Ecosystem Effects of Marine Heat Waves

The Blob and its impacts on marine ecology in the Salish Sea

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Summary

Marine Heat Waves (MHW) influence system production, energy flow, and species distribution, recruitment and survival. In 2014, climatologists documented a MHW, known as “The Blob,” in which sea surface temperatures on the Pacific coast North America rose 1-4°C above the historical mean. Waters with elevated temperatures moved from the central Gulf of Alaska to coastal systems in fall with the seasonal shift to downwelling conditions. In the inland waters of the Salish Sea (Fig. 1), this had pronounced effects on the marine ecosystem. The Pelagic Ecosystem Function Research Apprenticeship (2004-2019) has been examining patterns in oceanographic properties, and the abundance, condition, and species composition of plankton and marine vertebrates. Elevated seawater temperatures were noted 2014-2016. Time series analyses reveal coincident shifts in N/P ratios, decreases in nitrate concentration, increase in the abundance of amphipods relative to copepods, decreases in mean condition in an important forage fish, Pacific sand lance, and reduced densities of marine birds and mammals. This synoptic view of the system provides insight into trends and linkages throughout the system. As MHWs become more prolonged and common, it is essential to study these effects to better understand short and long-term impacts on local populations and ecosystems.

Methods and Results

More than 200 transects were conducted (2004-2016) in the San Juan Channel (Fig. 2). Oceanographic data was collected at North Station (Fraser River influence) and South Station (Pacific Ocean influence), using CTD casts, nutrients, oxygen, phytoplankton, and zooplankton. Marine birds and mammals were surveyed along transect and acoustic data was collected on zooplankton and forage fishes. Pacific sand lance (*A. personatus*) were collected from benthic habitats in the San Juan Channel sand wave field and in multiple other locations throughout the San Juan Archipelago. Weather data and climate indices (http://nvs.nanoos.org/Climatology) were evaluated to correlate broadscale physical drivers to local observations.

Climate indices indicated a shift in 2014 to a negative phase of NPGO and a positive phase of ENSO and PDO (Fig. 3). Sea surface and bottom temperatures at both North and South stations reflected local warming 2014-2016 relative to previous years (Fig. 4).

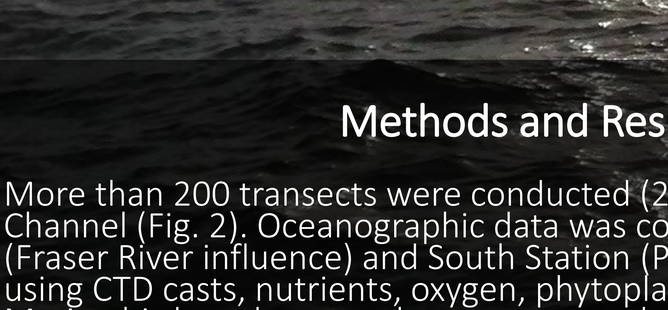

Figure 1. Map of Salish Sea

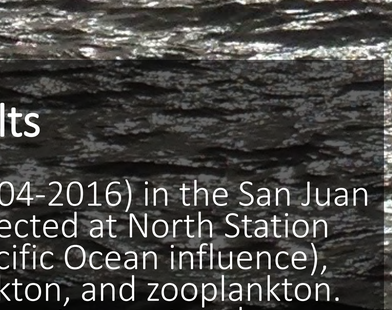

Figure 2. Survey transect

Results

In 2014 there was a shift in relative abundance of calanoid copepods and amphipods (Fig. 5) and a marked decline in mean condition for fish populations in three separate locations in contrast to previous years (Fig. 6). A GLM examining mean annual condition as a function of annual environmental conditions (SST, PAR, UI) and climate indices (ENSO, PDO, NPGO) found all 6 explanatory variables were influential.

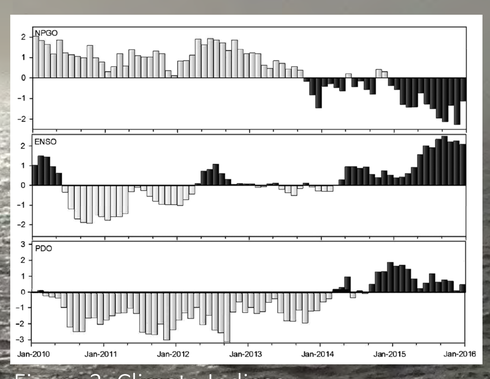

Figure 3. Climate Indices

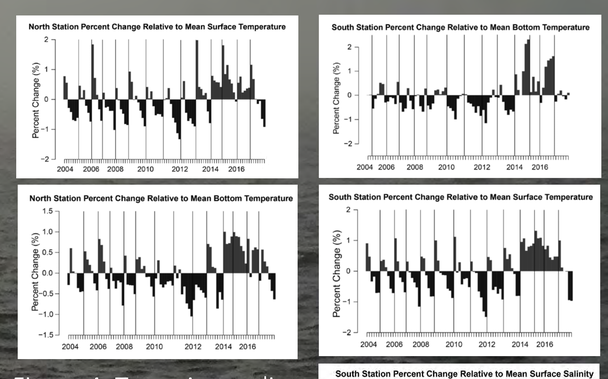

Figure 4. Temp Anomalies

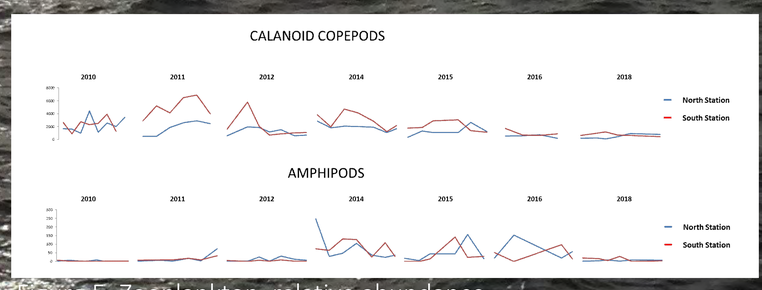

Figure 5. Zooplankton, relative abundance

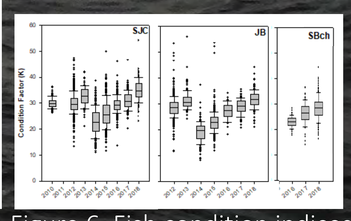

Figure 6. Fish condition indices

Results

The 2014-2016 MHW precipitated a decline and sequential rebuild in nutrients and fish condition (Fig. 7), decline in South Station O2 (Fig. 8), and significant and sustained reduction in phytoplankton abundance and fluorescence (Fig. 9). Marine bird and mammal abundances were reduced relative to the preceding cold years (2010-2013).

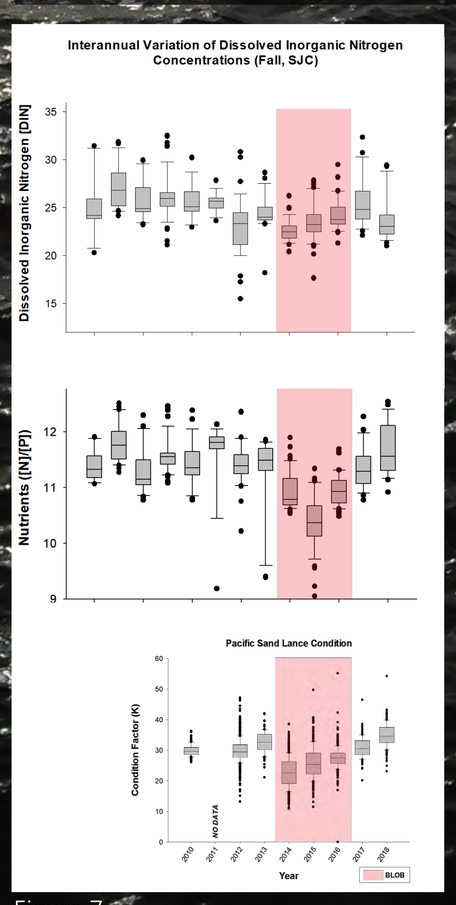

Figure 7.

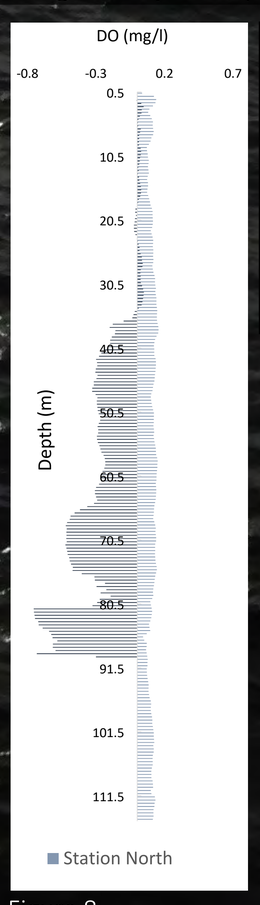

Figure 8.

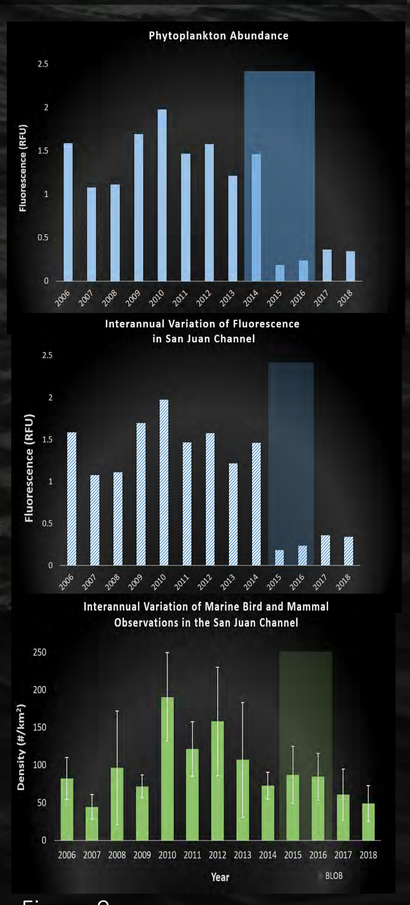

Figure 9.