Chapter 3

An assessment of fucoid "success" along the salinity gradient in Yaquina Bay in Newport, OR

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Introduction

Interest in the invasive species *Carcinus maenas* spurred the study of Yaquina Bay. During a preliminary survey for species present at several sites along the salinity gradient of the bay, we noticed a difference in the apparent "health" of *Fucus spiralis* and *Fucus gardneri* with the healthiest looking plants closer to the mouth of the bay. These healthier-looking plants had thicker thalli, a slick, glossy appearance, and were more difficult to remove from the substrate when pulled. Plants at the upper bay site had very thin thalli, a dark, decaying appearance, and were easily removed from the substrate. These observations were of particular interest because previous studies in New England have shown that juvenile *C. maenas* are commonly associated with *Fucus* spp. and with *Ascophyllum nodosum* (Carlton 1992a). In fact, in San Francisco Bay, the megalophae larvae of *C. maenas* settle in the *Fucus* zone (G. Jensen, unpublished observation). Therefore, the health of both *F. spiralis* and *F. gardneri* in Yaquina Bay may have a direct influence upon the success of *C. maenas* settlement.

Both *F. spiralis* and *F. gardneri* are species of marine brown algae commonly found in the upper intertidal to midtidal zones (Hillson, 1977; Abbott and Hollenberg, 1976). The blades have an olive green to dark brown color with a midrib down the center of the thalli which is more prominent in *F. spiralis*. Reproduction is similar in both species. Mature thalli develop swollen tips called receptacles in which gamete production occurs. In *F. gardneri*, these tips can comprise up to one-half of the total length of the thallus and may appear hollow and inflated in calmer waters (Dawson and Foster, 1982). Receptacles in *F. spiralis* tend to have an oval to oblong shape and a warty appearance (Hillson, 1977).

We decided to assess the status of *Fucus spiralis* and *Fucus gardneri* along a salinity gradient in Yaquina Bay in order to determine if there is a discernible difference in the "health" of plants along the salinity gradient.

This was evaluated using general appearance, size, reproductive status, and epiphyte load as indicators of individual success.

Materials and Methods

Temperature and salinity measurements were made at 15 sites along Yaquina Bay, starting at the jetty and moving inland (see report by Cronick and McGuire). The temperature was measured using a thermometer and a refractometer was used to take the salinity readings. South Jetty, Sawyer�s Landing and Upper Bay became the chosen sites for this study because they represented areas located on a decreasing salinity gradient.

The substrate at the South Jetty site (abbreviated as SJ) is dominated by large boulders (see map). Organisms at this site experience the greatest wave action. The substrate at Sawyer�s Landing (SL) ranges from cobbles to large cement blocks with reduced wave action. At the Upper Bay site (UB), the substrate is again dominated by large boulders with some cobbles and thick, anoxic silt at the lower levels. Though wave action from boat traffic is reduced at this site, the organisms must cope with a greater variation in salinity due to the changing ratio of fresh water to salt water inputs.

At each site, a meter tape was laid out 10 meters across the high zone, which was marked by a wide band of barnacles and *Fucus* plants, and 4 plots (50 cm x 50 cm) were picked using a random number table. Five plants within these were haphazardly chosen and sampled from each of the plots, for a total of 20 plants at each site. We recorded grazer abundance on each plant by counting the number of grazers present on all parts of the plants. The length of the plant was determined by measuring from the base of the holdfast to the tip of the longest blade. The number of receptacles per plant, along with the length and width of the largest receptacle were recorded. The width of the receptacle was measured by pinching the tips of the receptacles together in order to close the gap between them and then measuring the length and width using a ruler. We used these measurements to estimate the average area of receptacles per plant at each site (Area = length x width). The epiphyte load of each plant was estimated by looking for epiphytes on both the topside and underside of the plant. We recorded this as the percentage of each plant which was covered by epiphytes.

Results

We do not report average grazer abundance per plant at our three study sites because the number of grazers found on each plant was very low.

We combined the data for F. gardneri and F. spiralis because we found no significant difference between the two species in any of the parameters.

The average length of Fucus spp. appeared to be greatest at the South Jetty, with an average of 14.04 cm and a standard error of 1.80. The average length of Fucus spp. is similar at both Sawyers Landing (average length was 9.58 cm with a standard error of 1.70) and Upper Bay (average length was 9.34 cm with a standard error of 0.93) (Fig.1).

The average number of receptacles appeared to be very similar between Sawyers Landing and the South Jetty, while the number of receptacles present at the Upper Bay site was far less. Sawyers Landing had an average of 3.5 receptacles per plant, with a standard error of 1.18, while South Jetty had an average of 3.7 receptacles per plant with a standard error of 0.55. (Fig. 2).

Figure 3 examines the average area of receptacles per plant among the three sites. South Jetty had an average area of 3.4 cm^2 per plant, with a standard deviation of 1.66. This site appeared to have receptacles with the largest area. Sawyers Landing had an average area of 1.9 cm^2 per plant, with a standard error of 0.45, while Upper Bay had an average area of 0.1 cm^2 per plant, with a standard error of 0.35.

The average epiphyte load among the three sites is illustrated in Figure 4. Sawyer�s Landing had largest percentage of epiphytes with a 40% epiphyte load and a standard error of 4.68. *Fucus* individuals at South

Jetty had an average epiphyte load of 20% with a standard error of 5.3. The epiphyte load at Upper Bay was similar to that of the South Jetty with a 16% epiphyte load and a standard error of 4.34.

Table 1. Temperature and salinity ranges for South Jetty, Sawyer�s Landing, and Upper Bay.

Site	Temperature	Salinity
SJ	13 - 16 C	25 � 31 ppt
SL	13 - 16 C	17 � 31 ppt
UB	13 - 15 C	4 � 16 ppt

Discussion

Average length

Average lengths of individuals at the South Jetty were significantly greater than the average lengths of plants at Sawyer's Landing and at the Upper Bay site (Fig. 1). Average length of plants at SL and UB were similar. The longer length of plants at SJ could be attributed to many factors, including more favorable growing conditions or differences in ages of plants. Since epiphyte load on individuals at SJ was reasonably low (Fig. 4), so the plants have more surface area open to light reception for photosynthesis.

Plants at SL were more variable in length because some were adults and some were juveniles. Both often had a high epiphyte cover which would effectively decrease the photosynthetic efficiency. This could result in less energy for plant growth and development.

Plants at UB had lower epiphyte load but were in an area of high sedimentation. Fine, anoxic sediment covered all surfaces which were submerged during high tide. This further decreased surface area open to light reception and photosynthesis. Additionally, we noticed an oily glaze to the water's surface, indicating that there may also be more pollution at this site or more stagnant conditions with less nutrient flux. Oil might also have negative effects on photosynthetic activity or even have toxic effects on the plants.

Receptacles

The average number of receptacles was highest on individuals measured at Sawyer's Landing and South Jetty (Fig. 2). Individuals at SJ averaged between 3-4 receptacles per plant which implies that there may be greater success at SJ for accelerated reproductive development. Average area of receptacles was highest for individuals at SJ (Fig. 3), despite the fact that receptacles on these plants appeared to be at the lowest level of maturity for the three sites. In fact, many of the receptacles were just forming, while receptacles on plants at UB were either just forming or very swollen and yellowish colored (Fig. 5). Receptacles on plants at SL were very swollen, indicating that they were farther along in development than those at SJ. These had an olive-green color.

Average epiphyte load at three sites

Epiphytes common to all three sites were *Enteromorpha linza*, diatoms, and a type of filamentous brown alga. SJ also had an epifaunal species of barnacle. Plants at SL also carried barnacles and *Ulva taeniata* and plants at UB carried a species of *Ulva*. Exact identification of epiphytic and epifaunal species was difficult due to time constraints, limited daylight, and the small size of the specimens.

Epiphyte load on individuals at Sawyer's Landing was significantly higher than that at the upper bay (UB) and the south jetty (SJ) (Fig. 4). This may have been related to the size of the individuals which we sampled. Many juveniles were measured so they had proportionately less area for epiphytes to cover.

One factor which would undoubtedly affect epiphyte load is grazer abundance. The most common grazers present were littorine snails, but limpets were also present at SJ. *Idotea wosnesenskii* were identified at SL and an isopod species was also present at UB. We saw few grazers in the vicinity, which may have been due to very low tide level since grazers typically hide under rocks to avoid desiccation and predation, or there may not be very many grazers present at SL. Additionally, the nature of the site, which is basically a cobble beach with a few large boulders at the higher tide level, could contribute to high epiphyte load with low grazer activity. As such, fucoids were primarily restricted to the tops of the boulders which were spaced far apart. Grazers would experience greater difficulty moving from one area to another here where they might not at UB or SJ which were almost exclusively composed of large boulders stacked on or near each other. There was evidence of grazing on fucoids at SL but not many grazers were actually found on plants when the measurements were taken. Grazers appeared to be more abundant at UB and SJ (visual estimate). However, it is likely that we missed some grazers at all sites during our inspection because they were very small (ex. amphipods).

There also might be differences in the nutrient concentration of the water at the three sites, though we don't have data to support this. Higher nutrients, especially nitrogen and phosphorus, would significantly increase epiphyte growth (Neundorfer and Kemp, 1993). Most of the epiphytes were ephemeral algae species which grow much faster than *Fucus*.

Other Factors Affecting Fucoid Success

Several studies indicate that cumulative temperature of the water during high tide is the main determinate for release of zygotes in several types of brown algae (Hales and Fletcher, 1990; Bacon and Vadas, 1991). In particular, a model developed for predicting the release of gametes in the brown alga *Ascophyllum nodosum* uses cumulative water temperature as an important parameter (Bacon and Vadas, 1991). This is directly related to receptacle development. It is possible that UB was warmer earlier in the season, resulting in accelerated receptacle development. However, Hales and Fletcher (1990) also mention that this factor may not affect *Fucus*. Additionally, temperatures at the three sites, though not measured during high tide, were similar (Table 1). Therefore, temperature may not be the main factor affecting *Fucus* growth in Yaquina Bay.

Salinity has also been suggested as a factor affecting the development of algae. In fact, the lower salinity limit for the brown alga *Sargassum muticum* may be determined by the tolerance of its male gametes (Hales and Fletcher, 1990). Salinity at the three sites was very different (Table 1). The Upper Bay site experiences the greatest range of measurements. This is attributed to variation in freshwater input from the river due to changes in precipitation and runoff. Since both species of *Fucus* are marine algae, it stands to reason that they would grow better at a higher salinity.

Role of *Carcinus maenas*

First, it is difficult to say what affect *Carcinus maenas* will have on the "health" of *Fucus*. It may vary according to the life stage of the crab. For instance, larval *Carcinus* may positively affect *Fucus* by feeding on epiphytic algae.

However, larger crabs will probably indirectly decrease the "health" of *Fucus* by removing larger *Littorina* spp., limpets, and isopods at all sites, though the effect may be less prominent at the south jetty site since *C. maenas* does not do as well in higher energy environments (Cohen et al. 1995; Grosholz and Ruiz, 1995). These grazers may act as cleaners by preferentially feeding on epiphytic species without causing significant damage to the fucoid hosts (Raffaelli and Hawkins, 1996; Underwood et al. 1992). Studies have shown that, in situations where epiphyte cover increases too much, the epiphytes can actually slow the growth of host plants (Hay, 1986). Without grazers to remove them, the faster growing epiphytes could outcompete fucoids by covering all surfaces or at least covering enough surface area to decrease photosynthetic activity of *Fucus*.

Conclusions

There appears to be a difference in *Fucus* success along the salinity gradient of Yaquina Bay. This difference is reflected in the variation of epiphyte load, plant length, receptacle count and size, and the general appearance of plants at the three sites. In the future, we suggest increasing the sample size to at least 40-50 individuals per site to decrease error bars and using a gridded quadrat to randomly sample plants in plots rather than using haphazard sampling. We would like to expand this investigation to cover two more sites along the salinity gradient. These sites are Boat Works, where we also noticed decreased *Fucus* "health" during the preliminary survey of sites along the bay, and Hatfield.

Abundance of fucoids could directly affect larval success of *Carcinus maenas*. Much more information is needed in order to accurately predict the effect of *C. maenas* upon the *Fucus* population of Yaquina Bay. However, it is most likely that the crab will have a negative effect on fucoid "health" by consuming grazers which preferentially feed on epiphytes, thereby allowing epiphyte cover to increase.