

Exploratory 2:

Effectiveness of the Basket Cockle, *Clinocardium nuttallii*, Escape Response to *Pycnopodia helianthoides* on Different Substrates

Audrey Douglas

OIMB Summer 2005
Adaptations of Marine Animals
Prof. Charlie Hunter

Introduction

The basket cockle (a.k.a. Nuttall's cockle, heart cockle, *Cardium corbis*), *Clinocardium nuttallii*, lives on both sand and mud beaches from mid-intertidal to sub-tidal depths of 80 feet (24 m) from the Bering Sea, Alaska to San Diego, California (Sept 1999). Since *C. nuttallii* has very short siphons, less than 2 cm when extended, it is usually found on or near the surface, usually less than 1 cm below the substrate, of tidal flats (Change and Levings 1978). Consequently, its predators include the giant pink star, *Pisaster brevispinus*, and the sunflower star, *Pycnopodia helianthoides*, which both specialize in the excavation of large bivalves. *P. helianthoides* also specializes in pursuing exposed prey (Sloan *et al.* 1983). *Clinocardium nuttallii* has developed an interesting escape response to these predators. When the tube feet of the sea stars touch the exposed tissue of the cockle, it extends its long foot in a thrusting motion to push off its enemy and "pole-vault" away from the sea star (Kozloff 1993, Sept 1999).

This escape response was demonstrated in Charlie Hunter's Adaptations of Marine Animals class in a salt water table. The demonstration was performed on a bare bottom and the observed *C. nuttallii* response did not appear to be very affective for the amount of energy apparently put into the action. This observation led me to wonder if the type of substrate the *C. nuttallii* is on has an impact on the effectiveness of each push of the foot. I believe that the presence of a substrate will increase the effectiveness of each push and that the type of substrate will also have an impact. I predict that the muddy substrate that *Clinocardium nuttallii* is naturally found in will allow for a more effective push by the foot than a rocky, sandy or absent substrate.

Methods

Clinocardium nuttallii were collected from the Portside mudflat and only six individuals that were within the size range of 5.0 cm wide x 5.0 cm long x 3.5 cm high to 6.0 cm wide x 6.0 cm long x 4.0 cm high were chosen. A metal tray 45 cm long x 28.5 cm wide x 2 cm deep was filled with a layer of small fish tank rocks 1.25 cm deep. A *C. nuttallii* was placed in the middle of the tray with the siphon pointed to the right and was allowed to acclimate for 2 minutes. Then a *Pycnopodia helianthoides* was placed directly on top of the *C. nuttallii*. The number of pushes the *C. nuttallii* made with its foot was counted and the total distance traveled was measured. The count of pushes was stopped once the *C. nuttallii* was no longer on the substrate. The total distance traveled started at the point that the *C. nuttallii* was first placed and ended at the point where it landed as a result of the last push counted. Each step was repeated with the following: a muddy substrate collected at low tide from the Portside mudflat, a sandy substrate collected from Coast Guard Beach, and no substrate (empty tray). Each of the six *C. nuttallii* was tested three times on each substrate. The same *P. helianthoides* specimen was used in all trials.

Results

The data from two *Clinocardium nuttallii* individuals are not included in the calculations because they did not respond to the presence of *Pycnopodia helianthoides* (see Appendix A). As a result, the final data set is for four *C. nuttallii* individuals.

Figure 1 shows the results for the average distance/push for each *C. nuttallii* individual on each substrate. The *C. nuttallii* were able to move a longer distance per push on a substrate than with no substrate. All four *C. nuttallii* were able to move the furthest on the muddy substrate and then the rocky substrate. The sandy substrate had the most variability between the *C. nuttallii* individuals, with the lowest at 3.75 cm/push and the highest at 12.43 cm/push.

Figure 1

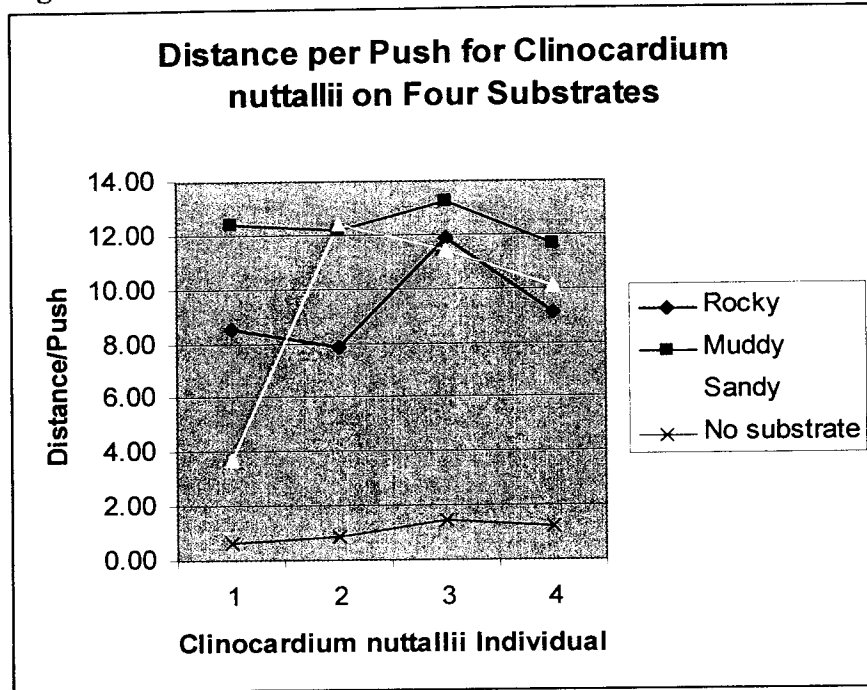
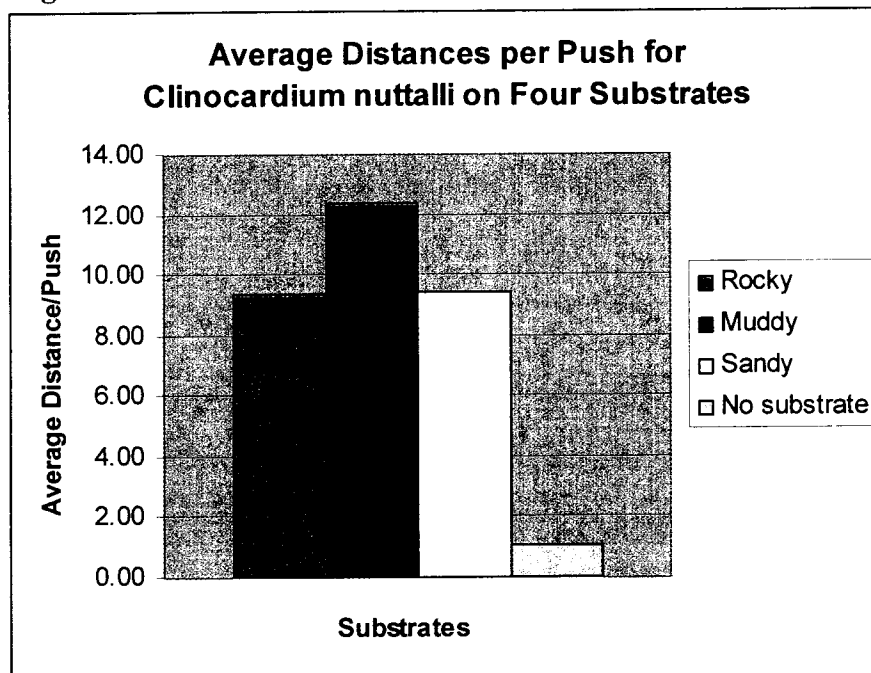


Figure 2 shows the average distances/push for all trials on each of the four substrates. On average, the *Clinocardium nuttallii* traveled the most distance/push on the muddy substrate and the least distance/push with no substrate.

Figure 2



Discussion

Based on the four *Clinocardium nuttallii* individuals tested, it is apparent that the presence or absence of substrate affects the effectiveness of each push by the foot in an attempt to escape a predator. All four *C. nuttallii* individuals showed a much greater distance traveled per push of the foot when on a substrate than they did in the absence of a substrate. However, the distance per push of the foot was greatest on the muddy substrate. The difference in the distance traveled per push of the foot on the rocky and sandy substrates was very small, 0.06 cm/push. These results make sense when the substrates are considered more closely. All of the substrates provided some traction for the foot of the *C. nuttallii* to push against. In addition to the traction, the muddy substrate also provided a more stable surface to push against than the sand or the rocks. By stable, I mean that the muddy substrate was more compact so when the *C. nuttallii*'s foot pushed against it the mud did not give and shift around the foot. Instead, the mud stayed pretty much in place. On the other hand, the sandy and rocky substrates shifted around under the foot when it pushed against them. This was most apparent after each trial when the path of the *C. nuttallii* was clearly visible in both the rocky and sandy substrates, but not the muddy substrate.

The calculated distance per push of the foot may be slightly underestimated due to the *Pycnopodia helianthoides* being on top of or in the path of the early pushes or the 3-dimensional direction traveled as a result of the push. In some of early pushes, usually restricted to the first 2 or 3 pushes, the *P. helianthoides* may have still been on top of the *C. nuttallii* and thus restricted the maximum distance per push possible. This was accounted for by removing the *P. helianthoides* after *C. nuttallii*'s escape response was initiated or by not counting the first push if the distance traveled was negligible (less than 1 cm). Additionally, some of the pushes propelled the cockle's shell straight up into the water column instead of to the side along the substrate. In

these instances the push was counted and the small distances traveled horizontally was measured, but the vertical distance was not included. This underestimation may have lowered the distance traveled per push of the foot, but it does not appear that it has made much of difference.

My hypothesis that substrate impacts the effectiveness of the escape response of *Clinocardium nuttallii* to predatory sea stars was supported by the result of this experiment. Additionally, my prediction that the muddy substrate that the *Clinocardium nuttallii* is naturally found in allowing for a more effective push of the foot than any other type of substrate was also supported. It makes sense that *C. nuttallii* has adapted its escape response to be most effective in the environment in which it lives.

References

- Change, B.D., Levings, C.D. 1978. Effects of burial on the heart cockle *Clinocardium nuttallii* and the Dungeness crab *Cancer magister*. *Estuaries and Coastal Marine Science*. 7: 409-412.
- Kozloff, E.N. 1993. *Seashore Life of the Northern Pacific Coast: an illustrated guide to Northern California, Oregon, Washington, and British Columbia*. Seattle: University of Washington.
- Sept, J.D. 1999. *The Beachcomber's Guide to Seashore Life in the Pacific Northwest*. BC Canada: Harbour.
- Sloan, N.A., Robinson, S.M.C. 1983. Winter feeding by asteroids on a subtidal sandbed in British Columbia. *Ophelia*. 22(2):125-140.

Appendix A

Figure 3 - Size of each *Clinocardium nuttallii* individual

Individual #	Size (cm)		
	width	length	height
1	5.6	5.3	3.6
2	5.3	5.3	3.5
3	5.5	5.4	3.6
4	5.7	5.8	3.8
5	5.9	5.9	4.0
6	5.2	5.1	3.6

Figure 4 - Data collected for each *Clinocardium nuttallii* individual on each substrate type

Substrate	Individual #	average # of pushes	average distance (cm)	distance/push
Rocky	1	3.00	25.67	8.56
	2	7.00	31.67	4.52
	3	X	X	X
	4	4.30	34.00	7.91
	5	2.30	27.33	11.88
	6	3.70	34.00	9.19
Muddy	1	3.00	37.33	12.44
	2	X	X	X
	3	X	X	X
	4	3.67	44.67	12.18
	5	2.67	35.33	13.25
	6	3.33	39.00	11.70
Sandy	1	8.00	30.00	3.75
	2	X	X	X
	3	X	X	X
	4	2.33	29.00	12.43
	5	2.67	30.67	11.50
	6	3.33	33.67	10.10
No substrate	1	11.33	7.33	0.65
	2	X	X	X
	3	X	X	X
	4	4.00	3.67	0.92
	5	8.67	12.67	1.46
	6	7.67	9.67	1.26

X denotes no response

Figure 5 - Image of *Clinocardium nuttallii*

