EXPLORING DIFFERENT JUVENILE CLAM ABUNDANCE SURVEY METHODS

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ABSTRACT

In response to observed declines in tribally-important clam species, the Swinomish Fisheries Department conducted an exploratory juvenile clam abundance study in 2014 to assess recruitment patterns. Sediment samples (6 cm in diameter, 7 cm deep; n=85) were collected and processed at three beaches in Whidbey basin. Due to low counts of juvenile clams, survey methods were modified in 2015 and 2016. Instead of one-time sediment samples, 10 PVC tubes (10 cm in diameter, 15 cm deep) covered with 1 mm mesh were placed flush with the tideflat at two beaches and the top 5 cm of sediment were collected in June, July, and August 2015 for processing. In 2016, the PVC tubes were replaced with 1 mm mesh bags (15 cm long, 10 cm wide) filled with pea gravel that were deployed in April and collected in August. All samples were sieved using 1 mm mesh sieve and clams <15 mm were identified and measured. Over all three years a total of 332 clams and 12 different species were found. *Macoma* spp. were the most abundant in our samples, followed by *Rochefortia tumida.* Counts of target clams such as *Leukoma staminea, Saxidomus gigantea,* and *Clinocardium nuttallii* and *Tresus* spp. were typically zeros with only a few out of 185 samples containing juveniles of these species. Median total clam counts per sample were 0, 2, and 1 for 2014, 2015, and 2016, respectively. While the results from this effort were unsuccessful in locating juvenile clams of tribally-important species, there are a suite of variables to consider for future survey modifications, including local currents and bedload transport.

Keywords: Juvenile clams, recruitment, Puget Sound

INTRODUCTION

For the Swinomish Indian Tribal Community (SITC), clams are an important traditional food that provides physical, cultural, and economic sustenance (Donatuto et al. 2011). In order to optimize harvest opportunities for tribal members, the Swinomish Fisheries Department conducts annual clam biomass surveys on Reservation tidelands and on public tidelands in Whidbey Basin as co-managers with the Washington Department of Fish and Wildlife. These intertidal surveys quantify standing stock biomass of wild bivalve populations and are used to inform management practices and calculate harvest quotas (Campbell 1996, Barber et al. 2012). However, these surveys target adult populations and do not incorporate clams smaller than the legal harvest length (38 mm). While monitoring adult spawning stocks is fundamental to fisheries management, quantifying recruitment patterns is also an essential parameter that can help resource managers assess the sustainability of management practices, even for highly fecund species such as bivalves (Jamieson 1993, Myers & Barrowman 1996, Peterson 2002). Indeed, settlement and early post-settlement events often govern overall population dynamics of bivalves and other marine invertebrates (Olafsson et al. 1994, Hunt & Scheibling 1997, Gosselin & Qian 1997).

Thus, when a precipitous decline in *Clinocardium nuttallii* was observed in 2013 by tribal clam diggers in Whidbey Basin, the Swinomish Fisheries Department began to focus research efforts on juvenile clams (2-15 mm in length) to better understand local clam population dynamics and inform harvest management practices. The overarching objectives for our juvenile clam research included:

1. Assess juvenile clam abundance on tribally-important beaches
2. Examine spatial distribution of juvenile clams by beach and tidal elevation
3. Compare bivalve species richness among beaches
4. Investigate patterns of juvenile and adult clam populations by beach

To address these objectives, we designed an exploratory juvenile clam abundance study in 2014 based off previous research conducted in Washington state (i.e., Dethier pers. comm). Due to unexpectedly poor results in juvenile clam counts, we modified our sampling methods for subsequent surveys conducted in 2015 and 2016. This report summarizes results from the different methods we tested and provides suggestions for how to improve results in the future.

METHODS

For all surveys, we targeted the following juvenile clam species: *C. nuttallii*, *Leukoma staminea*, *Saxidomus gigantea*, and *Tresus* sp. All clam species, however, were recorded including naturally small adults (<15 mm in length but sexually mature) such as *Rochefortia tumida* and *Nutricola tantilla*.

2014

Juvenile clam abundance surveys were conducted in August on three beaches within Whidbey Basin: Kiket Island (KI), and Lone Tree (LT) located on the Swinomish Reservation in Skagit Bay and Blowers Bluff (BB), a public beach in Oak Harbor, Whidbey Island (Figure 1).

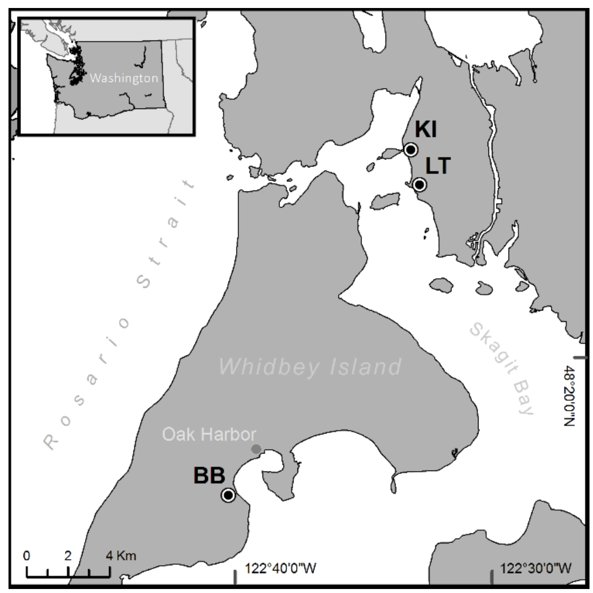

Figure 1. Location of juvenile clam abundance study sites. KI = Kiket Island, LT = Lone Tree, BB = Blowers Bluff.

At each site, a section of the tideflat was selected based on areas of high adult clam biomass that had been identified by previous intertidal surveys. Three 100 m transects (A, B, C) were placed alongshore at +0.30 m, 0 m, and -0.30 m relative to MLLW, respectively, and two transects (D and E) were placed cross-shore starting at +0.61 m MLLW, crossing the alongshore transects at the 30 m and 70 m mark, and extending to the waterline. Five core samples, 6 cm in diameter and 7 cm deep, were collected into 120 ml jars from transects A-C and 7 samples from transects D & E. Sample locations were randomly chosen on transects A, B, and C whereas samples on D and E were collected at +0.91m, +0.61 m, +0.30 m, 0 m, -0.30 m, -0.46 m, and -0.61 m relative to MLLW, except at LT where +0.91m samples were not taken. Samples were sieved using 1 mm mesh, clams <15 mm were placed into vials and preserved in 40%

isopropyl alcohol. A dissecting microscope and calipers were used to enumerate and identify clams according to (Coan et al. 2000, Catton & Dethier 2001). Clams were considered juveniles if the species reached a length >15 mm as adults. Individuals identified as species that are <15 mm as adults were categorized as "other" for analysis purposes because these species were quite prevalent in our samples.

2015

To reduce the spatial scope of our study and focus on temporal changes in recruitment, one beach on the north (LTN) and south (LTS) side of LT were sampled three times over the summer using methods modified from Dethier (2012). On 22 April, two 50 m transects were laid alongshore at +0.61 m and 0 m relative to MLLW at both beaches. Five PVC tubes, 10 cm in diameter and 15 cm deep, were buried every 10 m along each transect so the top was flush with the surface of the beach. Each tube was filled with de-faunated sediment that originated from the site and was frozen for a week before being thawed and placed in a PVC tube. The tubes were covered with a piece of 1 mm mesh to deter predation. In June, July, and August the top 5 cm of sediment were collected and the tubes were refilled with sterile sediment, except for the last sampling event when the tubes were removed. The samples were processed using the same methods as in 2014 but preserved in 95% denatured ethanol because the isopropyl alcohol in 2014 caused too much pitting in the preserved shells, making identification difficult.

2016

In April, surveys were conducted on beaches less than 50 m away from the 2015 LT sites as well as a north and south beach on KI using methods modified from Ruesink et al. (2014). Two 50 m transects were placed alongshore at +1.22 m and +0.61 m relative to MLLW. We placed 1 mm mesh bags (15 x 10 cm) filled with pea gravel every 10 m along the transect lines. Each bag was buried in the top layer of the sediment so the bag was flush with the beach surface and staked into the substrate. Bags were collected in August and processed using the same methods as 2015.

Statistical analysis

Total clam counts from all three years were insufficient to warrant qualitative analysis. Therefore, clam abundance and species richness were qualitatively examined.

RESULTS

We counted a total of 332 clams across all three study years. Six species were identified as juveniles: *C. nuttallii*, *L. staminea*, *Tresus* spp., and *S. gigantea*, which are all tribally-important, and *Macoma* spp. and *Mya arenaria* (Figure 2). Other clams included *Rochefortia tumida*, *Nutricolla tantilla*, *Axinopsida serricata*, *Lasaea sp.*, *Parvilucina tenuisculpta*, and *Tellina modesta*.

2014

At all of the sites combined, 69 clams were found with a median abundance of 0 (Figure 2) and species richness of 7 (Figure 3). Kiket Island had the highest total abundance with 36 clams compared to 23 and 10 at BB and LT, respectively. *Macoma* spp. were the most abundant at all sites (n = 34), followed by *N. tantilla* (n = 20) and *R. tumida* (n = 17). Of the culturally-important species, *C. nuttallii* and *Tresus* spp. were not found at any of the three sites, LT had 2 *L. staminea* and 1 *S. gigantea*, and KI had 2 *L. staminea*. Qualitatively, there appeared to be no difference in abundance between samples collected below, above, or at 0 m relative to MLLW.

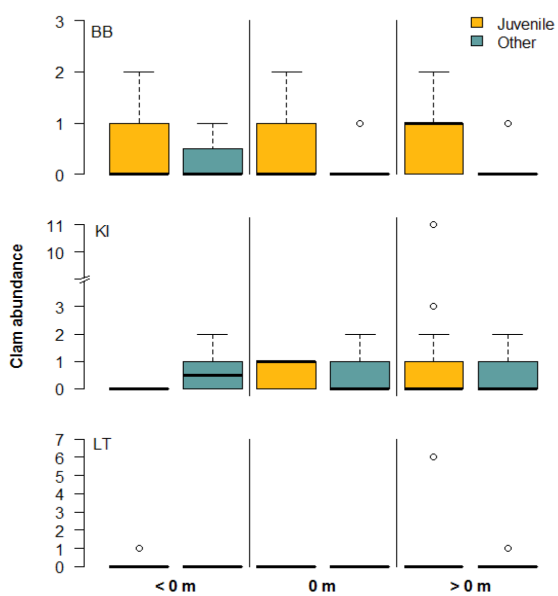

Figure 2. Boxplots of < 15 mm clam abundance in 2014 from three different sites (KI = Kiket Island, LT = Lone Tree, BB = Blowers Bluff) at three tidal elevations relative to mean lower low water (MLLW). Juvenile = clam species that reach an adult length > 15 mm, Other = clam species that are < 15 mm as adults.

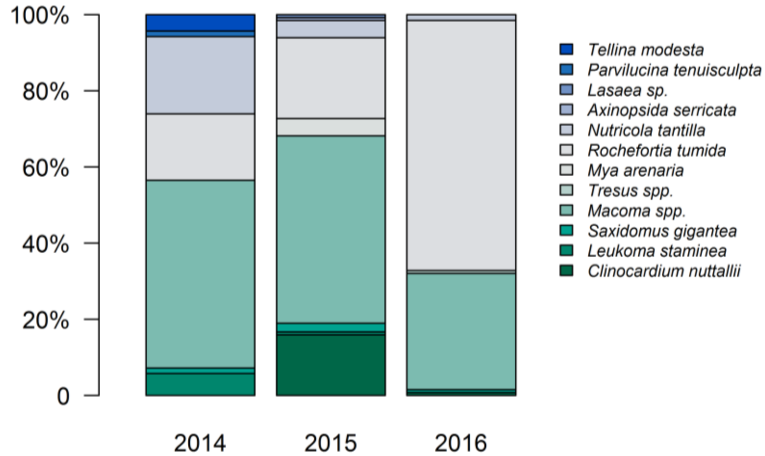

Figure 3. Percentage of species found in clam (< 15 mm) abundance surveys conducted in 2014, 2015, and 2016.

2015

Samples collected in August had the highest abundance (n= 63) of clams compared to June and July (n = 35 and 34, respectively) (Figure 4). The median abundance across all samples was 2 with a species richness of 9 (Figure 3). Slightly more clams were found at LTS than LTN (74 and 58, respectively) but, qualitatively, there appeared to be no difference in abundance between tidal elevations (n = 65 and 67 at 0 m and +0.61 m relative to MLLW, respectively). The most abundant clams were *Macoma* spp. (n = 65) followed by *R. tumida* (n = 28) and *C. nuttallii* (n = 21). Lone Tree North at +0.61 m relative to MLLW had 1 *L. staminea*. One *S. gigantea* was found at all locations except LTN +0.61. No *Tresus* spp. were found at any of the sites.

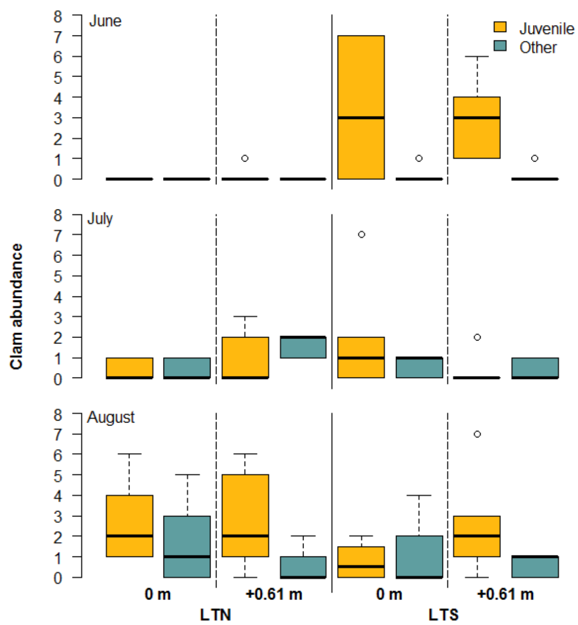

Figure 4. Boxplots of < 15 mm clam abundance in 2015 from three different sampling events at two beaches (LTN = Lone Tree North, LTS = Lone Tree South) and two tidal elevations relative to mean lower low water (MLLW). Juvenile = clam species that reach an adult length > 15 mm, Other = clam species that are < 15 mm as adults.

2016

At KI and LT a total of 131 clams were found, 107 at KI and 24 at LT, 81 of which were found at KIS (Figure 5). The median abundance across all samples was 1 with a species richness of 6 (Figure 3). *R. tumida* had the highest abundance (n = 86) followed by *Macoma* spp. (n = 33). No *L. staminea* were found in any of the samples, 1 *C. nuttallii* and 1 *Tresus* spp. were found at KIS +0.61 m MLLW, and 1 *S. gigantea* was found at LTS +0.61 m MLLW.

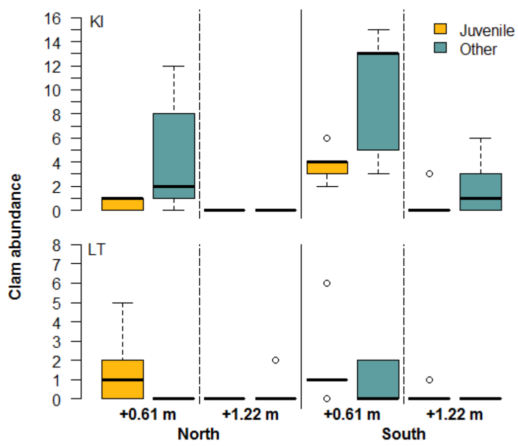

Figure 5. Boxplots of < 15 mm clam abundance in 2016 on two beaches at two sites (KI = Kiket Island, LT = Lone Tree) and two tidal elevations relative to mean lower low water (MLLW). Juvenile = clam species that reach an adult length > 15 mm, Other = clam species that are < 15 mm as adults.

DISCUSSION

Our extremely low clam abundance across all three years was surprising compared to results in other studies using similar methods. Dethier et al. (2012) had a median count of 6 clams per cylinder compared to our 2015 median count of 2 clams per cylinder. Likewise, Ruesink et al. (2014) had a median of ~17 clams per mesh bag while we only had a median abundance of 1 using the same mesh bag method. Our lower counts may have been due to inadequate sample size, poor environmental conditions, low larval supply or a combination of these and other factors not included in the studies. It is also plausible that recruitment occurs earlier in this region of Washington than expected. While working on an unrelated project that involved intertidal sampling, we were surprised to find high numbers of juvenile *L. staminea*, *C. nuttallii*, and *S. gigantea* in May 2018 (S. Grossman, unpublished data). Future studies should be conducted in the early spring as well as the summer to account for potential early recruitment.

Bivalves are notorious for highly variable year-to-year recruitment (Beukema et al. 2001). Larvae and juveniles are vulnerable to myriad abiotic and biotic factors including hydrodynamics, bioturbation, temperature, salinity, pH, predation (Hunt & Scheibling 1997, Morse & Hunt 2013, Clements et al. 2016) which influence settlement, growth, and survival. This can result in post-settlement losses that exceed 90% (Williams 1980, Gosselin & Qian 1997). Furthermore, in addition to passive dispersal that corresponds with local sediment transport (Hunt et al. 2007), some species are capable of active transport using byssal threads to drift to different tidal elevations. For example, *M. balthica* have been documented actively moving from densely populated low intertidal areas to higher elevations where predation is reduced but feeding time is shorter (Armonies 1996, Morse & Hunt 2013). As a consequence, settlement and recruitment patterns can vary spatially and temporally, and it can be difficult to predict locations where juvenile clams may reside (Hunt et al. 2003).

While some studies on bivalves have observed similar distribution and abundance patterns between recruit and adult populations (Hunt & Scheibling 1997, Morse & Hunt 2013, Ruesink et al. 2014), the presence of adult clams is not necessarily indicative of finding juvenile clams (Dethier et al. 2012). Within Puget Sound, WA, Dethier et al. (2012) found significantly different spatial patterns between juvenile and adult populations. The presence of adult clams can have mixed effects on early life-history survival. Adults may provide a settlement cue for larvae and juveniles (Rodriguez et al. 1993), but they can also increase predation rates either directly through inhalation of larvae or indirectly via bioturbation which exposes newly settled recruits to other predators (Lima et al. 2000, Beukema et al. 2001). We used biomass hotspots of tribally-important clams from data collected during the adult intertidal clam surveys to determine general beach locations for our juvenile studies. Our low juvenile abundance results may indicate a negative feedback effect of adult clams as we observed decoupling between different clam life stages, similar to results Dethier et al. (2012) report; however, there are a suite of other variables that need to be assessed before any conclusion can be made.

Although most of the clams found in these three studies were not tribally-important species harvested for subsistence or commercial purposes, the results can provide insight into the health of the nearshore environment. Small clams provide ecological benefits to the larger community by filtering phytoplankton from the water column. Newly settled clams are also a food source for other marine organisms including fishes, birds, crabs, drilling snails, and polychaetes (Hunt & Scheibling 1997, Beukema et al. 2010). Spatial distribution of small clams, such as *M. balthica*, can also indicate the presence of contaminated sediments (McGreer 1982). Therefore, monitoring population patterns of clams <15 mm can provide valuable information that compliments research assessing ecosystem health as well as fisheries management.

It is clear our methods require further modification in order for us to obtain a robust data set. By increasing sampling efforts, sampling earlier in the year, and incorporating more tidal elevations, we might obtain more comprehensive samples of juvenile clam habitat and improve our chances of finding juvenile clams. Additionally, considering drift cells and current patterns that correspond to adult hotspots may allow us to more strategically identify potential settlement locations. A sediment transport study examining movement of particle sizes comparable to juvenile clams could also enhance our ability to determine areas where recruits might reside. Although our results are a work in progress thus far, it is essential that the Swinomish Fisheries Department continues juvenile clam research efforts. Monitoring patterns in early life stages will increase our understanding of local population trends and improve our ability to sustainably manage clam populations for future generations.

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REFERENCES

Armonies W (1996) Changes in distribution patterns of 0-group bivalves in the Wadden Sea: Byssus-drifting releases juveniles from the constraints of hydrography. Journal of Sea Research 35:323–334

Barber JS, Mitchell T, Gibson J, Hoyopatubbi T, Gobert T, Ferderer A (2012) Clam population variability within a Puget Sound bivalve management region. Swinomish Indian Tribal Community - Technical Report SWIN-TR-2012-01:32

Beukema J, Dekker R, Essink K, Michaelis H (2001) Synchronized reproductive success in the main bivalve species in the Wadden Sea: causes and consequences. Mar Ecol Prog Ser 211:143–155

Beukema J, Dekker R, Philippart C (2010) Long-term variability in bivalve recruitment, mortality, and growth and their contribution to fluctuations in food stocks of shellfish-eating birds. Mar Ecol Prog Ser 414:117–130

Campbell WW (1996) Procedures to determine intertidal populations of *Protothaca staminea, Tapes philippinarum*, and *Crassostrea gigas* in Hood Canal and Puget Sound, Washington. Washington Department of Fish and Wildlife, Procedures Manual MRD96-01:81 pp

Catton C, Dethier M (2001) An illustrated reference to the juvenile clams of Central and South Puget Sound. University of Washington, Friday Harbor Laboratories

Clements JC, Woodard KD, Hunt HL (2016) Porewater acidification alters the burrowing behavior and post-settlement dispersal of juvenile soft-shell clams (*Mya arenaria*). Journal of Experimental Marine Biology and Ecology 477:103–111

Coan EV, Valentich Scott P, Bernard FR (2000) Bivalve Seashells of Western North America. Sana Barbara Museum of Natural History, Santa Barbara, California

Dethier MN, Ruesink J, Berry H, Sprenger AG (2012) Decoupling of recruitment from adult clam assemblages along an estuarine shoreline. Journal of Experimental Marine Biology and Ecology 422-423:48–54

Donatuto JL, Satterfield TA, Gregory R (2011) Poisoning the body to nourish the soul: Prioritising health risks and impacts in a Native American community. Health Risk Soc 13:103–127

Gosselin LA, Qian P-Y (1997) Juvenile mortality in benthic marine invertebrates. Mar Ecol Prog Ser 146:265–282

Hunt HL, Archie McLean D, Mullineaux LS (2003) Post-settlement alteration of spatial patterns of soft shell clam (Mya arenaria) recruits. Estuaries 26:72–81

Hunt H, Maltais M, Fugate D, Chant R (2007) Spatial and temporal variability in juvenile bivalve dispersal: effects of sediment transport and flow regime. Mar Ecol Prog Ser 352:145–159

Hunt H, Scheibling R (1997) Role of early post-settlement mortality in recruitment of benthic marine invertebrates. Mar Ecol Prog Ser 155:269–301

Jamieson GS (1993) Marine Invertebrate Conservation: Evaluation of Fisheries Over-exploitation Concerns. Am Zool 33:551–567

Lima M, Brazeiro A, Defeo O (2000) Population dynamics of the yellow clam Mesodesma mactroides: recruitment variability, densitydependence and stochastic processes. Mar Ecol Prog Ser 207:97–108

McGreer ER (1982) Factors affecting the distribution of the bivalve, Macoma balthica (L.) on a mudflat receiving sewage effluent, Fraser river estuary, British Columbia. Marine environmental research 7:131–149

Morse BL, Hunt HL (2013) Impact of settlement and early post-settlement events on the spatial distribution of juvenile Mya arenaria on an intertidal shore. Journal of Experimental Marine Biology and Ecology 448:57–65

Myers RA, Barrowman NJ (1996) Is fish recruitment related to spawner abundance? Fishery Bulletin 94:707–724

Olafsson EB, Peterson CH, Ambrose Jr. WG (1994) Does recruitment limitation structure populations and communities of macro-invertebrates in marine soft sediments: The relative significance of pre- and post - settlement processes. Oceanography and Marine Biology 32:65–109

Peterson CH (2002) Recruitment overfishing in a bivalve mollusc fishery: hard clams (*Mercenaria mercenaria*) in North Carolina. Can J Fish Aquat Sci 59:96–104

Rodriguez SR, Ojeda FP, Inestrosa NC (1993) Settlement of benthic marine invertebrates. Mar Ecol Prog Ser 97:193–207

Ruesink JL, Raay K van, Witt A, Herrold S, Freshley N, Sarich A, Trimble AC (2014) Spatio-temporal recruitment variability of naturalized Manila clams (Ruditapes philippinarum) in Willapa Bay, Washington, USA. Fisheries Research 151:199–204

Williams JG (1980) Growth and survival in newly settled spat of the Manila clam, *Tapes japonica*. Fishery Bulletin 77:891–900