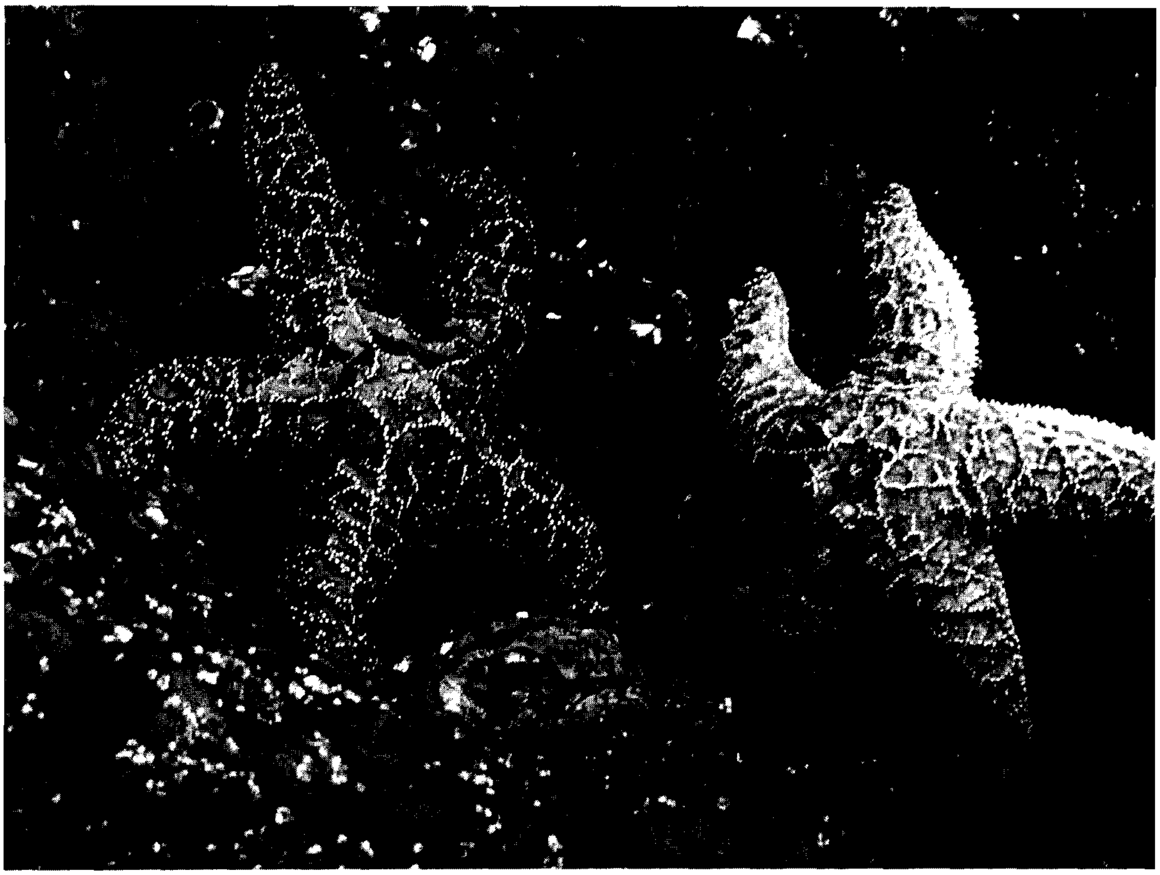

Polymorphism in *Pisaster ochraceus*

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Exploratory 2: Polymorphism in *P. ochraceus*

Introduction:

The sea star *Pisaster ochraceus* is one of the most conspicuous creatures to observe along the Northeastern Pacific coast, appearing as a brilliant purple, orange, or reddish-brown. If one were to ask a marine biologist, they would estimate that ¼ to 1/3 of *P. ochraceus* in any given site along the Pacific coast are orange (Raimondi, 2007). The coloring of *P. ochraceus* is thought to arise genetically or through diet. It has been discovered that at least two carotenoid pigments, mytiloxanthin and astaxanthin, produce these two colors, with mytiloxanthin accumulating through feeding and astaxanthin occurring as the end product of several distinct metabolic pathways (Harley, 2006). According to Raimondi et al, animals generally do not produce carotenoids, suggesting that diet plays a significant role in coloration (Raimondi, 2007). In preliminary studies of *P. ochraceus*, I overturned many in search of what they were eating, and found them to be eating many of the same foods, including barnacles, mussels, and snails. If diet appears to be fairly uniform among both color morphs of *P. ochraceus*, than there must be some other factor influencing their color distribution (frequency). Therefore, I propose that more purple *P. ochraceus* in the intertidal are found than orange *P. ochraceus* because they are less conspicuous to predators than orange *P. ochraceus*.

Methods/ Materials

I counted *P. ochraceus* at five different locations in Coos County, Oregon. These locations included Fossil Point, South Cove (two separate sites) and North Cove, Cape Arago, and Sunset

Bay. No samples were collected, but distributions were recorded at the lowest low tide for one week and noted according to the following criteria.

1. Observed *P. ochraceus* were classified as exposed or hidden. "Exposed" was listed as being within 2 m from the observer, usually lying horizontal within a tide pool or on top of a rock or patch of mud. A "hidden" *P. ochraceus* was classified as being not clearly visible within 2 m from the observer, oftentimes tucked vertically or underneath a rock.
2. Observed *P. ochraceus* were also classified according to its microhabitat (e.g. rock, tide pool, mud, and surge channel). A "rock" microhabitat meant *P. ochraceus* was attached dryly to a rock at low tide, "tide pool" was when *P. ochraceus* was submerged at least partially at low tide within a tide pool, "mud" was where it was sitting plainly in the mud at low tide, and "surge channel" where it was attached to the sides of a surge channel.

Results:

The average number of orange *P. ochraceus* over all five sites was 14.2 individuals with a standard deviation of 1.6 and the average number of purple was 41.6 with a standard deviation of 21.7 (a 1:4 ratio, respectively). The east side of South Cove saw the largest percentage of the orange morph at 35% orange, whereas Fossil Pt saw the lowest percentage at 16.4% orange. The number of orange vs. purple *P. ochraceus* were tabulated and graphed in Figure 1, which shows their distribution in number of individuals in all five areas.

There were more hidden than exposed individuals of *P. ochraceus* (both color morphs), with orange morphs averaging at 65% hidden and purple 62%. The only exception was the east side of South Cove at Cape Arago, which had equal numbers of exposed and hidden orange morphs (6 individuals) and more exposed purple morphs than hidden (13 exposed, 9 hidden).

The number of hidden and exposed *P. ochraceus* was tabulated for both color morphs of *P. ochraceus* and graphed in Figure 2.

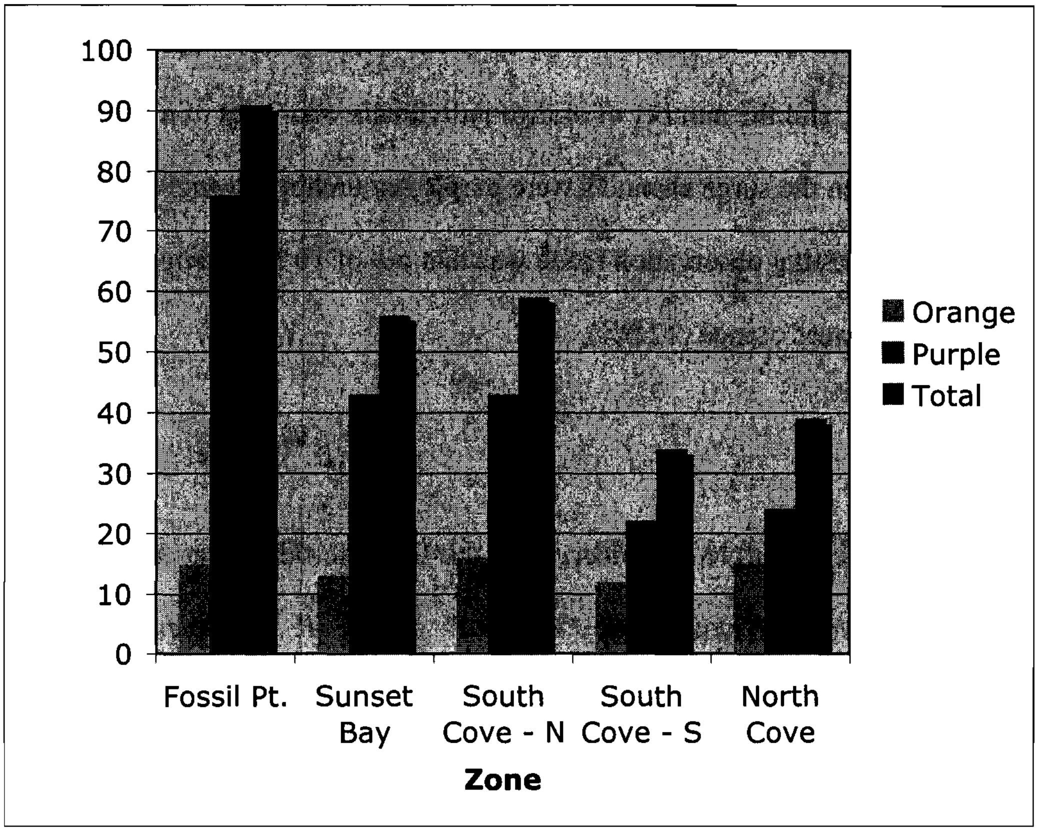

Figure 1: Number of each color morph and the total *P. ochraceus* at each of the five sites.

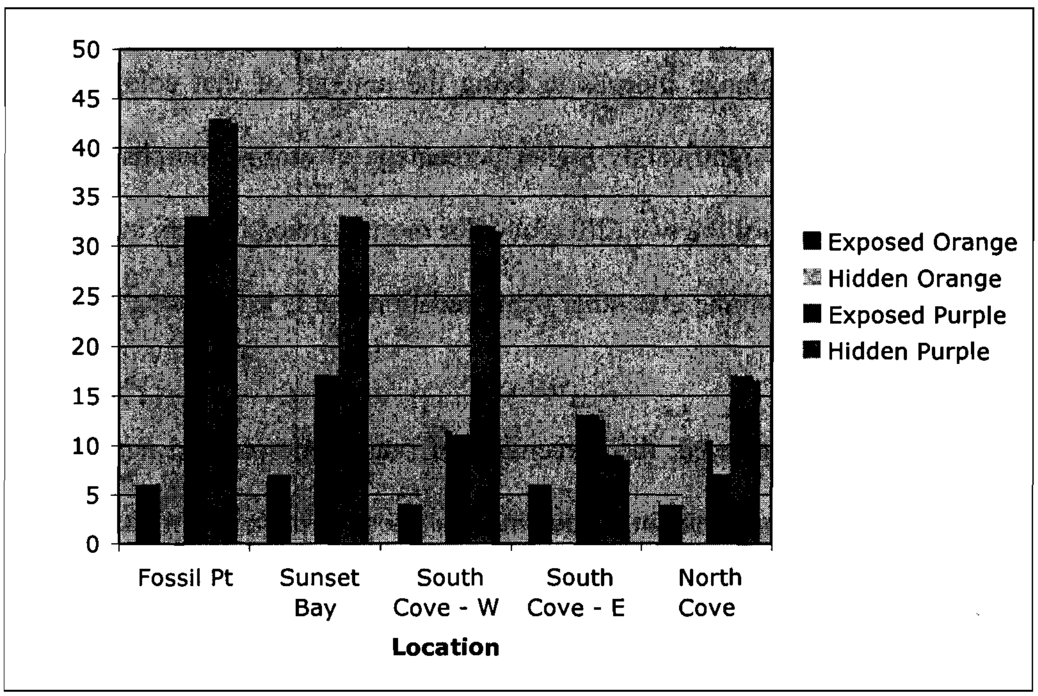

Figure 2: Number of each color morph of *P. ochraceus* classified as hidden or exposed.

The average number of orange *P. ochraceus* attached to rocks was 7 out of an average total of 24.3 individuals attached to rocks (about 28.3%), while the average number in tide pools was about 4 out of an average total of 16.3 (about 26%). Only one site, Sunset Bay, had a surge channel (two channels, actually), and the number of orange individuals was 7 out of a total of 26 (about 27%). Within and between the surge channels were purple sea urchin (*Strongylocentrotus purpuratus*) holes, and one interesting observation made was that out of 16 *P. ochraceus* near or covering an urchin hole, only 2 were orange (12.5%).

Discussion:

The percentage of orange to purple *P. ochraceus* in the five intertidal areas agreed with literature percentages. However, the number of "exposed" orange *P. ochraceus* did not significantly differ from the number of "hidden" orange *P. ochraceus*, nor did the percentage of hidden orange morphs differ that much from hidden purple morphs. This means there is an advantage to being hidden, but it is not specific to orange morphs. If there were significant predation from above targeting the orange morphs to bring the amount of that color morph present down, then there would be a significantly higher percentage of orange morphs hidden. Since the percentages are about equal for the two different color morphs being hidden, but purple is still greater in number, there is something else other than predation that is influencing the ratio of color morphs.

For the three microhabitats surveyed, the percentage of orange morphs did not change much in response to the change in environment, indicating that these specific microhabitats do not apply (significant) selective pressures on the different colors of *P. ochraceus*. If the different microhabitats were to show any specificity toward one specific color, there would be more of one color in a specific microhabitat over another.

At the east side of South Cove where the statistical anomalies occurred for the two color morphs (hidden less than or equal to exposed *P. ochraceus*), both color morphs (not just orange) saw decreases in the number of individuals present and the number of individuals hidden, suggesting an external force was acting on both color morphs. This could be because most of the area I covered was protected and did not have substantial rock coverage, so many *P. ochraceus* were out in the open for sheer lack of a 3D environment (places to hide). However, Fossil Pt., where the largest amount of *P. ochraceus* was counted, is also a protected intertidal area (though more rocky).

As for the large percentage of purple *P. ochraceus* on the urchin holes, I was led to wonder if the purple coloring had anything to do with purple sea urchins, as noted by Feder in his publication in which he noted that *P. ochraceus* does in fact eat the purple sea urchin, *S. purpuratus* and by Harley et al. who noted that one of the carotenoid pigments that causes the purple coloring in *P. ochraceus*, mytiloxanthin, has been isolated from the California mussel, *Mytilus californianus* (Feder, 1959 and Harley, 2006).

Works Cited:

1. Feder, H.M. (1959). The Food of the Starfish, *Pisaster ochraceus*, along the California Coast. *Ecology*. 40(4): 721-724.
2. Harley, C.D.G. et al (2006). Color Polymorphism and Genetic Structure in the Sea Star *Pisaster ochraceus*. *Biol. Bull.* 211:248-262.
3. Raimondi, P.T. et al (2007). Consistent Frequency of Color Morphs in the Sea Star *Pisaster ochraceus* (Echinodermata: Asteriidae) across Open-Coast Habitats in the Northeastern Pacific. *Pacific Science.* 61(2):201-210.