



Possible prey of three species of euphausiids in the North Pacific Ocean inferred from DNA metabarcoding

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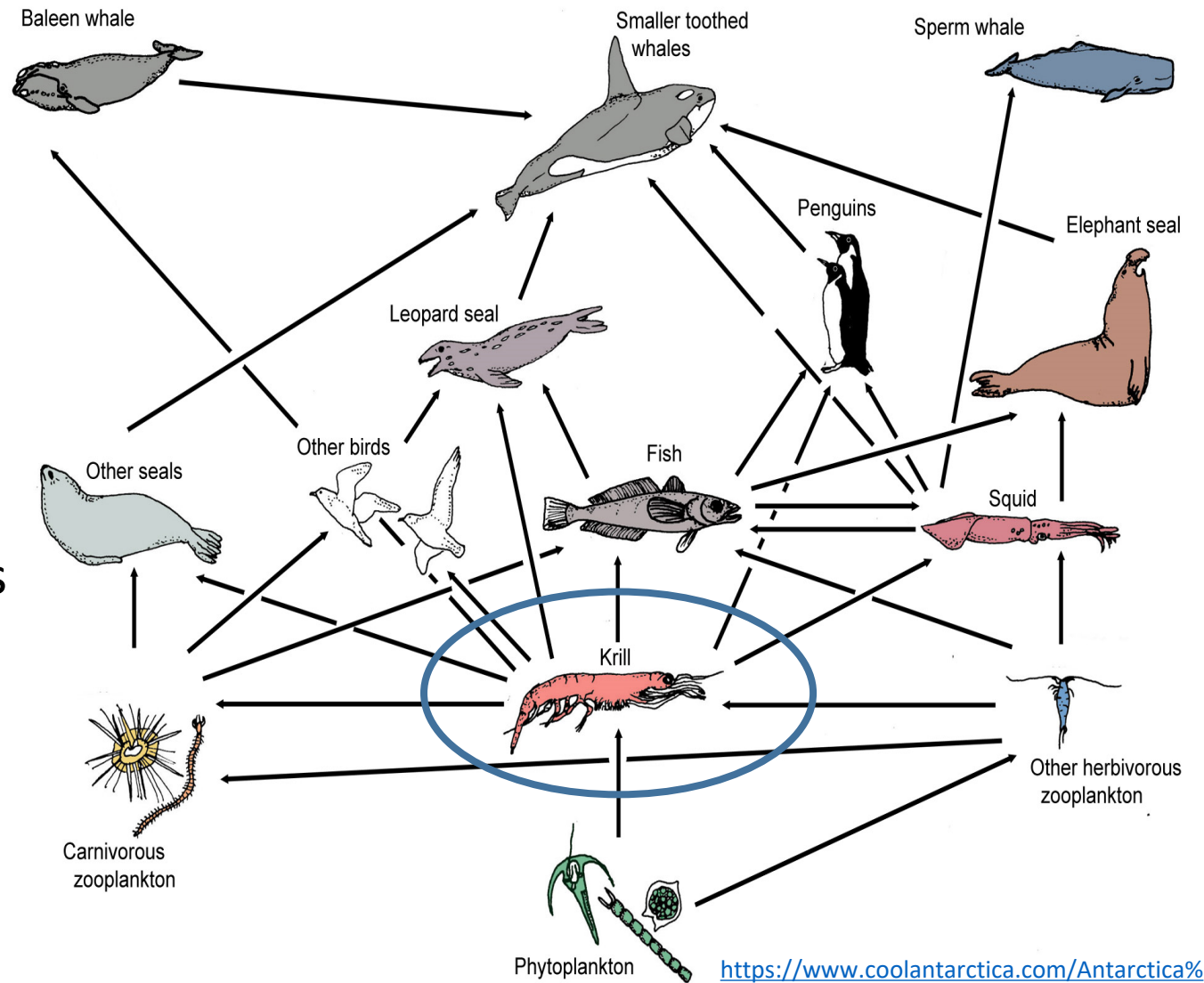
PICES-2019 Manual Meeting

Background: Euphausiids in the ecosystem

Euphausiids:

- ✓ 86 known species, 15 mm-20 mm, mesopelagic/ epipelagic (<500 m)
- ✓ the major fractions of zooplankton biomass
- ✓ filter feeding + raptorial feeding
- ✓ Prey: diatoms/ small zooplankton/ detritus
- ✓ Predator: fish, birds, whales, seals

Linking higher and lower trophic levels



Background: methods of euphausiids feeding habit study



Gut contents microscopy/ stomach fluorescence

Stable isotopes/ fatty acids analysis

LOW taxonomy resolution



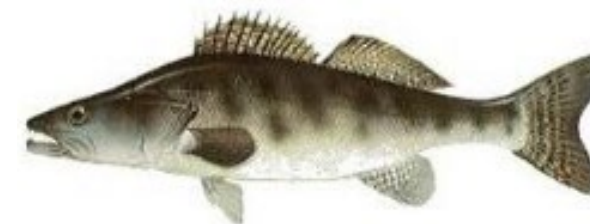
(Yasuto NISHINO et al., 1994)



DNA metabarcoding

recover taxonomic compositions easily;
be capable of detecting traces of DNA

$\delta^{15}\text{N}$



Sampling

- **Euphausiids samples:**

0-500m during the night by MOHT net

Station3: California Current

Station8: Eastern North Pacific subtropical gyre

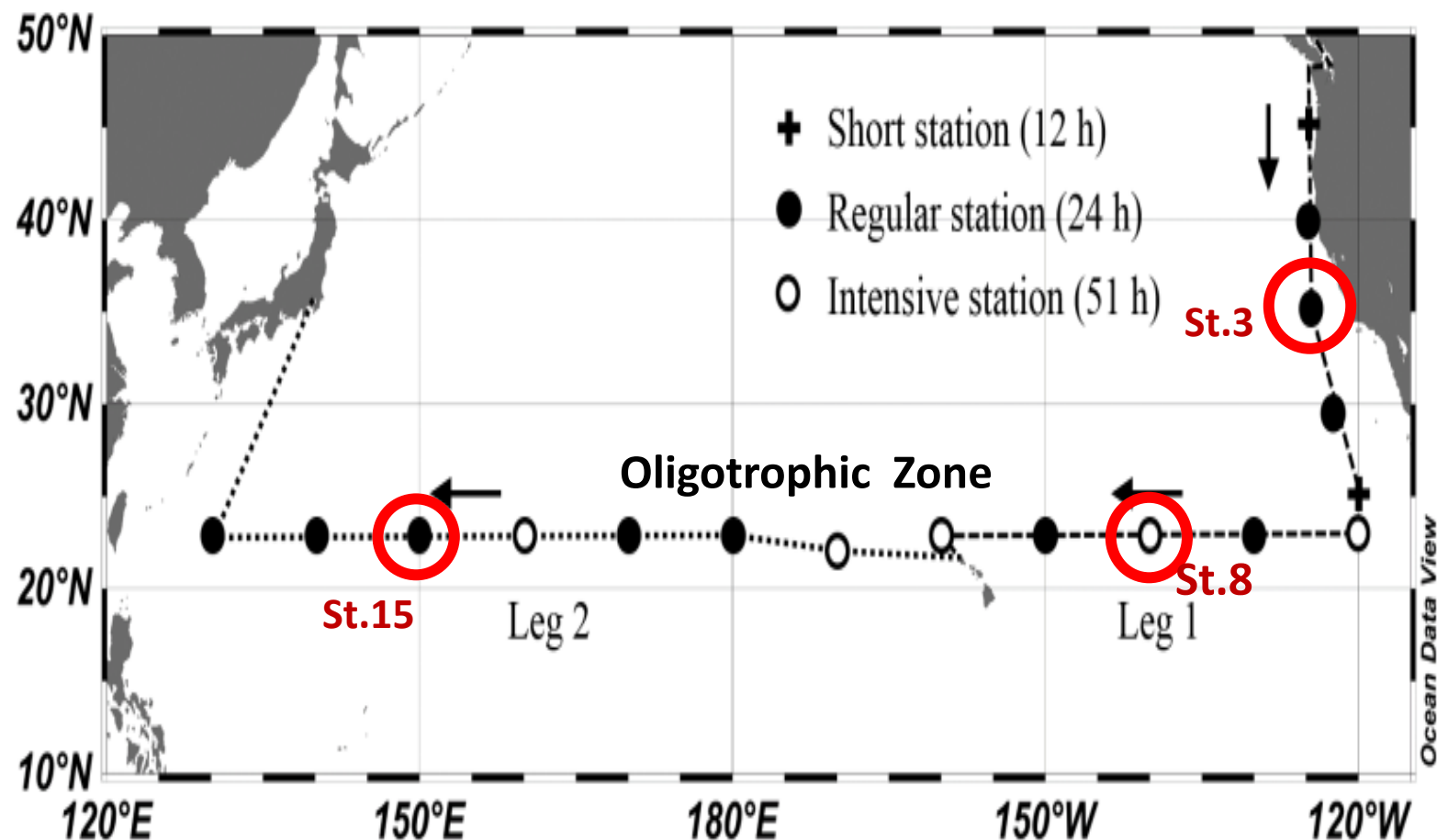
Station15: Western North Pacific subtropical gyre

- **Filtered seawater samples:**

0m, 10m, 100m, 200m, 400m, SCM

- **Ambient zooplankton samples:**

500m-200m-0m by VMPS net



August-October, 2017

Methods:

Find out dominant species in
3 selected stations



18S V9 metagenetic analysis on gut
contents of targeted species and
environmental samples



Bioinformatic analysis:
Quality-filtered sequence reads; OTUs
clustering; BLAST dominant OTUs in NCBI

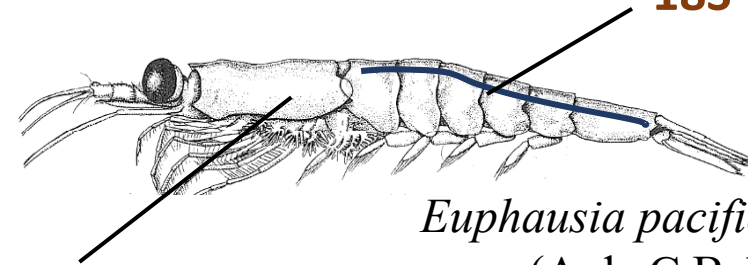
Dominant species:

Station 3: *Euphausia pacifica*

Station 8: *Euphausia brevis*

Station 15: *Euphausia hemigibba*

**Gut content analysis:
18S V9 region**









Euphausia pacifica

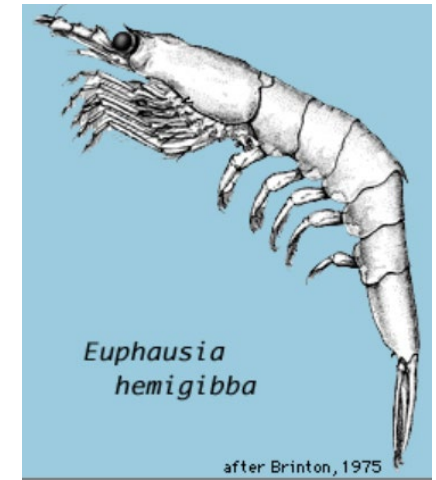
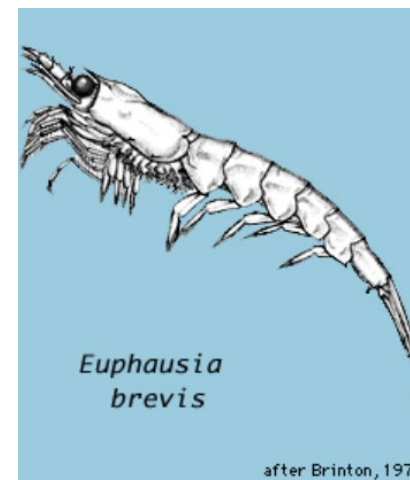
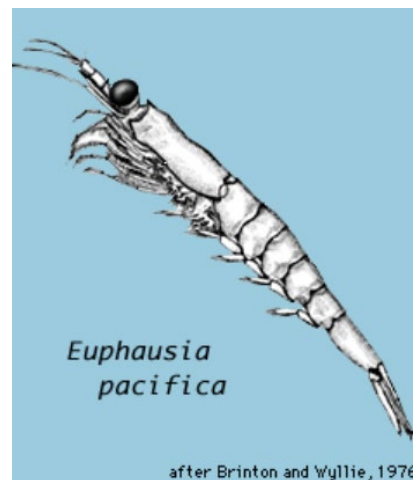
(A.de C.Baker et al., 1975)

**Identification of euphausiid
species**

3 dominant Euphausiids species:

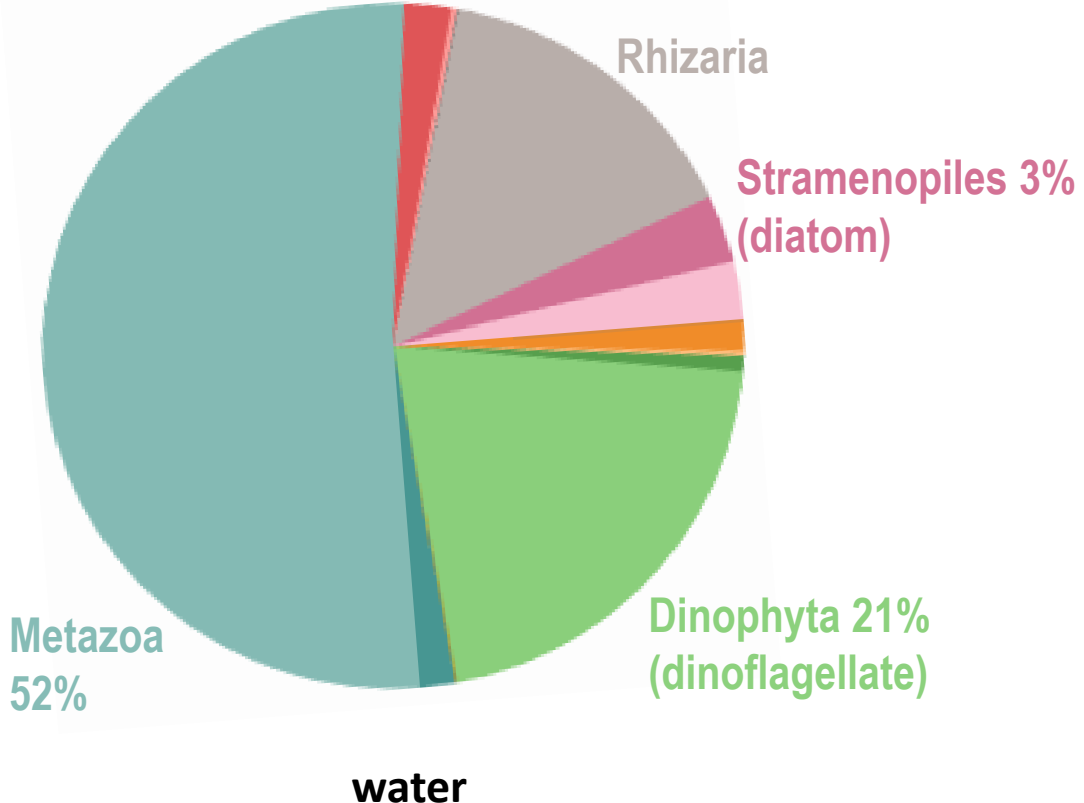
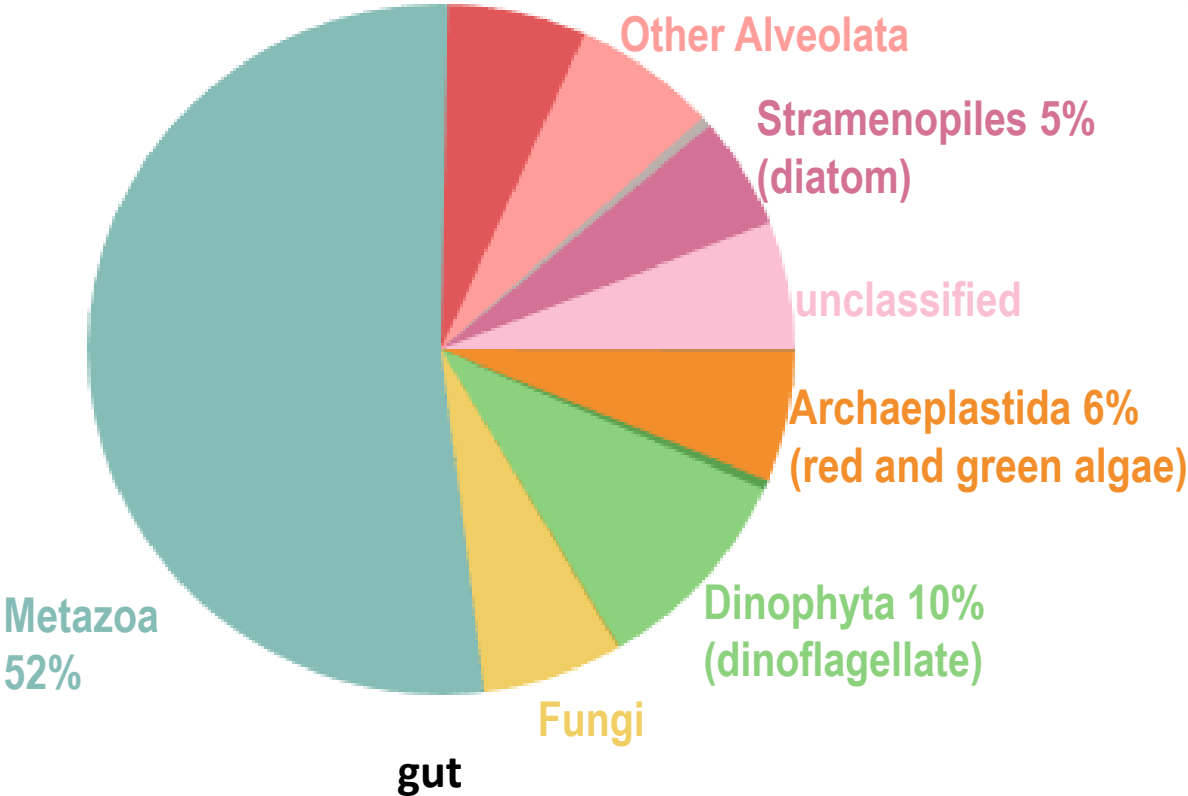
	<i>Euphausia pacifica</i> (California Current)	<i>Euphausia brevis</i> (Eastern subtropical gyre)	<i>Euphausia hemigibba</i> (Western subtropical gyre)
length	11-25 mm	8-10 mm	9-14 mm
vertical distribution	 close to surface  Near 300 m	 <100 m  >300 m	 <100 m  400-550 m
horizontal distribution	principal species in the California Current	subtropical in all ocean basins	subtropical North Pacific

appearance



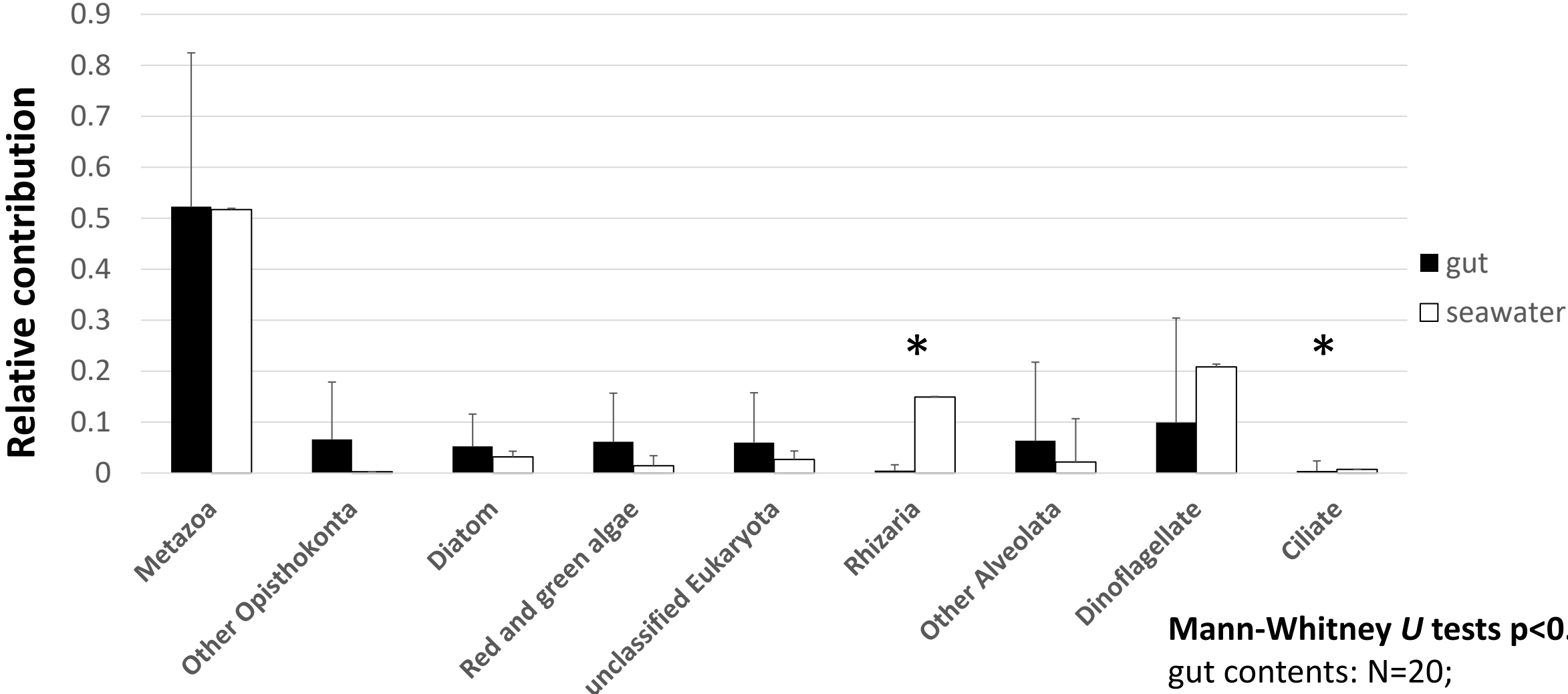
Results: prey of *Euphausia pacifica* (California Current)

In Eukaryota (22,000 sequences, n=20)



**abundant groups :
Metazoa, Dinophyta**

Results: prey of *Euphausia pacifica* (California Current)



Mann-Whitney *U* tests $p < 0.01$
gut contents: N=20;
seawater samples: N=5

Results: prey of *Euphausia pacifica* (California Current)

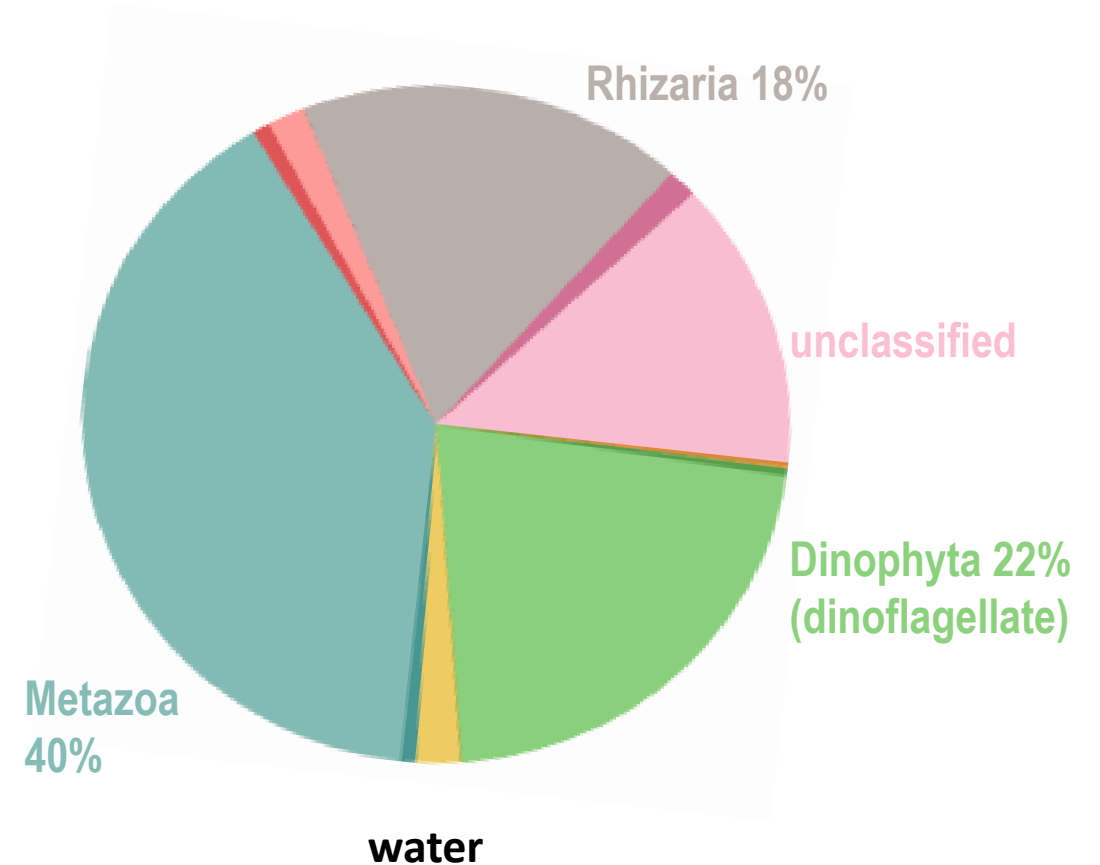
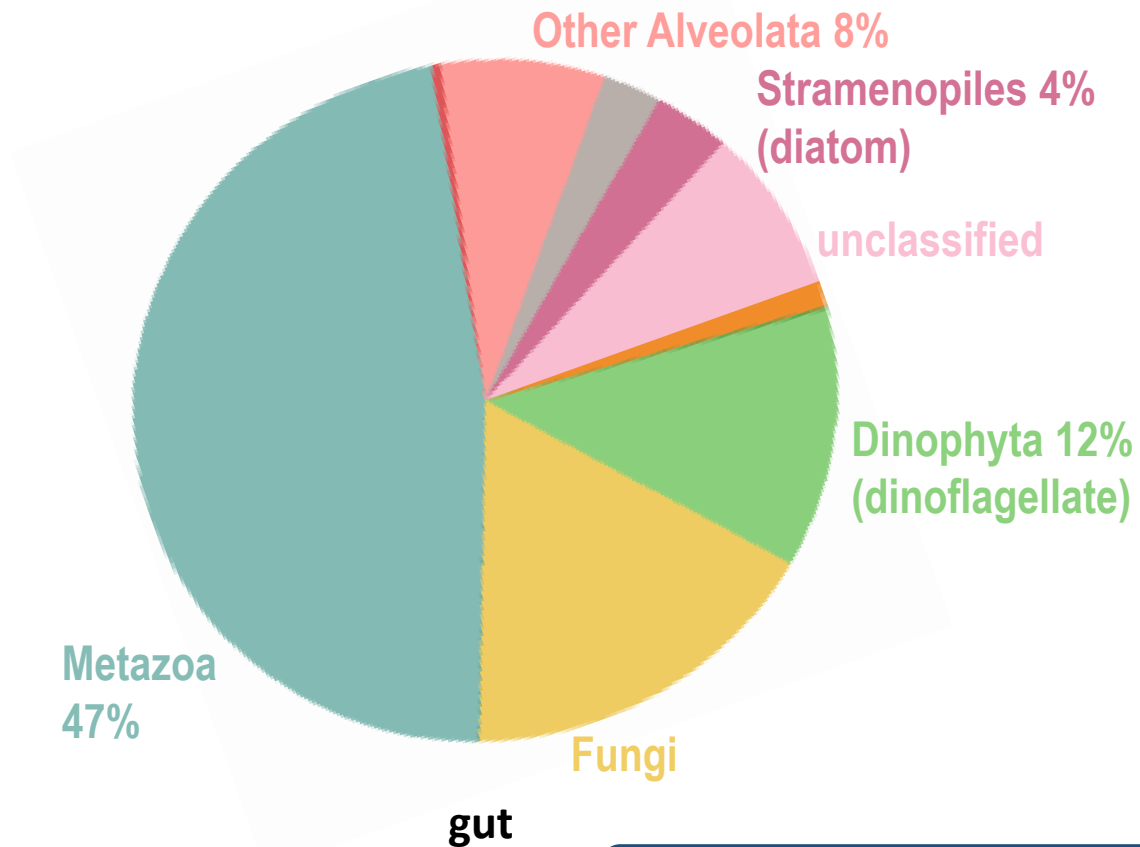
Dominant OTUs in the gut content

average reads(%)	species name	occurrence frequency
8.64	hydrozoa	0.65
2.13	<i>Pyrosomella verticillata</i> (hydrozoa)	0.50
1.48	<i>Sphaeronectes haddocki</i> (hydrozoa)	0.45
1.04	<i>Eucalanus elongatus</i> (Copepoda)	0.40
1.29	<i>Paraeuchaeta gracilis</i> (Copepoda)	0.35
1.98	<i>Pelagomonas calceolata</i> (Stramenopiles)	0.30
1.36	<i>Prasinoderma coloniale</i> (green algae)	0.30
1.17	<i>Cocoid</i> pelagophyte CCMP1395 (dinoflagellate)	0.25

(Excluding unclassified OTUs)

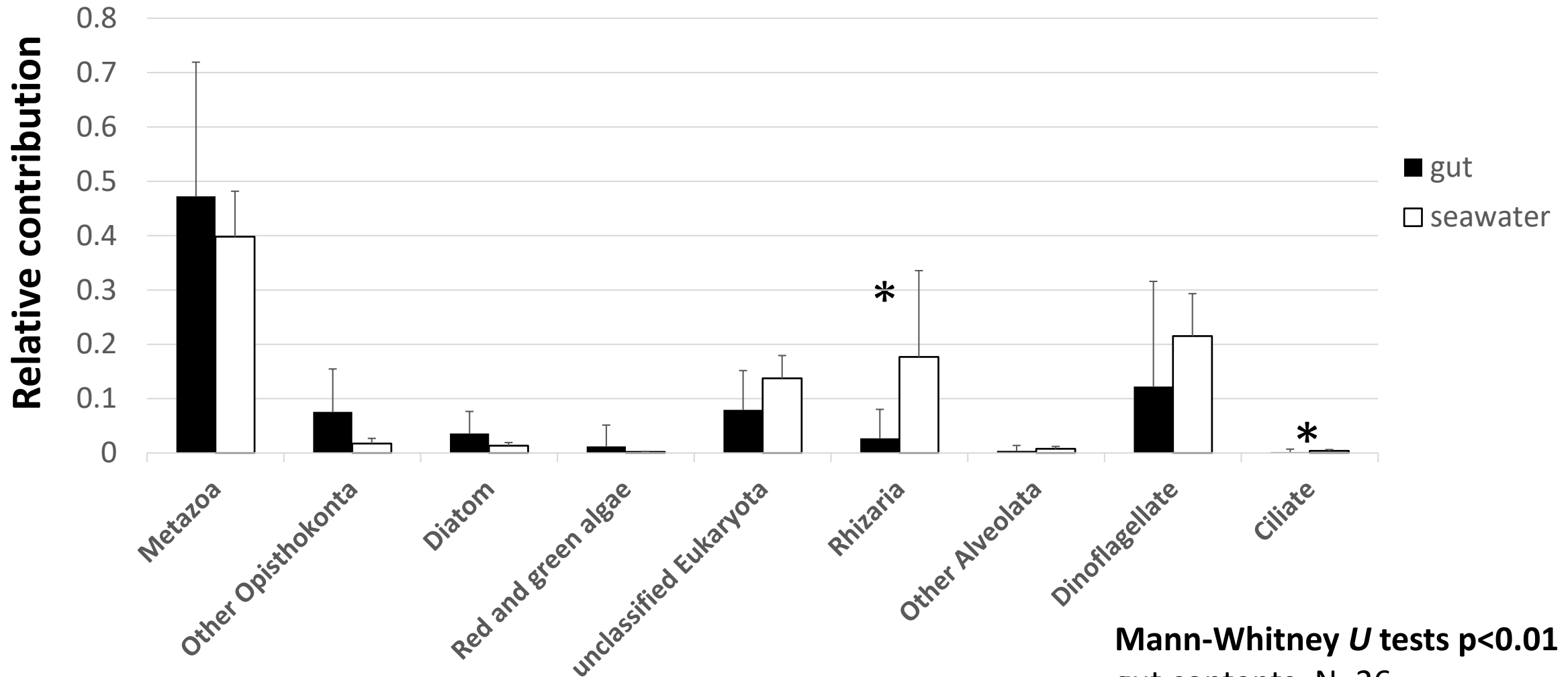
Results: prey of *Euphausia brevis* (Eastern North Pacific subtropical gyre)

In Eukaryota (240,000 sequences, n=26)



abundant groups :
Metazoa, Dinophyta

Results: prey of *Euphausia brevis* (Eastern North Pacific subtropical gyre)



Mann-Whitney *U* tests $p < 0.01$

gut contents: N=26;

seawater samples: N=6

Results: prey of *Euphausia brevis* (Eastern North Pacific subtropical gyre)

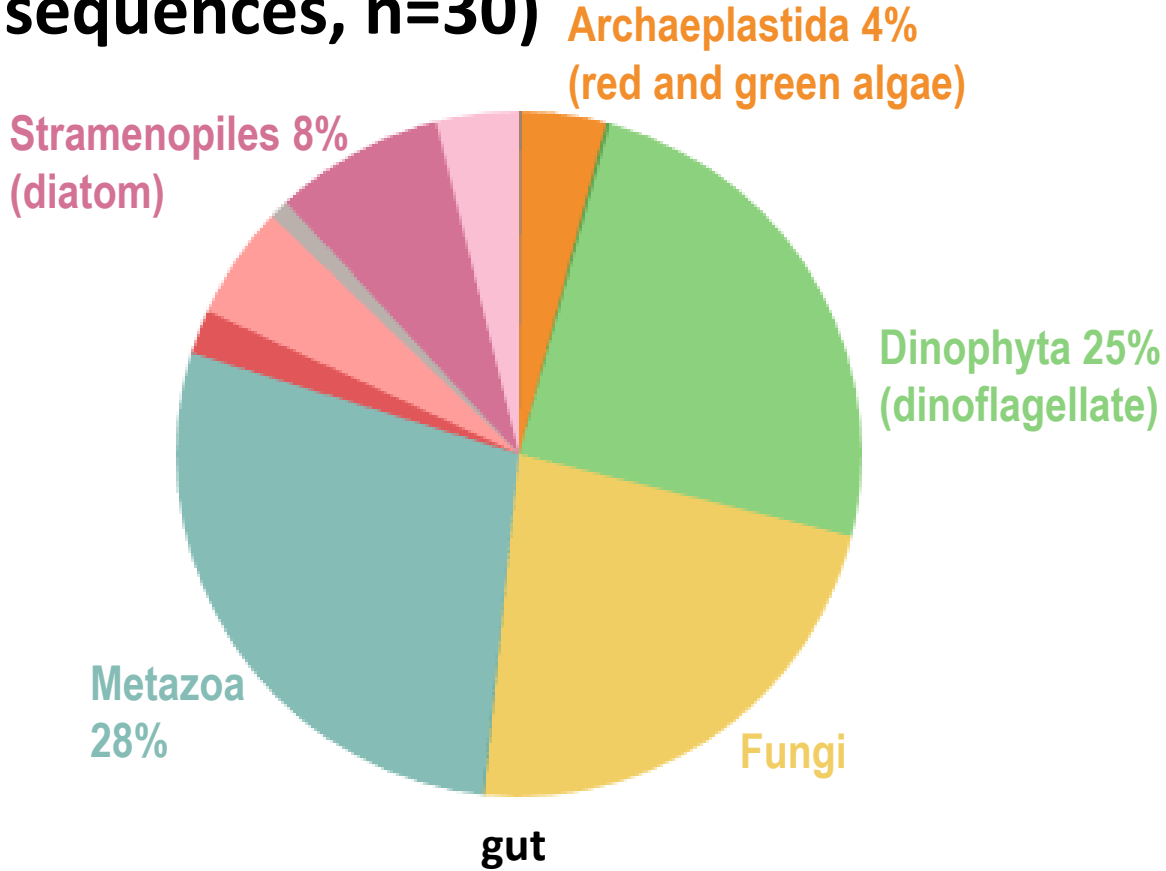
Dominant OTUs in the gut content

average reads(%)	species name	occurrence frequency
15.43	hydrozoa	0.96
1.39	<i>Sphaeronectes haddocki</i> (hydrozoa)	0.92
1.11	<i>Labidocera bataviae</i> (Copepoda)	0.73
4.10	euphausiids	0.62

(Excluding unclassified OTUs)

Results: prey of *Euphausia hemigibba* (Western North Pacific subtropical gyre)

In Eukarota (132,000 sequences, n=30)



abundant groups :
similar percentage of Metazoa and Dinophyta







Results: prey of *Euphausia hemigibba* (Western North Pacific subtropical gyre)

Dominant OTUs in the gut content

average reads(%)	species name	occurrence frequency
4.51	<i>Sphaeronectes haddocki</i> (hydrozoa)	0.97
1.51	<i>Paraeuchaeta gracilis</i> (Copepoda)	0.8
4.21	<i>Gymnoxanthea radiolariae</i> (dinoflagellate)	0.47
1.22	<i>Gymnodinium sp</i> (dinoflagellate)	0.33
3.11	<i>Scrippsiella sp.</i> (dinoflagellate)	0.17
1.89	<i>Prorocentrum mexicanum</i> (dinoflagellate)	0.17
1.45	<i>Pyrocystis sp.</i> (dinoflagellate)	0.13

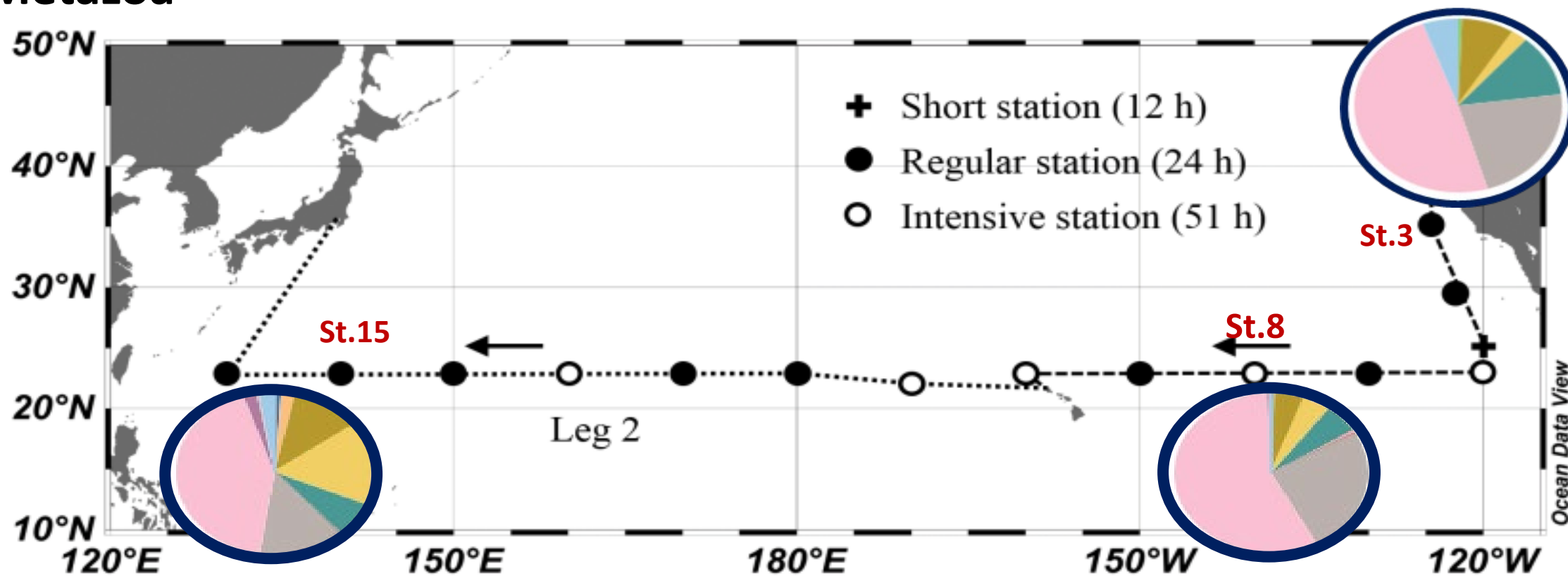
(Excluding unclassified OTUs)

3 dominant Euphausiids species:

	<i>Euphausia pacifica</i> (California Current)	<i>Euphausia brevis</i> (East subtropical gyre)	<i>Euphausia hemigibba</i> (West subtropical gyre)
length	11-25 mm	8-10 mm	9-14 mm
vertical distribution	 close to surface  Near 300 m	 <100 m  >300 m	 <100 m  400-550 m
horizontal distribution	principal species in the California Current	subtropical in all ocean basins	subtropical North Pacific
main prey	hydrozoa, copepoda, diatoms	hydrozoa, copepoda	hydrozoa, Dinoflagellates, copepoda

Discussion

In Metazoa



Large amount of unclassified : potential unknown predator-prey relationship

- Metazoa_unclassified
- Copepoda
- Hydrozoa
- Craniata(fish)

Discussion

- **High percentage of hydrozoa: cod-end feeding?**
 - short sampling time;
 - additional stable isotope analysis
- **Fungi sequences: prey or parasite?**

Summary

3 target euphausiid species:

- ✓ Omnivorous feeding habit
- ✓ Common taxa: Hydrozoa, Dinophyta and Copepoda
- ✓ Feeding avoidance: Rhizaria and Ciliates (*E.pacifica*, *E.brevis*)
- ✓ Multiple feeding mode
 - cells <50 μm : suspension (filter) feeding ✓
 - cells >50 μm / zooplankton: raptorial feeding



Thank you for watching!



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