Abundance, metabolism and body composition of the euphausiid *Euphausia pacifica* and *Thysanoessa inspinata* during spring phytoplankton bloom in the Oyashio region

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Introduction

- Spring phytoplankton bloom has been documented as a key mechanism to drive biological processes in high latitude seas.
- Euphausiids are one of keystone species in the high latitude seas.
- In the Oyashio region:
  - *Euphausia pacifica* is the most dominant euphausiids, followed by *Thysanoessa inspinata*.
  - Euphausiids are important prey of both pelagic and ground fishes.
- *E. pacifica* is the target species of krill fishery off northeastern Japan.

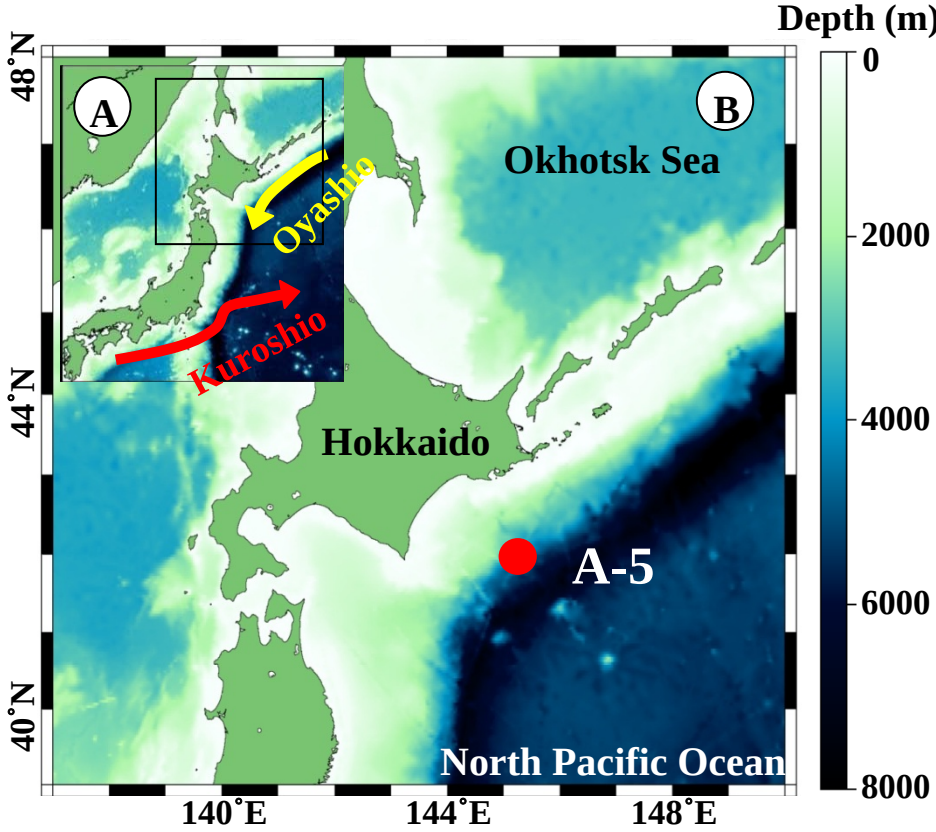
The aim of this study

- Evaluation of temporal features of euphausiids during spring phytoplankton bloom in the Oyashio region, such as
  - Abundance
  - Population structure
  - Metabolism
  - Body composition

Materials and methods

Field sampling

- A5 (42˚00’ N, 145 ˚15’ E)
- 8-14 Mar. 2007 (Oshoro-Maru)
- 5 Apr.-1 May 2007 (Hakuho-Maru)
- Bongo nets
  (mouth diameter 75 cm, mesh 500 μm)
- 200 m depth-surface; oblique tow
- Fresh and preserved samples



Materials and methods

Environmental parameters

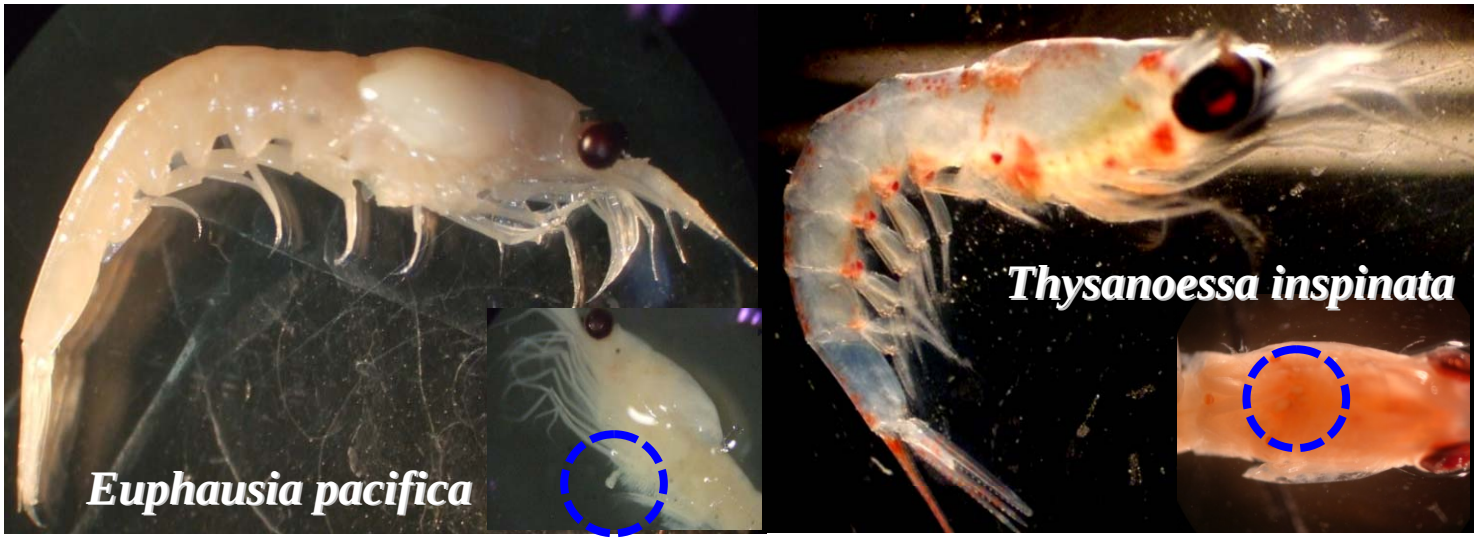
- CTD (Sea-bird):
  Temperature, Salinity and Chlorophyll *a* pigment

On board treatments

- Metabolism:
  Oxygen consumption rate
  Ammonia excretion rate
- Body composition:
  Water contents
  Carbon and Nitrogen contents
  Ash

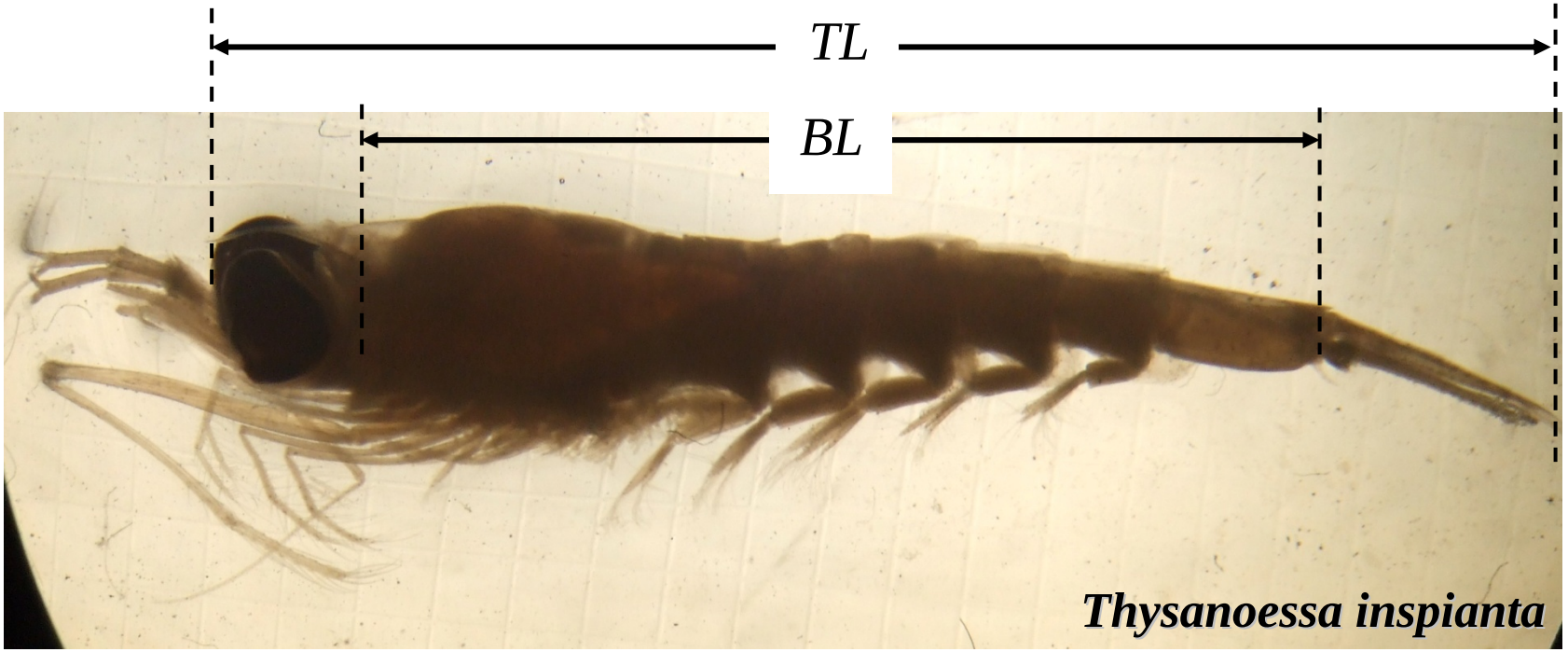
Analysis in the land laboratory

- Sorted and enumerated euphausiid species from entire samples
- Dominant *Euphausia pacifica* and *Thysanoessa inspinata* were separated into juveniles, adult males, and adult females without and with spermatophores



Females with spermatophores attached

- Measurement of body length (*BL*: mm) and total length (*TL*: mm)

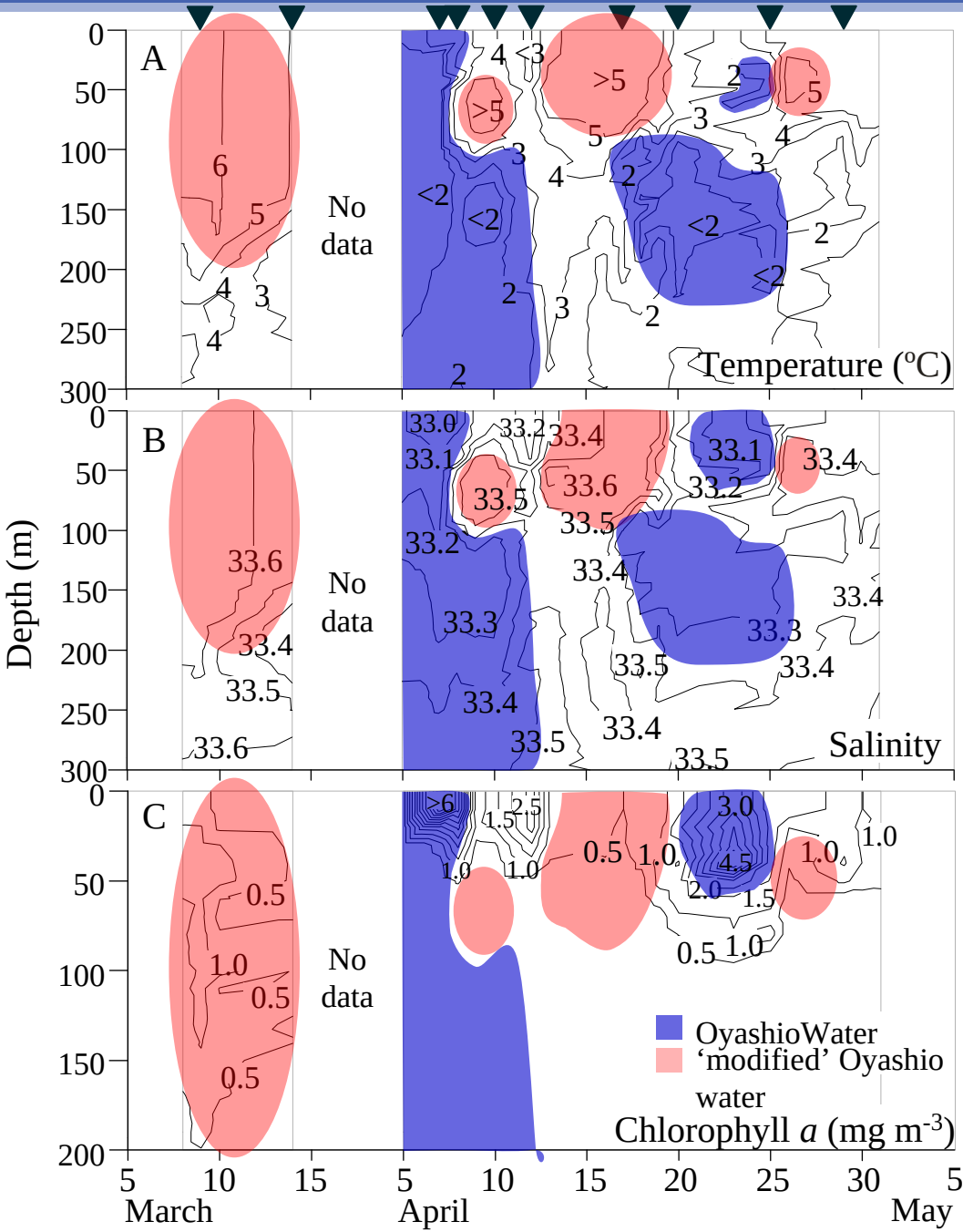


- Allometric equations

Euphausia pacifica $TL = 1.2921BL + 0.0762$ ($r = 0.999$, $n = 67$, $p < 0.01$)

Thysanoessa inspinata $TL = 1.5141BL - 0.5753$ ($r = 0.995$, $n = 91$, $p < 0.01$)

Results



Hydrography

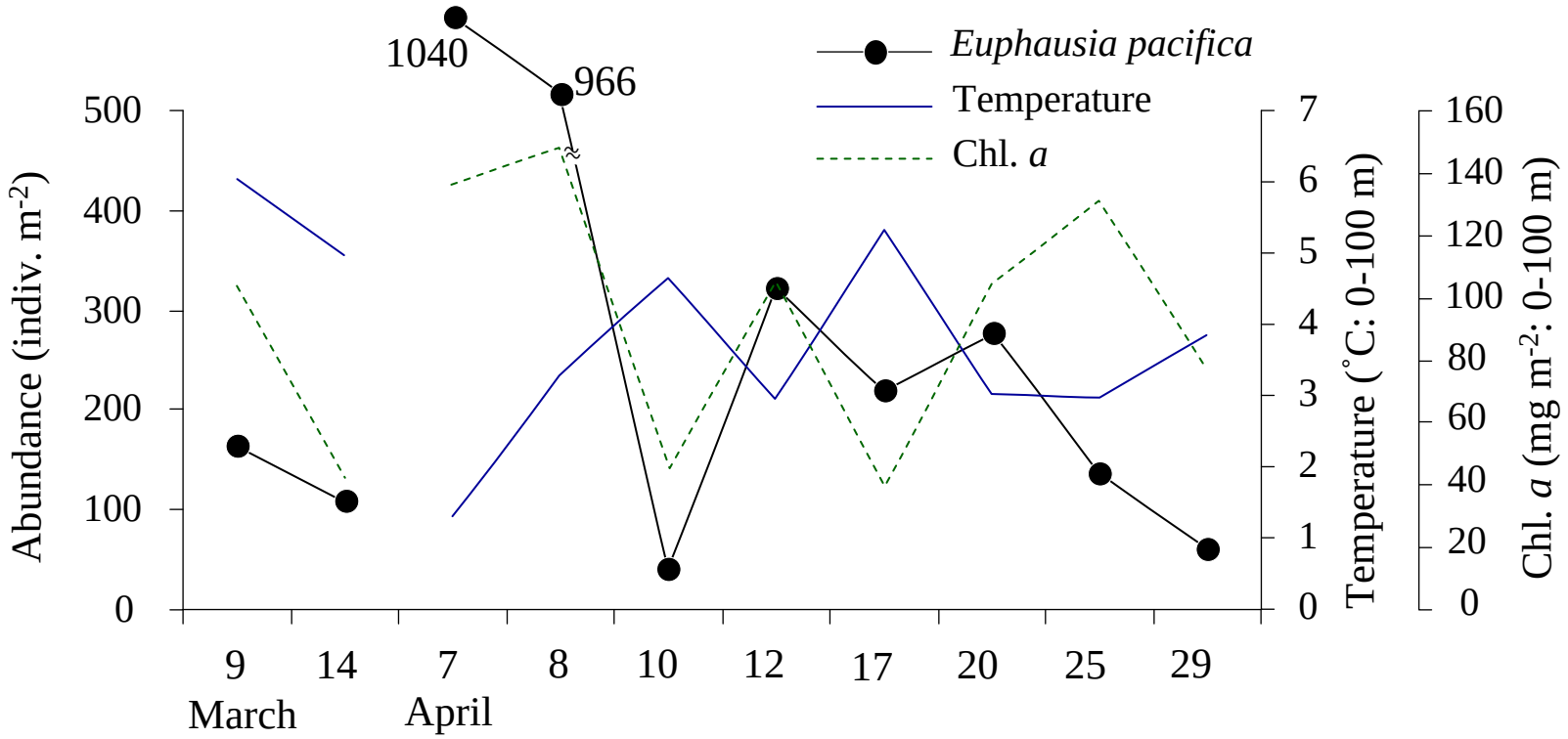
- Surface temperature 1.5-6.1°C
- Oyashio water
  (Temp. <3 °C, salinity 33.0-33.3 psu)
  - 5-8 April (upper 300 m)
  - 20-25 April (upper 200 m)
- 'Modified' Oyashio water
  - 9-14 March (upper 200 m)
  - 13-19 April (upper 100 m)
- Chlorophyll *a*
  - March (0.2-1.0 mg m^{-3})
    < April (0.5-6.3 mg m^{-3})
  - Peak: 7-8 April (6.3 mg m^{-3})
    23 April (4.5 mg m^{-3})

Euphausiid abundance

Table. Euphausiid abundance (individuals m^{-2}) during spring phytoplankton bloom in the Oyashio region

	9 Mar.	14 Mar.	7 Apr.	8 Apr.	10 Apr.	12 Apr.	17 Apr.	20 Apr.	25 Apr.	29 Apr.	Mean
Euphausia pacifica	164.1 (72.7)	109.2 (62.2)	1039.8 (84.5)	965.5 (91.1)	40.9 (15.8)	320.6 (66.5)	219.4 (79.9)	275.8 (63.7)	134.6 (57.9)	59.2 (38.9)	333 (73.6)
Thysanoessa inspinata	59.3 (26.3)	64.1 (36.5)	185.6 (15.1)	92.1 (8.7)	174.6 (67.6)	148.5 (30.8)	50.4 (18.4)	151.9 (35.1)	89.6 (38.5)	90.0 (59.2)	111 (24.5)
T. longipes	0.9 (0.4)	0.3 (0.2)	2.5 (0.2)	1.5 (0.1)	37.0 (14.3)	10.9 (2.3)	3.7 (1.4)	3.4 (0.8)	5.5 (2.4)	1.3 (0.8)	6.7 (1.5)
T. inermis	0	0.3 (0.2)	1.9 (0.2)	0.6 (0.1)	4.9 (1.9)	1.2 (0.3)	0.5 (0.2)	1.4 (0.3)	0.8 (0.4)	0	1.2 (0.3)
Tessarabrachion oculatum	0.9 (0.4)	0.3 (0.2)	0	0.6 (0.1)	0.8 (0.3)	0.6 (0.1)	0.5 (0.2)	0.6 (0.1)	1.9 (0.8)	1.6 (1.0)	0.8 (0.2)
Stylocheiron spp.	0.5 (0.2)	1.4 (0.8)	0	0	0.3 (0.1)	0	0	0	0	0	0.2 (0.04)
Total	226	65.7	1230	1060	258	482	275	433	233	152	452

Abundance of *Euphausia pacifica*

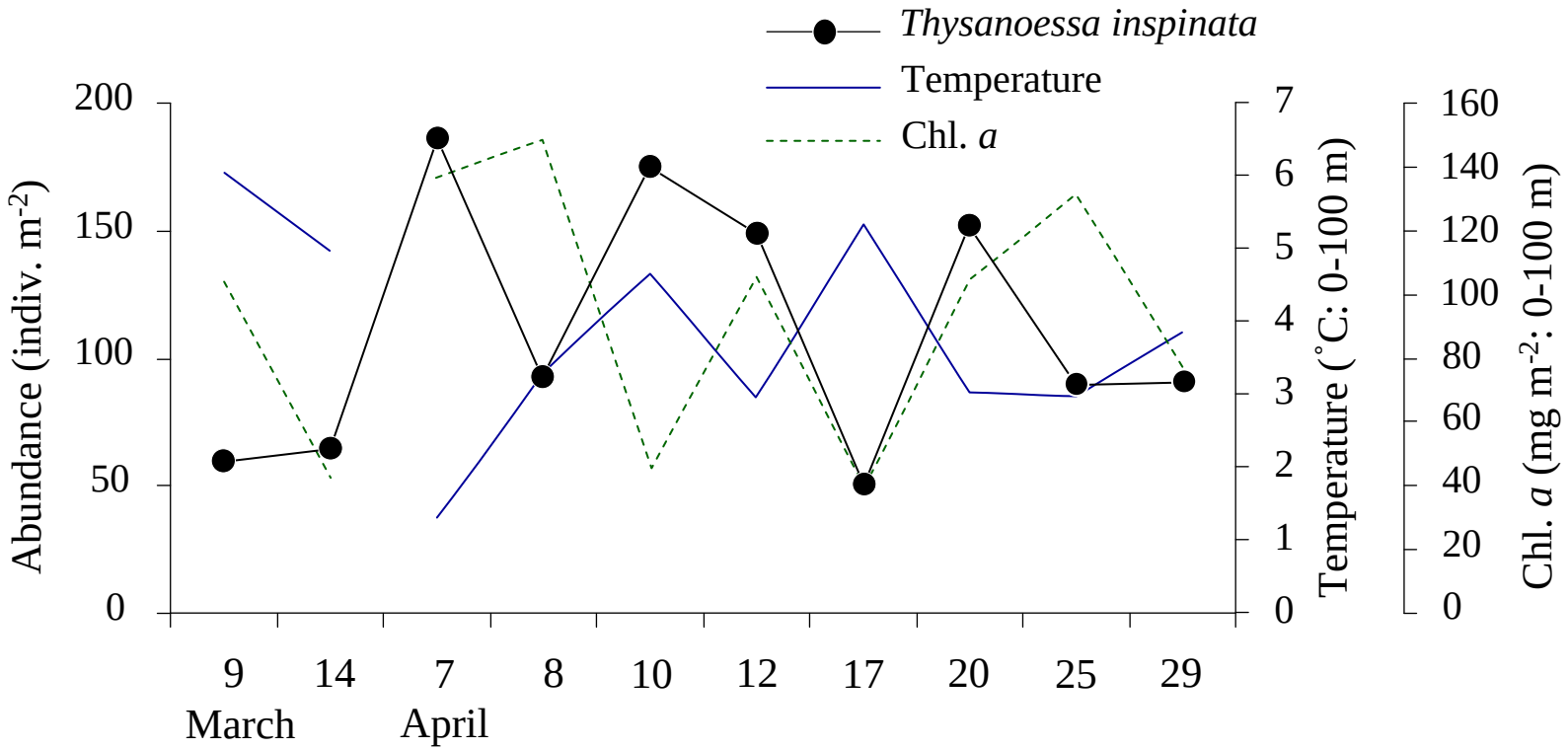


Abundance : 44-1,040 (mean : 333 indiv. m^{-2})

	df	Temp. (0-100m)	Chl. *a* (0-100m)
Abundance (indiv. m^{-2})	8	-0.638*	0.687*

df = *n* - 2, *: $p<0.05$

Abundance of *Thysanoessa inspinata*

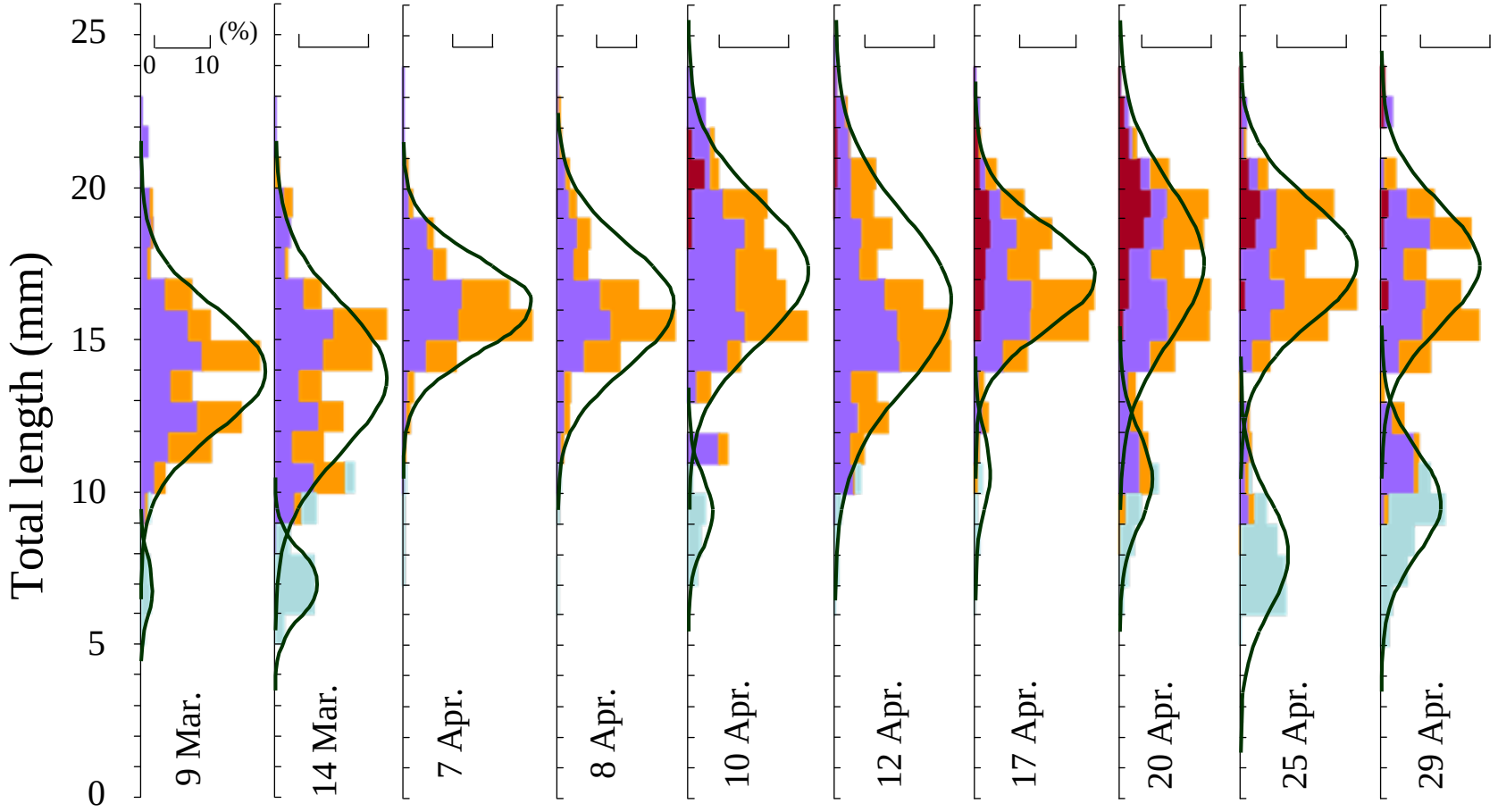


Abundance: 50-186 (mean : 111 indiv. m^{-2})

	df	Temp. (0-100m)	Chl. *a* (0-100m)
Abundance (indiv. m^{-2})	8	-0.679*	0.257^{NS}

df = *n* - 2, *: $p<0.05$, *NS* : not significant

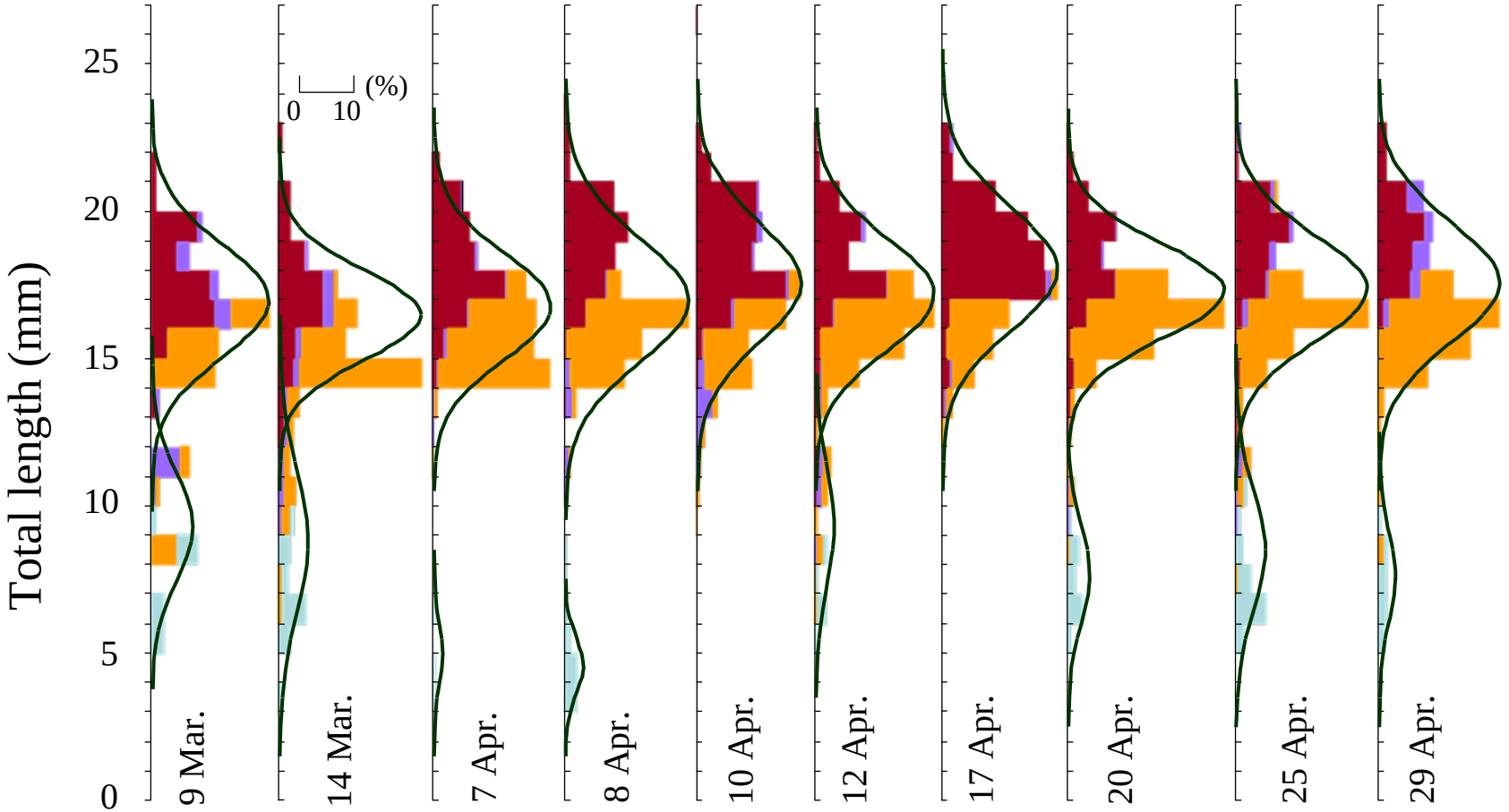
Population structure of *Euphausia pacifica*



- Total length range: 5.2-25.4 mm
- Mean total length of the large size group:
  March (13.8-14.0 mm), April (16.2-17.6 mm)
- Mean growth rate： 0.082 mm day^{-1}

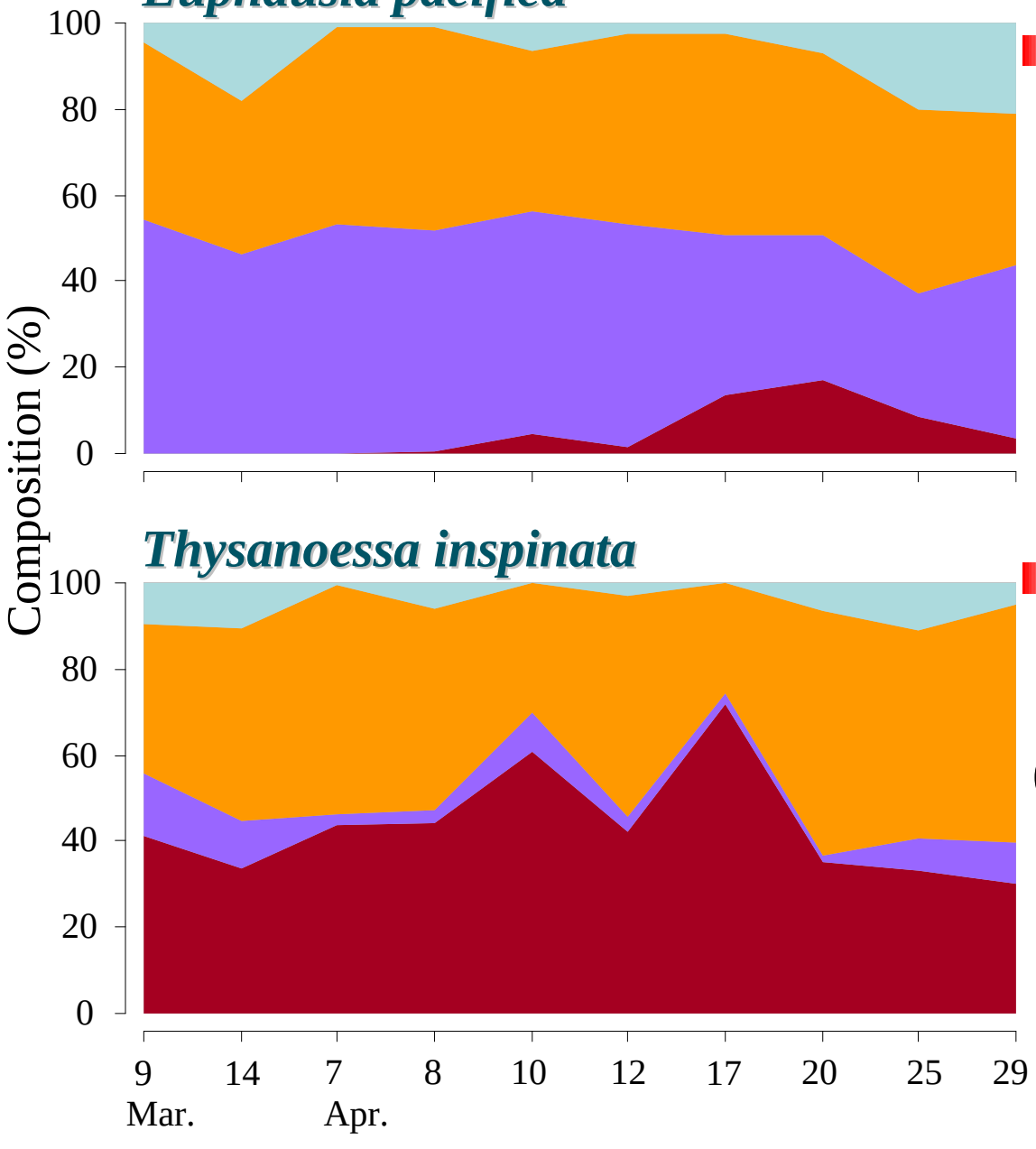
Juveniles
Males
Females without spermatophores
Females with spermatophores

Population structure of *Thysanoessa inspinata*



- Total length range: 3.7-26.7 mm
- Mean total length of the large size group:
  March (16.5-16.7 mm), April (16.8-18.1 mm)
- Mean growth rate： 0.022 mm day^{-1}

Euphausia pacifica



- Females with spermatophores occurred from10 April (mean: 5% of total population)

Thysanoessa inspinata

- Females with spermatophores occurred from the entire study period (mean: >40% of total population

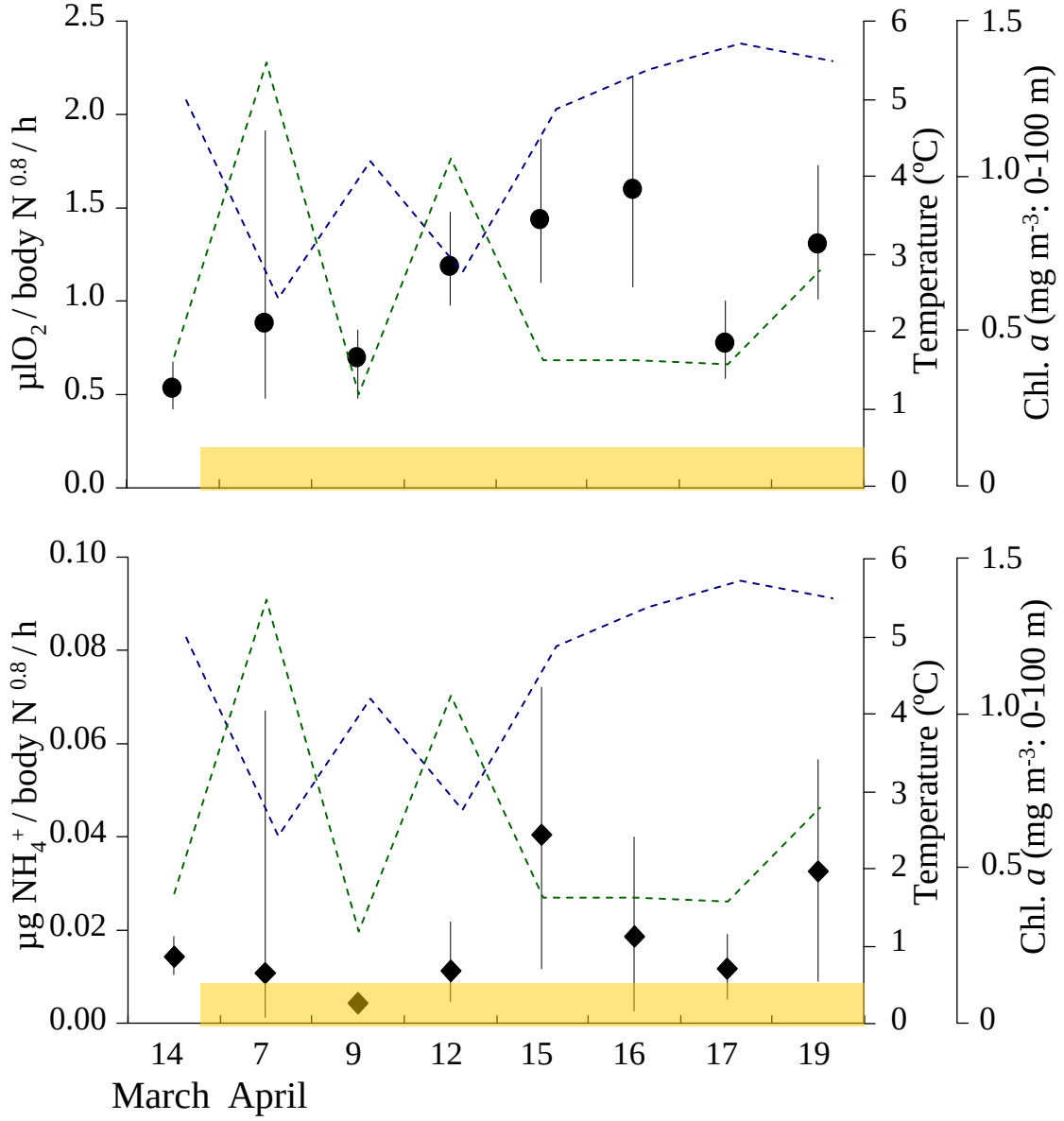
Juveniles

Males

Females without spermatophores

Females with spermatophores

Metabolism of *Euphausia pacifica*



- **Adjusted Metabolic Rate (AMR):**
  - No correlation with environmental parameters

Correlation	Temp.	Chl. *a*
Respiration	0.598^{NS}	-0.233^{NS}
Excretion	0.547^{NS}	-0.328^{NS}

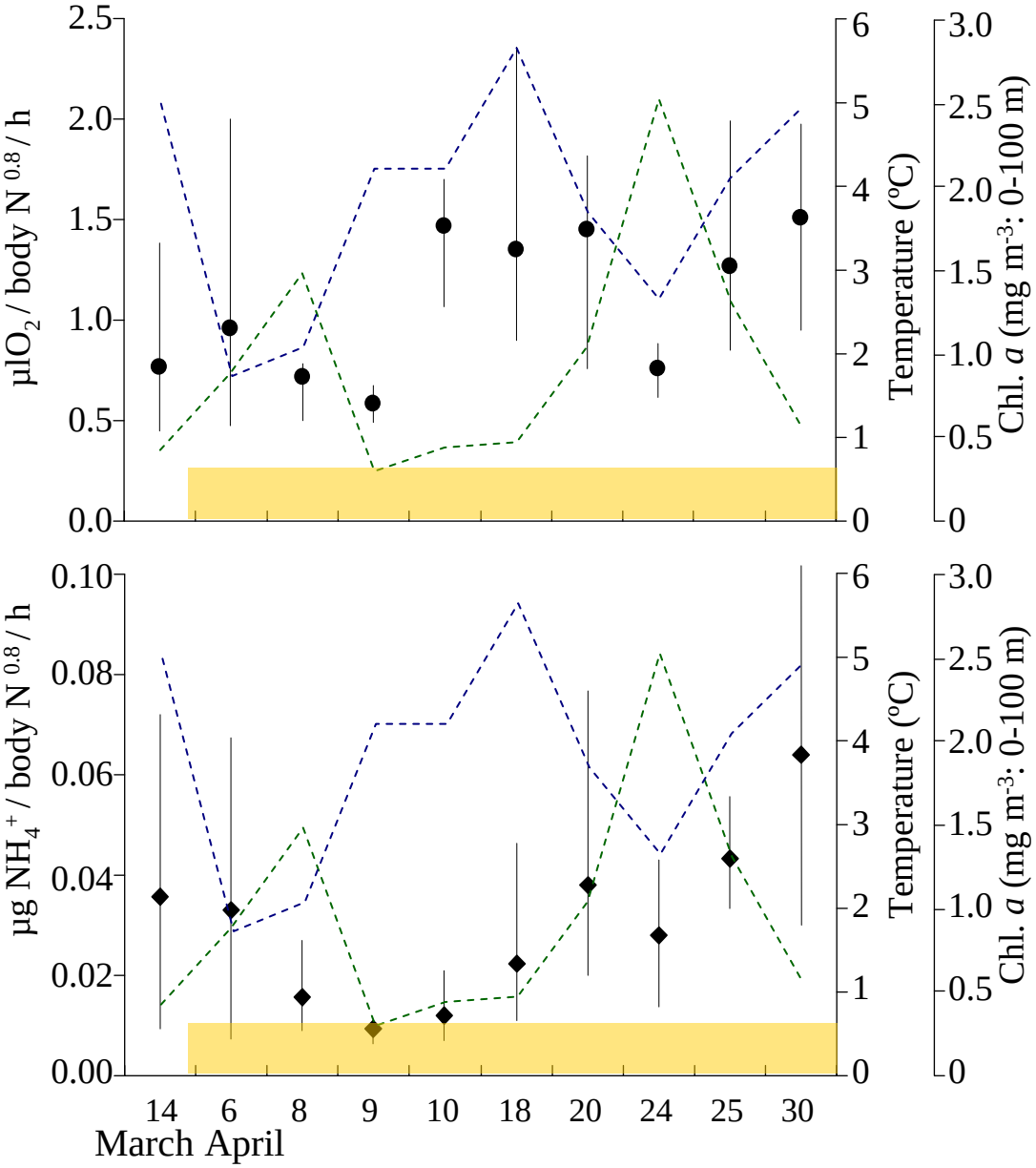
NS: not significant

Surface temperature (ºC)

Chl. *a* (mg m^{-3})

Phytoplankton bloom

Metabolism of *Thysanoessa inspinata*



- **Adjusted Metabolic Rate (AMR):**
  - No correlation with environmental parameters

Correlation	Temp.	Chl. *a*
Respiration	0.536^{NS}	-0.349^{NS}
Excretion	0.616^{NS}	-0.183^{NS}

NS: not significant

Surface temperature (ºC)

Chl. *a* (mg m^{-3})

Phytoplankton bloom

Euphausiid body composition

Table. Body composition of euphausiid *Euphausia pacifica* and *Thysanoessa inspinata* in March (before Bloom) and April (in bloom) in the Oyasiho region

2007	*E. pacifica*	No.	Water (%WM)	C (% DM)	N (% DM)	C:N	Ash
March	Females	4	77.90±1.08	33.66	9.47	3.55	14.67
	Males	3	77.53±0.82	35.13	9.56	3.68	10.96
April	Females	35	76.64±2.50	38.01	9.74	3.90	9.17
	Males	16	75.82±1.92	34.48	8.79	3.92	10.18

	T. inspinata	No.	Water (%WM)	C (% DM)	N (% DM)	C:N	Ash
March	Females	8	78.75±1.12	36.20	9.76	3.71	12.44
	Males	6	77.44±1.22	36.98	10.09	3.66	10.51
April	Females	25	78.26±4.61	36.98	9.81	3.77	10.02
	Males	28	78.46±6.19	37.21	10.19	3.65	10.55

- No appreciable difference between March and April was evident in both *Euphausia pacifica* and *Thysanoessa inspinata*.

Summary (1)

- Both *Euphausia pacifica* and *Thysanoessa inspianta* occurred throughout the entire study period (less effect of water mass changes).

- Correlation between abundance and environmental parameters

  E. pacifica: water temperature (-) and chlorophyll *a* (+)

  T. inspinata: water temperature (-)

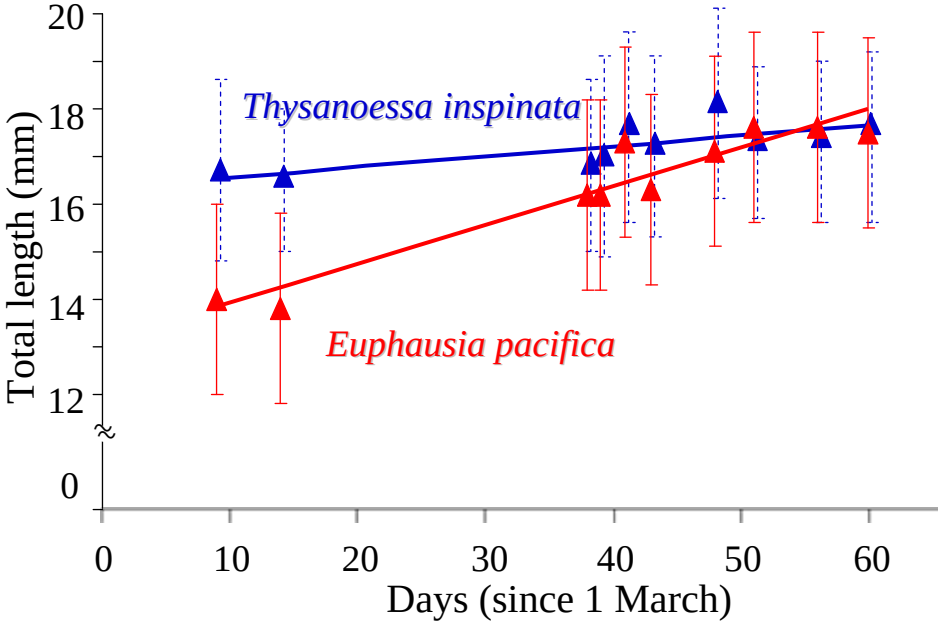
- Growth rates:

  E. pacifica (0.082 mm day^{-1})

  > *T. inspinata* (0.022 mm day^{-1})

- Proportion of females with spermatophores (an indicator of spawning activity)

  T. inspinata (>40%) > *E. pacifica* (5%)



- Allocation of energy ingested

  E. pacifica: somatic growth, *T. inspinata*: reproduction

Summary (2)

- Metabolism:

  Adjusted oxygen consumption and ammonia excretion rates of the two euphausiids were not correlated with environmental parameters (temperature and chl. *a*) in March (before the bloom) and April (in the bloom).

- Body composition:

  No appreciable differences were seen in water and ash contents, C and N composition, and C:N ratios of the two euphausiids in March (before the bloom) and April (in the bloom)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