Introducing a Different Kind of Blob in the PNW – the Snark!

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Introduction

Puget Sound experienced progressively saltier conditions from 2017-2019 compared to time-averaged seasonal norms from 1999-2018. Reduced freshwater inflow from rivers drove much of these salinity increases.

We report on another process raising salinity on the landward end of Case Inlet. Like "Meddies" in the Mediterranean Sea, evaporation leads to the formation of hypersaline blobs of surface water, known as "snarks".

Materials and methods

- From 1997-2007, we measured salinity, temperature, and density with three different probes (CTDs) aboard two vessels (R/V Barnes and Skookum).
- During the non-winter months, we detected snarks over 70% of the time.
- We also report direct measurement of temperature from the sunlit mudflats, and make an energetic argument to connect the two.
- Data are from different years because we were not planning to look for snarks. We were monitoring for low oxygen levels.

Results

Figure 1. Mud flats at low tide in Oakland Bay.

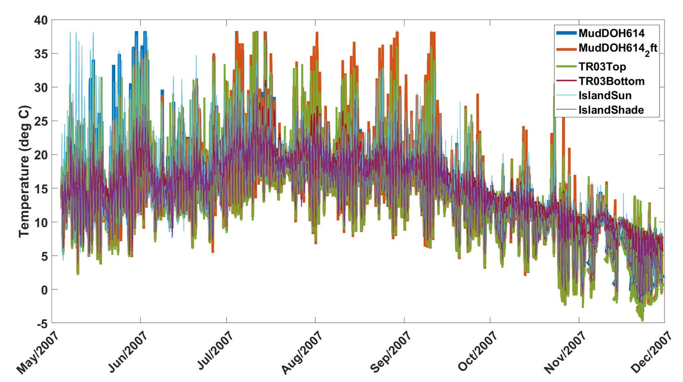

Figure 2. Time series of mud temperatures in Oakland Bay.

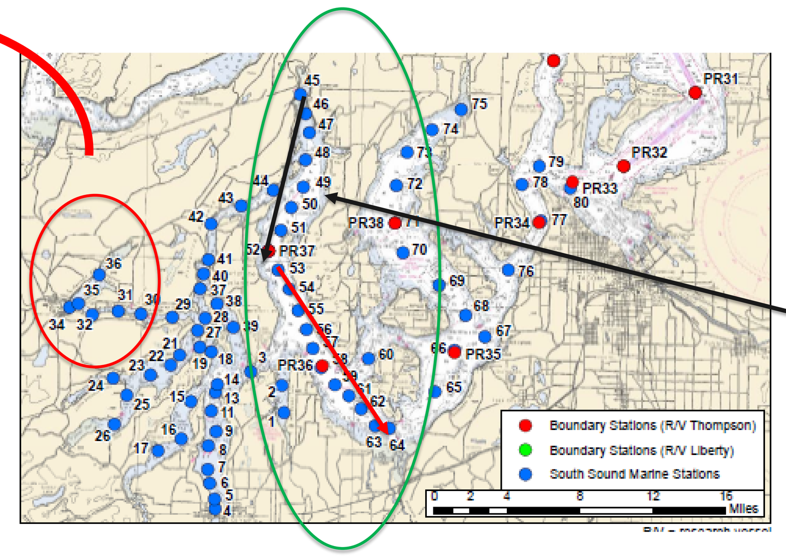

Figure 3a. Stations 46 (northern) to 64 (southern) in Case Inlet used in vertical contour plot.

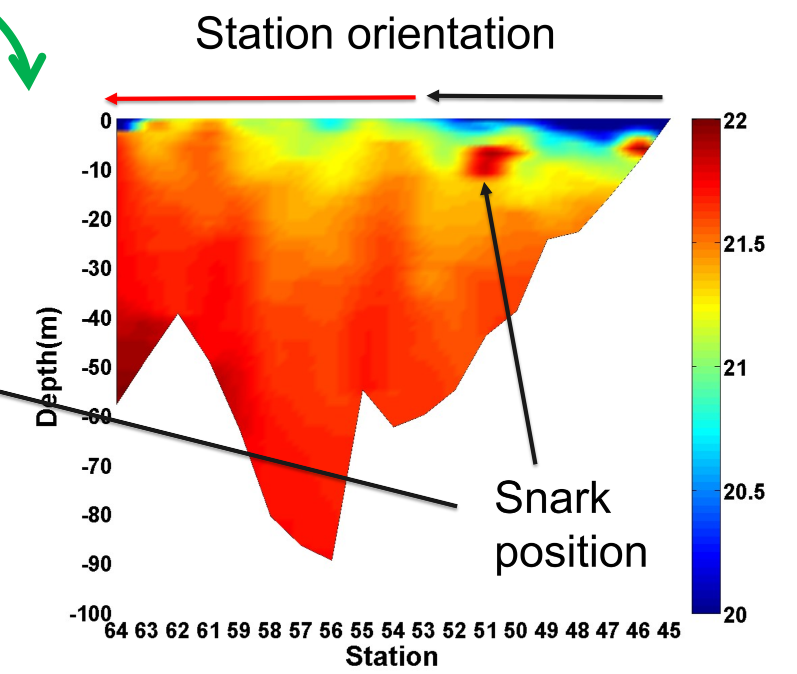

Figure 3b. Vertical contour of density in Case Inlet showing two snarks.

- Temperatures of nearly 40°C were recorded on the mud flat surfaces of Oakland Bay (Figs 1 and 2) during 2007 (Squaxin acknowledgment), which was not as warm a year as 2003-2006, or 2015-2016 (PSEMP references).
- A 2-km x 1-km snark, about 5 m thick, was observed sinking in Case Inlet south of Pickering Passage during September, 1997 (Fig 3a & b), which is a volume of about 10,000,000 m^3. The salinity within the snark was 29.7 psu, and it was 28.9 psu in the surrounding water (Fig. 4 shows the relationship to density). This means a volume of about 270,000 cubic meter would have to be evaporated on the mud flats if they were a suitable explanation.

The surface area of the mudflats and the water for Oakland Bay and Totten Inlet are about 2,500,000 m^2 and 917,000,000 m^2, respectively. Assuming an average wind speed of 5 m/s, an average air temperature of 25°C with a relative humidity of 50 (using a Mollier diagram), and a 24-hour average solar input of 240 W/m^2 during the longer days of summer, it would take about 2.7 day to evaporate enough water to achieve this. This seems feasible, especially during sunnier and warmer years. We also know, from a dye release study at the WWTP in Shelton that 92% of the water removed from Oakland Bay by estuarine circulation is refluxed back into the bay – it is a very retentive system (Albertson, 2004). We might look for sporadic salinity jumps in the summer within the long-term record at Ecology station OAK004 (Fig 5).

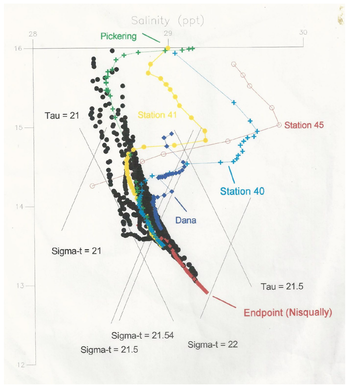

Figure 4. A T-S diagram showing the relationship of temperature, salinity, and density for the observed snark.

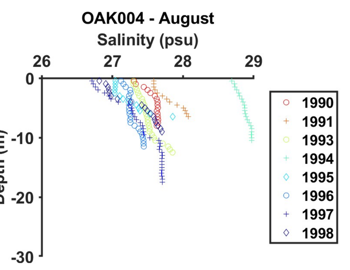

Figure 5. Spaghetti plots of salinity profiles in Oakland Bay showing a sporadic salinity jump in 1994.

Conclusions

- When denser, hypersaline water sinks on the landward side of an estuary, it can cause inverse-estuarine conditions and increase the residence time of the embayment.
- Snarks may amplify documented stressors to key estuarine species in South Puget Sound, such as Olympia oysters and salmon (Lawlor and Arellano, 2020) inhabiting shallow water.
- Climate change will extend periods of warm, dry weather in the summer and this can lead to more widespread instances of snarks in Case Inlet and potentially elsewhere.
- We present repeated observations of this phenomenon, which show that some of these snarks can extend for 10 km and be vertically 10m thick.
- Better understanding of snark formation and persistence is important for managing shellfish and other fisheries.

Literature cited

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https://apps.ecology.wa.gov/publications/SummaryPages/2203018.html.

Also see: https://ecology.wa.gov/Research-Data/Monitoring-assessment/Puget-Sound-and-marine-monitoring.