the cetacean species. *Mammal Study* 28 (1): 57–66.

Ohishi, K., Zenitani, R., Bando, T., Goto, Y., Uchida, K., Maruyama, T., Yamamoto, S., Miyazaki, N. and Fujise, Y. 2003. Pathological and serological evidence of *Brucella*-infection in baleen whales (Mysticeti) in the western North Pacific. *Comp. Immun. Microbiol. Infect. Dis.* 26 (2): 125–136.

2004 (8)

Amemiya, K., Iwanami, Y., Kobayashi, T., Terao, T., Fukui, Y., Ishikawa, H., Ohsumi, S., Hirabayashi, M. and Hochi, S. 2004. Acquirement of oocyte-activating factor in Antarctic minke whale (*Balaenoptera bonaerensis*) spermatogenic cells, assessed by meiosis resumption of microinseminated mouse oocytes. *J. Mamm. Ova*

Res. 21: 149–156.

Branch, T.A., Matsuoka, K. and Miyashita, T. 2004. Evidence for increase in Antarctic blue whales based on Bayesian modeling. *Marine Mammal Science* 20 (4): 726–754.

Fujihira, T., Kinoshita, M., Sasaki, M., Ohnishi, M., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2004. Comparative studies on lipid analysis and ultrastructure in porcine and southern minke whale (*Balaenoptera bonaerensis*) oocytes. *Journal of Reproduction and Development* 50 (5): 525–532.

Fukui, Y., Togawa, M., Abe, N., Takano, Y., Asada, M., Okada, A., Iida, K., Ishikawa, H. and Ohsumi, S. 2004. Validation of the sperm quality analyzer and the hypo-osmotic swelling test for frozen-thawed ram and minke whale (*Balaenoptera bonarensis*) spermatozoa. *Journal of Reproduction and Development* 50 (1): 147–154.

Ikumi, S., Sawai, K., Takeuchi, Y., Iwayama, H., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2004. Interspecies somatic cell nuclear transfer for *in vitro* production of Antarctic minke Whale (*Balaenoptera bonaerensis*) Embryos. *Cloning and Stem Cells* 6 (3): 284–293.

Iwayama, H., Hochi, S., Kato, M., Hirabayashi, M., Kuwayama, M., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2004. Effects of cryodevice type and donorʹs sexual maturity on vitrification of minke whale (*Balaenoptera bonaerensis*) oocytes at germinal vesicle-stage. *Zygote* 12 (4): 333–338.

Muranishi, Y., Sasaki, M., Hayashi, K., Abe, N., Fujihira, T., Ishikawa, H., Ohsumi, S., Miyamoto, A. and Fukui, Y. 2004. Relationship between the appearance of preantral follicles in the fetal ovary of Antarctic minke whales (*Balaenoptera bonaerensis*) and hormone concentrations in the fetal heart, umbilical cord and maternal blood. *Zygote* 12 (2): 125–132.

Tetsuka, M., Asada, M., Mogoe, T., Fukui, Y., Ishikawa, H. and Ohsumi, S. 2004. The pattern of ovarian development in the prepubertal Antarctic minke whale (*Balaenoptera bonaerensis*). *Journal of Reproduction and Development* 50 (4): 381–389.

2005 (6)

Ishikawa, H. and Shigemune, H. 2005. Improvements in more humane killing methods of Antarctic minke whales, *Balaenoptera bonaerensis*, in the Japanese Whale Research Program under Special Permit in the Antarctic Sea (JARPA). *Jpn. J. Zoo Wildl. Med.* 10 (1): 27–34.

Iwayama, H., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2005. Attempt at *in vitro* maturation of minke whale (*Balaenoptera bonaerensis*) oocytes using a portable CO_2 incubator. *Journal of Reproduction and Development* 51 (1): 69–75.

Matsuoka, K., Pitman, R. and Marques, F. 2005. A note on a pigmy right whale (*Caperea marginata*) sighting in the southwestern Pacific Ocean. *J. Cetacean Res. Manage.* 7(1): 71–73.

Matsuoka, K., Hakamada, T., Kiwada, H., Murase, H. and Nishiwaki, S. 2005. Abundance increases of large baleen whales in the Antarctic based on the sighting survey during Japanese Whale Research Program (JARPA). *Global Environmental Research* 9 (2): 105–115.

Nikaido, M., Sasaki, T., Makino, H., Goto, M., Kanda, N., Pastene, L.A. and Okada, N. 2005. Phylogenetic reconstruction of baleen whales and detection of their past extensive radiation event by the SINE insertion analysis. *Fossils* 77: 22–28 (in Japanese).

Sasaki, T., Nikaido, M., Hamilton, H., Goto, M., Kato, H., Kanda, N., Pastene, L.A., Cao, Y., Fordyce, R.E., Hasegawa, M. and Okada, N. 2005. Mitochondrial phylogenetics and evolution of mysticete whales. *Systematic Biology* 54 (1): 77–90.

2006 (9)

Fujihira, T., Kobayashi, M., Hochi, S., Hirabayashi, M., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2006. Developmental capacity of Antarctic minke whale (*Balaenoptera bonaerensis*) vitrified oocytes following *in vitro* maturation, and parthenogenetic activation or intracytoplasmic sperm injection. *Zygote* 14 (2): 89–95.

Honda, K., Aoki, M. and Fujise, Y. 2006. Echochemical approach using mercury accumulation of Antarctic minke whale, *Balaenoptera bonaerensis*, as tracer of historical change of Antarctic marine ecosystem during 1980–1999. *Bull. Environ. Contam. Toxicol.* 76: 140–147.

Iwanami, K., Mita, H., Yamamoto, Y., Fujise, Y., Yamada, T. and Suzuki, T. 2006. cDNA-derived amino acid sequences of myoglobins from nine species of whales and dolphins. *Comparative Biochemistry and Physiology, Part B* 145: 249–256.

Kobayashi, T., Amemiya, K., Takeuchi, K., Tsujioka, T., Tominaga, K., Hirabayashi, M., Ishikawa, H., Fukui, Y. and Hochi, S. 2006. Contribution of spermatozoal centrosomes to the microtubule-organizing centre in Antarctic minke whale (*Balaenoptera bonaerensis*). *Zygote* 14 (1): 45–51.

Konishi, K. 2006. Characteristics of blubber distribution and body condition indicators for Antarctic minke whale (*Balaenoptera bonaerensis*). *Mammal Study* 31 (1): 15–22.

Mori, M. and Butterworth, D.S. 2006. A first step towards modelling the krill–predator dynamics of the Antarctic ecosystem. *CCAMLR Science* 13: 217–277.

Nikaido, M., Hamilton, H., Makino, H., Sasaki, T., Takahashi, K., Goto, M., Kanda, N., Pastene, L.A. and Okada, N. 2006. Baleen whale phylogeny and a past extensive radiation event revealed by SINE insertion analysis. *Mol. Biol. Evol.* 23 (5): 866–873.

Rock, J., Pastene, L.A., Kaufman, G., Forestell, P., Matsuoka, K. and Allen, J. 2006. A note on East Australia Group V Stock humpback whale movement between feeding and breeding areas based on photo-identification. *J. Cetacean Res. Manage.* 8 (3): 301–305.

Yabuki, T., Suga, T., Hanawa, K., Matsuoka, K., Kiwada, H. and Watanabe, T. 2006. Possible source of the Antarctic bottom water in the Prydz Bay Region. *Journal of Oceanography* 62 (5): 649–655.

2007 (7)

Asada, M., Tetsuka, M., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2007. Ultrastructural changes during maturation and cryopreservation of follicular oocytes of Antarctic minke whales (*Balaenoptera bonaerensis*). *Jpn. J. Zoo. Wildl. Med.* 12 (1): 51–66.

Branch, T.A., Stafford, K.M., Palacios, D.M., Allison, C., Bannister, J.L., Burton, C.L.K., Cabrera, E., Carlson, C.A., Galletti Vernazzani, B., Gill, P.C., Hucke-Gaete, R., Jenner, K.C.S., Jenner, Mn. M., Matsuoka, K., Mikhalev, Y.A., Miyashita, T., Morrice, M.G., Nishiwaki, S., Sturrock, V.J., Tormosov, D., Anderson, R.C., Baker, A.N., Best, P.B., Borsa, P., Brownell Jr, R.L., Childerhouse, S., Findlay, K.P., Gerrodette, T., Ilangakoon, A.D., Joergensen, M., Kahn, B., Ljungblad, D.K., Maughan, B., Mccauley, R.D., Mckay, S., Norris, T.F., Oman Whale and Dolphin Research Group, Rankin, S., Samaran, F., Thiele, D., Van Waerebeek, K. and Warneke, R.M. 2007. Past and present distribution, densities and movements of blue whales in the Southern Hemisphere and adjacent waters. *Mammal Rev.* 37 (2): 116–175.

LeDuc, R.G., Dizon, A.E., Goto, M., Pastene, L.A., Kato, H., Nishiwaki, S. and Brownell, R.L. 2007. Patterns of genetic variation in southern hemisphere blue whales, and the use of assignment test to detect mixing on the feeding grounds. *J. Cetacean Res. Manage.* 9 (1): 73–80.

Nagai, H., Mogoe, T., Ishikawa, H., Hochi, S., Ohsumi, S. and Fukui, Y. 2007. Follicle size-dependent changes in follicular fluid components and oocyte diameter in Antarctic minke whales (*Balaenoptera bonaerensis*). *Journal of Reproduction and Development* 53 (6): 1265–1272.

Nishida, S., Goto, M., Pastene, L.A., Kanda, N. and Koike, H. 2007. Phylogenetic relationships among cetaceans revealed by Y-chromosome sequences. *Zoological Science* 24 (7): 723–732.

Onbe, K. Nishida, S., Sone, E., Kanda, N., Goto, M., Pastene, L.A., Tanabe, S. and Koike, H. 2007. Sequence variation in the *Tbx4* gene in marine mammals. *Zoological Science* 24 (5): 449–464.

Pastene, L.A., Goto, M., Kanda, N., Zerbini, A.N., Kerem, D., Watanabe, K., Bessho, Y., Hasegawa, M., Nielsen, R., Larsen, F. and Palsbøll, P.J. 2007. Radiation and speciation of pelagic organisms during periods of global warming: the case of the common minke whale, *Balaenoptera acutorostrata. Molecular Ecology* 16: 1481–1495.

2008 (4)

Ishikawa, H. and Shigemune, H. 2008. Comparative experiment of whaling grenades in the Japanese Whale Research Program under Special Permit (JARPA and JARPN). *Jpn. J. Zoo Wildl. Med.* 13 (1): 21–28.

Konishi, K., Tamura, T., Zenitani, R., Bando, T., Kato, H. and Walløe, L. 2008. Decline in energy storage in the Antarctic minke whale (*Balaenoptera bonaerensis*) in the Southern Ocean. *Polar Biol* 31 (2): 1509–1520.

Ohishi, K., Fujise, Y. and Maruyama, T. 2008. *Brucella* spp. in the western North Pacific and Antarctic cetaceans: a review. *J. Cetacean Res. Manage.* 10 (1): 67–72.

Yunoki, K., Ishikawa, H., Fukui, Y. and Ohnishi, M. 2008. Chemical properties of epidermal lipids, especially sphingolipids, of the Antarctic minke whale. *Lipids* 43 (2): 151–159.

2009 (2)

Ono, N., Yamaguchi, T., Ishikawa, H., Arakawa, M., Takahashi, N. Saikawa, T. and Shimada, T. 2009. Morphological varieties of the Purkinje fiber network in mammalian hearts, as revealed by light and electron microscopy. *Arch Histol Cytol* 72 (3): 139–149.

Tamura, T. and Konishi, K. 2009. Feeding habits and prey consumption of Antarctic minke whale (*Balaenoptera bonaerensis*) in the Southern Ocean. *J. Northw. Atl. Fish. Sci.* 42: 13–25.

2010 (15)

Fujise, Y., Nishiwaki, S. and Ishikawa, S. 2010. Overview of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA). *Bull. Jpn. Soc. Fish. Oceanogr.* 74: 43–44 (in Japanese).

Fujise, Y., Hatanaka, H. and Ohsumi, S. 2010. Changes in the Antarctic marine ecosystem as revealed by the JARPA research: What has happened to the Antarctic minke whale stocks? *Ottar* (Tromsø Museum) 280: 29–34 (in Norwegian).

Glover, K.A., Kanda, N., Haug, T., Pastene, L.A., Øien, N., Goto, M., Seliussen, B.B. and Skaug, H.J. Migration of Antarctic minke whales to the Arctic. *PLoS ONE* 5 (12): e15197.

Ishikawa, H. 2010. Animal Welfare—Introduction—. *Jpn. J. Zoo. Wildl. Med.* 15 (1): 1–3 (in Japanese).

Ishikawa, H. 2010. Lethal Research for Wildlife. *Jpn. J. Zoo. Wildl. Med.* 15 (1): 9–14 (in Japanese).

Kokubun, N., Yasuma, H., Murase, H. and Naganobu, M. 2010. Distribution of seabirds in the Ross Sea, Antarctica. *Bull. Jpn. Soc. Fish. Oceanogr.* 74: 42–43 (in Japanese).

Matsuoka, K., Kiwada, K., Murase, H. and Nishiwaki, S. 2010. Whale species composition and their distribution patterns in the Ross Sea, Antarctica. *Bull. Jpn. Soc. Fish. Oceanogr.* 74: 44–45 (in Japanese).

Murase, H., Matsuoka, K., Hakamada, T., Nishiwaki, S., Naganobu, M. and Kitakado, T. 2010. Estimation of spatial distribution pattern of cetacean using environmental covariates in the Ross Sea, Antarctica. *Bull. Jpn. Soc. Fish. Oceanogr.* 74: 47–48 (in Japanese).

Naganobu, M. and Murase, H. 2010. Ecological linkage between oceanographic environment and distribution of top predators and their preys in the Ross Sea region. *Bull. Jpn. Soc. Fish. Oceanogr.* 74: 48–49 (in Japanese).

Naganobu, M., Murase, H., Nishiwaki, S., Yasuma, H., Matsukura, R., Takao, Y., Taki, K., Hayashi, T., Watanabe, Y., Yabuki, T., Yoda, Y., Noiri, Y., Kuga, M., Yoshikawa, K., Kokubun, N., Iwami, T., K., Itoh, K., Goto, M., Isoda, T., Matsuoka, K., Tamura, T. and Fujise, Y. 2010. Structure of marine ecosystem of the Ross Sea, Antarctica—overview and synthesis of the results of the Japanese multidisciplinary study by *Kaiyo-Maru* and JARPA—. *Bull. Jpn. Soc. Fish. Oceanogr.* 74: 1–12.

Naganobu, M., Nishiwaki, S., Nagai, N. and Tohyama, D. 2010. Multidisciplinary ecological survey by the R/V *Kaiyo Maru* and JARPA in the Ross Sea, Antarctica. *Bull. Jpn. Soc. Fish. Oceanogr.* 74: 34–35 (in Japanese).

Pastene, L. A., Acevedo, J., Goto, M., Zerbini, A.N., Acuna, P. and Aguayo-Lobo, A. 2010. Population structure and possible migratory links of common minke whales, *Balaenoptera acutorostrata*, in the Southern Hemisphere. *Conserv Genet* 11 (4): 1553–1558.

Tamura, T., Konishi, K., Nishiwaki, S., Taki, K., Hayashi, T. and Naganobu, M. 2010. Feeding ecology of the Antarctic minke whales in the Ross Sea, Antarctica. *Bull. Jpn. Soc. Fish. Oceanogr.* 74: 46–47 (in Japanese).

Yabuki, T., Noiri,Y., Murase, H., Kiwada, H., Matsuoka, K. and Naganobu, M. 2010. Physical and chemical study of hydrographic feature based on the R/V *Kaiyo Maru* cruise and JARPA in the Ross Sea, Antarctica. *Bull. Jpn. Soc. Fish. Oceanogr.* 74: 35–36 (in Japanese).

Zenitani, R. and Kato, H. 2010. The growth of baleen plates in Antarctic minke whales, with special reference to the V-shape notch appearing at the outer edge of the plates. *Nippon Suisan Gakkaishi* 76 (5): 870–876 (in Japanese with English abstract).

2011 (1)

Matsuoka, K., Hakamada, T., Kiwada, H., Murase, H. and Nishiwaki, S. 2011. Abundance estimates and trends for humpback whales (*Megaptera novaeangliae*) in Antarctic Areas IV and V based on JARPA sighting data. *J. Cetacean Res. Manage.* (special issue) 3: 75–94.

2012 (1)

*Sremba, A.L., Hancock-Hanser, B., Branch, T.A., LeDuc, R.L. and Baker, C.S. 2012. Circumpolar diversity and geographic differentiation of mtDNA in the critically endangered Antarctic blue whale (*Balaenoptera musculus intermedia*). *PLoS ONE* 7 (3): e32579.

2013 (6)

Glover, K.A., Kanda, N., Haug, T., Pastene, L.A., Øien, N., Seliussen, B.B., Sørvik, A.G.E. and Skaug, H.J. 2013. Hybrids between common and Antarctic minke whales are fertile and can back-cross. *BMC Genetics* 14: 25.

Hakamada, T., Matsuoka, K., Nishiwaki, S. and Kitakado, T. 2013. Abundance estimates and trends for Antarctic minke whales (*Balaenoptera bonaerensis*) in Antarctic Areas IV and V for the period 1989/90–2004/05. *J. Cetacean Res. Manage.* 13 (2): 123–151.

Kitakado, T., Lockyer, C. and Punt, A.E. 2013. A statistical model for quantifying age-reading errors and its application to the Antarctic minke whales. *J. Cetacean Res. Manage.* 13 (3): 181–190.

Murase, H., Kitakado, T., Hakamada, T., Matsuoka, K., Nishiwaki, S. and Naganobu, M. 2013. Spatial distribution of Antarctic minke whales (*Balaenoptera bonaerensis*) in relation to spatial distributions of krill in the Ross Sea, Antarctica. *Fish. Oceanogr.* 22 (3): 154–173.

Sasaki, M., Amano, Y., Hayakawa, D., Tsubota, T., Ishikawa, H., Mogoe, T., Ohsumi, S., Tetsuka, M., Miyamoto, A., Fukui, Y., Budipitojo, T. and Kitamura, N. 2013. Structure and steroidogenesis of the placenta in the Antarctic minke whale (*Balaenoptera bonaerensis*). *Journal of Reproduction and Development* 59 (2): 159–167.

Shibata, Y., Matsuishi, T., Murase, H., Matsuoka, K., Hakamada, T., Kitakado, T. and Matsuda, H. 2013. Effects of stratification and misspecification of covariates on species distribution models for abundance estimation from virtual line transect survey data. *Fish Sci* 79 (4): 559–568.

2014 (4)

Konishi, K., Hakamada, T., Kiwada, H., Kitakado, T. and Walløe, L. 2014. Decrease in stomach contents in the Antarctic minke whale (*Balaenoptera bonaerensis*) in the Southern Ocean. *Polar Biol* 37 (2): 205–215.

Punt, A.E. 2014. A summary history of the application of statistical catch-at-age analysis (SCAA) to Antarctic minke whales. *J. Cetacean Res. Manage.* 14: 81–92.

Punt, A.E., Hakamada, T., Bando, T. and Kitakado, T. 2014. Assessment of Antarctic minke whales using statistical catch-at-age analysis (SCAA). *J. Cetacean Res. Manage.* 14: 93–116.

Sasaki, M., Amano, Y., Hayakawa, D., Tsubota, T., Ishikawa, H., Mogoe, T., Ohsumi, S., Tetsuka, M., Miyamoto, A., Fukui, Y., Budipitojo, T. and Kitamura, N. 2014. Areolae of the placenta in the Antarctic minke whale (*Balaenoptera bonaerensis*). *Journal of Reproduction and Development* 60 (1): 62–67.

2015 (2)

Konishi, K. and Walløe, L. 2015. Substantial decline in energy storage and stomach fullness in Antarctic minke whales (*Balaenoptera bonaerensis*) during the 1990's. *J. Cetacean Res. Manage.* 15: 77–92.

Yasunaga, G., Fujise, Y., Zenitani, R., Tanabe, S. and Kato, H. 2015. Spatial and temporal variation of PCBs and organochlorine pesticides in the Antarctic minke whales, *Balaenoptera bonaerensis*, in the period 1987–2005. *Chemosphere* 126: 11–17.

2016 (2)

Pastene, L.A. and Goto, M. 2016. Genetic characterization and population genetic structure of the Antarctic minke whale *Balaenoptera bonaerensis* in the Indo-Pacific region of the Southern Ocean. *Fish Sci* 82 (6): 873–886.

Wada, N., Yamanaka, S., Shibato, J., Rakwal, R., Hirako, S., Iizuka, Y., Kim, H., Matsumoto, A., Kimura, A., Takenoya, F., Yasunaga, G. and Shioda, S. 2016. Behavioral and omics analyses study on potential involvement of dipeptide balenine through supplementation in diet of senescence-accelerated mouse prone 8. *Genomics Data* 10: 38–50.

2017 (3)

Isoda, T. and Tamura, T. 2017. Report of a White Adélie Penguin *Pygoscelis adeliae* in the Antarctic Ocean. *J. Yamashina Inst. Ornithol.* 48 (2): 74–77.

*Leduc, R.G., Archer, F.I., Lang, A.R., Martien, K.K., Hancock-Hanser, B., Torres-Florez, J.P., Hucke-Gaete, R., Rosenbaum, H.C., VanWaerebeek, Bownell, R.L. and Taylor, B.L. 2017. Genetic variation in blue whales in the eastern pacific: implications for taxonomy and use of common wintering grounds. *Molecular Ecology* 26: 740–751.

Yasunaga, G., Pastene, L.A., Bando, T., Hakamada, T. and Fujise, Y. 2017. Age estimation of Antarctic minke whales *Balaenoptera bonaerensis* based on aspartic acid racemization technique. *Fish Sci* 86 (6): 947–954.

2019 (1)

Inoue, S., Yasunaga, G. and Pastene, L.A. 2019. Comparison of progesterone concentrations in blubber and plasma among female Antarctic minke whales of known reproductive status. *Fish Sci* 85 (6): 971–977.

2020 (6)

Cunen, C., Walløe, L. and Hjort, N.L. 2020. Focused model selection for linear mixed models with an application to whale ecology. *Ann. Appl. Stat.* 14 (2): 872–904.

Goto, M., Kitakado, T. and Pastene, L.A. 2020. A preliminary study of epigenetic estimation of age of the Antarctic minke whale *Balaenoptera bonaerensis*. *Cetacean Population Studies* 2: 5–14.

Konishi, K., Isoda, T., Bando, T., Minamikawa, S. and Kleivane, L. 2020. Antarctic minke whales find ice gaps along the ice edge in foraging grounds of the Indo-Pacific sector (60°E and 140°E) of the Southern Ocean. *Polar Biol* 43 (4): 343–357.

Matsuoka, K. and Hakamada, T. 2020. Density distribution of several major whale species in the Indo-Pacific region of Antarctic using JARPA and JARPAII sighting data obtained through 1987/88–2008/09 seasons. *Cetacean Population Studies* 2: 15–38.

Murase, H., Palka, D., Punt, A.E., Pastene, L.A., Kitakado, T., Matsuoka, K., Hakamada, T., Okamura, H., Bando, T., Tamura, T., Konishi, K., Yasunaga, G., Isoda, T. and Kato, H. 2020. Review of the assessment of two stocks of Antarctic minke whales (eastern Indian Ocean and western South Pacific). *J. Cetacean Res. Manage.* 21: 95–122.

Tanabe, A., Shimizu, R., Osawa, Y., Suzuki, M., Ito, S., Goto, M., Pastene, L.A., Fujise, Y. and Sahara, H. 2020. Age estimation by DNA methylation in Antarctic minke whales. *Fish Sci* 86 (1): 35–41.

2021 (13)

Cunen, C., Walløe, L., Konishi, K. and Hjort, N.L. 2021. Decline in body condition in the Antarctic minke whale (*Balaenoptera bonaerensis*) in the Southern Ocean during the 1990s. *Polar Biol* 44 (2): 259–273.

Fujise, Y. and Pastene, L.A. 2021. Whales as indicators of historical and current changes in the marine ecosystem of the Indo-Pacific sector of the Antarctic. pp. 85–104. *In*: M. Kanao, D. Godone and N. Dematteis (Eds.). *Glaciers and Polar Environment.* IntechOpen. 200 pp.

Isoda, T., Matsuoka, K., Tamura, T. and Pastene, L.A. 2021. Spatial and temporal distribution of floating marine macro debris in the Indo-Pacific region of the Antarctic. *Cetacean Population Studies* 3: 198–211.

Isoda, T., Tamura, T. and Pastene, L.A. 2021. Ingestion of marine debris and evidence of entanglements involving Antarctic minke whales (*Balaenoptera bonaerensis*) sampled in the Indo-Pacific sector of the Antarctic. *Cetacean Population Studies* 3: 286–294.

Kato, H., Fujise, Y., Nakamura, G., Hakamada, T., Pastene, L.A. and Best, P.B. 2021. Dwarf minke whales: morphology, growth and life history based on samples collected from the higher latitudes in the Southern Hemisphere. *Cetacean Population Studies* 3: 93–128.

Kim, Y., Nishimura, F., Bando, T., Fujise, Y., Nakamura, G., Murase, H. and Kato, H. 2021. Fetal development in tail flukes of the Antarctic minke whale. *Cetacean Population Studies* 3: 231–238.

Konishi, K. and Tamura, T. 2021. Preliminary use of near-infrared spectroscopy to estimate the biochemical components of the muscles of the Antarctic minke whale *Balaenoptera bonaerensis*. *Cetacean Population Studies* 3: 281–285.

Nakamura, G., Zenitani, R., Bando, T., Fujise, Y., Yamamoto, R., Nishimura, F., Hirose, A., Kim, Y. and Kato, H. 2021. Skeletal measurements on some large cetacean species done by scientists of TUMSAT and ICR. *Cetacean Population Studies* 3: 215–230.

Nishimura, F., Kim, Y., Bando, T., Fujise, Y., Nakamura, G., Murase, H. and Kato, H. 2021. Morphological differences in skulls and feeding apparatuses between Antarctic (*Balaenoptera bonaerensis*) and common (*Balaenoptera acutorostrata*) minke whales, and the implication for their feeding ecology. *Can. J. Zool.* 99 (12): 1067–1079.

Ohashi, Y., Goto, M., Taguchi, M., Pastene, L.A. and Kitakado, T. 2021. Evaluation of a paternity method based on microsatellite DNA genotypes for estimating the abundance of Antarctic minke whales (*Balaenoptera bonaerensis*) in the Indo-Pacific region of the Antarctic. *Cetacean Population Studies* 3: 139–151.

Pastene, L.A., Goto, M., Taguchi, M. and Matsuoka, K. 2021. Genetic matches of southern right whales in the Indian sector of the Antarctic: a contribution towards understanding their movement and site-fidelity. *Cetacean Population Studies* 3: 129–138.

Uchida, M., Suzuki, I., Ito, K., Ishizuka, M., Ikenaka, Y., Nakayama, S.M.M., Tamura, T., Konishi, K., Bando, T. and Mitani, Y. 2021. Estimation of the feeding record of pregnant Antarctic minke whales (*Balaenoptera bonaerensis*) using carbon and nitrogen stable isotope analysis of baleen plates. *Polar Biol* 44 (3): 621–629.

*Yamazaki, K., Aoki, S., Katsumata, K., Hirano, D. and Nakayama, Y. 2021. Multidecadal poleward shift of the southern boundary of the Antarctic Circumpolar Current off East Antarctica. *Sci. Adv.* 7 (24): eabf8755.

2022 (3)

Ishikawa, H., Otsuki, M., Tamura, T., Konishi, K., Bando, T., Ishizuka, M., Ikenaka, Y., Nakayama, S.M.M. and Mitani, Y. 2022. Foraging ecology of mature male Antarctic minke whales (*Balaenoptera bonaerensis*) revealed by stable isotope analysis of baleen plates. *Polar Science* 31: 100785.

Pastene, L.A., Goto, M., Taguchi, M. and Fujise, Y. 2022. Phylogeny and population genetic structure of minke whales worldwide: a review of recent studies. pp. 11–37. *In*: H.A.E. Kaoud (Ed.). *Marine Mammals*. IntechOpen. 126 pp.

Yasunaga, G., Inoue, S., Bando, T., Hakamada, T. and Fujise, Y. 2022. Aspartic acid enantiomer quantification using ultraperformance liquid chromatography–tandem mass spectroscopy combined with deuterium-chloride hydrolysis to improve age estimation in Antarctic minke whale *Balaenoptera bonaerensis*. *Marine Mammal Science* https://doi.org/10.1111/mms.12977.

JARPN/JARPNII/NEWREP-NP surveys

1996 (3)

Butterworth, D.S., Geromont H.F. and Wada S. 1996. Further analysis of allele frequency data to provide estimates of the extent of mixing between the various North Pacific minke whale stocks, and their implications for the status of the "O"stock. *Rep. int. Whal. Commn* 46: 443–451.

Kuramochi, T., Machida, M., Araki, J., Uchida, A., Kishiro, T. and Nagasawa, K. 1996. Minke whales (*Balaenoptera acutorostrata*) are one of the major final hosts of *Anisakis simplex* (Nematoda: Anisakidae) in the Northwestern North Pacific Ocean. *Rep. int. Whal. Commn* 46: 415–419.

Miyashita, T. and Fujise, Y. 1996. Abundance estimate of the western North Pacific minke whale in sub-area 9 with notes on the results of dedicated surveys. *Rep. int. Whal. Commn* 47: 543–551.

1997 (6)

Aono, S., Tanabe, S., Fujise, Y., Kato, H. and Tatsukawa, R. 1997. Persistent organochlorines in minke whale (*Balaenoptera acutorostrata*) and their prey species from the Antarctic and the North Pacific. *Environmental Pollution* 98: 81–89.

Araki, J., Kuramochi, T., Machida, M., Nagasawa, K. and Uchida, A. 1997. A note on the parasite fauna of the western North Pacific minke whale (*Balaenoptera acutorostrata*). *Rep. int. Whal. Commn* 47: 565–567.

Goto, M. and Pastene, L.A. 1997. Population structure of western North Pacific minke whale based on an RFLP analysis of mtDNA control region. *Rep. int. Whal. Commn* 47: 531–537.

Hatanaka, H. and Miyashita, T. 1997. On the feeding migration of the Okhotsk Sea-West Pacific stock of minke whales, estimates based on length composition data. *Rep. int. Whal. Commn* 47: 557–564.

Hatanaka, H. 1997. A short review of hypotheses on minke whale stock structure in the Northwestern part of the North Pacific. *Rep. int. Whal. Commn* 47: 553–555.

Pastene, L.A., Goto, M., Itoh, S., Wada, S. and Kato, H. 1997. Intra- and inter-oceanic patterns of mitochondrial DNA variation in the Bryde's whale, *Balaenoptera edeni*. *Rep. int. Whal. Commn* 47: 569–574.

1998 (4)

Lindstrøm, U., Fujise, Y., Haug, T. and Tamura, T. 1998. Feeding habits of western North Pacific minke whales, *Balaenoptera acutorostrata*, as observed in July-September 1996. *Rep. int. Whal. Commn* 48: 463–469.

Pastene, L.A., Goto, M. and Kishino, H. 1998. An estimate of mixing proportion of 'J' and 'O' stocks minke whales in sub-area 11 based on mitochondrial DNA haplotype data. *Rep. int. Whal. Commn* 48: 471–474.

Tamura, T., Fujise, Y. and Shimazaki, K. 1998. Diet of minke whales *Balaenoptera acutorostrata* in the Northwestern part of the North Pacific in summer 1994 and 1995. *Fish Sci* 64 (1): 71–76.

Uchida, A., Kawakami, Y., Yuzu, S., Kishikawa, S., Kuramochi, T., Araki, J., Machida, M. and Nagasawa, K. 1998. Prevalence of parasites and histopathology of parasitisation in minke whales (*Balaenoptera acutorostrata*) from the western North Pacific Ocean and Southern Sea of Okhotsk. *Rep. int. Whal. Commn* 48: 475–479.

1999 (2)

Le, T.H.L., Takahashi, S., Saeki, K., Nakatani, N., Tanabe, S., Miyazaki, N. and Fujise, Y. 1999. High percentage of butyltin residues in total tin in the livers of cetaceans from Japanese coastal waters. *Environmental Science & Technology* 33 (11): 1781–1786.

Martinez, I. and Pastene, L.A. 1999. RAPD-typing of central and eastern North Atlantic and western North Pacific minke whales, *Balaenoptera acutorostrata*. *ICES Journal of Marine Science* 56 (5): 640–651.

2000 (2)

Punt, A.E., Butterworth, D.S. and Wada, S. 2000. On the use of allele frequency data within a Bayesian framework: evaluation of relative probabilities of alternative stock structure hypotheses for North Pacific minke whales. *J. Cetacean Res. Manage.* 2 (2): 151–158.

Uchida, A. and Araki, J. 2000. The ectoparasites and endoparasites in the minke whale, *Balaenoptera acutorostrata* from the western North Pacific Ocean. *J. Jpn. Vet. Med. Assoc.* 53 (2): 85–88 (in Japanese).

2001 (1)

Okamura, H., Matsuoka, K., Hakamada, T., Okazaki, M. and Miyashita, T. 2001. Spatial and temporal structure of the western North Pacific minke whale distribution inferred from JARPN sightings data. *J. Cetacean Res. Manage.* 3 (2): 193–200.

2002 (5)

Abe, H. and Goto, M. 2002. The application of microsatellite DNA for determining population structure of minke whale. pp. 109–113. *In*: A. Nishimura (Ed.). *Technical Reports of the Hokkaido National Fisheries Research Institute No.5*. Hokkaido National Fisheries Research Institute, Hokkaido.

Cui, G., Punt, A.E., Pastene, L. A. and Goto, M. 2002. Bayes and Empirical Bayes approaches to addressing stock structure questions using mtDNA data, with an illustrative application to North Pacific minke whales. *J. Cetacean Res. Manage.* 4 (2): 123–134.

Ohsumi, S. and Tamura, T. 2002. Dietary studies on baleen whales in the North Pacific. *Fish Sci* 68 (Suppl. I): 260–263.

Pastene, L.A., Goto, M. and Kanda, N. 2002. The utility of DNA analysis for the management and conservation of large whales. *Fish Sci* 68 (Suppl. I): 286–289.

Tamura T. and Fujise Y. 2002. Geographical and seasonal changes of the prey species of minke whale in the Northwestern Pacific. *ICES Journal of Marine Science* 59 (3): 516–528.

2003 (4)

Hayashi, K., Nishida, S., Yoshida, H., Goto, M., Pastene, L.A. and Koike, H. 2003. Sequence variation of the *DQB* allele in the cetacean MHC. *Mammal Study* 28 (2): 89–96.

Nishida, S., Pastene, L.A., Goto, M. and Kanda, N. 2003. *SRY* gene structure and phylogeny in the cetacean species. *Mammal Study* 28 (1): 57–66.

Nishida, S., Hayashi, K., Pastene, L.A., Goto, M., Kanda, N. and Koike, H. 2003. Polymorphic analysis of cetacean MHC—A case study on the minke whales—. *Mammalian Science* (Suppl.) 3: 75–78 (in Japanese).

Ohishi, K., Zenitani, R., Bando, T., Goto, Y., Uchida, K., Maruyama, T., Yamamoto, S., Miyazaki, N. and Fujise, Y. 2003. Pathological and serological evidence of Brucella-infection in baleen whales (Mysticeti) in the western North Pacific. *Comp. Immun. Microbiol. Infect. Dis* 26 (2): 125–136.

2004 (5)

Kim, E.Y., Iwata, H., Fujise, Y. and Tanabe, S. 2004. Searching for novel CYP members using cDNA library from a minke whale liver. *Marine Environmental Research* 58: 495–498.

Ohishi. K., Takishita, K., Kawato, M., Zenitani, R., Bando, T., Fujise, Y., Goto, Y., Yamamoto, S. and Maruyama, T. 2004. Molecular evidence of new variant *Brucella* in North Pacific common minke whales. *Microbes and Infection* 6: 1199–1204.

Ohishi, K., Takishita, K., Kawato, M., Maruyama, T., Zenitani, R., Bando, T., Fujise, Y., Goto, Y. and Yamamoto, S. 2004. Molecular characterization of *Brucella* from North Pacific common minke whale. *Oceans'04*: 499–504.

Watanabe, H., Mogoe, T., Asada, M., Hayashi, K., Fujise, Y., Ishikawa, H., Ohsumi, S., Miyamoto, A. and Fukui, Y. 2004. Relationship between serum sex hormone concentrations and histology of seminiferous tubules of captured baleen whales in the western North Pacific during the feeding season. *Journal of Reproduction and Development* 50 (4): 419–427.

Zharikov, K., Fujise, Y., Tamura, T., Kiwada, H., Bando, T., Konishi, K. and Isoda, T. 2004. Distribution and feeding of large cetaceans based on the data of JARPN II—2003 May, 17–July, 9. *Marine Mammals of the Holarctic* 2004: 207–210.

2005 (5)

Birukawa, N., Ando, H., Goto, M., Kanda, N., Pastene, L.A., Nakatsuji, H., Hata, H. and Urano, A. 2005. Plasma and urine levels of electrolytes, urea and steroid hormones involved in osmoregulation of cetaceans. *Zoological Science* 22 (11): 1245–1257.

Nikaido, M., Sasaki, T., Makino, H., Goto, M., Kanda, N., Pastene, L.A. and Okada, N. 2005. Phylogenetic reconstruction of baleen whales and detection of their past extensive radiation event by the SINE insertion analysis. *Fossils* 77: 22–28 (in Japanese).

Niimi, S., Watanabe, M.X., Kim, E.Y., Iwata, H., Yasunaga, G., Fujise, Y. and Tanabe, S. 2005. Molecular cloning and mRNA expression of cytochrome P4501A1 and 1A2 in the liver of common minke whales (*Balaenoptera acutorostrata*). *Marine Pollution Bulletin* 51 (8): 784–793.

Ohishi, K., Takishita, K., Kawato, M., Zenitani, R., Bando, T., Fujise, Y., Goto, Y., Yamamoto, S. and Maruyama, T. 2005. Chimeric structure of *omp2* of *Brucella* from North Pacific common minke whales (*Balaenoptera acutorostrata*). *Microbiol. Immunol.* 49 (8): 789–793.

Sasaki, T., Nikaido, M., Hamilton, H., Goto, M., Kato, H., Kanda, N., Pastene, L.A., Cao, Y., Fordyce, R.E., Hasegawa, M. and Okada, N. 2005. Mitochondrial phylogenetics and evolution of mysticete whales. *Systematic Biology* 54 (1): 77–90.

2006 (5)

Iwanami, K., Mita, H., Yamamoto, Y., Fujise, Y., Yamada, T. and Suzuki, T. 2006. cDNA-derived amino acid sequences of myoglobins from nine species of whales and dolphins. *Comparative Biochemistry and Physiology, Part B* 145: 249–256.

Kanda, N., Goto, M. and Pastene, L.A. 2006. Genetic characteristics of western North Pacific sei whales, *Balaenoptera borealis*, as revealed by microsatellites. *Marine Biotechnology* 8: 86–93.

Mitani, Y., Bando., T., Takai., N. and Sakamoto, W. 2006. Patterns of stable carbon and nitrogen isotopes in the baleens of common minke whale *Balaenoptera acutorostrata* from the western North Pacific. *Fish Sci* 72

(1): 69–76.

Nikaido, M., Hamilton, H., Makino, H., Sasaki, T., Takahashi, K., Goto, M., Kanda, N., Pastene, L.A. and Okada, N. 2006. Baleen whale phylogeny and a past extensive radiation event revealed by SINE insertion analysis. *Molecular Biology and Evolution* 23 (5): 866–873.

Ohishi, K., Maruyama, T., Ninomiya, A., Kida, H., Zenitani, R., Bando, T., Fujise, Y., Nakamatsu, K., Miyazaki, N. and Boltunov, A.N. 2006. Serologic investigation of influenza a virus infection in cetaceans from the western North Pacific and the Southern Oceans. *Marine Mammal Science* 22 (1): 214–221.

2007 (11)

Fukui, Y., Iwayama, H., Matsuoka, T., Nagai, H., Koma, N., Mogoe, T., Ishikawa, H., Fujise, Y., Hirabayashi, M., Hochi, S., Kato, H. and Ohsumi, S. 2007. Attempt at intracytoplasmic sperm injection of *in vitro* matured oocytes in common minke whales (*Balaenoptera acutorostrata*) captured during the Kushiro coast survey. *Journal of Reproduction and Development.* 53 (4): 945–952.

Kanda, N., Goto, M., Kato, H., McPhee, M.V. and Pastene, L.A. 2007. Population genetic structure of Bryde′s whales (*Balaenoptera brydei*) at the inter-oceanic and trans-equatorial levels. *Conservation Genetics* 8 (4): 853–864.

Konishi, K. and Tamura, T. 2007. Occurrence of the minimal armhook squids *Berryteuthis anonychus* (Cephalopoda: Gonatidae) in the stomachs of common minke whales *Balaenoptera acutorostrata* in the western North Pacific. *Fish Sci* 73 (5): 1208–1210.

Murase, H., Tamura, T., Kiwada, H., Fujise, Y., Watanabe, H., Ohizumi, H., Yonezaki, S., Okamura, H. and Kawahara, S. 2007. Prey selection of common minke (*Balaenoptera acutorostrata*) and Bryde′s (*Balaenoptera edeni*) whales in the western North Pacific in 2000 and 2001. *Fish. Oceanogr.* 16 (2): 186–201.

Niimi, S., Kim, E.Y., Iwata, H., Watanabe, M.X., Yasunaga, G., Fujise, Y. and Tanabe, S. 2007. Identification and hepatic expression profiles of cytochrome P450 1–4 isozymes in common minke whales (*Balaenoptera acutorostrata*). *Comparative Biochemistry and Physiology, Part B* 147: 667–681.

Nishida, S., Goto, M., Pastene, L.A., Kanda, N. and Koike, H. 2007. Phylogenetic relationships among cetaceans revealed by Y-chromosome sequences. *Zoological Science* 24 (7): 723–732.

Onbe, K. Nishida, S., Sone, E., Kanda, N., Goto, M., Pastene, L.A., Tanabe, S. and Koike, H. 2007. Sequence variation in the Tbx4 Gene in marine mammals. *Zoological Science* 24 (5): 449–464.

Pastene, L.A., Goto, M., Kanda, N., Zerbini, A.N., Kerem, D., Watanabe, K., Bessho, Y., Hasegawa, M., Nielsen, R., Larsen, F. and Palsbøll, P.J. 2007. Radiation and speciation of pelagic organisms during periods of global warming: the case of the common minke whale, *Balaenoptera acutorostrata*. *Molecular Ecology* 16: 1481–1495.

Urashima, T., Kobayashi, M., Asakuma, S., Uemura, Y., Arai, I., Fukuda, K., Saito, T., Mogoe, T., Ishikawa, H. and Fukui, Y. 2007. Chemical characterization of the oligosaccharides in Bryde′s whale (*Balaenoptera edeni*) and Sei whale (*Balaenoptera borealis*) milk. *Comparative Biochemistry and Physiology, Part B* 146: 153–159.

Watanabe, H., Tateno, H., Kusakabe, H., Kamiguchi, Y., Fujise, Y., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2007. Fertilizability and chromosomal integrity of frozen-thawed Bryde′s whale (*Balaenoptera edeni*) spermatozoa intracytoplasmically injected into mouse oocytes. *Reproduction, Fertility and Development* 19 (1): 306.

Watanabe, H., Tateno, H., Kusakabe, H., Matsuoka, T., Kamiguchi, Y., Fujise, Y., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2007. Fertilizability and chromosomal integrity of frozen-thawed Bryde′s whale (*Balaenoptera edeni*) spermatozoa intracytoplasmically injected into mouse oocytes. *Zygote* 15 (1): 9–14.

2008 (3)

Birukawa, N., Ando, H., Goto, M., Kanda, N., Pastene, L.A. and Urano, A. 2008. Molecular cloning of urea transporters from the kidneys of baleen and toothed whales. *Comparative Biochemistry and Physiology, Part B* 149: 227–235.

Ishikawa, H. and Shigemune, H. 2008. Comparative experiment of whaling grenades in the Japanese Whale Research Program under Special Permit (JARPA and JARPN). *Jpn. J. Zoo Wildl. Med.* 13 (1): 21–28.

Ohishi, K., Fujise, Y. and Maruyama, T. 2008. *Brucella* spp. in the western North Pacific and Antarctic cetaceans: a review. *J. Cetacean Res. Manage.* 10 (1): 67–72.

2009 (9)

Bhuiyan, M.M.U., Suzuki, Y., Watanabe, H., Hirayama, H., Matsuoka, K., Fujise, Y., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2009. Attempts at in vitro fertilization and culture of in vitro matured oocytes in sei *(Balaenoptera borealis*) and Bryde′s (*B. edeni*) whales. *Zygote* 17 (1): 19–28.

Fujita, H., Honda, K., Hamada, N., Yasunaga, G and Fujise,

Y. 2009. Validation of high-throughput measurement system with microwave-assisted extraction, fully automated sample preparation device, and gas chromatography-electron capture detector for determination of polychlorinated biphenyls in whale blubber. *Chemosphere* 74: 1069–1078.

Hiwasa, M., Suzuki, Y., Watanabe, H., Bhuiyan, M.M.U., Matsuoka, K., Fujise, Y., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2009. Effects of semen extenders and storage temperatures on characteristics of frozen-thawed Bryde′s (*Balaenoptera edeni*) whale spermatozoa. *Journal of Reproduction and Development* 55: 599–606.

Konishi, K., Tamura T., Isoda, T. Okamoto, R., Hakamada, T., Kiwada, H. and Matsuoka, K. 2009. Feeding strategies and prey consumption of three baleen whale species within the Kushiro-Current Extension. *J. Northw. Atl. Fish. Sci.* 42: 27–40.

Lee, E., Bhuiyan, M.M.U., Watanabe, H., Matsuoka, K., Fujise, Y., Ishikawa, H. and Fukui. Y. 2009. Production of cloned sei whale (*Balaenoptera borealis*) embryos by interspecies somatic cell nuclear transfer using enucleated pig oocytes. *J. Vet. Sci.* 10 (4): 285–292.

Matsukura, R., Yasuma, H., Murase, H., Yonezaki, S., Funamoto, T., Honda, S. and Miyashita, K. 2009. Measurements of density contrast and sound-speed contrast for target strength estimation of Neocalanus copepods (*Neocalanus cristatus*) in the North Pacific Ocean. *Fish Sci* 75 (6): 1377–1387.

Murase, H., Ichihara, M., Yasuma, H., Watanabe, H., Yonezaki, S., Nagashima, H., Kawahara, S. and Miyashita, T. 2009. Acoustic characterization of biological backscatterings in the Kuroshio-Oyashio inter-frontal zone and subarctic waters of the western North Pacific in spring. *Fish. Oceanogr.* 18 (6): 386–401.

Murase, H., Nagashima, H., Yonezaki, S., Matsukura, R. and Kitakado, T. 2009. Application of a generalized additive model (GAM) to reveal relationships between environmental factors and distributions of pelagic fish and krill: a case study in Sendai Bay, Japan. *ICES Journal of Marine Science* 66 (6): 1417–1424.

Tsuki, K., Sato, A., Kaneko, H., Yasunaga, G., Fujise, Y. and Nomata, H. 2009. Comparison of physiologically significant imidazole dipeptides in cetaceans sampled in Japanese whale research (short paper). *Sci. Rep. Hokkaido Fish. Exp. Stn.* 74: 25–28 (in Japanese).

2010 (7)

Bhuiyan, M.M.U., Suzuki, Y., Watanabe, H., Lee, E., Hirayama, H., Matsuoka, K., Fujise, Y., Ishikawa, H., Ohsumi, S. and Fukui, Y. 2010. Production of sei whale (*Balaenoptera borealis)* cloned embryos by inter- and intra-species somatic cell nuclear transfer. *Journal of Reproduction and Development* 56: 131–139.

Funakasa, N., Yoshioka, M. and Fujise, Y. 2010. Features of the Ocular Harderian Gland in three Balaenopterid species based on anatomical, histological and histochemical observations. *Mammal Study* 35 (1): 9–15.

Ogawa, G., Ishida, M., Kato, H., Fujise, H. and Urano, N. 2010. Identification of facultative anaerobic bacteria isolated from the intestine of the minke whale *Balaenoptera acutorostrata* by 16S rRNA sequencing analysis. *Fish Sci* 76 (2): 177–181.

Pastene, L.A., Fujise, Y. and Hatanaka, H. 2010. JARPNII: a challenging multidiscipline research program focused on whales in the western North Pacific. *Ottar* (Tromsø Museum) 280: 23–28 (in Norwegian).

Shishido, R., Ohishi, K., Suzuki, R., Takishita, K., Ohtsu, D., Okutsu, K., Tokutake, K., Katsumata, E., Bando, T., Fujise, Y., Murayama, T. and Maruyama, T. 2010. Cetacean Toll-like receptor 4 and myeloid differentiation factor 2, and possible cetacean-specific responses against Gram-negative bacteria. *Comp. Immun. Microbiol. Infect. Dis.* 33 (6): 89–98.

Suzuki, Y., Umatani, M., Bhuiyan, M.M.U., Watanabe, H., Mogoe, T., Matsuoka, K., Fujise, Y., Ishikawa, H., Ohsumi, S., Sasaki, M. and Fukui, Y. 2010. Effects of equilibration steps, type of sugars and addition of whale follicular fluid on viability and in vitro maturation of vitrified whale oocytes. *Jpn. J. Zoo Wildl. Med* 15 (2): 65–72.

Tojo, N., Matsukura, R., Yasuma, H., Yonezaki, S., Watanabe, H., Kawahara, S., Murase, H. and Miyashita, K. 2010. Spatial analysis of isada krill (*Euphausia pacifica*) distribution in frontal environments in the North Pacific Ocean. *GIS/spatial analyses in fisheries and aquatic science*. 4. International Fishery GIS Society: 115–138.

2011 (20)

Hakamada, T. and Matsuoka, K. 2011. Abundance estimate for common minke, Bryde′s and sei whales in the offshore region of the western North Pacific. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 173–174 (in Japanese).

Kanda, N., Goto, M. and Pastene, L. A. 2011. Genetic stock structure of baleen whales. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 191 (in Japanese).

Kato, H. and Fujise, Y. 2011. General discussion: Symposium on "Marine ecosystem of the western North Pacific with special interest in cetaceans." *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 194–195 (in Japanese).

Kishiro, T., Yoshida, H., Tamura, T., Konishi, K., Kanda, N., Okamoto, R. and Kato, H. 2011. Relationship between maturity and feeding ecology of common minke whales off Kushiro in autumn. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 175–176 (in Japanese).

Maehara, T., Aoki, I., Yonezaki, S., Watanabe, H., Murase, H. and Yamaguchi, A. 2011. Feeding ecology of the Japanese anchovy in the offshore area east of Honshu, Japan in summer. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 187 (in Japanese).

Matsuoka, K., Kiwada, H., Fujise, Y. and Miyashita, T. 2011. Distribution of baleen whales in the western North Pacific based on the JARPN and JARPN II sighting surveys (1994 to 2007). *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 178–179 (in Japanese).

Miyashita, K., Matsukura, R., Tojo, N., Minami, K., Yasuma, H., Nagashima, H., Onodera, K., Watanabe, H., Yonezaki, S. and Murase, H. 2011. Monitoring of prey of cetaceans by using quantitative echosounders. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 183–184 (in Japanese).

Mori, M., Watanabe, H., Hakamada, T., Tamura, T., Konishi, K., Murase, H. and Matsuoka, K. 2011. Development of an ecosystem model of western North Pacific using Ecopath with Ecosim. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 189 (in Japanese).

Murase, H., Kawabata, A., Kubota, H., Nakagami, M., Amakasu, K., Abe, K., Miyashita, K. and Oozeki, Y. 2011. Effect of depth-dependent target strength on biomass estimation of Japanese anchovy. *Journal of Marine Science and Technology* 19: 267–272.

Murase, H., Tamura, T., Isoda, T., Okamoto, R., Kato, H., Yonezaki, S., Watanabe, H., Tojo, N. Matsukura, R., Miyashita, K., Kiwada, H., Matsuoka, K., Nishiwaki, S., Inagake, D., Okazaki, M., Okamura, H. and Fujise, Y. 2011. Prey selection of common minke, Bryde′s and sei whales in the offshore region of the western North Pacific. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 180–181 (in Japanese).

Nishiwaki, S., Otani, S. and Tamura, T. 2011. The satellite tracking of the western North Pacific. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 193–194 (in Japanese).

Onodera, K., Nagashima, H., Matsukura, R., Miyashita, K., Yonezaki, S. and Murase, H. 2011. Cetacean prey species and oceanographic surveys in Sendai Bay. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 184–185 (in Japanese).

Pastene, L.A., Hatanaka, H., Fujise, Y., Kanda, N., Murase, H., Tamura, T., Miyashita, T. and Kato, H. 2011. Whale research program under special permit in the western North Pacific—Phase II (JARPNII): origin and objectives. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 172–173 (in Japanese).

Pastene, L.A., Hatanaka, H., Fujise, Y., Kanda, N., Murase, H., Tamura, T., Yasunaga, G., Kishiro, T., Yoshida, H., Miyashita, T. and Kato, H. 2011. The Japanese Whale Research Program under Special Permit in the western North Pacific Phase-II (JARPNII): origin, objectives and research progress made in the first six years period (2002–2007), including scientific considerations for the next research period. *Aquabiology* 33 (2): 171–185 (in Japanese).

Sasaki, Y., Saito, S., Matsuoka, K., Murase, H. and Kiwada., H. 2011. Spatial distribution patterns of sei and Bryde′s whales. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 179–180 (in Japanese).

Tamura, T., Konishi, K., Isoda, T., Hakamada, T., Kiwada, H., Okamoto, R. and Matsuoka, K. 2011. The food habitat, relation of habitat factor and prey consumption of three baleen whale species in the offshore region of the western North Pacific. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 174–175 (in Japanese).

Watanabe, H., Kiwada, H., Kumagai, S., Yonezaki, S., Kishiro, T., Konishi., K. and Yoshida, H. 2011. Habitat and prey selection of common minke whale off Kushiro in autumn—Estimation of distribution and migration of common minke whale using environmental information—. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 182–183 (in Japanese).

Yamaguchi, A., Hanamiya, Y., Murase, H. and Watanabe, H. 2011. Vertical flux of materials by diel vertical migration of macrozooplankton. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 185–186 (in Japanese).

Yasunaga, G. and Fujise, Y. 2011. Monitoring of pollutants in the baleen whales and their prey species in the western North Pacific. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 190 (in Japanese).

Yoshida, H., Kishiro, T., Goto, M., Bando, T., Tamura, T., Konishi, K., Okamoto, R. and Kato, H. 2011. Feeding ecology of common minke whales in coastal waters off Sanriku in spring. *Bull. Jpn. Soc. Fish. Oceanogr.* 75 (3): 177–178 (in Japanese).

2012 (4)

Maeda, H. and Kato, H. 2012. Technical improvements of the age character (earplug) collections in common minke whales. *Bull. Jpn. Soc. Fish. Oceanogr.* 76 (2): 59–65 (in Japanese).

Murase, H., Kawabata, A., Kubota, H., Nakagami, M., Amakasu, K., Abe, K., Miyashita, K. and Oozeki, Y. 2012. Basin-scale distribution patterns and biomass estimation of Japanese anchovy *Engraulis japonicus* in the western North Pacific. *Fish Sci* 78 (4): 761–773.

Nakamura, G., Kato, H. and Fujise, Y. 2012. Relative growth of the skull of the common minke whale *Balaenoptera acutorostrata* from the North Pacific in comparison to other *Balaenoptera* species. *Mammal Study* 37 (2): 105–112.

Watanabe, H, Okazaki, M., Tamura, T., Konishi, K., Inagake, D., Bando, T., Kiwada, H. and Miyashita, T. 2012. Habitat and prey selection of common minke, sei, and Bryde′s whale in mesoscale during summer in the sub-arctic and transition regions of the western North Pacific. *Fish Sci* 78 (3): 557–567.

2013 (5)

*Kershaw, F., Leslie, M.S., Collins, T., Mansur, R.M., Smith, B.D., Minton, G., Baldwin, R., LeDuc, R.G., Anderson, R.C., Brownell, R.L. and Rosenbaum, H.C. 2013. Population differentiation of 2 forms of Bryde′s whales in the Indian and Pacific Oceans. *Journal of Heredity* 104 (6): 755–764.

Maeda, H., Kawamoto, T. and Kato, H. 2013. A study on the improvement of age estimation in common minke whales using the method of gelatinized extraction of earplug. NAMMCO *Scientific Publications* 10: 17 pp.

Matsukura, R., Sawada, K., Abe, K., Minami, K., Nagashima, H., Yonezaki, S., Murase, H. and Miyashita, K. 2013. Comparison of measurements and model calculations of target strength of juvenile sandeel in Sendai Bay. *Nippon Suisan Gakkaishi* 79 (4): 638–648 (in Japanese).

Sasaki, H., Murase, H., Kiwada, H., Matsuoka, K., Mitani, Y. and Saitoh, S. 2013. Habitat differentiation between sei (*Balaenoptera borealis*) and Bryde′s whales (*B. brydei*) in the western North Pacific. *Fish. Oceanogr.* 22 (6): 496–508.

Shimizu, Y., Ohishi, K., Suzuki, R., Tajima, Y., Yamada, T., Kakizoe, Y., Bando, T., Fujise, Y., Taru, H., Murayama, T. and Maruyama, T. 2013. Amino acid sequence variations of signaling lymphocyte activation molecule and mortality caused by morbillivirus infection in cetaceans. *Microbiol Immunol* 57: 624–632.

2014 (6)

Inoue, S., Kishiro, T., Fujise, Y., Nakamura, G. and Kato, H. 2014. Seasonal changes in the testis of the North Pacific common minke whale. *Nippon Suisan Gakkaishi* 80 (2): 185–190 (in Japanese).

Murase, H., Hakamada, T., Matsuoka, K., Nishiwaki, S., Inagake, D., Okazaki, M., Tojo, N. and Kitakado, T. 2014. Distribution of sei whales (*Balaenoptera borealis*) in the subarctic–subtropical transition area of the western North Pacific in relation to oceanic fronts. *Deep Sea Research Part II*: Topical Studies in Oceanography 107: 22–28.

Nakamura, G., Kadowaki, I., Nagatsuka, S., Fujise, Y., Kishiro, T. and Kato, H. 2014. Variation in a color pattern of white patch on the flippers of North Pacific common minke whales: potential application for their interoceanic difference. *La mer* 52: 31–47.

Nakamura, G. and Kato, H. 2014. Developmental changes in the skull morphology of common minke whales *Balaenoptera acutorostrata. Journal of Morphology* 275: 1113–1121.

Niimi, S., Imoto, M., Kunisue, T., Watanabe, M.X., Kim, E.Y., Nakayama, K., Yasunaga, G., Fujise, Y., Tanabe, S. and Iwata, H. 2014. Effects of persistent organochlorine exposure on the liver transcriptome of the common minke whale (*Balaenoptera acutorostrata*) from the North Pacific. *Ecotoxicology and Environmental Safety* 108: 95–105.

*Rosel, P.E. and Wilcox, L.A. 2014. Genetic evidence reveals a unique lineage of Bryde′s whales in the northern Gulf of Mexico. *Endang Species Res.* 25 : 19–34.

2015 (1)

Kitayama, C., Sasaki, M., Ishikawa, H., Mogoe, T., Ohsumi, S., Fukui, Y., Budipitojo, T., Kondoh, D. and Kitamura, N. 2015. Structure and functions of the placenta in common minke (*Balaenoptera acutorostrata*), Bryde′s (*B. brydei*) and sei (*B. borealis*) whales. *Journal of Reproduction and Development* 61 (5): 415–421.

2016 (6)

Hirako, S., Suzuki, M., Kim, H., Iizuka, Y., Matsumoto, A., Wada, N., Okabe, M., Takenoya, F., Yasunaga, G., Yamanaka, S., Miyazaki, A. and Shioda, S. 2016. Hepatic lipid accumulation is ameliorated in obese KK mice by dietary sei whale oil. *Fish Sci* 82 (3): 509–517.

Miyakawa, N., Kishiro, T., Fujise, Y., Nakamura, G. and Kato, H. 2016. Sexual dimorphism in pelvic bone shape of the North Pacific common minke whales (*Balaenoptera acutorostrata*). *Open Journal of Animal Sciences* 6: 131–136.

Murase, H., Tamura, T., Otani, S. and Nishiwaki, S. 2016. Satellite tracking of Bryde′s whales *Balaenoptera edeni* in the offshore western North Pacific in summer 2006 and 2008. *Fish Sci* 82 (1): 35–45.

Nakamura, G., Kadowaki, I., Nagatsuka, S., Hayashi, R., Kanda, N., Goto, M., Pastene, L.A. and Kato, H. 2016. White patch on the fore-flipper of common minke whale, as a potential morphological index to identify stocks. *Open Journal of Animal Sciences* 6: 116–122.

Nakamura, G., Takahashi, M., Hirose, A., Hayashi, R., Fujise, Y., Miyakawa, N., Inoue, S. and Kato, H. 2016. Presence of an interparietal bone and morphological variation in the vertex of the skull in North Pacific common minke whale. *La mer* 54 (1): 1–10.

Ohishi, K., Bando, T., Abe, E., Kawai, Y., Fujise, Y. and Maruyama, T. 2016. Long-term and large-scale epidemiology of *Brucella* infection in baleen whales and sperm whales in the western North Pacific and Antarctic Oceans. *J. Vet. Med. Sci.* 78 (9): 1457–1464.

2017 (3)

Bando, T., Nakamura, G., Fujise, Y. and Kato, H. 2017. Developmental changes in the morphology of western North Pacific Bryde′s whales (*Balaenoptera edeni*). *Open Journal of Animal Sciences* 7: 344–355.

Ishii, M., Murase, H., Fukuda, Y., Sawada, K., Sasakura, T., Tamura, T., Bando, T., Matsuoka, K., Shinohara, A., Nakatsuka, S., Katsumata, N., Okazaki, M., Miyashita, K. and Mitani, Y. 2017. Diving behavior of sei whales *Balaenoptera borealis* relative to the vertical distribution of their potential prey. *Mammal Study* 42 (4): 191–199.

Maeda, H., Fujise, Y., Kishiro, T. and Kato, H. 2017. Utility of the transition phase in earplugs of the North Pacific common minke whale as an indicator of age at sexual maturity. *Open Journal of Animal Sciences* 7: 414–424.

2018 (3)

Hirose, A., Kishida, T. and Nakamura, G. 2018. Nasal mucosa resembling an olfactory system in the common minke whale (*Balaenoptera acutorostrata*). *Cetacean Population Studies* 1: 25–28.

Huijser, L.A.E., Bérubé, M., Cabrera, A.A., Prieto, R., Silva, M.A., Robbins, J., Kanda, N., Pastene, L.A., Goto, M., Yoshida, H., Vikingsson, G.A. and Palsbøll, P.J. 2018. Population structure of North Atlantic and North Pacific sei whales (*Balaenoptera borealis*) inferred from mitochondrial control region DNA sequences and microsatellite genotypes. *Conserv Genet* 19: 1007–1024.

Nakamura, G., Ryeng, K.A., Kadowaki, I., Hayashi, R., Nagatsuka, S., Hirose, A., Fujise, Y. and Haug, T. 2018. Comparison of shapes of the white flipper patch between two sub-species of common minke whales (*Balaenoptera acutorostrata*). *Cetacean Population Studies* 1: 15–24.

2019 (1)

Watari, S., Murase, H., Yonezaki, S., Okazaki, M., Kiyofuji, H., Tamura, T., Hakamada, T., Kanaji, Y. and Kitakado, T. 2019. Ecosystem modeling in the western North Pacific using Ecopath, with a focus on small pelagic fishes. *Mar Ecol Prog Ser* 617–618: 295–305.

2020 (1)

Yasunaga, G. and Fujise, Y. 2020. Concentration of persistent organic pollutants (POPs) in three species of baleen whales in the western North Pacific. *Cetacean Population Studies* 2: 39–53.

2021 (8)

Bando, T. 2021. Improved estimates of some life-history parameters of the pelagic subspecies of Bryde′s whale in the western North Pacific. *Cetacean Population Studies* 3: 239–245.

Gomes, T.L., Quiazon, K.M., Kotake, M., Fujise, Y., Ohizumi, H., Itoh, N. and Yoshinaga, T. 2021. *Anisakis* spp. in toothed and baleen whales from Japanese waters with notes on their potential role as biological tags. *Parasitology International* 80: 102228.

Maeda, H. and Kato, H. 2021. Seasonal changes in the earplug germinal layers of North Pacific common minke whales. *Cetacean Population Studies* 3: 246–251.

Matsuoka, K., Hakamada, T. and Miyashita, T. 2021. A note on recent surveys for right whales *Eubalaena japonica* in the western North Pacific. *Cetacean Population Studies* 3: 252–257.

Nakamura, G., Zenitani, R., Bando, T., Fujise, Y., Yamamoto, R., Nishimura, F., Hirose, A., Kim, Y. and Kato, H. 2021. Skeletal measurements on some large cetacean species done by scientists of TUMSAT and ICR. *Cetacean Population Studies* 3: 215–230.

Nishimura, F., Kim, Y., Bando, T., Fujise, Y., Nakamura, G., Murase, H. and Kato, H. 2021. Morphological differences in skulls and feeding apparatuses between Antarctic (*Balaenoptera bonaerensis*) and common (*Balaenoptera acutorostrata*) minke whales, and the implication for their feeding ecology. *Can. J. Zool.* 99 (12): 1067–1079.

Suyama, S., Yanagimoto, T., Nakai, K., Tamura, T., Shiozaki, K., Ohshimo, S. and Chow, S. 2021. A taxonomic revision of *Pennella* Oken, 1815 based on morphology and genetics (Copepoda: Siphonostomatoida: Pennellidae). *Journal of Crustacean Biology* 41 (3): ruab040.

Taguchi, M., Goto, M., Milmann, L., Siciliano, S., Tiedemann, R. and Pastene, L.A. 2021. New insights into the genetic structure of sei whales (*Balaenoptera borealis*) at the inter-oceanic scale. *Cetacean Population Studies* 3: 152–163.

2022 (4)

Pastene, L.A., Goto, M., Taguchi, M. and Fujise, Y. 2022. Phylogeny and population genetic structure of minke whales worldwide: a review of recent studies. pp. 11–37. *In*: H.A.E. Kaoud (Ed.). *Marine Mammals*. IntechOpen. 126 pp.

Taguchi, M., Goto, M., Matsuoka, K., Tiedemann, R. and Pastene, L.A. 2022. Population genetic structure of Bryde′s whales (*Balaenoptera brydei*) on the central and western North Pacific feeding grounds. *Can. J. Fish. Aquat. Sci* (in press).

Takahashi, M., Tamura, T., Bando, T. and Konishi, K. 2022. Feeding habits of Bryde′s and sei whales in the western North Pacific inferred from stomach contents and skin stable isotope ratios. *Journal of Sea Research* 184: 102204.

Zhu, Y., Mizutani, K., Minami, K., Shirakawa, H., Kawauchi, Y., Shao, H., Tomiyasu, M., Iwahara, Y., Tamura, T., Ogawa, M., Tatsuyama, K. and Miyashita, K. 2022. Target strength measurements of free-swimming sandeel species, *Ammodytes* spp., in a large indoor experimental aquarium. *Journal of Marine Science and Engineering* 10 (7): 966.

Other surveys

1993 (2)

Fujise, Y., Ishikawa, H., Saino, S. and Kawasaki, M. 1993. Catch and struck-and-lost rate in the Japanese Dall′s porpoise hand-harpoon fishery. *Rep. int. Whal. Commn* 43: 453–457.

Taga, Y. 1993. Generalization of HT strategy and its application. *Yokohama Mathematical Journal* 40 (2): 163–173.

1995 (1)

Shimada, H. and Pastene, L.A. 1995. Report of a sightings survey off the Solomon Islands with comments on Bryde′s whale distribution. *Rep. int. Whal. Commn* 45: 413–418.

1997 (4)

Kimura, T., Ozawa, T. and Pastene, L.A. 1997. Sample preparation and analysis of mitochondrial DNA from whale baleen plates. *Marine Mammal Science* 13 (3): 495–498.

Ljungblad, D.K., Stafford, K.M., Shimada, H. and Matsuoka, K. 1997. Sounds attributed to blue whales recorded off the southwest coast of Australia in December 1995. *Rep. int. Whal. Commn* 47: 435–439.

Ohmagari, K. and Berkes, F. 1997. Transmission of indigenous knowledge and bush skills among the Western James Bay Cree Women of Subarctic Canada. *Human Ecology* 25 (2): 197–222.

Shimamura, M., Yasue, H., Ohshima, K., Abe, H., Kato, H., Kishiro, T., Goto, M., Munechika, I. and Okada, N. 1997. Molecular evidence from retroposons that whales form a clade within even-toed ungulates. *Nature* 388: 666–670.

1998 (2)

Miyazaki, N., Fujise, Y. and Iwata, K. 1998. Biological analysis of a mass stranding of melon-headed whales (*Peponocephala electra*) at Aoshima. *Japan. Bull. Natn. Sci. Mus.*, Tokyo, Ser. A 24 (1): 31–60.

Otani, S., Naito, Y., Kawamura, A., Kawasaki, M., Nishiwaki, S. and Kato, A. 1998. Diving behavior and performance of harbor porpoises, *Phocoena phocoena*, in Fukuoka bay, Hokkaido, Japan. *Marine Mammal Science* 14 (2): 209–220.

1999 (5)

Corkeron, P.J., Ensor, P. and Matsuoka, K. 1999. Observations of blue whales feeding in Antarctic waters. *Polar Biol* 22 (3): 213–215.

Iino, Y. 1999. Treaty Implementation: the 1946 International Convention for the Regulation of Whaling. System Compliance in Ocean Management. Southeast Asian Programme in Ocean Law. *Policy and Management*: 189–193.

Pastene, L.A. and Shimada, H. 1999. Report of a sighting survey in Chile′s Exclusive Economic Zone with comments on sei whale distribution. *Anales Instituto Patagonia, Serie Cs. Nat.* 27: 51–62.

Shimamura, M., Abe, H., Nikaido, M., Ohshima, K. and Okada, N. 1999. Genealogy of families of SINEs in cetaceans and artiodactyls: the presence of a huge superfamily of tRNAGlu-derived families of SINEs. *Mol. Biol. Evol.* 16 (8): 1046–1060.

Yoshida, H. and Kato, H. 1999. Phylogenetic relationships of Bryde′s whales in the western North Pacific and adjacent waters inferred from mitochondrial DNA sequences. *Marine Mammal Science* 15 (4): 1269–1286.

2000 (3)

Goto, M. and Ohsumi, S. 2000. Response to ″Scientific Whaling Source of illegal Products for Market″ By Baker *et al. Science* 290: 1695–1696.

Otani, S., Naito, Y., Kato, A. and Kawamura, A. 2000. Diving behavior and swimming speed of a free-ranging harbor porpoise, *Phocoena phocoena. Marine Mam-*

mal Science 16 (4): 811–814.

Takahashi, S., Le, L.T.H., Saeki, H., Nakatani, N., Tanabe, S., Miyazaki, N. and Fujise, Y. 2000. Accumulation of butyltin compounds and total tin in marine mammals. *Water Science and Technology* 42 (7–8): 97–108.

2001 (2)

Abe, H., Goto, M., Pastene, L.A., Dewa, K. and Naito, E. 2001. Practical use of multiplex fluorescent PCR for cetacean sex identification. *Marine Mammal Science* 17 (3): 657–664.

Yoshida, H., Yoshioka, M., Shirakihara, M. and Chow, S. 2001. Population structure of finless porpoises (*Neophocaena phocaenoides*) in coastal waters of Japan based on mitochondrial DNA sequences. *Journal of Mammalogy* 82 (1): 123–130.

2002 (1)

Konishi, K. and Sakurai, Y. 2002. Geographical variations in infection by larval *Anisakis simplex* and *Contracaecum osculatum* (Nematoda, Anisakidae) in walleye pollock *Theragra chalcogramma* stocks off Hokkaido, Japan. *Fish Sci* 68 (3): 534–542.

2003 (1)

Matsuoka, K., Ensor, P., Hakamada, T., Shimada, H., Nishiwaki, S., Kasamatsu, F. and Kato, H. 2003. Overview of the minke whale sighting survey in IWC/IDCR and SOWER cruises from 1978/79 to 2000/01. *J. Cetacean Res. Manage.* 5 (2): 173–201.

2004 (5)

Branch, T.A., Matsuoka, K. and Miyashita, T. 2004. Evidence for increases in Antarctic blue whales based on Bayesian modelling. *Marine Mammal Science* 20 (4): 726–754.

Escorza-Trevino, S., Pastene, L.A. and Dizon, A.E. 2004. Molecular analyses of the Truei and Dalli morphotypes of Dall's porpoise (*Phocoenoides dalli*). *Journal of Mammalogy* 85 (2): 347–355.

Ikemoto, T., Kunito, T., Watanabe, I., Yasunaga, G., Baba, N., Miyazaki, N., Petrov, E.A. and Tanabe, S. 2004. Comparison of trace element accumulation in Baikal seals (*Pusa sibirica*), Caspian seals (*Pusa caspica*) and northern fur seals (*Callorhinus ursinus*). *Environmental Pollution* 127: 83–97.

Murase, H., Matsuoka, K., Nishiwaki, S., Hakamada, T. and Mori, M. 2004. Effect of observed covariates (school size, sighting cue, latitude and sea state) on the Antarctic minke whale abundance estimation parameters in the IWC/IDCR-SOWER surveys. *J. Cetacean Res. Manage.* 6 (3): 283–292.

Yanagimoto, T. and Konishi, K. 2004. *Acanthochondria priacanthi* (Copepoda: Chondracanthidae) as a biological indicator for stock identification of sandfish *Arctoscopus japonicus* (Steindachner). *Fish Sci* 70 (2): 336–338.

2005 (5)

Agusa, T., Matsumoto, T., Ikemoto, T., Anan, Y., Kubota, R., Yasunaga, G., Kunito, T., Tanabe, S., Ogi, H. and Shibata, Y. 2005. Body distribution of trace elements in black-tailed gulls from Rishiri Island, Japan: age-dependent accumulation and transfer to feathers and eggs. *Environ. Toxicol. Chem.* 24 (9): 2107–2120.

Agusa, T., Kunito, T., Yasunaga, G., Iwata, H., Subramanian, A., Ismail, A. and Tanabe, S. 2005. Concentrations of trace elements in marine fish and its risk assessment in Malaysia. *Marine Pollution Bulletin* 51 (8–12): 896–911.

Fukui, Y., Ishikawa, H. and Ohsumi, S. 2005. Difficulties in publishing research results from scientific whaling. *Marine Mammal Science* 21 (4): 781–783.

Prudente, M., Tanabe, S., Kunisue, T., Yasunaga, G., Watanabe, I. and Miyazaki, N. 2005. Accumulation of trace elements and persistent organochlorines in resident and migratory waders from Calatagan Bay, Philippines. *Coastal Marine Science* 29 (2): 133–140.

Sanino, G.P., Waerebeek, K.V., Van Bressem, M. and Pastene, L.A. 2005. A preliminary note on population structure in eastern South Pacific common bottlenose dolphins, *Tursiops truncatus. J. Cetacean Res. Manage.* 7 (1): 65–70.

2006 (6)

Acevedo, J., Aguayo-Lobo, A. and Pastene, L.A. 2006. Filopatria de la ballena jorobada (*Megaptera novaeangliae* Borowski, 1781), al area de alimentacion del Estrecho de Magallanes. *Revista de Biologia Marina y Oceanografia* 41 (1): 11–19.

Acevedo, J., Aguayo-Lobo, A., Acuna, P. and Pastene, L.A. 2006. A note on the first record of the dwarf minke whale (*Balaenoptera acutorostrata*) in Chilean waters. *J. Cetacean Res. Manage.* 8 (3): 293–296.

Hayashi, K., Yoshida, H., Nishida, S., Goto, M., Pastene, L.A., Kanda, N., Baba, H. and Koike, H. 2006. Genetic Variation of the MHC DQB locus in the finless porpoise (*Neophocaena phocaenoides*). *Zoological Science* 23 (2): 147–153.

Mori, M. and Butterworth, D.S. 2006. A first step towards modelling the krill–predator dynamics of the Antarctic ecosystem. *CCAMLR Science* 13: 217–277.

Sekiguchi, K., Olavarria, C., Morse, P., Olson, P., Ensor, P., Matsuoka, K., Pitman, R., Findlay, K. and Gorter, U. 2006. The spectacled porpoise (*Phocoena dioptrica*) in Antarctic waters. *J. Cetacean Res. Manage.* 8 (3): 265–271.

Takahashi, Y., Ohwada, S., Watanabe, K., Ropert-Coudert, Y., Zenitani, R., Naito, Y. and Yamaguchi, T. 2006. Does elastin contribute to the persistence of corpora albicantia in the ovary of the common dolphin (*Delphinus delphis*). *Marine Mammal Science* 22 (4): 819–830.

2007 (2)

Acevedo, J., Rasmussen, K., Felix, F., Castro, C., Llano, M., Secchi, E., Saborio, M.T., Aguayo-Lobo, A., Haase, B., Scheidat, M., Dalla-Rosa, L., Olavarria, C., Fosestell, P., Acuna, P., Kaufman, G. and Pastene, L.A. 2007. Migratory destinations of humpback whales from the Magellan Strait feeding ground, Southeast Pacific. *Marine Mammal Science* 23 (2): 453–463.

Branch, T.A., Stafford, K.M., Palacios, D.M., Allison, C., Bannister, J.L., Burton, C.L.K., Cabrera, E., Carlson, C.A., Galletti Vernazzani, B., Gill, P.C., Hucke-Gaete, R., Jenner, K.C.S., Jenner, Mn. M., Matsuoka, K., Mikhalev, Y.A., Miyashita, T., Morrice, M.G., Nishiwaki, S., Sturrock, V.J., Tormosov, D., Anderson, R.C., Baker, A.N., Best, P.B., Borsa, P., Brownell Jr, R.L., Childerhouse, S., Findlay, K.P., Gerrodette, T., Ilangakoon, A.D., Joergensen, M., Kahn, B., Ljungblad, D.K., Maughan, B., Mccauley, R.D., Mckay, S., Norris, T.F., Oman Whale and Dolphin Research Group, Rankin, S., Samaran, F., Thiele, D., Van Waerebeek, K. and Warneke, R.M. 2007. Past and present distribution, densities and movements of blue whales in the Southern Hemisphere and adjacent waters. *Mammal Rev.* 37 (2): 116–175.

2009 (1)

Nambu, H., Tokutake, K., Ishikawa, H., Ohta, M., Fujita, K. and Yamada, T.K. 2009. Observation of a gray whale, *Eschrichtius robustus*, in Tokyo Bay in 2005. *Japan Cetology* 19: 17–22 (in Japanese).

2010 (3)

Nambu, H., Ishikawa, H. and Yamada, T. 2010. Records of the western gray whale *Eschrichtius robustus*: its distribution and migration. *Japan Cetology* 20: 21–29 (in Japanese).

Pastene, L.A. and Quiroz, D. 2010. An Outline of the History of Whaling in Chile. pp. 73–98. *In*: International Center for Folk Culture Studies (Ed.). *Human Culture from the Perspective of Traditional Maritime Communities, International Symposium Report No. 1*. Kanagawa Shimbun Press, Kanagawa. 199 pp.

Taguchi, M., Ishikawa, H. and Matsuishi, T. 2010. Seasonal distribution of harbour porpoise (*Phocoena phocoena*) in Japanese waters inferred from stranding and bycatch records. *Mammal Study* 35 (2) : 133–138.

2011 (2)

Acevedo, J., Olavarría, C., Plana, J., Aguayo-Lobo, A., Larrea, A. and Pastene, L.A. 2011. Occurrence of dwarf minke whales (*Balaenoptera acutorostrata* subsp.) around the Antarctic Peninsula. *Polar Biol* 34 (2): 313–318.

Acevedo, J., Plana, J., Aguayo-Lobo, A. and Pastene, L.A. 2011. Surface feeding behavior of humpback whales in the Magellan Strait. *Revista de Biologia Marina y Oceanografia*. 46 (3): 483–490.

2013 (4)

Acevedo J., Haro D., Dalla R.L., Aguayo-Lobo A., Hucke-Gaete R., Secchi E., Plana J. and Pastene L.A. 2013. Evidence of spatial structuring of eastern South Pacific humpback whale feeding grounds. *Endang Species Res* 22 (1): 33–38.

Kitamura, S., Matsuishi, T., Yamada, K., Tajima, Y., Ishikawa, H., Tanabe, S., Nakagawa, H., Uni, Y. and Abe, S. 2013. Two genetically distinct stocks in Baird's beaked whale (Cetacea: Ziphiidae). *Marine Mammal Science* 29 (4): 755–766.

Murase, H., Temoai, I., Kirata, T., Finkaso, S., Yasunaga, G. and Pastene, L.A. 2013. A note on cetaceans off Kiribati and Tuvalu from a research cruise in October 2010. *J. Cetacean Res. Manage.* 13 (2): 153–158.

Sugino, T., Yasunaga, G. and Fukuda, M. 2013. Effect of whale meat extract on fatigue induced by physical load and by daily activities in humans. *Jpn. Pharmacol. Ther* 41 (9): 879–893 (in Japanese).

2014 (3)

Pastene, L.A. 2014. Macaya Hermanos y Compania. Notas sobre las actividades de la empresa ballenera de más larga historia en Chile. Colección Mocha Dick pp 255–274.

Quiroz, D. and Pastene, L.A. 2014. Norwegian whaling in Chile in the 20th Century and its influence on Chilean local communities. pp. 61–70. *In*: J.E. Ringstad (Ed.). *Whaling and History IV*. Commander Chr. Christensen's Whaling Museum, part of Vestfoldmuseene IKA, Sandefjord. 192 pp.

Quintela, M., Skaug, H.J., Øien, N., Haug, T., Seliussen, B.B., Solvang, H.K., Pampoulie, C., Kanda, N., Pastene, L.A. and Glover, K.A. 2014. Investigating population genetic structure in a highly mobile marine organism: the minke whale *Balaenoptera acutorostrata acutorostrata* in the North East Atlantic. *PLoS ONE* 9 (9): e108640.

2015 (3)

Funasaka, N., Kirihata, T., Kato, H. and Ohsumi, S. 2015. The first record of a true albino common bottlenose dolphin *Tursiops truncatus* from Japan. *Mammal Study* 40 (1): 19–22.

Pastene, L.A., Acevedo, J., Siciliano, S., Sholl, T.G.C., de Moura, J.F., Ott, P.H. and Aguayo-Lobo, Anelio. 2015. Population genetic structure of the South American Bryde′s whale. *Revista de Biologia Marina y Oceanografia* 50 (3): 453–464.

Sakamoto, M., Itai, T., Yasutake, A., Iwasaki, T., Yasunaga, G., Fujise, Y., Nakamura, M., Murata, K., Chan, H.M., Domingog, J.L. and Marumoto, M. 2015. Mercury speciation and selenium in toothed-whale muscles. *Environmental Research* 143: 55–61.

2017 (3)

Funasaka, N., Kirihata, T., Hosono, M., Kato, K. and Ohsumi, S. 2017. Three Cases of Anomalously White Risso′s Dolphins *Grampus griseus* in Japan. *Mammal Study* 42 (3): 173–178.

Hakamada, T., Matsuoka, K., Murase, H. and Kitakado, T. 2017. Estimation of the abundance of the sei whale *Balaenoptera borealis* in the central and eastern North Pacific in summer using sighting data from 2010 to 2012. *Fish Sci* 83 (6): 887–895.

Malde, K., Seliussen, B.B., Quintela, M., Dahle, G., Besnier, F., Skaug, H.J., Øien, N., Solvang, H.K., Haug, T., Skern-Mauritzen, R., Kanda, N., Pastene, L.A., Jonassen, I. and Glover, K.A. 2017. Whole genome resequencing reveals diagnostic markers for investigating global migration and hybridization between minke whale species. *BMC Genomics* 18: 76.

2019 (1)

Takahashi, M., Kato, H. and Kitakado, T. 2019. Sex prediction by machine learning methods for small sample sizes: a case study of cranial measurements of killer whales (*Orcinus orca*). *Mammalian Science* 59 (1): 67–78 (in Japanese).

2020 (2)

Kawasaki, K., Mikami, M., Goto, M., Shindo, J., Amano, M. and Ishiyama, M. 2020. The evolution of unusually small amelogenin genes in cetaceans; pseudogenization, X–Y gene conversion, and feeding strategy. *Journal of Molecular Evolution* 88 (2): 122–135.

Pastene, L.A., Acevedo, J. and Branch, T.A. 2020. Morphometric analysis of Chilean blue whales and implications for their taxonomy. *Marine Mammal Science* 36 (1): 116–135.

2021 (4)

Diallo, S.T., Sane, A., Nelson, T., Katsumata, T. and Hakamada, T. 2021. Cetaceans off Gabon based on a 2011 sighting survey, with a preliminary density estimate of the humpback whale *Megaptera novaeangliae*. *Cetacean Population Studies* 3: 258–264.

Katsumata, T., Hirose, A., Nakajo, K., Shibata, C., Murata, H., Yamakoshi, T., Nakamura, G. and Kato, H. 2021. Evidence of winter migration of humpback whales to the Hachijo island, Izu Archipelago off the southern coast of Tokyo, Japan. *Cetacean Population Studies* 3: 164–174.

Milmann, L., Taguchi, M., Siciliano, S., Baumgarten, J.E., Oliveira, L.R., Valiati, V.H., Goto, M., Ott, P.H. and Pastene, L.A. 2021. New genetic evidences for distinct populations of the common minke whale (*Balaenoptera acutorostrata*) in the Southern Hemisphere. *Polar Biol* 44 (8): 1575–1589.

Takahashi, M., Nakamura, G. and Kato, H. 2021. Growth-related changes in the cranium of killer whales in the western North Pacific. *Cetacean Population Studies* 3: 175–188.

2022 (5)

Cabrera, A.A., Schall, E., Bérubé, M., Anderwald, P., Bachmann, L., Berrow, S., Best, P.B., Clapham, P.J., Cunha, H.A., Dalla Rosa, L., Dias, C., Findlay, K.P., Haug, T., Heide-Jørgensen, M.P., Hoelzel, R., Kovacs, K.M., Landry, S., Larsen, F., Moreira Lopes, X., Lydersen, C., Mattila, D.K., Oosting, T., Pace III, R.M., Papetti, C., Paspati, A., Pastene, L.A., Prieto, R., Ramp, C., Robbins, J., Sears, R., Secchi, E.R., Silva, M.A., Simon, M., Víkingsson, G., Wiig, Ø., Øien, N. and Palsbøll, P.J. 2022. Strong and lasting impacts of past global warming on baleen whales and their prey. *Global Change Biology* 28 (8): 2657–2677.

Hirose, A., Kodera, R., Uekusa, Y., Katsumata, H., Katsumata, E., Nakamura, G. and Kato, H. 2022. Comparative anatomy of and around the posterior nasofrontal sac of a beluga whale. *Marine Mammal Science* 38 (3): 1272–1285.

Matsuoka, K., Crance, J.L., Taylor, J.K.D., Yoshimura, I., James, A. and An, Y.-R. 2022. North Pacific right whale (*Eubalaena japonica*) sightings in the Gulf of Alaska and the Bering Sea during IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER) surveys. *Marine Mammal Science* 38 (2): 822–834.

Pastene, L.A., Taguchi, M., Lang, A., Goto, M. and Matsuoka, K. 2022. Population genetic structure of North Pacific right whales. *Marine Mammal Science* 38 (3): 1249–1261.

Ponganis, P.J., Fujise, Y. and Miyazaki, N. 2022. Morphology and physiology in some small pelagic cetaceans: is Dall's porpoise a deep diver and a thoroughbred of the sea? *Marine Mammal Science* 38 (4): 1442–1469.