Mud and Mudflat Basics and Activities

(This is geared primarily for the tidal portions of the river and the estuary. Some material might be adaptable to impoundments and wetlands along the river.)

Background:

Mud is a general term that refers to saturated soil or dirt. If you take a bucket full of soil or dirt, add water and stir, you make mud. This mud is fun to play with, but it is not the mud that ecologists and other scientists usually study. The mud formed by sedimentation in a water body is, however, worthy of study. This mud is not merely wet dirt; it is soil. It is a habitat, it is an integral part of a functioning marine or aquatic ecosystem, and it can reveal a lot about the health of an ecosystem.

Safety note:

Walking on mudflats can be challenging or dangerous. Silty mud can be very unstable and creates great suction. Make sure boots have hand straps to help you pull out if necessary. If you go out wearing sneakers, make sure they are tied as tightly as possible so that the mud does not pull them off. Be aware that the mud might contain broken glass or broken sea shells. Do not explore the mudflat with bare feet. Always inform someone when you head out onto unknown mudflats or bring a buddy to help get you out if needed. Blood worms and clam worms can give a nasty bite, so be careful of their mouths. Because the mudflat has structure and is a habitat, take care to disturb as little mud as possible.

What is soil?

Soil is not dirt. Dirt is the stuff that is left when someone walks across a clean floor or wipes hands that have been working in a garden onto a clean cloth. Dirt has no definable structure and is rarely a desirable thing. Soil, on the other hand, has structure and is very valuable. Soil is composed of rock fragments of various sizes, water, gases, decaying organic material, and living things. The way the soil is laid down and moved around by water, wind, gravity, and living things determine and define its structure. Undisturbed mud is soil.

Soil texture:

As rock is weathered or otherwise broken down, the particle size decreases. In soil, the largest particles are cobbles. The smallest are clays. The larger the particle size, the faster it sinks in water and the less likely it is to move. The proportion of each particle size is defined by how active the water above the soil is. Only larger particles can settle in active water. In slow water, the smallest particles have the time needed to settle. The proportion of particle size also determines much about how water behaves in the soil and how living things use the soil. The chart below summarizes some of these properties.

particle size	particle name	key properties
64–256 mm	cobble	found in fast water, water flows through easily, no or low nutrients, can provide stable hiding places or attachment sites for animals
1.0—64.0 mm	gravel	found in medium-fast water, water flows through easily, medium to low nutrients, usually harbors only small invertebrates
.50—1.0 mm	coarse sand	found in water with medium velocity, water flows through fairly easily, medium nutrients, harbors burrowing animals that have a tough exterior
.25--.50 mm	medium sand	found in water with medium velocity, water does not flow through easily, harbors burrowing animals
.10--.25 mm	fine sand	found in medium-slow water, water does not flow through easily, harbors burrowing animals
.05--.10 mm	very fine sand	found in slow water, water does not flow through easily, harbors burrowing animals
.002--.05 mm	silt	found in very slow water,

		water does not flow through, alone has little to no structure, tends to have high nutrients, harbors short-lived animals that do not need much oxygen
less than .002 mm	clay	found in very slow water, when pure forms a solid mass and no water flows through, feels smooth to the touch, harbors some strong burrowing animals

How quickly do the various particle sizes settle?

This is easily demonstrated in the classroom. Fill a tall, see-through cylinder almost to the top with water. Drop a few pieces of gravel in and time the descent to the bottom if possible. Next, sprinkle in a teaspoon of sand. Time the descent for most of it to reach the bottom. After the water is clear, sprinkle in a teaspoon of fine sand. Time the descent. After the water has cleared, sprinkle in a teaspoon of silt and clay. Time the descent to the bottom. (Silt and clay are difficult to separate mechanically with a sieve series. If you have some modeling clay handy, mix a small amount with water until all clumps are thoroughly dissolved. Pour the mixture in the cylinder and time the descent. You should see that the pure clay settles slowly. Silt will settle slightly quicker.) Organic plant matter often will float at the surface. Clay and silt particles also tend to stay on the surface. Gently stir them into the water to help them sink. Dispose of the water and soil particles outside on a lawn or other vegetated area. Do not dispose of the contents down a sink.

Ask students how long it might take the various particle sizes to settle in 1 meter and 2 meters of water. What might slow the descent in the real world? Can the descent be accelerated? Would sea grasses slow, accelerate, or have no effect on sediment settling? Why? Have students think about major storm events. How long did the local river look muddy? Why?

How to determine particle size proportion:

Materials needed:

- medium size coffee can or similar sampling container
- shovel or garden trowel

- large metal roasting pan or cookie sheet with raised edges
- geologic sieve series (available from Acorn Naturalists for +/- $70.00 to $100.00 for good set, $43.00 for economy set)
- Ziploc freezer bags
- kitchen or chemistry scales

Most local mud contains a mix of particle sizes. The way to determine the exact ratio is to get a sample, such as with a coffee can plunged straight down into the mud. The sample must contain material from the very surface and material from below. Remove the sample from the sampling device and spread out on a metal sheet to dry. If the sample is composed mostly of large particles, drying can occur in air with occasional gentle mixing to break up clumps. If the sample contains smaller particles, place the sheet in an oven set at a low temperature. Occasionally mix the sample to break up clumps. Keep drying and mixing until all clumps are broken up. Samples with a lot of clay can take many hours to dry. Once completely dry, make sure the sieve series is set up correctly. Place the sieve with the largest mesh on top. Place progressively smaller sieve meshes below. The bottom piece will have a solid bottom, not mesh.

Spoon the dried sample into the top of the series. Place the lid on the top sieve and gently shake or vibrate. Always leave the series upright. As the top sieve empties, add more sample. Once the sample is mostly or entirely in the series, the top sieve or two can be removed to make the additional shaking easier. Remember to put the lid on the remaining sieves before shaking.

The top sieve is likely to have some organic matter, such as sticks or grasses. The larger pieces can be removed by hand. Smaller pieces can be picked out with tweezers. Place the organic material in a Ziploc bag and label.

Once the sample is completely shaken and separated, empty the contents of each sieve into a Ziploc bag and label. Measure the mass of an empty bag. Measure the mass of each bagged sample. Subtract the mass of the empty bag. Record the masses on a data sheet. Sum the masses for the sample total. Divide each sample part by the total to get the percentage.

What lives in mud?

As with garden soil, mud typically has a collection of worms, snails, and arthropods. Mud also supports clams and other bivalves.

Materials needed:

- mud sample
- sand size sieve
- bucket
- rose Bengal stain
- 70% ethyl alcohol (70% isopropyl alcohol can be substituted if necessary)
- collection jar for later analysis (optional)

To collect the animals in the mud sample, place a section of the sample into a jar or small bucket. Create a mixture of rose Bengal stain by adding 1 gram of stain to 99 ml of water. The stain will be taken up by all living organisms. It will not be taken up by dead organisms. Pour some of the stain mixture into the jar containing the sample and gently shake. Let stand for 5 minutes. Place the sand-size sieve on a lawn or over a collection bucket. Do not rinse the sieve contents into a sink or other plumbed receptacle. Gently pour the stained sample onto the sieve. Gently collect all organisms that are readily visible. Gently spray water onto the sieve to wash off additional soil particles. Alternatively, the sieve can be repeatedly dipped gently into water and swished to separate the soil from the organisms. Avoid rigorous washing; some of the creatures will be damaged. The stained organisms can be identified immediately or preserved for later analysis by placing them in a jar containing 70% ethyl alcohol. Ethyl alcohol will eventually deplete the stain, so analysis should be undertaken sooner rather than later.

Oxygenation of mud:

The organisms that live in or on the mud are often determined by how much oxygen is available, both in the mud itself and in the water that overlies it. As one might expect, if oxygen is limited, the variety of organisms is often limited. One key difference between mud and terrestrial soil is how organisms that live in the soil obtain oxygen. The oxygen that all animals use for respiration is actually oxygen gas, O2. Terrestrial soil has air pockets and the animals can get oxygen directly. Oxygen in mud is dissolved in water, and water naturally holds much less oxygen than air. Two other factors complicate the issue further: 1. Warm water has less capacity to hold oxygen than does cold water and 2. Water or mud that is full of bacteria that are engaged in decomposition deplete oxygen that might otherwise be available to other organisms. Even under the best of conditions when water is cold and decomposition is minimal, mud does not have a lot of oxygen. The organisms that live in the mud must, therefore, have physical or behavioral adaptations that allow them to survive. Some worms dig tunnels that allow for oxygen interchange with the water above. Other worms and crustaceans create tubes that provide contact with the water above and protect the animal from chemical stress caused by low-oxygen (anaerobic) conditions. Clams live below the surface of the mud, but extend their siphons (“necks”) to the surface of the mud so that they can take up water with oxygen and food particles and expel wastes.

The animals that are found in well oxygenated mud can survive at deeper depths in the mud. Soft shelled clams (also known as long-necks or steamers) live fairly deep in the mud and extend their long siphons to the surface. Bait worms such as clam worms and blood worms are active burrowers and hunters. In sandy mud, worms often build rubbery tubes to protect them from abrasions from the sand.

Animals that live in low oxygen conditions must stay near the surface of the mud and have physical protection against chemical damage caused by toxic anaerobic byproducts . Shallow burrowing worms, tube building crustaceans, and little neck clams (also known as cherrystones, hard shell clams, or quahogs) are common in low oxygen conditions. If the mud is low in oxygen, only the hardiest animals will survive. Their shells or tubes will often be stained black.

How can the relative amount of oxygen in mud be determined?

One of the first observations to be made about mud is its smell. If it smells like a combination of regular soil and the ocean, low oxygen is probably not a problem. If the mud smells like rotten eggs (hydrogen sulfide), low oxygen is a big problem. If the mud lacks an odor initially but then smells after it is disturbed by a shovel or boots, oxygen is or was a problem.

A second method to obtain information about relative oxygen is to look at the mud. The surface will almost always have a greenish-brown tint due to phytoplankton that have settled out of the water. If black patches are present, oxygen is a problem. Slice through the mud vertically to get a cross-section. If black layers are present, this indicates that iron has been chemically reduced to form iron sulfide and those areas have no oxygen. Normally, mud in this region is gray. If the gray is light, oxygen is probably not a problem. The closer the gray is to being black, the less oxygen is present. If you find a worm tunnel in the cross section, it often will appear orange. The orange is due to oxidation of iron, or rust, and indicates good oxygenation.

What are the causes and effects of low oxygen?

Oxygen gas is present in water due to several processes: passive contact with air, mixing of air and water through wave action, and photosynthesis by phytoplankton, sea grasses, sea weeds, and salt marsh grasses. Oxygen is depleted by warm temperatures, lack of contact with air and photosynthesizing plants, and bacterial decomposition. Low oxygen conditions are rare in winter when temperatures are cold and bacterial decomposition is slowed. Low oxygen, or hypoxia, is most common in summer when temperatures are warm and bacterial decomposition is enhanced. Although low levels of oxygen can occur naturally, true anoxia, or no oxygen, is rare in nature. Anoxia is most commonly associated with eutrophication, or the over-fertilization of a waterway. When human activities result in excess soil, sewage, or nutrients' reaching a waterway, phytoplankton reproduce explosively and certain algae grow unchecked. As these plants die, they sink and provide abundant food for bacteria at the bottom. As bacteria decompose the dead material, they consume oxygen. Especially in summer, this mass decomposition can leave the water with little or no dissolved oxygen. Without oxygen, animals in the water can suffocate and animals in the mud also come into contact with toxic byproducts of anaerobic decomposition. The result is commonly called a “fish kill”.

How do intertidal mudflats compare with subtidal mud?

The intertidal can be a very difficult habitat. Compared with subtidal areas, conditions are more extreme. Mudflats are exposed seasonally to very low and very high temperatures determined by the temperature of air. Daily temperature swings can occur when the tide changes. During rain storms, mudflats can be drenched in fresh water, which is extremely stressful for salt water creatures. The salinity of the mud can be increased and the surface of the mud can be baked into a solid crust in the hot sun of summer. The animals are hunted by predators from the sea as well as the land. Given these additional stresses, subtidal mud usually has a greater diversity of organisms than what can be found intertidally. That said, some organisms, such as mud snails, use the intertidal to their advantage to avoid predators that cannot tolerate being out of water.

Extension questions and activities:

What animals are associated with various mud types? Where are the best clam flats in your town? Where do fishermen dig for bait worms? How do people find these animals?

What is “red tide”? Why can’t we eat shellfish harvested during a red tide?

What is benthic ecology? What are some of the key questions benthic ecologists study?

Sediment cores reveal much about the history of a site. How are they obtained? What might layers that alternate between silt and sand indicate? What might a layer of dark sediment indicate? In cores of Great Bay, a significant black band from the mid 1800s has been identified. What might have caused this band?

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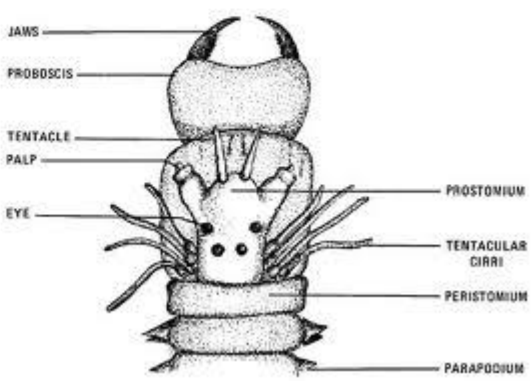
clam worm

Size: to 15", generally much smaller

Worms like this can be found anywhere from tidal flats to deep depths, burrowed in the sediment or hiding in crevices.

These greenish segmented worms have four sharp hooks on their jaws and can give you a good bite if you're not careful. They can also swim, although not very well. The "legs" are called parapodia, and are actually gills. The best place to see a clam worm is at the bait shop.



njscuba.net

blood worm

 www.gulfofme.com	 Tip of blood worm mouth when extended. from www.innovations-report.com

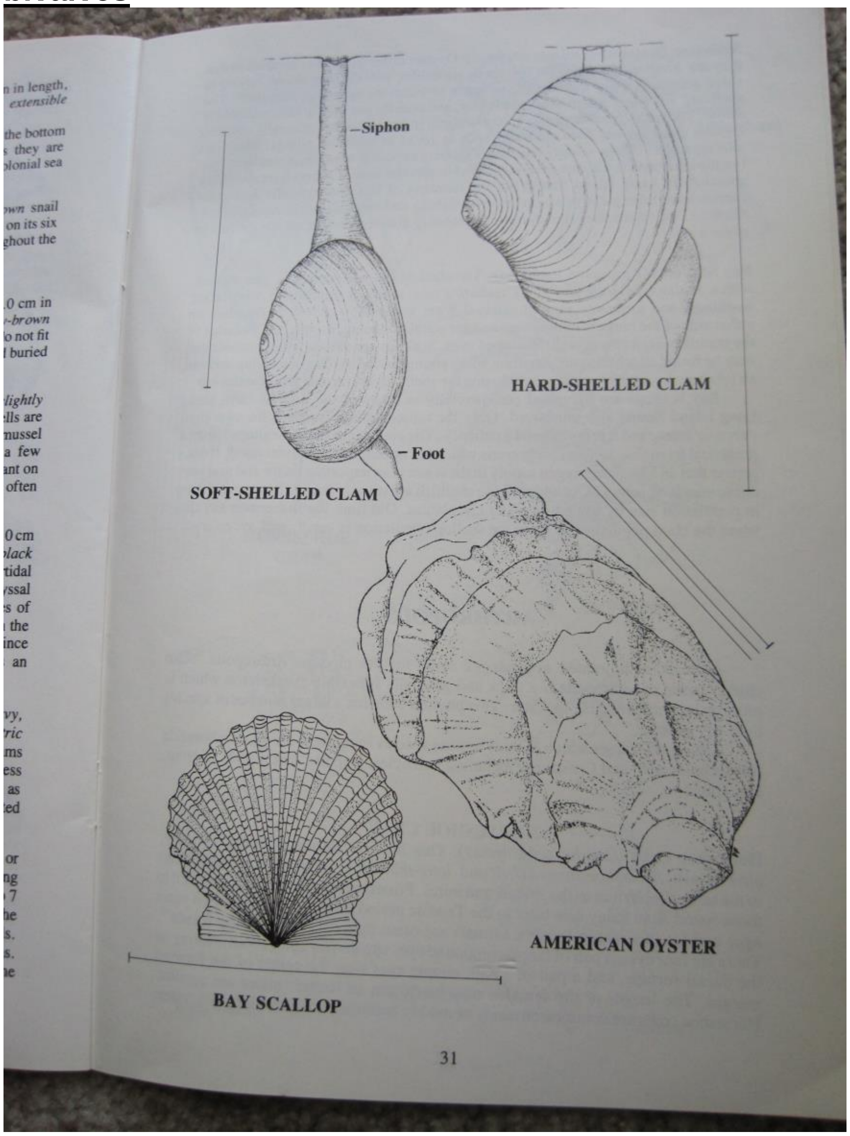
Active swimming predator. Can grow to more than 12 inches long. Looks like an earth worm with tiny paddles along the sides. Gets its name from a red vein that runs along its back. This is not a blood sucker. When not feeding or defending itself, the mouth is hidden. The mouth is located at the tip of what looks like a big pink/red bubble. Fangs are located at the tip of the "bubble" and can deliver a painful bite.

mud snail

	 www.exoticsguide.org

The shell is dark gray and is often covered with mud and algae (and sometimes with the Atlantic bryozoan *Alcyonidium polyoum*). In most older snails, the tip of the shell is eroded and might appear white. They graze debris from the mud surface and scavenge dead animals. A shown above, they often form herds.

bivalves



from Plants and Animals of the Estuary, 1978, Connecticut College Arboretum

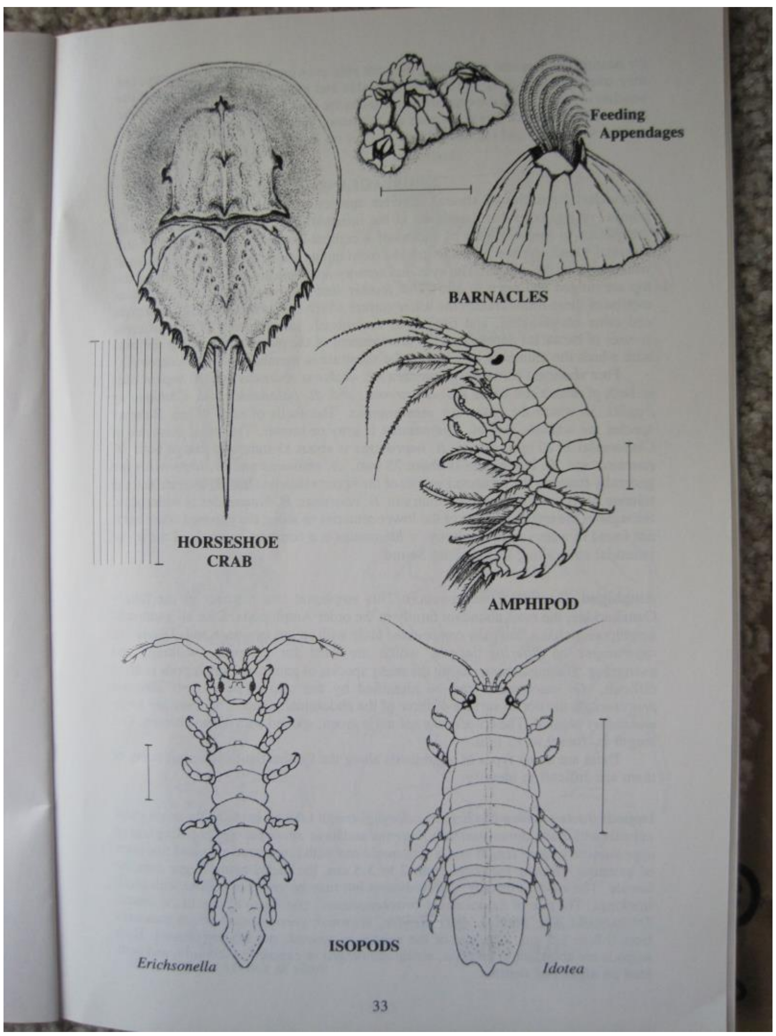
soft-shelled clam, also known as a “steamer” or “long neck” clam, is a deep burrower. It extends its long siphon (or “neck”) to the surface of mud to take in water. The water travels down through one side of the siphon and circulates through the clam’s body. Food particles in the form of plankton are collected. Wastes are expelled through a second tube in the siphon. If you walk on the surface of mud, you will see small holes. Some of those holes will squirt water at you. This is caused by the clam’s retracting its siphon for protection.

hard-shelled clam, also known as a “quahog”,” little neck”, or “cherry stone”, is a shallow burrower. It is much more tolerant of nutrient-rich, polluted water than the soft-shelled clam. These clams are much more common south of Cape Cod.

Bay scallops live on top of the mud, especially near eel grass beds where they find cover and protection from predators and storms. They are active swimmers and have a ring of tiny eyes along the edge of their shells. The scallop that you eat is actually the just muscle that closes the shell and allows it to swim.

Oysters are critically important to the health of Great Bay and other estuaries. They actively filter impurities and debris from the water. They are tolerant of pollution and some burial by sediments, but severe storms can kill them. In recent years they have also been attacked by a virus. UNH is working very hard to keep oyster populations healthy in the bay and is involved in creating and restoring oyster habitat. Once they get past their initial mobile phase, oysters settle and cement themselves to a hard surface, often old oyster shells.

arthropods



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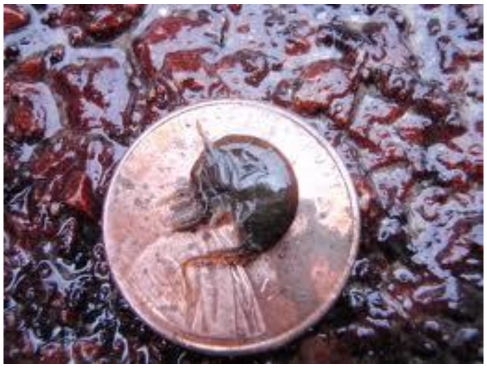
amphipod



downeastinstitute.org

Amphipods can come in many shapes and sizes. Most around here are very small. Amphipods are like tiny shrimp that are flattened side to side. They are often found curled. Some amphipods live among seaweed, eel grass, or salt marsh plants. Amphipods of polluted or nutrient-rich water sometimes build long, rubbery tubes that provide shelter from low-oxygen mud and also provide cover from predators. They eat detritus.

Isopods are tiny and are flattened front to back. They eat algae and detritus. (The food part of detritus comes from the bacteria that cover dead material. The dead material itself is usually not what is actually useful.)

Horseshoe crabs are prehistoric creatures. They are not crabs, but are more closely related to spiders. Their blue blood is collected and used to test the purity of medicines that are injected into humans. If the medicine causes the blood to clot, it is impure and will not be given to people. Once a horseshoe crab has donated blood, it is returned to the ocean, unharmed, we hope. Horseshoe crabs are also gathered and ground to use as bait for large snails or whelks. These whelks are shipped to Europe as food. The loss of horseshoe crabs has been linked to declines in shorebird populations that rely on horseshoe crab eggs to fuel their long migrations.