Do salinity and temperature in Budd Inlet drive jellyfish mass aggregations?

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Introduction

Mass aggregations of the jellyfish, *Aurelia labiata*, in the waters of South Puget Sound can become so large that they can be seen from small aircraft.

Jellyfish biomass reached record levels in Budd Inlet and the other finger inlets of South Puget Sound in the fall of 2014 and summer of 2015, coinciding with 'the Blob' of unusually warm water and with the drought.

This study explores the abiotic factors that might be contributing to the large jellyfish aggregations (masses or smacks). We conducted a qualitative assessment of the number and density of jellyfish masses in Budd Inlet by reviewing aerial photographs taken during *Eyes Over Puget Sound* flights. These data were then compared to salinity and temperature data collected on the same day to look for correlations.

Jellyfish smacks can easily exceed hundreds of millions of individuals and contain extremely high biomass.

Methods

This study uses aerial photography to categorize relative jellyfish abundance into five categories based on the number and size of jellyfish seen on aerial photographs collected monthly (Figure 1).

We sorted 62 photos over a 5.5-year period (2011-2016) into five categories, ranging from absent (no visible jellyfish) to highest number of aggregations.

The categories of jellyfish smacks were analyzed using a standard multiple regression analysis in relation to salinity, temperature, and density stratification to explore abiotic jellyfish predictors for future climate scenarios of the Northwest Region (Mekonnen et al. 2016) (Figure 3).

Figure 1a-d. Reference photographs of Budd Inlet used to determine which of 5 jellyfish categories (from least to most jellyfish) each photo (2011-2016) was placed into.

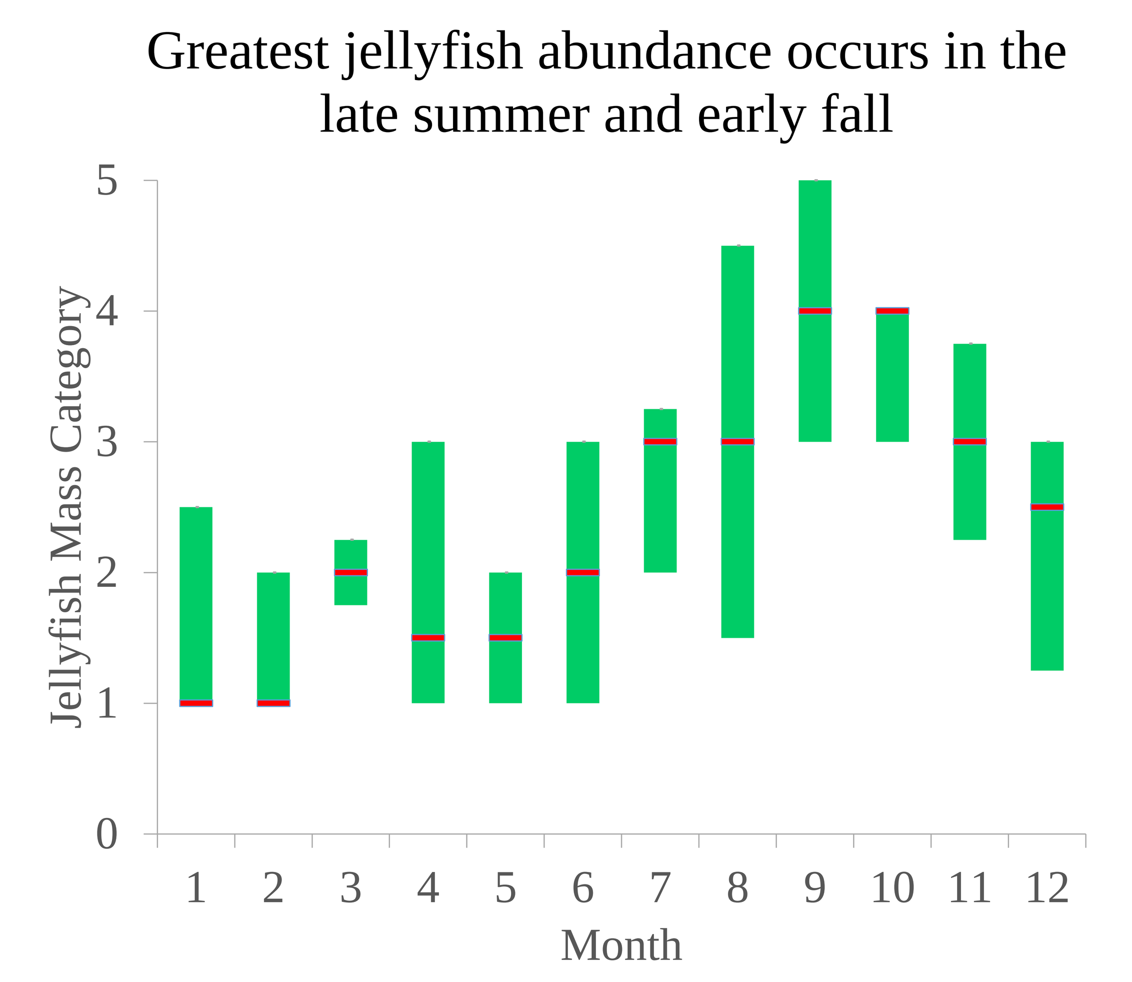

Figure 2. The median (blue line) and interquartile range (green bar indicating 25-75% of observations) of categories of jellyfish aggregation sizes, grouped by month (2011-2016), derived from aerial photography.

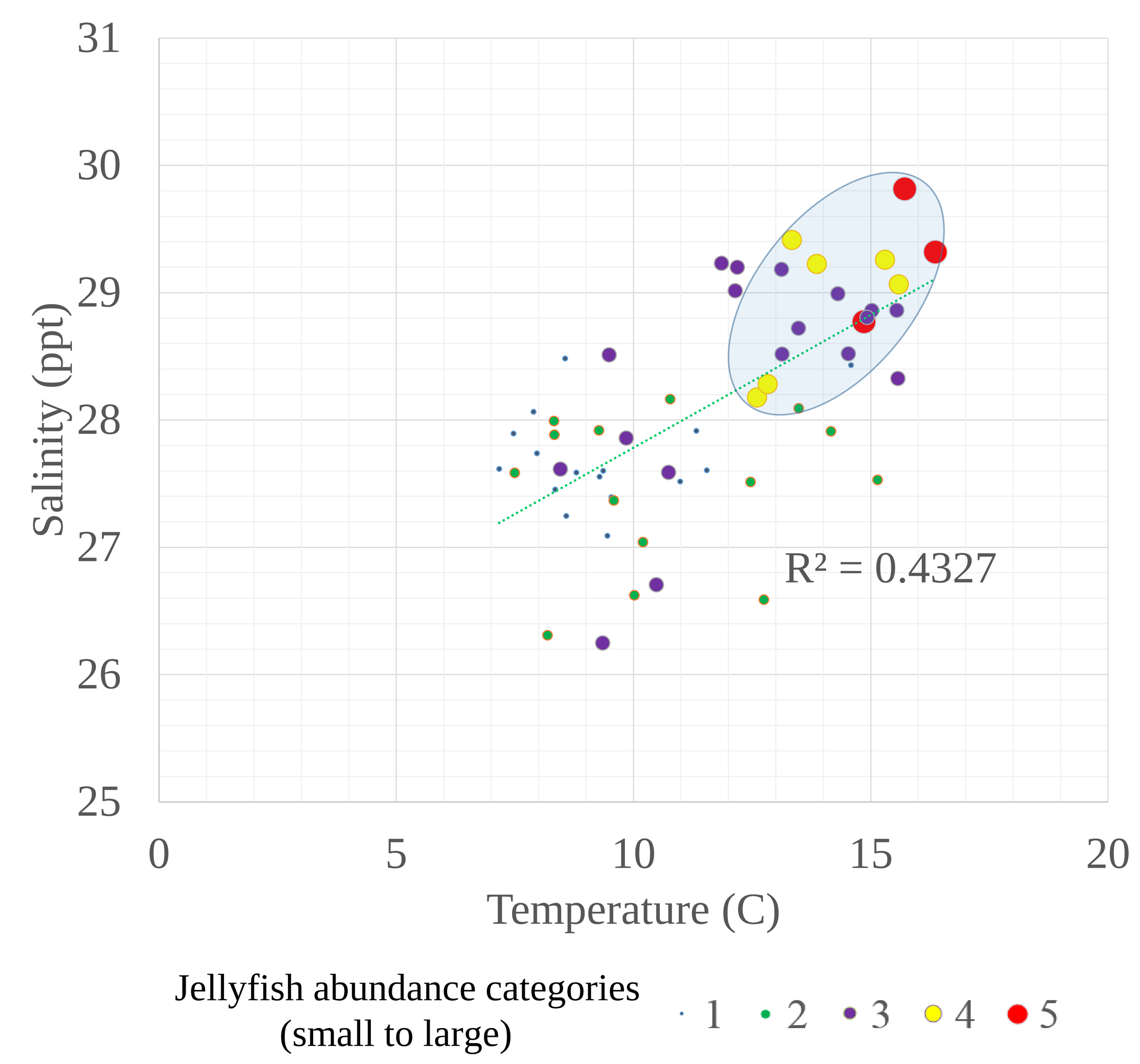

Figure 3. Jellyfish biomass categories plotted against salinity (ppt) and temperature (°C). Each dot represents a photo categorized and associated with salinity and temperature. Dot sizes correspond to aggregation size. The blue oval shows the "sweet spot" where salinity and temperature correspond with the biggest smacks.

Results

- Jellyfish abundance in Budd Inlet was greatest in September and October (Figure 2) and during 2012, the warmest year in this study (Figure 4).
- Salinity and temperature were highly correlated with relative jellyfish abundance in Budd Inlet (Figure 3).
- The linear combination of salinity and temperature was significantly related to the assigned categories, F (2,58) 9.47E-09, $p < .05$. The multiple correlation coefficient was 0.69, indicating that approximately 69% of the variance of relative jellyfish abundance can be accounted for by the linear combination of salinity and temperature (Figure 3).
- The optimum salinity and temperature range occurred from 28.1 to 29.8 ppt and from 12.6 to 16.4 °C, respectively. The two highest temperatures in our data set were both classified with very large jellyfish aggregations.

Jellyfish aggregation in Budd Inlet.

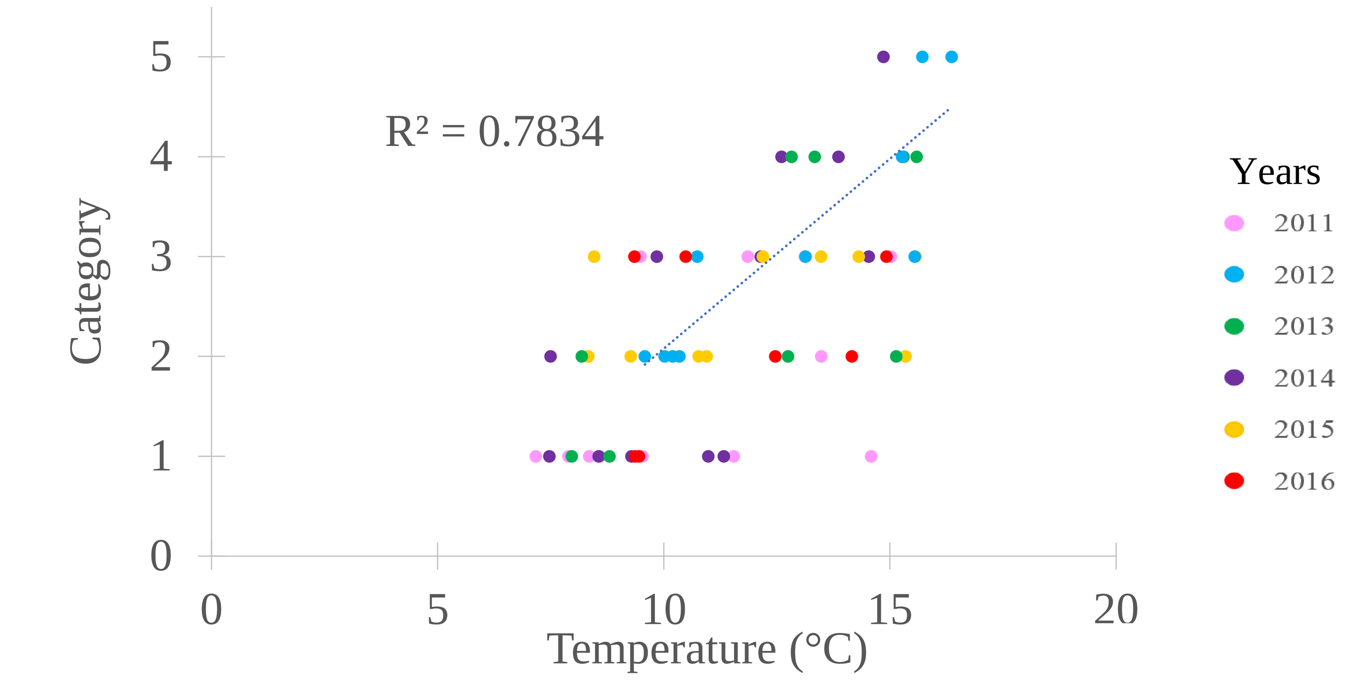

Figure 4. Comparison of the temperature (°C) of the Budd Inlet water column to the jellyfish biomass category assigned.

Summary

- Inter-annual variability in salinity and temperature has a large effect on the timing and magnitude of jellyfish mass aggregations (Figure 3).
- As freshwater input into Puget Sound in summer begins to decrease, water in Budd Inlet and the rest of South Puget Sound will experience increases in salinity and temperature at times when jellyfish biomass is already seasonally highest.
- **With high salinity and temperature being a good predictor for jellyfish mass aggregations, we can expect an increase in jellyfish mass aggregations with predicted regional climate change scenarios (Mekonnen et al. 2016).**

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