The importance of peak river flow timing to copepod abundance in the Fraser River Estuary

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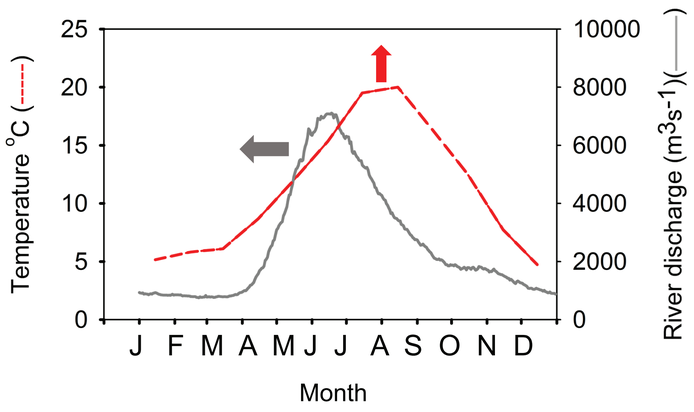
The seasonal delivery of freshwater to estuaries is changing

Through our research on the Fraser River Estuary, we hope to better understand how changes to the seasonal delivery of freshwater will impact the pelagic ecosystems of snowmelt-dominated estuaries.

Zooplankton are central to pelagic estuarine food webs. River discharge, through its effect on salinity and water residence time, strongly influences the presence, composition, and abundance of zooplankton in estuaries[1,2]. Precipitation is increasingly falling as rain rather than snow, and snowmelt is occurring earlier. The resulting change in the annual river hydrograph is expected to be most striking for rivers whose discharge is dominated by snowmelt[3], such as the Fraser River in Canada. Fraser River peak discharges are occurring earlier and temperatures are warming[4], to unknown effect on zooplankton production and dynamics.

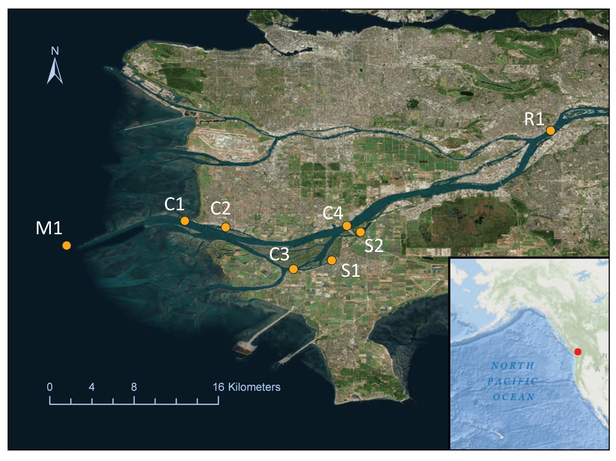
Fig 1. River discharge for the Fraser River (1912 – 2014) from wateroffice.ec.gc.ca and average temperature measured in the inner estuary over the course of this study. Arrows indicate direction of predicted change.



Zooplankton monitoring program

The Fraser River is among the most productive salmon and forage fish bearing rivers in the world and has been designated by the UN as a 'Wetland of International Importance' (Ramsar site). The zooplankton of its estuary, however, remain largely unstudied.

Fig 2. The Fraser River Estuary delta, British Columbia, Canada. Locations of sampling sites (●).



- 1-2x month zooplankton sampling
- August 2013 – May 2016
- Tows of a 0.5 m mouth, 100 µm mesh conical net
- CTD casts, chlorophyll, and nutrients

Water residence time limits copepod abundance

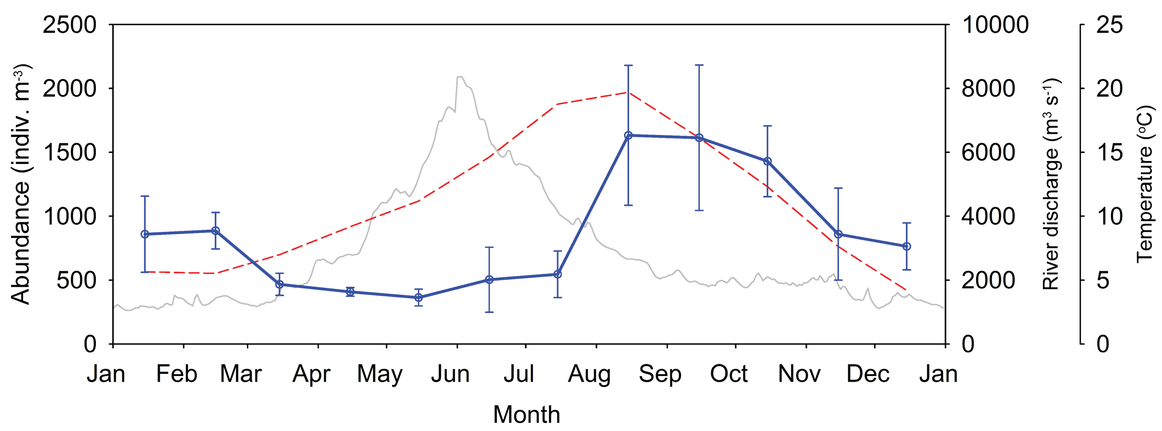


Fig 3. Copepod abundance decreased approx. 50% during high river discharge. Average monthly copepod abundance (±1 SE) (excluding nauplii) plotted with average river discharge (——) (wateroffice.ec.gc.ca) and temperature (-----) during the study period (2013-2016).

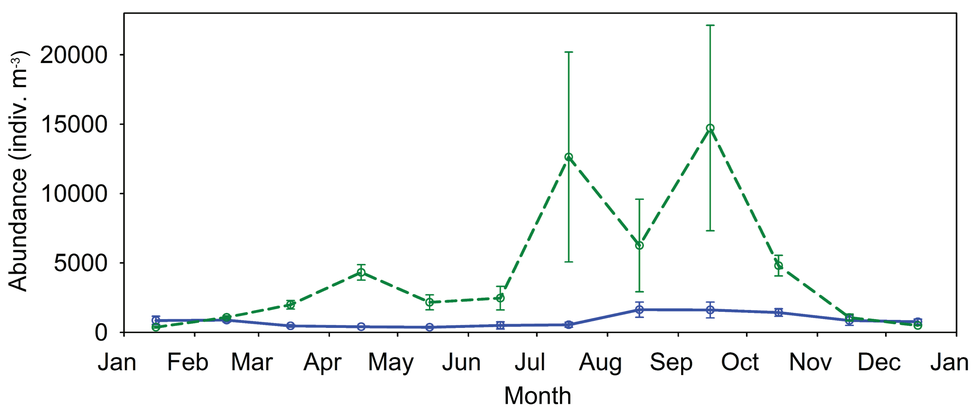


Fig 4. Copepod abundance was higher in sloughs. Average monthly copepod abundance (±1 SE) (excluding nauplii) was higher at slough stations (S1 and S2) than at channel stations (C1, C2, C3, and C4).

These results suggest that water residence time limits copepod abundance during the spring and summer.

How do copepods avoid being swept away?

High abundances in sloughs were due primarily to estuarine endemic taxa (Fig 5). The presence of estuarine plankton in an estuary depends on the availability of the appropriate temperature-salinity conditions and water residence time sufficient to allow for population growth.

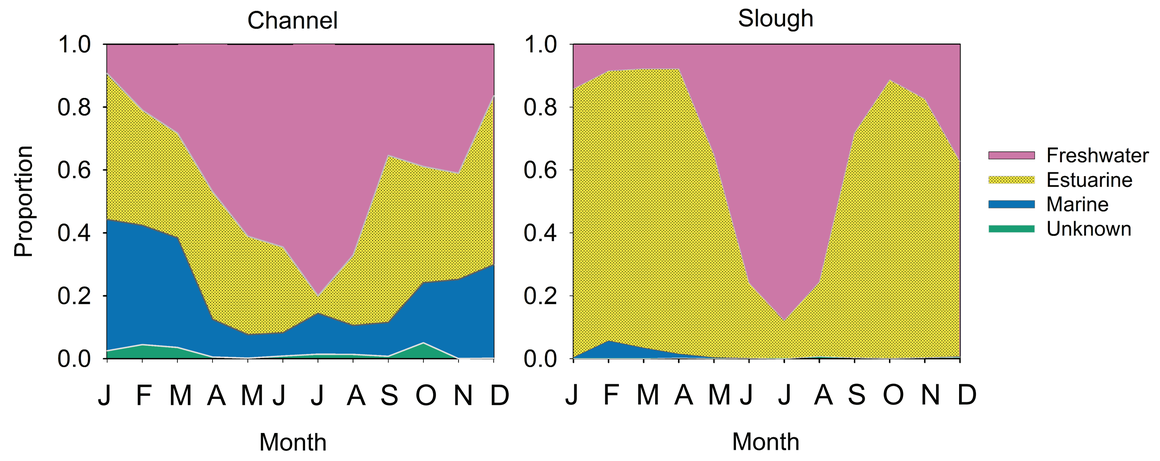


Fig 5. Estuarine (brackish) copepods accounted for, on average, 65% of total copepod abundance at slough stations but only 35% of copepod abundance at channel stations.

Estuarine zooplankton use a variety of methods to avoid being swept away, including high reproductive rate and tidal vertical migration. The most abundant estuarine copepod in the Fraser River Estuary, *Eurytemora affinis*, may produce resting eggs to avoid being flushed from the estuary. To our knowledge, this method of estuarine retention hasn't been reported before in estuarine species.

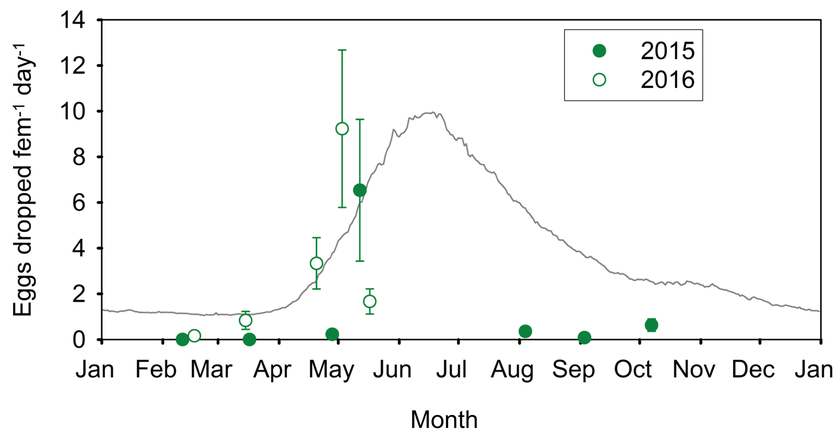


Fig 6. *E. affinis* dropped eggs in the spring. Average number of eggs dropped (± 1 SE) per female per day during 24-hr incubations plotted against average discharge (m^3 s^{-1}) for the Fraser River (1912 – 2014) from wateroffice.gc.ca. Monthly incubations were conducted over 2 spring periods and a single summer/autumn period.

How will earlier peak river discharge impact the estuary?

- Removal of the warmest part of the spring growing season and extension of the late summer/autumn growing season
- Introduction of a novel niche where higher salinity occurs with warm temperatures could facilitate the establishment of nonindigenous species. A nonindigenous copepod that could exploit this niche has already been collected from the estuary
- Life history events of estuarine copepods may be timed to coincide with peak discharge. In the case of *E. affinis*, earlier peak discharge reduce contribution to the egg bank.
- Altered feeding landscape for fishes

Ongoing work

- Modelling *Eurytemora* population dynamics under various river discharge and warming scenarios.

Acknowledgements & References

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