DIFFERENCE IN TEST THICKNESS IN THE PURPLE SEA URCHIN (*STRONGYLOCENTROTUS PURPURATUS*) AT TWO LOCATIONS WITH VARYING WAVE EXPOSURE

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INTRODUCTION

The rocky intertidal is an extremely variable environment where organisms must be exceptionally versatile in order to survive changing sea conditions. Phenotypic plasticity, changes in phenotype due to short-term interactions with the environment, is common in echinoderms, and particularly evident in sea urchin tests, the morphologies of which vary between and among populations. Some of these differences include taller or squatter tests with changes in microhabitat (Grupe 2006), or the shrinkage of tests in response to changes in food availability (Ebert 1996). Sea urchins such as *Echinus esculentus* and *Echinometra lucunter* have flatter and thicker tests in wave-exposed areas compared with urchins living in calmer waters (Lewis & Storey 1984). Larger, long-lived urchins also tend to have thicker tests (Carefoot 1977). Thicker tests are stronger and provide an adaptive advantage in stressful intertidal environments (Lawrence 1987). Test thickness is correlated with larger gonads in the red urchin, *Strongylocentrotus fransiscanus*, highlighting a relationship between structural morphology and reproductive success (Rodgers-Bennett 1996).

I investigated structural adaptations in the purple sea urchin, *Strongylocentrotus purpuratus* (Fig 5), at two locations on Cape Arago on the Oregon coast. I collected purple urchins from Middle Cove, a wave-exposed site, and from South Cove, a more protected site (Fig. 4). I hypothesize that urchin tests at Middle Cove have thicker tests than those at South Cove. This proposed difference, if it exists, could be due to physical differences pertaining to wave exposure.

MATERIALS & METHODS

Eighty-two tests of *S. purpuratus* were collected from South Cove and Middle Cove, Cape Arago near Charleston, Oregon. Forty tests collected from South Cove were either completely or partially intact. Those that were partially intact showed signs of past raccoon predation (indicated by a large orally located break near the peristome), or were broken so that the diameter could still be measured. At Middle Cove, however, almost all of the 42 tests collected had recently been consumed by raccoons and still had spines and organic material attached. Tests were submerged in fresh-water for 72 hours and in a 3% Sodium Hypo-chlorite solution for 24 hours. All tests were removed and laid outside to dry in a slight breeze for 24 hours before being measured.

Measurements of width and diameter of each test were taken using Guogen Stainless Hardened electronic calipers. Test thickness was measured to the nearest 0.01 mm at the ambitus of the test from an ambulaclar plate where the test is thickest (Lawrence 1987). Test diameter was measured to the nearest 0.01 mm at the ambitus of the test from one ambulacral sections to the opposite interambulacral section. Mean and standard deviations were calculated for test thickness and diameter measurements at South Cove and Middle Cove, and t-tests were used to compare the two groups.

RESULTS

Thickness was measured for 40 urchins tests from South Cove resulting in an average test thickness of 1.59 ± 0.19 mm. Thickness was measured for 42 urchin tests from Middle Cove resulting in an average test thickness of 1.82 ± 0.34 mm. This difference between test thicknesses at South Cove and Middle Cove is highly significant (Fig. 1, t-test, $p < 0.001$).

Test diameter was measured for 18 of the 40 urchin tests from South Cove resulting in an average diameter of 61.29 ± 7.00 mm. Test diameter was measured for 29 of the 42 urchin tests from Middle Cove resulting in an average diameter of 66.88 ± 7.29 mm. This difference between test diameters at South Cove and Middle Cove is significant (Fig. 2, t-test, $p < 0.01$).

Test thickness and diameter of purple urchins was correlated at both South Cove and Middle Cove. However, Fig. 3 indicates that urchins from Middle Cove have thicker tests than urchins of the same size from South Cove.

DISCUSSION

The data support my original hypothesis that purple urchins at Middle Cove have thicker tests than those at South Cove. Although test thickness is positively correlated with test volume (Carefoot 1977) and I sampled larger urchins at Middle Cove than South Cove, Fig. 3 shows that the difference in test thickness is not a sampling artifact. Urchin tests from Middle Cove were consistently thicker than those from South Cove through a range of sizes.

Thicker tests at Middle Cove could be an adaptation to increase strength to combat higher wave action (Lawrence 1987). It seems naive, however, to believe that in this environment, wave action would be the only variable at play. Middle Cove and South Cove could also differ with respect to food availability, microhabitat, salinity, predators, and other physical and biological factors. Though wave action seems a likely explanation, this simple investigation cannot determine the cause of the differences in test thickness between the sites, especially since wave action was not quantified. Perhaps in

future investigations wave action could be measured and correlated with the input of plankton or settlement of macroalgae, which could in turn induce changes in test thickness.

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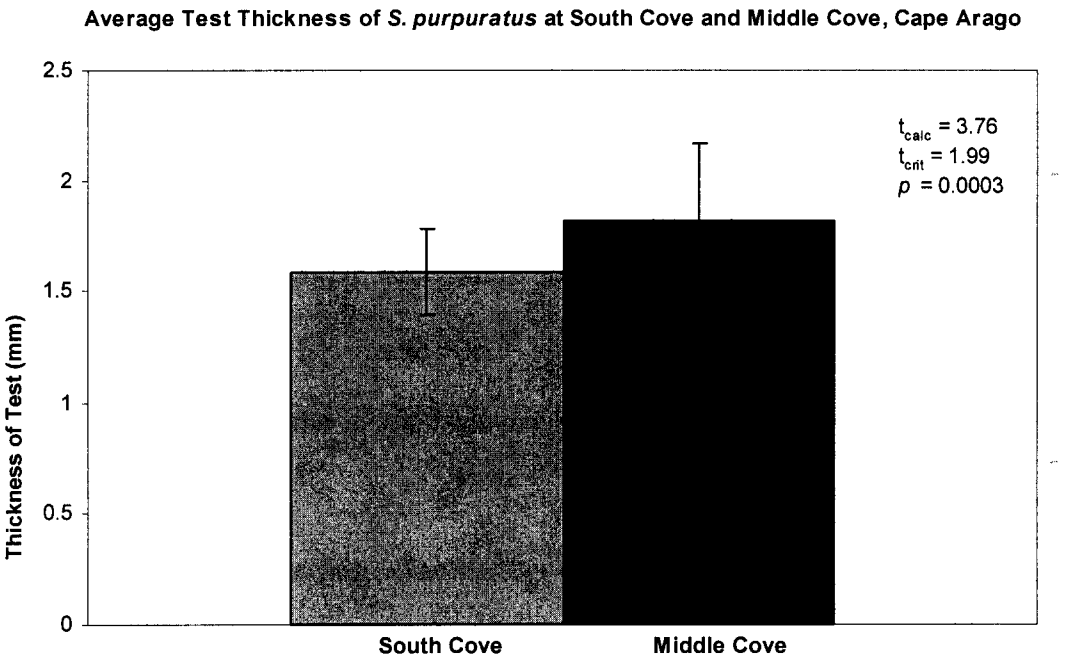


Figure 1: Average thickness of *S. purpuratus* tests at South Cove and Middle Cove.

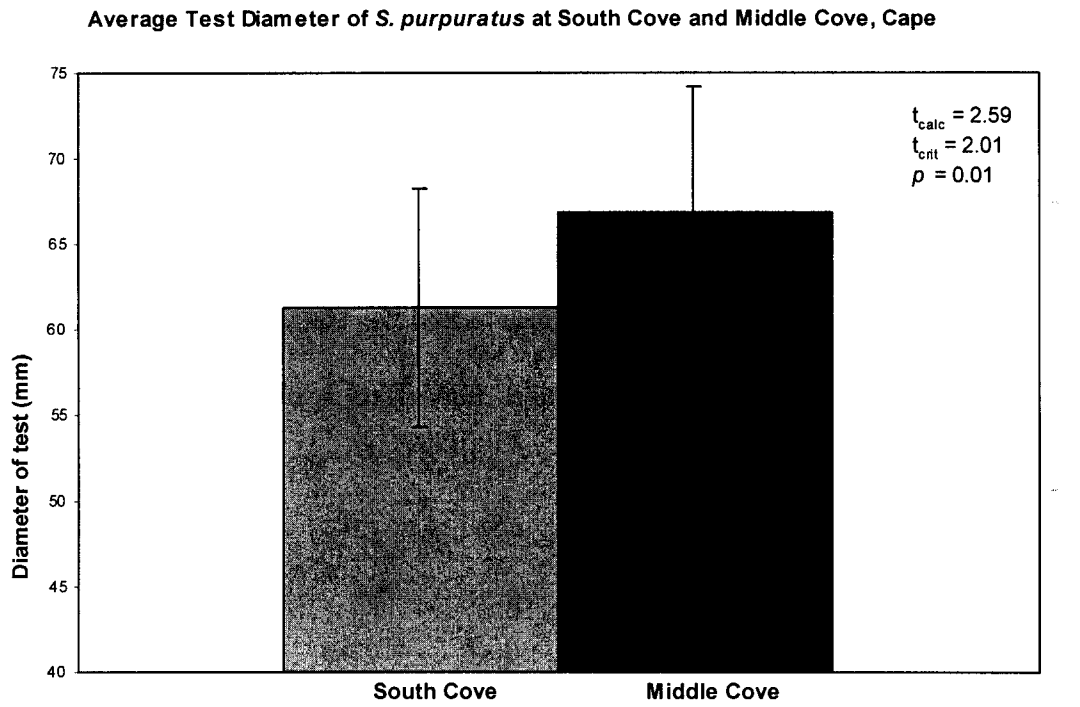


Figure 2: Average diameter of *S. purpuratus* tests at South Cove and Middle Cove.

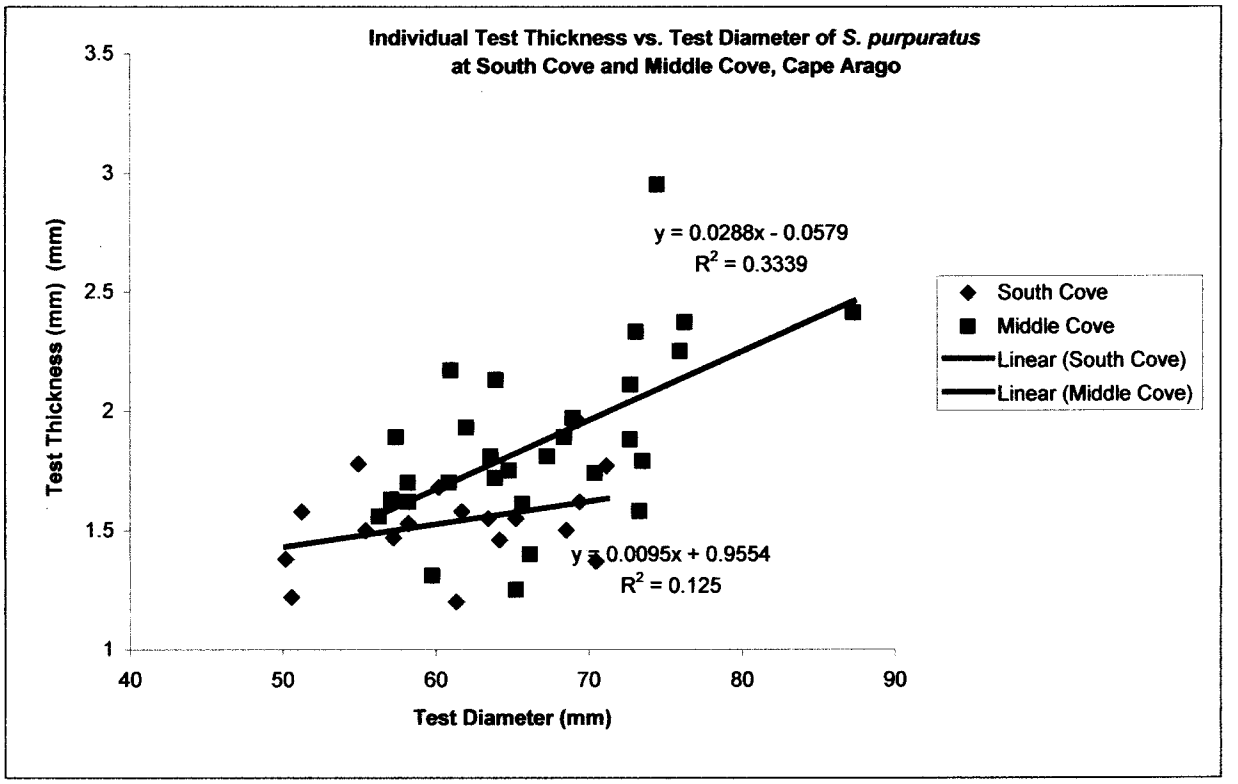


Figure 3: Correlation of individual test thickness and test diameter of *S. purpuratus* at South Cove and Middle Cove.

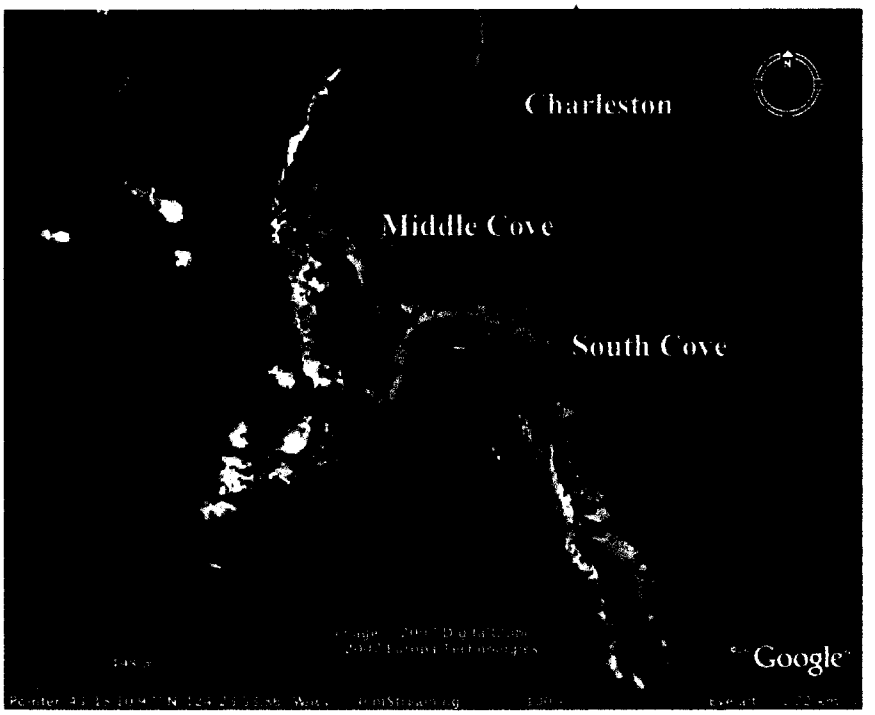
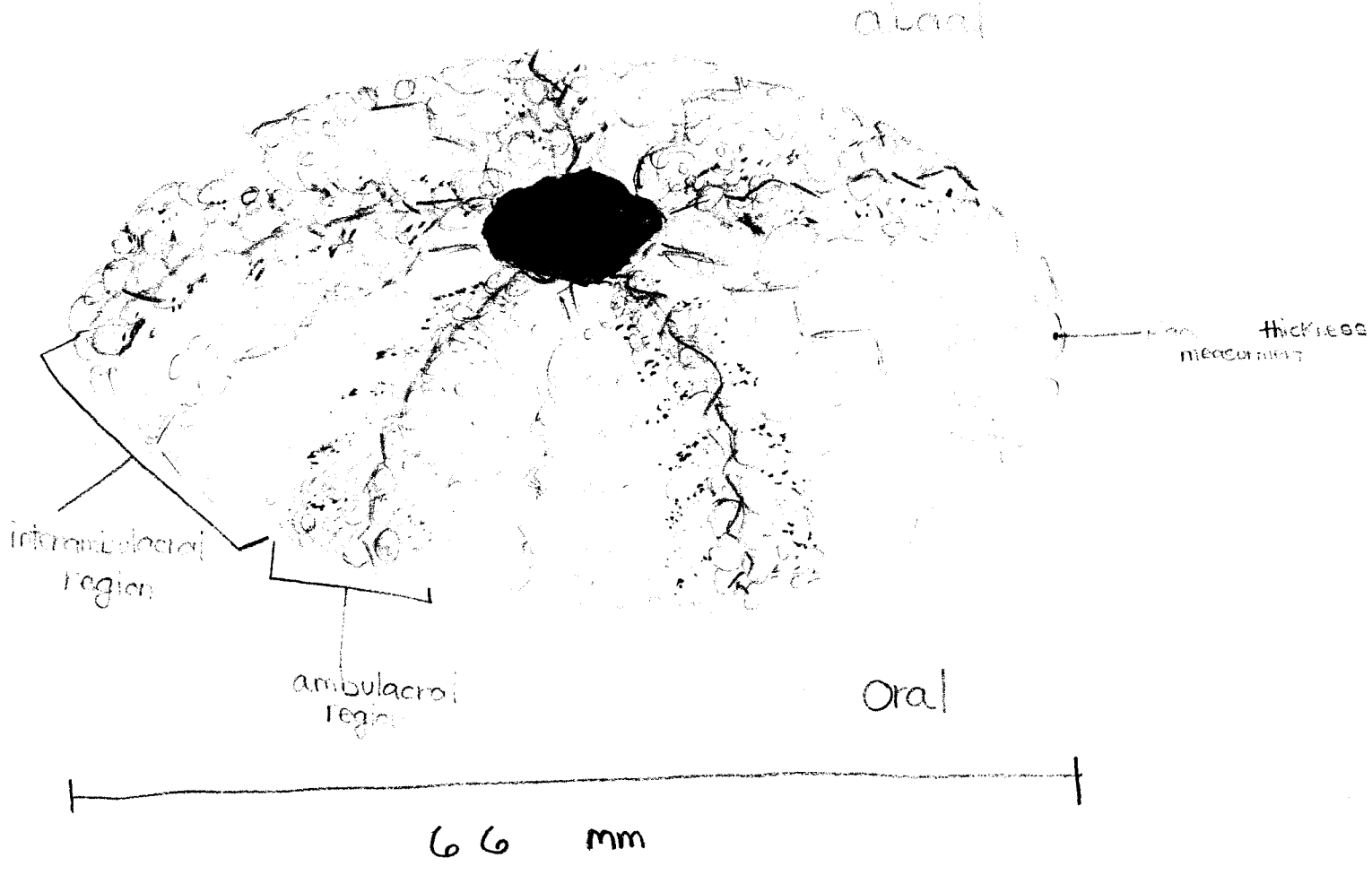


Fig 4: Geographic map of Middle Cove and South Cove with relation to Charleston and wave exposure.

Fig 5: Sketch of a [illegible] test of S. purpuratus.



4x magnification