Essential Fish Habitat project status report

Reporting date: 10/22/2012

Project number: 2011-1

Title: Determinants of juvenile tanner crab growth from different nursery embayments

PIs:Ryer, Spencer, Iseri, Ottmar, Copeman

Funding year:2011

Funding amount: $83,000

Status: ☐ Complete ☒ Incomplete, on schedule ☐ Incomplete, behind schedule

Planned completion date if incomplete: All field work has been complete. All lipid samples and non-extracted crabs were lost in a -80 freezer failure. New samples were taken in 2012 and have been extracted and sent to Memorial University for analysis. Anticipate manuscript combining this work and 2012 project will be published in 2014.

Reporting: Have the project results been reported? If yes, state where the results were reported and attach an electronic copy of the report.

Result have not yet been fully reported. Anticipated 2014

Results: What is the most important result of the study?

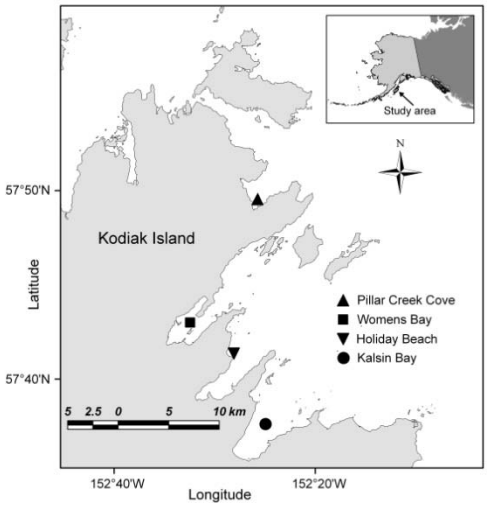

Figure 1. Location of study sites.

Our 2011 research grew out of research from the prior year demonstrating age-0 yr Tanner crabs recruiting to different Kodiak embayments may be experiencing differing growth rates. We had sampled crabs from 4 Kodiak embayments; Pillar Creek Cove, Holiday Beach, Kalsin Bay and Women's Bay Fig. 1). By July 2010 age-0 Tanner crabs from Women's and Kalsin were one molt stage larger than those in Pillar and Holiday. Larger size at the end of the first summer could provide increased fitness to Women's Bay crabs as they are less vulnerable to predation. Further, because growth in Tanner crabs is determinate, 1 molt stage difference in growth equates to maturation 1 year earlier.

Understanding how nursery/habitat influences growth and size/age at maturity provides a direct linkage between essential fish habitat and stock productivity

(HEPR_EFH Level 3 & 4).

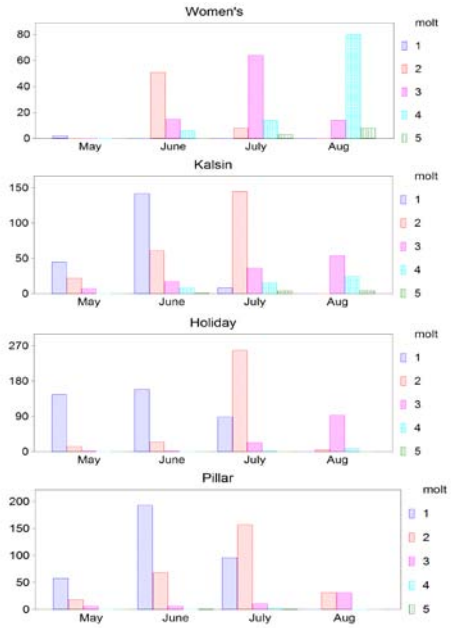

Figure 2. Relative size frequency distributions of age-0 yr Tanners from each site, May – August**.**

Our 2011 HEPR funded research addressed 4 specific hypotheses as possible reasons for this difference in size:

1) Timing of recruitment (settlement)*: *Megalopae recruit earlier to Kalsin and Women's Bay, allowing for greater cumulative growth. We compared the May size-frequency distributions in all 4 embayments (Fig. 2, G = 32.57, df = 12, P = 0.001). The major difference involved Women's, where age-0 crabs (C1-C3) were nearly absent in May. Yet by mid June, crabs appearing at Women's were already C2 or larger; 1 molt > than other sites. This molt advantage persisted throughout the summer. There were other minor differences in size between population, perhaps suggesting some differences in timing of recruitment. For example, crabs at Kalsin were somewhat large than the other sites, with more C2 and even C3 crabs. However, the major effect in the data remains the size disparity between site in June and onwards. If anything, crabs at Women's appear to have recruited somewhat later than at the other sites. Hence, early recruitment cannot explain their great size in June.

*2) **Size selective predation: High predation upon smaller crabs at Womens and Kalsin truncates the size frequency distribution.*** Recruitment was largely complete by July (Fig. 2). Hence, population changes from July to August are due to mortality or emigration/immigration. Neither Women's nor Kalsin experienced significant population declines from July to August (Fig. 3, Women's: Wilcoxon, P = 0.413, Kalsin: P = 0.204). At Pillar, crab abundances declined significantly (Wilcoxon U, P = 0.040). Decline at Holiday was not significant (Wilcoxon, P = 0.419). Crabs were surviving and remaining in residence at Women's and Kalsin, and to a lesser extent Holiday, but dying and/or emigrating at Pillar. This pattern of population change is not consistent with the hypothesis as stated, which would entail greater population changes at Women's and Kalsin, not Holiday and Pillar. Therefore, we can reject the size selective

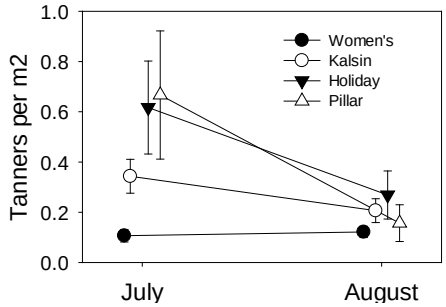

Figure 3. July to August population size changes at each site.

predation hypothesis, as an explanation for larger crabs at Women's and Kalsin Bay.

3) ***Environmental control of growth: Higher temperatures at Kalsin and Women's Bay accelerates growth.*** Our temperature mediated growth experiment is not yet complete; crabs at 2°C, as well as some of the 6°C crabs have yet to reach the C4 stage. We anticipate all remaining crabs will reach C4 by December, 2011. However, preliminary results clearly indicate that higher temperature significantly accelerated Tanner growth in the lab (Fig. 4). The most relevant temperatures that relate to field temperatures during May and June are 6°C and 9°C . So for this discussion we ignore the results for the 2°C and 12°C treatments. The C2-C3 intermolt period was 46 days at 6°C, but only 30 days at 9°C. Similarly, the C3-C4 intermolt period was 56 days at 6°C, but 43 days at 9°C. This clearly indicates that 3 degrees of temperature differential can markedly influence growth at this time of year. However, temperature loggers from 2011 at each site (~15m depth) indicated only minor temperature differences. During the early summer, when crabs at Women's underwent accelerated growth, the average delta T between all sites was only 0.3^{o}C. While we will have to await completion of the experiment and further analysis to completely model crab growth at these sites, we consider it unlikely that temperature was a significant contributor to the deviations in growth between populations. Therefore, we reject the hypothesis of temperature mediation of growth as the principle causative factor in the differential growth patterns.

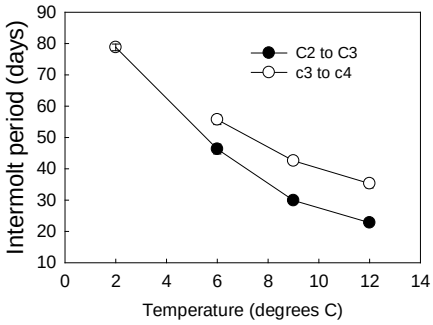

Figure 4. Influence of temperature on C2-C3 and C3-C4 intermolt periods.

4) ***Food quality control of growth: Higher food quality at Kalsin and Women's Bay accelerates growth/ improves crab condition.*** 2011 crab subsamples are currently being extracted for analysis of storage lipids and fatty acid biomarkers. Further, plankton and ampharetid polychaetes biomarker samples will potentially clarify source of dietary organic carbon in each embayment (Copeman et al. 2009). However, we do have completed lipid and fatty acid biomarker data for samples taken at Women's, Pillar and Holiday during July 2010. These samples may foreshadow what we may see from 2011crabs. Significant differences occurred in the amount of storage lipid in crabs from the three coves. Pillar crabs had significantly lower storage lipid (triacylglyercols, ~8%) compared to Holiday and Women's ~20%). Women's crabs had consistently higher levels of fresh diatom fatty acid biomarkers than crabs from the other embayments. More specifically, the levels of 20:5n-3 was significantly higher in crabs from Women's Bay. This specific essential fatty acid biomarker has previously been demonstrated to accelerate growth in larval Pacific cod (Copeman & Laurel 2011), larval rock sole (Copeman et al. in prep), and wild red king crabs juveniles (Copeman et al. 2011). Not only was this essential fatty acid and diatom marker found at higher levels in Women's Bay, it was strongly correlated with the carapace widths of juvenile C3 crabs across the three embayments (Fig. 5, $r^2 = 0.60$). While 2011 samples will further clarify this mechanism, these data support the food quality hypothesis.

In summary, our data thus far have refined our thinking and allowed us to focus in on 2 potential hypotheses to explain the patterns of crab size in the 4 embayments. First, lipid and fatty acid data suggest that crabs at Women's are consuming food with a strong diatom signal. This same fatty acid has been shown to accelerated growth in other species. We therefore consider it likely that nutrition, perhaps in the form of benthic diatoms, plays a major factor in controlling growth in the various embayments. The lower wave energy at Women's and, to a lesser extent Kalsin, may allow establishment of benthic diatoms in the shallows, which supports crab growth. Interestingly, in both Women's and Kalsin crabs tend to be found at shallower depths than the other 2 sites. This should be further resolved when our 2011 samples have be processed and analyzed. In addition, laboratory experimentation could be undertaken to determine whether a diet rich in these fatty acids can be demonstrated to accelerate growth.

A second question, dealing with different July – August rates of population decline, also needs to be resolved. We hypothesize that there is a generalized behavior innate to age-0 yr Tanner crab that leads them to seek deeper water as they grow through the course of their first summer. This hypothesis is supported by some limited data collected in 2010 and 2011. This could be further resolved by more focused sampling at Pillar Creek Cove, where there is a gently sloping bottom that reaches depths of 70m in Monashka Bay. Interestingly, the retention of crabs in Women's Bay may be a function of the shallow sill (~15m) at the Bay's entrance. This may preclude juveniles from emigrating out, leading to the large number of age-1 yr crabs, as well as the subsistence fishery for Tanners that is supported in Women's Bay. Women's bay may be a good model system for understanding the larger Fiords that are prevalent in southeast Alaska.