Some Possible Student Research Questions Involving Local Aquatic Ecosystems

Some of these lend themselves more to field research, some to laboratory research …but many of the most clever investigations will combine a field study and a lab study! Each has advantages and drawbacks. In particular, field studies tend to be closer to reality, but lab experiments make it easier to isolate and control variables.

In ecology, there are two basic types of scientific research: **mensurative** and **manipulative**. Mensurative studies just ***measure*** quantities in the natural environment. They make mathematical, graphical, and statistical comparisons in the natural world, but they do not alter the environmental conditions in any way. In a manipulative experiment, by contrast, the scientist deliberately alters or ***manipulates*** variables in some way. This can be done in the field as well as the lab. BOTH the mensurative and the manipulative approach can be used to test hypotheses and gain valid insight about ecological relationships and realities. However, only a manipulative experiment with a control group, constants, and carefully isolated variables can establish a genuine ***cause-and-effect*** relationship. Anything less will only reveal **correlations** …patterns, trends, similarities, differences, but not necessarily cause-and-effect.

Habitat Fragmentation in Marshes

The rise of sea level throughout the Bay is causing many marshy islands (like Fox Tangier) to shrink in size. Also, big islands are breaking up into smaller islands. How does the shrinking and fragmentation of marshes affect living conditions, species composition, species distribution, etc.?

Other marshes are shrinking and fragmenting from the inside out as low areas in the marsh's interior turn into ponds (called "salt pannes"). How does the expansion of salt pannes affect living conditions, species composition, distribution, etc.?

Fragmentation of marshes increases the ratio of edge (waterline/shoreline) to area (interior of the marsh). How do conditions and species composition change with distance from a marsh's edge?

Small Streams in Developed Areas

Small streams may be especially vulnerable to the presence of humans, clearing of forests, and building of paved surfaces in their watersheds. How do urban, suburban, farmland, and/or forest streams compare in terms of water quality, habitat conditions, flow rates, species diversity, etc.? Do rainfall events affect the differences between them?

Low pH on Maracossic Creek

Maracossic Creek (which flows from Bowling Green to the King William border, into the Mattaponi River) is listed by the Virginia Department of Environmental Quality as an "impaired" creek due to unexplained occurrences of low pH. One possible cause is the presence of swamps along the creek's flanks (bacterial decay of organic matter lowers local pH). Are wetlands responsible? Or could it be some human impact? How might pH affect the creek's native inhabitants?

Salinity Stratification and Dissolved Oxygen Diffusion

Pulses of freshwater from recent rain in the watershed can cause rivers to become temporarily stratified, with a sharp layer of freshwater sitting like a ceiling atop a deeper, denser layer of saltier water. This can temporarily prevent oxygen from reaching benthic animals on the river bottom. How fast does D.O. diffuse down a stratified tank of water? What effect would wind and tidal mixing have on this rate of downward diffusion? In real rivers, is there a correlation between stratification and benthic D.O.?

Benthic Animals and Hypoxia

After plankton blooms, bacterial decay on the seafloor can rob benthic habitats of dissolved oxygen. How do benthic animals like crabs and worms react and respond to episodes of depressed D.O.? What happens to their metabolic or survival rates?

Beaver Ponds

Beavers are a controversial species. Their dams may help improve water quality downstream by trapping sediments and other pollutants, but can also block the upstream spawning migrations of river herring. After a heavy rainfall, does turbidity, TSS (total suspended solids), and/or water quality differ on the upstream and downstream sides of a beaver pond?

Phragmites as Habitat for Small Mammals, Birds, or Fish

Phragmites australis is an invasive species that is overtaking many fresh and brackish wetlands, crowding out native grasses. Phrag is a large reed with thick stems that grow in dense thickets. How does Phrag compare to other marsh grasses in terms of habitat quality and shelter for small rodents, birds, and fish? Do such animals display preferences for/against stem diameters and densities comparable to Phrag's? How do stem diameter and density affect their mobility?

SAV Meadows as Habitat

Eelgrass and widgeon grass meadows have good summers and bad summers. When water temperatures get unusually high, or when the water is especially turbid with phytoplankton, the grass thins and meadows become patchier. How does the density or patchiness of the grass affect the abundance and diversity of meadow life? Do Chesapeake animals refer thicker or thinner grass?

Phytoplankton Growth and Zooplankton Grazing

Phytoplankton blooms may be triggered by elevated concentrations of nitrogen, phosphorus, or perhaps both in combination. Other factors may include temperature, duration of daylight, turbidity, and the presence of zooplanktonic grazers. For phytoplankton species in local waters, which nutrient (N or P) is more likely to stimulate a bloom? How do other factors play in? Can the presence of grazers or suspension feeders (like oysters) suppress a bloom?

Ecological Succession of Fouling Communities

When humans immerse any solid surface in brackish water, from boat bottoms to pier pilings to riprap, it is soon colonized by a variety of "fouling" organisms like barnacles and hydroids. Does the texture or type of surface influence the sequence or species that colonize it? Do patterns of vertical zonation appear (e.g., in intertidal vs. subtidal areas)? Does local salinity affect patterns of succession?

Predator Avoidance in Small Fish

Small fish may use shallows or wetlands for shelter. Many large fish are visual predators, hunting by sight. Do small pelagic fish like anchovies and silversides retreat to shallows during daylight? Do smaller fish tend toward shallower water than bigger fish? Do killifish venture away from marshes and shorelines at night? Do local fish exhibit habitat preferences in response to the amount of light? Does the tidal cycle influence daily spatial distributions of small fish? How about depth of nearshore water?

Competition and Chemical Weapons in Marsh Plants

Plants compete with one another for space, sunlight, soil, water, and fertilizer. Some plants secrete chemicals that prevent the seeds of other plants from germinating. How does the intensity of competition among marsh plants vary with salinity and other variables? Do marsh plants wield chemical weapons? If so, does this correlate with the intensity of competition?

Impact of Human-made Structures in Habitat Quality for Small Fish

Many aquatic animals tend toward 3-D structures for shelter and safety, with more complex structures providing a higher quality habitat. Humans have both altered and added structures along shorelines and elsewhere. How does riprap compare to seawalls as a habitat for small fish and other animals? How do these compare to natural shorelines like sandy beaches, marsh edges, and forested margins with fallen trees? How about pier pilings and bridge struts?

Lateral Transport between Pelagic and Littoral Environments

An important dynamic for the health of the Bay and its rivers is the lateral transport of detritus, nutrients, sediments, and water between wetlands and adjacent waterways. What are patterns of such lateral transport, and what forces drive them? Do tidal cycles play a role? How about salinity (hence density and pressure) gradients? How about currents over the shoals versus the channel?

Stress and Species Diversity

Species diversity often varies inversely with an environment's stressfulness and harshness. How does species diversity differ between high energy and low energy environments? Between salty and fresh? Between tidal and non-tidal creeks? Between edges and interior of marshes?

Erosion Control by Wetlands

The number one source of suspended sediments in Bay water is shoreline erosion. Marsh plants counteract this by rooting soil together and absorbing the shock of approaching waves. How does the ability of marsh grasses to dissipate wave energy depend upon stem diameter? Grass density? Width of the marsh? Shoreline steepness?

Filtration Rates of Oyster and other Suspension Feeders

Oysters and other suspension feeders can help clean and clear the turbid waters of the Bay. How do various suspension-feeding animals compare in their ability to filter water? Does the size of suspended particles matter? How about the size, age, or density of the animals?

Vertical Patterns in the Water Column over the Tidal Cycle

Column studies investigate changes in environmental conditions down the water column. How do vertical patterns in salinity, temperature, density, dissolved oxygen, and/or turbidity change over the course of a tidal cycle? How do spring and neap patterns compare?

Periwinkle and Fiddler Crab Behavior

Fiddler crabs emerge from their burrows at low tide to browse on the mudflats. Periwinkle snails migrate up and down the stems of marsh grasses to remain above the rising and falling tide, venturing down onto the exposed mudflats only at low tide to forage for detritus. At low tide, higher elevations of the marsh are exposed for longer periods than lower elevations. Is periwinkle density driven more by the availability of grass stems or by local elevation? How about fiddlers?

Color of Light, Phytoplankton Growth, and Zooplankton Behavior

Sunlight is a composite of all the colors of the rainbow. Seawater absorbs some wavelengths more quickly than others, with red light penetrating only a few meters, yellow light a bit further, and blue deepest of all. How does this affect the growth of phytoplankton at different depths in the water column? Do zooplankton exhibit preferences based on color, and does this correlate with phytoplankton productivity? Do zooplankton migrate in response to daylight versus nightfall?

Artificial Reefs

A major hurdle in constructing artificial oyster reefs is the availability of oyster shell. Could other materials be used instead as the solid substrate? How do different materials and 3-D configurations compare in their ability to attract and shelter animals?

Fish Habitat Preferences

Many fish also exhibit an attraction toward 3-dimensional structures. What aspects of such a structure make it preferable? The vertical relief? The horizontal component? The shape? The density?

Zooplankton Distributions

Zooplankton are a critical step in the food web and may help to suppress algal blooms. Although incapable of overcoming horizontal currents, they do have some ability to control their vertical position in the water column. Do they alter their vertical distribution in response to tides or time of day? Do they seem to use tidal cycles and/or estuarine two-way circulation to control their *horizontal* position along a river?

Island Biogeography

Newborn islands, lakes, and other habitats are quickly colonized by plants and animals from already existing ecosystems, either by migration or by dispersal of seeds and larvae. This is something one could imitate by using a lawnmower to outline and maintain grass "islands" that are allowed to grow up and undergo ecological succession. How would distance from a nearby forest affect the rates of succession? How does size of the plots affect the diversity of colonists?

Docks, Piers, and Fallen Trees as Habitat

As sea level rises, shoreline trees gradually fall into the water. These fallen trees provide shade and 3-D shelter for fish and other animals. Waterfront real estate owners, however, often clear away shoreline forest in order to improve their view of the water, thereby removing fallen trees both past and future. What are the consequences of this removal? Can docks and piers help to replace this lost habitat? How do the benefits (if any) diminish with increasing distance away from the tree or pier?

Battle of the Invasives: Phrag vs. Loosestrife

Phragmites australis can outcompete most other marsh plants, but anecdotal evidence suggests that there are two species that can actually outcompete Phrag: the native shrub Marsh Elder (*Iva frutescens*) and the introduced flower Purple Loosestrife (*Lythrum salicaria*). If so, the "weapon" at work may be simple shading or it may be chemical (allelopathy). Which is it? If a phytochemical is at work, does it also affect native grasses such as big cordgrass (*Spartina cynosuroides*)? (This might be an important finding, for it might be the key to developing a safe natural herbicide or even giving native grasses an ability to make that same phytochemical through gene transfer.)

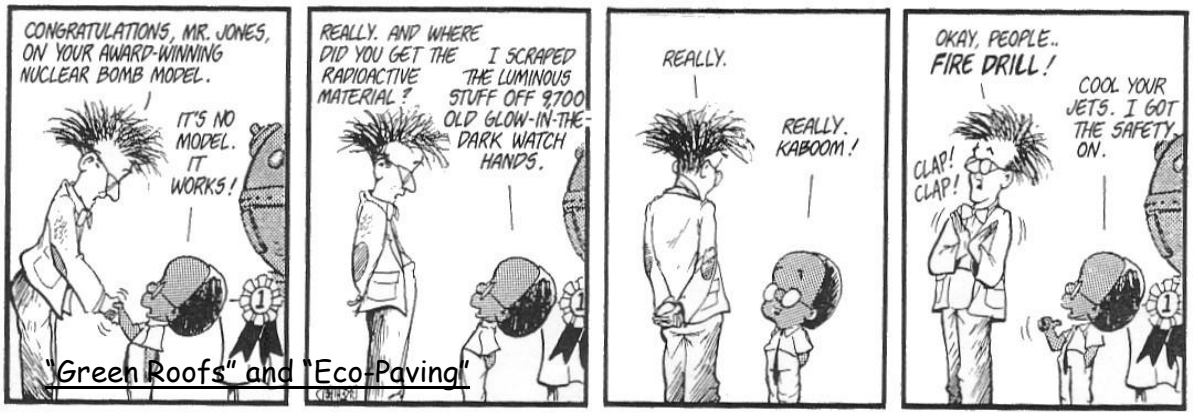
Hot Local Issue: "Deltaville vs. Reedville" (Recreational Fishing & Menhaden)

In a classic conflict of "user groups," local recreational fishermen have recently organized to confront and criticize the commercial menhaden fishery (Omega Protein in Reedville). The recreational fishers don't fish for menhaden (they're planktivorous, and won't bite a hook), but they do contend that because menhaden are a key step in the food chain between plankton and large fish, the menhaden fishery is damaging the ecosystem that supports desirable gamefish. Also, they argue that the plankton-straining menhaden are a crucial "keystone species" that help clean the water and suppress plankton blooms. Can menhaden really help to suppress plankton blooms?

Benefits of Oyster Aquaculture

Raising oysters in floats and bottom cages is a fast-growing enterprise in Virginia. The main reason to raise oysters via aquaculture, of course, is seafood. But there may be ecological benefits as well. Does oyster aquaculture help promote water quality in the Bay? Does the gear – oyster floats and cages – provide good habitat for other marine flora and fauna, and if so, how does this compare to other shallow water habitats such as SAV meadows?

Another question: Oyster farmers often ship their oysters fresh (that is, still alive!) to restaurants far away. One nice thing about eastern oysters (*Crassostrea virginica*) is that they keep well once out of water, presumably because they are intertidal animals adapted for exposure to air during low tide. The Asian oyster (*C. ariakensis*) now being brought into the Bay for aquaculture may not be an intertidal species. How does the "shelf life" of the two species compare?



"Green Roofs" and "Eco-Paving"

The replacement of vegetated earth with impervious surfaces (hard rooftops, roads, parking lots, driveways, etc.) is a major water quality concern, for it diminishes the ability of soil and plants to "shock absorb" sudden pulses of rain runoff, which flush sediments and pollutants to local streams and rivers. "Green Roofs" and "Eco-Paving" are ways to reduce runoff from impervious surfaces. The former are rooftops covered with sod, grass, and other plants, and the latter builds parking lots either with a porous material or with rows of small holes where soil collects and grass grows. How effective are these methods for reducing hard runoff and improving water quality following a rain event? What species of plants and other design features make for an effective green roof? (The big new Union Bankshares building near Carmel Church has a green roof, a parking lot with "rain gardens," and other runoff-reducing features. It might be possible to do research at this nifty new facility.)

Water Quality: Correlations between Hydrolab and other Methods

When we monitor water quality in local creeks, we use three different methods to estimate Turbidity: Secchi disk, transparency tube, and Hydrolab (and we actually have a 4th method that we can use: a turbidimeter). It would be very useful to have empirically determined mathematical formulas that enable us to convert back and forth between Secchi readings (in meters), transparency tube readings (in cm), and Hydrolab readings (NTU's). Along the same lines, it would be useful to know how well our Hydrolab estimates of pH and dissolved oxygen correlate with pH and D.O. measurements using chemical methods.

Fiddler Crab Behaviors

When do fiddlers retreat into their burrows? Certain tides? Night versus day? Why??? …a "tethering" study might be possible, here.

Fiddlers come in a variety of sizes, and they can dig their burrows to different depths. How does the depth and diameter (hence crab size) of fiddler burrows vary in relation to distance from the waterline, species of grass, size of sediment particles, etc.? An important ecological function of fiddler burrows is that they help oxygenate the mud, which in turn affects detritus decomposition rates (aerobic vs. anaerobic…). How might patterns of fiddler burrowing affect the health of the marsh? …a cool way to study fiddler burrows is to make "burrow casts" by pouring in a fiberglass liquid resin that quickly solidifies. Muddy work.

Aquaponics (a cool idea!)

Aquaponics is an idea to combine agriculture with aquaculture (fish farming). Fish in captivity produce nitrates and other wastes. These either have to be filtered out or else released into local waters where they can cause plankton blooms and other problems. However, these waste products could also be used as fertilizer for terrestrial crops. Can you develop and evaluate a small-scale aquaponics system using a local fish species and local crop?

Derelict Crab Pots

Each year local crabbers accidentally lose crab pots in the Bay and local rivers. These "derelict" pots continue to "ghost fish" for years. Fish and crabs enter the pot for food or shelter, get trapped, and die …and thus become bait that attracts more fish and crabs. They're self-baiting! Obviously this is no good for crab and fish populations, nor for the fishery. Over the course of weeks and months, how effectively do ghost pots catch fish and crabs?

Still looking for ideas and background information for projects related to the ecology and environmental science of the Chesapeake Bay? The following books and website may help. CBGS has copies of both books:

Life in the Chesapeake Bay by Alice Jane Lippson & Robert L. Lippson

Turning the Tide by Tom Horton & William Eichbaum

Chesapeake Bay Program (www.chesapeakebay.net)

You might also try the education webpages at:

VIMS (see "The Bridge")

Maryland Sea Grant

NOAA

Chesapeake Bay Foundation

Alliance for the Chesapeake Bay

Still stumped? A great way to develop a research idea is to build off the work of real scientists. First think of a general topic that interests you, and then do some homework to find out what scientists have been doing in that area. Search "Science News" on MSN, etc., for recent discoveries. Maybe you can put your own original spin on their research!

Also, there are bound to be some good websites out there about student science research projects.

Find something that jazzes YOU, YOU, YOU!!!

CBGS Stock of Scientific Equipment

Hydrolab and other electronic meters:

- Salinity (via conductivity)
- Dissolved Oxygen
- pH
- Temperature
- Turbidity
- Depth

Water Quality by titration, colorimeter, or spectrophotometer:

- Dissolved Oxygen
- pH
- Nitrates
- Phosphates

Fecal Coliform Testing (Coliscan Easygel & Incubator)

Flowmeter
Refractometer
Thermometers
Secchi Disk
Transparency Tube
Sediment Grab
Water Sampling Bottle (for vertical column studies)

Handheld Compass
Lead Sounding Line (for depth)
Wind Speed Gauge
Spring Scales
Fish Measuring Board
Tape Measures, Metersticks, etc.
Calipers (for accurate measuring of width, diameter, and length of small objects)
Line Levels (for measuring elevation ..can purchase)
Quadrats (square enclosures for marking off sampling areas)
Handheld GPS (Global Positioning System …for accurate spatial coordinates)

Cast Nets
Seine Nets (12', 20', & 50')
Plankton Nets (large zooplankton & small macrophytoplankton net)
Otter Trawl (requires a muscular boat)
Minnow Traps
Kick Net (for shallow streambeds)

Kayaks (w/ adult supervision)
Life Vests*

Aquaria & Pumps
Wave Tank (6 foot)
Microscopes (compound & binocular)
Chemistry Glassware, Hotplates, Balances, etc.
Safety Goggles*

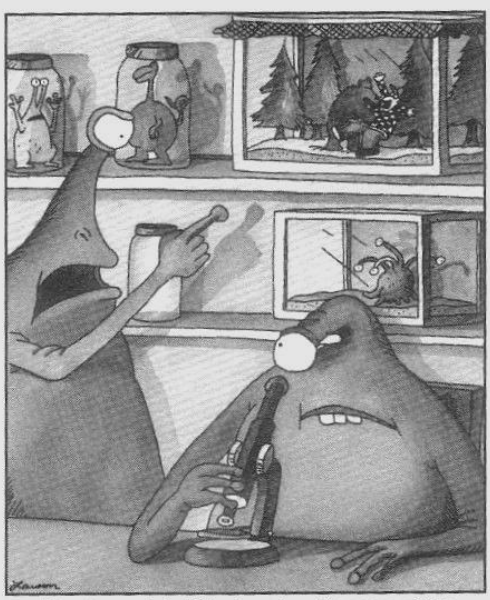
Duggy's science project gets in Mr. Og's hair.

***Safety First in all Scientific Research!!! ⇒⇒⇒**
Both lab and field studies can present potentially dangerous situations. All student research proposals must be both safe and safety-conscious. Some activities may warrant adult supervision.

Some Easy Species to Work With in a Lab:

- Killifish** (mummichogs, striped killis, etc.)
- Goldfish** and guppies**
- Brine Shrimp
- Daphnia ("water fleas")
- Duckweed (*Lemna*)
- Snails & slugs (periwinkles, pond snails, garden slugs…)
- Crabs (blue, fiddler, mud…)
- Mice**

Animals must be treated with respect. Use of ***vertebrates* in particular must adhere to strict rules for ethical treatment, and must be approved by faculty advisor.



"Zorak, you idiot! You've mixed incompatible species in the earth terrarium!"

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