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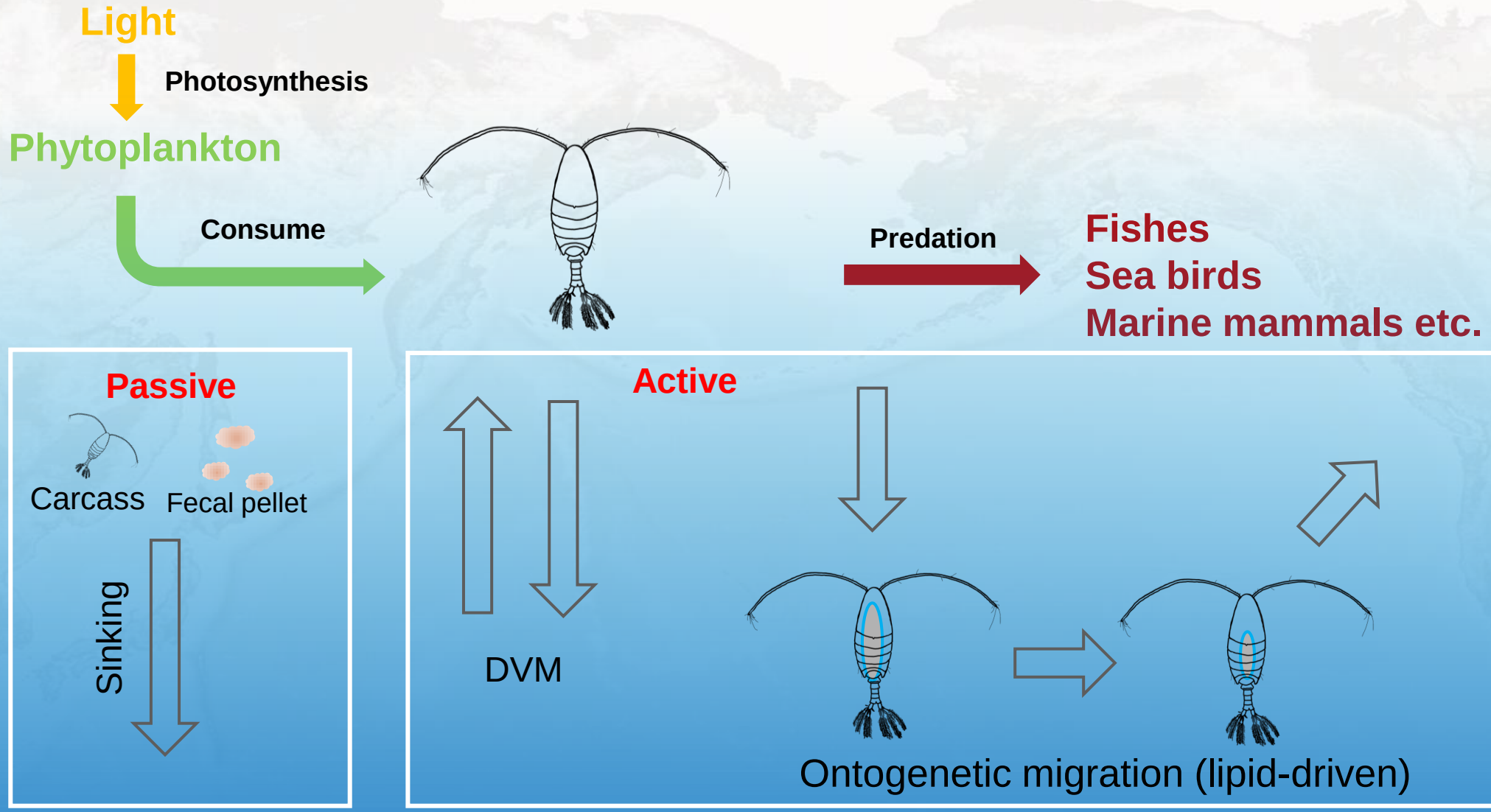
Atmosphere and Ocean Research Institute
The University of Tokyo

# A Population Dynamics Model Incorporating Structural and Lipid Dynamics of Copepod *Neocalanus plumchrus* in the Subarctic Pacific

**Yu-An Chen,** Hiroaki Saito

(Topography data from NOAA)

# Role of copepods in the biological pump

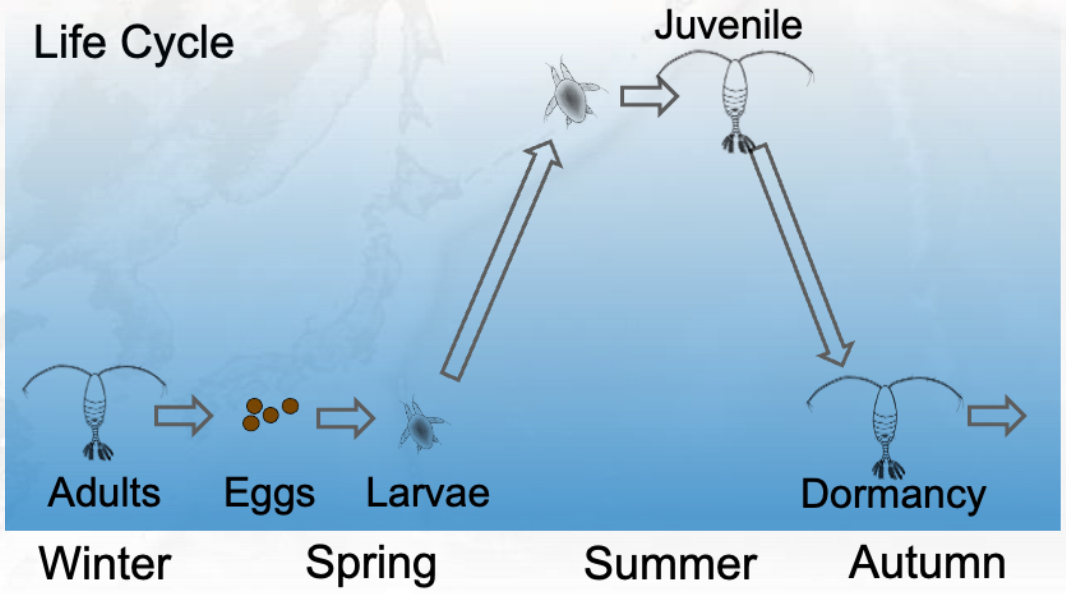


# *Neocalanus plumchrus* in the Subarctic Pacific

***Neocalanus plumchrus***

- A dominant copepod species
- Large body size
- Lipid accumulation
- Ontogenetic vertical migration



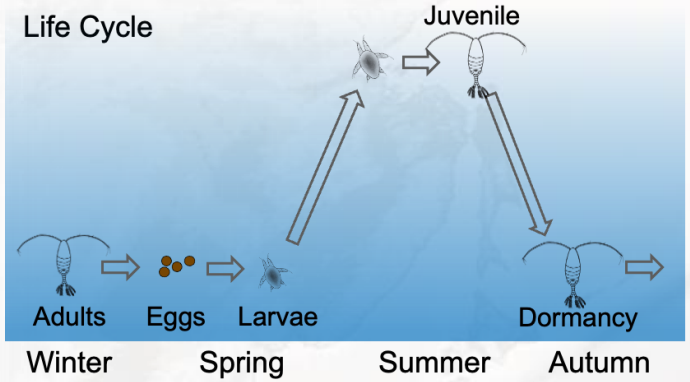



**Knowledge Gap:**

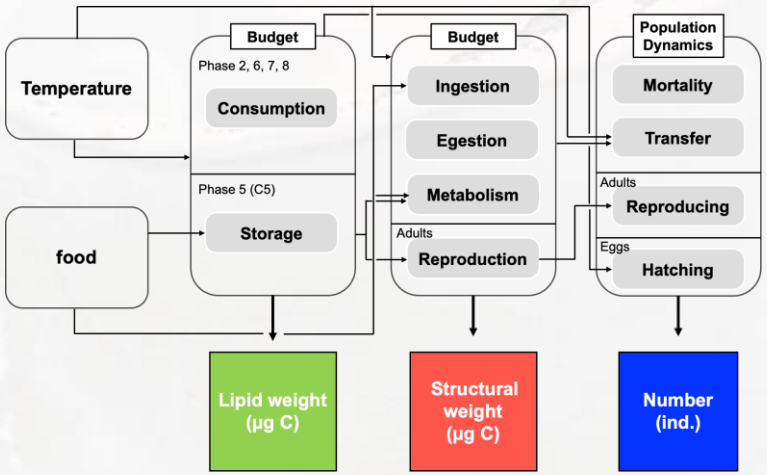
- Most lipid-driven OVM studies focus on Atlantic species (*Calanus finmarchicus*, surface-spawning).
- Active carbon export by *Neocalanus* spp. (deep-spawning) remains poorly quantified.

# Objective

The research aims to develop **a population dynamics model of *N. plumchrus*** incorporating lipid utilization.




**Lipid-driven dormancy hypothesis**




**Population Dynamics Model**

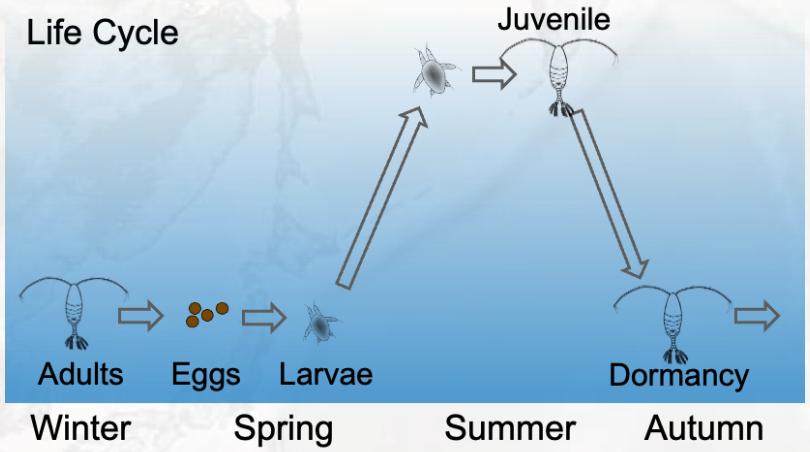
**Carbon transport**

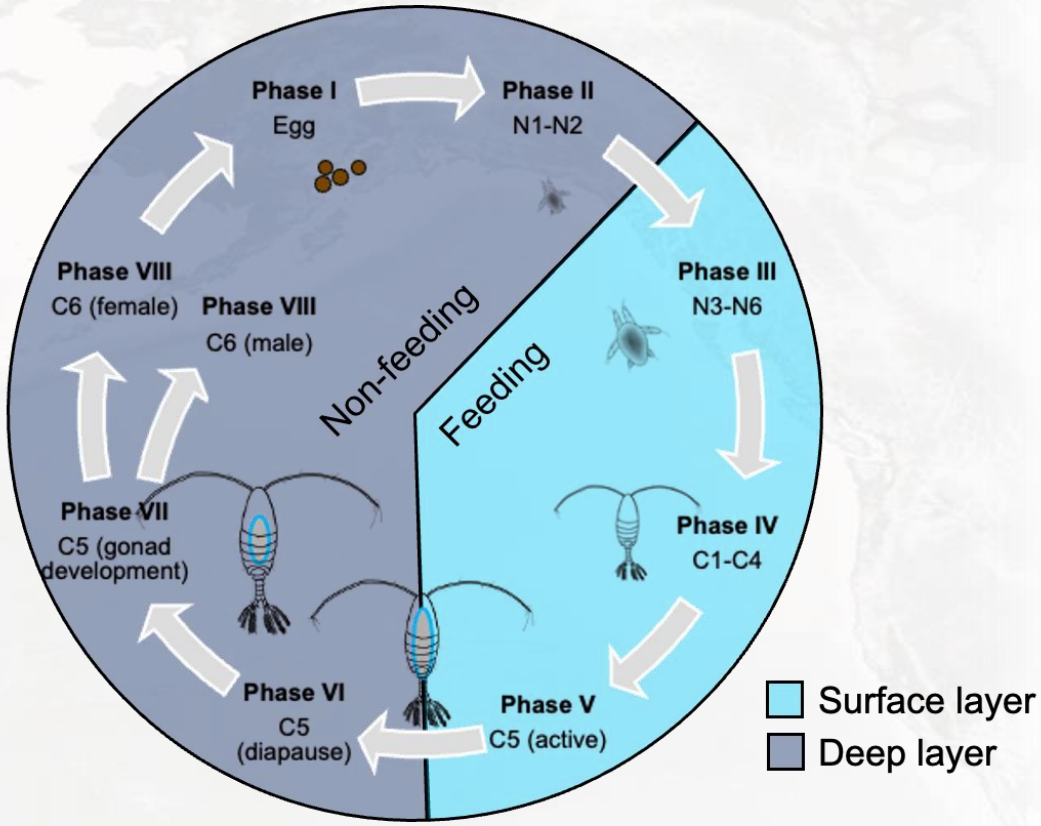
# Materials and Methods

## Population Dynamics Model

- **8 developmental phases**

13 life stages: Egg + 6 nauplius + 6 copepodite



# Materials and Methods

- **Model Structure**
  - Carbon currency
  - 0-dimensional box model
  - 3 individual states

3 individual states

Output

Abundance (ind./m²)

Structural Weight (µg C)

Lipid Weight (µg C)

**Temperature (WOA23)**

**Food condition (Aqua MODIS Chla)**

Input

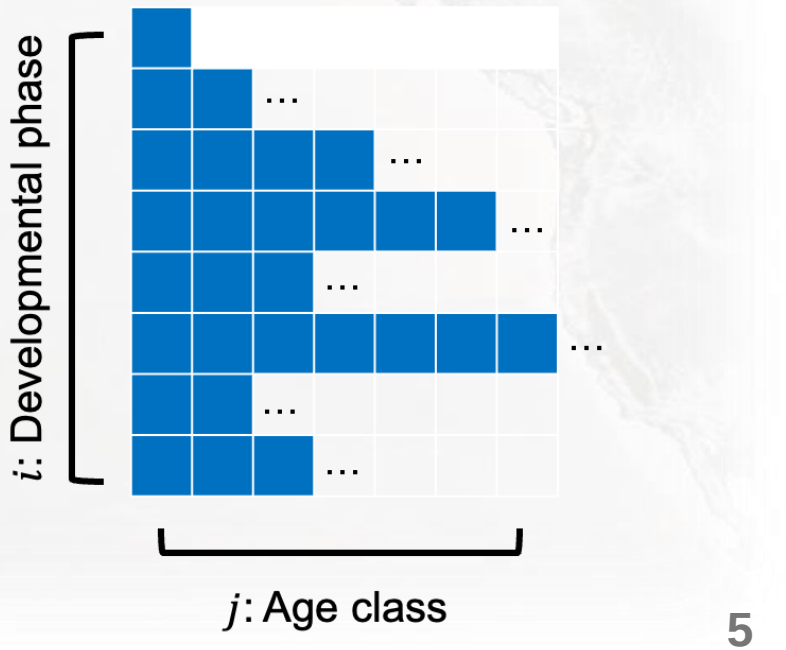
Surface box

Phase III to Phase V (N3-C5)

Deep box

Phase VI to Phase II (C5D-N2)

**Population dynamic model**



# Materials and Methods

- **Governing equations**

## Change in abundance ($N_{i,j}$)

- Transition (hatching and reproduction)
- Mortality
  - Constant
  - Density-dependent

## Change in structural weight ($Ws_{i,j}$)

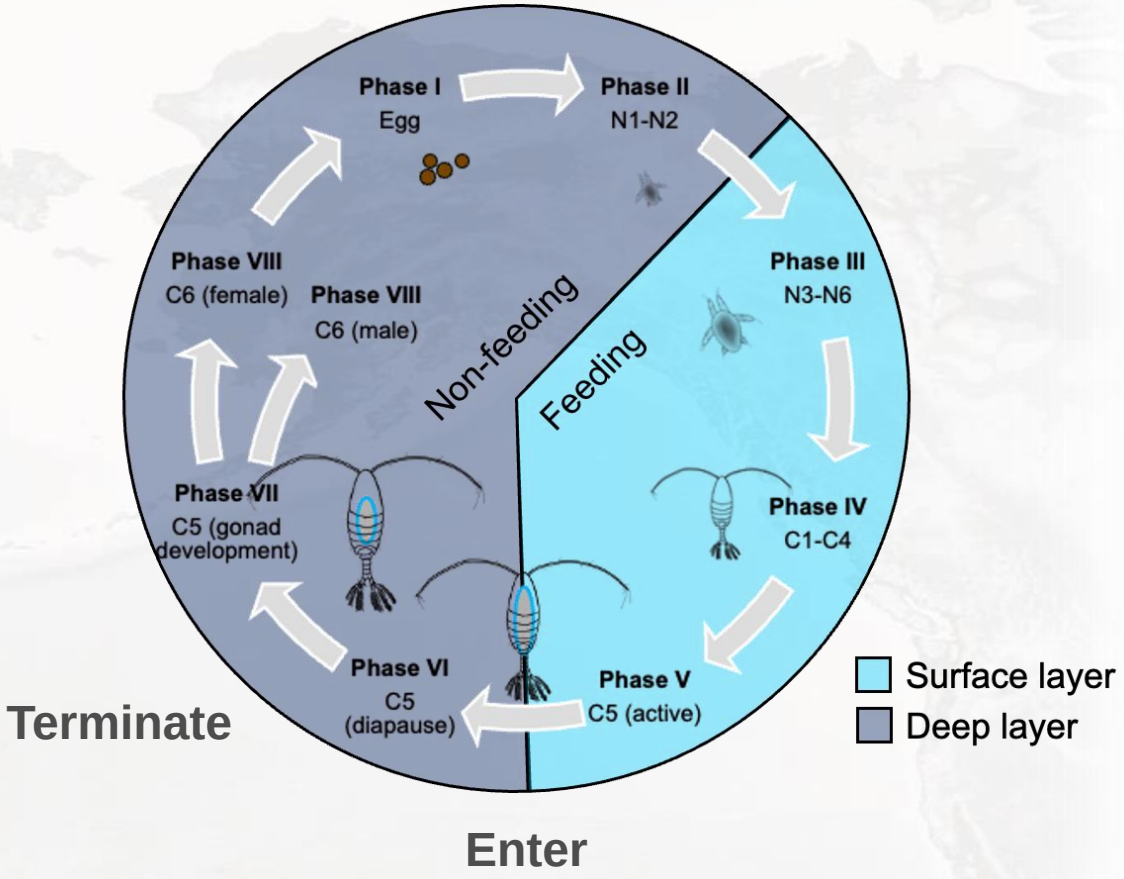
- Growth:

$$G = Ingestion - Egestion - Metabolism$$

- Reproduction

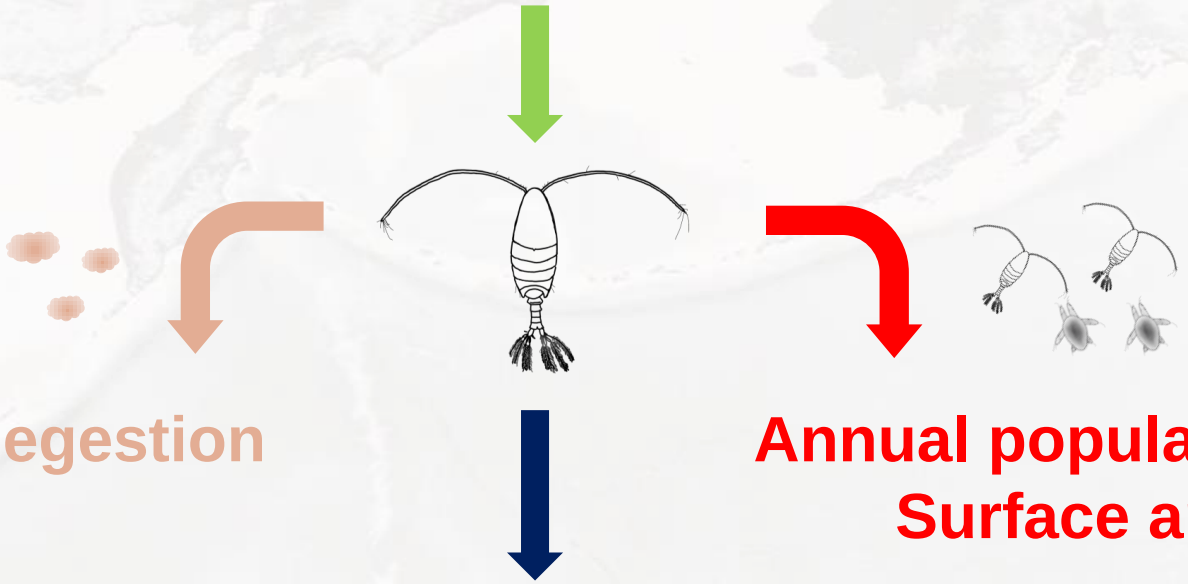
## Change in lipid weight ($Wl_{i,j}$)

- Accumulation
- Consumption
- Reproduction



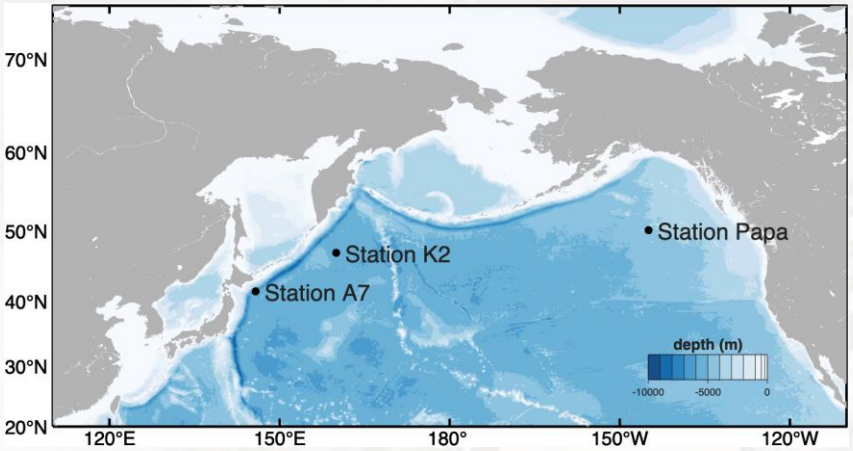
# Materials and Methods

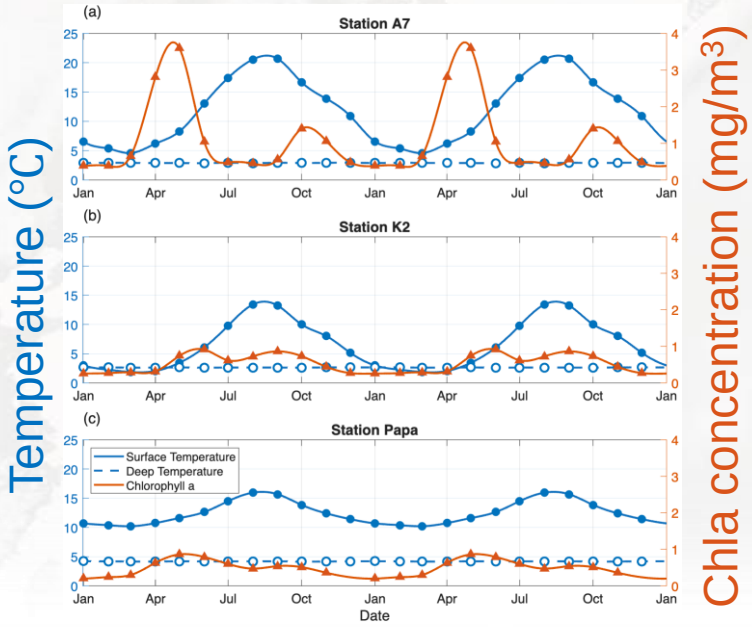
- **Estimation of annual carbon transport**

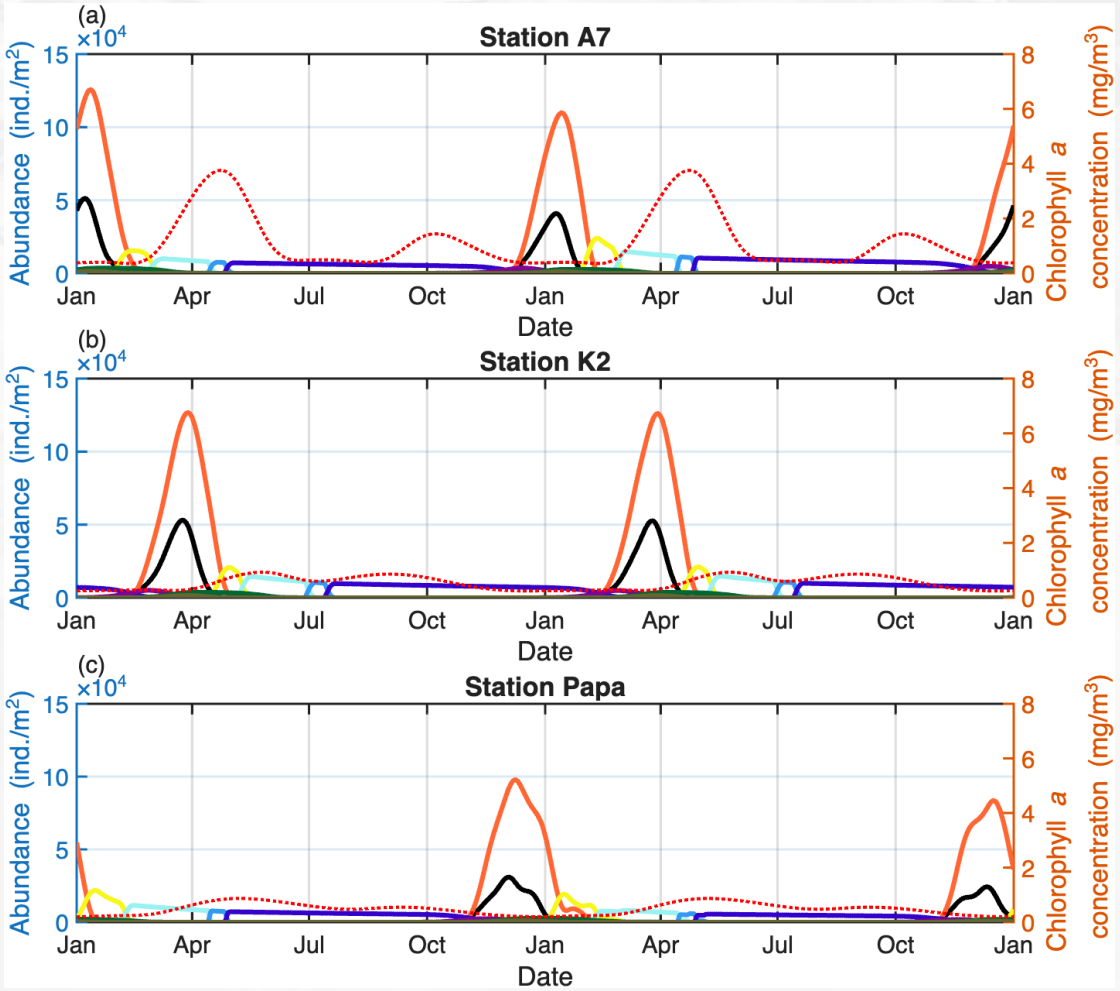


# Results and Discussion

- **Dynamics on abundance (ind./m²)**



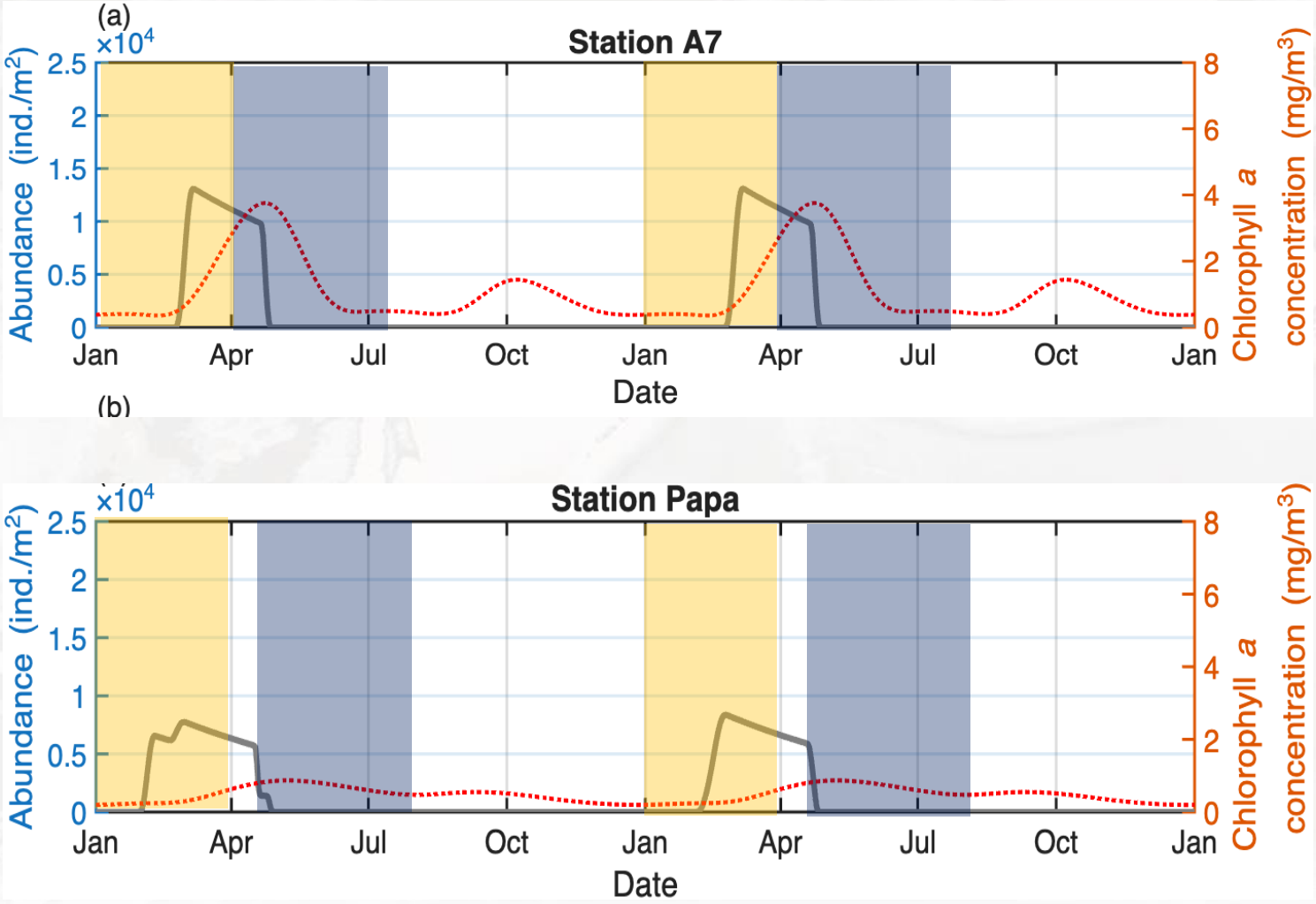




Last two year of 10,000 days simulation

# Results and Discussion

- **Comparing simulated copepodite timing to observations**



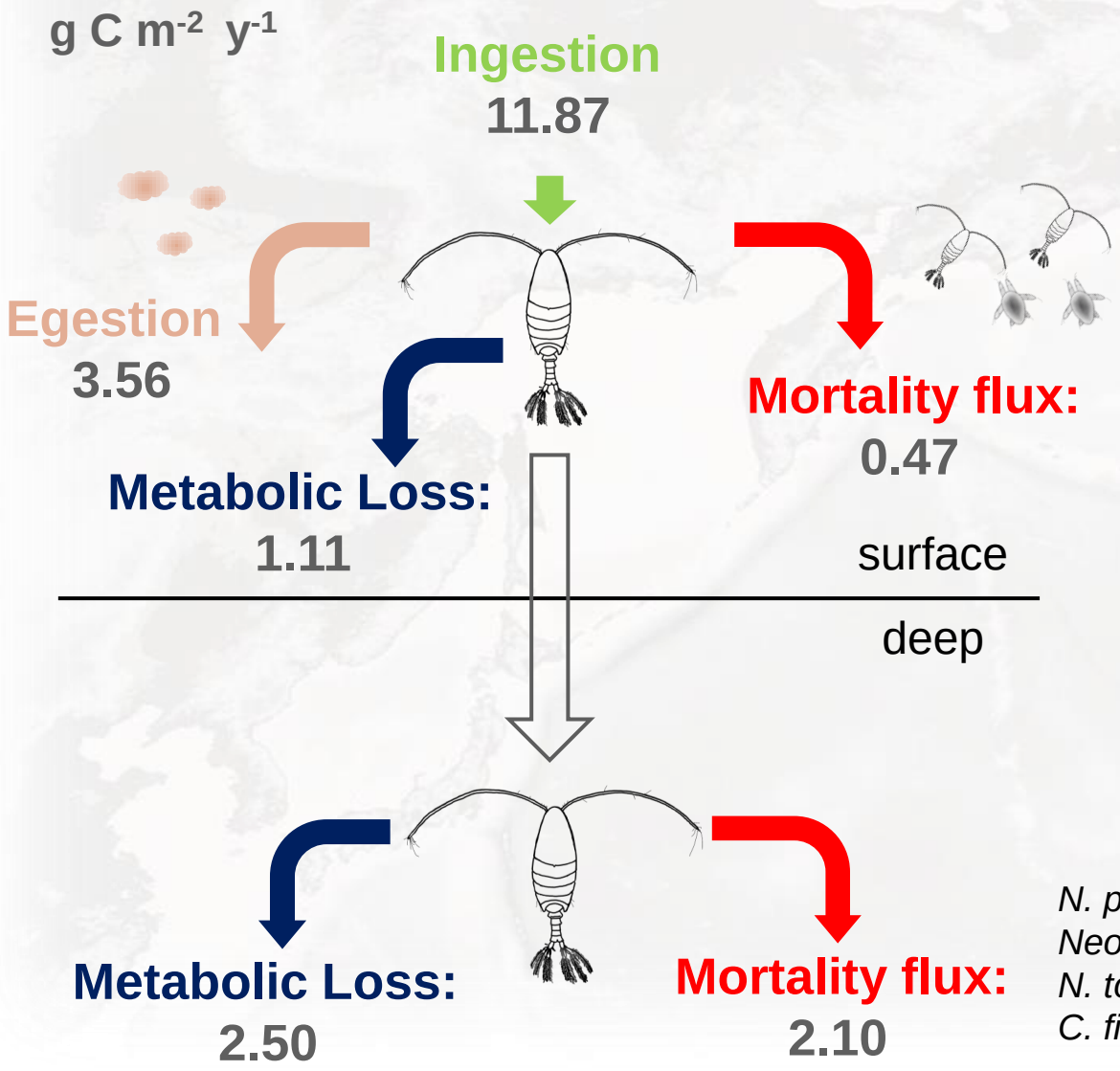

**First appearance**

**Migration time**

(Liu et al. 2010)

# Results and Discussion

- **Carbon transport by *N. plumchrus***

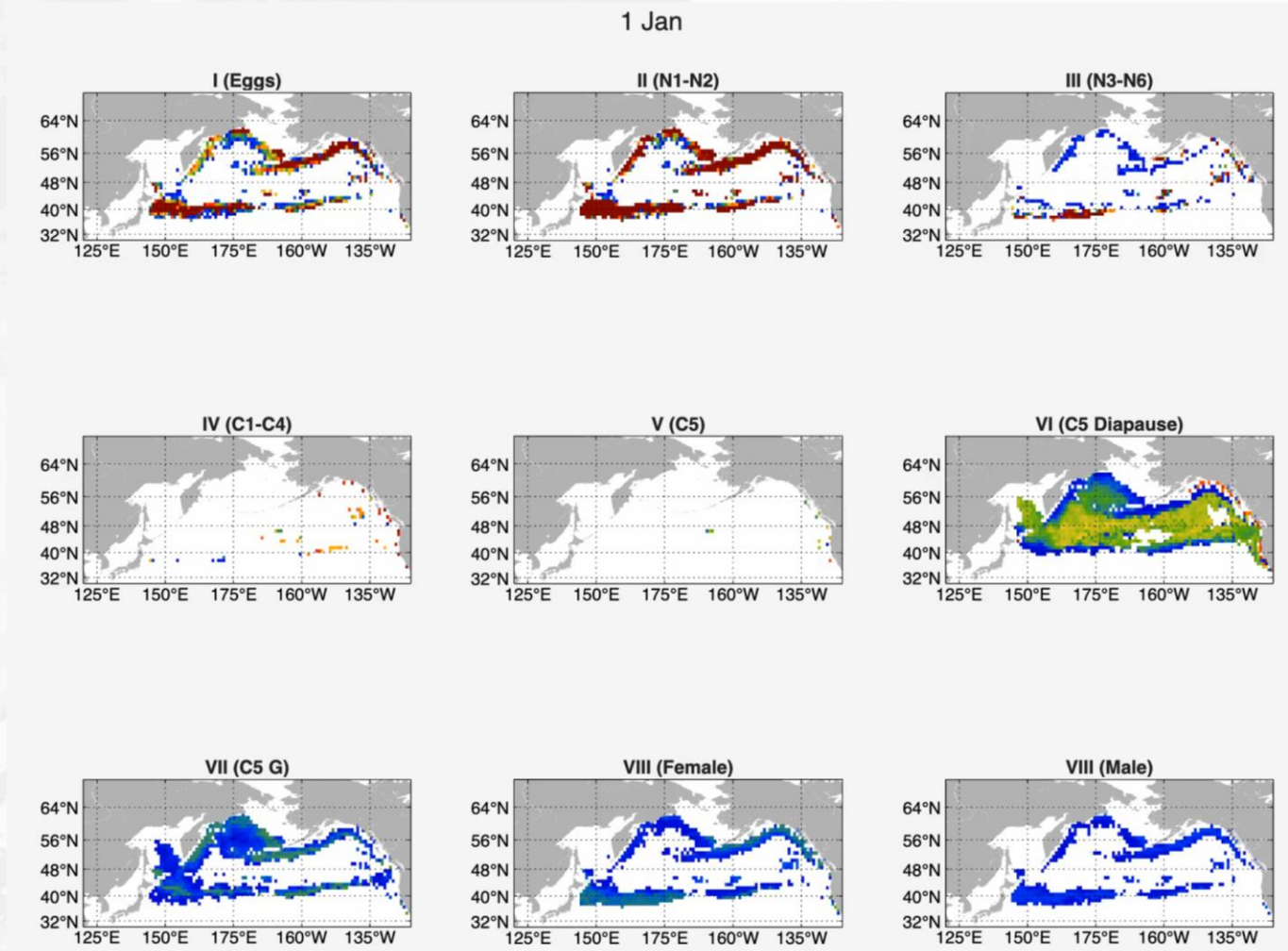



| | A7 | K2 | Papa |
|---|---|---|---|
| Ingestion | 11.87 | 11.66 | 6.68 |
| Egestion | 3.56 (30.0) | 3.5 (30.0) | 2.0 (30.0) |
| Metabolism (surface) | 1.11 (9.3) | 1.45 (12.5) | 0.83 (12.4) |
| Metabolism (deep) | 2.50 (21.1) | 2.63 (22.5) | 1.66 (24.8) |
| Mortality flux (Surface) | 0.47 (4.0) | 0.53 (4.5) | 0.28 (4.1) |
| Mortality flux (deep) | 2.10 (17.7) | 1.97 (16.9) | 1.01 (15.1) |
| **Carbon flux (OVM)** | **4.60 (38.8)** | **4.60 (39.4)** | **2.67 (39.9)** |

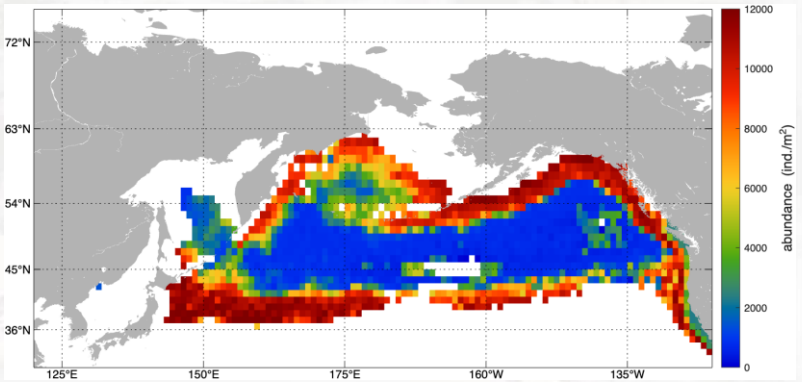
| | | |
|---|---|---|
| *N. plumchrus+N. cristatus*: | **1.72** | Station K2 (Kobari et al. 2008) |
| *Neocalanus* copepods: | **4.3** | Oyashio Region (Kobari et al. 2003) |
| *N. tonsus*: | **1.7–9.3** | Southern Ocean (Bradford-Grieve et al. 2001) |
| *C. finmarchicus*: | **2–6** | Atlantic Ocean (Jónasdóttir et al. 2015) |

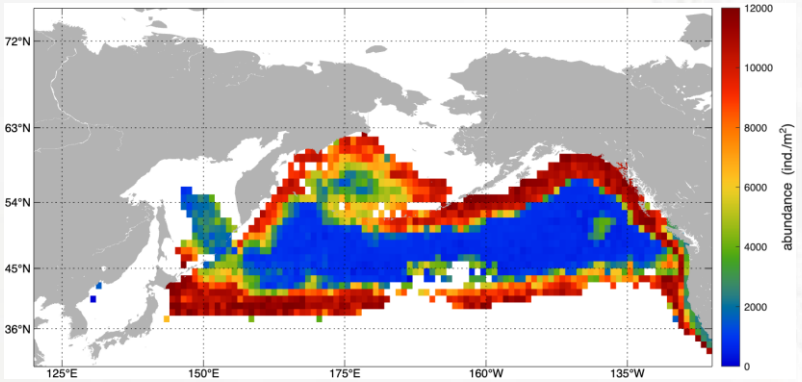
# Results and Discussion

- **Application of the population dynamics model**




Average daily abundance




+1°C SST

# Take Home Message

- The population dynamics model for *N. plumchrus* successfully reproduces the life cycle across different hydrographic conditions.
- Based on this model, we estimated reasonable carbon flux through ontogenetic migration**.**
- Coupling this population dynamics model with climate change scenarios to project future shifts in *N. plumchrus* distribution and the biological pump.

PICES-2026 | Nanaimo, Canada

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# Thank you for listening!

## Question & Answer

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