Luta incognita…

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This essay, a continuation of my article in the last issue of *The Dredgings*, illuminates another aspect of the question of how little we really know about our local habitats covered by salt water. For this article, I will mostly discuss "mud", whatever that might be. "Mud" in its truly infinite diversity of textures, colors, and yes… flavors, is the common characteristic of habitats regarded by most folks to be the least enticing habitats to explore. Nevertheless, it might be a good idea to cultivate an appreciation for the muddy things of life. The idea that most of the subtidal habitats in the Greater Puget Sound region are rocky is patently false. Soft sediment benthic communities in one form or another dominate the region, with rocky substrata being mostly edge phenomena. Nonetheless, why enjoy the disgusting mud habitats? Well, simply put, such environments comprise the vast majority of the planetary surface; overall, that's where the life is. In fact, life may have originated around hot vents in the deep muddy ocean floor. In possibly the most profound way possible oceanic mud may be our longest lost ancestral home.

Our shallow-water, non-polluted soft sediments, ranging from silts to sandy muds to sandy habitats are the nearest analogue we have of the deep-sea benthos or bottom habitats. In all, muds in one form or another cover between 75% and 80% of our misnamed planet's surface. Our home isn't dry earth… it is wet mud covered with water, and the planet should probably be called Oceana rather than Terra.

And then, to just make life a tad more interesting, both relatively, and absolutely, speaking…we don't know diddly-doo about any deep-sea muddy benthic habitats. As a person who has spent a large part of his professional life working and wallowing on and in shallow muddy marine environments, I can categorically state there are no dry or freshwater environments like them. We tend to forget they are three-dimensional, and they may be a lot thicker than most people realize. In some places marine muds (called oozes) are miles thick and creatures live all through them. This is a totally unimaginable habitat. It is frigid - deep ocean bottom temperatures are truly cold. And it is lightless - blacker than the proverbial insides of a black cat in a coal mine at midnight.

It used to be thought that these deep muds were anaerobic dead zones but recently living aerobic organisms have been recovered from under 9 kilometers of sediments. In the Salish Sea, the burrowing heart urchin, *Brisaster latifrons,* lives under at least a few meters of soft sediments beneath the bottom surface of Elliott Bay. Bivalves such as *Yoldia thraciaeformis* and *Pandora grandis*, and huge examples of the polychaete worm *Travisia pupa* also live deep within the sediment.

Travisia is a true favorite of mine on dredging field trips because it is one of the most memorable animals found in the local marine ecosystems. Most specimens from the Salish Sea are smaller, but in Barkley Sound it commonly reaches lengths of 15 cm or more and emits a truly amazingly foul, revoltingly-disgusting and intensely pungent odor, perfectly suited for waking those sleepy invertebrate zoology students from their blissful shipboard field trip stupor. This odor seems to bring to mind a ghastly fragrance that is a combination of rotting garlic and carbide that truly will bring tears to one's eyes, along with gasping for one's breath. *Travisia*, and others, are found within sediments to an estimated depth of 3 meters or more, along with the straight scaphopod, *Rhabdus rectius*. The worms' distinctive odor has been proposed to be a predator deterrent, but that doesn't seem to be the case. When near the sediment surface, all of these animals are eaten by the ratfish, *Hydrolagus colliei*, which has them more commonly in its gut than one would expect. Perhaps, for the rats, the odor is a nice condiment.

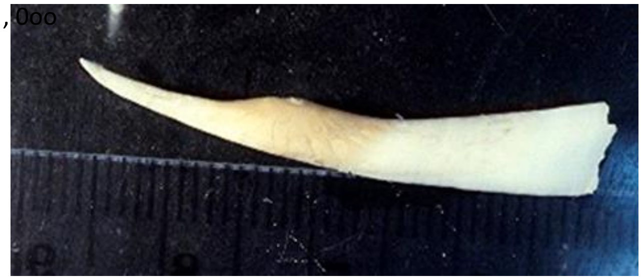
A ratfish, *Hydrolagus colliei*, photographed in Barkley Sound.

I think it would be a real hoot to construct an autonomous burrowing drone vehicle to investigate such environments, as there is simply no way to get down into the substrate to sample them adequately. A dive to the deep muddy ocean bottom to look for critters would be one of the most hazardous undertakings on the planet. Consider, no person has ever walked on the bottom of the deep ocean and likely never will, yet people have walked on the moon.

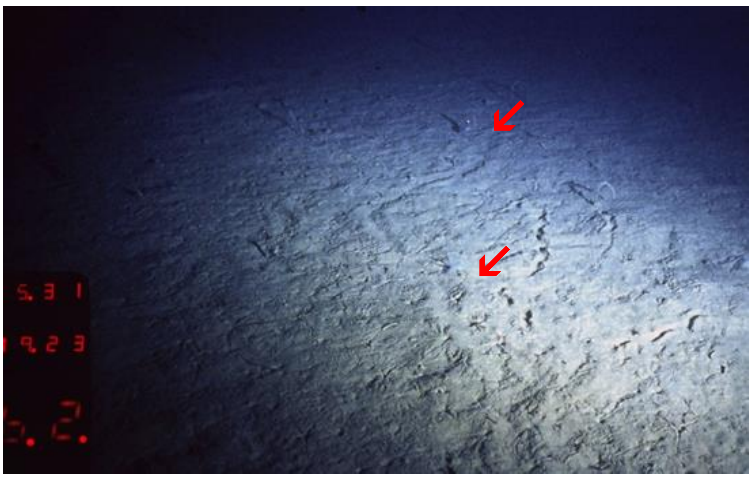
Even without getting to them, these are the most difficult ecosystems on the planet to study. Extreme areas can only be sampled using extreme means, and in scientific studies, "extreme" is buzzword meaning "extremely expensive". Thus having shallow water analogues is vitally important to understanding what may be expected in much deeper environments, like the shallow water muddy areas discussed here.

Lots of quantitative grab samples of the bottom substrates have been taken, epibenthic sleds have been drawn over the surfaces, remotely operated vehicles and submersibles have been used to investigate deep ocean habitats. By and large, all such samples by these methods are relatively small, and get smaller as the area the sample is taken from increases in depth. I will go out on a limb, and state, “The total amount of bottom surface area quantitatively investigated, photographed, or sampled since and including the Challenger Expedition is less than Perseverance Rover covers in any kind of quantitative way on Mars in a few days. All the quantitative samples taken of the deep ocean bottoms, when added together would likely cover less than a square mile (2.6 sq.km). This is out of a total surface area of 139 million $miles^2$ or 361 million km^2.”

Here just for illustrative purposes is a scaphopod specimen collected from about 4100 m off the California coast I described the species in an article published in 1997. This depth is very near the depth at which carbonate ions are not saturated in sea water. Below that saturation depth no calcium carbonate shells will be found, consequently only mollusks without calcium carbonate shells like squids, octopuses, and shell-less snails can persist. Some bivalves are found, but they lack calcareous materials in their shells, which are wholly proteinaceous.



Fissidentalium actiniophorum Shimek, 1997. The tan object is a sea anemone which fastens on the functionally top surface of the scaphopod as a symbiote. The species name of the scaphopod, *actiniophorum,* may be interpreted to mean “anemone bearer”.



Left - Area M, off California coast, depth 4100m. Image taken from the DSRV Alvin. The red arrows point to bluish sea anemones, note the trails leading to them. The anemones could not move on their own in this habitat, so they are likely attached to a scaphopod, and the trail reflects where the scaphopod dragged the anemone through the mud. Notice all the tubes, trails, indentations and other indications of life in this deep mud community.

Understanding Our Shallow Water Environments Is The Only Hope We Have Of Understanding The Deep Ocean.

Are all muddy substrates the same? Of course not, but how is it possible to compare the faunal associations between areas? Well, samples of the substrate must be taken, and all of the animals in the samples counted and identified. Then the array of animal species and their abundances are compared by statistical means, and a decision is made as to whether the same assemblage is found the different regions.

The graduate work that I did at Friday Harbor Labs in the early 1970’s illustrates the challenges of studying these soft-bottom habitats. I did roughly 500 dives in Friday Harbor Bay; with practice, I was able to distinguish several distinct “communities” or “assemblages” in what initially appeared to be a visually homogeneous bottom habitat. The very slight visual differences between the habitats I observed was later substantiated by quantitative infaunal sampling. The infauna from each of these assemblages was distinctive, and together they formed a mosaic of assemblages. Generally, each mosaic “tile” assemblage was in its own sediment pocket a few meters in diameter, in the bottom sediments.

Four Habitats

To illustrate some of the initial problems, what follows are examples of four of the 20 or so distinct habitats found in Friday Harbor Bay, more-or-less directly offshore of the UW Friday Harbor Labs. Prior to starting my intensive research program and committing myself to spending a lot of effort in samples and surveys, I wanted to find study sites where my research animals (the so-called “turrid” snails) were common or diverse or, hopefully, both. I did preliminary surveys in various areas, and found that Friday Harbor Bay, directly in front of the UW Friday Harbor Laboratories might be a place to study. So, I thought surely there would be some information available about this large region. I started a library literature search as well as checking old file cabinets, desks, and other places where a report might have been placed and forgotten. After several weeks of effort, I found nothing either formally published or informally added onto the shelves in the library: no student reports, no preliminary research, not even a guess of what was found in the bay. After several decades of research at the labs, there was not one iota of any prior information about what might be found in the largest marine habitat directly adjacent to the facility. I went into my research effectively blind.

Is Seeing Believing?

Although the habitats illustrated in the rest of this article may appear to be similar, they truly were quantitatively distinctive and had different arrays or assemblages of infaunal animals, mostly polychaete annelids (aka “bristle worms”), small bivalves and crustaceans, living within or on the sediments. They also contained different species of conaceans

(=venomous, predatory snails called “turrids” at the time), all of which consumed polychaetes in those habitats. These quantitative data are available in my dissertation on the shelves in the UW Suzallo Library or in reprints in the club library.

These environments were not characterized when I started my research on the conacean snails, for good reason. First, there were no consistent protocols about how to repeatedly sample such habitats adequately and efficiently. In North America, most methodology had been derived from limnological studies of small lakes or ponds; for many reasons, such methods were inadequate. Perhaps more importantly, when I started, I was apparently the first person on the west coast to study such unpolluted, soft sediment, marine habitats.

Unfortunately, 50 years on, the situation hasn’t changed much. At depths greater than a few meters, it is essentially impossible to adequately sample most marine environments from the surface. The biggest problem is that proper replication is very difficult if it is impossible to see the habitat being sampled. The people taking the samples use GPS data to geo-locate the positions of their boats, but not the positions of the actual samples, resulting in the basic assumption being made that if the sampling boat is “parked” at a specific site, station, locality, or place, that it must be over the same environment that it was sampling at a previous time. Unfortunately, it is almost never “ground-truthed” to ascertain that the sampled environment is homogeneous, in other words that only one environment is being sampled with the replicates. Doing such quality assurance simply costs too much. As a result, the assumption is made that any two samples from a geo-located sampling site are sampling the same community. On top of that, the sampling equipment is often inadequate for the precision required. If the habitat is patchy, and the patches are moderately sized, the standard sampling devices often take samples that are large enough to straddle patch boundaries which results in spurious conclusions.

Some Habitats…

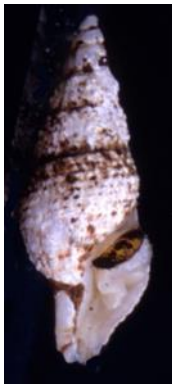
These images were taken at 14m to 18m depth within five lateral meters of one another. It would be impossible to reliably sample any of these habitats consistently from the water surface, as random water current and wind-driven vessel movement would make consistent positioning of the boat impossible. Precise sampling by divers, while tedious, involves working measured distances from permanent markers emplaced in the bottom. All of the habitats had distinctly different populations of infauna. Note as well, all of these areas are visually heterogeneous. Simple mud flats having the same assemblage in all directions did not occur in this region.

Mud Habitat A

Oenopota elegans, a most beautiful conacean was commonly found in this habitat. Scale bar in mm.

Mud Habitat B

This habitat was characterized by the presence of *Ophiodermella cancellata*, a conid snail that is a specialized predator upon a single species of bristle worm, *Myriochele oculata*. Where the worm lived relative to the snail remained a mystery even after two years of bimonthly samples. I collected 11,667 polychaete worms from the nearby sites, but only found 2 *M. oculata* individuals.



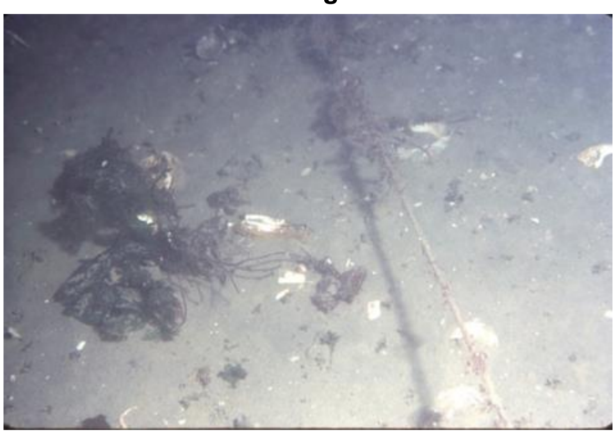
Left - *Ophiodermella cancellata*

Right - Several other conid snails were found in this habitat, including *Oenopota excurvata*, shown below. Most of these small snails are covered in a mucous coat when they are foraging, so their sculpturing was often obscured. The individual in the photograph was about 5 mm long.

Bark Chip Habitat

A layer of cedar bark chips is commonly found at many shallow Salish Sea areas dominated by unconsolidated sediments, and was very evident at this site. I think these chips had been in place for several hundred years and were most likely the result of natural sloughing from trees that died and drifted downstream, probably in pre-European days. Distributed rather widely in the San Juan Islands, they are often appear like a cedar bark bathtub ring around the upper edges of the soft sediment subtidal habitats of quiet embayments in the region. These bark areas are characterized by a very sparse array of infauna, presumably due to the leaching of tannins from the bark; such bark fragments decompose very slowly. I found no conids, and precious few macrofauna of any sort in this habitat.

A Plate of Mud With a Side of Shell Fragments



Kurtziella crebricostata

Organically, slightly enriched sediments with shell fragments exposed on the surface are commonly found in slightly deeper water. Many conids are found in these areas. A portion of one of my permanent transect lines is visible in the image. *Kurtziella crebricostata*, shown above, a conid typical of this habitat, is one of the most widely distributed of Salish Sea conoideans, found in a wide variety of muddy sand and sandy environments. It seems, overall, more commonly found in organically-enriched habitats than are most conoideans. I should note such environments gave no indication of being polluted, the organic enrichment was due to runoff from slowly moving streams and algal decomposition.

Most sport divers and diving scientists gravitate to the presumably more aesthetically pleasing rocky areas. This is all well and good, I suppose, but as a result, most Salish Sea benthic areas which are unconsolidated sediment habitats have remained essentially unexplored. And by and large, the organisms found in these areas and their cumulative natural history remain unknown; these habitats are not Terra incognita, (unknown lands), but Luta incognita (unknown muds).

There are about 50 species of conoidean snails in the shallow mud-bottom habitats of the Salish Sea; most are in the genus *Oenopota*, but also in several other genera. Based on long ago discussions, I suspect most members of the PNWSC who collect local shells have fewer than 10 species represented in their collections. In other words, if you want a collection actually representing the diversity of snails in the region you need to go to work trying to find some of these conoideans.

Potentially Interesting References

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