A Structural Comparison Between Two Varieties of *Haliclona Permollis*

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Introduction

Phenotypic plasticity is an adaptive trait that allows an organism to alter its very growth pattern to better suit the environment in which it exists, changing its very structural form. This adaptation can cause very specific and beneficial differences to develop between individuals of the same species that are simply responding to different environmental forces. These differences allow each organism to be more individually successful, as their structural make-up is in effect tailored to fit where they live. The importance of phenotypic plasticity as an adaptive trait is heightened in sessile organisms such as sponges, as these stationary organisms are unable to relocate from one environment to another in search of a more compatible habitat in which they can thrive. Rather, many sessile animals must grow where they settled as free-floating larvae, at the mercy of the environmental factors at that specific location. Such organisms will simply be more successful is they are able to alter their physical growth pattern as they mature to suit where they have landed, each individual responding to the environmental pressures that it specifically encounters. *Haliclona permollis* is an example of an intertidal sea sponge that displays such phenotypic plasticity.

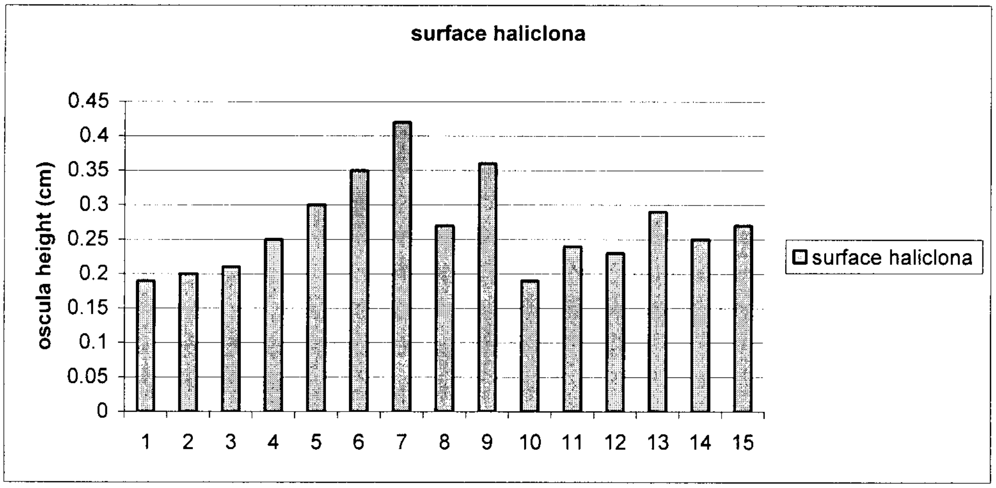
H. permollis is an encrusting variety of purple sea sponge prevalent within many different environments along the Oregon coast, growing successfully in high-energy habitats such as that of the lower rocky intertidal as well as in more placid, submerged environments such as on docks and pilings. The phenotypic plasticity of this species is particularly extreme and discrete growth forms are apparent even between environments that are only slightly different. *H. permollis* grows by extending many protruding ex-current openings, called oscula, outward from the encrusting mat that connects the sponge to its substrate. The average height of these delicate, structural protrusions seems to have a strong correlation with the environment in which the sponge lives, the fundamental nature of the growth form linked to the conditions that the organism encounters. Previous research has shown that the growth form of *H. permollis* becomes increasingly compact, with shorter ex-current projections, as the sponge is exposed to higher levels of water movement and wave action[i]. It is thus hypothesized that *H. permollis* growing in a more turbulent environment will develop oscula which are closer to the encrusting mat, to protect against wave damage occurring which could cause damage to the sponge's delicate tissue. Conversely, organisms from a calmer environment, where wave action will no longer limiting growth, will develop much more extended oscula, maximizing the available surface area for filter feeding.

Materials and Methods

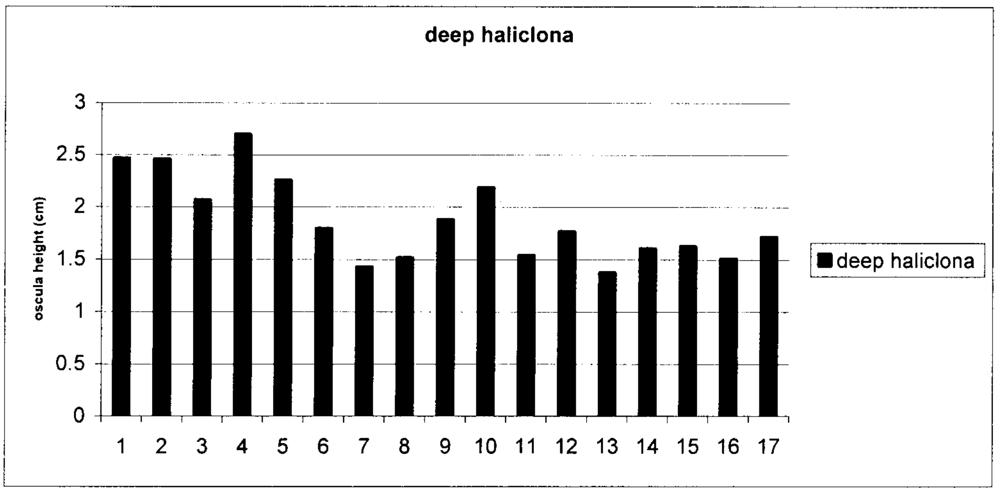
Two samples of *H. permollis* were collected from a submerged portion of dock in the Charleston Boat basin. The two samples were taken from the same general area on the dock to minimize confounding variables that could possible impact growth, such as levels of food availability, water quality and predation levels. The two samples taken also had similar areas. The first sample of sponge taken was growing 7.2 centimeters below the water's surface at its highest point; deep enough to be protected from rough water. The second sample taken was growing on the side of the dock exactly at the level of the waters surface. The position of this surface sample was thus affected by any wave action produced between the dock-water interface throughout its development. The two different samples were removed from the dock surface using a scraping tool to separate the body of the sponge from the growth surface. At each removal site the entire body of the sponge, including the encrusting mat, was detached and removed from the substrate in one piece. For each sponge sample, the height of each individual osculum was measured using Vernier calipers, the height defined as the distance between where the sponge was directly attached to the substrate to the tip of the fully extended osculum opening in question. For each depth sample of *H. permollis*, an average osculum height was calculated, as well as the standard deviation and standard error for each depth sample. For the deeper sponge variety some of the shorter oscular openings were excluded, as they would have sharply skewed the average to be too low. These oscula were assumed to be immature openings that the sponge was extending as it spread out, and that they would eventually reach the height of the larger, older openings that were present.

Results:

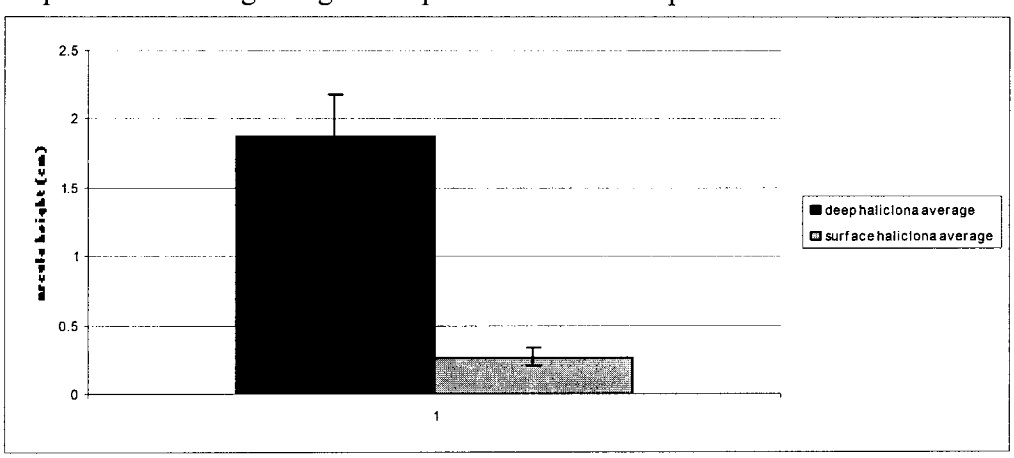
Graph one: Surface sponge: Average oscula height .27 cm, Standard deviation .067 cm



Graph two: Deep sponge: average oscula height 1.88 cm, Standard deviation: .41 cm



Graph three: Average height comparison between depths



Discussion

When two samples of the sea sponge *H. permollis* were collected from locations that experienced different environmental pressures, different growth forms could be clearly observed. The variety of sponge collected from the deeper waters had oscula that projected further outwards from the base of the sponge compared to the variety of sponge collected from the waters surface. The different environmental factors had caused the each of the two sponges to exhibit a specific phenotype, their very physical shape altered by the external conditions that they encountered.

Sponge collected from an area of deeper water exhibited a growth form that was significantly different compared to the same species of sponge that had grown at the waters surface. The deeper *H. permollis* variety had very long oscular openings that projected out from the sponge's base encrusting mat. The average height of these fragile pores was 1.88 centimeters; a value that is statistically different when compared oscular height of the sponge growing at the surface. The extended oscular length exhibited by the deeper sponge supports that hypothesis that *H. permollis* is capable of phenotypic plasticity: the growth pattern reflects the calm water condition that occurs where it grew on the dock. In response to the low levels of water turbulence the sponge is able to extend it's oscula openings out further into the water, a distinct growth form that maximizes the surface area of tissue that is in contact with the surrounding water. The tissue that makes up each osculum is made of thousands of tiny incurrent pores through which water is pulled into the body of the sponge, supplying that sponge with both nutrients and oxygen[ii]. Prominent oscula are clearly beneficial as the sponge would be able to pull water in at a more efficient rate. Thus, *H. permollis* expresses this beneficial phenotype in the deep-water conditions where wave action will not immediately destroy the fragile tissue. The sponge has responded to the environmental factors in such a way as to develop the most favorable physical structure that is suited to the external conditions.

Conversely, the variety of *H. permollis* collected from the waters surface had a very compressed growth form. It had very compact oscula, with very little distance between the encrusting mat of the sponge and the tip of the oscula openings. The average height of the oscula for the surface sponge was only .27 centimeters, the pore openings barely extending past the top of the mat connecting the body of the sponge to the dock substrate. This phenotype makes sense when the environmental factors affecting the sponge are considered. Growing at the waters surface *H. permollis* was impacted by a heavy amount of wave action, its growth influenced by any water movement created between the side of the dock and the water. This excess of movement caused the surface sponge to develop a specific phenotype that is more compatible with wave action. Wave action at the surface could potentially damage the delicate oscula if they protrude too far from the stabilizing base of the sponge. As hypothesized, the surface sponge adopted a growth form in which its oscula only slightly extend out into the turbulent water, the pores barely past the encrusting mat connecting the sponge firmly to its substrate. This phenotype is beneficial to the surface *H. permollis*: while the sponge has lost a large percentage of incurrent openings it has gained the ability to remain intact and whole when confronted with the rough water movement that surrounds it. Like the deeper sponge, the surface level *H. permollis* also seems to have altered its phenotype to best suit the environment in which it lives.

It is clear that *H. permollis* exhibits phenotypic plasticity between environments with different environmental pressures acting on the sponge, but many questions must still be answered before this adaptive process is truly understood. For example, is the ideal phenotype for the sponge selected at the larval stage when it settles in a particular environment, the growth form becoming unalterable once the sponge begins to grow and mature? Or does the phenotype remain plastic and variable through out the lifetime of the sponge, allowing the mature sponge to re-adapt as the environmental conditions around it change, and if this is the case can the sponge change its growth pattern between seasons or is a process that only responds to years of slow, steady adjustments? The research that would provide answers to these posed questions would further the understanding of phenotypic plasticity in *H. permollis* and other organisms with this unique and complex adaptation.

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[i] J.A Kaadrop "Morphological analysis of growth forms of branching sessile organisms along environmental gradients" Marine Biology 1999, 2: 295-306.

[ii] Engene N. Kozloff, Seashore Life of the Northern Pacific Coast (Seattle: University of Washington Press, 1983) 48.

Figure 1
Deeper Variety of *Haliclona permollis*:
1.5 magnification

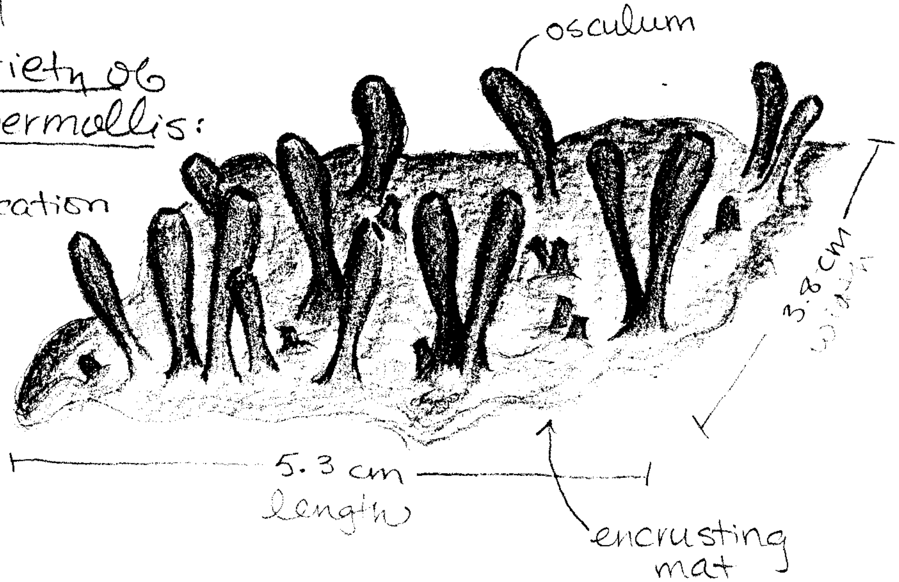

Figure 2
Surface level variety of *Haliclona permollis*:
x magnification