Investigating the timing of Saanich Inlet's summer mini-blooms

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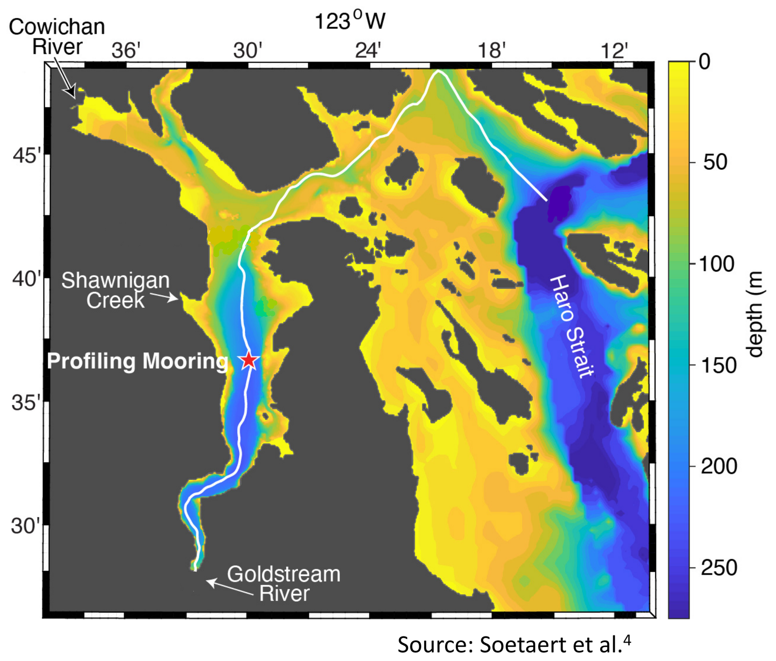
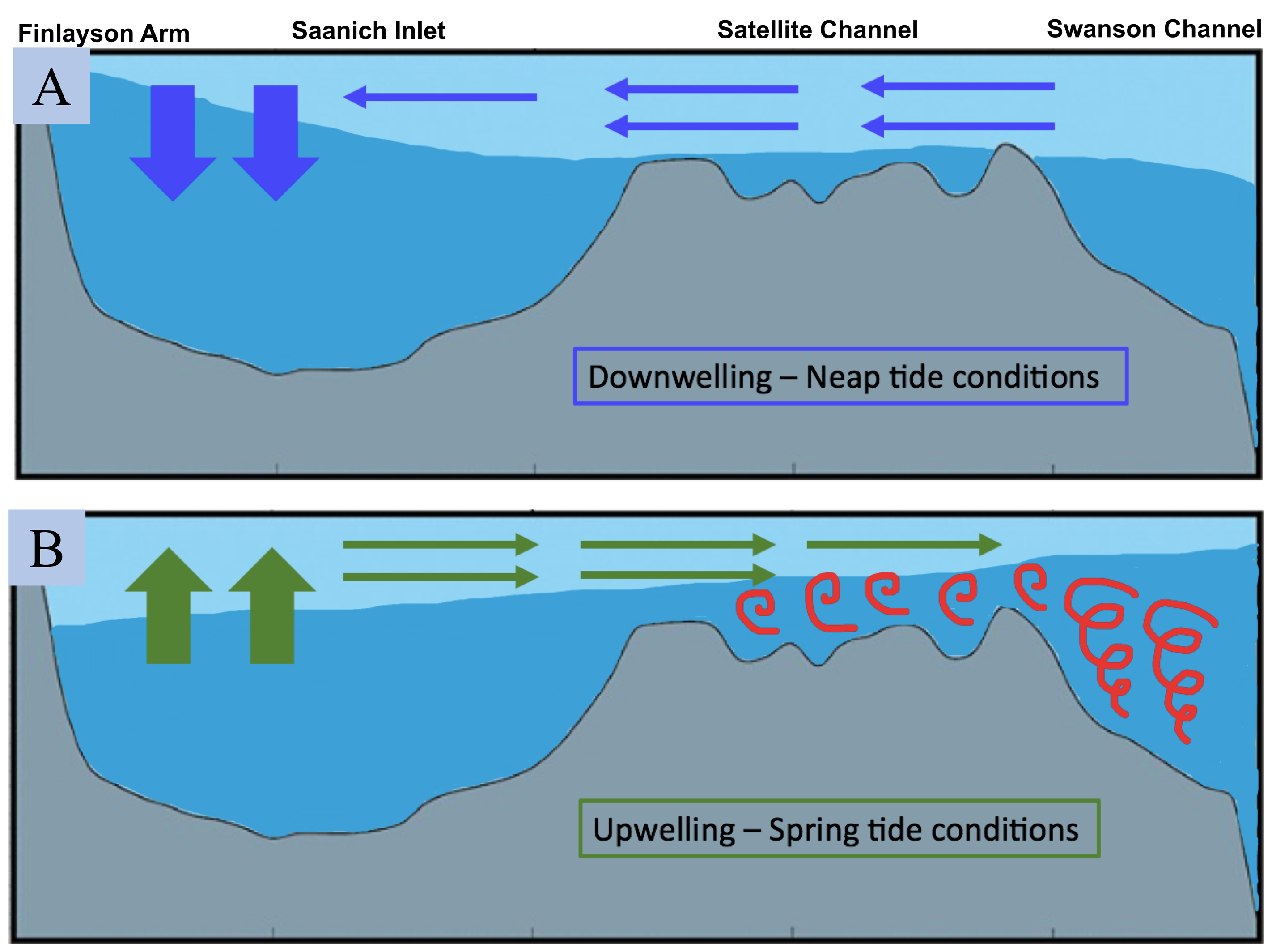
BACKGROUND

- Saanich Inlet is a fjord located on south Vancouver Island with an unusually high level of primary productivity[1,2].
- The inlet is known to have large spring and fall blooms of phytoplankton.
- In the summer, productivity is nutrient limited during brief periods, sparking interest into what mechanism drives this cycle of nutrient resupply.
- The summer mini-blooms generated when nutrients are present appear to relate to the 14-day spring/neap cycle (which modulates tidal strength)[3]
- The basin normally possesses reverse estuarine circulation which provoke downwelling conditions (A).
- Downwelling conditions are unfavorable for phytoplankton growth as nutrient rich deep water is being moved to depth rather than being brought to the surface.



Source: Soetaert et al.[4]

The proposed mechanism[5] for these mini-blooms is thought to be upwelling generated through reversal of Saanich Inlet's estuarine flow after spring tides cause mixing in surrounding channels (B).



This figure shows a cross-section of Saanich Inlet and surrounding waters, with an idealized salinity gradient and arrows representing the direction of surface flow. As is shown in panel B, spring tides generating mixing (in red) outside the inlet leads to upwelling through a reversal in the salinity gradient.

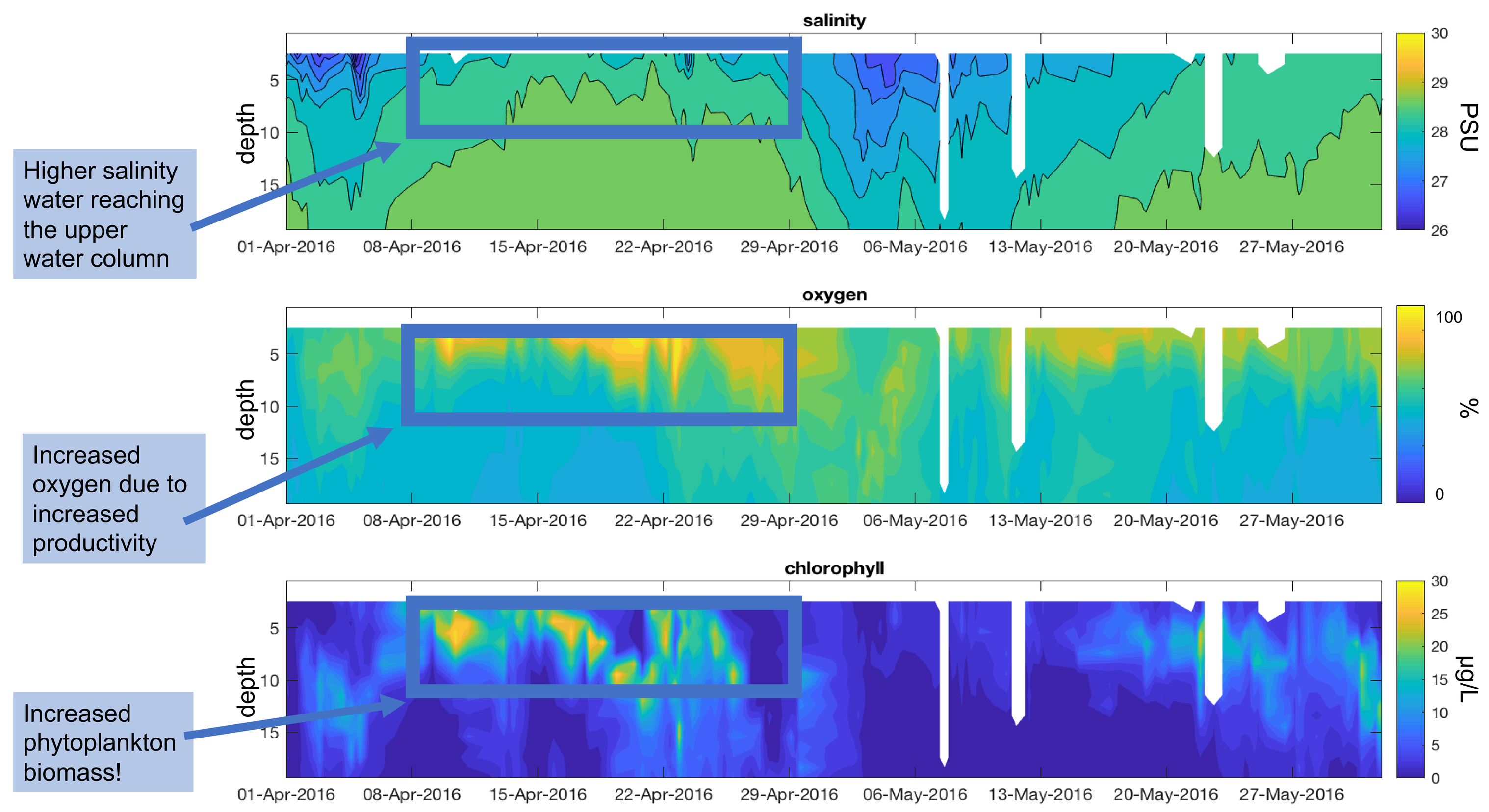
OBJECTIVES

How does the spring/neap tidal cycle influence the summer productivity cycle of Saanich Inlet, through impacting the chemistry of the euphotic zone?

1. Visualize when nutrients are being upwelled into surface waters as a result of spring tides, through looking at changes in surface salinity and tidal range data
2. Compare surface salinity data with chlorophyll and transmissometer data to see if and when nutrients result in increased biomass
3. Determine lag times between spring tides and higher salinities, and between higher salinities and period of increased biomass

METHODS

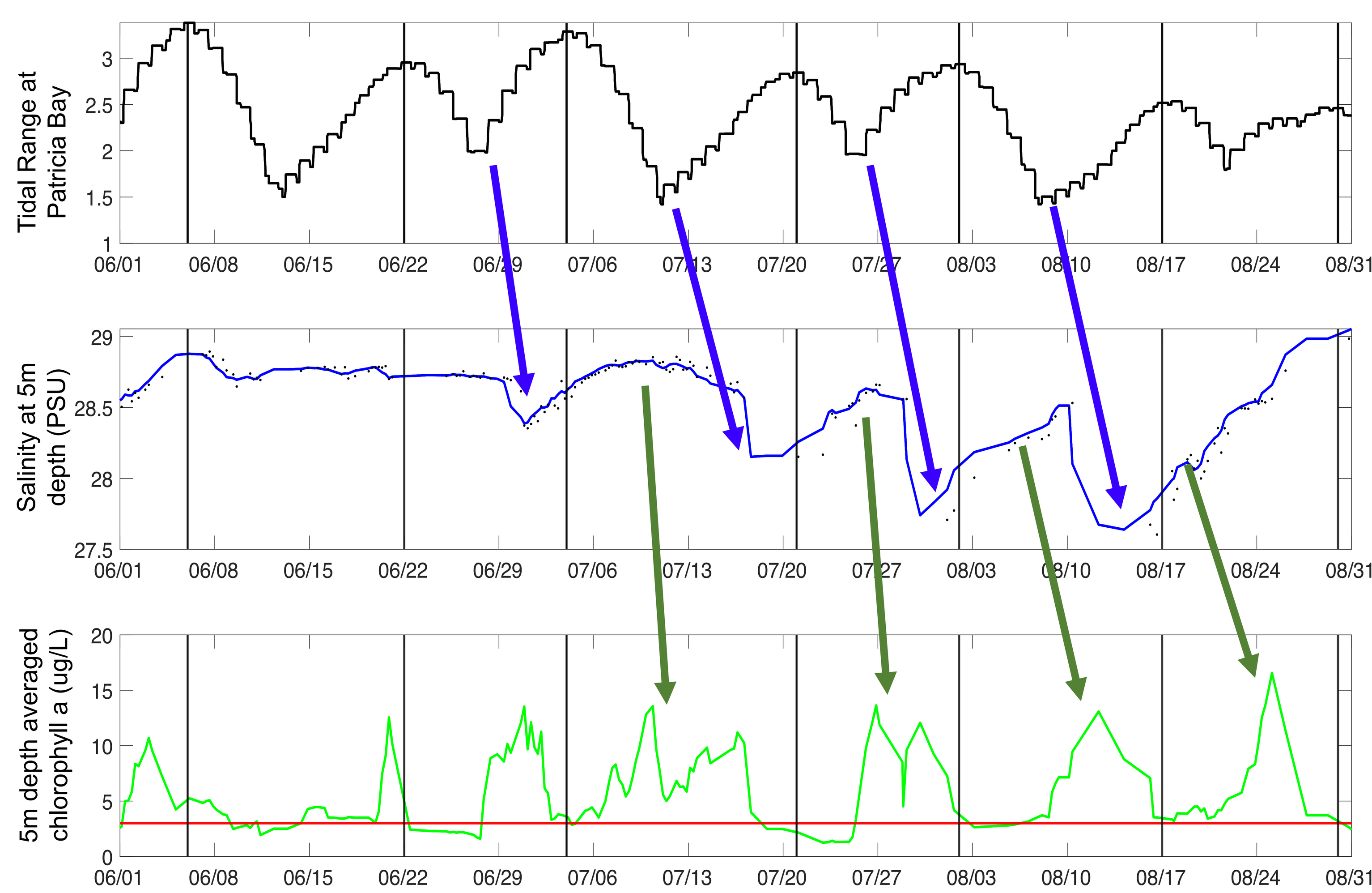
- This project uses three years of salinity and chlorophyll data from water column profiles taken by a profiling mooring (shown on the map with a red star).
- This mooring is operated by Ocean Networks Canada and sampled with a frequency of 4-8 times a day in 2014, 2016 and 2022.
- Tidal data was taken from Patricia Bay, just north of the mooring site.
- Parameters like salinity and chlorophyll were averaged over 3 timepoints, and chlorophyll was additionally depth integrated to different depths (5, 10, 15, 20m).



Initially, contour plots like this one were used to try and visualize periods of increased salinity and increased biomass associated with spring tides. In the top panel, we can see a long period of increased salinity across April which corresponds with high surface oxygen and chl a values.

RESULTS

Timing of spring/neap tides, salinity and chla; May to September 2016

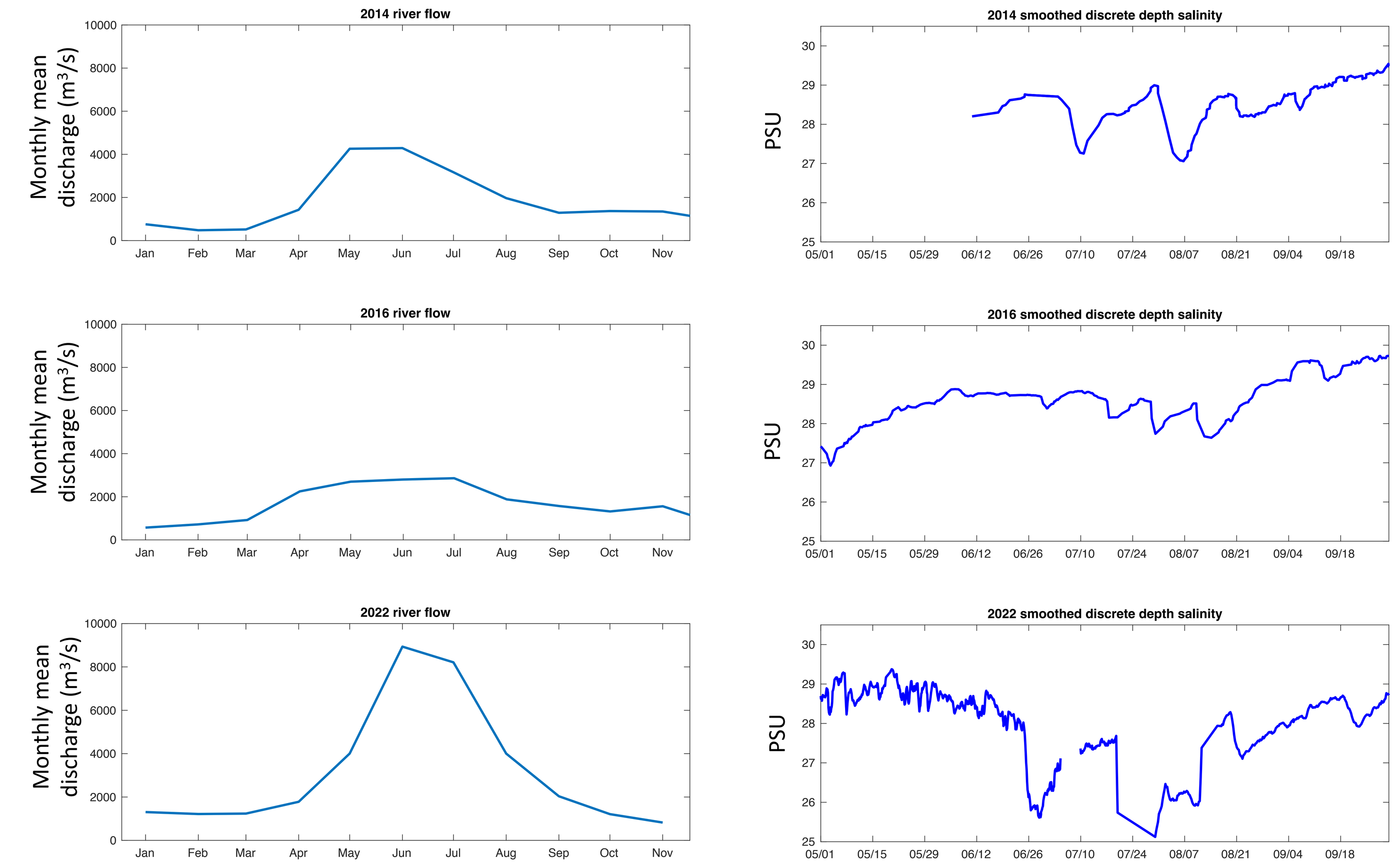


This figure shows the link between tidal range, salinity and chl a over the summer of 2016. The top panel shows tidal range variation, with highs being spring tides and lows being neap tides. The blue arrows draw links between these low neaps and lows in surface salinity. Using the green arrows, we can then look at how the highs in salinity correspond with increased periods of biomass shown through chla a concentration.

Takeaways:

- Surface salinity minima due to neap tides are very distinct and so can be used in choosing what summer events are related to this mechanism
- There is a significant lag between neap tidal events and when the minimum in surface salinity is seen (~7 days for 2016)
- There is also a significant lag between when increased surface salinities from spring tidal events lead to increased biomass (~4 days for 2016)

Differences in Fraser river outflow between years & subsequent salinity differences

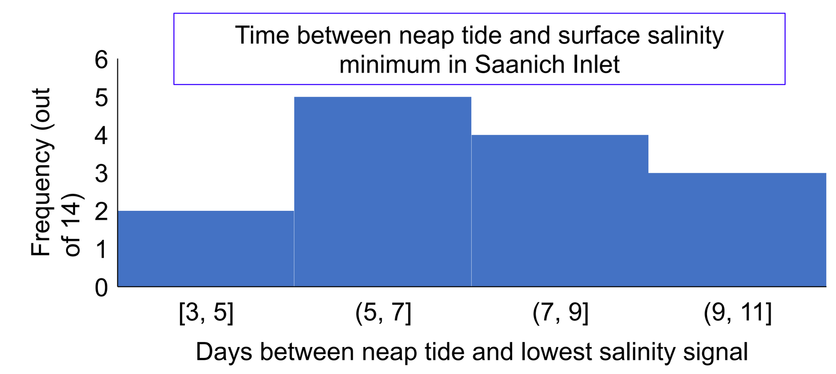


This figure shows the large difference in Fraser river output over the three years in relation to the summer surface salinity trend, with 2016 having relatively low Fraser river input over a broader time window than 2014 and 2022 which both see larger inputs centered around May/Jun/Jul.

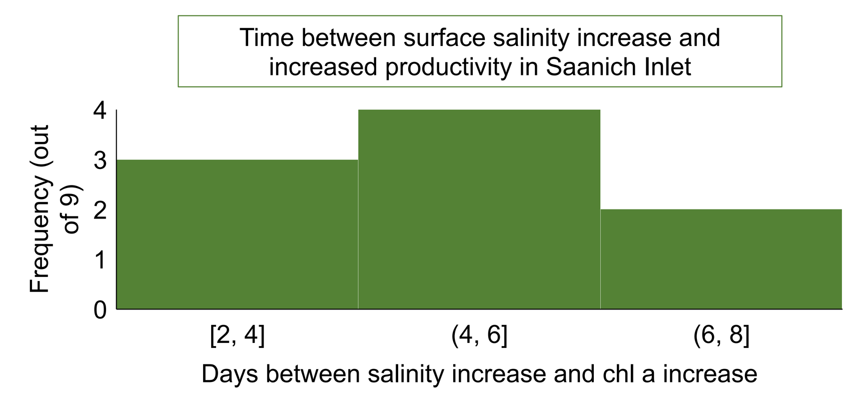
Takeaway:

- The size of surface salinity change due to a neap/spring event doesn't only depend on the change in tidal range itself but also the freshwater input from the Fraser river (and additionally, upon the salinity of water coming up through Haro Strait due to coastal upwelling)

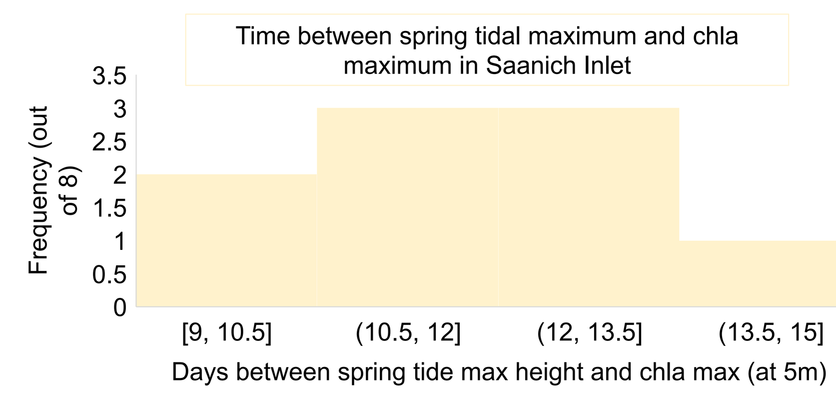
CONCLUSIONS



Out of fourteen events where the neap tide low salinity signature could clearly be observed at 5m depth, the lag between the tidal minimum and the salinity minimum was around 7 days.



Out of nine events where there was an increase in productivity following spring tide high salinity signature, the lag between the salinity increase and the increase in chl a was around 5 days.



Out of eight events where there was enough data to define a range of dates when max chl a might have occurred, the lag between the spring tidal maximum and the max chl a was around 12 days.

ACKNOWLEDGEMENTS

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References:

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