Integrated Science Activities for the Study of Salt Marsh Ecosystems

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In general, the commentaries on the state of science education have been negative, with many calling for revision of science curriculum in order to make them more interesting and relevant to students (Green 1989; Simpson & Oliver 1990). Many precollege students do not perceive careers in science as acceptable, and this poses serious national concerns (Malcom 1990; Norman 1991). This is not surprising since students are seldom given the opportunities to understand scientific inquiry (Brickhouse 1990). Science class experiences can excite students and they should see the relevancy of the activities that go on in classroom sessions.

The salt marsh environments—soil, oceanic waters, tidal flows, plant and animal communities—provide an ideal model for the conceptual understanding of the functioning of natural ecosystems. The biotic and abiotic components of a salt marsh ecosystem are ideal for developing integrated science activities that are relevant to precollege students as they develop an appreciation for such systems. The need for such activities has been emphasized in the National Science Education Standards where instructors are encouraged to choose activities that will give students the abilities to function and make informed decisions as citizens in the community as well as continue to grow personally and professionally (NRC 1992). In general such relevant and meaningful experiences are often overlooked in science instruction (Carter 1993). However, integrated science activities are now seriously being considered as new science programs are being developed across the nation (Aldridge 1990; Ward 1990).

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Although salt marsh sites are often chosen as sites for annual class field trips in coastal areas, the activities are generally limited to organismal studies (i.e. species composition distribution, density and productivity). The abiotic component (soil chemical and physical characteristics, oceanic waters, tidal inundations) is mostly ignored. This paper details some specific science activities to be carried out in the field and laboratory for investigations of some aspects of the abiotic component of a salt marsh that can be incorporated with biotic studies for completing integrated science activities.

The intricate working of natural systems arouses curiosity in individuals. Building on this need to understand, such field activities can revitalize instructional strategies. Students will learn about the dynamics of salt marsh environments by focusing on hands-on science activities at field sites and during laboratory activities. They will develop science process skills in a relevant and meaningful manner. Science activities at salt marsh sites will provide opportunities for doing science in a natural environment that provide opportunities for solving problems associated with natural phenomena. Investigative activities by students will provide meaningful data for tabulation and analyses. Data derived from their personal explorations allow students to make meaningful associations and arrive at reliable conclusions about the workings of natural systems.

Many schools are now equipped with Apple Macintosh computers. The use of simple computer programs will not only enhance science process skills but also prepare students for doing real science in a technological world. MYSTAT (version of SYSTAT, Evanston, IL) is an easy and simple statistics and graphics package. CRICKET GRAPH[1] (Great Valley Corporate Center, PA) will produce high quality graphs for presenting data. Several fast document processors including WRITENOW[1] (Mountain View, CA) can easily be obtained.

Studies of salt marsh environments are well suited for collaborative work. The importance of collaborative group skills cannot be overlooked in successful learning environments (Johnson & Johnson 1987). Studies in salt marsh environments (i.e. collection of soil cores, mapping out soil horizons) can develop cooperative group skills that are known to enhance learning and successful group work later on. Success in collecting and analyzing data will depend on individual accountability as well as intra-group cooperation.

These activities were presented to middle and high school teachers (California Science Teachers Association Statewide Conference, San Jose, CA 1992) as science activities for integrated field and laboratory investigations of salt marsh. After active participation and completion, the activities were evaluated as most useful and appropriate for incorporating the physical and biological sciences in studies of natural ecosystems such as marsh environments. Although several of the teachers often chose the salt marsh for the annual field site studies, many admitted stressing the organisms present but ignoring the abiotic aspects. The teachers were also surprised at the simplicity and low cost of the equipment needed for carrying out

[1]MYSTAT, SYSTAT, Inc. Evanston, IL 60201; CRICKET GRAPH, Great Valley Corporate Center, Malvern, PA 19355; WRITENOW, T/Maker Company, Mountain View, CA 94041.

these activities. They were particularly encouraged that the technical concepts necessary for carrying out the experiments (excluding the osmometer) were simple enough to be addressed at middle as well as high school.

The activities listed here are not new to the scientific world but are a collection of isolated assays used commonly by soil chemists, geologists, agriculturalists and ecologists. These activities are not only safe and inexpensive but are considered suitable and appropriate for the precollege students carrying out investigations of the total field environments in natural ecosystems.

Field Activities

Materials Needed for Field Sampling

Metric tapes
Shovel—1.5 meters
Meter sticks
Wooden stakes for making quadrats
Handouts for data collection
Plastic Ziploc® bags, quart and gallon sizes
Plexiglas® tubes (3.2-cm diameter)
Cans for collating soils
Paper and pencils

Sampling Areas at Salt Marsh

Soil sampling will be carried out using transects marked with twine or measured tapes. The transects will be perpendicular to the shore and will extend from lower to upper marsh areas. At intervals along the transect, quadrats (25 × 50 cm) will be marked out with wooden stakes. The number of transects (3–5) will vary according to the time available for sampling as well as the lengths (40–80 m) of the transects, which will depend on the topography and width of the marsh. The number of quadrats laid down within each zone (lower and upper marsh areas) must be sampled to give correct estimates of the variation within the lower and upper marsh areas, but again the number will vary with the time available for doing so.

Collection of Soil Samples

Soil cores (3) will be taken from randomly chosen quadrats (5–8) from lower and upper marsh areas by using Plexiglas tubes (3.2-cm diameter) or containers (coffee cans) of known volumes. The cores should be measured for specific depths. Soils from upper soil depth (1–15 cm) and lower soil depths (15–30 cm) should be analyzed separately and protected from drying out until fresh weights can be obtained. This can be done by securing soils in polyethylene bags during transportation back to the laboratory for soil moisture estimations.

Soil Profiles—Comparisons in Low & High Marsh Areas

Soil profile: A vertical section of soil through its horizons.
Soil horizons: Layer of soil approximately parallel to the land surface that differs from adjacent related layers, e.g. color, texture, etc.

Examinations of Soil Profile

Using a large shovel, dig through upper 1.5 m soil layers exposing a vertical view of soil horizons from lower and upper marsh regions. Soil profiles from these two areas can be compared by examining the following features:

1. Number of visible horizons (based on color and texture; pH for more advanced classes)
2. Thickness of horizons
3. Color of horizons
4. Texture of horizons.

Soil profiles will differ with locations in the marsh (lower or upper marsh). However, the two most obvious horizons in each soil profile are likely to be the upper "O" horizon (organic), and the lower "A" horizon (humus accumulation) which is usually dark in color.

Laboratory Activities

Soil pH (H + Concentration)

Soil pH is important because it directly affects nutrient availability. Marsh soils generally have high pH (pH > 7) because of the high concentrations of ions present (sodium, calcium, chloride, potassium, magnesium). Nitrogen, phosphorus, potassium, sulfur, calcium and magnesium are most commonly found at the middle pH ranges (pH 6.0–8.5). However, iron, manganese, boron, copper and zinc are more abundant at the lower pH range. (See Truog 1946.)

Soil Kits (five kits for class of 30 students)

Soil pH can be obtained by using soil testing kits (sold inexpensively at garden supply stores ≈ $6.00) that use color indicators covering the pH range from acid to alkaline. Litmus paper can also be used, but it does not provide marked changes in acid soils for reliable determinations. Many of the soil kits provide wells for placing in them a pinch of soil together with a few drops of indicators provided. Almost instantly color changes will indicate the pH of soil samples by comparisons with color charts provided in kits.

Determination of Soil pH Using a pH Meter

1. Mix one part of soil (50 gm) with one part distilled water (50 ml).
2. Shake mixture in covered container for 48 hours.
3. Remove 10 ml of aqueous mixture and centrifuge.
4. Measure pH of soil solution using a pH meter.

Method of Assessing Soil Texture

Soil texture (sizes of soil particles) directly affects soil aeration, soil permeability and soil nutrients. Soil texture can be estimated by feel (more appropriate for lower grades) or by using soil sieves (upper grades). The textural analysis can be more accurately estimated by the use of a relatively inexpensive hydrometer (see Thompson & Troeh 1973). Particle size analysis: sand (2.0–0.05 mm); silt (0.05–0.002 mm); clay (<0.002 mm).

Soil Texture by Feel

Knead a small amount of soil with water. The clay content of the soil affects the nature of the soil mixture. Clay soils are sticky, whereas sandy soils do not hold together and are loose and grainy. Loams are mixtures of sand, silt and clay where properties of each size particle are expressed. Clay or silt loams are smooth-feeling mixtures that are high in the finer particles. Sandy loams are sticky mixtures of sand. Gravelly soils have large amounts of gravel or stones (particles larger than sand grains). Organic soils have a larger proportion of organic matter to mineral fraction and are generally sticky and dark in color.

Soil Moisture

Soils collected at field sites from lower and upper marsh areas at two depths will be placed separately in soil cans after fresh weights are obtained. The soils will be dried in a hot air drying oven for 48 hours at 100° C, after which the dry weights of the soils will be recorded. Water content will be determined by subtracting the weight of the core after drying from the initial fresh weight. The water content will be affected by the amounts of organic matter as well as soil textural characteristics.

Soil Salinity

Gravitational Method—Evaporation to Dryness

For the lower grades, relative soil salinities at low and high marsh regions can be estimated by adding known volumes of distilled water to measured volumes of soils from the two regions. After being shaken for 48 hours (use automatic shaker), known volumes of soil solution can be evaporated to dryness and dry weights for residual salts can be obtained.

Use of Osmometers

This method is more suitable for upper grades. Use osmometers (vapor pressure or freezing point depression) to obtain osmolalities of soil solutions. After obtaining measurements for the amounts of soil water present in soil cores, estimations of salinities in soils can be obtained as shown below.

Soil Osmolalities (Mahall & Parks 1976)

1. Obtain fresh weight of soil sample.
2. Dry in hot-air drying oven 48 hours.
3. Add a known volume of distilled water to dried soil (approximately twice that of soil).
4. Shake soil solution for 48 hours on a shaker.
5. Centrifuge part of soil solution to obtain a clear solution.
6. Using a vapor pressure or freezing point depression osmometer, obtain relative osmolalities (1 M NaCl = 2 os/kg water).
7. Apparent soil osmolalities of soil solution *in situ* can be calculated based on the known amounts of water originally present in soil samples.

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