Prey preferences of common minke, Bryde's and sei whales in the western North Pacific

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Ecosystem Approach to Fisheries (EAF)
= a management concept

↑ Management advice

Ecosystem models (EM)
= operating models to evaluate management strategies of EAF

↑ Integration of RSFs

Resource Selection Functions (RSF)
= functions of species interactions
(e.g. prey preference of whales)

↑ Integration of data from multiple sources

Multidisciplinary Ecological Surveys
= input data to RSF

Examples of input data

Oceanographic observation

Net sampling

Hydroacoustics

Whale surveys

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Backgrounds (1)

- Prey preference of whales is one of the key parameters in ecosystem models.

- Stomach contents of whales and biomass of prey species are required to estimate prey preference.

- Few prey preferences of whales have been estimated in other region of the world because it requires extensive multidisciplinary data set.

- This is the first report of prey preferences of minke, Bryde's and sei whales in the offshore region of the western North Pacific.

- This study was conducted as a part of the Japanese Whale Research Program under Special Permit in the western North Pacific phase II (JARPN II).

Backgrounds (2)

- Five leading fisheries research institutes and universities in Japan participate in the large scale research.

 The Institute of Cetacean Research

 National Research Institute of Far Seas Fisheries

 National Research Institute of Fisheries Science

 Hokkaido University

 Tokyo University of Marine Science and Technology

Scale of interests

- Prey preference at <u>meso scale</u> is studied in this study.

- There are three spatiotemporal scales regarding feeding ecology of whales (IWC, 2003).

<u>Macro scale</u>: whales migrate seasonally between feeding and breeding grounds.

<u>Meso scale</u>: whales move over days and weeks in search of preferred local abundance of food.

<u>Micro scale</u>: whales dive and search for food within localised area.

Survey vessels

Whale survey

A research base vessel
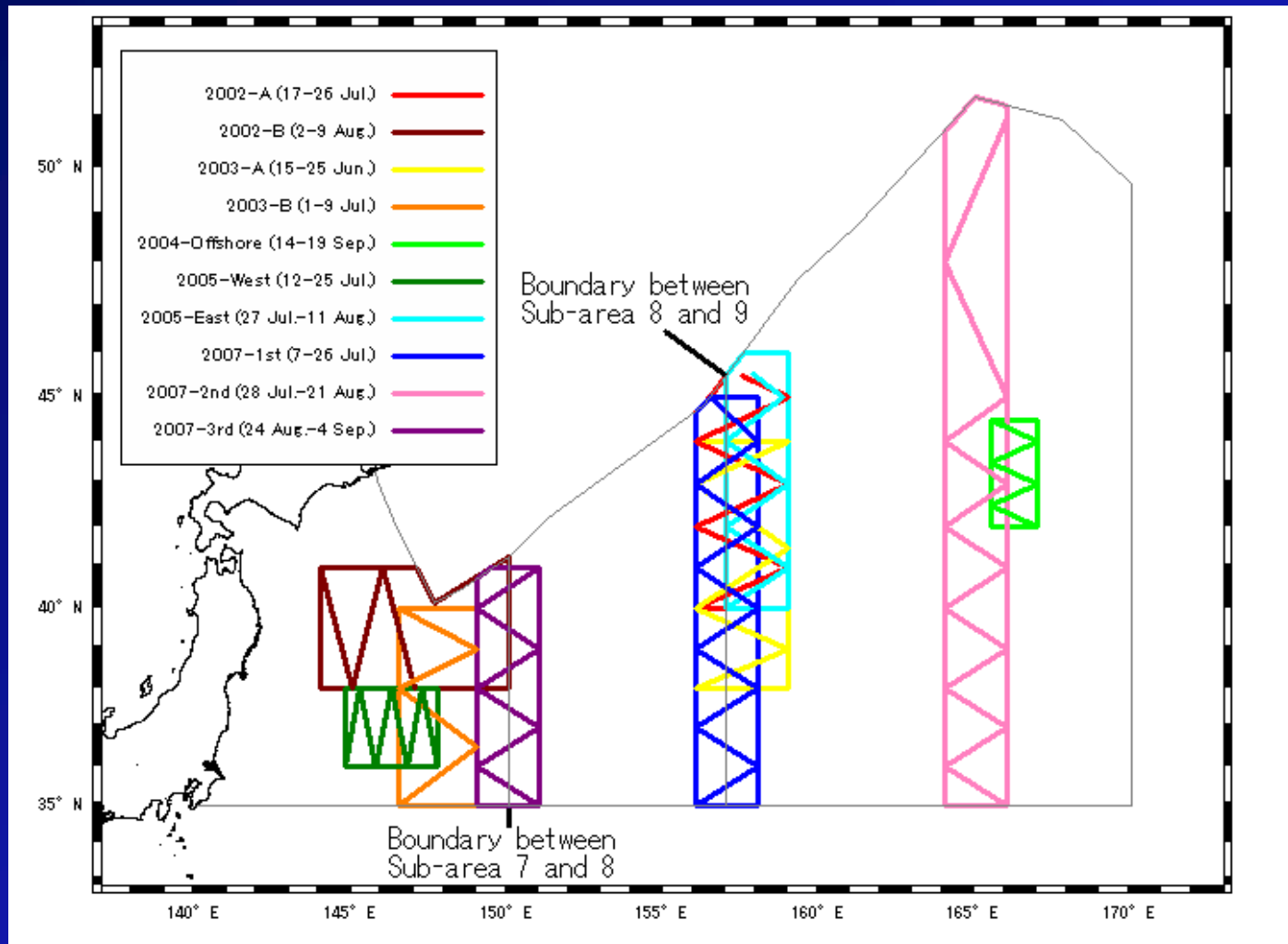(Biological survey)

A sighting
survey vessel

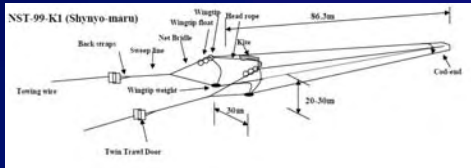
Three Sighting &
sampling survey vessels

Prey survey

A trawler type fisheries
research vessel

Survey area and timing

Prey survey methods

Net sampling

Midwater trawl
(a total of 141 tows)

IKMT
(a total of 30 tows)

MOCNESS
(a total of 24 tows)

NORPAC
(a total of 141 tows)

Echosounder

A total of 12,838 n.mile data recording

CTD

A total of 160 casts

Whale survey methods

Sighting and sampling surveys

Biological surveys

Biological measurement

Sampling of stomach contents

Classification of prey

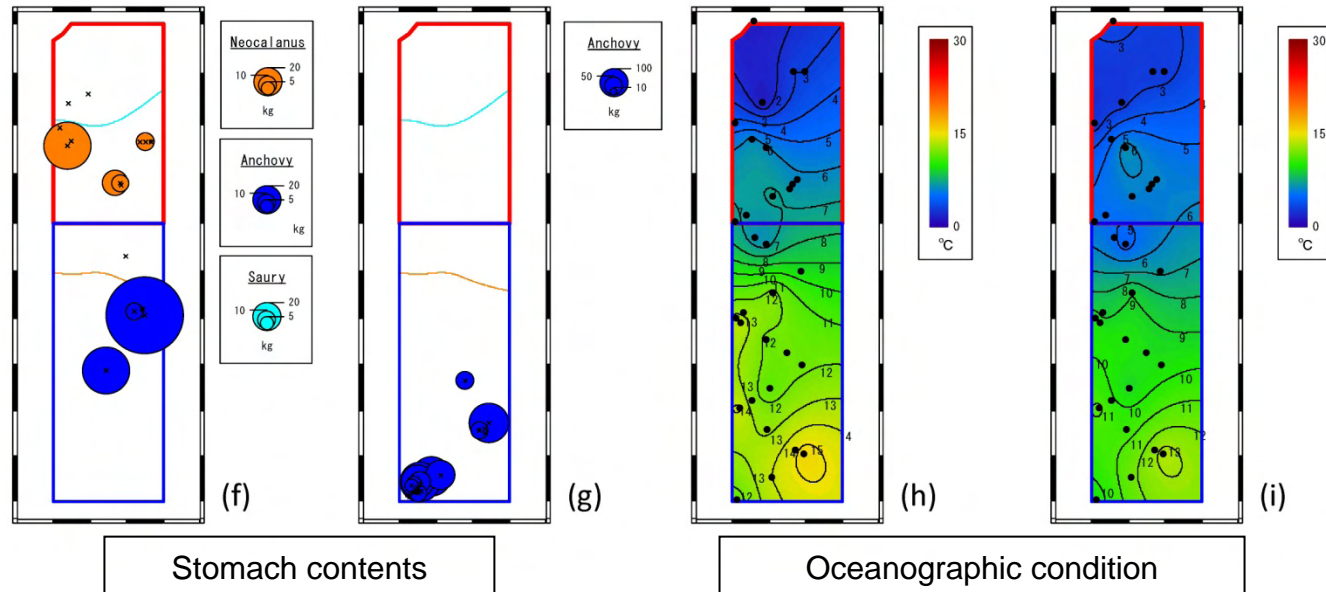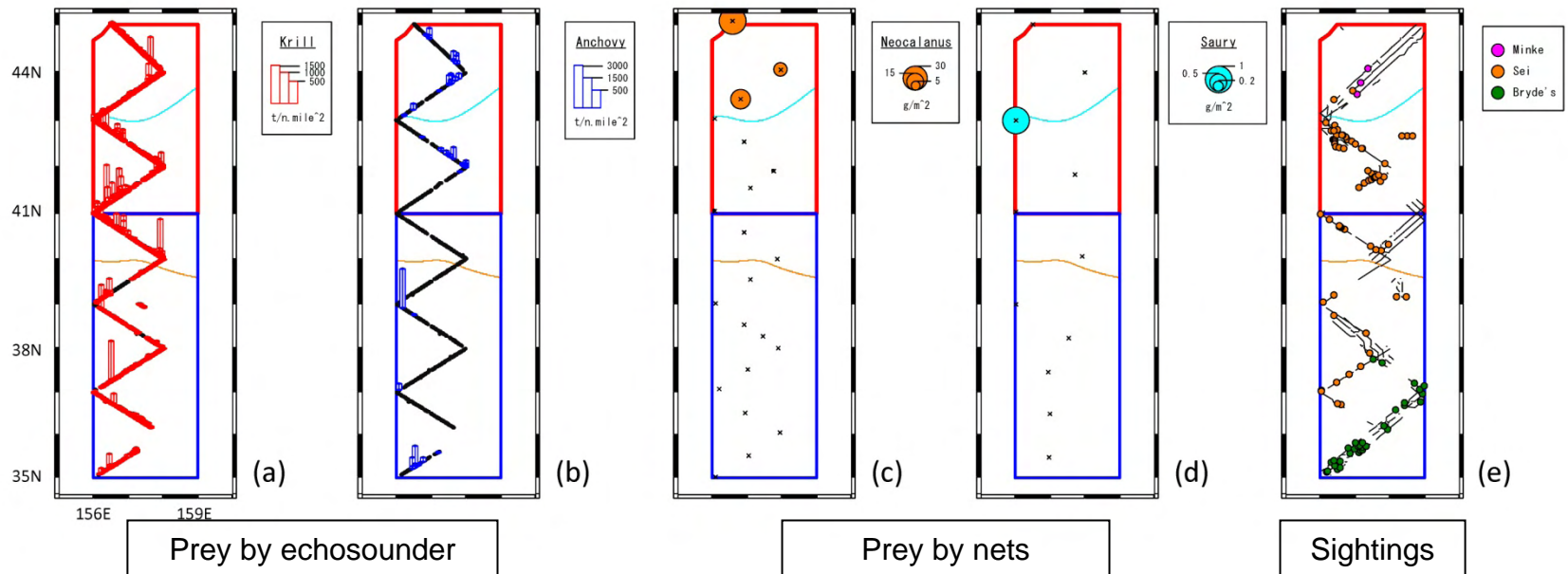## Number of whales examined

Minke whale: 39 ind.

Bryde's whale: 64 ind.

Sei whale: 66 ind.

An example of distribution maps

Prey by echosounder

Prey by nets

Sightings

Stomach contents

Oceanographic condition

Methods of estimation of prey preference (1)

- A prey preference index, Manly's α, was used.

$$\text{Forage ratio } (w_i) = \frac{\text{Proportion of number of whales consuming prey } i}{\text{Proportion of biomass of prey } i \text{ in environment}}$$

*Forage ratio is also called as "Manly's selection index"

$$\text{Manly's } \alpha \, (Bi) = \frac{w_i}{\sum_i wi}$$

*Sum of forage ratio for all prey species is standardized to 1.0 in Manly's α.

*If Manly's α is equal to 1/I, species i is randomly selected. If Manly's α is greater than 1/*I*, species *i* is actively selected. If Manly's α is less than 1/*I*, species i is avoided. *I* is total number of prey species.
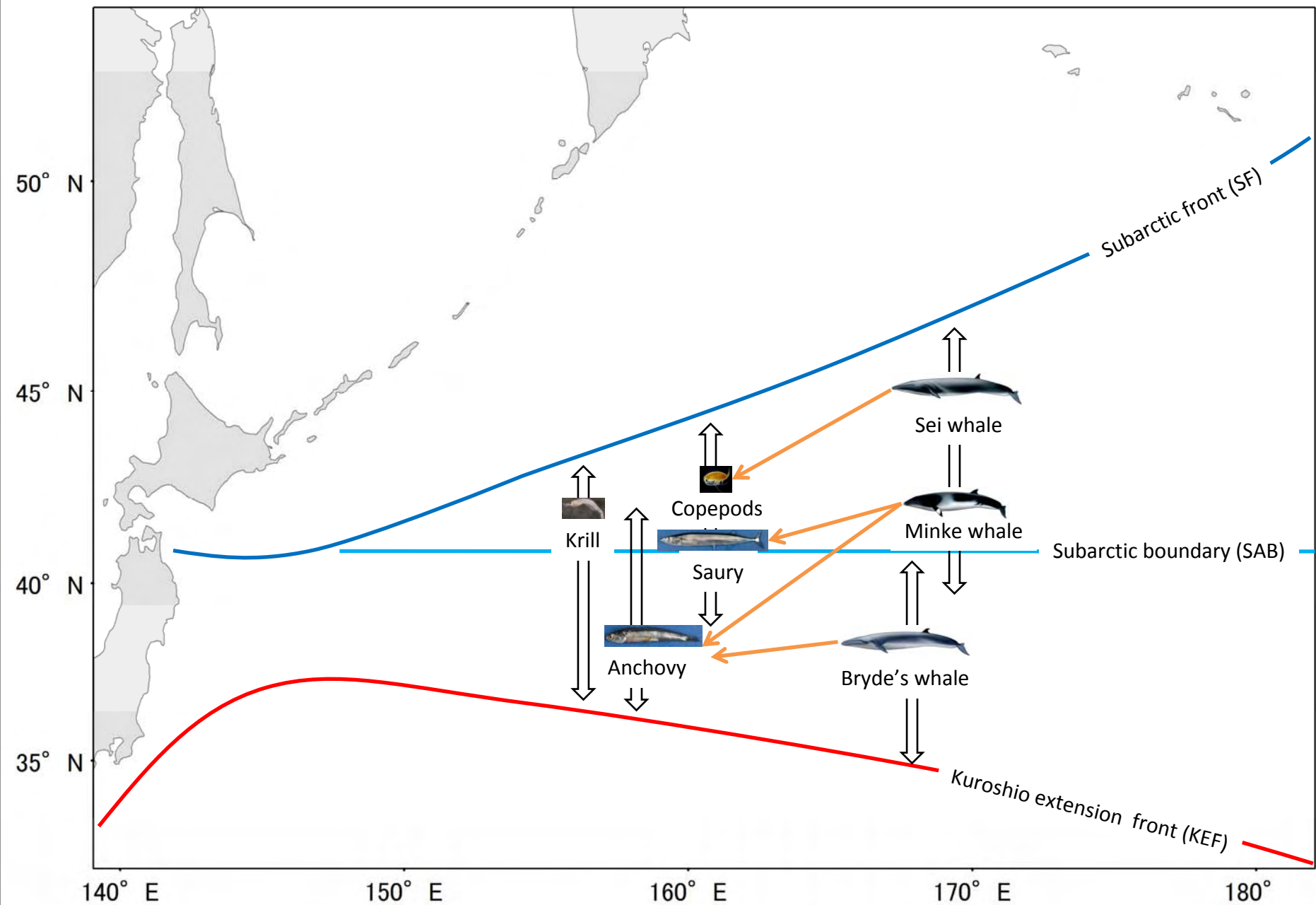
Methods of estimation of prey preference (2)

- Manly's α was calculated for each survey block each year.

- Average values of Manley's α from 2002 to 2007 were calculated.

- To account for the variation in estimation of preference indices, a Monte Carlo simulation technique with 1000 permutations was used.

Average values of Manley's α from 2002 to 2007

Species	Copepods		Krill		Japanese anchovy		Pacific sauey	
	Manly's α	se	Manly's α	se	Manly's α	se	Manly's α	se
Minke whale	-	-	0.05	0.03	0.36	0.19	0.59	0.17
Bryde's whale	-	-	0.05	0.04	0.95	0.04	-	-
Sei whale	0.41	0.10	0.13	0.04	0.25	0.10	0.20	0.08

* If Manly's α is equal to $1/I$, species *i* is randomly selected. If Manly's α is greater than $1/I$, species *i* is actively selected. If Manly's α is less than $1/I$, species *i* is avoided.

Subarctic front (SF)

50° N

45° N

Sei whale

Copepods

Krill

Subarctic boundary (SAB)

Saury

40° N

Anchovy

Minke whale

Bryde's whale

35° N

Kuroshio extension front (KEF)

140° E   150° E   160° E   170° E   180°

Future directions

- Long term ecosystem monitoring program is critically important because both climatic and biological regime shifts have been reported in the North Pacific.

  ←However , nobody knows how whales interact with the regime shifts.

- Long term data collection of prey preference of whales is required to estimate functional responses (relationship between consumption by predator and prey availability).

  ←Even though the functional responses play an important role in ecosystem models, no attempt has been made to estimate them at meso scale using actual data.

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