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Exploratory on Structural Adaptation
Due: 7/16/07

An Exploratory Comparison of the Root Morphologies of Two Sea Grasses, *Phyllospadix* and *Zostera*

INTRODUCTION:

Background:
The importance of sea grasses for habitat and biodiversity can hardly be overstated. Many species and communities are associated with sea grass beds. The two groups of sea grasses common to the Pacific Northwest are *Phyllospadix* (surf grass) and *Zostera* (eelgrass). Both are members of the family Zosteraceae. Though not true grasses, they are flowering plants with true roots, and are descended from terrestrial plants. (Sept, 2000. p.183) Both *Phyllospadix* and *Zostera* are home to a diverse array of organisms, and both provide important food sources for birds, fish, and crabs, as well as important habitat for fish and crabs. (Hemminga and Durante, 2000. pp.154-155, pp.209-239) Declines in sea grass areas can negatively affect commercial crab and fish industries, as well as many other ecological communities. (Durante, 2002. p.1-5)

The lists that follow are only a generalized overview of some of the more obvious and prominent groups of plants and animals. They do not include detailed lists of the different species of each group, of which there are many, nor do they include the plethora of microscopic organisms present. In short, it is only the tip of the iceberg when discussing how many and which organisms are present in these communities. (Kozloff, 1993, pp.320-328)

In the Pacific Northwest, eelgrass beds host populations of diatoms, bacteria, protozoans, worms such as turbellarians and nemerteans, snails, limpets, nudibranchs, clams, sea stars, brittle stars, sea cucumbers, hydroids, sea anemones, jellyfish, isopods, and crabs. Many algae are also associated with eelgrass, including *Smithora naiadum,* and *Kornmannia zostericola.* (Kozloff, 1993. pp.320-328) While I conducted this exploratory project, I found literally hundreds of polychaete worms and ribbon worms; I approximated about 30 per square inch, if not more. I also found young Dungeness crabs, pill clams, an anemone, hundreds of amphipods and isopods (many were bright green to match the eelgrass), tiny shrimp, snails, and many species of algae, possibly including *Lola lubrica* and *Enteromorpha.* The book *Pacific Seaweeds* compares eelgrass to an intensely managed Puerto Rican alfalfa field in terms of productivity. (Druehl, 2000. p.42) Eelgrass can also be an important tool in habitat conservation, particularly on disturbed or unstable areas, as it has the ability to root into soft muddy sediments and prevent erosion. (Druehl, 2000. p.42)

Surf grass communities in the Pacific Northwest are also home to an amazing range of organisms. A few common organisms amid the surf grass include: diatoms, bacteria, limpets such as *Notoacmea paleacea, Lacunas* and other snails, and several isopods belonging to the genus *Idotea.* Typical algae present on surfgrass include encrusting coralline red algae, *Smithora naiadum,* and the green alga *Kornmannia zostericola.* (Kozloff, 2000, pp320-328) In my relatively small sample of surf grass, which measured about one square foot, I found: dozens of snails, several whelks, about 20 hermit crabs, dozens of white ribbon worms, hundreds of polychaetes (some of which I believe were *Thelepus*), 10 brittle stars, a sipunculid, a broke-back shrimp, about 30 amphipods, a kelp crab, and a shore crab.

The Exploratory:
Because of the importance of sea grasses, and their beauty, I chose to do my exploratory on comparing *Phyllospadix* and *Zostera.* I decided to start with morphology, in particular the root morphologies of the two sea grasses. *Phyllospadix* is a low intertidal and subtidal angiosperm that prefers rocky intertidal areas. *Zostera* is a low intertidal and subtidal angiosperm that prefers quiet bays with muddy bottoms. (Sept, 1999. p.183; Hemminga and Durante, 2000. p.4)

Hypothesis:
My hypothesis was that the morphology of the roots on the two plants would be very different due to their substrate preferences, and that *Zostera* would exhibit much longer roots than *Phyllospadix.*

METHODS:
For this exploratory, I collected approximately one square foot samples of both eelgrass and surf grass, with some substrate attached. I compared the differences in morphologies by measuring the length of the roots, depth of the root clumps, and how many branches a root clump had. I also measured how many blade groupings were associated with the root clump, counted the number of blades, and measured their length.

Although there are different species of both *Pyhllospadix* and *Zostera*, I decided not to identify the sea grasses down to the species level, as distinction between some species can be exceedingly difficult, and the genus level of identification sufficiently serves the purpose of comparing the structural adaptations of the two groups.

I immediately ran into some difficulty in measuring the roots of each type of grass, as they both have rhizomes that break off extremely easily. And, in the case of surf grass, it is very difficult to tell one rhizome from the next, or to separate them. The eelgrass presents similar problems, as it grows so deeply into the mud that it is very difficult to dig the roots out without breaking them. Hence, very few of my measurements of root lengths were done on a whole root system. Another problem I ran into was attempting to define what, indeed, could be considered a single individual plant to do measurements on. I learned that an eelgrass bed could theoretically be a single organism, all connected by rhizomes born of a single parent plant. This is also true of the surf grass beds. (Durante, 2003. p.1-5) The morphology of both types of plants, in different ways, made it beyond the scope of my project to attempt to define and collect an adequate sample size of single organisms. To solve this problem, I moved away from measuring individual plants to instead measuring clumps, which I defined as the groupings of roots and branches that easily came away from each other. For the purposes and scope of this exploratory, I felt that this approach was more than adequate to illustrate the differences in structural adaptation, and the general differences in root morphologies.

The surf grass samples were taken on 07.07.2007, 11.45PST, at low tide peak (1.11'), on the South Cove of Cape Arago beach in Charleston, Oregon. The rocky tidal pool in which these samples were collected was on the North side of the cove, about 150 meters from where the rocks start on the sandy beach area, and about half way between the cliff face and the water. Much of the immediate surrounding vicinity was also covered with *Pyhllospadix.* In that general area, 55cm seemed to be the maximum depth to which the surf grass grew, and most of it was in water about 10 to 20 cm deep. Once the water level reached approximately 5cm or below, the *Phyllospadix* began to dry out and some of it appeared to be dying. As long as it was wet it appeared to be alive, but much that was exposed and dry was brown and completely limp or crispy.

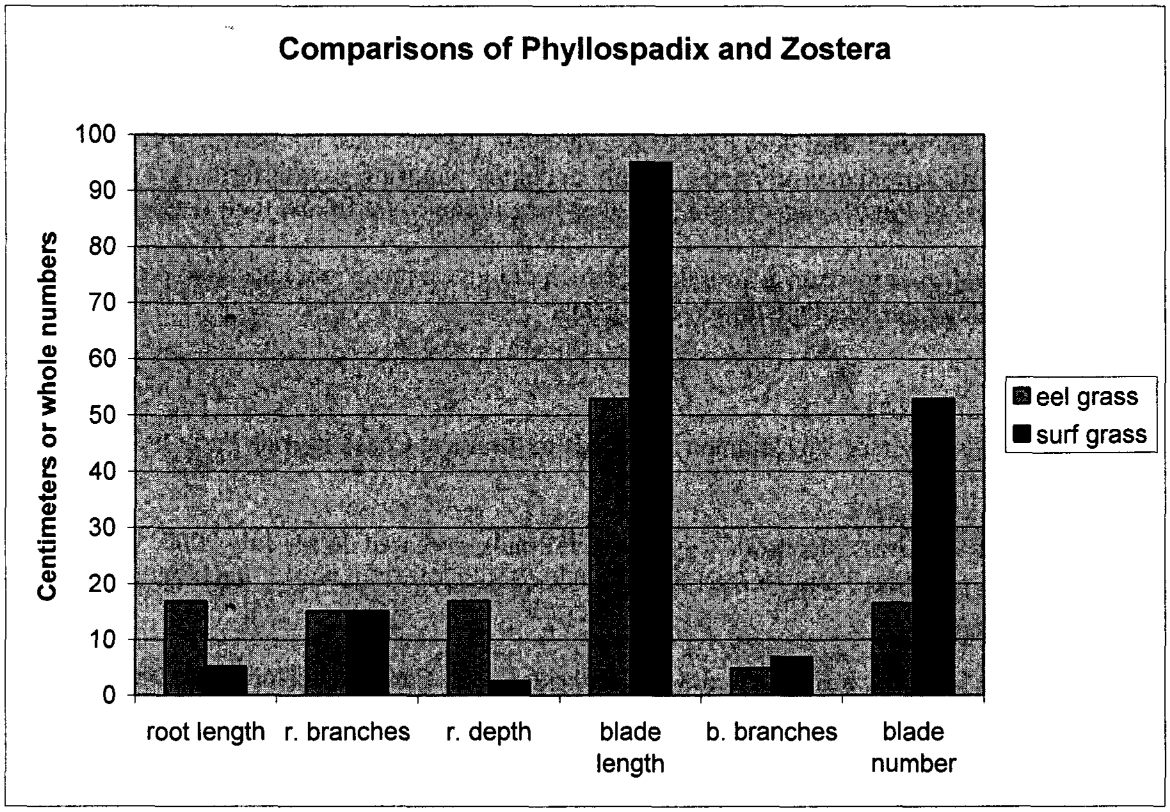
The eelgrass samples were taken on 07.08.2007, 13.00PST, one-quarter hour after the peak of the low tide (1.88', at 12.45PST). The samples were taken on the mud flats near the overpass that is the bridge between Charleston and Coos Bay, on the Charleston side of the bridge, and kitty corner to the Davey Jones Locker on the intersection just before the bridge. The mud flat area I took the sample from is on the right if you are facing towards the bridge. The eelgrass bed that this sample came from was barely submerged in about 3cm to 4 inches of water. The bed is about 15 feet long by about 4 or 5 feet wide, depending on the area. Some areas were wider and some are shorter. I took the sample from a thin section at the edge of the bed. Also present in the area was a flock of some sort of small sandpiper-like shorebirds that were attempting to feed in the eelgrass bed, as well as a heron. They did not like my presence, and so I made short work of collecting my samples. There seemed to be other eelgrass beds in the area, but I did not explore so as to not disturb the birds.

Samples were put in buckets, and taken back to the lab. There, I slowly sorted through the samples to find any organisms present. Afterwards, I used a meter stick to measure the roots and blades. Surf grass and eelgrass samples were eventually returned to their general areas, along with their associated organisms.

RESULTS:

I took measurements on 15 clumps of each type of sea grass. I measured root length, number of root branches (large, main roots, not small fibrous roots), number of blades, number of blade branches, blade length, and depth of root mass from the base of the blades to the lowest reaching rhizome. The following numbers are the mean values:

	Zostera:	*Phyllospadix*:
Root length:	16.81 cm	5.09 cm
Number of root branches:	15	15
Dept of root mass:	16.81 cm	2.43 cm
Blade length:	52.77 cm	94.96
Number of blade branches:	4.73	6.73
Number of blades:	16.4	52.8



DISSCUSSION:

The root morphology of *Phyllospadix* does indeed have a much more shallow growth pattern than *Zostera*, as the *Phyllospadix* is attaching to a hard rocky substrate rather than soft muddy sediments. The root mass of the *Phyllospadix* is more reminiscent of an algal holdfast, and has many thick small roots growing off of the main taproot, boring and tangling into the substrate. The roots of *Zostera*, on the other hand, are similar to the roots of many terrestrial plants that grow in loose soils. Masses of thin fibrous root hairs grow off of a more centralized taproot, which is long and relatively straight. What I did find surprising, however, is that despite this shallow growth habit, the roots of *Pyhllospadix* support more blades, and blades of a longer length, than do those of *Zostera*. Perhaps this is possible due to the holdfast-like nature of the roots of the surf_grass, in which the fibrous smaller roots are thick and fleshy, tangling into the rock and giving the plant something to hold onto. Phyllospadix roots are a tangled mass of hard, thick root fibers inseparably meshed together with rock, shell, sediment, sand, and polychaete tubes, firmly rooted onto the rock. *Zostera* only has shifting sediments to cling to, and so it has the strategy of deep growth with many thin hairs to help adhere to, and hold in place, it's potentially shifting sandy mud environment. Perhaps this arrangement does not allow for supporting a greater mass of blade structures, or perhaps the extra blades are not needed.

I believe that this difference in morphology between the two groups appropriately reflects the differences and trade-offs in root transport of nutrients, which I would think is much greater in *Zostera*, as it grows on a nutrient rich substrate. Sea grasses are capable of nutrient uptake and transport in both their roots and their leaves, and the ratio varies according to species. (Hemminga and Durante, 2000. p.127) It makes sense that since *Phyllospadix* does not get as much nutrient uptake from the roots as compared to many other plants (it is, after all, growing on a rocky substrate), that the root function would have the primary function of holding on, while the plant would need more leaves for nutrient uptake. (Terrados and Williams, 1997) The roots of *Phyllospadix* do transport some nutrients, just not nearly as much as *Zostera* or other angiosperms. Similar theories were discussed in *Seagrass Ecology* (Hemminga and Durante, 2000. p.129) and also in the *Seagrasses* (Phillips and Ernani, 1988). In any event, the differences between the two root functions as well as their morphologies are distinct.

In terms of the hypothesis, the results for root lengths are problematic in terms of accuracy, as there were many breakages. However, I think that the numbers do reflect the differences in general morphology, i.e., that *Zostera* has deeper roots, which support fewer and shorter blades. However, that does not necessarily mean that the roots are longer, even though I do suspect this is the case. I did include the length measurements, simply to help in picturing growth form. It is possible, however, that the dense, coiled root fibers of *Phyllospadix* might be just as long if one could follow their tangled and confusing journey.
Comparisons of root length was not as apt a comparison as root depth, which did give a much more accurate picture of the dramatic differences in the root morphology due to adaptation in each genus.

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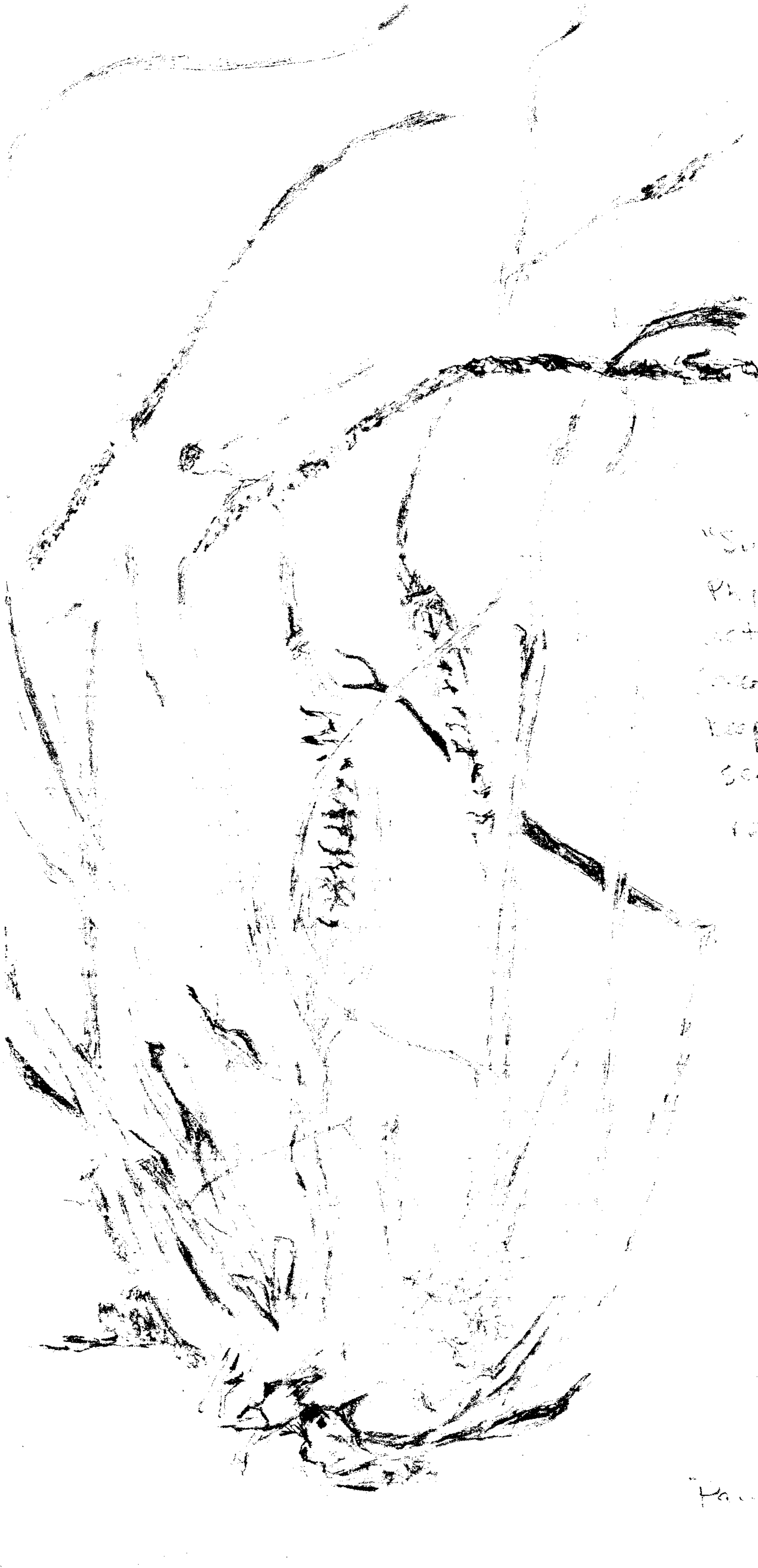

"Surf grass"
Phyllospadix
actual size
except blade
length (?) w/
seed pods &
root structure

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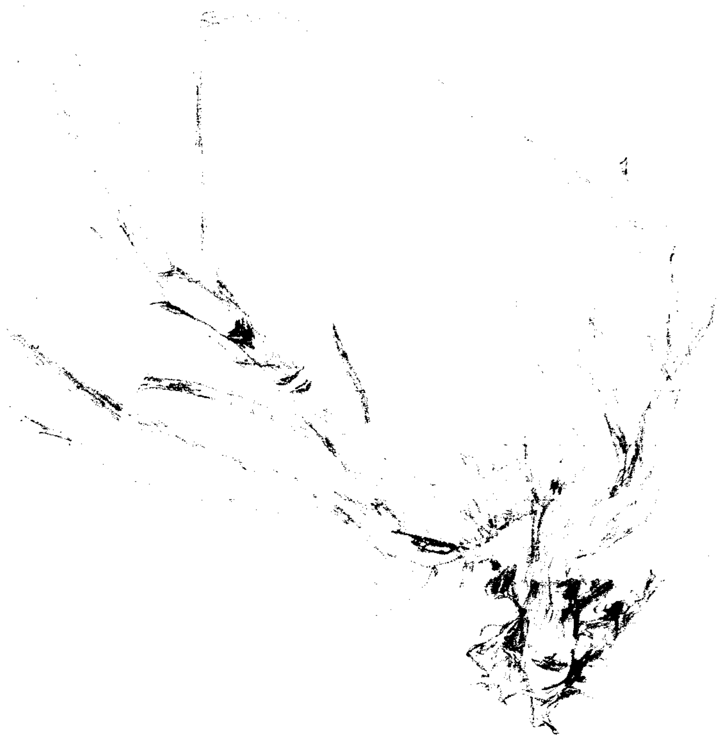
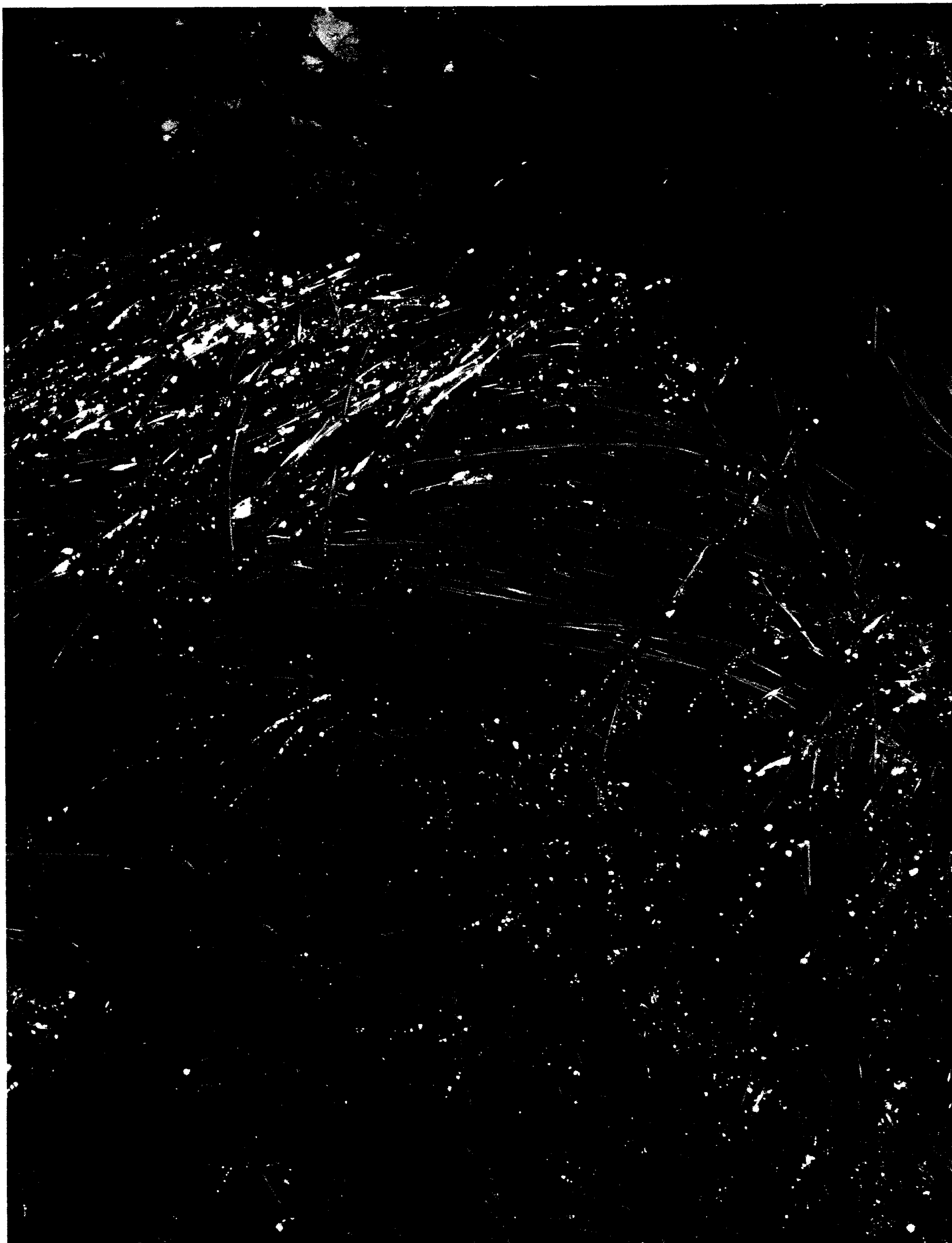
ACTUAL SIZE
The boring tip of the root?
Phyllospadix



ACTUAL SIZE
ROOT STRUCTURE
& PART OF BLADES

Zostera



Picture by George