# Illuminating the black box of North Pacific salmon food webs: identifying trophic pathways and interspecific competition through an ecosystem approach

**Genyffer C. Troina**, Evgeny A. Pakhomov, Aleksey Somov, Brian P. V. Hunt

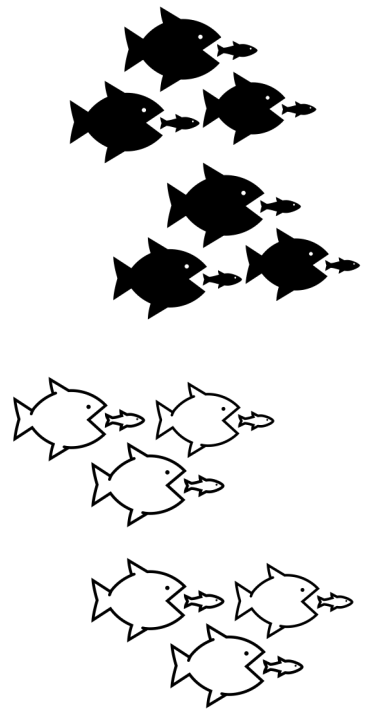
Contact: g.troina@oceans.ubc.ca

Pelagic Ecosystems Lab

Institute for the Oceans and Fisheries

University of British Columbia

# Competition for food...



Sympatric species may co-occur and succeed because they consume different prey types

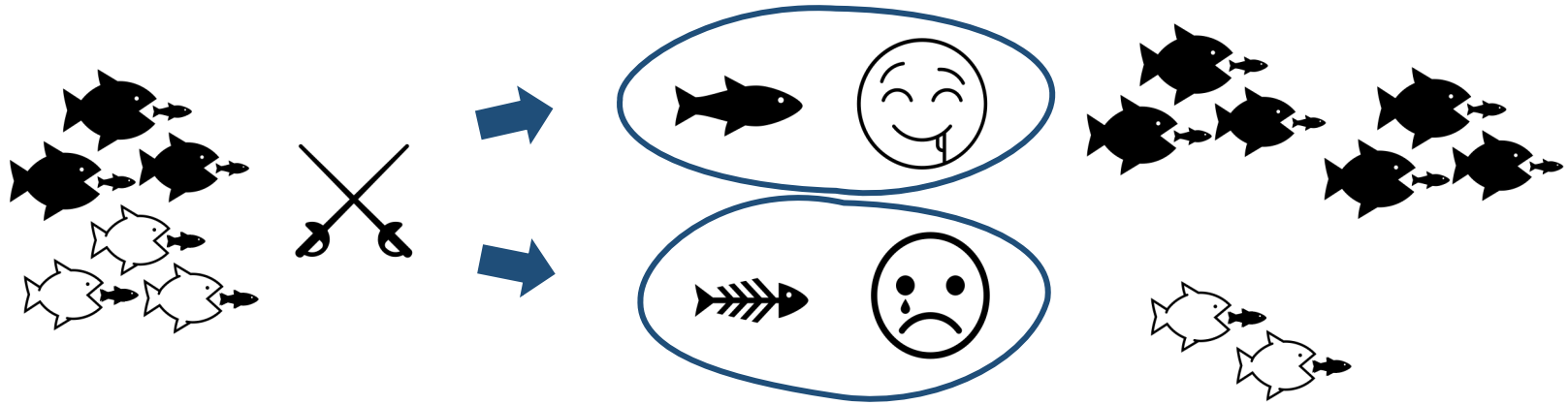
Not competing for resources

# Competition for food...

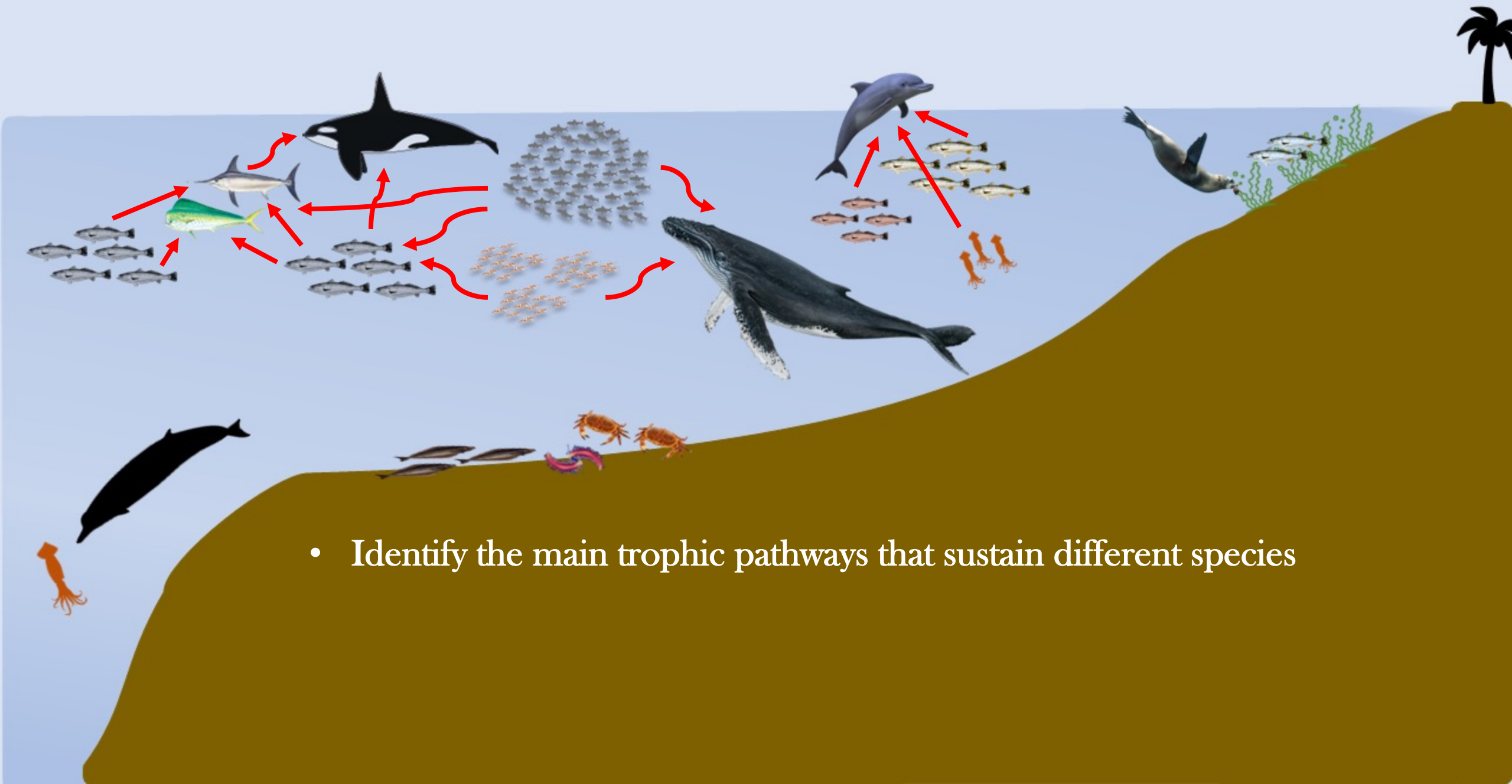
Competing species coexistence

- ≠ spatial or temporal distributions at finer scales
- Differential resource utilization

## May affect species' reproduction success, growth and survival

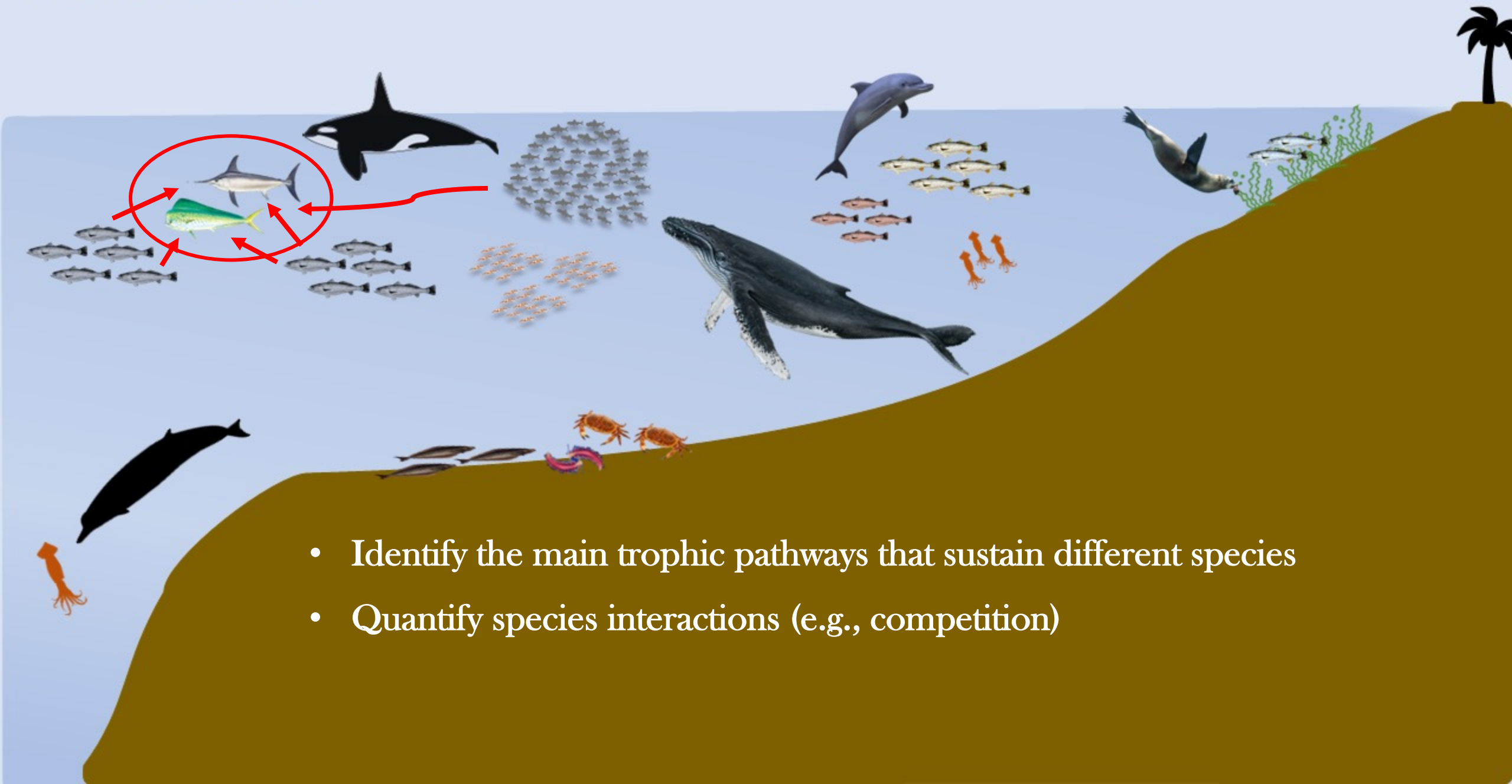


# Marine food webs



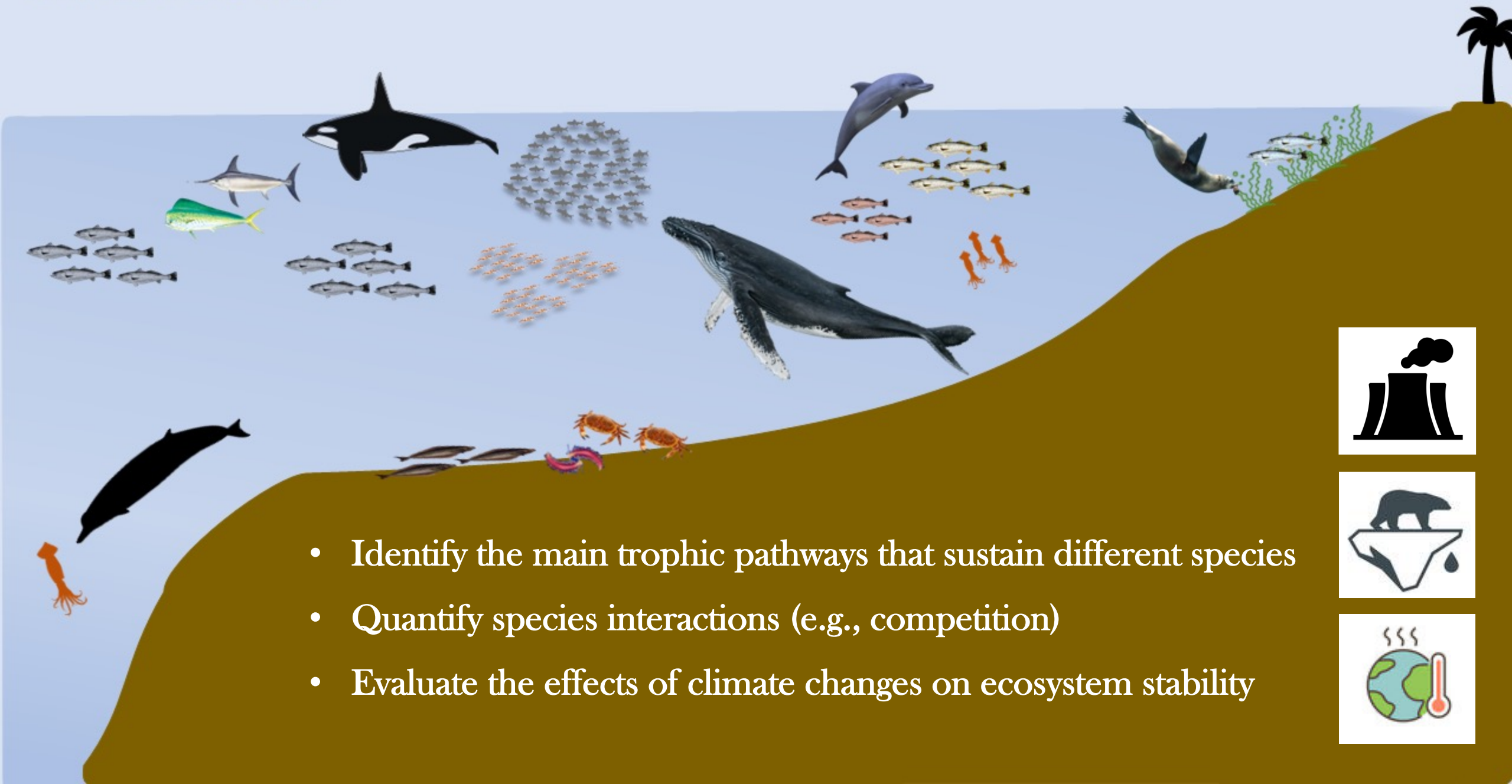
- Identify the main trophic pathways that sustain different species

# Marine food webs



- Identify the main trophic pathways that sustain different species
- Quantify species interactions (e.g., competition)

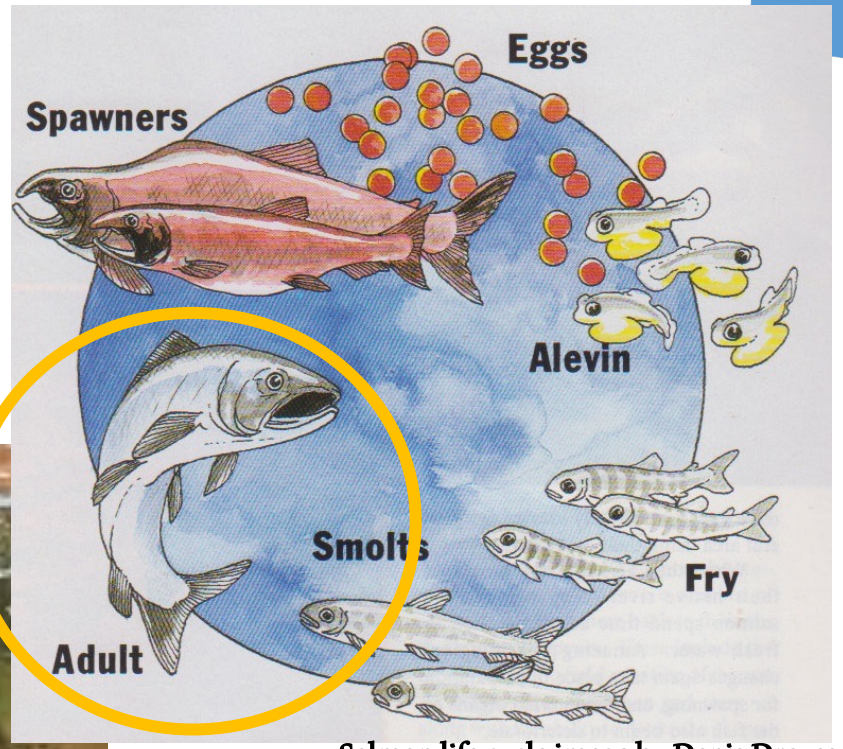
# Marine food webs



- Identify the main trophic pathways that sustain different species
- Quantify species interactions (e.g., competition)
- Evaluate the effects of climate changes on ecosystem stability

# Pacific salmon life cycle

Fresh water




Salmon life cycle image by Denis Dreves

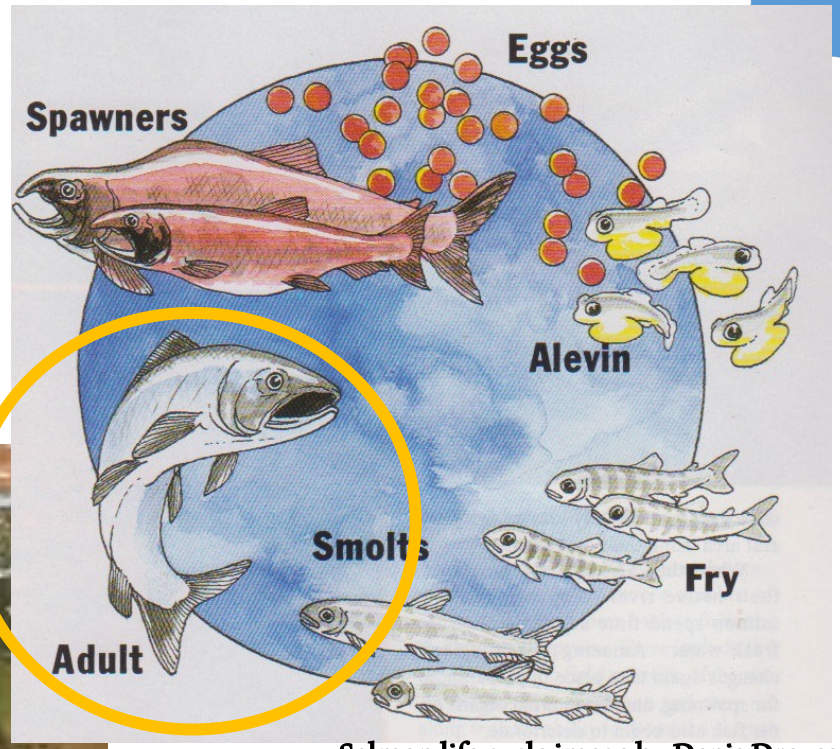
Offshore

Coastal

# Pacific salmon life cycle

**International Year of the Salmon**

Fresh water




Salmon life cycle image by Denis Dreves

Offshore

Coastal

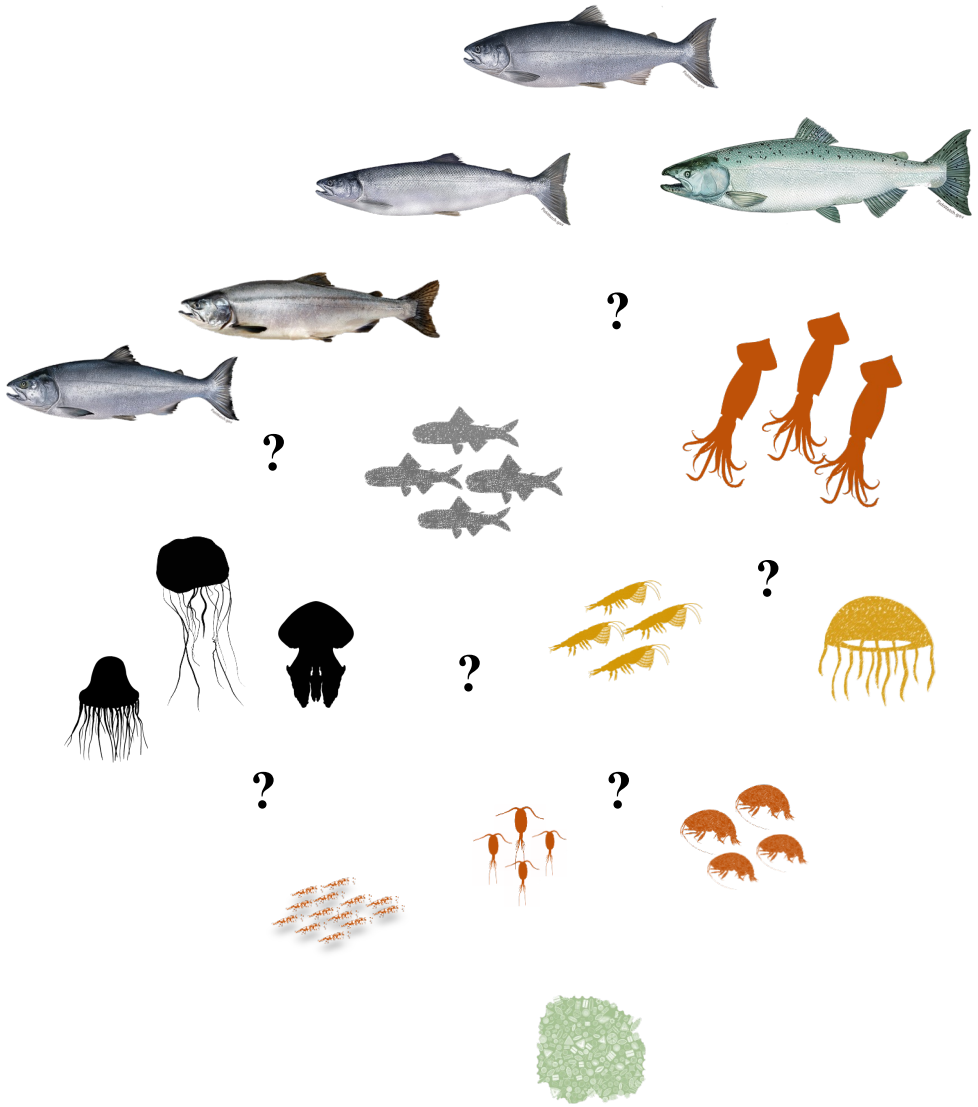
# Objectives

1) Describe the trophic structure of the Gulf of Alaska pelagic food webs;

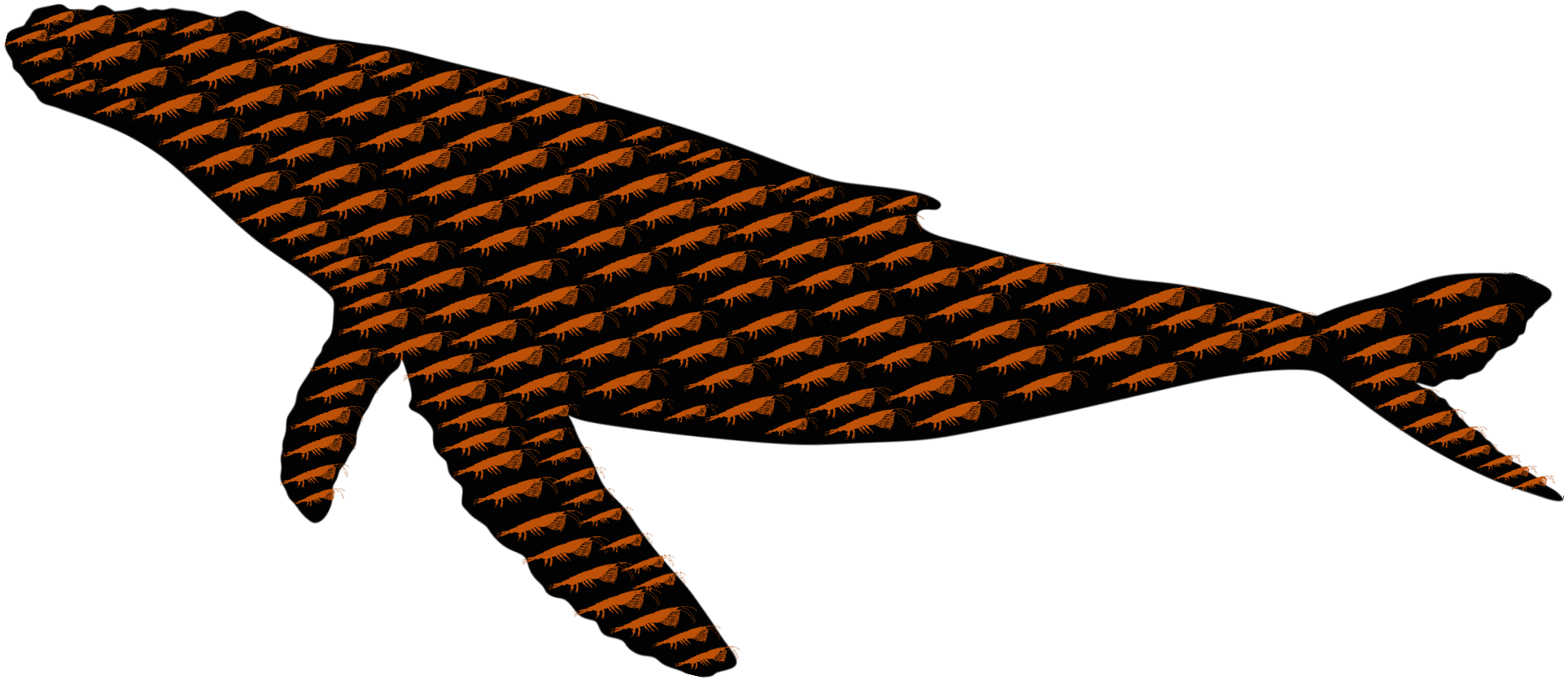
2) Identify species that compete with salmon for resources in the high seas.

Diet (stomach contents)

Stable isotopes ($\delta^{13}C$ & $\delta^{15}N$)



# “You are what you eat”

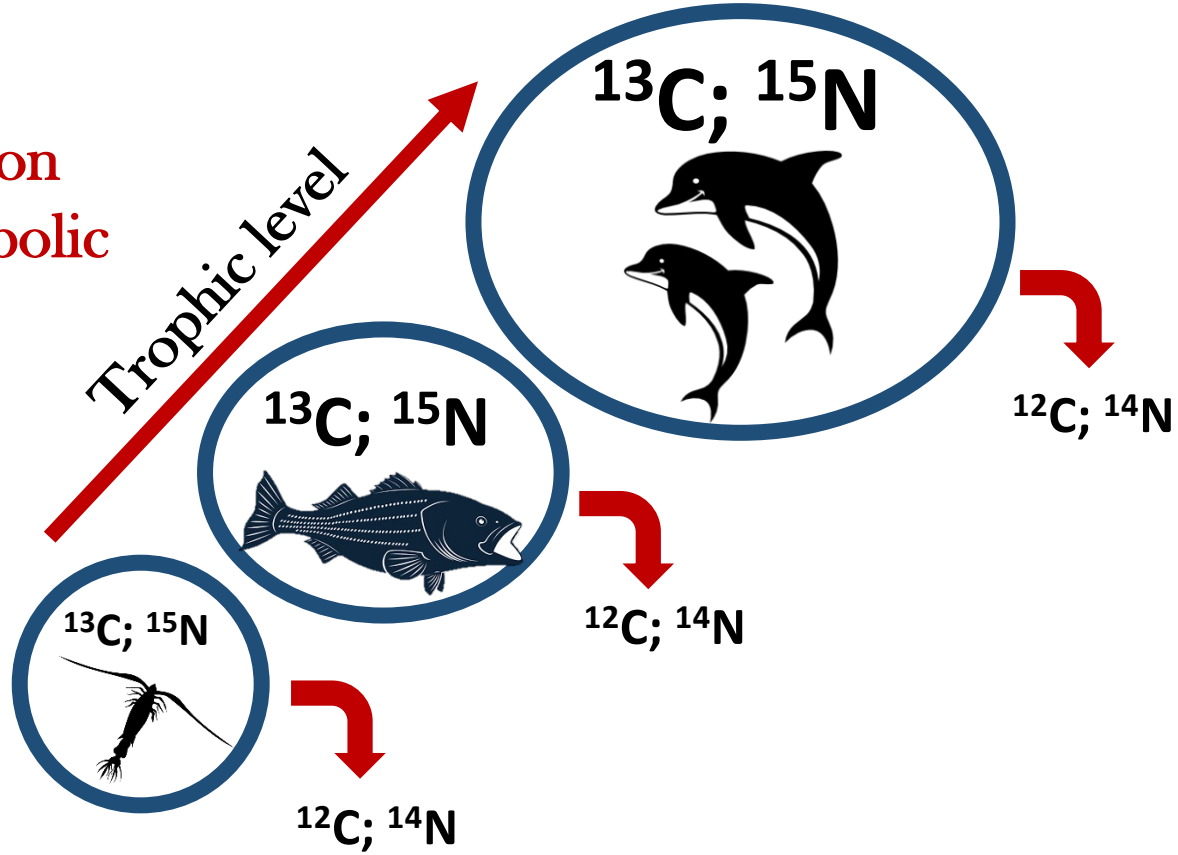


# Stable Isotopes

## "You are what you eat" *plus a few per mille…*

- TL differences:
  - $\delta^{13}C$ and $\delta^{15}N$ increase with each increase in TL;

Discrimination during metabolic processes



# Stable Isotope Analysis

"You are what you eat" *plus a few per mille…*

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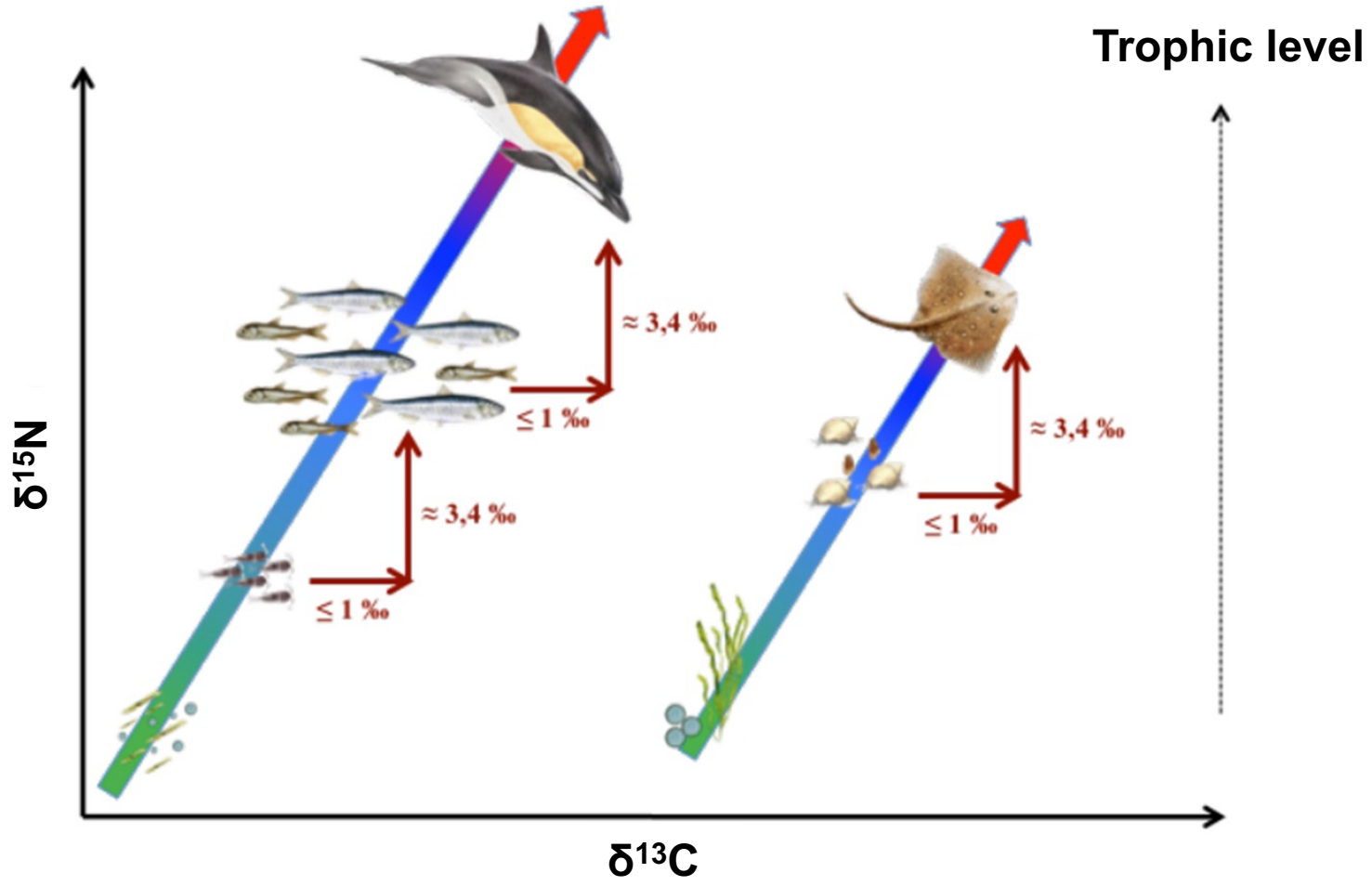
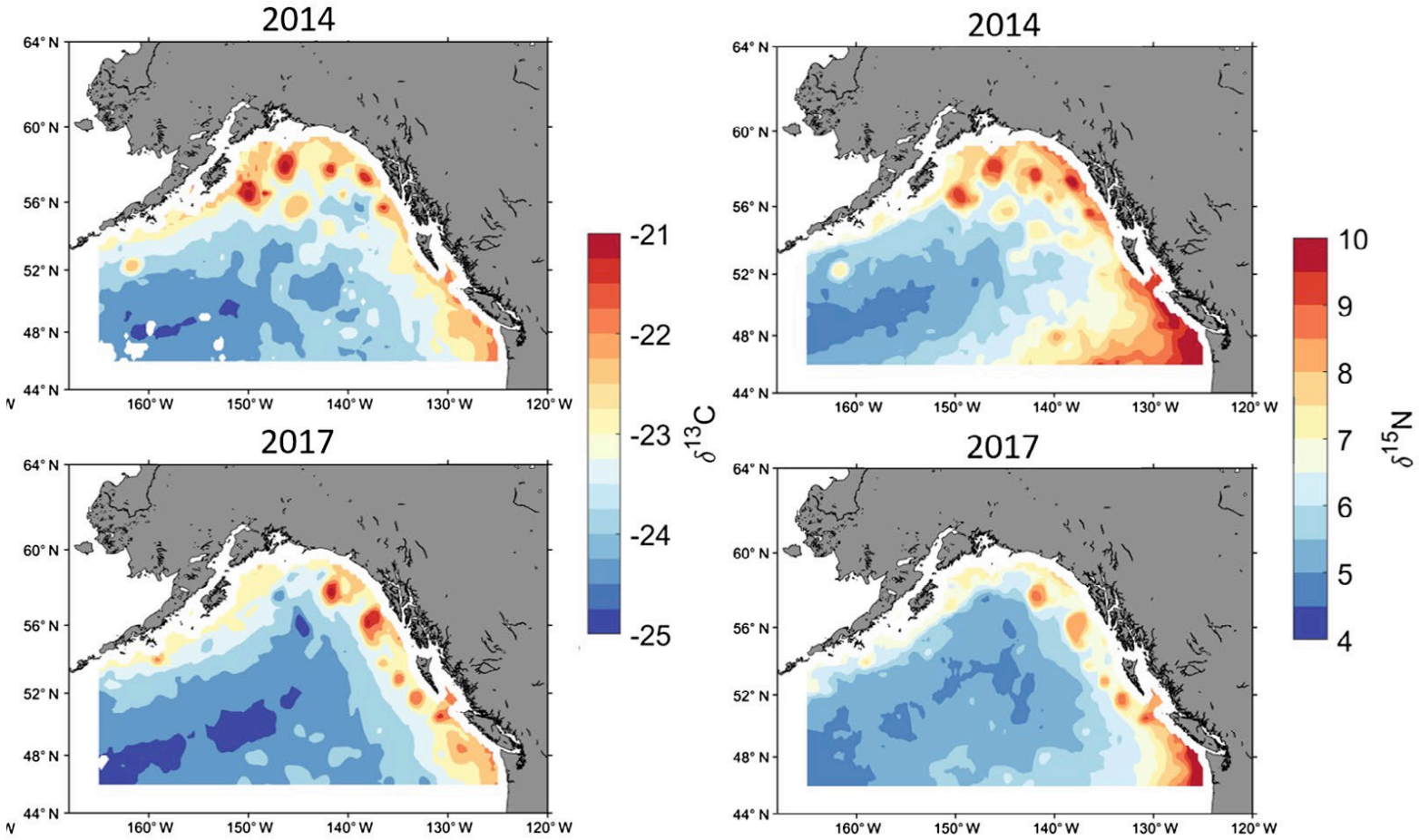


# Stable Isotope Analysis

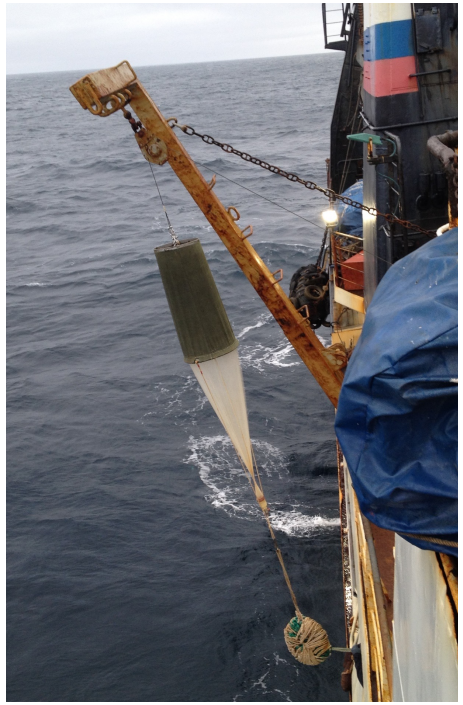
- TL differences:
  - $\delta^{13}C$ and $\delta^{15}N$ increase with each increase in TL;
- Spatial gradient:
  - Temperature, type of nutrient and primary producer species → ≠ $\delta^{13}C$ & $\delta^{15}N$



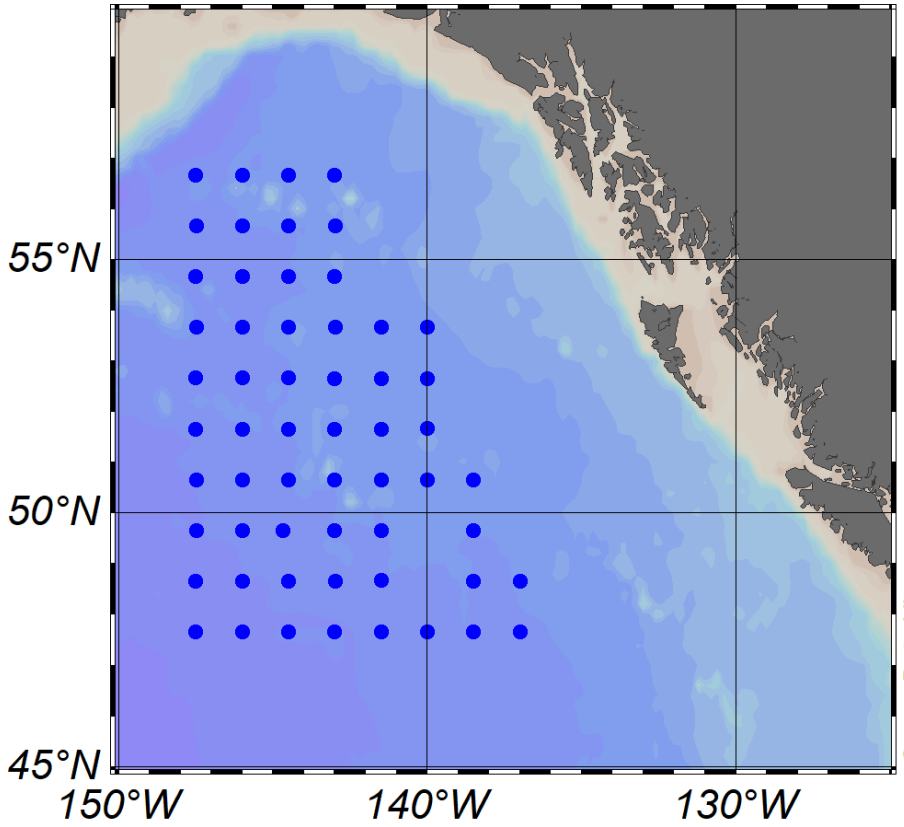

Espinasse et al. 2019

# International Year of the Salmon – 2019

- Salmon: Coho, Chum, Pink, Sockeye & Chinook
- Particulate organic matter (POM)
- Zooplankton (size-fraction)
- Jellyfish, squids, & non-salmonid fish



Gulf of Alaska (GoA)



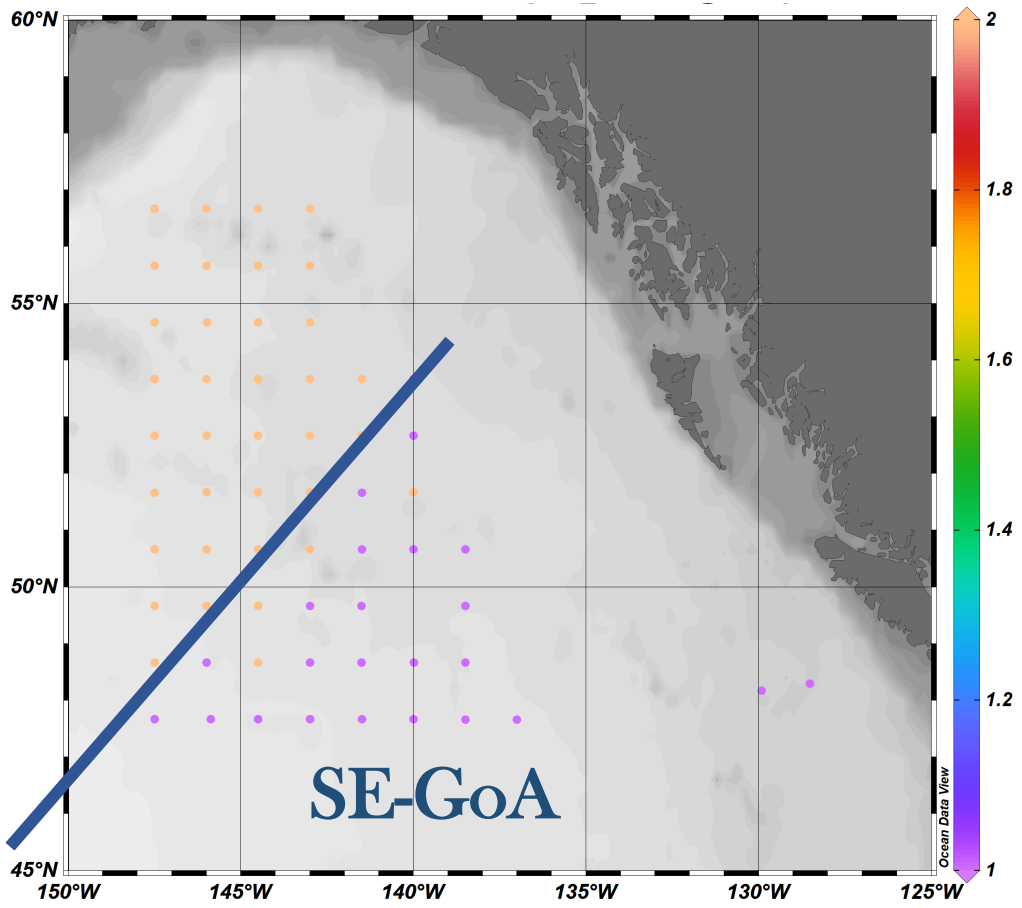
# Subareas - hierarchical cluster analysis (oceanography data)

## NW-GoA

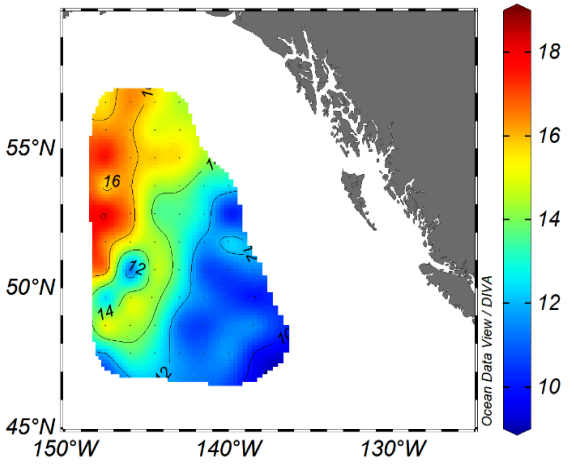
Temperature

Salinity

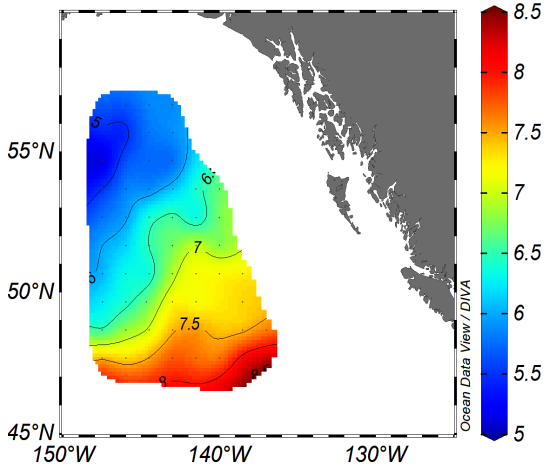
Nutrient []

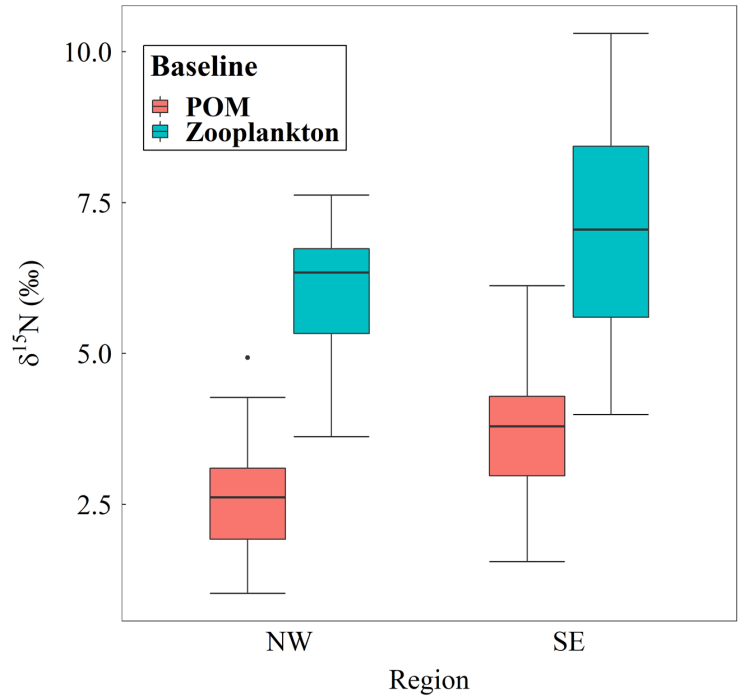



Nutrients

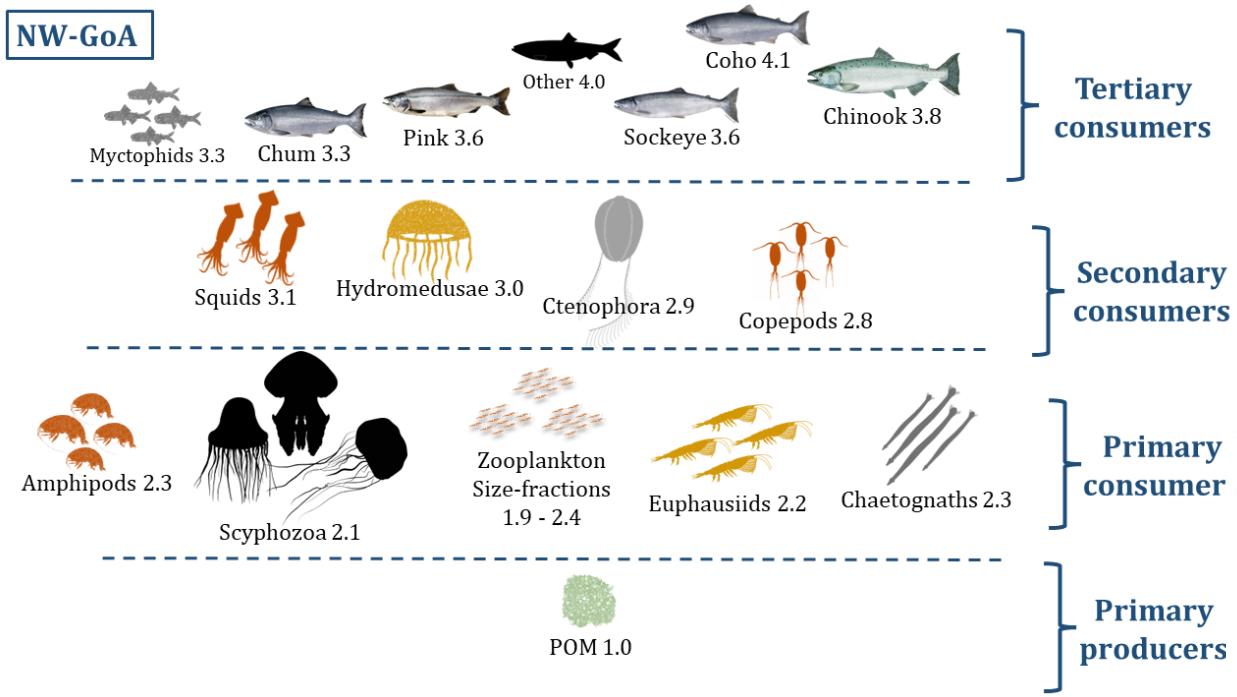



Temperature

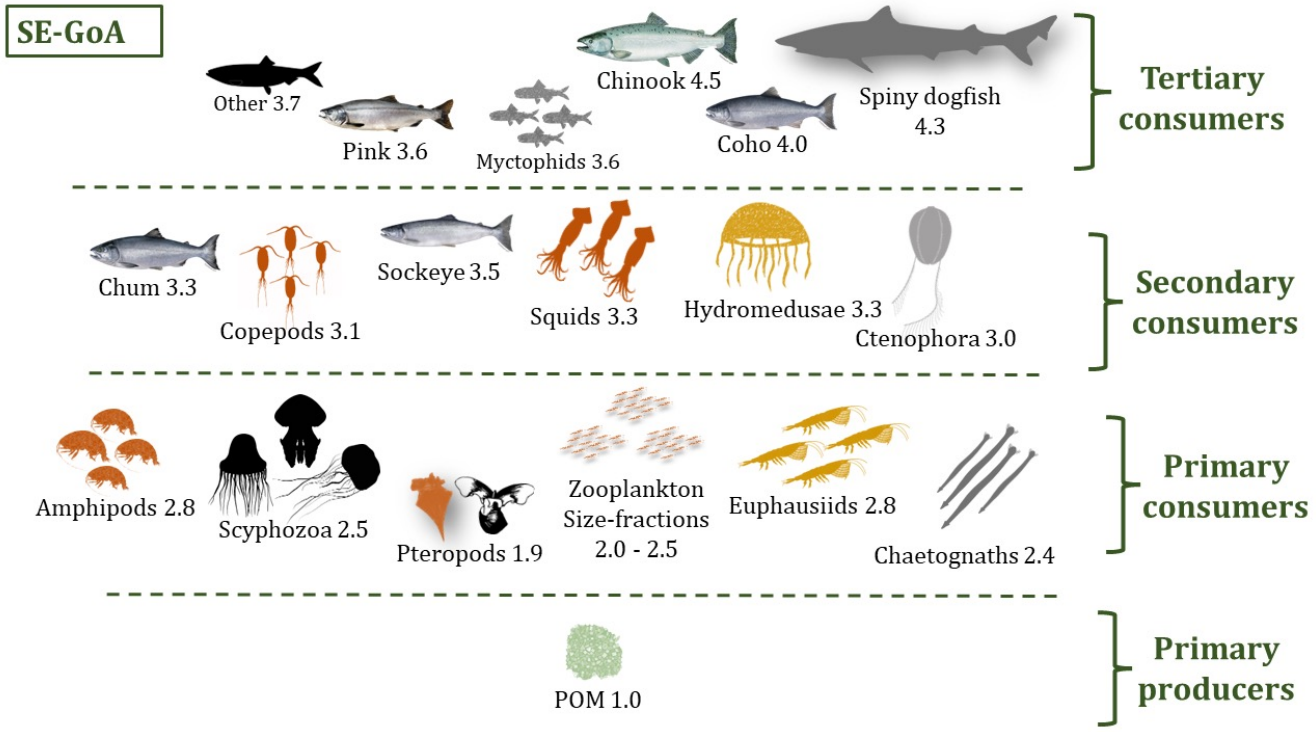


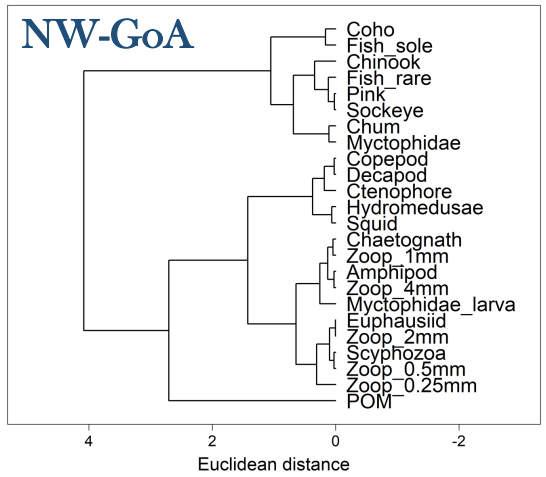



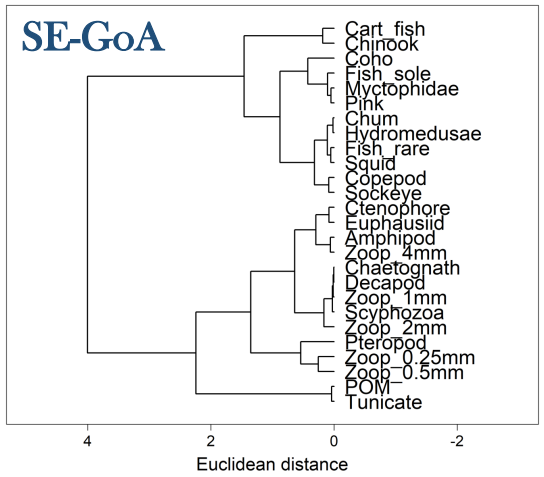
# Food web structure – Trophic positions




$$TP = \frac{\left(\delta^{15}N_{consumer} - \delta^{15}N_{Baseline}\right) + 1}{TEF}$$

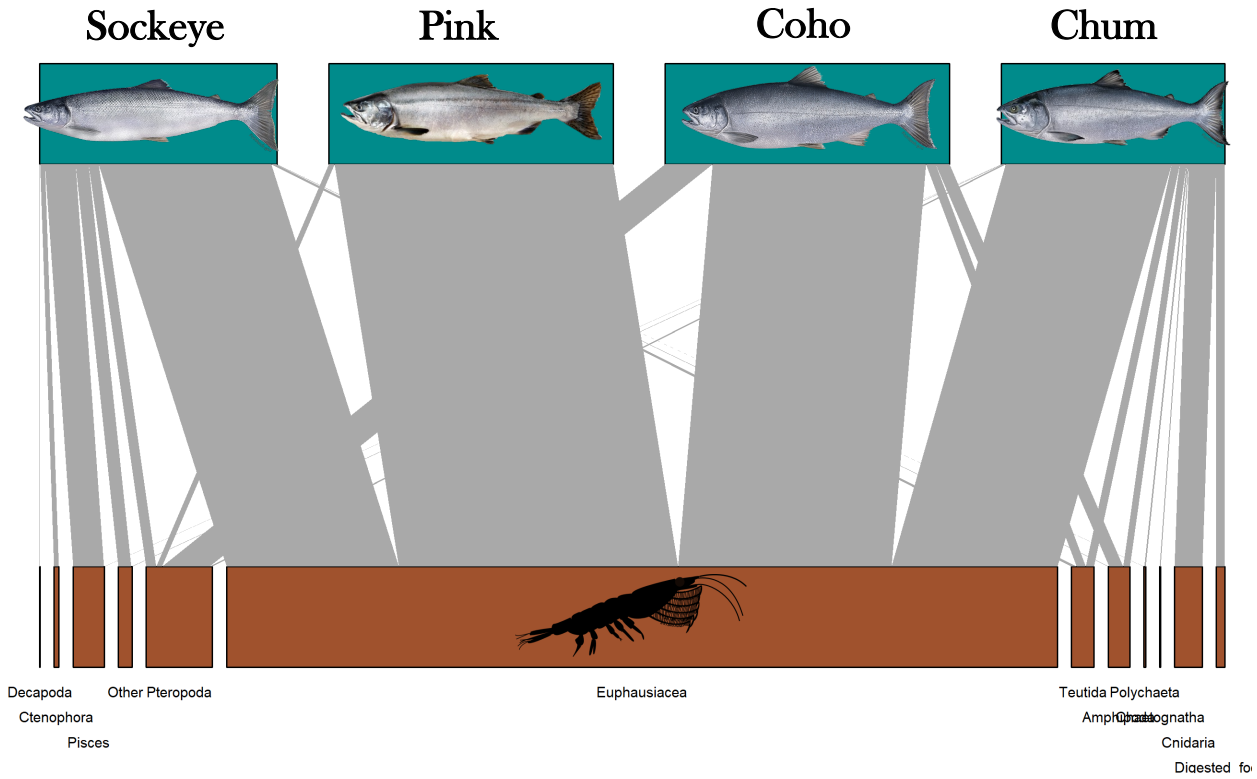


# Salmon diet – Stomach content data

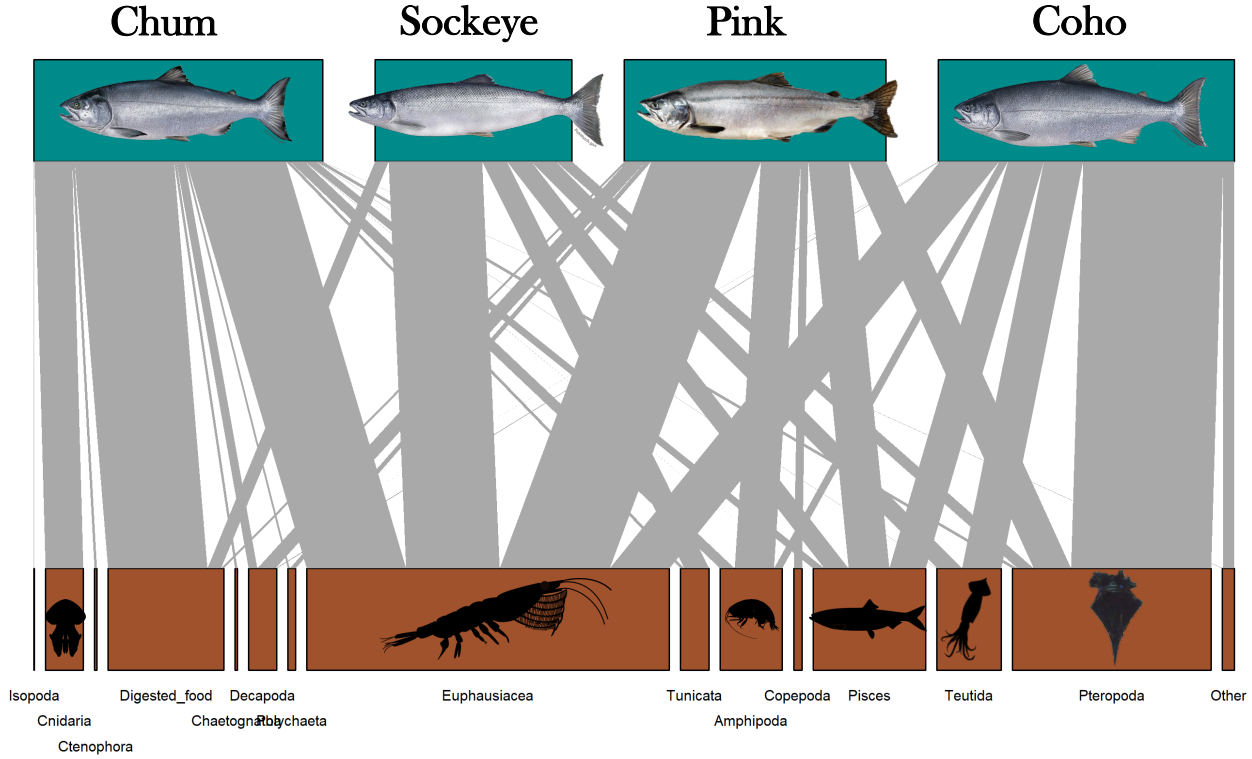
## NW-GoA



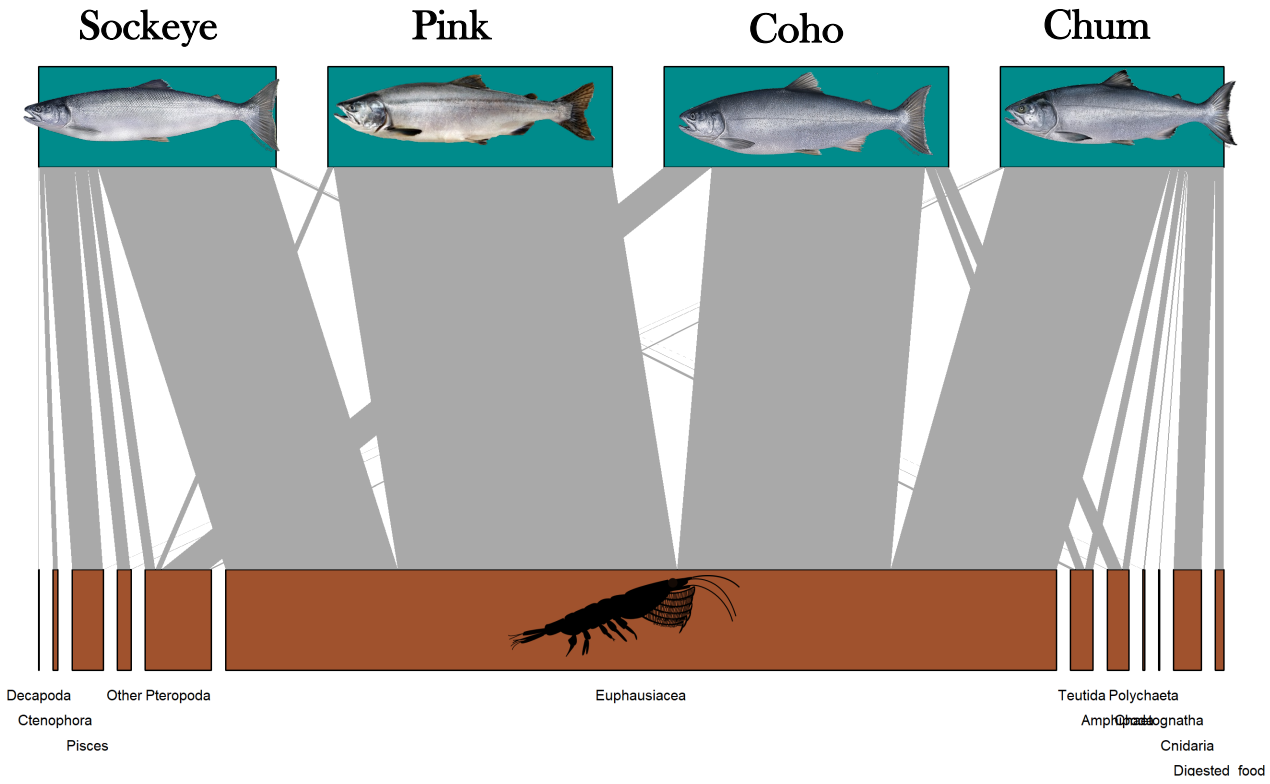

NW-GoA – 60 – 75% krill

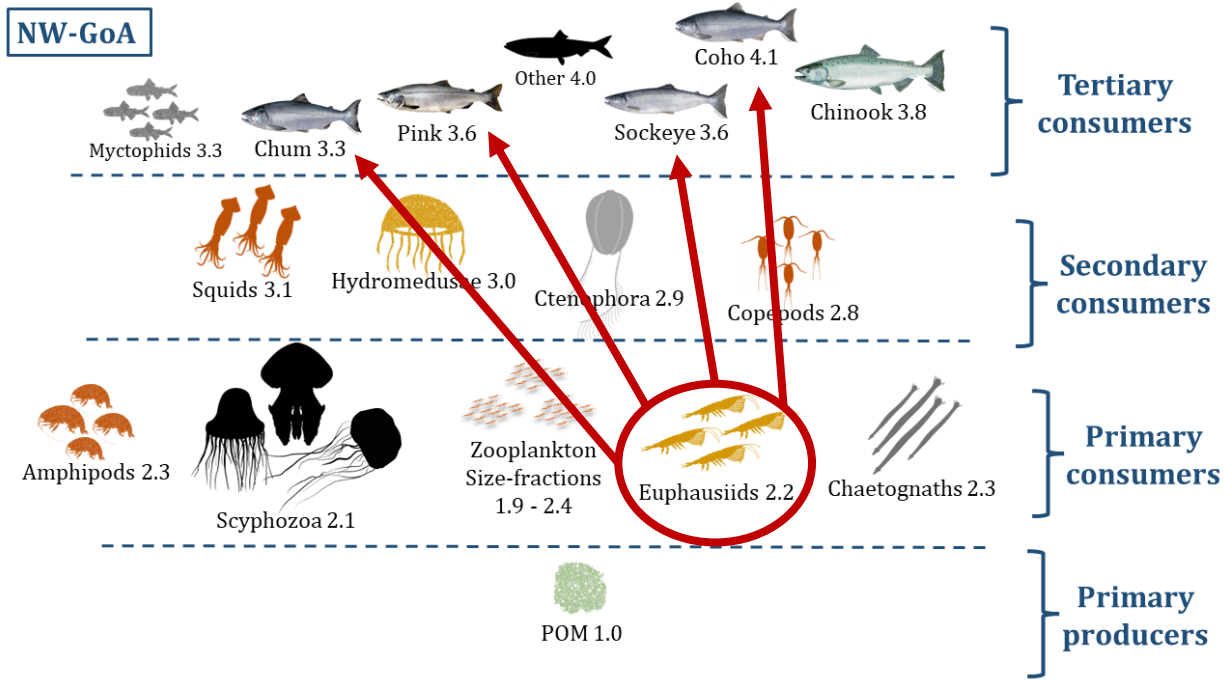
- SE-GoA krill ↘ 30-35%
- ↗ consumption of:
  - Pteropods – Coho, Pink salmon
  - Cnidaria – Chum salmon
  - Fish – Sockeye, Pink salmon
  - Amphipods - Pink salmon

## SE-GoA



# Trophic pathways – NW-GoA

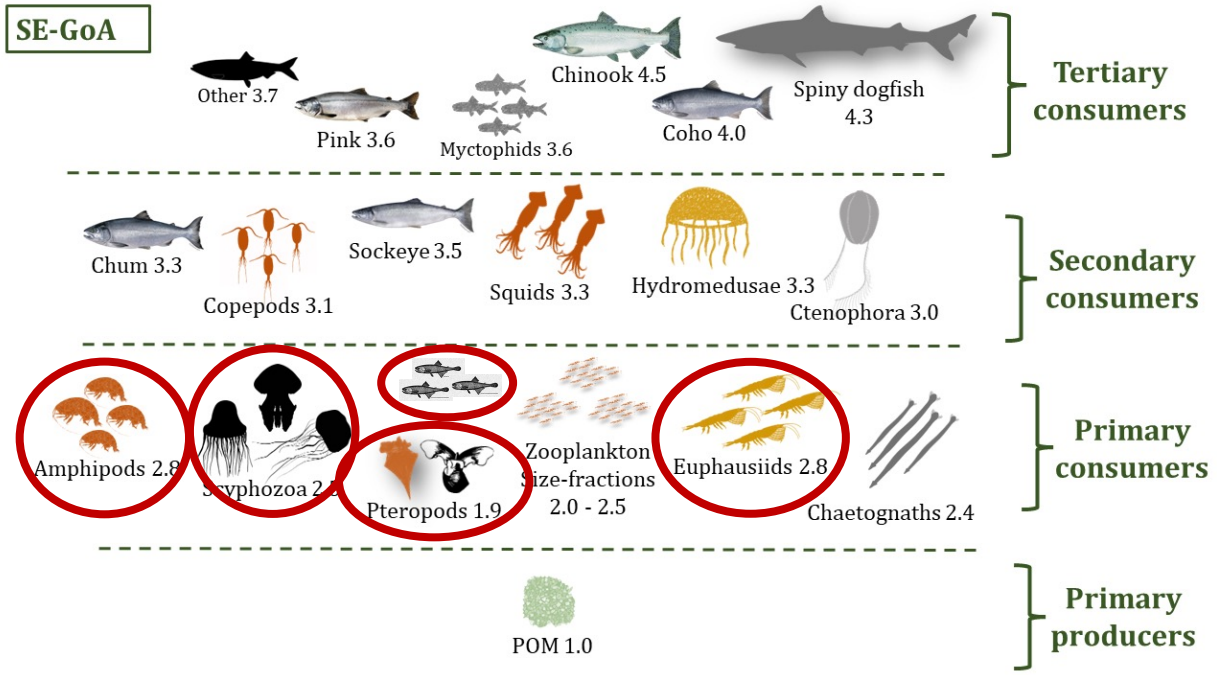


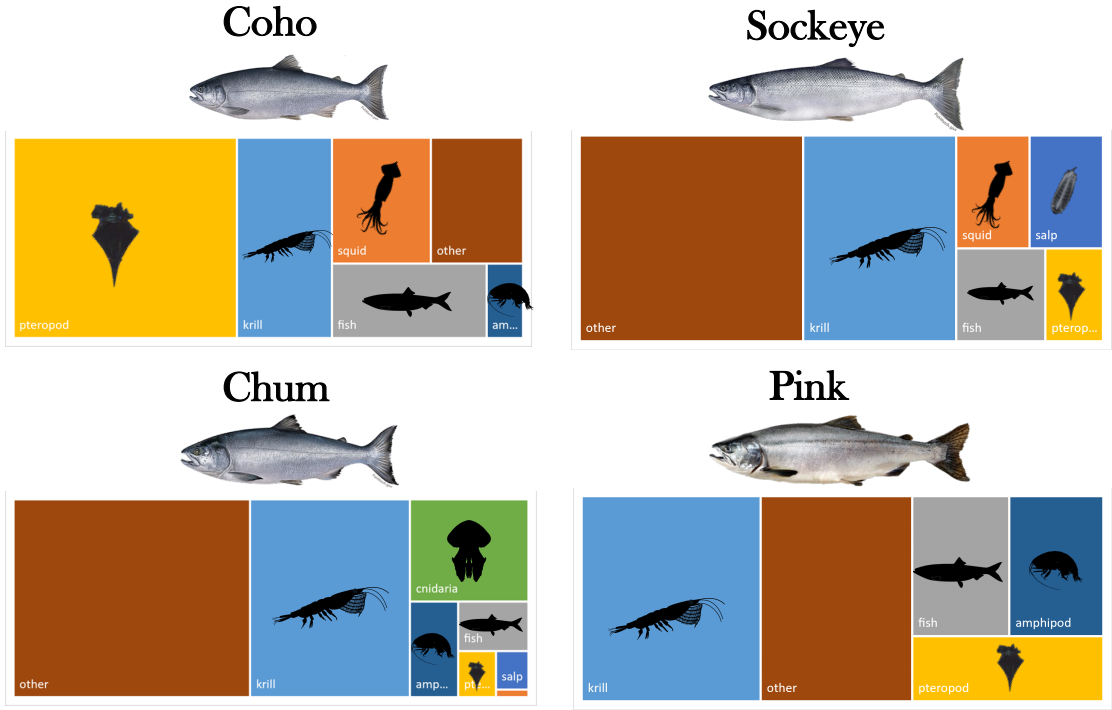




NW-GoA – 60 – 75% krill

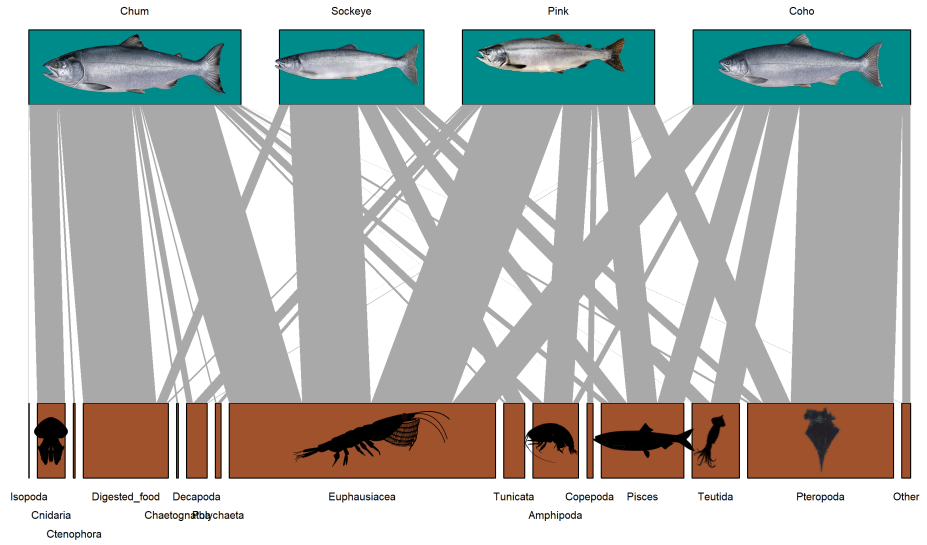
Main pathway between phytoplankton and salmon

# Trophic pathways – SE-GoA



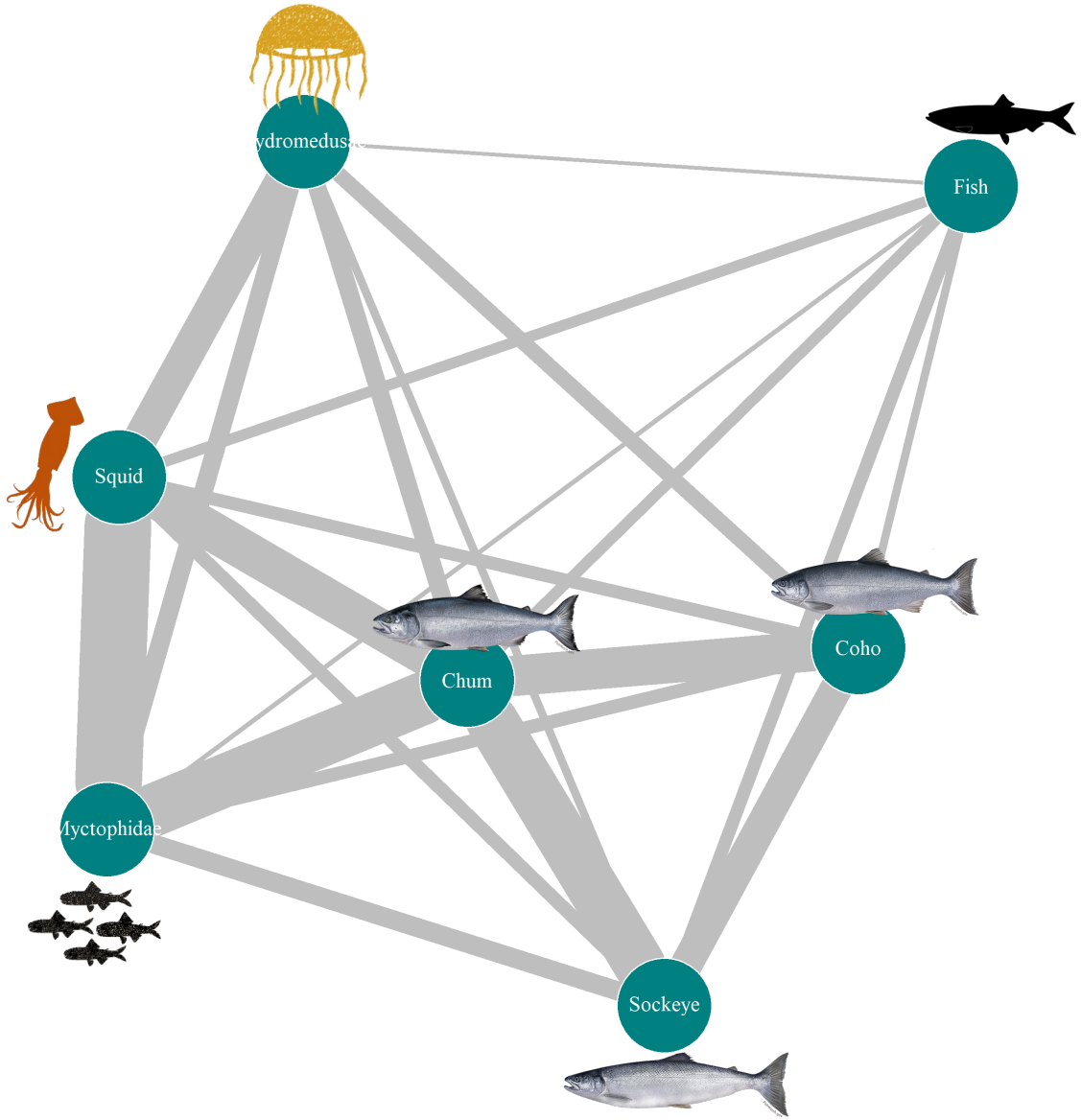




In the SE-GoA salmon consumed a greater diversity of prey

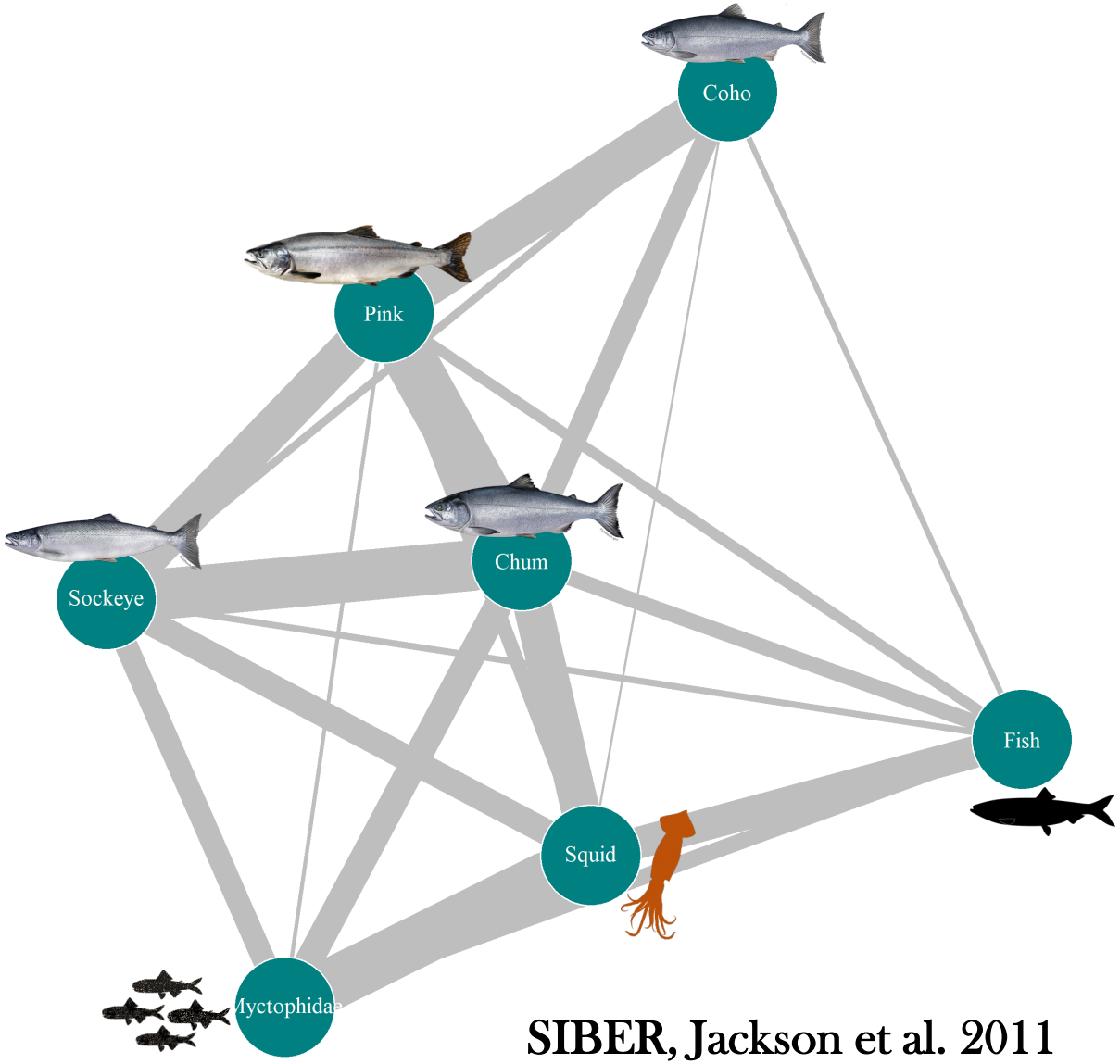


# Isotopic niche overlap

## NW-GoA



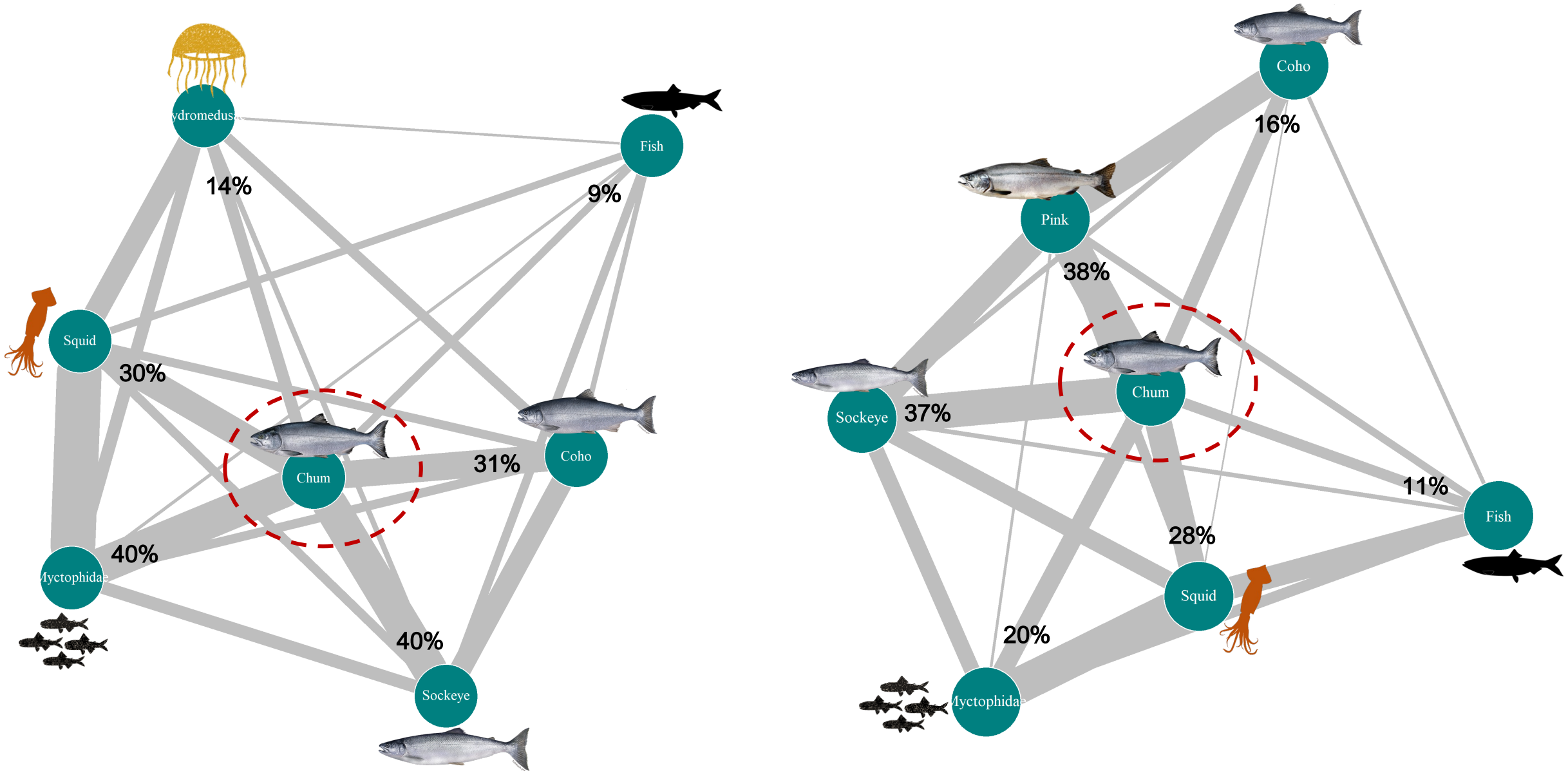

## SE-GoA




SIBER, Jackson et al. 2011

Network analysis

# Isotopic niche overlap



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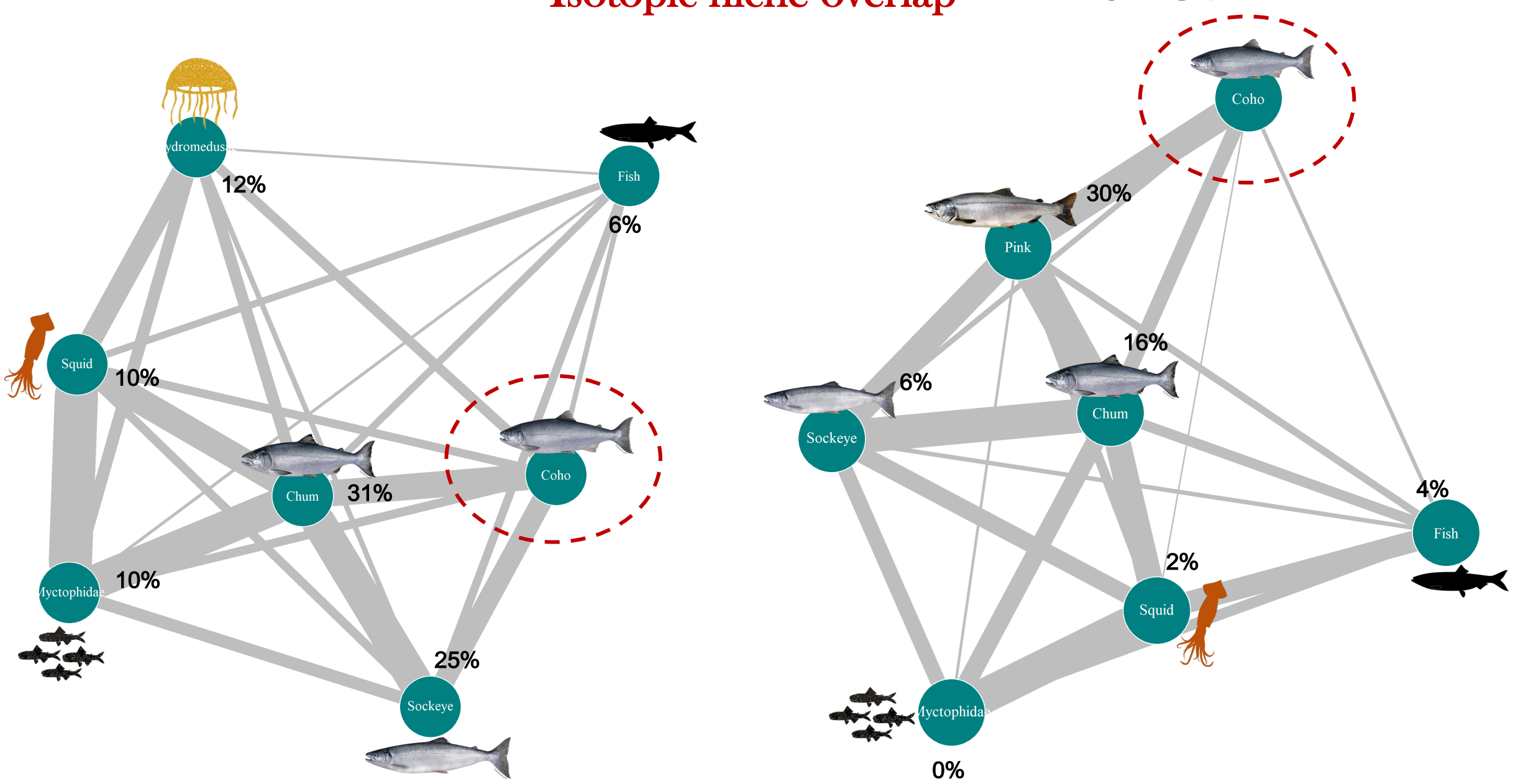

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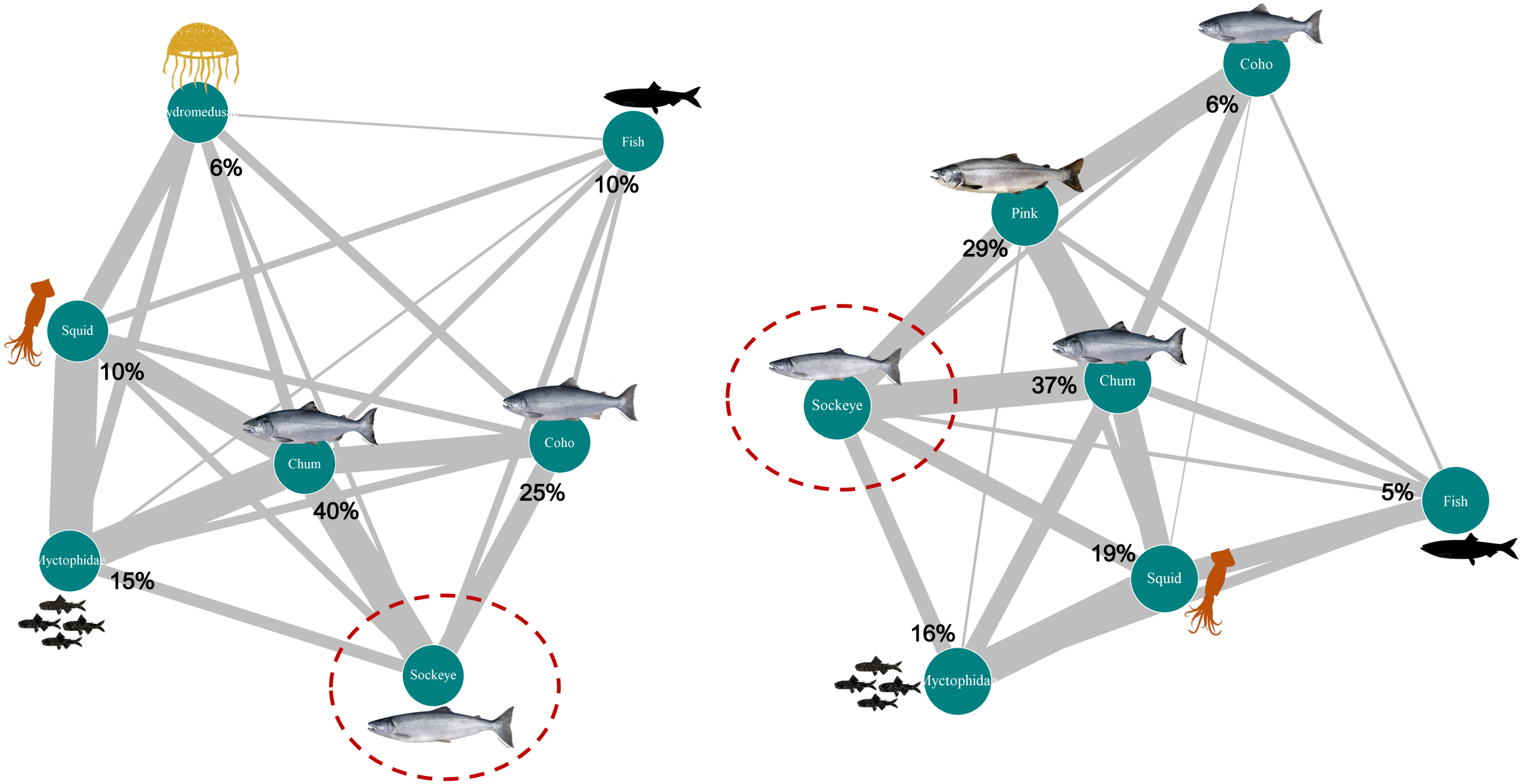
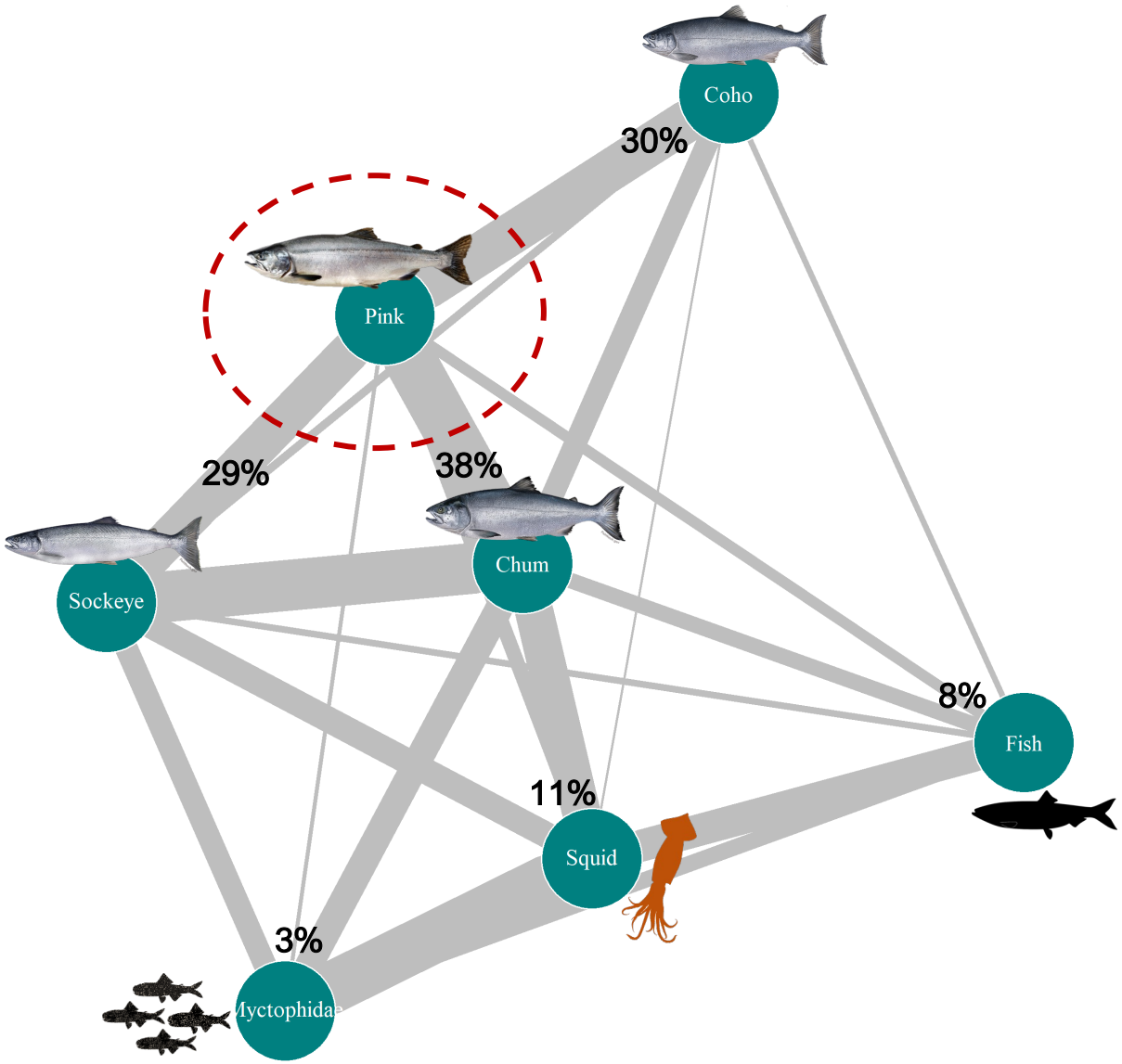


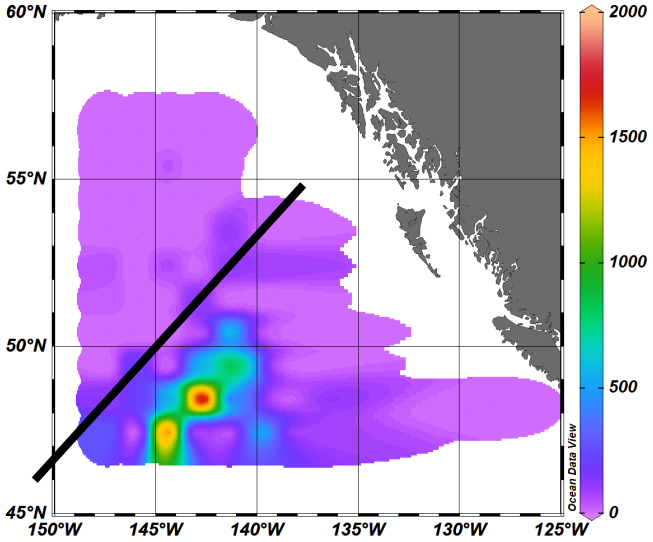
# Isotopic niche overlap

## SE-GoA

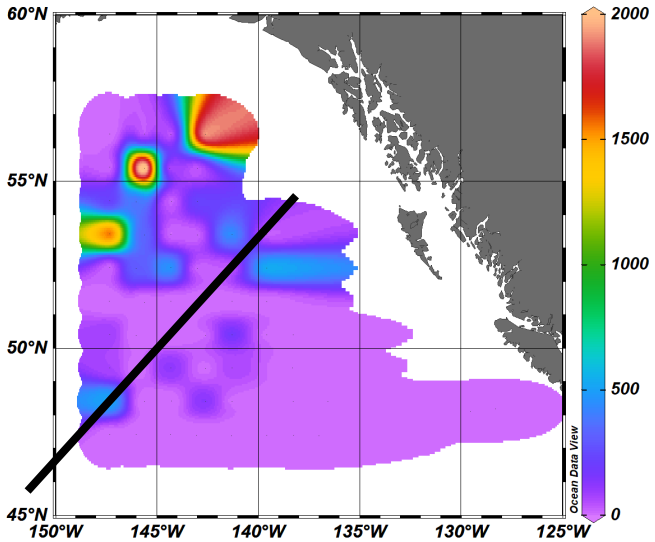


# Salmon biomass distribution

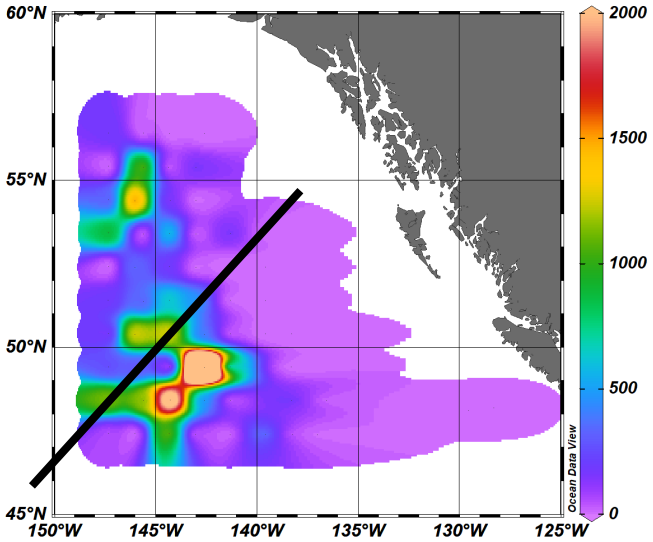
Coho



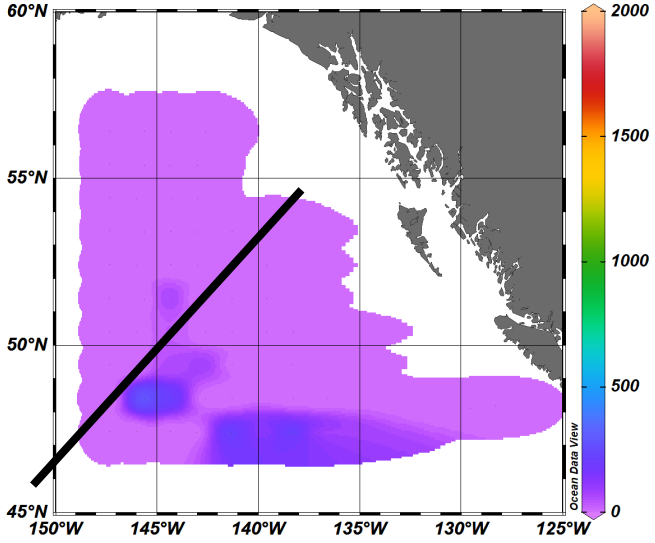
Sockeye



Chum



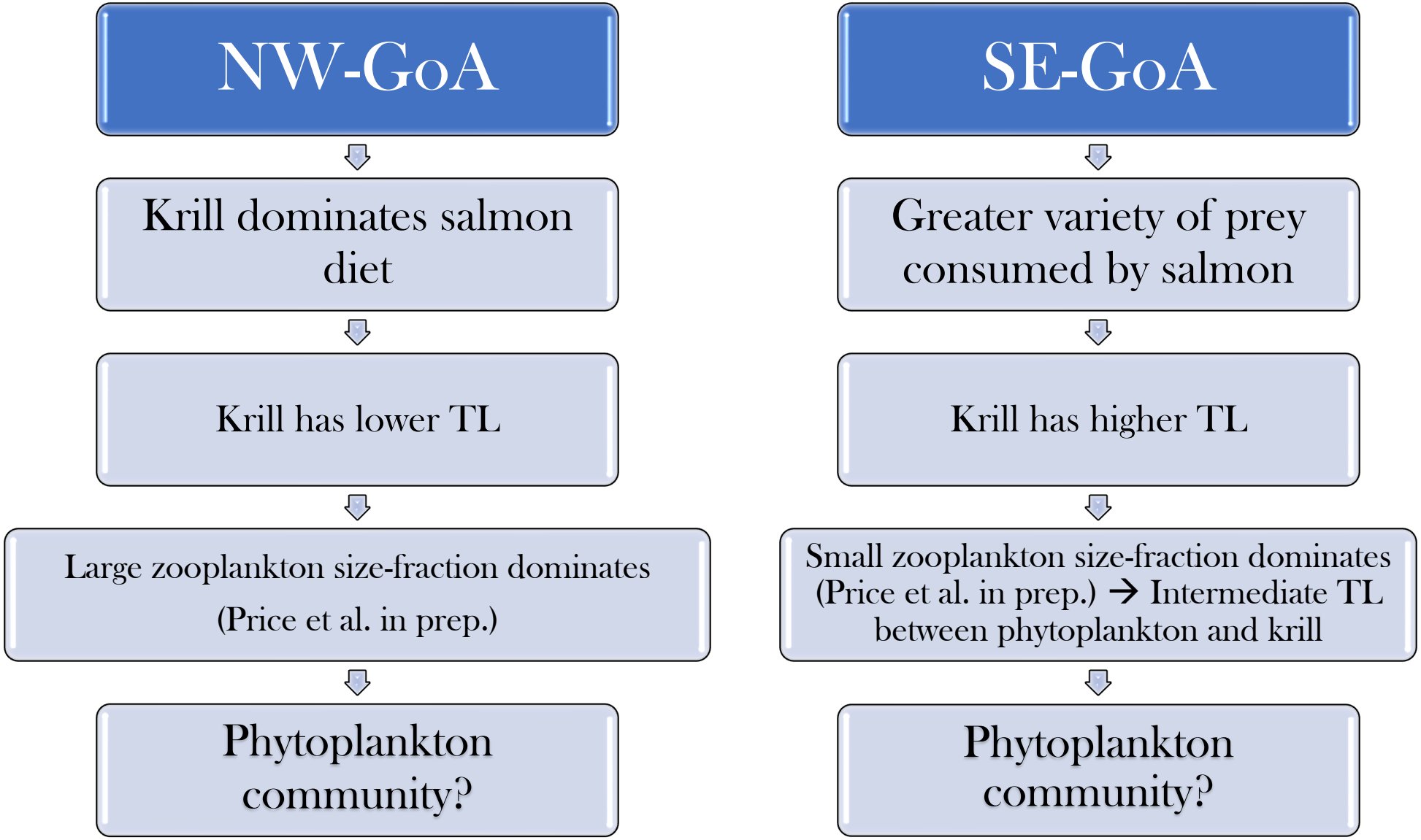
Pink

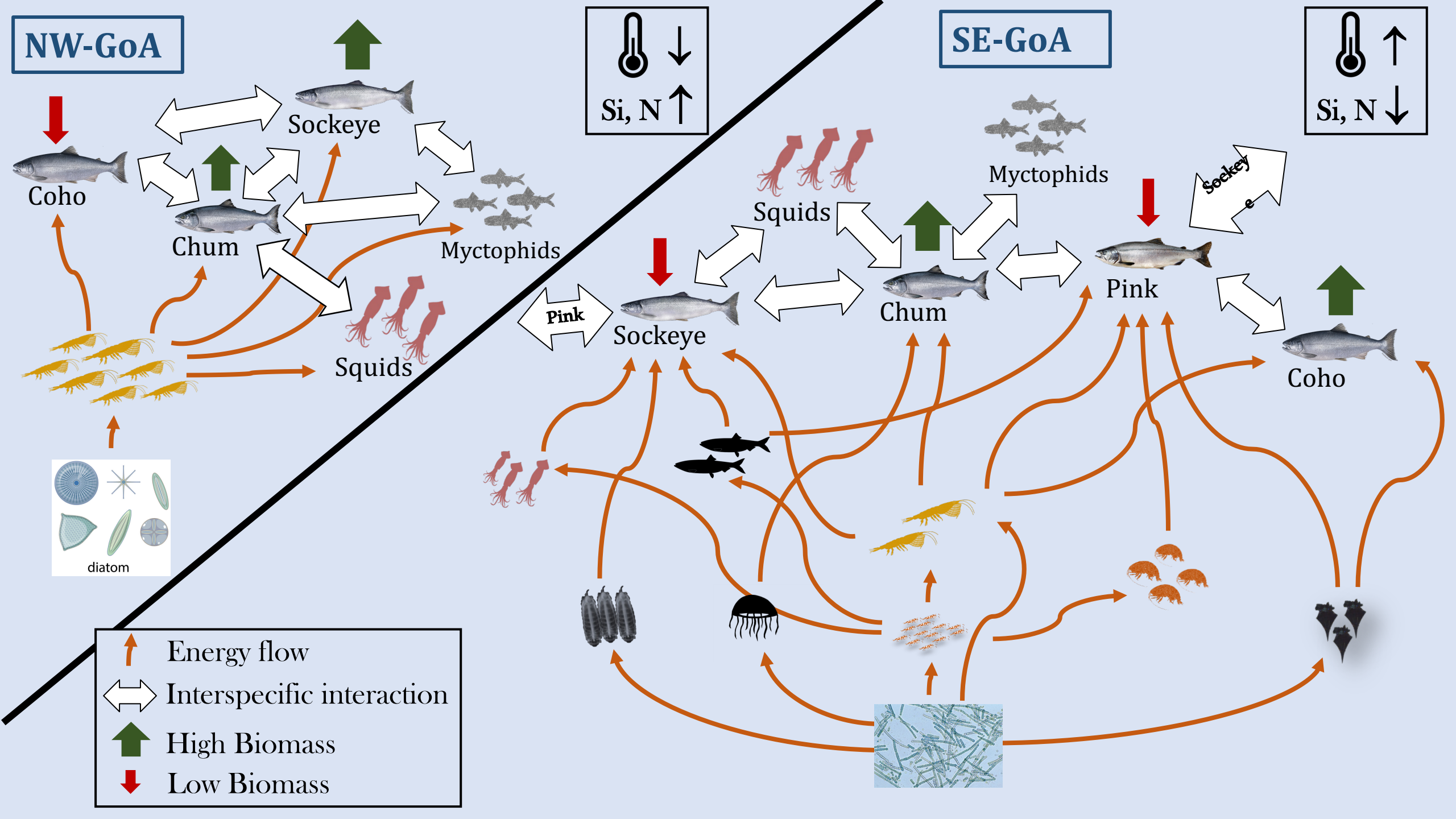


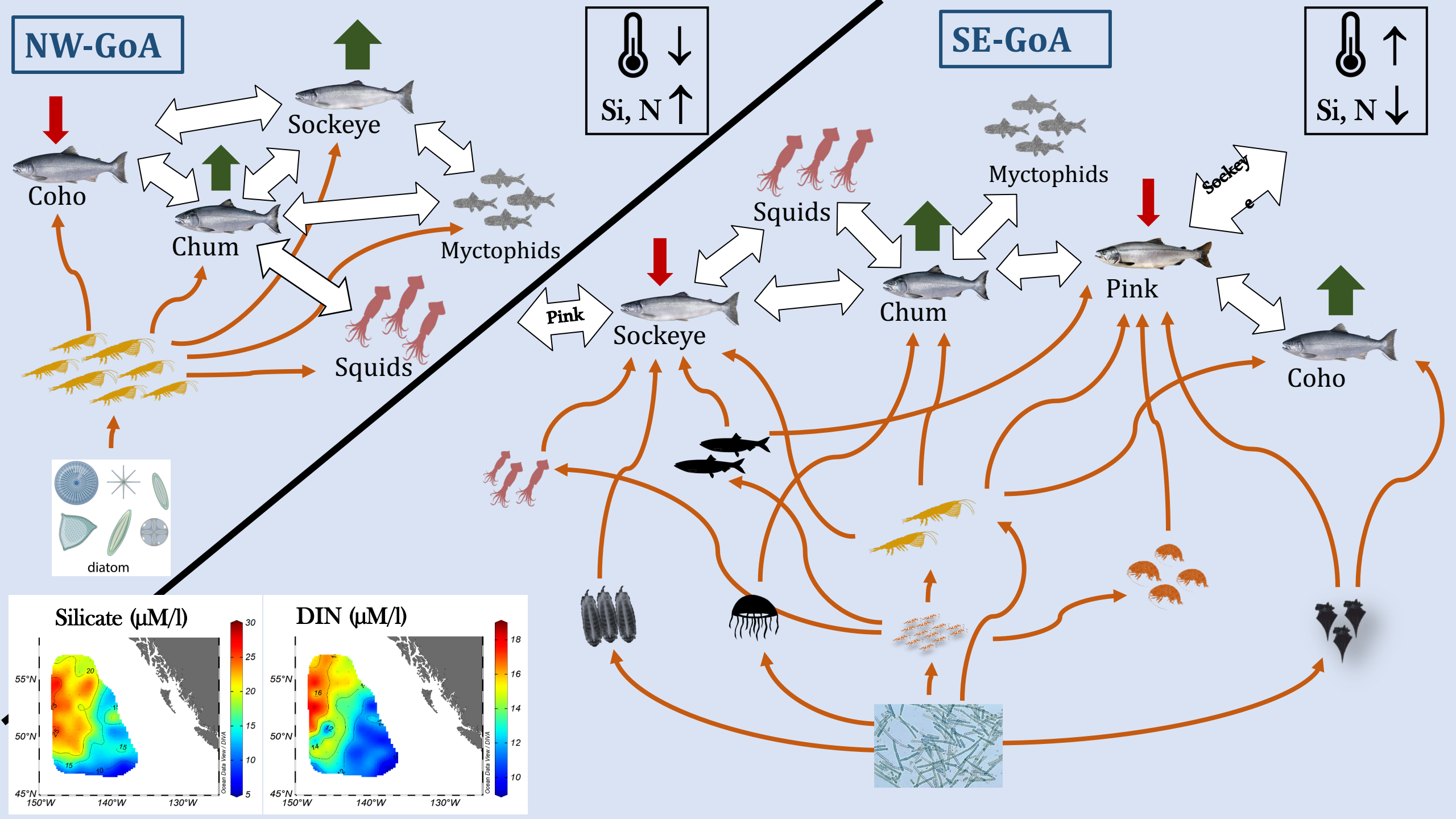

Biomass (thousand tons)

Biomass (thousand tons)

# Summary: base of the food webs




NW-GoA
Si, N ↓
Si, N ↑
SE-GoA
Sockeye
Coho
Chum
Myctophids
Squids
Pink
diatom
Energy flow
Interspecific interaction
High Biomass
Low Biomass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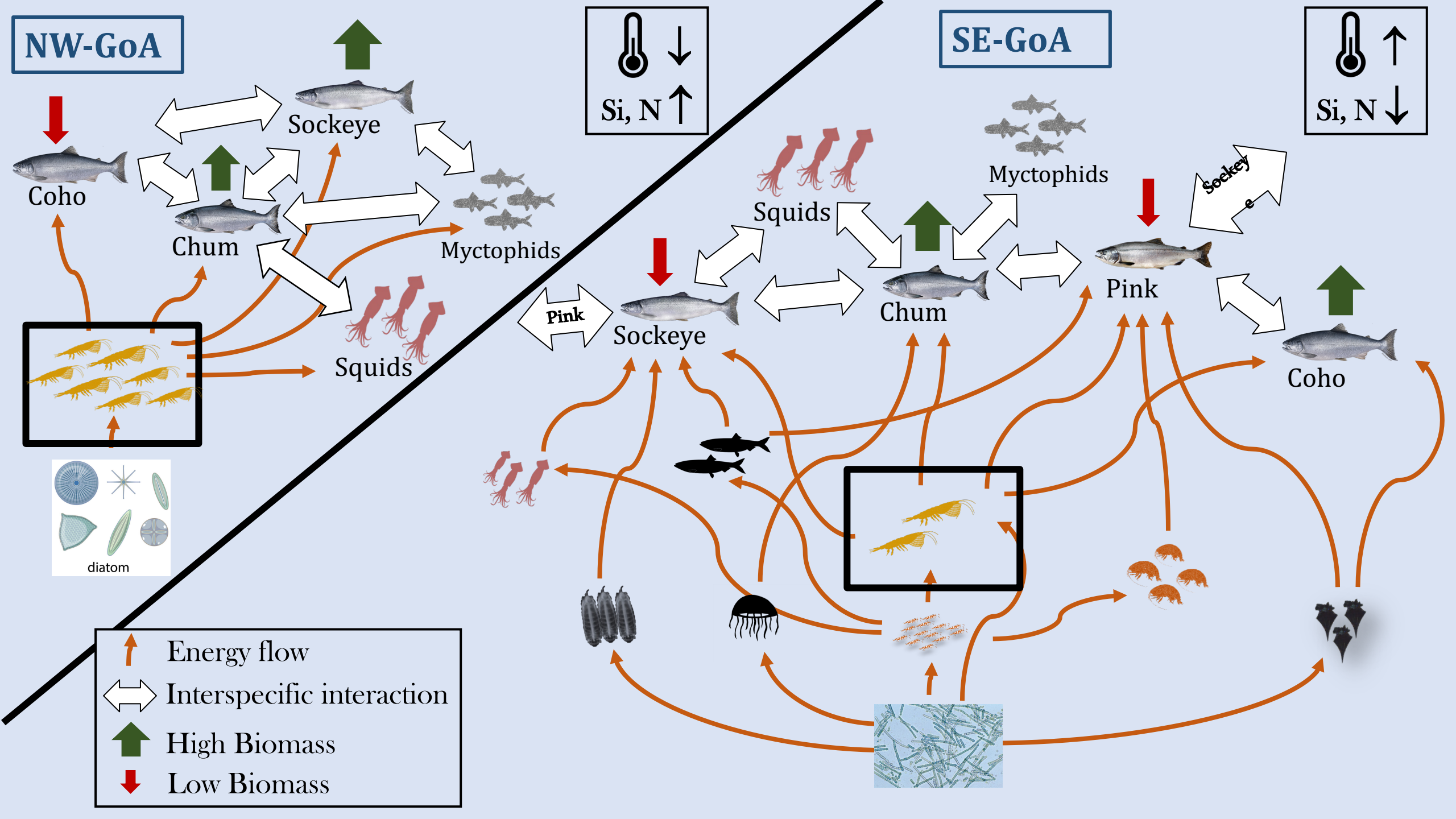
Sockeye
Coho
Chum
Myctophids
Squids
Pink
diatom
Silicate (µM/l)
DIN (µM/l)
55°N
50°N
45°N
150°W
140°W
130°W
Ocean Data View / DIVA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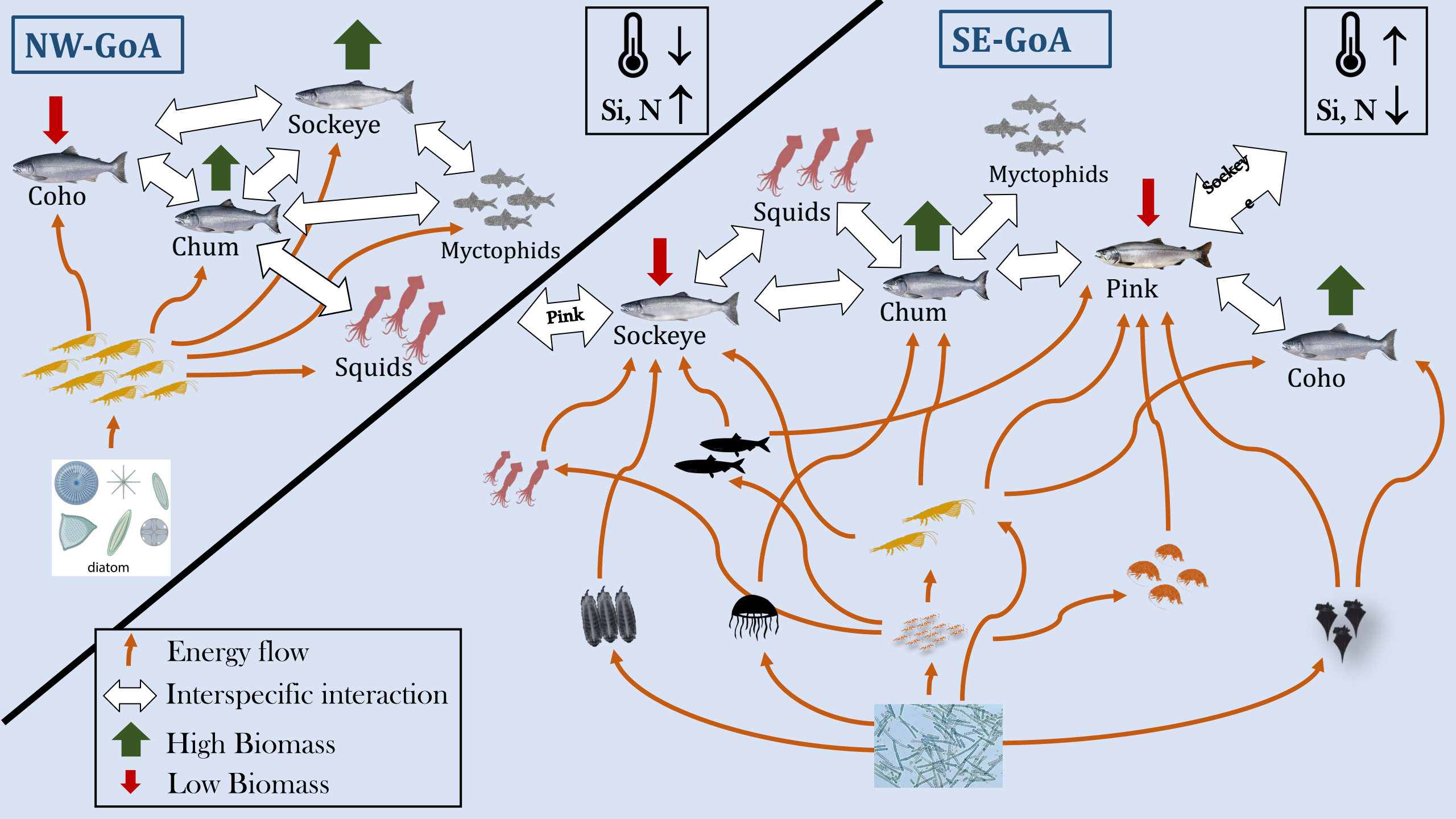
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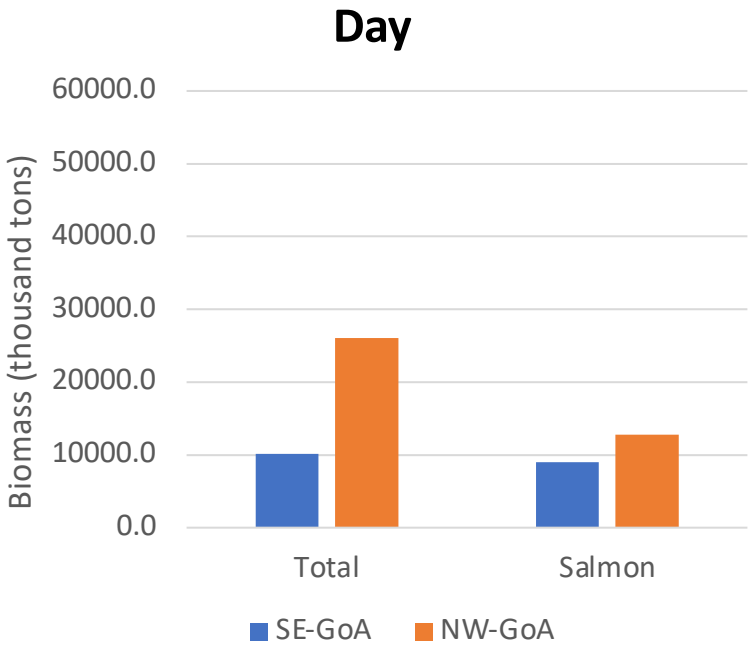
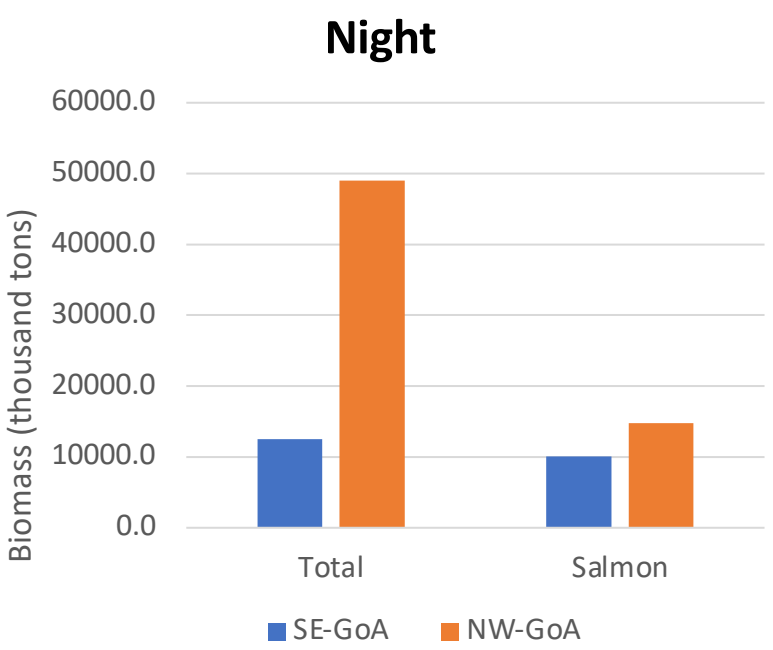
# Main takeaways

- **Describe the trophic structure of the Gulf of Alaska pelagic food webs:**
  1. Oceanographic gradients (NW-SE) → gradients in food web structure & main prey consumed by different salmon species;
  2. Food web less efficient in the SE-GoA – Total & Salmon biomass ↑ NW-GoA




Total = micronekton + salmon

# Main takeaways

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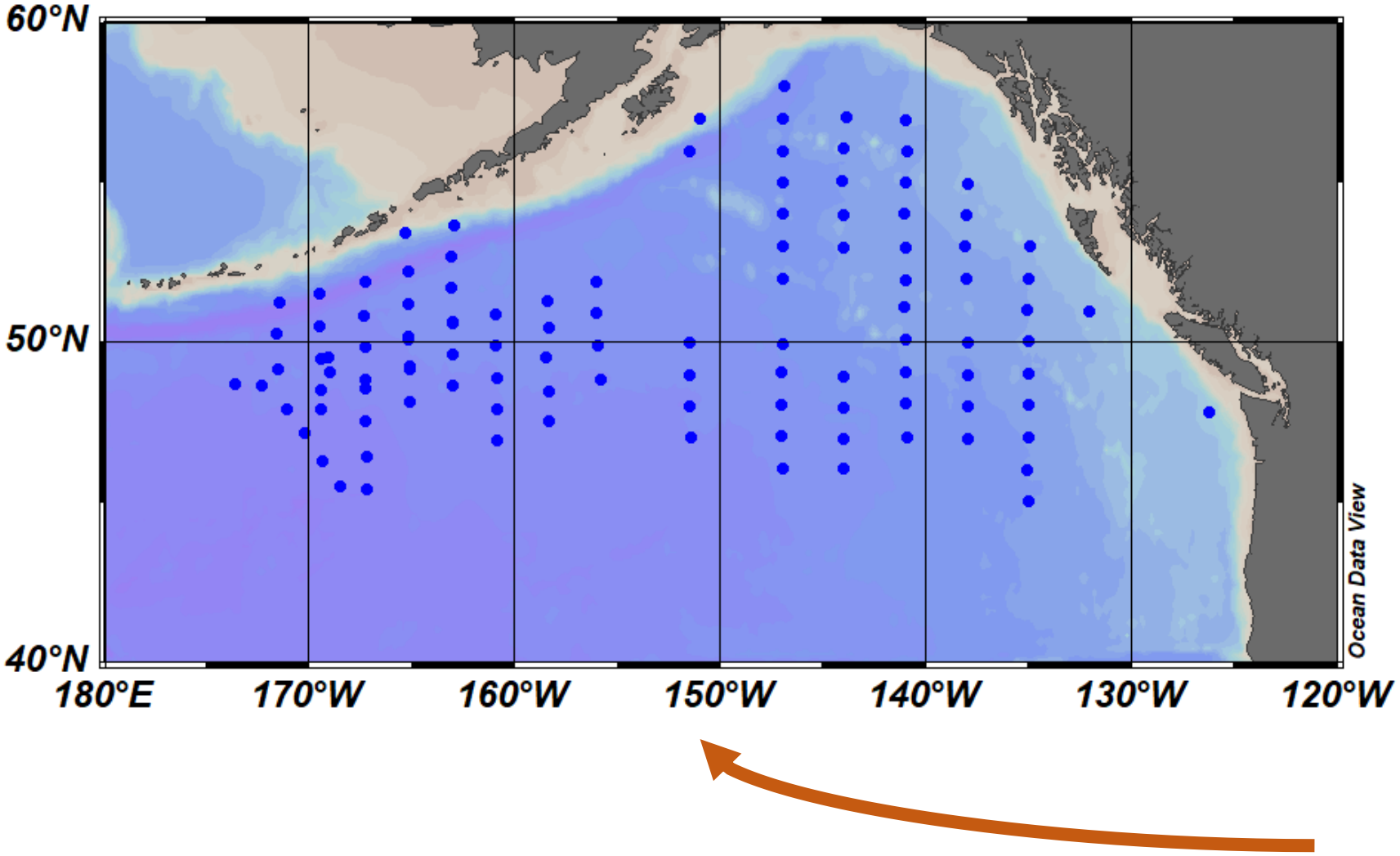
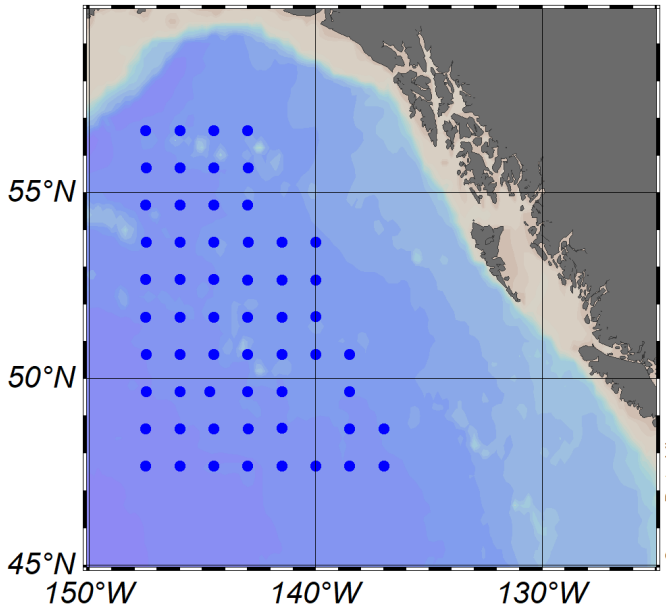
  2. Food web less efficient in the SE-GoA – Total & Salmon biomass ↑ NW-GoA

- **Identify species that compete with salmon for resources in the high seas:**
  1. Chum salmon compete with other salmon, squids and myctophids in both regions
  2. Pink salmon compete with all other salmon species (SE-GoA)
  3. Coho salmon: competition (for krill) in the NW-GoA but not in the SE-GoA – consuming more pteropods and higher biomasses
  4. Sockeye high competition & lower food web efficiency in the SE-GoA → preference for NW region

# IYS 2022 – Pan-Pacific expeditions



# Thank you

g.troina@oceans.ubc.ca