The Presence of Distinct Offshore Planktonic Communities in Coastal British Columbia Inlets

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Introduction


Metridia pacifica

- The British Columbia coastline hosts several unique oceanographic regions: offshore, shelf/neritic, inside waters, and several deep (>400m) inlets (fjords)
- Many species have preferred habitats among these oceanographic regions, subject to change in warmer (El Niño) or cooler (La Niña) years and seasons
- 'Typical' offshore and neritic species have been showing up in high concentrations for both inside waters and inlet regions
- How might these offshore species be transported to the inside and inlet waters?
- Are these species established or is there an annual renewal process occurring?

Regions and Transports

Mainland Inlets

Strait of Georgia / "Salish Sea"

Fraser River
(freshwater input)

Vancouver

Alaska Current

Davidson Current
(Winter)

California Undercurrent
(Summer)

Shelf/Neritic

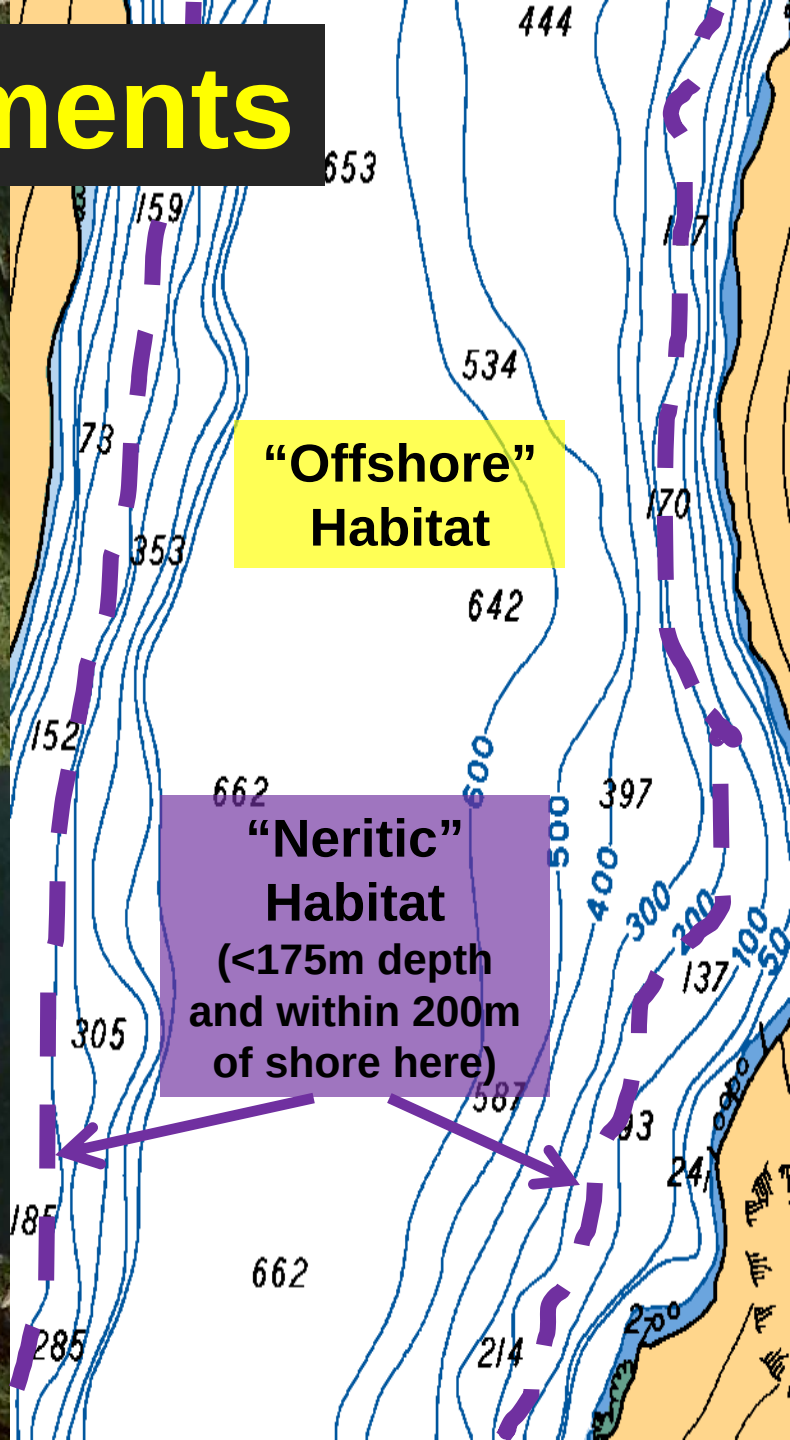
Offshore

Eddies carry species offshore

Tidal Mixing

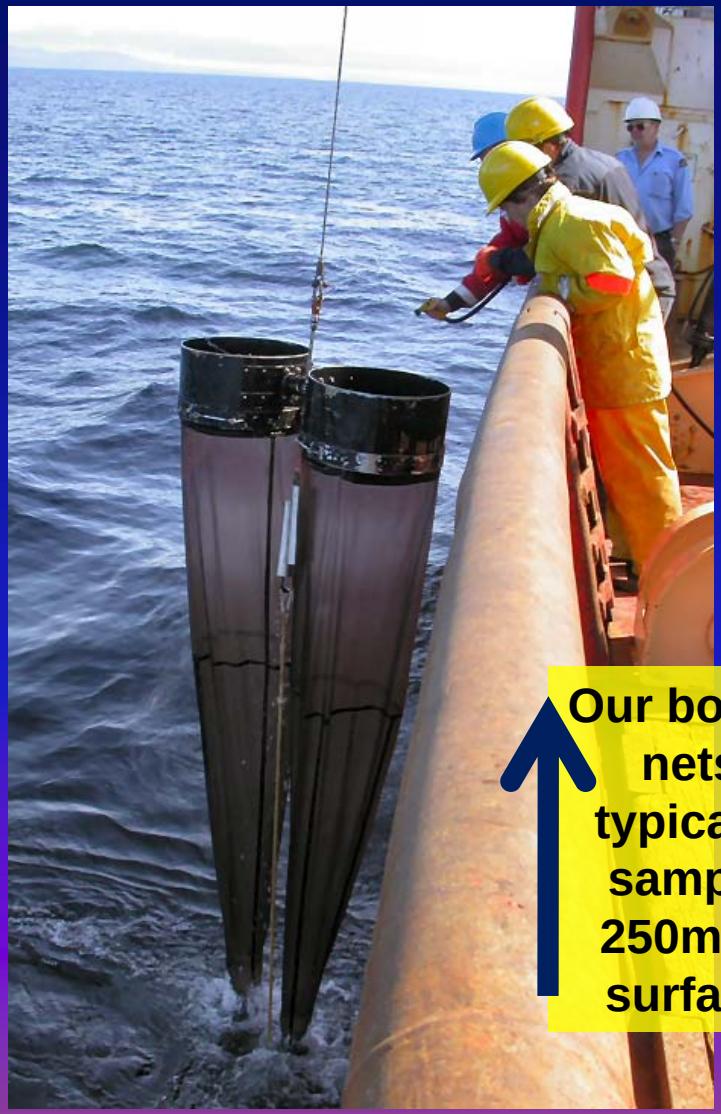
Inlet/Fjord Environments

Steep mountains/cliffs and deep water similar to offshore depths (middle of this channel about 650m depth)



Our data spans from 1990-2010 and we identified ~25 species collected using vertical bongo net tows for this study. Species groupings include:

1. Exclusive Offshore/Neritic (not found in inside waters)
2. Offshore/Neritic (found in inside waters)
3. Widely Distributed
4. Inside Water Performers (offshore and/or neritic that do well in inside waters)
5. Offshore Inlet Performers (offshore that do well in inside waters)



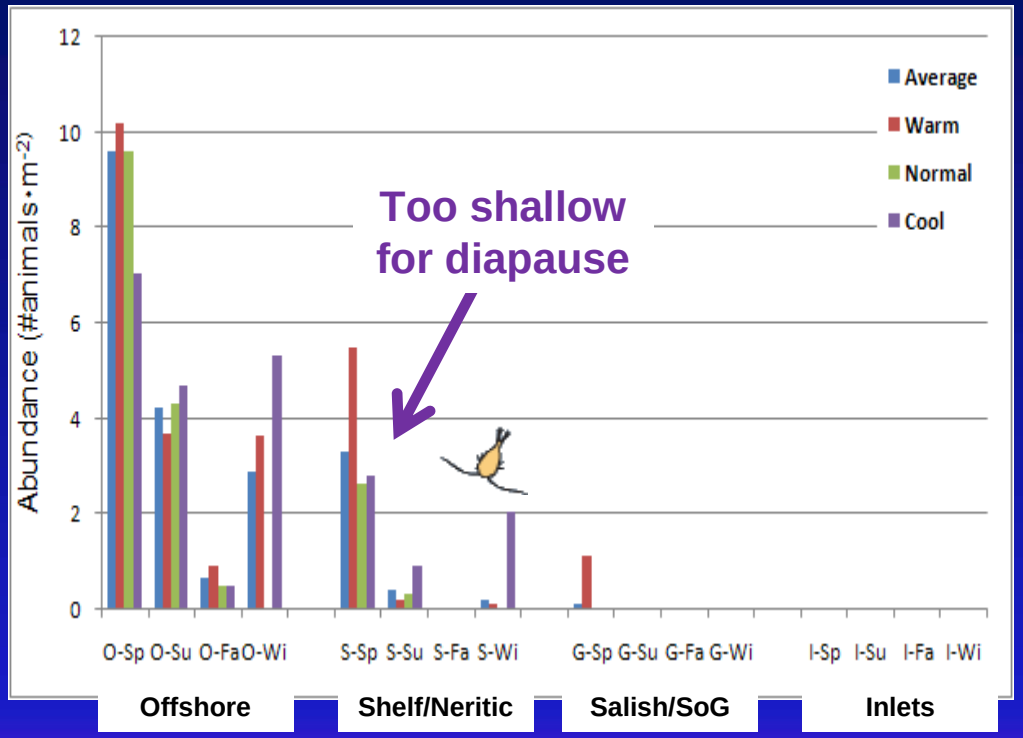
We grouped two decades of data into seasons and calculated zooplankton abundances for each of our regions for overall long-term averages, warm (El Niño), cool (La Niña), and "normal" periods based on the ONI.

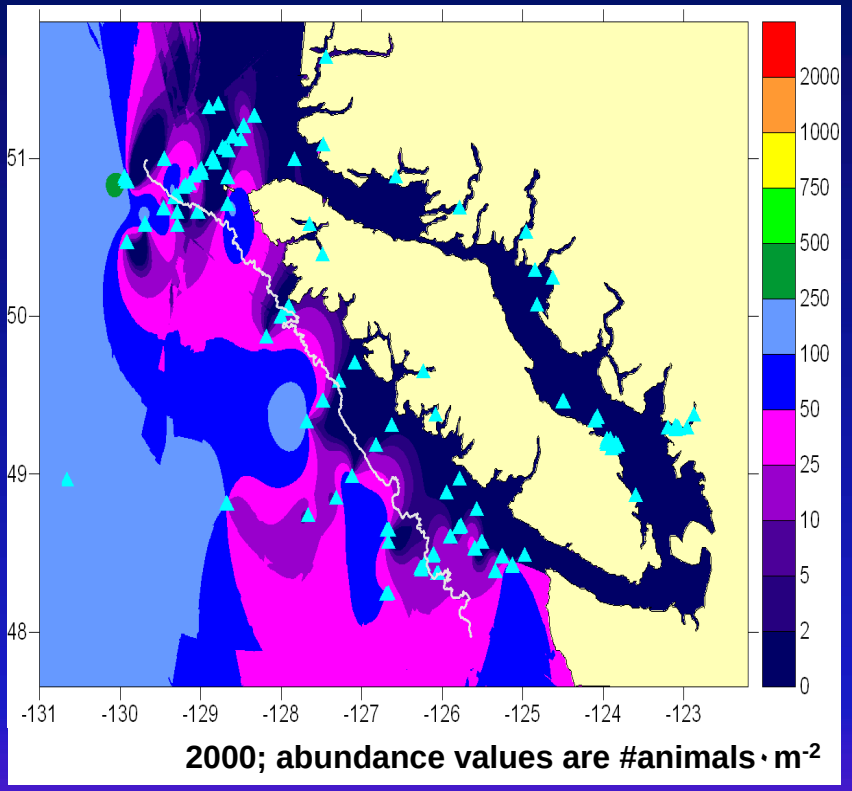
Season	Winter	Spring			Summer			Fall			Winter	
Year	J	F	M	A	M	J	J	A	S	O	N	D
1990	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4
1991	0.4	0.3	0.3	0.4	0.6	0.8	1	0.9	0.9	1	1.4	1.6
1992	1.8	1.6	1.5	1.4	1.2	0.8	0.5	0.2	0	-0.1	0	0.2
1993	0.3	0.4	0.6	0.7	0.8	0.7	0.4	0.4	0.4	0.4	0.3	0.2
1994	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.9	1.2	1.3
1995	1.2	0.9	0.7	0.4	0.3	0.2	0	-0.2	-0.5	-0.6	-0.7	-0.7
1996	-0.7	-0.7	-0.5	-0.3	-0.1	-0.1	0	-0.1	-0.1	-0.2	-0.3	-0.4
1997	-0.4	-0.3	0	0.4	0.8	1.3	1.7	2	2.2	2.4	2.5	2.5
1998	2.3	1.9	1.5	1	0.5	0	-0.5	-0.8	-1	-1.1	-1.3	-1.4
1999	-1.4	-1.2	-0.9	-0.8	-0.8	-0.8	-0.9	-0.9	-1	-1.1	-1.3	-1.6
2000	-1.6	-1.4	-1	-0.8	-0.6	-0.5	-0.4	-0.4	-0.4	-0.5	-0.6	-0.7
2001	-0.6	-0.5	-0.4	-0.2	-0.1	0.1	0.2	0.2	0.1	0	-0.1	-0.1
2002	-0.1	0.1	0.2	0.4	0.7	0.8	0.9	1	1.1	1.3	1.5	1.4
2003	1.2	0.9	0.5	0.1	-0.1	0.1	0.4	0.5	0.6	0.5	0.6	0.4
2004	0.4	0.3	0.2	0.2	0.3	0.5	0.7	0.8	0.9	0.8	0.8	0.8
2005	0.7	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.2	-0.1	-0.4	-0.7
2006	-0.7	-0.6	-0.4	-0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.1	1.1
2007	0.8	0.4	0.1	-0.1	-0.1	-0.1	-0.1	-0.4	-0.7	-1	-1.1	-1.3
2008	-1.4	-1.4	-1.1	-0.8	-0.6	-0.4	-0.1	0	0	0	-0.3	-0.6
2009	-0.8	-0.7	-0.5	-0.1	0.2	0.6	0.7	0.8	0.9	1.2	1.5	1.8
2010	1.7	1.5	1.2	0.8	0.3	-0.2	-0.6	-1	-1.3	-1.4	-1.4	-1.4

Oceanic Niño Index: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Exclusive Offshore/Neritic: Not in Inside Waters

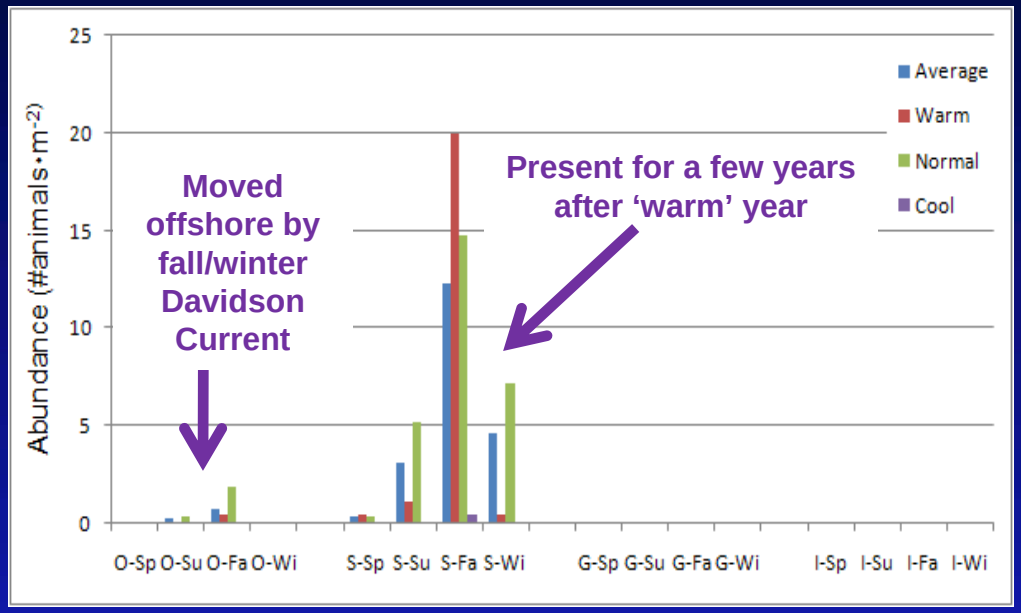
Neocalanus cristatus (Subarctic habitat)

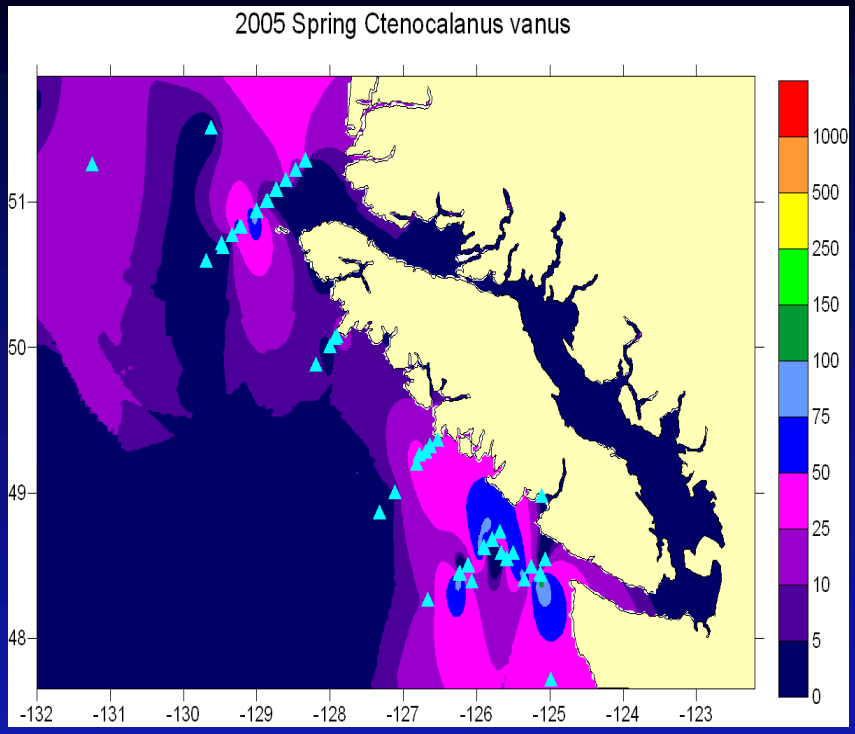




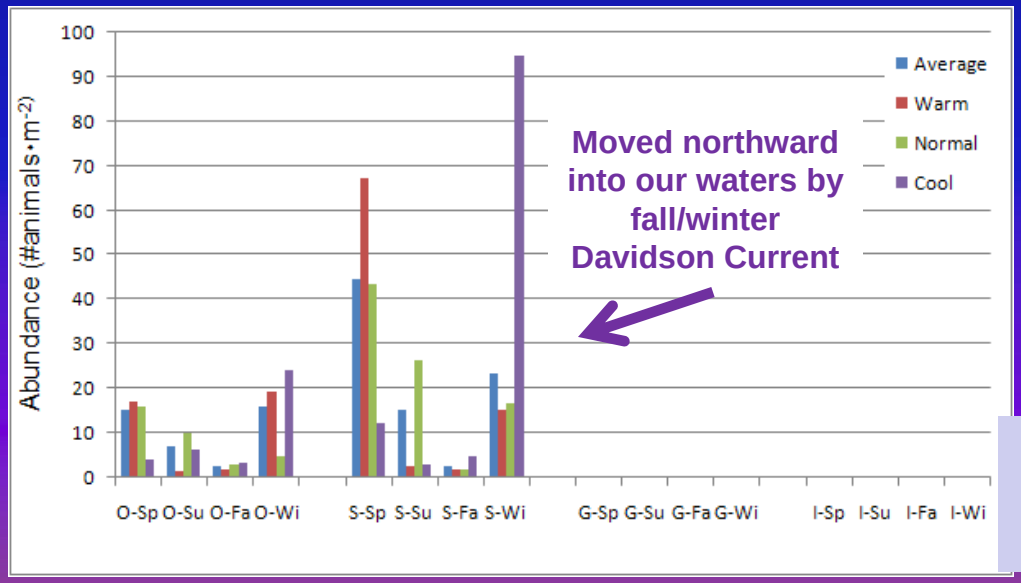
- Deep overwintering offshore species; drops in early June-July to ~1200m
- Not present in offshore/shelf water column during summer Salish Sea flushing
- Some deep inlets (>600m) might provide suitable habitats, but we have not found them present (possibly due to our net tows do not exceed 250m)

Acartia tonsa (Warm Neritic)





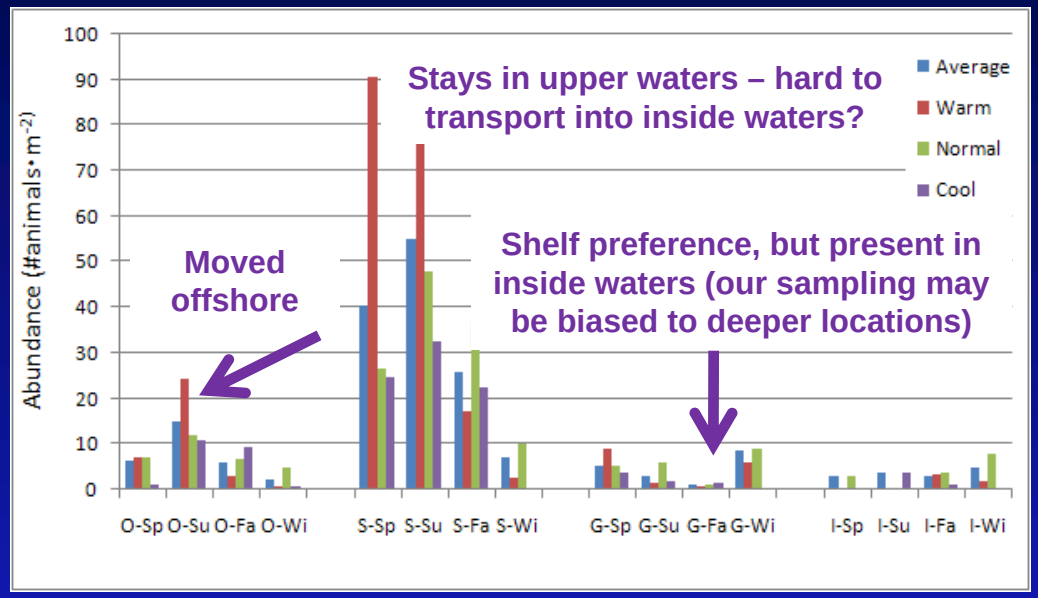
Ctenocalanus vanus (Warm Neritic)

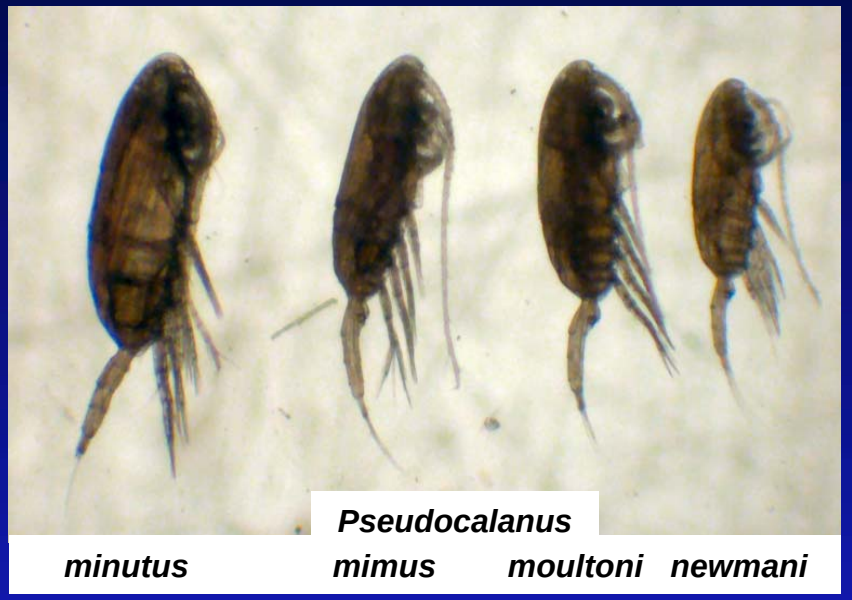


Both are surface water animals therefore hard to transport to inside waters (stay tuned)

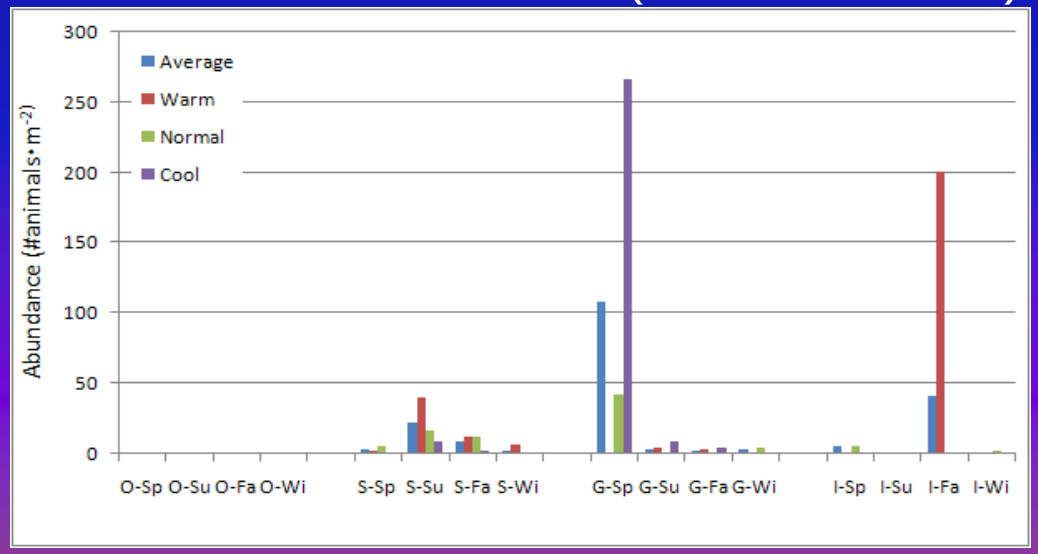
Onshore/Neritic: Found in Inside Waters

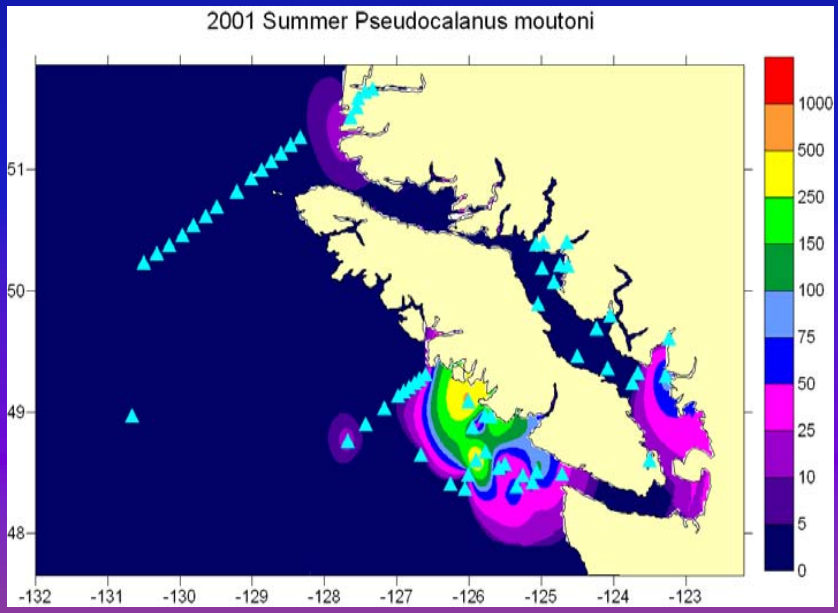
Calanus marshallae (Cold Neritic)





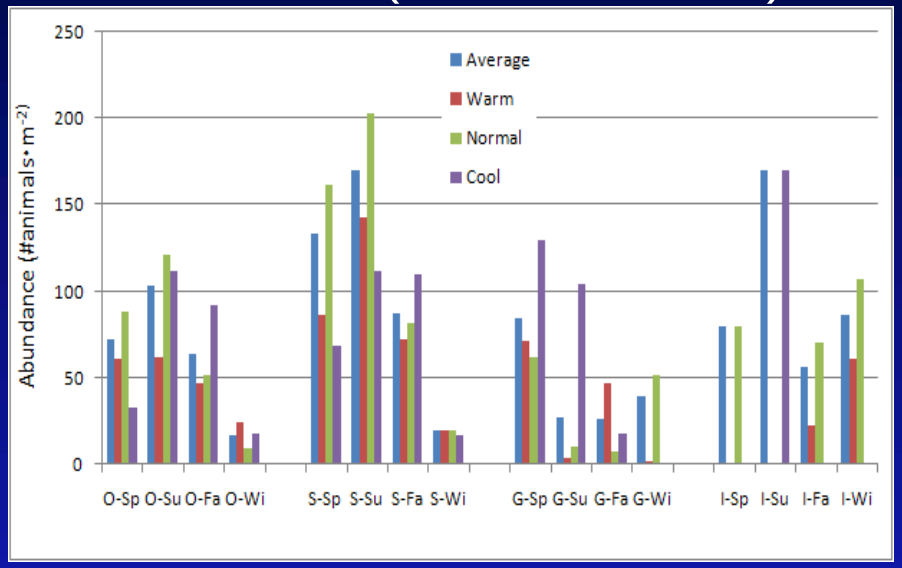
Pseudocalanus moultoni (Boreal to Arctic)



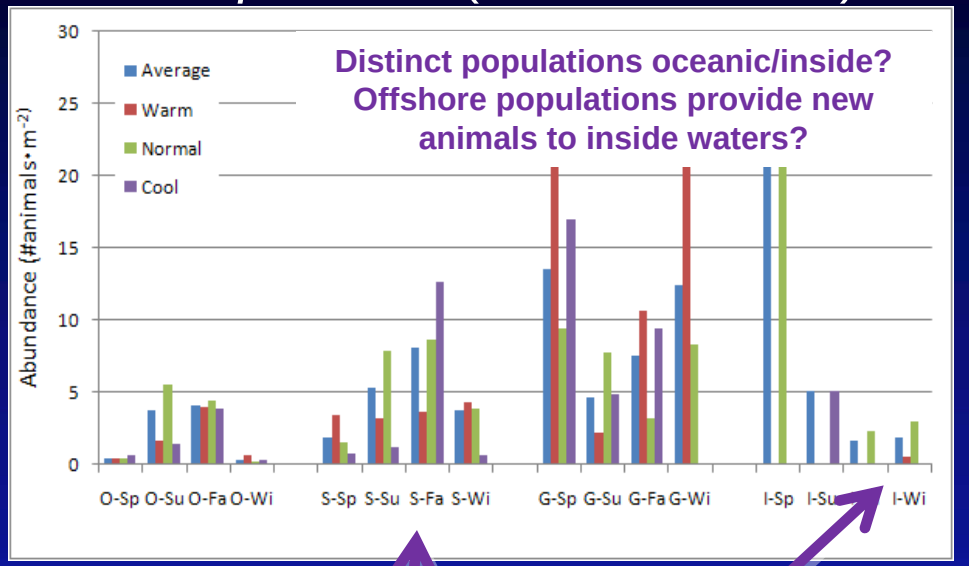


Widely Distributed

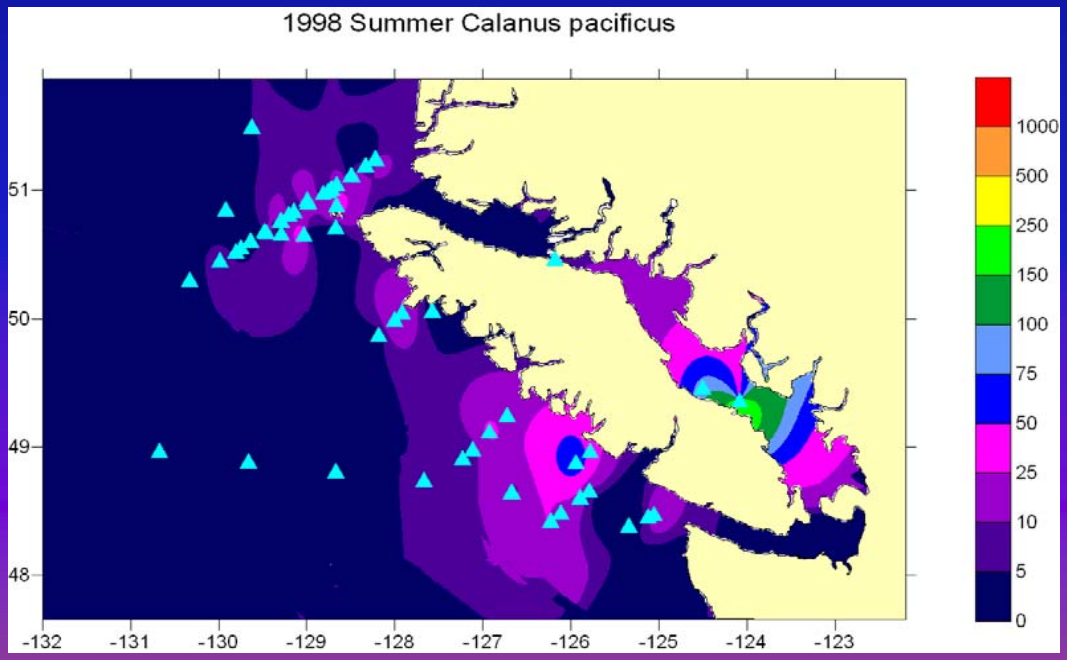
Oithona similis (Surface Waters)



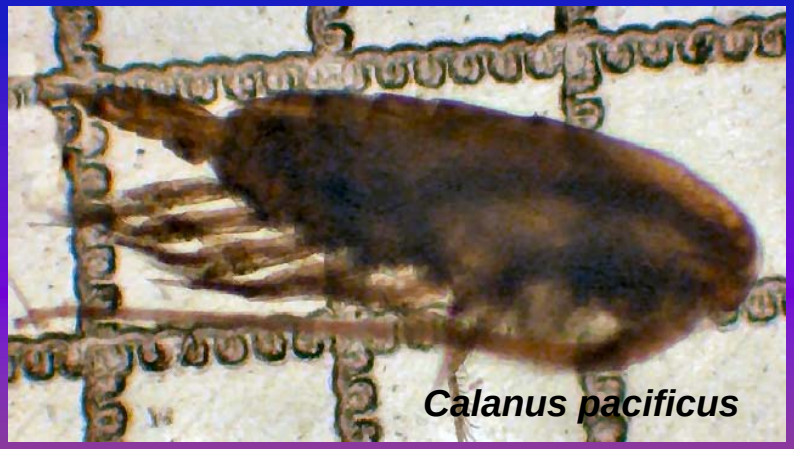
Calanus pacificus (Warm Offshore)



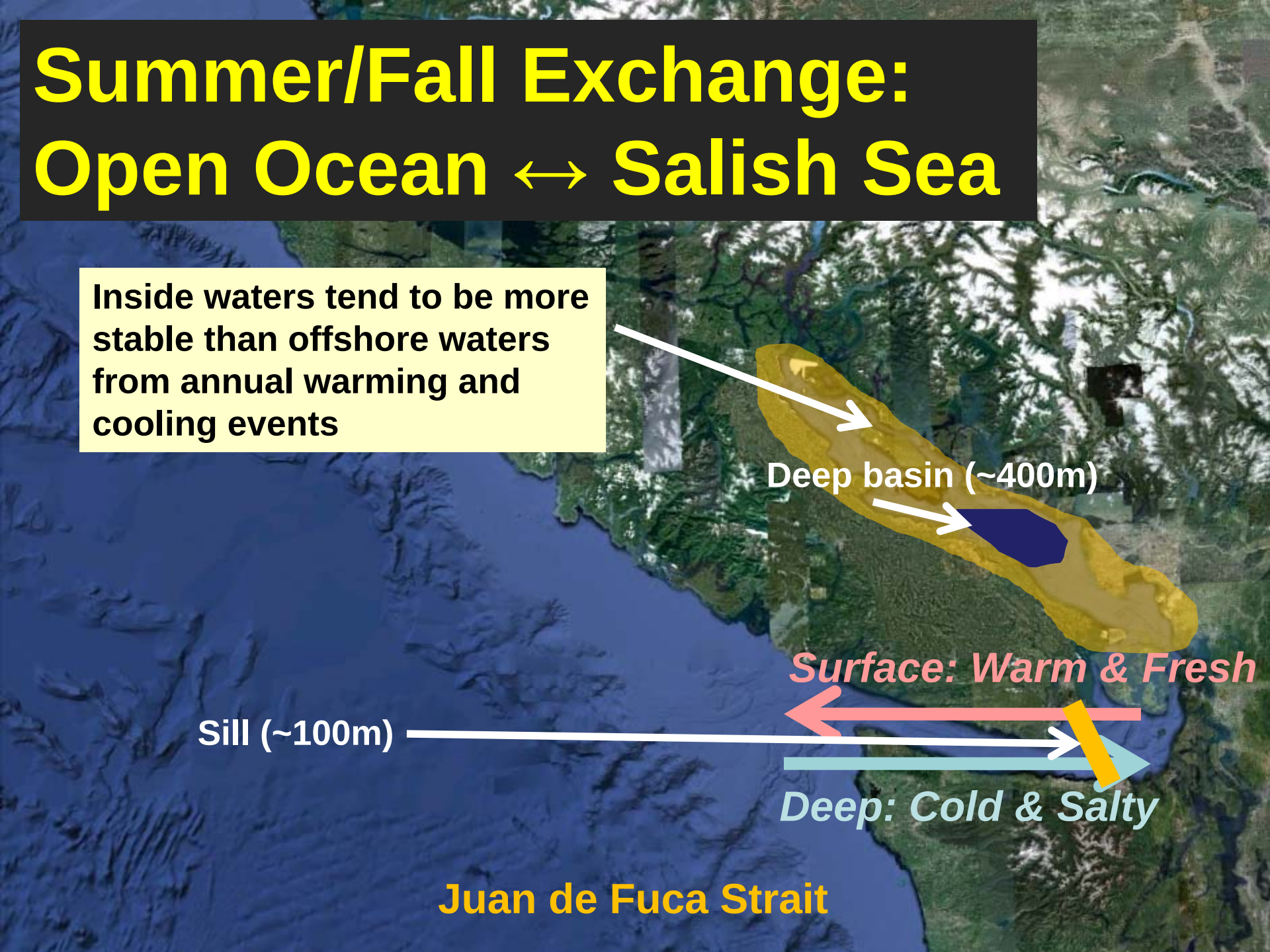
Inlet populations seem to be resident



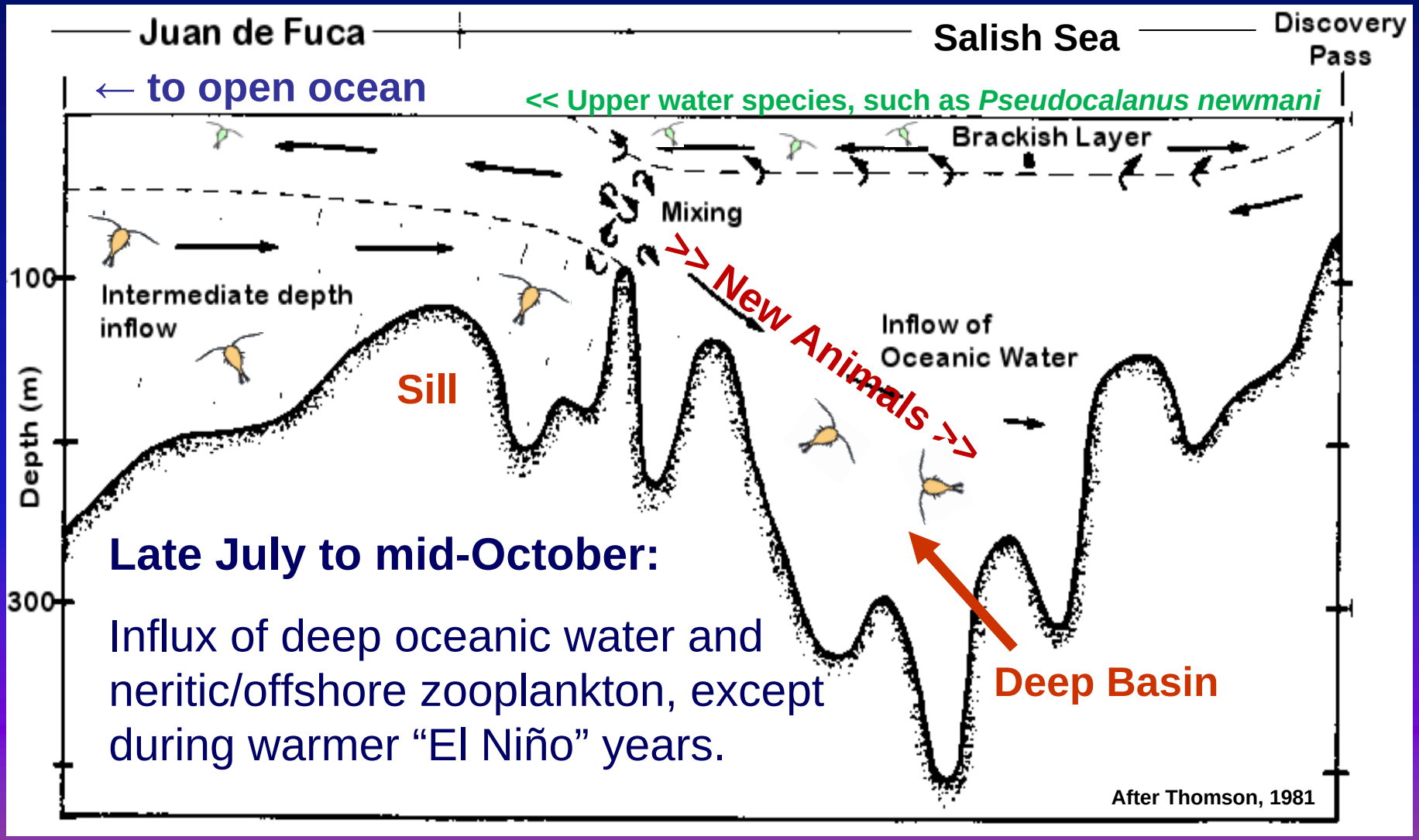
Cold years bring oceanic animals to shelf, warm years bring California animals northwards



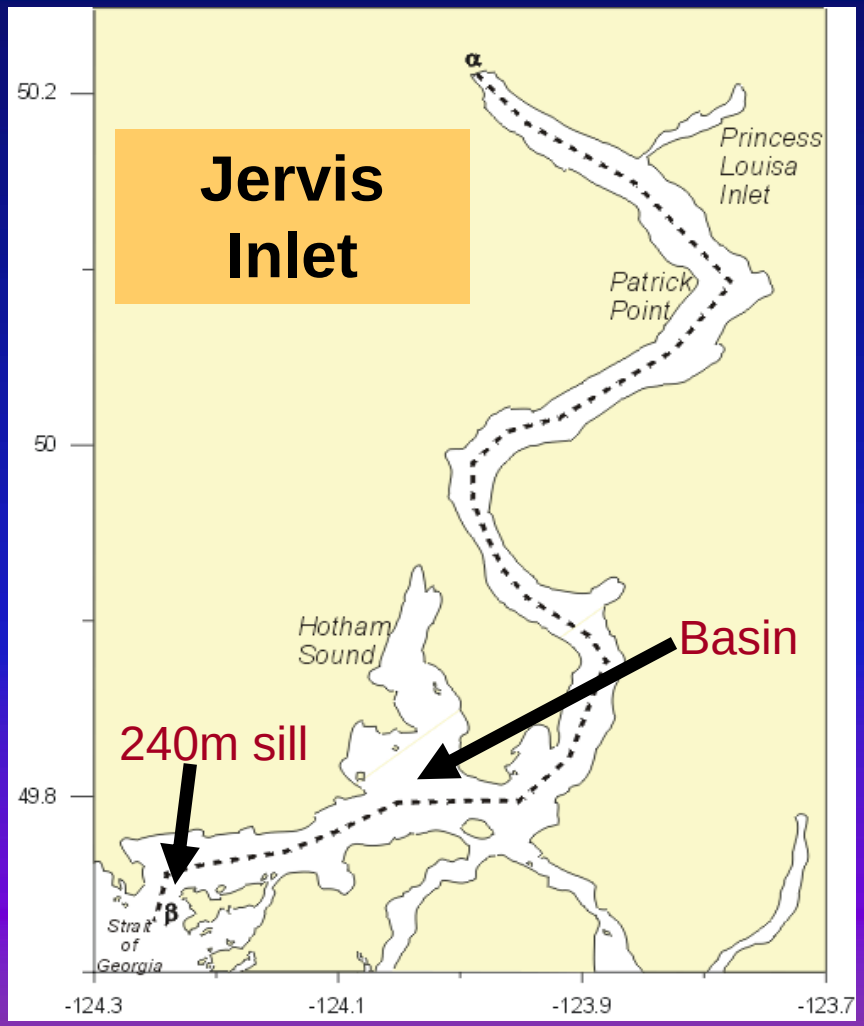
Summer/Fall Exchange: Open Ocean ↔ Salish Sea

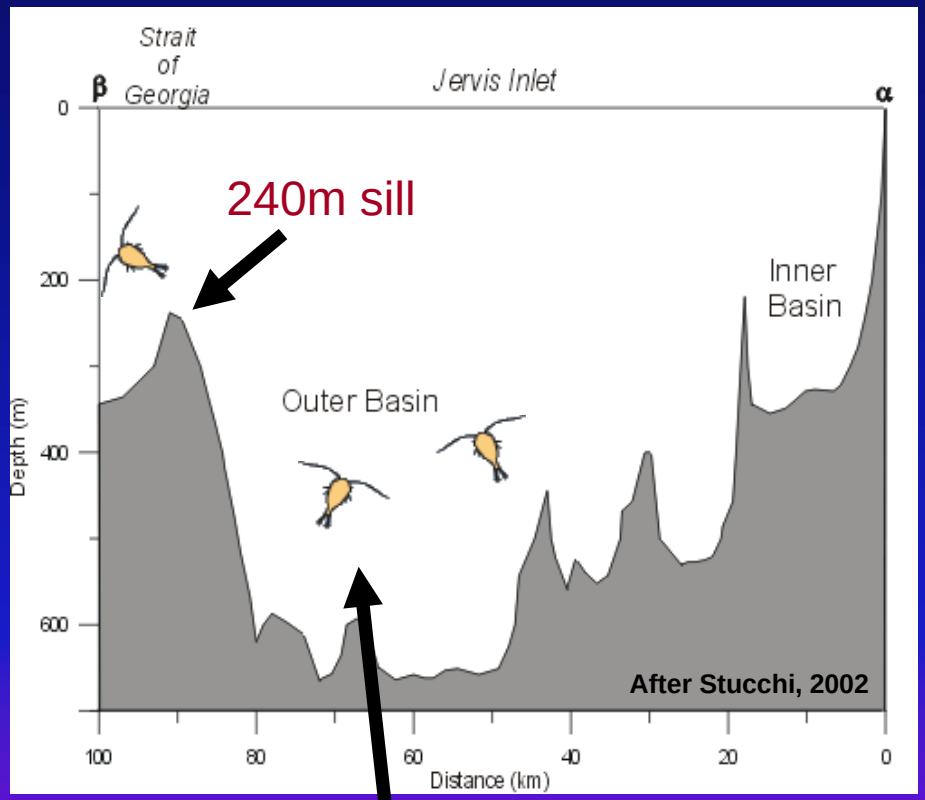


How Could Offshore/Shelf Zooplankton Enter the Salish Sea?



How Could Offshore/Shelf Zooplankton Then Enter Salish Sea Inlets?

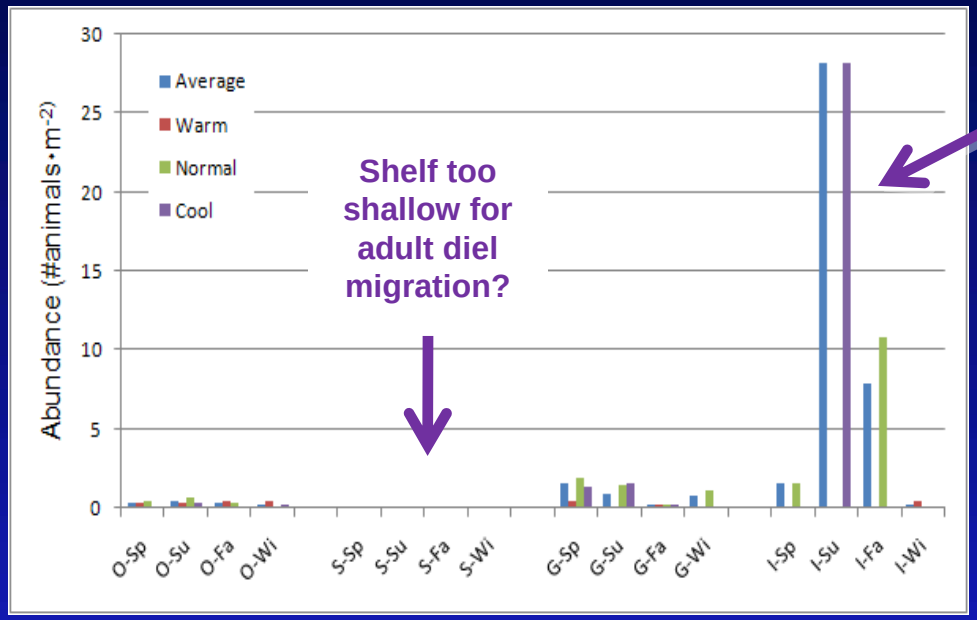




Jervis Inlet (and other inlets) deep water renewal usually occurs between late July-November

Inside Water Performers: Salish Sea & Inlets

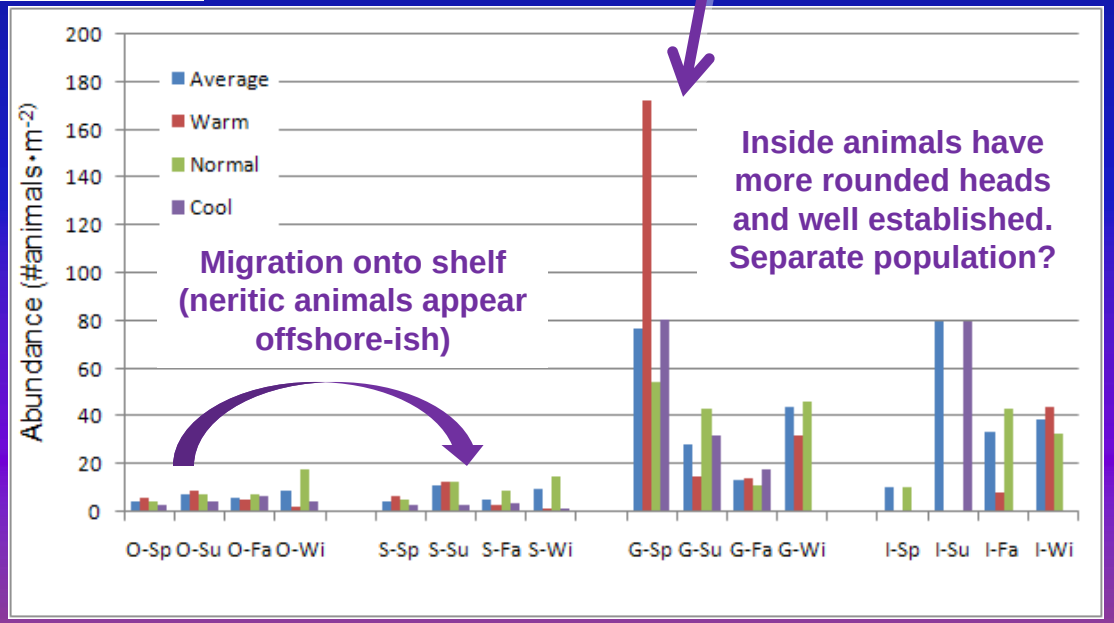
Tomopteridae



Inside animals usually <10mm and >20mm. Intermediate sizes might be hugging inlet "shelf" areas that are typically not sampled?

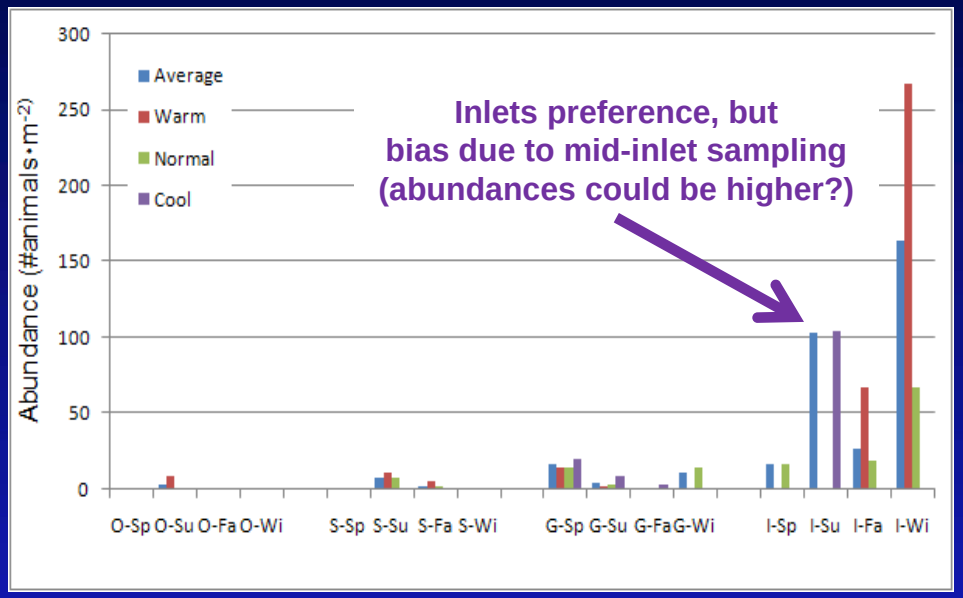
Metridia pacifica (Subarctic)

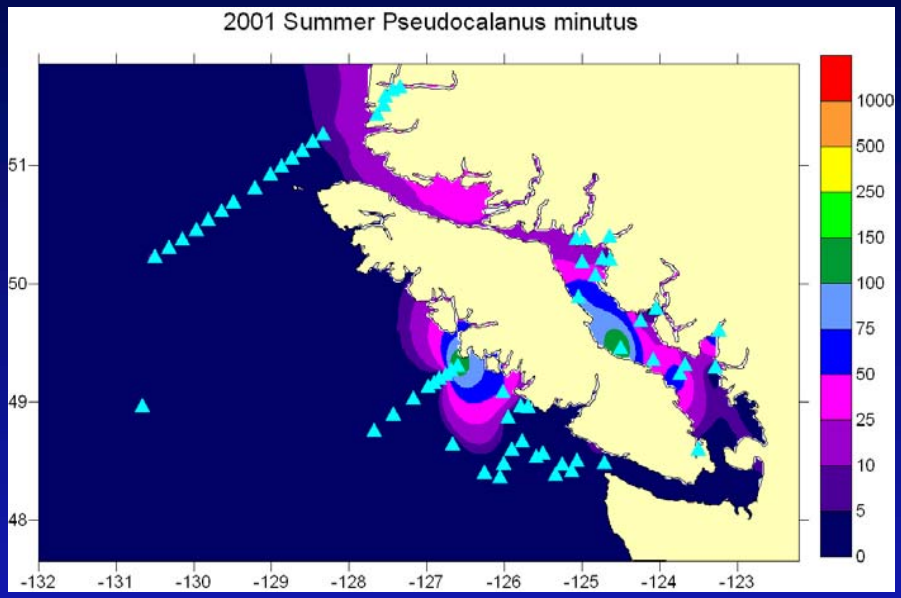
***Metridia pacifica* does well in Salish Sea in ~400m depth waters, possibly due to lack of competition from *Neocalanus cristatus* (which needs deeper waters for diapause). Possibly more food (diatoms) available?**



Inside Water Performers: Salish Sea & Inlets

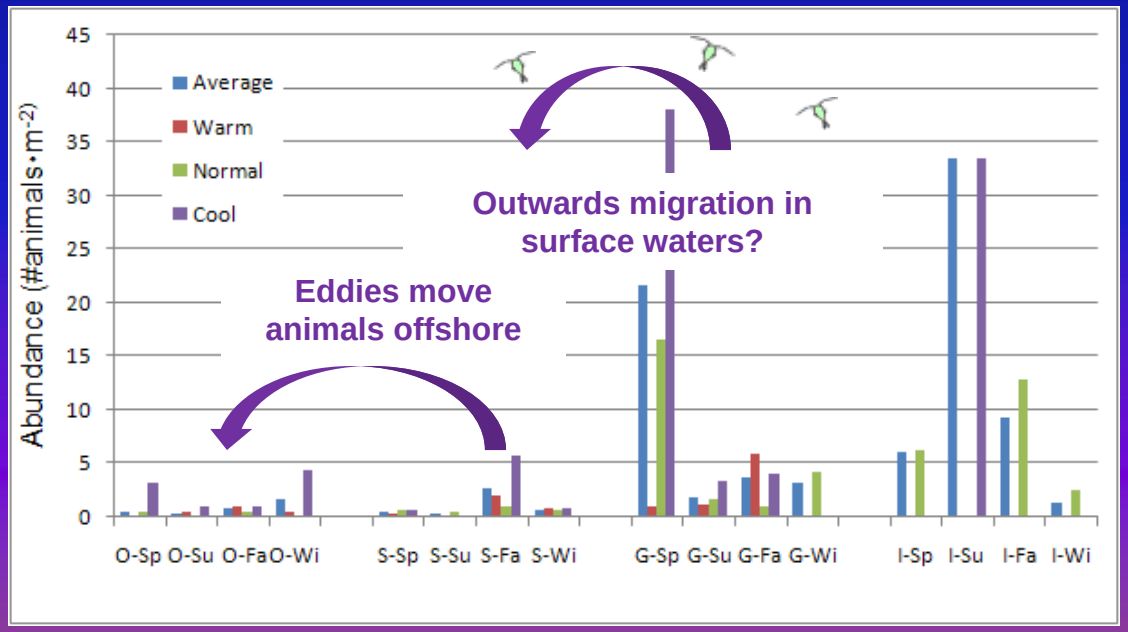
Pseudocalanus minutus (Cold Shelf/Neritic)





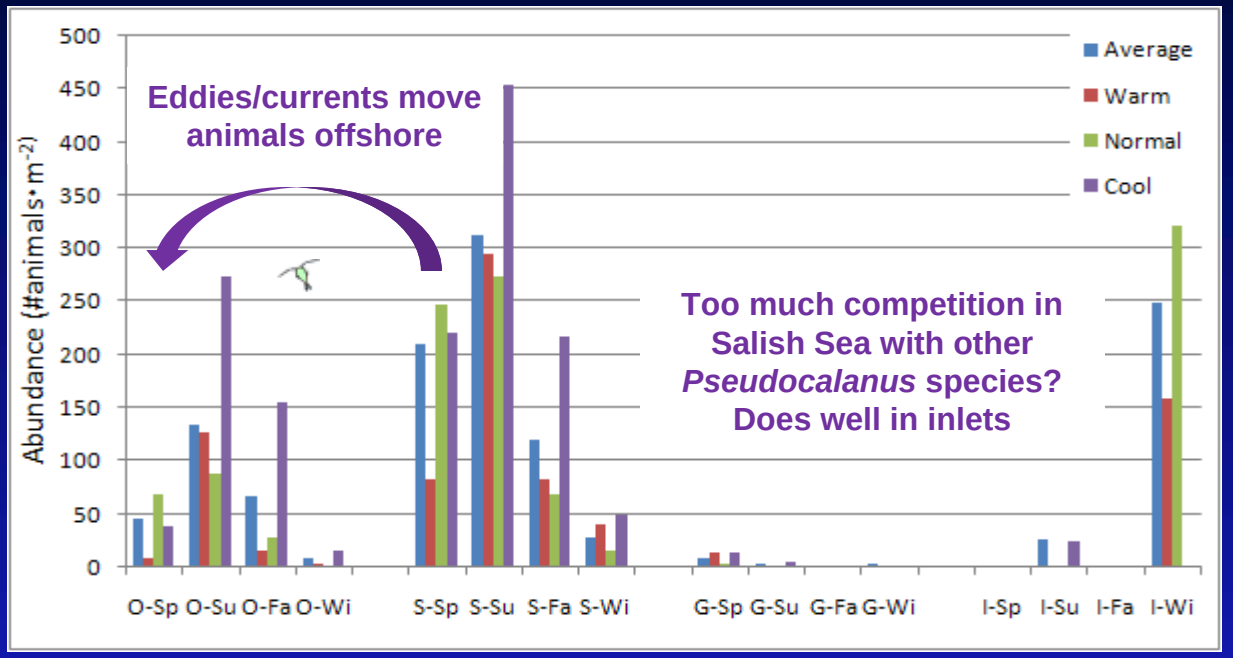
Pseudocalanus newmani (Cold Shelf/Neritic – tends to hug inner shelf)

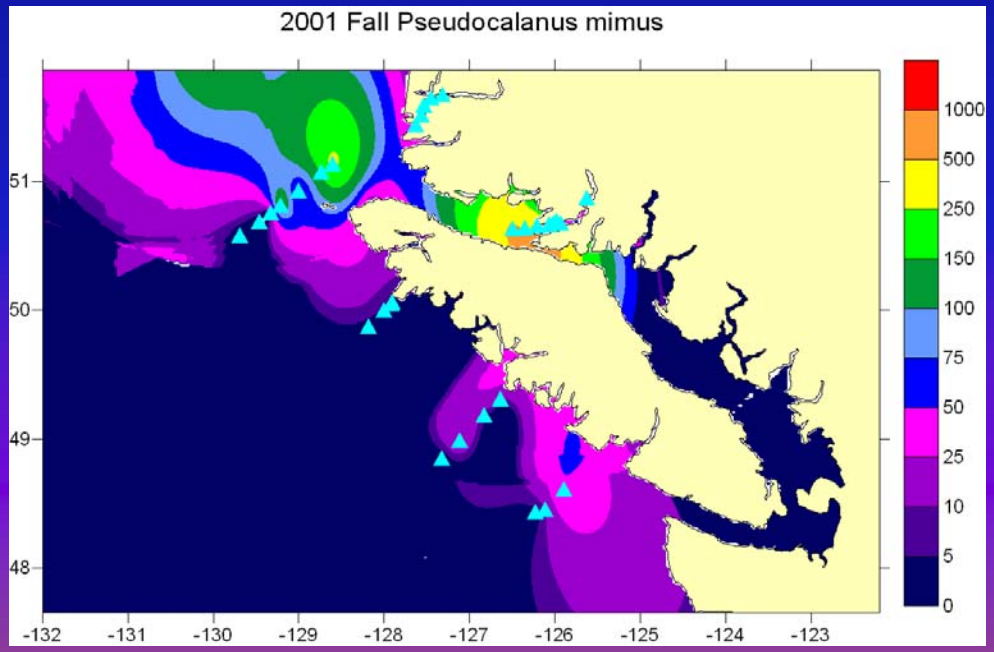
For *Pseudocalanus newmani*, we find high concentrations for inside surface waters. We suspect that animals are being carried outwards with the warm, fresh water and populating the shelf regions.



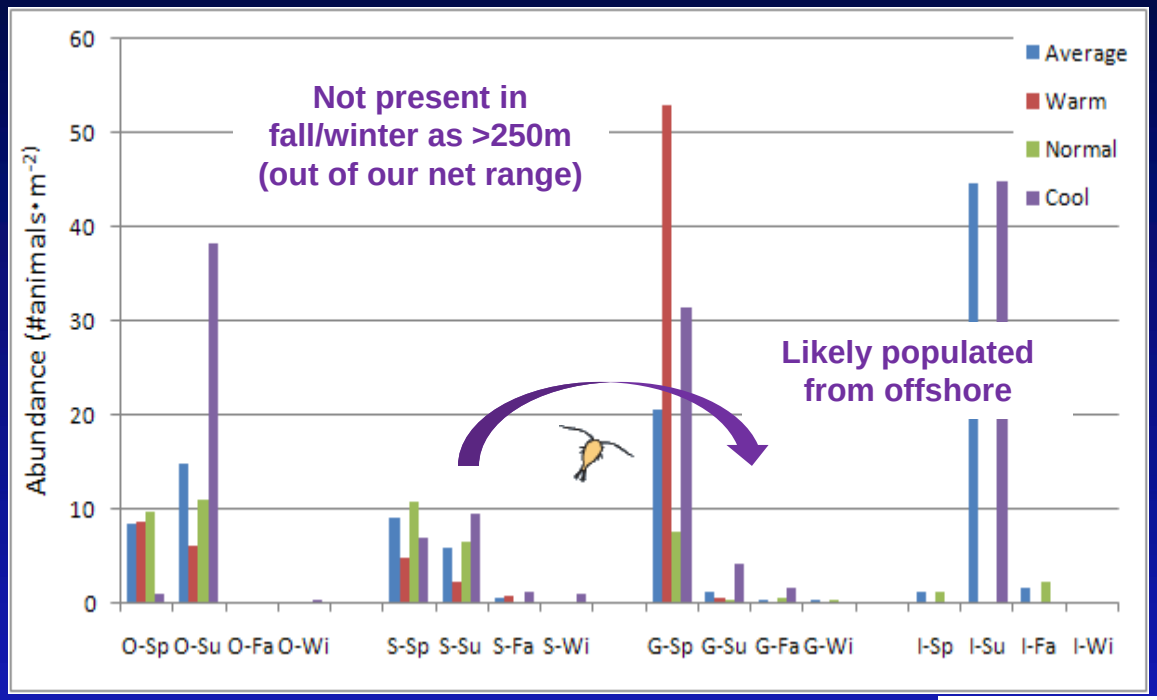
Inside Water Performers: Salish Sea & Inlets

Pseudocalanus mimus
(Cold Shelf/Neritic)



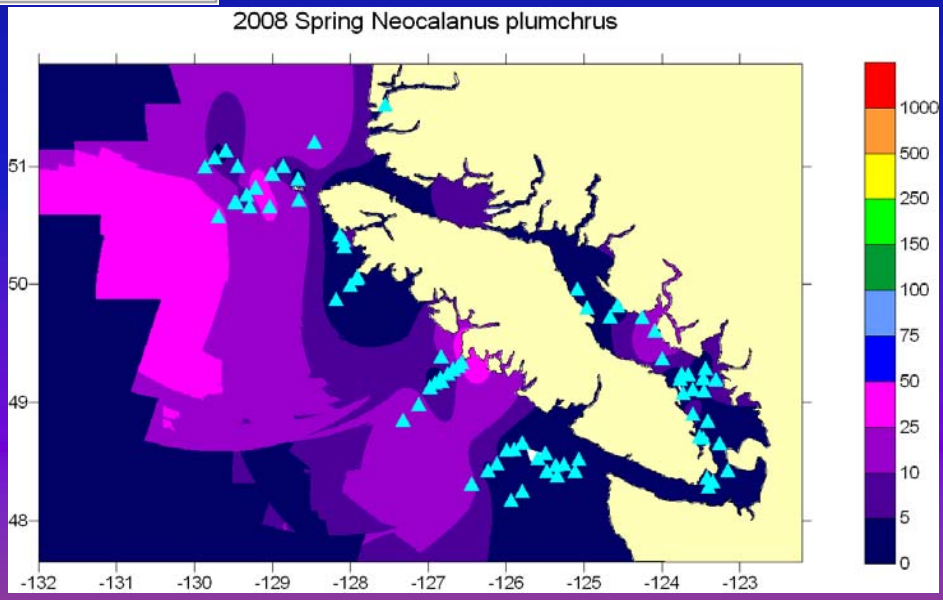


Offshore Inlet Performers: *Neocalanus plumchrus*



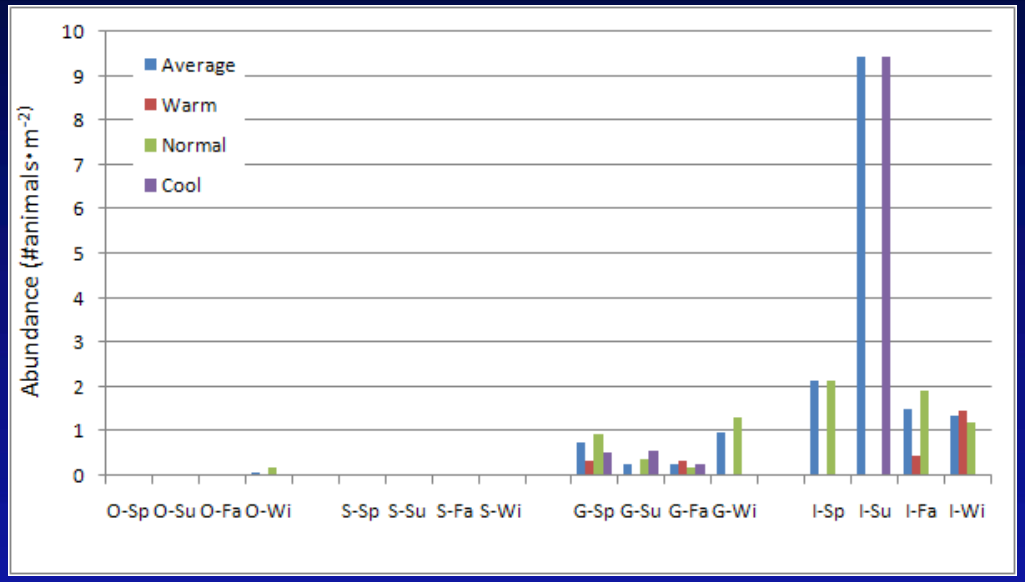
Neocalanus plumchrus (Subarctic)

Neocalanus plumchrus **does well in the Salish Sea and Inlets, except during warm years. We find that they cannot get to cool overwintering waters and the population crashes. It takes several years to recover to normal levels, likely from transport of new oceanic animals into the Salish Sea and Inlets.**



Offshore Inlet Performers: Amphipods

Cyphocaris sp. (Subarctic)

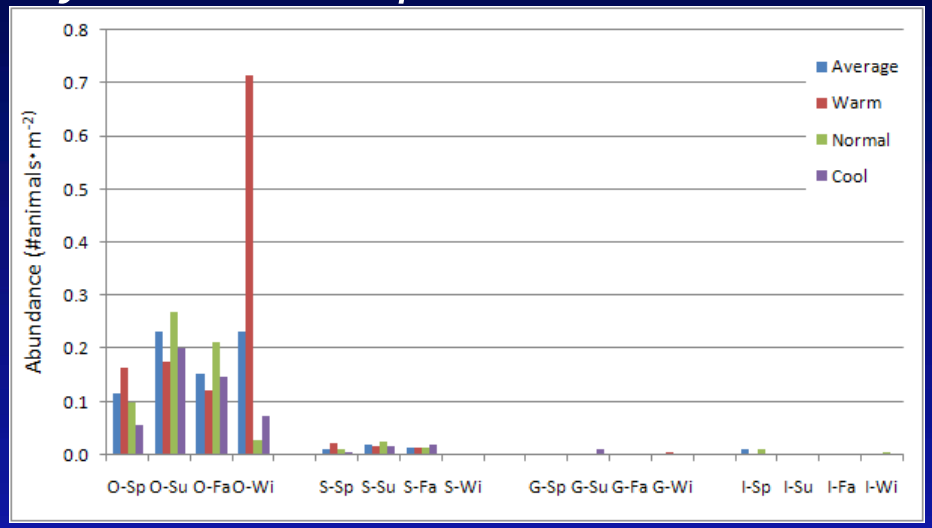


Neritic and inside water animals tend to have a rounded head and rounded body compared to the offshore pointed head and thinner body shape.

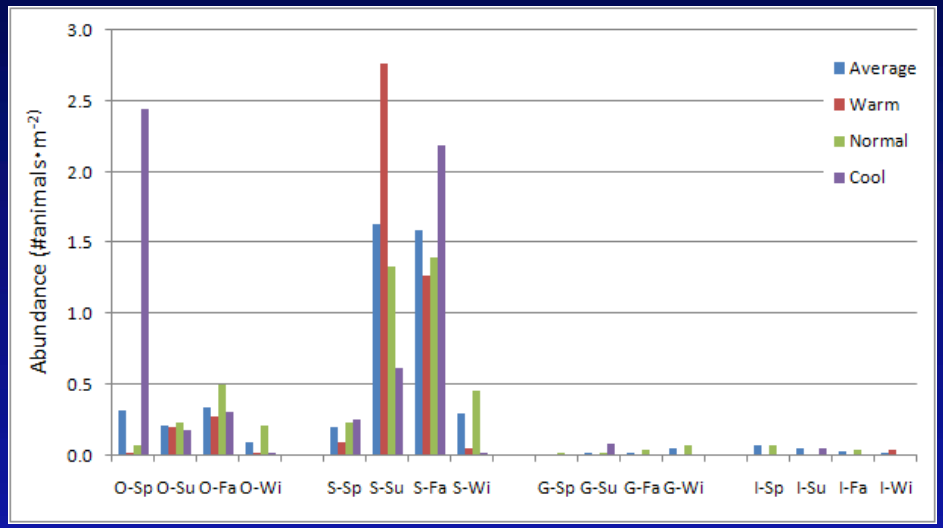
Could this have something to do with stabilization in the water?

Euphausiids: Offshore to Inlets Abundances

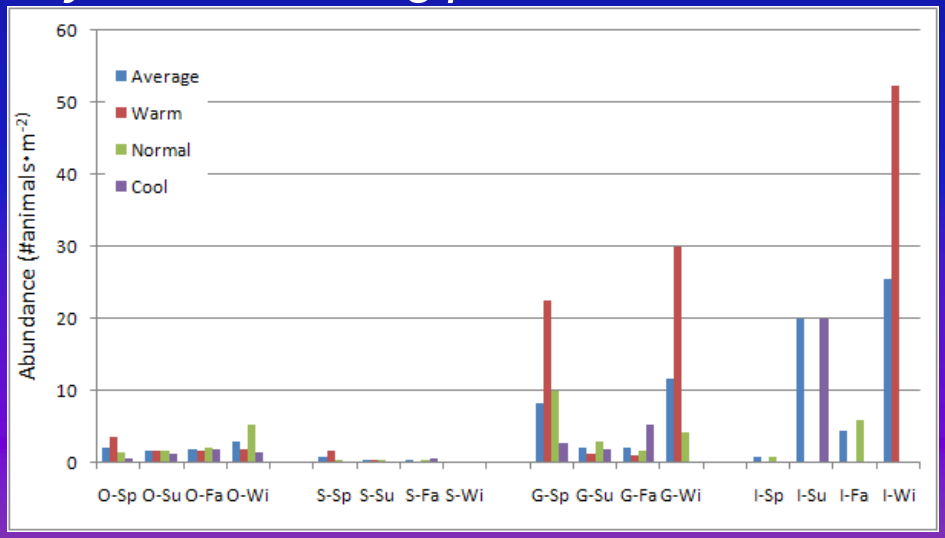
Thysanoessa inspinata



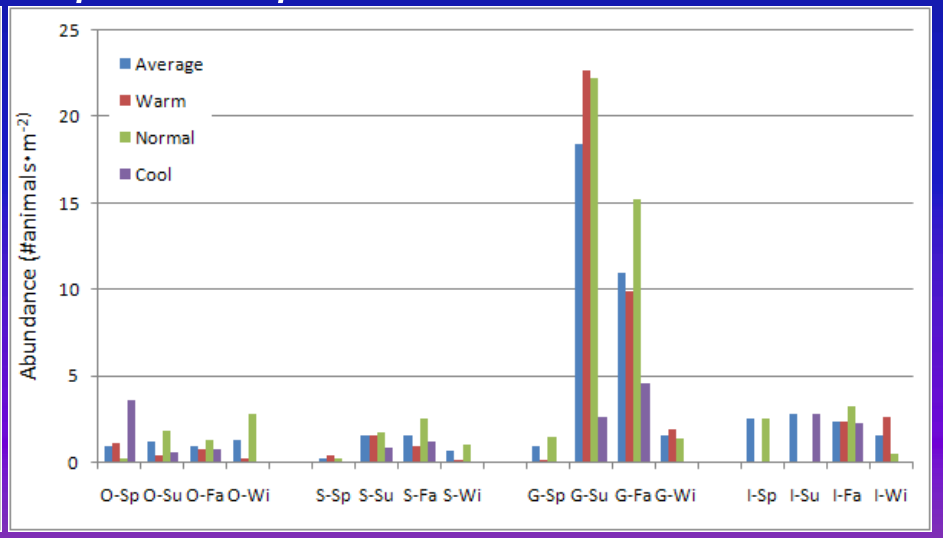
Thysanoessa spinifera



Thysanoessa longipes



Euphausia pacifica

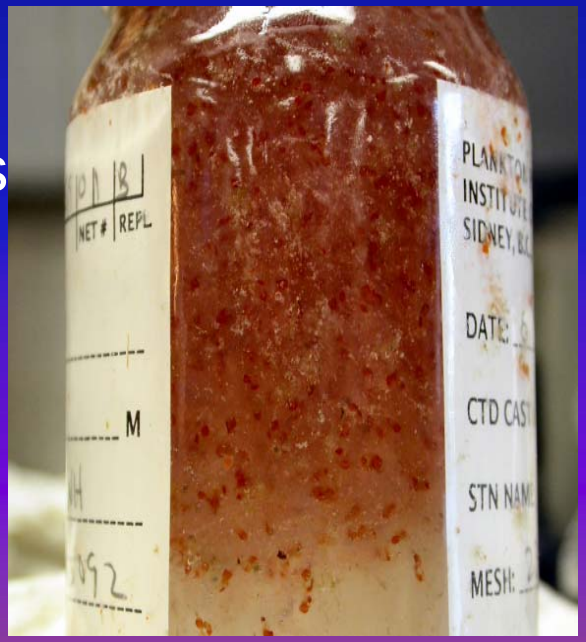


Discussion and Conclusions

- The Salish Sea is flushed annually with 75% of the water entering or leaving through Juan de Fuca Strait
- Populations are likely renewed with the influx of deeper water (>100m) over the sill from late July to mid-October, except in warmer years
- Both the Salish Sea and inlets offer unique and deep micro-habitats. Food resources and habitat preferences may be more abundant from available nutrients (e.g., spring blooms occur earlier in the year), tidal, and estuarine mixing

Discussion and Conclusions

- Our sampling may be biased in the Inlets to mid-channel as it is often difficult to sample close to shore where conditions may be similar to a neritic environment
- Many ‘typical’ offshore species are found in higher abundances within the Salish Sea and/or inlets. These species may have diel migrations/life histories that may favour establishing populations in deep inside waters (e.g., *Neocalanus cristatus* vs. *Neocalanus plumchrus)*.
- Some deep-dwelling plankton populations might be restricted in their exchange and species variations may be present, but not enough work has been done to verify if distinct populations exist through DNA analysis.



Acknowledgements

- Collection of these data were done by various scientists including Dave Mackas, Doug Yelland, Doug Moore, Dario Stucchi, Marc Trudel, David Welch, Marie Robert and others at the Institute of Ocean Sciences and the Pacific Biological Station
- The officers and crew of various CCG ships, including *Tully*, *Ricker*, *Parizeau*, and *Vector*
- All of our zooplankton data are housed in the Pacific Region Zooplankton Database (with updates by Deborah Faust)
- Interpolation plots and data extractions were performed by several students from Southampton University on summer exchange programs with our research facility over the last few years

Students visiting the *Vector* to learn more about oceanography of the Salish Sea, October 2010