

Decadal scale changes in the feeding habits of sei whales in the western North Pacific off Japan



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Biology of sei whale



Balaenoptera borealis
length 13-14m weight >30t

Characteristic baleen plates adapted
for feeding copepods

Migrates to subarctic area in spring
for food from low latitude.

Large biomass in the study area

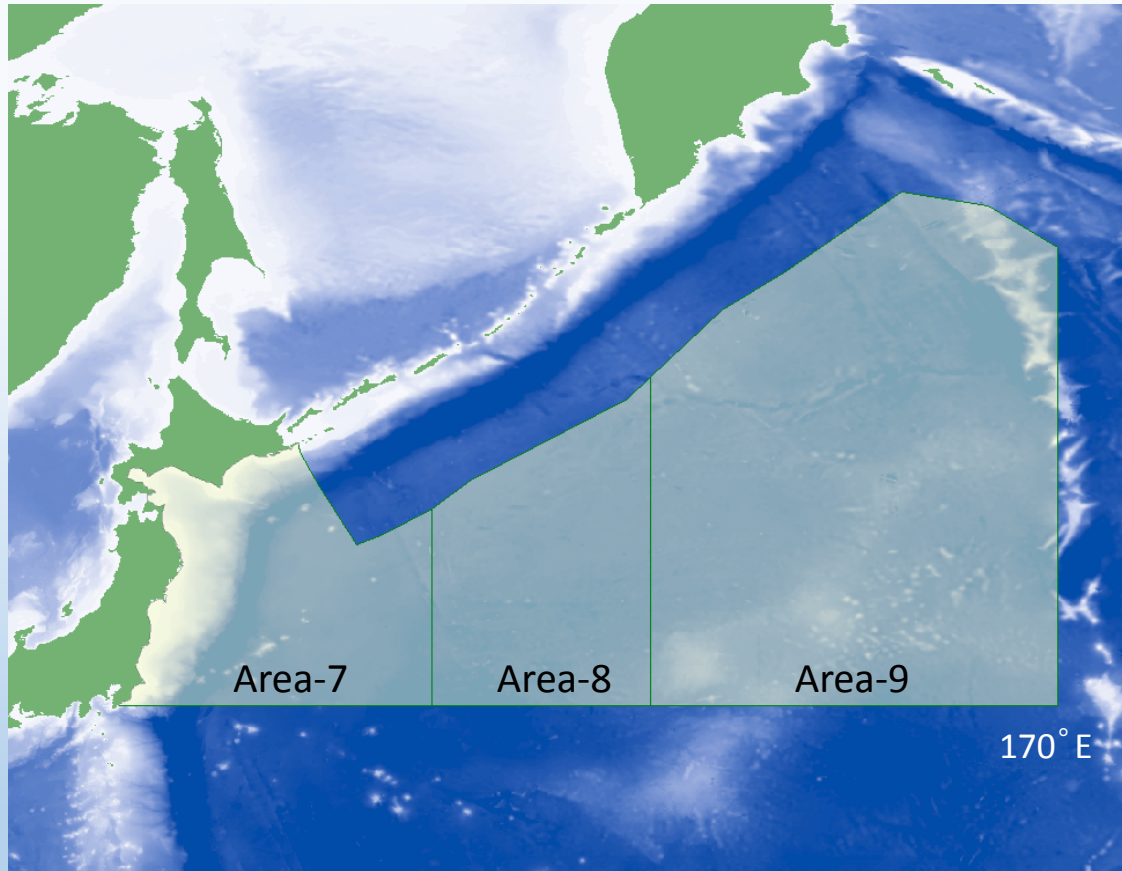


Baleen of sei whale

Second phase of Japanese Whale Research Program under Special Permit (JARPN II)

- Since 2000 and the completion in 2016
- Purpose of JARPN II
 - **1) Feeding ecology and ecosystem studies.** (including consumption estimates)
 - 2) Monitoring environmental pollutants in cetaceans and the marine ecosystem.
 - 3) Stock structure of whales.
- Target species
 - Target species: **sei**, Bryde's, common minke and sperm whales.
 - Sei whale has been sampled since 2002.
- Combination with Sampling, dedicated sighting, trawling and echo sounder surveys

Survey area and method in JARPN II



Abundance of sei whales
5300-7600 ind. in summer season (Hakamada 2009)

Period 2002-2015 May-Oct.



Sighting and
sampling vessel



Research base vessel
Nisshin Maru

Purpose of this study

JARPA II program has shown that...

Pelagic fish such as anchovy carried by Kuroshio-Current are important in the study area.

Anchovy which are commonly found in the stomach from surveys in early 2000s has declined in occurrence in recent surveys.



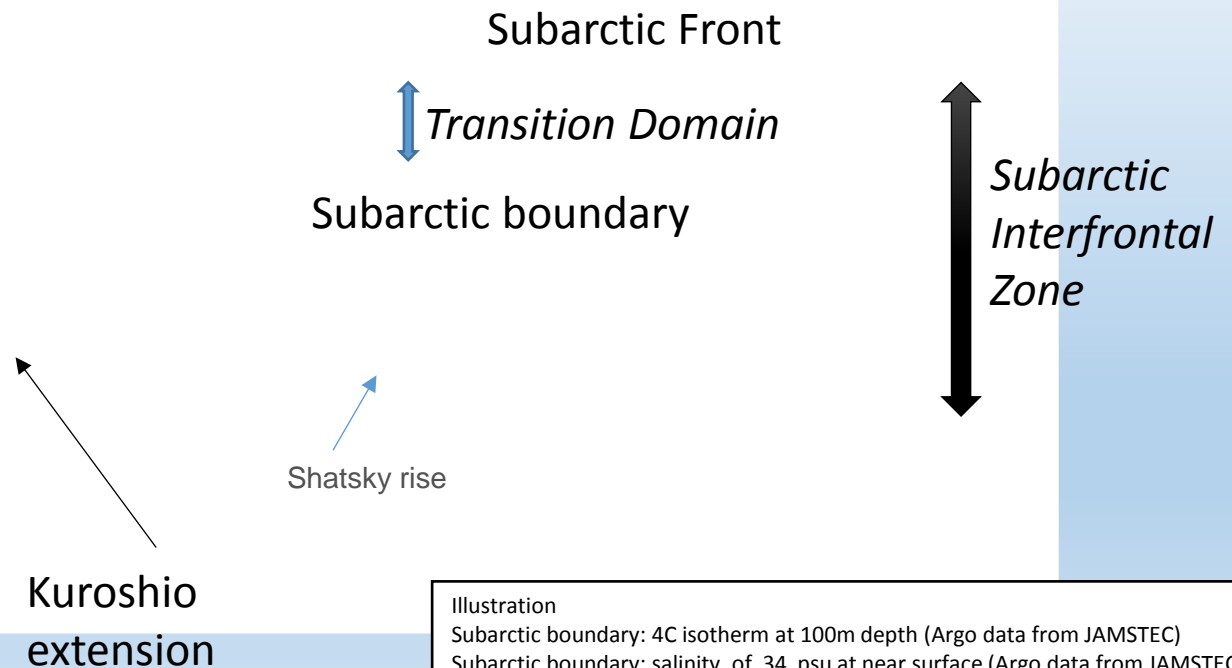
Early 2000s JARPNII

1. General feeding habits of sei whales in the study area.
2. Decadal change in feeding habits of sei whales during 2002-2015.

Study area and oceanographic structure

Example from 2014 JARPAN II cruise

- Sampling positions of sei whales in 2014



Illustration

Subarctic boundary: 4C isotherm at 100m depth (Argo data from JAMSTEC)

Subarctic boundary: salinity of 34 psu at near surface (Argo data from JAMSTEC)

Kuroshio extension: Sea surface height AVISO absolute dynamic topography

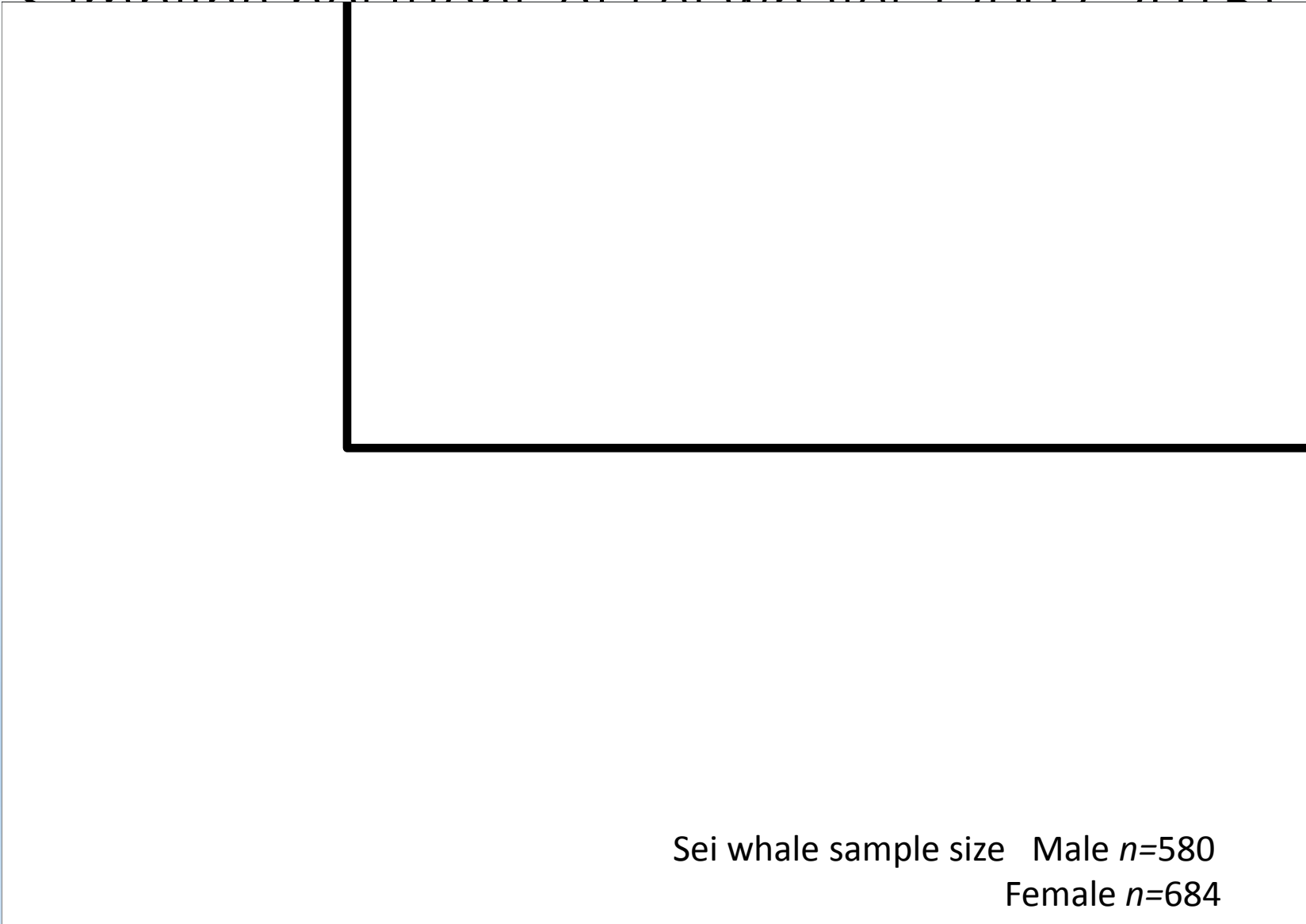
Sampling of stomach contents on board

- Weighing, sampling, identification and measurements of prey species
- Sub samples were stored for later examination



Results

Sampling positions of sei whales (2002-2015)



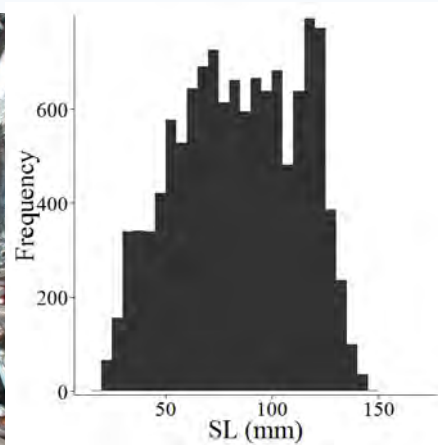
Sei whale sample size Male $n=580$

Female $n=684$

Major prey species (fish)



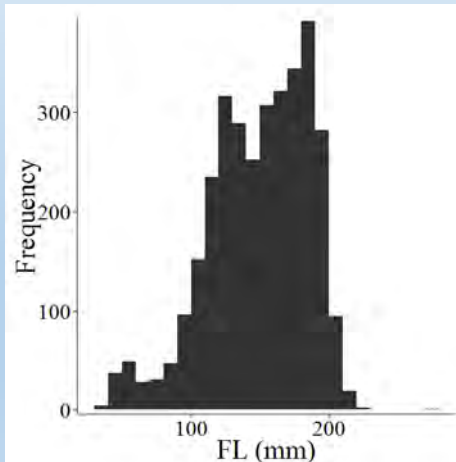
Japanese anchovy (*Engraulis japonicas*)



Japanese sardine (*Sardinops melanostictus*)



Mackerels
(*Scomber japonicus*, *S. australasicus*)



Major prey species (zooplankton)



Copepods

- *Neocalanus cristatus*
- *N. plumchrus*



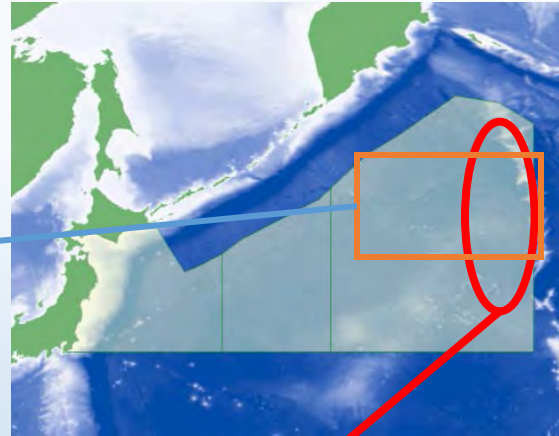
Euphausiids

- *Euphausia pacifica*
- *E. similis*
- *Thysanoessa gregaria*

Minor prey species of sei whale in the western North Pacific



Pacific Saury (*Cololabis saira*)



Minimal armhook squid (*Berryteuthis anonychus*)



Distribution of prey species (fish) from

chovy

ackerels

ean forestomach content
eight per 0.5 degree mesh

Distribution of prey species (sardine) from stomach contents (2014-2015)



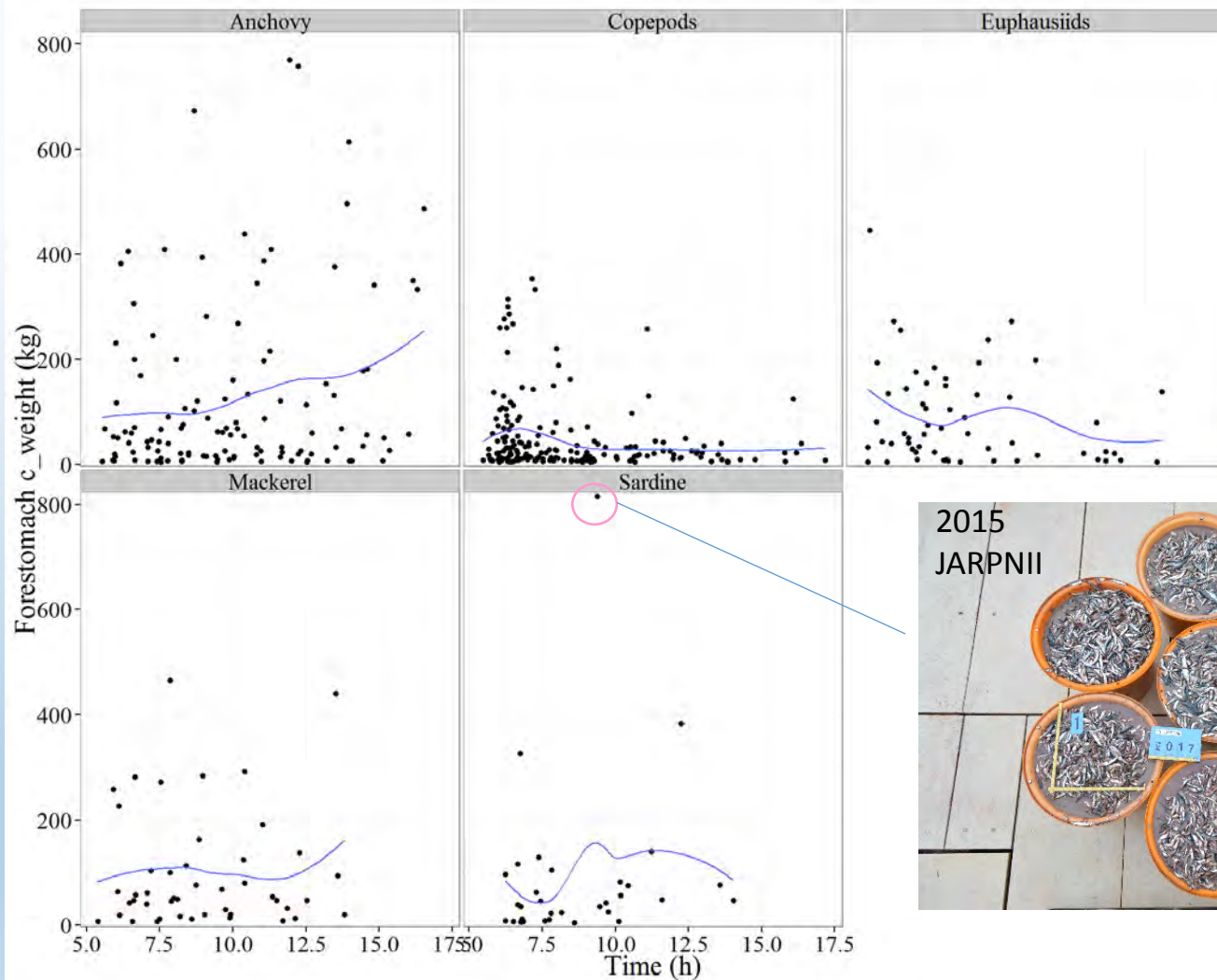
Sardine

Distribution of prey species (zooplankton) from

opepods

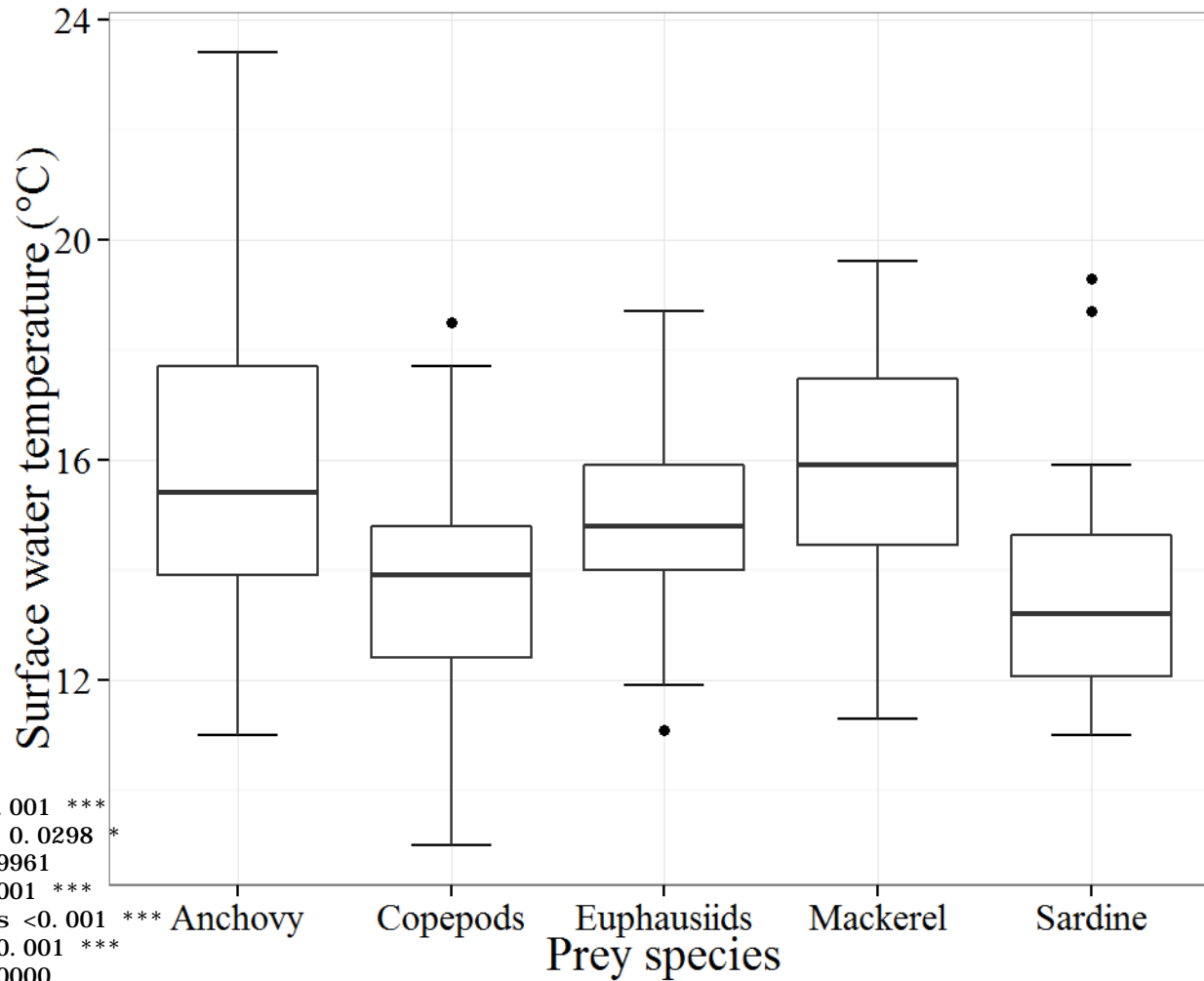
uphausiids

Weight of contents and Daily Feeding Patterns



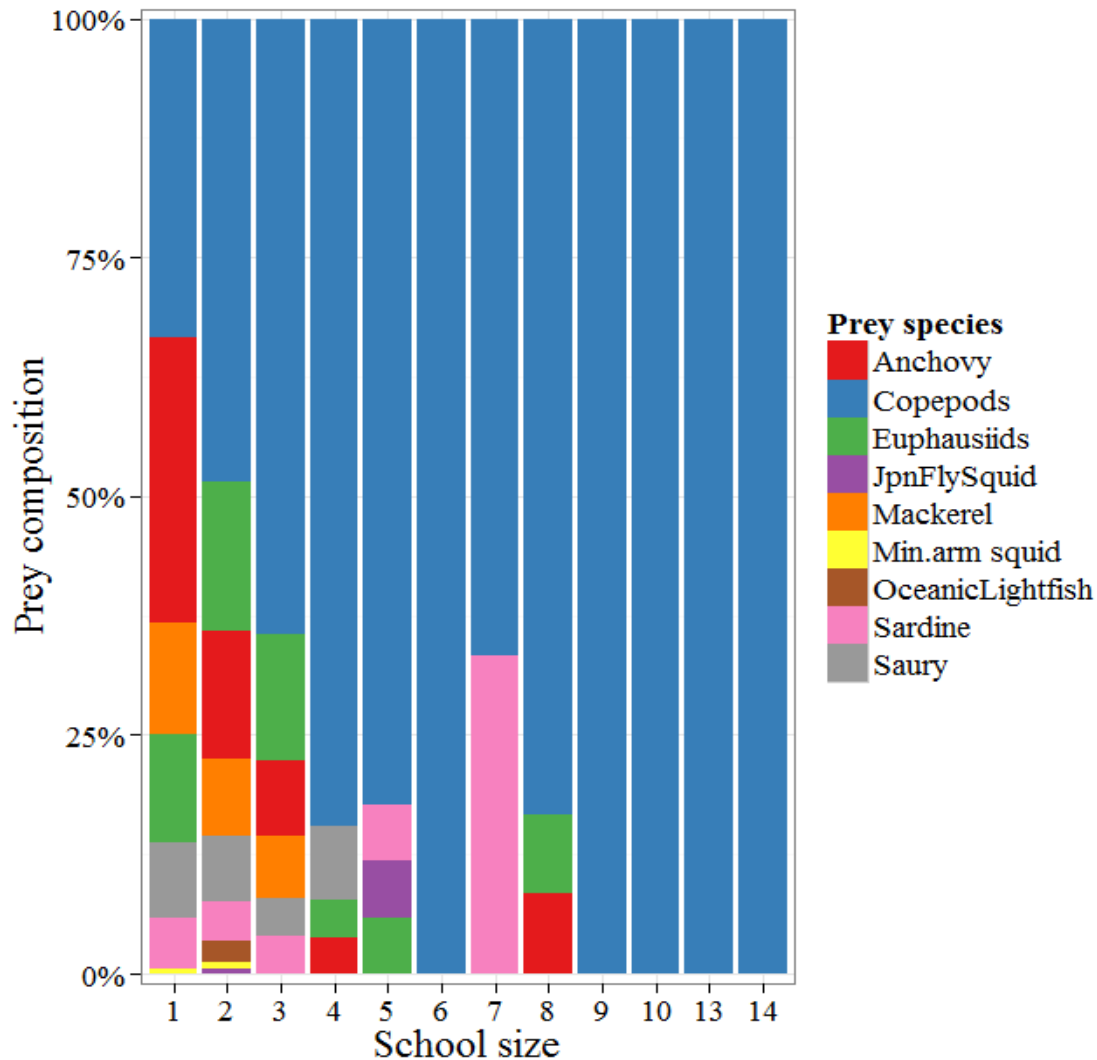
Lines are drawn by Lowess smoothing

Water temperature among prey species



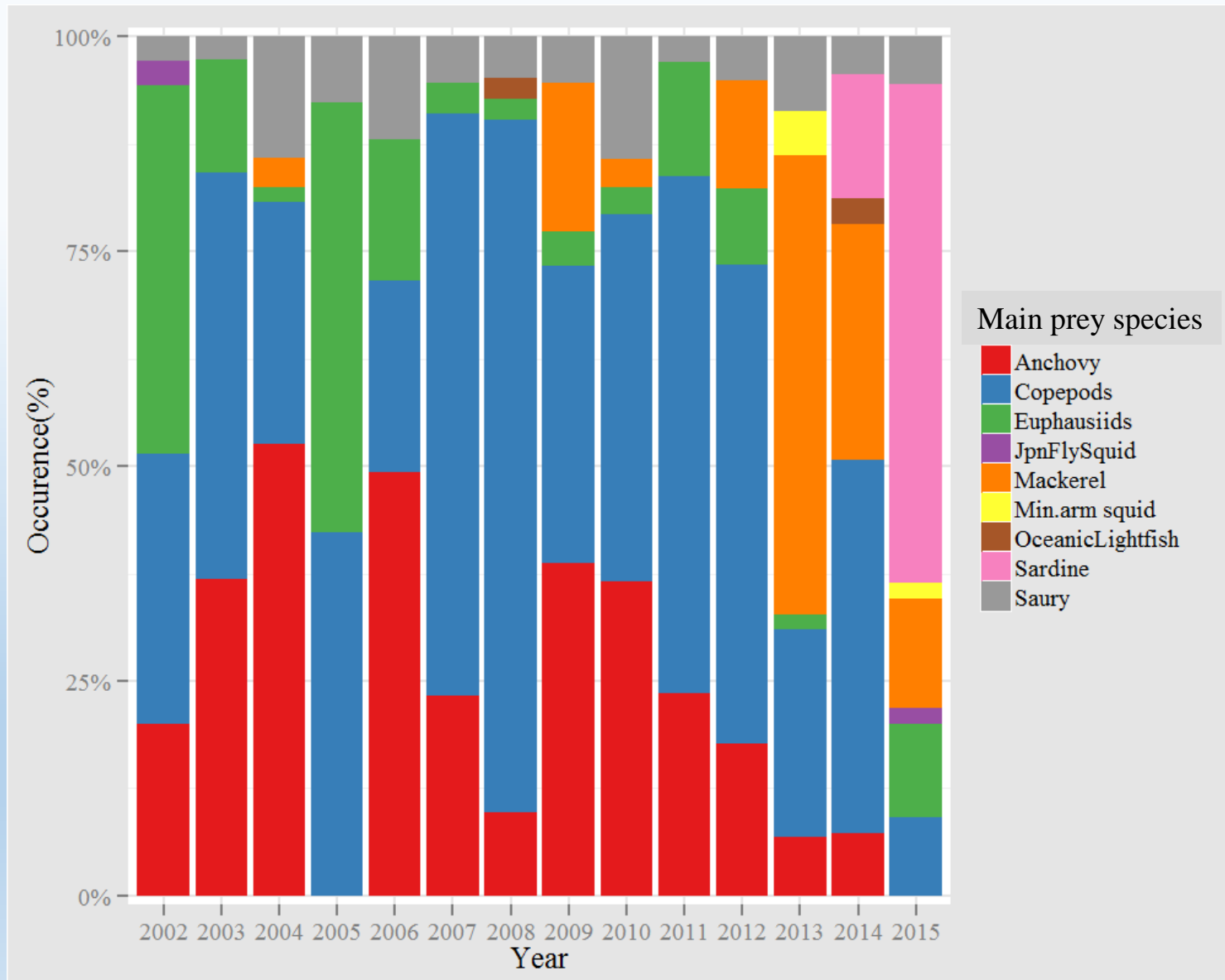
Tukey Contrast test
Copepods - Anchovy <0.001 ***
Euphausiids - Anchovy 0.0298 *
Mackerel - Anchovy 0.9961
Sardine - Anchovy <0.001 ***
Euphausiids - Copepods <0.001 ***
Mackerel - Copepods <0.001 ***
Sardine - Copepods 1.0000
Mackerel - Euphausiids 0.2348
Sardine - Euphausiids 0.0262 *
Sardine - Mackerel <0.001 ***

Prey species and school size



N= 548 173 76 25 17 9 6 12 1 1 1 1

Trend of prey species composition (2002-2015)

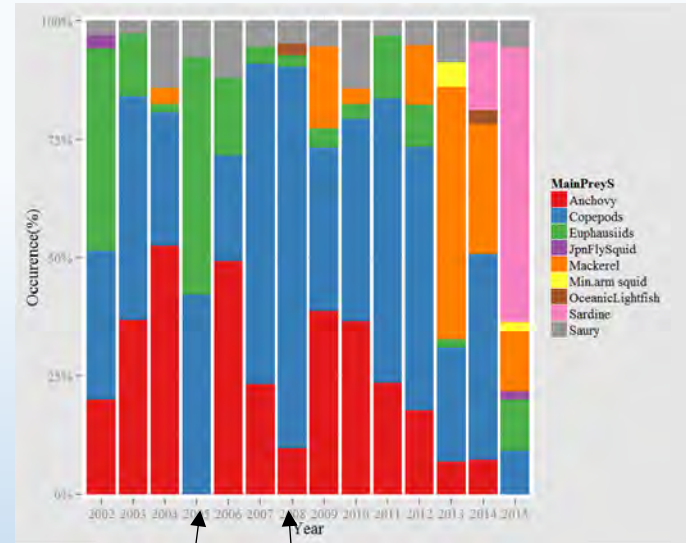
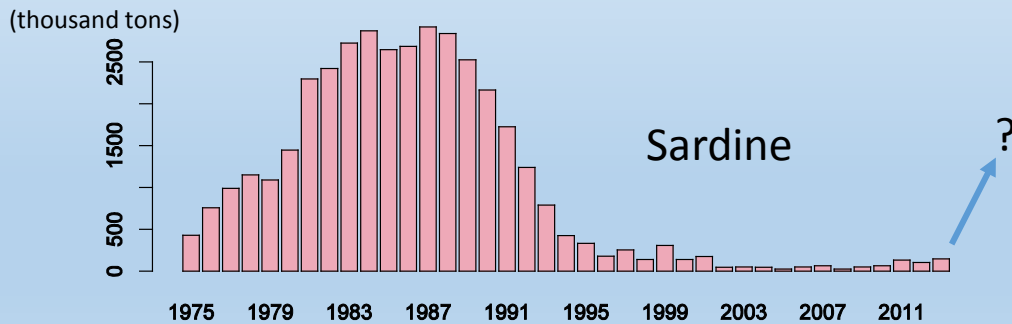
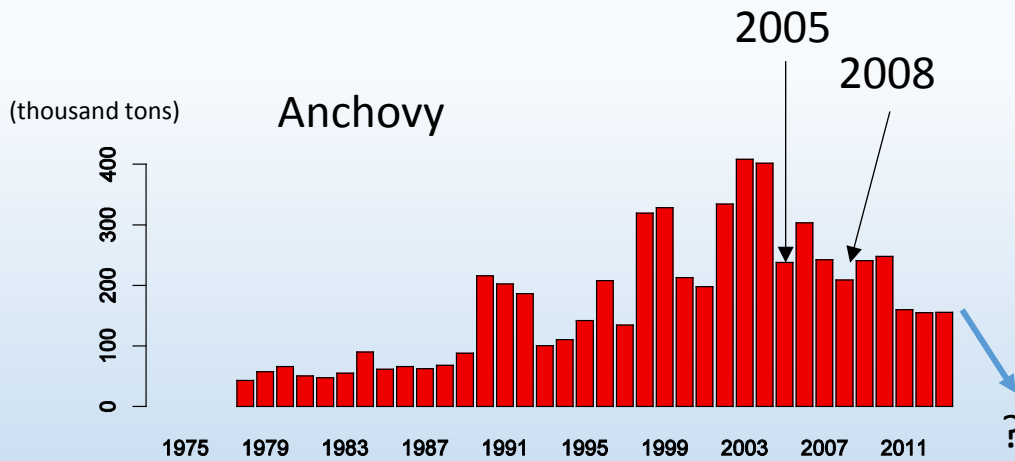


Summary of the results

- Feeding habits of sei whale in the western North Pacific
 - Pelagic fish are suitable prey which can fill the stomach at one time and available through daytime. But the availability differs among years.
 - Copepods are available in broad area every year. But time of feeding is limited to evening to early morning.
 - Euphausiids are mainly fed at longitude between 150°E-160°E.
 - Sea surface temperature where sei whale distribute depend on the prey species.
 - Sei whale changes its school size in relation to the prey species.
- Trend of prey species composition
 - Main fish prey of sei whale in the western North Pacific completely changed from anchovy in early 2000s to mackerels and sardine.

Discussion

Comparison to Japan's fisheries catch statistics



2005 2008
Prey of sei whales (JARPNII)

Catches of pacific stocks of pelagic fishes

Data from Fisheries Agency of Japan and Fisheries Research Agency

Conclusion

- This study illustrated that.....
 - Sei whale flexibly change its prey in relation to the food availability) (opportunistic feeding)
 - In the study area, the pelagic fishes carried by Kuroshio-Current are important prey species (only large amount of prey)
 - Sei whale changes its behavior (where it occurs and school size) in relation to prey species and SST



- **Prey composition trend reflects the trend of prey availability for of sei whale during 2002-2015 in the study area**
- **The distribution of pelagic fish carried by Kuroshio-extension is key to determine the prey composition of sei whale.**



Thank you