2015 Olympia Oyster, *Ostrea lurida*, Brooding Results From Northern Puget Sound

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Introduction

Olympia oysters, *Ostrea lurida*, are the only native oyster to Washington State and were once a bountiful bivalve species with cultural, economic, and environmental importance. Following European settlement, population numbers of *O. lurida* drastically decreased. Currently, only ~5% of historic native oyster beds remain in Puget Sound. While government and non-profit organization restoration efforts have expanded greatly throughout the west coast, data describing basic biological information of distinct populations still require further attention. Of particular importance to Olympia oyster restoration work is understanding the reproductive activity within specific populations because spawning conditions appear to vary depending on the geographic location (Pritchard et al. 2015).

In 2012, the Swinomish Indian Tribal Community began a collaborative restoration effort with the Puget Sound Restoration Fund to establish, expand, and research Olympia oyster populations in unique pocket estuary (lagoon) habitats. Part of our research involved monitoring reproductive activity in order to describe the timing and duration of oyster brooding within these populations. In particular, we were interested in answering the following questions:

- How do Olympia oyster larval stages vary during the sampling season?
- Does mean percent brooding vary by site?
- How do temperature data qualitatively relate to brooding at the restoration sites?
- How do these results compare to results from other reproductive studies conducted on the west coast of North America?

Methods

The Lone Tree (LT) and Kiket (KI) lagoons are located in Skagit and Similk Bays, respectively, in northern Puget Sound on the Swinomish Reservation (Figure 1). The Olympia oyster plots are located in lagoon channels that are inundated with water even at extreme low tides. Olympia oysters were out-planted to both lagoons in 2012, 2013, and 2015.

Sampling methods:

- Water temperature was logged in 15 min. intervals at each site from April to September 2015 using HOBO UA-002-64 pendants.
- Oysters were collected from three to five 1/16th m^2 quadrats per site, totaling roughly 500 individuals per lagoon per week from May 6 through August 25, 2015 (n=17 sampling dates) (Figure 2A).
- Individuals were desiccated for a minimum of 45 min. and transferred into a treatment of 75g/L Epsom salt mixed with a 50/50 seawater/freshwater solution for 45 min. (Figure 2B) (Heare et al., in review).
- Oysters were removed from the solution and open individuals were inspected for brooding activity (Figure 2C & 2D) using a black zip tie to visually check for brooded larvae (Figure 2E).
- Length of the brooding oyster was recorded as well as the color of the brooded larvae ("sic") to denote the stage of larval development (Figure 2F).

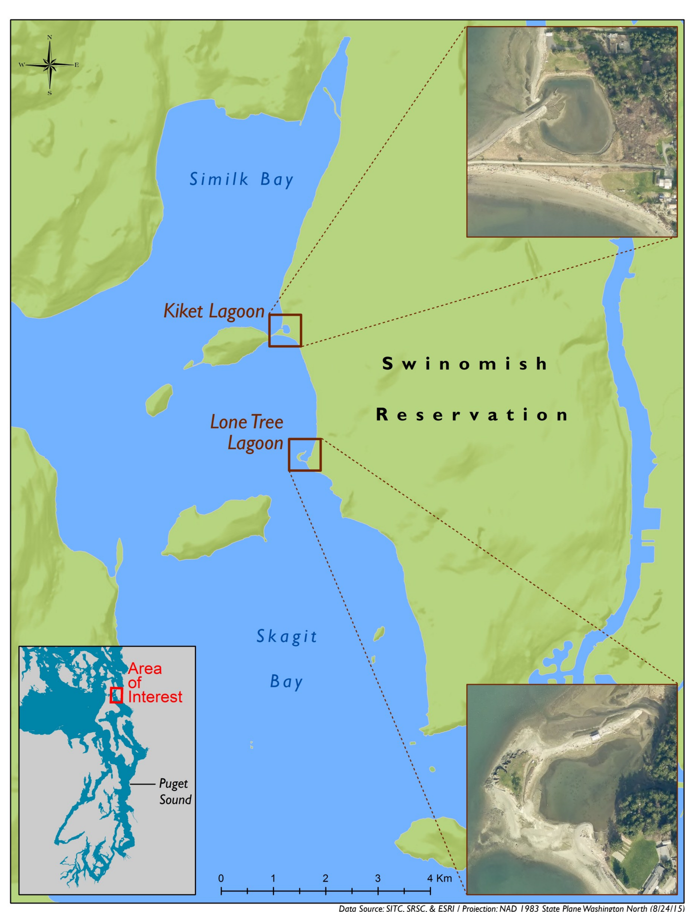

Figure 1. Map of restoration sites within the Swinomish Reservation.

- SYSTAT 13 was used for all statistical analysis
- SigmaPlot 12.3 was used for all graphs

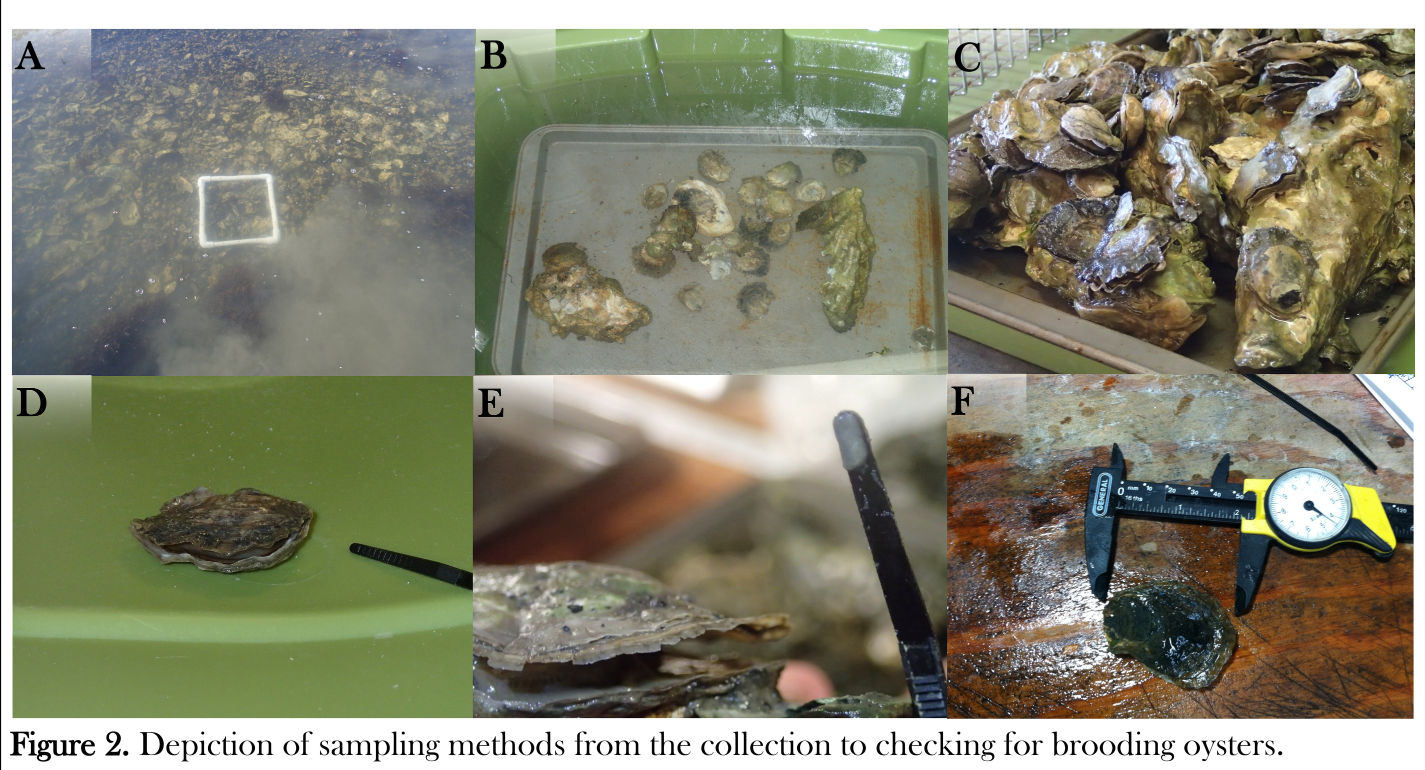

Figure 2. Depiction of sampling methods from the collection to checking for brooding oysters.

Results

- No statistical difference was found between two cohorts at LT (ANOVA $F_{1,31}$0.689, p=0.413), therefore we combined these datasets for all subsequent analyses. Only one cohort was studied at KI.
- Brooding oysters were found at LT on the first sampling event (May 6, white sic only) but not until a week later (May 11, white and gray sic) at KI (Figure 3). Gray sic were not detected at LT until May 21, 2015. More black sic were noted at KI than LT. Brooding ended at both lagoons after the first week of August (Figures 3 & 4).
- Between May 26 and June 9, 2015 mean percent brooding peaked at 11.8±4.6% for KI and 16.1±2.5% for LT (Figure 4). The main brooding peak at LT occurred before daily minimum water temperature reached 12.5°C (Figure 4B).
- We found no significant difference in mean percent brooding by site ($F_{1,107}$0.002, p=0.97), nor did we find a significant interaction between site and date ($F_{16,106}$1.131, p=0.34).
- Qualitatively it appears that the daily minimum water temperature is higher at KI than LT, even though both lagoons exhibit typical fluctuations due to diurnal air-temperature variations and tidal exchanges.

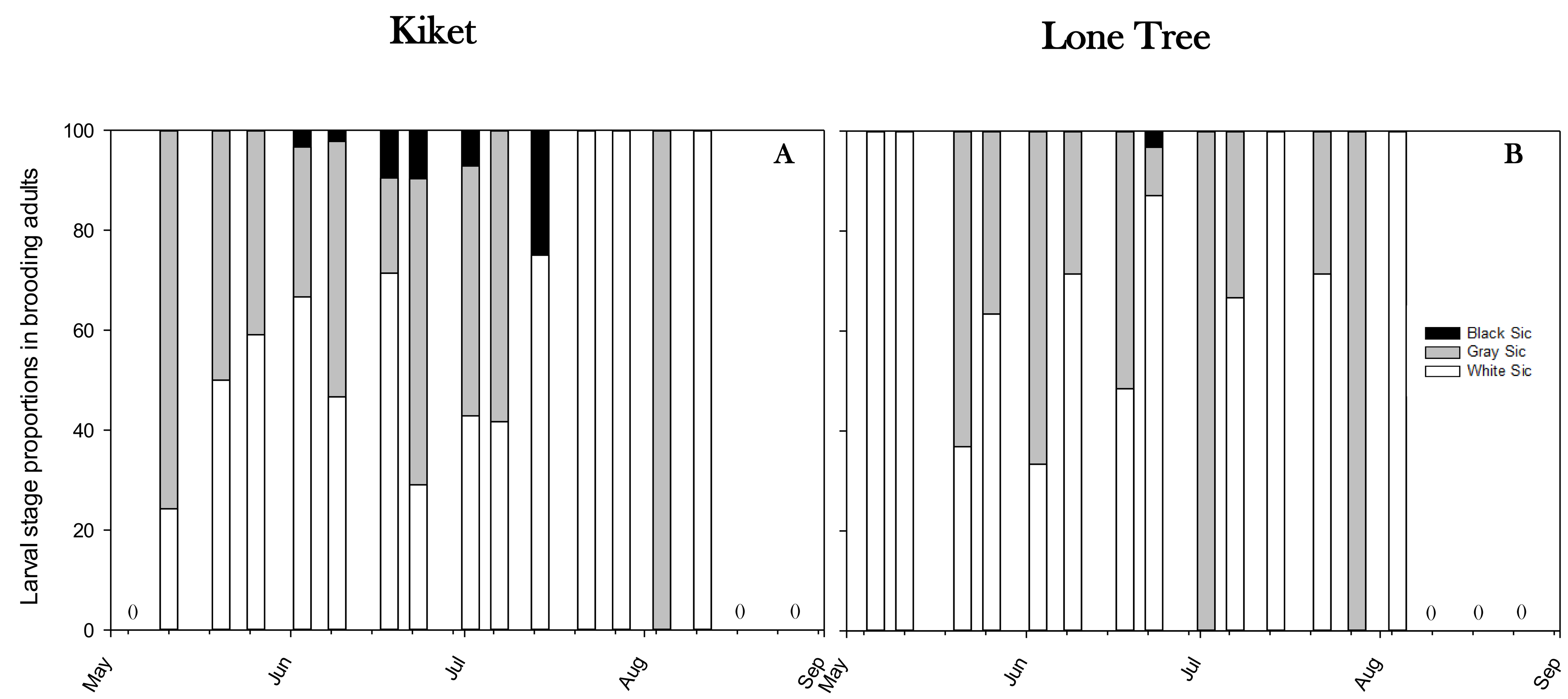

Figure 3. Larval stage proportions in brooding female Olympia oysters at Kiket Lagoon (A) and Lone Tree Lagoon (B) from May 6 to August 26, 2015. 0 = zero brooders.

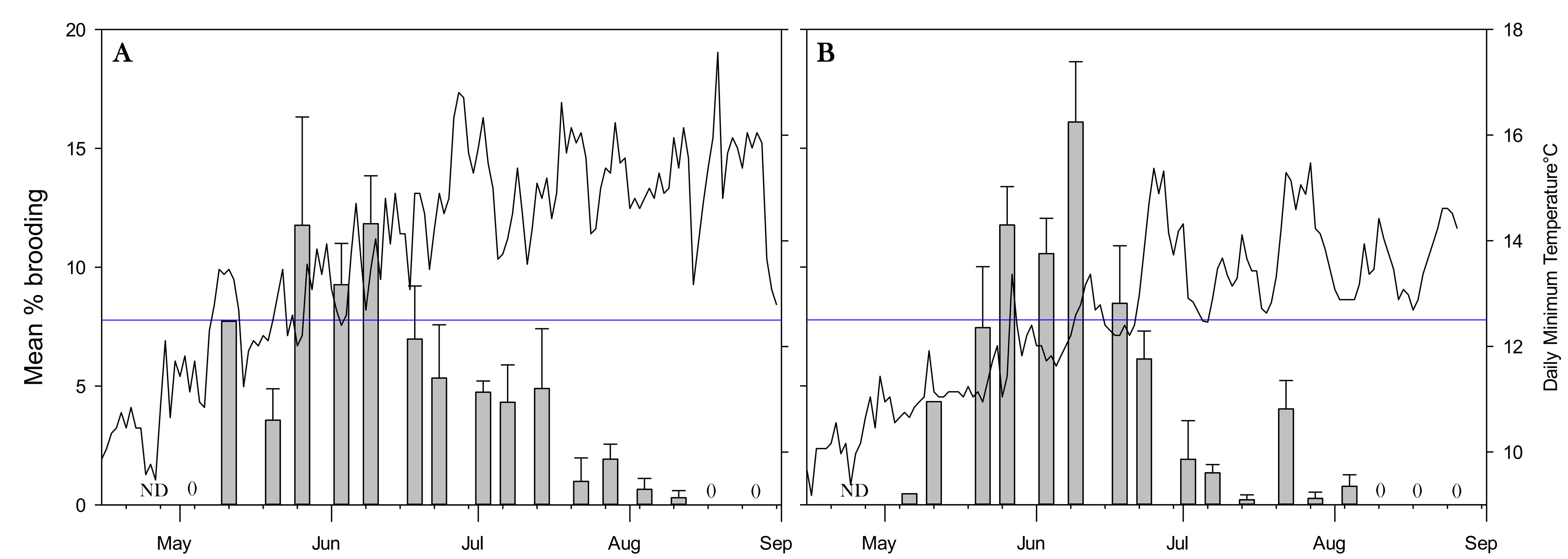

Figure 4. Mean percent brooding for Olympia oysters at Kiket Lagoon (A) and Lone Tree Lagoon (B) from May 6 to August 26, 2015 and associated daily minimum water temperature (°C). Horizontal blue line=the temperature known to initiate spawning in southern Puget Sound, 12.5°C (Hopkins 1937). ND = no data and 0 = zero brooders.

Discussion

- In southern Puget Sound, Hopkins (1937) brooding stages slowly progressed from primarily white sic in the beginning of the season (May-June) to primarily gray/black sic at the end of the season (July). Our results more closely mirror Carson's (2010) California study where white sic and gray/black sic co-occurred throughout the spring and summer. However, it should be noted that a higher sampling frequency may have returned results that more closely resembled Hopkins (1937) data.
- Results from published studies demonstrates that a wide range of temperatures are known to initiate the spawning season (e.g. 13°C in southern British Columbia, 16°C in southern California) which generally occurs in May in Puget Sound (Pritchard et al. 2015). Hopkins (1937) reported a possible 12.5°C minimum spawning temperature in diked oyster farms in southern Puget Sound. Based on similarities in environmental conditions and geographic location, one would expect that our brooding data would have closely paralleled Hopkins' results. Yet our data clearly indicate that northern Puget Sound oysters located in pocket estuaries can begin brooding before May at temperatures below the published thresholds.
- Our data demonstrates that we either (1) missed quantifying the beginning of the brooding season or (2) started recording data concurrently with the start of the brooding season. Although our oysters began brooding at cooler temperatures than expected, an unseasonably warm winter may have been partially responsible for the unexpectedly early start to brooding. As sea surface temperatures continue to increase due to climate change, one would expect that Olympia oysters will begin brooding earlier in the year. Our results may be more representative of these future brooding seasons rather than representative of current summers in terms of sea surface temperature in Washington state.
- Because KI minimum water temperature appears to be higher than the LT temperature, one could reasonably expect to record brooding first in KI oysters. Yet, no significant difference in mean percent brooding by site was found. This most likely means that water temperature represents one factor in a group of factors that determine the start of the brooding season.
- In the future, brooding studies at higher latitudes should start quantifying reproductive activity in mid-April rather than early May and increase sampling frequency to twice a week to ensure recording the start of brooding. Furthermore, we suggest monitoring additional factors in addition to temperature (e.g. pH, chlorophyll *a*) in order to examine other parameters that may influence spawning timing. These results may greatly enhance the ability of restoration managers to capitalize on spat recruitment and settlement and promote restoration success.

References

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