Using artificial cover as a sampling method of shore crab density

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Introduction

In response to a previous study examining the use of patio slabs as habitat by shore crabs at one study site on Yaquina Bay, Oregon (see Appendix), a second study was conducted examining the use of a material other than the slabs as artificial habitat. The decision was made to cut plywood into squares of two different sizes and place these squares at the same site where the slabs had been placed, Hatfield Marine Science Center pump house (HMSC), and a second site, Sawyer's Landing (SL). The squares were placed in both the upper and mid tidal zones and allowed to remain in place approximately two weeks. Crabs found beneath the squares were then sampled by the same methods as described by Oliver and Schmelter (chapter 5) .

The study site at HMSC is located on the south side of the bay and is closer to the mouth of the Yaquina River than is the SL site, which is located on the north side of the bay several miles upriver of the HMSC site (map 1). Both sites have been rip-rapped at the land margin with relatively large boulders (1-2 m diameter) and are bordered by stretches of intertidal rocky habitat that is covered by silts, sand, gravel, cobble, etc. Structurally, the SL site slopes less steeply from land to bay than does the HMSC site.

One purpose behind using artificial habitat of a known size (i.e. surface area) and sampling shore crabs found beneath them is to calculate estimates of the biomass densities of the various crab species at a given location or site. Secondly, a method for sampling shore crabs from standardized cover sizes may provide a relatively efficient means of assessing the species composition of a shore crab community. Along with composition of a community, estimates of abundance can be made. These estimates can be compared between sites. It is thought that effects of the highly predatorial green crab (*Carcinus maenas*) may be most noticeable on the native shore crabs. Ongoing monitoring of the shore crab populations at several sites in Yaquina Bay may aid in understanding any changes caused by the green crab should it move into the bay.

Lastly, it was expected that the numbers crabs sampled would be directly proportional to the surface area of the cover. If the numbers of crabs found under the artificial habitats are proportional to cover surface area, and the biomass densities are similar between the two different sized squares, it may be possible to compare size and abundance of native shore crabs between study sites.

Materials and Methods

On December 17, 1997, plywood squares were placed in the upper and mid tidal zones at two different sites on the shore of Yaquina Bay, Newport OR. A total of 48 squares (24 at each site) were placed at the Hatfield Marine Science Center pump house (HMSC) and Sawyer�s Landing (SL). The squares were two different sizes: (1) 1500 cm^2 and (2) 500 cm^2; thus, six squares of each size were placed in both the upper and mid intertidal zones at HMSC and SL. The large squares were alternated with the small squares in their placement within a tidal zone. The squares were stabilized by piling several rocks on top of them.

Sampling of shore crabs was conducted eleven days later (Dec 28) at the SL site and fourteen days later (Dec 31) at the HMSC site. In addition to sampling crabs found beneath the plywood squares, crabs found on top of the squares (beneath the stabilizing rocks) were also sampled. As a means for comparison, six rocks were flipped over at each site (three in each tide zone) and crabs were sampled from beneath them.

The carapace width of crabs sampled was measured with a vernier caliper, and the crabs were sexed and identified to species when possible. All crabs sampled from beneath rocks at HMSC were measured, sexed and identified to species. Due to the relatively large numbers of small crabs found beneath rocks flipped at SL, five crabs were blindly selected from the collecting bucket for each rock and identified to species. It should be noted that sampling began in the daylight at SL and proceeded into the night; whereas, the entire sampling session at HMSC was conducted in the dark (with the use of a flashlight and headlamps).

Biomass estimates were calculated from a regression equation relating carapace width to mass (see Results section). Biomass density estimates were calculated for each species in each zone with respect to habitat cover type. Total cover surface areas were calculated for each tidal zone for each of the two sizes of plywood squares, the rocks and one of the patio slabs used in a previous study (see Appendix). The total surface areas for the squares were obtained by multiplying the number of squares in each zone at each site (six per zone) times the surface area of an individual square (1500 cm^2 and 500 cm^2). All rocks flipped were measured at the widest length and width. The width and length were then averaged to obtain the dimensions as if the rocks were square. The total rock surface area was obtained by multiplying the mean rock surface area (for a particular zone) times the number of rocks (three were flipped in each zone at each site). The surface area of the circular slab was calculated and multiplied by the total number of slabs to obtain the total cover of the slabs. The biomass estimates derived from the regression equation were divided by the corresponding cover surface areas to obtain the estimates for the biomass densities.

Results

Abundance and carapace width

A total of 180 crabs were sampled from beneath the plywood squares; 102 of them were sampled at the HMSC site and 78 sampled at the SL site. There were a total of 153 *Hemigrapsus oregonensis* and 26 *H. nudus*. In addition, a 59 mm male *Cancer magister* was found in the mid zone at HMSC. The mean carapace widths (MCW) and sample sizes for *H. oregonensis* and *H. nudus* are shown in tables 1-2. Values were calculated with respect to species, tidal zone and cover type (squares and rocks) at each of the sample sites. The MCW for *H. oregonensis* ranged from 8.3 mm to 10.3 mm and from 14.7 mm to 16.2 mm for *H. nudus*. The MCW for *H. oregonensis* sampled at both sites from beneath the 1500 cm^2 squares was 9.6 mm, and the MCW for those sampled from beneath the 500 cm^2 squares was 9.9 mm, irrespective of tidal zone. Similarly, the MCW for *H. nudus* sampled at both sites from beneath the 1500 cm^2 squares was 15.5 mm, and for those sampled from beneath the 500 cm^2 squares, the MCW was 15.8 mm. Abundances of each species relative to tidal zone are shown in figures 1, 2, 3, and 4. Size distributions and frequencies of the crabs sampled from under the squares are given in figures 6, 7, 8, 9, 10, and 11.

A total of 286 crabs were sampled from beneath rocks at both the HMSC and SL sites. The relative abundances of *H. nudus* and *H. oregonesis* found under rocks in both the mid and upper tidal zones for both sample sites is shown in figure 5.

Of the 81 crabs sampled at the HMSC site, 59 were *H. oregonensis,* 22 were *H. nudus* and one was a 25 mm male *Cancer magister* found in the mid zone. The MCW for *H. oregonensis* sampled by flipping three rocks in each tidal zone was 9.4 mm for both tidal zones, and the MCW for *H. nudus* was 15.7 mm, which was only found in the upper tidal zone (and most of them sampled from beneath one rock). It should be noted that 27 *H. oregonensis* less than 5 mm were sampled from beneath the rocks; these were not included in calculating the MCW for *H. oregonensis* found under rocks at HMSC. Since the crabs sampled from beneath the rocks at the SL site were divided into only two size classes of <= 10 mm or >10 mm, the same was done for the crabs sampled from beneath rocks at the HMSC site. This data is shown in table 3. In addition, all the crabs sampled from beneath rocks at the HMSC site were individually measured. Table 4 shows the MCW and sample sizes for those crabs. The ratio between *H. oregonensis* <= 10 mm and > 10 mm found in the upper zone was approximately 2:1 and approximately 7.5:1 for the mid zone. *H. nudus* was found only in the upper zone and 21 of the 22 sampled were > 10 mm.

A total of 205 crabs were sampled from beneath the six rocks flipped at the SL site. The crabs were visually inspected while being divided into the two size classes (<= 10 mm and > 10 mm). As mentioned in the methods and materials section, species was determined by blindly selecting five crabs from each rock flipped. All 30 crabs selected were identified as *H. oregonensis*. From this, the inference was made that all crabs sampled from beneath rocks at the SL site were *H. oregonensis*. The ratio between the two size classes of crabs sampled in the upper zone was greater than 4:1. This large number (n=92) of small *H. oregonensis* indicates the occurrence of a larvae settlement event around the time when the sampling was conducted. On the other hand, the ratio between crabs <= 10 mm and > 10 mm sampled in the mid zone was nearly 1:1. Size distributions and frequencies for crabs found under rocks is shown in figures 12, 13, 14, 15, and 16.

Of the total 72 crabs sampled from beneath the rocks placed on top of the plywood squares for stabilization, 54 of them were *H. oregonensis*. Table 6 shows the MCW and samples sizes for both *H. oregonensis* and *H. nudus*. Approximately 50% of the crabs found on top of the 1500cm^2 squares were <= 10 mm and no crabs > 10 mm were found on top of the 500cm^2. In other words, smaller crabs were found on top of both sizes of squares, but no larger crabs were found on top of the smaller (500 cm^2) squares. Figures 17 and 18 display the size distributions and frequencies of *H. oregonensis* and *H. nudus* found on top of the two different sized squares only for the HMSC site. See table 7 for the abundance and sizes of crabs found on top squares at the SL site.

Relation between abundance and artificial cover surface area

Overall, more *H. oregonensis* (n=153) were sampled than *H. nudus* (n=26). The ratio of *H. oregonensis* sampled from the upper as compared to the mid tidal zone at both sites was approximately 1:1.7. Approximately equal numbers of *H. oregonensis* were sampled from both sites. No *H. nudus* were sampled from the mid zone at either site. The ratio between *H. nudus* sampled from the HMSC site to those sampled from the SL site was approximately 1.5:1.

Since the larger squares (1500 cm^2) possessed three times as much surface area as the smaller squares (500 cm^2), I tested the hypothesis that the larger squares sheltered three times as many crabs as the smaller squares using Chi-square tests. The ratio was 2.4:1 for *H. oregonensis* (X^2=1.41; df=1; p>0.05) and 2.7:1 for *H. nudus* (X^2=0.05; df=1; p>0.05); thus, both species conformed to the hypothesis that cover surface area is a good predictor of crab abundance.

Biomass and biomass density

The total biomass for *H. oregonesis* found under the plywood squares and the rocks in both zones and for *H. nudus* found under the squares and the rocks in the upper tidal zone at both sites was calculated from the following regression equation:

$$\mathbf{y= [2.984*10^{-4} * (x^{3.1421})]}$$

where R=1.00, **x**=carapace width (mm) and **y**=mass (g). This equation was developed from a previous shore crab study (Yamada *personal comm.*). Biomass densities were obtained by dividing the total biomass by the surface area for each species in each zone with respect to habitat type. Table 5 shows the surface areas used for calculating the biomass densities. Figures 19, 20, 21, 22, 23, and 24 display the total biomass and biomass densities estimates for each species. For comparison, biomass and biomass density estimates were calculated for *H. oregonensis* sampled from beneath the 30 cm diameter patio slabs at the HMSC site (see Appendix--figure 1). This biomass and biomass density estimates for the *H. oregonesis* sampled under the 30 cm diameter slabs is included with the estimates from this study in figures 21-22.

Discussion

Perhaps the first noteworthy information learned from this study was that none of the plywood squares were missing or moved from the sites during the time between placement and sampling. One of the concerns of using rocks for stabilization was that the tidal action might have been enough to knock rocks off the squares. Secondly, Yaquina Bay has quite a high level of boating activity, so even waves created by boat wakes could possibly move the rocks around if piled too high. In addition to the possible effects of tides or waves on the rocks, the presence of people walking around in the study site could have been another source of disturbance to the stabilizing rocks. As we learned from the slab study, the type of material used as artificial habitat can have value in the eyes of some people; thus, the slabs were removed from the site. One reason that the two study sites were chosen to conduct this study was that neither of them seemed to be heavily visited by people. Though a couple of the rocks used to stabilize the squares appeared to have slipped slightly on a couple of the smaller ones, no rocks moved a great distance in any case.

The condition of the sediment beneath the squares appeared to have an effect on whether crabs would be found. If the sediment was relatively fine, sandy and packed closely together, the number and size of crabs appeared to decrease. As discussed earlier in this report, *Hemigrapsus oregonensis* tend to be burrowers. If the sediment is tightly packed, burrowing may be impeded. Where the sediment was not as tightly packed and had a more "gravelly" consistence, it appeared that crabs (especially 10mm or less) could adequately burrow. Also, several of the rocks flipped at SL were embedded into the sediment up to 10 cm or so. As can be seen, a relatively large number of crabs were found beneath the rocks. From observations made during sampling crabs found under rocks and patio slabs, it was thought that clearance between the substrate and the rock was necessary for a rock to be suitable as habitat for a shore crab. Because a fair number of crabs were found beneath the embedded rocks at Sawyer�s Landing, it may be premature to assert that clearance between the rock (slab, plywood, etc.) is a necessary prerequisite for shore crab habitat. Rather, sizes of the crabs are probably a major factor in determining what habitat is suitable. The sediment condition in the upper zone at the SL site appeared to have been favorable for the recent settlement of *H. oregonensis* larvae.

Another conclusion from previous shore crab sampling might also have been made prematurely. The smallest slabs had few if any crabs found beneath them. It was thought that the small slabs were of little use as artificial habitat. On the other hand, smaller rocks, subjected to greater physical disturbance, may in fact serve as indicators for the relative abundance of a particular shore crab community (Daly 1981). Perhaps when the population numbers rise due to increased availability of prey, reduced intraspecific competition for food, and reduced interspecific competition for space, smaller rocks that may not have been preferable when population sizes where smaller are utilized.

In general, more *H. oregonensis* were found under the squares and slabs than were *H. nudus*. This may be due to competitive dominance by *H. nudus*. The additional cover provided by the artificial habitat may have been available to *H. oregonensis* due to the "ownership" of the natural habitat by *H. nudus*. Following the occupancy of the artificial habitats through time may shed light on patterns of habitat settlement. It might be that *H. oregonensis* are quicker to settle the artificial habitat than *H. nudus*. Over time, the competitively dominant *H. nudus* may displace the *H. oregonensis*.

Approximately one-half of the squares had at least one crab using the cover provided by the stabilizing rocks as habitat. The larger squares had more rocks piled on top of them, and in many cases, several crabs were found. There appeared to be a pattern in the size distribution of crabs found on top of the squares. The smaller squares had fewer rocks on them, *i.e.* less cover, than the larger squares. Larger crabs would be more exposed on the smaller squares. Due to the relatively high number of crabs found on top of the squares, it is difficult to ignore possible effects on the numbers of crabs found beneath the squares. It may be reasonable to merely add the crabs found beneath the squares to those found on top. For making biomass estimates, adding them may be no problem, but for making biomass density estimates, it is not as straightforward. Estimation of the increased cover surface area provided by the stabilizing rocks would certainly become more involved.

The calculation of biomass and biomass density estimates was useful as a means for making comparisons between tidal zones, sites and types of habitat cover as utilized by the particular shore crab species. As was seen, the MCW of *H. oregonensis* and *H.nudus* sampled from beneath the 1500 cm^2 squares and the 500 cm^2 squares did not appear to differ greatly. As was expected, the biomass would be greater under the larger squares as compared to the smaller squares. On the other hand, the biomass density estimates were relatively constant. The constancy of the estimates indicated in another way that the abundance, but not the size distribution, of the crabs was a function of the surface area of the cover. In this way, the biomass density estimates obtained from sampling data where plywood squares are used as artificial habitat can provide a relative means for monitoring the shore crab populations between different sites in Yaquina Bay.

There are several assumptions and limitations in this study that make it difficult at best to make inferences beyond the two sites where sampling was conducted. Placement of the plywood squares was not done randomly. They were spaced evenly apart. The assumption made was that shore crabs equally and randomly access any and all habitat. In actuality, shore crab community structure is greatly determined by sizes of the crabs, abundances of the populations, and time of year (Daly 1981). Conducting this study in two sites expanded the range of observations that could be made about shore crab use of the artificial habitat, but it would probably be beneficial if the study could be expanded to at least include the other two sites in the larger, "rock flipping" study. One complication to this idea comes from the fact that both Idaho Point and the NW Natural Gas site appear to have greater foot traffic. Other means of stabilization, such as large nails, spikes, screws, etc., may be needed to make them more resistant to any possible anthropogenic disturbance.

Elimination of the physical disturbance factor may have contributed to the squares, especially the smaller ones, functioning as "islands of false security" for the populations of the shore crab sampled. Though only twelve small squares were placed at each site, these refuges from physical disturbance could possibly skew the data if the balance of the cover is tipped toward them, especially in a location where disturbance factors greatly in structuring shore crab communities. Perhaps the next step in these artificial habitat studies is to examine the degree to which disturbance of the squares affects the use of them as cover by crabs. Using the alternative stabilizers mentioned above could possibly be used to adjust the amount of disturbance, or "play", of an individual square. It would be important to separate the intentional or experimental disturbance from disturbance caused by sampling. To examine the assumption that crabs move about freely and randomly in a given stretch of intertidal habitat, individual crabs sampled could be marked to facilitate identification of them. By sampling on a bi-weekly or monthly basis, researchers may identify movement patterns of the crabs and whether they have a "home". If the marked crabs were repeatedly found under a specific rock or plywood square, then perhaps the assumption that they moved about freely was not a good one.

At this point, it is difficult to assert that the placement of artificial habitat and the sampling of crabs found beneath them provide a means of accurately estimating the abundance of populations comprising a shore crab community. It appears that one can get a good idea of the species of crabs present. Data collected from a greater number of sites, or at least a greater length of time at the two sites examined in this study, will certainly provide greater insight into shore crab community habitat utilization.

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APPENDIX by Todd Ison and Dan Frerich

Using Concrete Slabs as Artificial Habitat for Shore Crabs

Based on the method of flipping "suitable" rocks (30-60 cm at widest width) for sampling shore crabs, the idea arose to attempt to standardize the habitat surface area by using three different sizes of common patio slabs (one square and two circular). By comparing the carapace widths, sexes, abundances and densities of the shore crabs sampled from the slabs to the same characteristics obtained from flipping the suitable rocks, we predicted that we�d see similar size distributions between slabs and rocks with the density of individuals varying proportionally with the surface area. In other words, the square slabs (15 cm x 15 cm or 225 cm^2) were expected to have fewer individuals than the larger circular slabs of 30 cm and 40 cm diameters (or � 710 cm^2 and 1260 cm^2, respectively), and the numbers of crabs found under the circular slabs would correspond to the numbers of crabs found under the rocks. The size distributions were expected to be similar regardless of slab or rock surface area. Alternatively, we thought that perhaps smaller sizes of crabs would be found under smaller slabs than larger slabs such that the density of individuals (number of individuals per slab) across slab sizes would remain fairly constant. Our objective was to determine the proportional relationships between shore crab sizes, abundances and densities and the surface area of natural rock and artificial slab habitats. With this information, future shore crab samplers may be better able to make more accurate temporal comparisons between samplings of shore crabs for the same study site (*i.e.* space is "fixed" and variations in abundance over time would become more apparent by controlling sample habitat size). (Table 1.)

Initially, the plan was to place the slabs in the upper, middle and lower tidal zones in two shore locations along Yaquina Bay, Newport OR. After an initial placement of two slabs at the NW Natural Gas site, we found that this site would not be adequate because when we returned a couple of weeks later to check them, the slabs were gone. We then decided to place all of the slabs at the HMSC pumphouse site due its being frequented less by the general public. Based on previous experience sampling shore crabs by flipping rocks, we learned that there needs to be some space, however slight, between the rock and the substrate, especially when the substrate is sediment or sand. Thus, it was important when placing the slabs to include adequate space to allow crabs access beneath the slabs.

Four weeks after the placement of the slabs (November 30, 1997) at the HSMC pump house we conducted a sampling of all the slabs. During the sampling we noted whether or not the slabs were "propped up" or lying level. The term "propped up" is defined as a slab that was more than one finger width above the substrate at any point around the circumference. This notation is used on Data Sheets 1 and 2 to identify those slabs that were not level. In addition, "HO" denotes *Hemigrapsus oregonensis* and "HN" is *Hemigrapsus nudus*.

Of the total 20 slabs sampled, 13 were defined as propped up and had a total of 12 individuals underneath them. The 7 slabs that were not propped up had a total of 38 individuals underneath them. The initial observation from the data indicates that a slab that is propped up will not reflect a suitable artificial habitat. The condition of being propped up is mostly likely due to the initial placement of the slabs with possible disturbance from tidal and wave action. Crabs may not select the propped up slabs due to increased exposure to predators, abiotic factors and instability of the slab habitat.

The use of slabs shows potential as way to standardize shore crab habitats for future experiments. As can be seen from the data of the level slabs, crabs will utilize them as a habitat, but more data are needed to determine which of the slab sizes accurately reflect actual population abundances and densities. It appears that the 15 cm square slabs may not be suitable as artificial habitats. Because of their small size, the square slabs were more prone to becoming propped up. The 30 cm and 40 cm diameter slabs may show more potential than the 15 cm squares, but more information needs to be gathered on how slab height above the substrate impacts the abundance of shore crabs. In addition, an anchoring system needs to be implemented to insure stability of the slabs over the duration of the time period between slab placement and sampling.