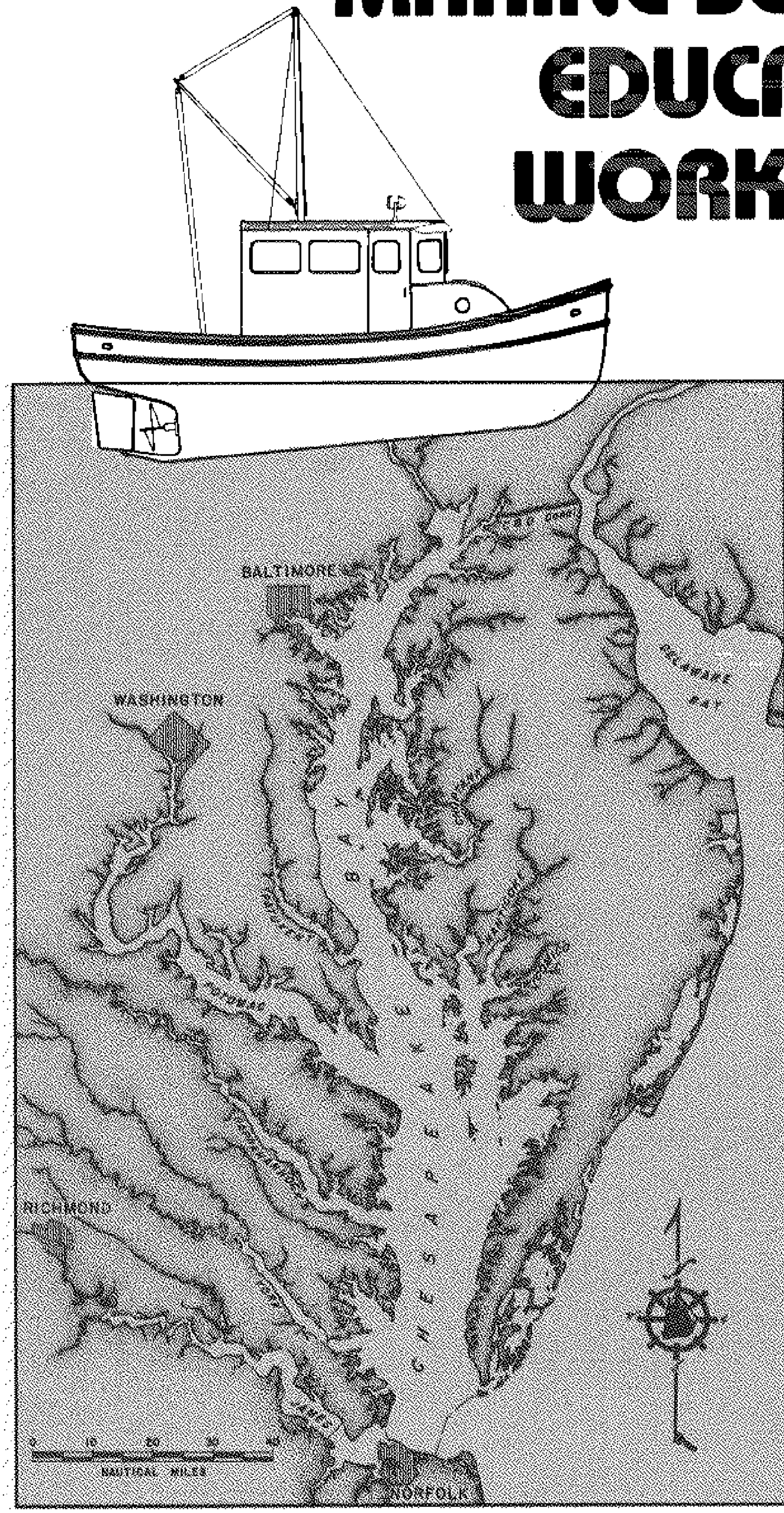
MARINE SCIENCE EDUCATION WORKSHOP



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Office of Sea Grant

Offered by Anne Arundel Community College
Marine Technologies Program

STUDY GUIDE FOR

MARINE SCIENCE EDUCATION WORKSHOP

ANNE ARUNDEL COUNTY MARYLAND

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Arnold, Maryland
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FOREWARD

The workshop you are participating in is being developed under a grant from the National Sea Grant Program as part of the University of Maryland's Sea Grant Program. Matching funds for the grant are being provided by the Board of Education and Anne Arundel Community College.

I am pleased to have you participating because without your interest in the marine environment such a workshop and its development would not be possible.

I am most thankful for the interest and support of several people without whose assistance this grant and project completion would not have been possible: Harold Bloom, Science Coordinator; Katherine Henry, Staff Development Coordinator; Russel Heyde, Outdoor Education Coordinator, Paul DeRoo all with the Anne Arundel County Board of Education; Paige Blick, typist; Bill Reem, cover design and Virginia Stibolt, my always helpful wife.

Kenneth A. Stibolt
Principal Investigator
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MARINE SCIENCE EDUCATION MINICOURSE FOR PUBLIC SCHOOL TEACHERS

This 15 hour short course is for public school teachers of the Anne Arundel County Unified Science Program. It is designed to provide useful background information about marine-oriented topics included in the Unified Science Program as well as information about activities teachers can use with their students in the classroom or at an outdoor location. All participants will receive a multipage companion study guide. Each short course is a program consisting of three components. First is a three hour introductory session. Second, participants will attend a day time nine hour session including marine environmental data sampling from the College's research vessel for half the time and shore-side and laboratory activities for the remaining time. The third component is a three hour follow-up session that includes discussion of field activity results, evaluation and marine education resource availability.

Credit: One (1) Workshop Credit through MSDE

Place: Arlington Echo Outdoor Education Center
975 Indian Landing Road
Millersville, Maryland 21108

Coordinator: Harold Bloom

Instructors: Paul DeRoo, Virginia Stibolt

Sponsors: Anne Arundel County Board of Education; Anne Arundel Community College; National Oceanic Atmospheric Administration, Office of Sea Grant

SELECTED MARINE-ORIENTED TAXONOMY OF OBJECTIVES FOR ANNE ARUNDEL COUNTY UNIFIED SCIENCE APPROACH

PROFICIENCY LEVEL 1

<u>Statement</u>: Man has identified specific relationships that exist between living and non-living things in our biosphere.

PLOS 4. The student will describe some plants and animals of a land habitat and a water habitat.

EOS 2. The student will draw a picture of some typical plants and animals within the Chesapeake Bay environment.

PLOS 5. The student will describe four properties of a liquid from the following list:

a. taste
b. smell
c. physical appearance
d. weight
e. occupies space
f. takes shape of container

EOS 1. The student will compare properties of various liquids in terms of taste, smell, and physical appearance.

PLOS 6. The student will discuss: (a) at least three places where water can be found in the earth, air, soil, bodies of water, and (b) the effects of precipitation on man.

EOS 1. The student will classify two types of bodies of water on earth, in terms of fresh and salt water.

PROFICIENCY LEVEL 4

<u>Statement</u>: Animals are adapted to their environment.

PLOS 1. The student will explain the relationship between plants and animals in the food chain.

EOS 2. The student will trace the source of foods from plant to animal in terms of a food chain.

PROFICIENCY LEVEL 4

Statement: Animals are adapted to their environment

PLOS 4. The student will describe how the following invertebrates are adapted to their environment: mollusks, arthropods, and worms.

EOS 1. The student will specify the distinquishing characteristics for each of the following groups: molluscs and arthropods (insects, spiders, and crabs).

EOS 2. The student will describe how worms are adapted to their environment.

EOS 3. The student will explain how molluscs are adapted to their environment.

EOS 4. The student will explain how arthropods (insects, spiders, and crabs) adapt to their environment in terms of body coverings, method of locomotion, body parts and senses (seeing, smelling, and hearing).

PLOS 5. The student will describe how the following vertebrates are adapted to their environment: birds, mammals, reptiles, amphibians, fish.

EOS 2. The student will specify three characteristics of fish that permit them to live in water in terms of: body temperature, body covering, locomotion, breathing apparatus and senses.

PROFICIENCY LEVEL 5

Statement: Changes on earth occur through time.

PLOS 1. The student will generalize that the earth's surface can be changed by flowing water.

EOS 4. The student will demonstrate how water can carry and redeposit soil to form deltas and fill up lake bottoms.

EOS 6. The student will summarize how water movement brings about erosion of the shore lines.

PROFICIENCY LEVEL 6

Statement: Changes on earth occur through time.

PLOS 3. The student will describe pollutants in terms of: (a) those pollutants altering the normal composition of air and water, (b) effects on living things, and (c) means of control.

EOS 3. The student will describe water pollution in terms of specific causes and effects on living things.

EOS 4. The student will discuss both: ways of eliminating pollutants from air and water, and preventing pollution in the future.

PROFICIENCY LEVEL 8

Statement: The functioning of living things is influenced by both natural and man-made factors in the biosphere.

PLOS 1. The student will explain: (a) that weather change is a good index of some environmental change, and (b) how instrumentation helps us to measure and record weather changes.

EOS 4. The student will determine the relative humidity over a period of several days using a hygrometer and psychrometer.

EOS 10. The student will determine the wind direction, wind speed, and kind of wind using the appropriate instruments and wind velocity scale.

EOS 11. The student will evaluate the effects of wind on living and non-living things.

PLOS 5. The student will specify how man uses and misuses the chemicals for control in the environment.

EOS 4. The student will determine: (a) how man sometimes misuses chemicals, and (b) the legal regulations concerning chemicals and fertilizers.

PROFICIENCY LEVEL 9

<u>Statement</u>: Interactions within the biosphere cause changes on earth.

PLOS 2. The student will summarize adaptations of plants and animals living in salt water in terms of structure, behavior and life cycle, and effects of pollutants on plant and animal life.

EOS 1. The student will specify the habitats of four animals (such as snails, barnacles, clams, worms, and crabs) from the Chesapeake Bay Shore.

EOS 2. The student will discuss the adaptation of a clam, oyster, blue crab or fish to its habitat in terms of breathing apparatus, means of locomotion, protective devices, sensory organs, eating habits, and stages of development.

PLOS 2. The student will summarize adaptations of plants and animals living in salt water in terms of structure, behavior and life cycle, and effects of pollutants on plant and animal life.

EOS 3. The student will describe a salt water plant, its structure, and how this structure functions to obtain necessary resources and energy for survival.

EOS 4. The student will discuss: (a) ways in which pollution occurs, (b) the effect of pollution on living things, and (c) means of controlling and preventing pollution.

PLOS 6. The student will discuss surface and internal change theories concerning changes in the earth's crust.

EOS 4. The student will demonstrate the formation of sedimentary deposits in terms of:
(a) faster the water flow, the more sediment it carries
(b) as water slows or stops, the sediment is dropped,

PROFICIENCY LEVEL 9

Statement: Interactions within the biosphere cause changes on earth.

EOS 4. (c) as land is eroded, sediment builds up elsewhere, such as in deltas,
(d) as weight of sediment increases it becomes consolidated to form sedimentary rock layers.

PLOS 9. The student will discuss air currents or winds as related to: (a) expansion and contraction of air, and (b) rate of heating or cooling of land and water.

EOS 2. The student will explain that: (a) as warm and less dense air rises, cool, denser air moves under and replaces the warmer air, and (b) air currents or winds are caused by temperature and density variations.

EOS 3. The student will explain the cause of land and ocean breezes in terms of: (a) rate of heating and cooling of land and water, (b) heat conduction from the land and the water to the air, and (c) the air flow between the regions of different densities.

PLOS 12. The student will explain: (a) the cause of the earth's tides, including spring and neap, (b) the effect of rotation on tides, and (c) the effect of tides on living things.

EOS 4. The student will designate how tides affect invertebrates such as clams, mussels, or barnacles which live between high and low tide areas.

PROFICIENCY LEVEL 10

Statement: Living things have adapted to their environment over the ages.

PLOS 3. The student will compare various types of invertebrates in terms of their adaptation to the environment.

PROFICIENCY LEVEL 10

Statement: Living things have adapted to their environment over the ages.

EOS 1. The student will conclude that the following animals without backbones are classified in groups according to differences in structure:

a. Porifera - sponge
b. Protozoa - amoeba, paramecium
c. Coelenterata - coral, jellyfish
d. Enchinodermata - starfish, sea urchin,
e. Mollusca - clam, oyster, snail,
f. Platyhelmentha - flatworm,
g. Annelida - earthworm,
h. Arthropoda - lobster, shrimp, spider, insect, millipede, crustacians, and arachnids.

EOS 2. The student will specify five different invertebrates found in the water, in air, and on land.

EOS 3. The student will discuss the structure, behavior and life cycle of one animal from each of the following categories as they are adapted to their environment: molluscs, coelenterata, porifera, echinoderms, and arthropoda.

PROFICIENCY LEVEL 14

Statement: Phenomena occurring in living and non-living systems can be qualitatively described and quantified.

PLOS 6. The student will explain the causes of ocean and wind currents in terms of heat transfer by conduction and convection.

EOS 1. The student will explain the process of heat conduction in water and air in terms of the kinetic molecular theory.

EOS 2. The student will demonstrate the differences between a heat conductor and an insulator.

PROFICIENCY LEVEL 14

Statement: Phenomena occurring in living and non-living systems can be qualitatively described and quantified.

EOS 3. The student will explain convection in terms of: fluids, varying temperatures, varying densities and gravitation effects.

EOS 4. The student will compare ten ocean currents of the world in terms of: location, directional nature, and approximate range in temperature change.

EOS 5. The student will explain the causes of global wind patterns.

EOS 6. The student will compare the pattern of winds in the atmosphere to the production of surface currents in the ocean in terms of: (a) a cause and effect relationship, and (b) the principles of conduction and convection.

PROFICIENCY LEVEL 15

Statement: The sun is the principal source of energy for our environment.

PLOS 3. The student will explain the albedo effect and Greenhouse effect in terms of a matter energy interaction.

EOS 1. The student will explain the albedo effect in terms of a daily cycle of incoming and outgoing energy.

PLOS 7. The student will summarize those factors that influence winds, ocean currents, and weather.

EOS 4. The student will summarize the relationships between color, surface texture and type of material on the rate and amount of radiant energy absorbed by the material.

PROFICIENCY LEVEL 15

Statement: The sun is the principal source of energy for our environment.

EOS 5. The student will specify the way in which land and sea breezes occur in terms of the concept of convection currents.

EOS 6. The student will specify the surface air currents created by unequal heating of the globe.

EOS 7. The student will explain the coriolis effect on wind in terms of: (a) relationship between the acceleration produced by a force on the direction of force in space, and (b) the relation of the earth.

EOS 8. The student will specify the characteristics of the following winds over the earth: horse latitudes, doldrums, polar easterlies, prevailing winds, and trade winds.

EOS 9. The student will summarize the causes of ocean currents in the major bodies of the earth's water.

EOS 10. The student will explain the effect of the following currents on the climate in nearby regions: South Equatorial Current, Peru Current, Equatorial Countercurrent, Labrador Current, California Current, Canary Current and Gulf Stream.

EOS 11. The student will contrast the physical and chemical properties of the Gulf Stream and its marine life with that of the North Atlantic.

PLOS 9. The student will summarize the interrelationship between organisms in a food chain and a food web in terms of the acquisition of food and energy transfer.

EOS 4. The student will prepare a food web of the organisms in a land and/or water environment.

PROFICIENCY LEVEL 15

Statement: The sun is the principal source of energy for our environment.

EOS 5. The student will analyze the energy lost at various steps of an energy pyramid.

PROFICIENCY LEVEL 18

Statement: Man seeks information about other environments

PLOS 3. The student will describe the history of man's attempts to understand the underwater environment of the world including the Chesapeake Bay.

EOS 1. The student will account for man's interest, past and present, in the waters of the world.

EOS 2. The student will describe the role of the oceanographer in generating scientific knowledge.

EOS 3. The student will summarize the major contribution of each of the following pioneers in oceanography: Forbes, Maury, Thornison, Murray, Palumbo, Hinsen, Chum, the Prince of Monaco, Lebmann, and Jacques Cousteau.

EOS 4. The student will describe the work of these early American men and organizations in oceanographic research: Agassiz, the Albatross and the Fish Commission, Hydrographic Office and the U.S. Navy, U.S. Coast Guard and the Geodetic Survey.

EOS 5. The student will describe various recent technological advancements in terms of assisting the oceanographer in conducting research.

EOS 6. The student will summarize the findings of early and recent projects carried out to study the Chesapeake Bay.

PROFICIENCY LEVEL 18

Statement: Man seeks information about other environments

PLOS 4. The student will describe the theories which account for the topography of the ocean floor and the Chesapeake Bay.

EOS 1. The student will compare the submergent, emergent, compound, and neutral shorelines according to their features and how they are formed.

EOS 2. The student will compare several continental shelves in terms of their structures, location, sizes, and methods of origin.

EOS 3. The student will describe several abyssal plains in terms of their size, depth, location, composition and method of origin.

EOS 4. The student will discuss the theories which account for faults and escarpments on the floors of the ocean.

EOS 5. The student will describe the system of mid-ocean ridges of the ocean floor.

EOS 6. The student will explain the current theories which account for the formation of submarine canyons and mountains.

EOS 7. The student will discuss several theories which account for the formation of seamounts, guyots, atolls, island reefs and island arcs.

EOS 8. The student will illustrate the bottom topgraphy of the Chesapeake Bay.

EOS 9. The student will summarize the history of the formation of the Chesapeake Bay.

PROFICIENCY LEVEL 18

Statement: Man seeks information about other environments.

PLOS 5. The student will describe the properties of the hydrosphere in various salt and brackish water bodies of the earth.

EOS 1. The student will describe the significance of the five basic salts in determining the chemistry of ocean brine.

EOS 2. The student will explain how the following factors affect the surface salinities of the ocean: evaporation, formation of sea ice, precipitation, melting of sea ice, and runoff from land.

EOS 3. The student will calculate the water pressure felt on an object at various ocean depths.

EOS 4. The student will describe the gases and their relative amounts which are dissolved in the waters of the earth.

EOS 5. The student will explain the fluctuations in the surface temperatures of the waters of the earth.

EOS 6. The student will explain the density variations of the waters of the earth in terms of the salinity and temperature of the waters.

EOS 7. The student will account for the various ocean currents of the world in terms of: temperature, density and surface winds.

EOS 8. The student will compare the organisms and chemistry of the Gulf Stream with the surrounding North Atlantic.

PLOS 6. The student will compare life forms in the ocean with life forms in the Chesapeake Bay in terms of: (a) types, (b) location, (c) affect on total life, (d) food web, (e) abundance, (f) distribution, and (g) adaptation.

PROFICIENCY LEVEL 18

Statement: Man seeks information about other environments.

EOS 1. The student will describe the role that a marine biologist plays in increasing the knowledge of the ocean and the Bay and methods which they use in sampling specimens.

EOS 2. The student will identify the types of plant life found in the Chesapeake Bay and the ocean.

EOS 3. The student will group animals which live in the Chesapeake Bay and oceans in terms of those that are either benthos (bottom dwellers) or nektons (free swimmers).

EOS 4. The student will dissect one illustration of a bottom dweller and a free swimmer.

EOS 5. The student will describe a specific food chain in the ocean and the Chesapeake Bay.

EOS 6. The student will summarize the economic importance to Maryland residents of one or more animals from the Chesapeake Bay.

EOS 7. The student will complete a recipe catalogue for the preparation of foods using Chesapeake Bay animals.

PROFICIENCY LEVEL 20

Statement: Pollution of the environment has increased with the growth of technology and population.

PLOS 1. The student will analyze the condition of our water resources in terms of: causes, effects and possible solutions of pollution in order to preserve the resources for future living and recreation.

PROFICIENCY LEVEL 20

Statement: Pollution of the environment has increased with the growth of technology and population.

EOS 1. The student will describe the water pollution problem for several major water areas in terms of: (a) geographical location and water current pattern, (b) the people and industry, (c) the people and industry placing demands on water resources, and (d) causes of pollution.

EOS 2. The student will determine the quality of water in several areas of Anne Arundel County.

EOS 3. The student will specify the causes of pollution in Anne Arundel County.

EOS 4. The student will summarize the effects that various water pollutants have on living things.

DEMONSTRATIONS AND FIELD EXPERIENCES PLAN

TIME: 8:00 am - 5:30 pm (Please be on time.)

PLACE: Arlington Echo Outdoor Education Center
975 Indian Landing Road
Millersville, Maryland 21108

DRESS: Wear clothing to match the weather conditions. No sessions will be canceled or postponed because of weather. Old clothes, enough layers for warmth, wind proof outer covering, hat, garden or work gloves for protection and some warmth. Rubber soled shoes or boots, the colder or wetter the weather the more foot protection you will need. No high heeled boots. If raining or rain is likely wear foul weather gear, jacket, pants and boots. If you don't own such gear ask your friends to borrow theirs. It is important to be comfortable. Adequate clothing will help provide you with that comfort. You can always remove clothes if you have too many.

LUNCH: Bring one, there will be no time or place to buy one. Select your drink to suit your preferences but consider the weather. A thermos of hot drink would be preferred on a cold day. Have plenty of food and drink. Being active outdoors for about 8 hours can make you very hungry and thirsty.

OTHER EQUIPMENT: Clipboard, sunglasses, camera (here is an opportunity to obtain visual material for use in the classroom), pencil, small cloth duffel bag for personal gear and lunch (ladies: I suggest not bringing a purse but instead transfer needed personal items into the duffel). If your class has a saltwater aquarium and you want to collect live specimens bring a 1 gallon plastic milk jug and a battery-operated aerator. If you are susceptible to motion sickness I suggest taking the recommended dose of MAREZINE.

FACILITIES

The facilities at Arlington Echo include classroom space, library with references, dissecting microscopes, compound microscopes, a dock with power, waders, seine nets, temperature and pH meters, semi-conduction meter, saline salt test, sample bottle, sechi disk, plankton net, sieve set, sounding weights, markers for tide change, a brackish marsh (water is 3.5 ppt salt). In addition we will be using Anne Arundel Community College's research vessel the R/V Bottlenose shown in the following line drawing. It was selected and customized to maximize its usefulness for teaching oceanography. Aft deck space and interior cabin space is adequate for 8 students. Port and starboard hand operated winches and booms allow two different instruments to be simultaneously lowered through the water. All necessary safety equipment for a 26 foot vessel is aboard. Additional safety equipment includes a recording fathometer, a VHF-Fm radiotelephone, radar and Loran C. In an emergency that required some one to contact you they can do so by calling the Baltimore Marine Operator who would call the R/V Bottlenose, call letters WYT 2108. The deck house and fo'c's'le provide good protection from the weather except, of course, for participants that are lowering equipment and tending cable. The fo'c's'le area can be closed to provide privacy for people using the head.

SCHEDULE

Four and one-half hours will be spent on the research vessel and four and one-half hours will be spent on the shore-side activities. There will be one-half hour break for lunch. Depending upon the number of participants you may go aboard the research vessel in the morning and do the shore-side activities in the afternoon or vice versa.

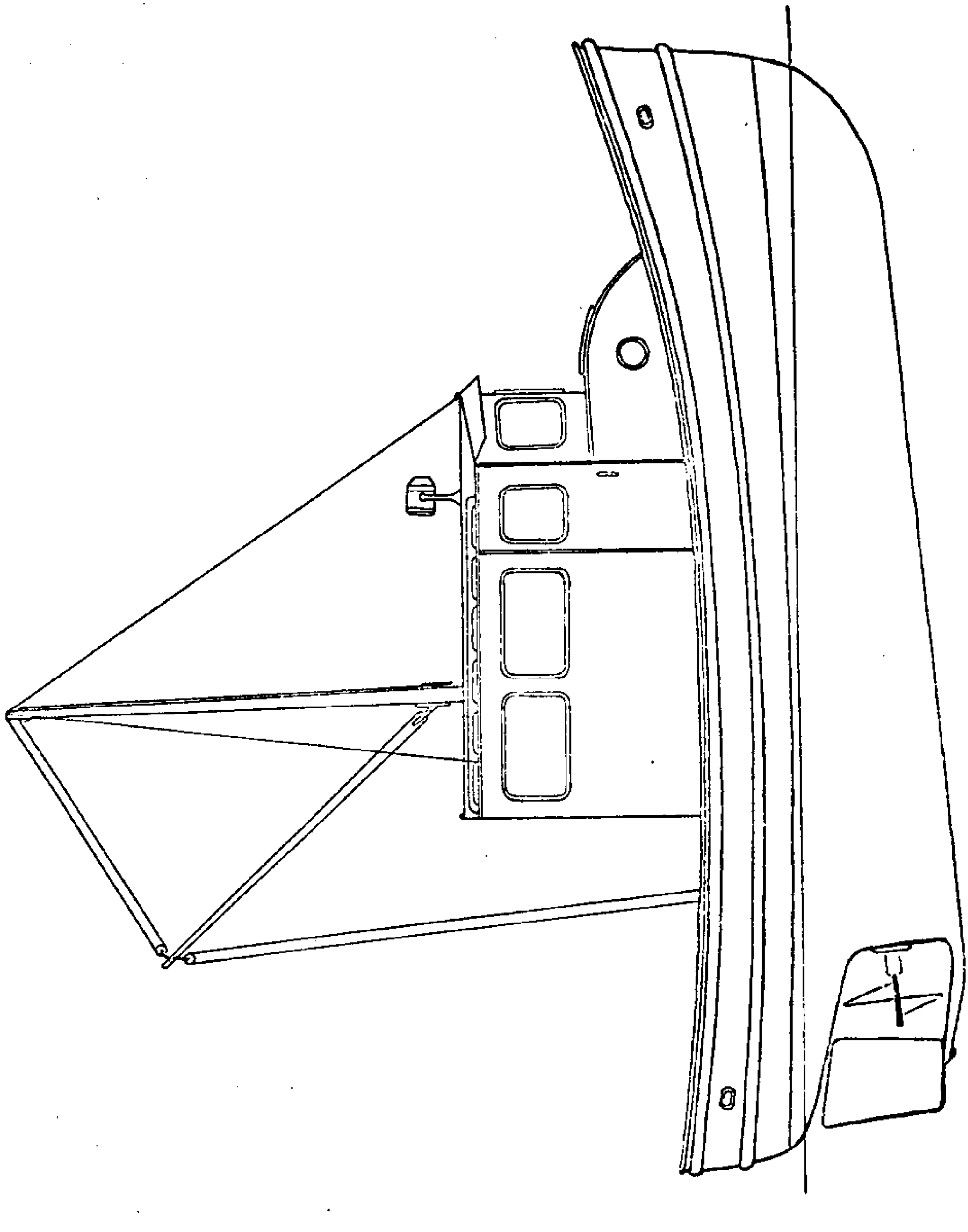
Shore-side activities Divide into two groups and rotate

8:00 - 10:00 or 1:00 - 3:00	Outside	Seining and collect catch (20 minutes)
		Plankton collection from dock with pump (20 minutes)
		Delta demonstration with sand colored according to size (20 minutes)
		Oil spill demonstration (20 minutes)
		Marsh plant observation and sparse collection (20 minutes - all)
		Marsh animal observation (20 minutes-all)

10:15-12:30 or 3:15-5:30	In Lab	Identification of fish, plankton and other organisms using keys (60 minutes) Convection experiment - show that density of water is keyed to salinity and temperature (setup and let sit for 15 minutes) Absorption experiment - show that soil and water absorb heat differently (setup and let sit for 1½ hours) Dissection of oyster and fish (45 minutes)

Onboard research vessel activities

8:00 or 12:30	Travel to station and anchor (15 minutes) Practice using winches (15 minutes) Use salinometer and refractometer, put bucket thermometer in water. Use current meter (30 minutes) Use D.O. meter, photometer and secchi disk (45 minutes) Use water sample bottles and titrate samples for D.O. and salinity. Measure ph, nitrates and phosphates (45 minutes) Use grab sampler, seives, and corer (45 minutes) Stow gear, ready trawl and wight anchor (15 minutes) Tow trawl, tow plankton net, identify collected organisms while returning (60 minutes)



DESCRIPTION OF SHORE-SIDE ACTIVITIES

I. Outside

A. Seining and collecting catch (20 minutes)
Purpose: to show the diversity of animals close to shore.

At least three people should put on waders. Two or four people should hold the poles at the end of net and then spread out net so that it is approximately perpendicular to shore then they should pull the net parallel to the shore for 10 - 20 meters with as little disturbance in the water as possible. The remaining people should be in the water walking noisily through the water toward the net so as to scare the fish into the net. When the net-pullers and the fish-scarers approach close to each other the net pullers farthest from shore should start heading towards shore while the other net-pullers should act as a pivot. When the net is parallel to shore, everyone should help to pull the net up on shore. Keep one or two specimens of each kind of organism for later identification in buckets. Throw the rest back. (The second group should try to seine in a slightly different location so as to get more variety.)

B. Plankton collection from dock with a pump (20 minutes)
Plankton is usually collected from a boat. The purpose of this exercise is to provide an alternative to boat use.

The submersible pump and attached hose can be lowered off the dock so water may be sampled from any level. Start this exercise by sampling water from near the surface. The stream of water should be directed into the plankton net. After five minutes of pumping place the plankton from the small jar at the end of the net into a sample bottle. Then repeat at a deeper level - be sure to record the depth and label the samples so a comparison may be made between the plankton at the two levels.

C. Delta demonstration with sand colored according to size (20 minutes)

The purpose of this exercise is to show how the size of a sand grain relates to the length of time it is carried by a water current.

DESCRIPTION OF SHORE-SIDE ACTIVITIES (cont.)

C. Delta demonstration with sand colored according to size (20 minutes)

Sand grains of several sizes will be mixed together in a shallow container. Push the sand all to one side of the container and then pour a small steady stream of water on a spot at the peak of the sand pile. A delta should be formed where the stream of water runs off of the sand. When a good-sized delta is formed stop the water flow and examine the delta. What can you conclude about the size of the sand grain as related to the length of time they are suspended in water?

D. Oil spill demonstration (20 minutes)
The purpose of this exercise is to show one method commonly used by the Coast Guard to clean up oil spills.

Try to locate a small oil film near the beach. Such films may be detected by a sheen or rainbow interference pattern. If no naturally occurring oil films are present, simulate one by using a few drops of vegetable oil on surface of the water and place some leaf litter or other buoyant debris on the oil to simulate the condition found in harbors.

After this film is found or made note the direction of the wind. Place the sorbent material in a curved line down-wind from the film. Then apply one or two drops of a piston film agent to the surface of the water upwind from the film. (Piston films are composed of detergent-like molecules that have an inherently high spreading pressure.)

E. Marsh plant and animal observation and collection (40 minutes)
The purpose of this exercise is to show the diversity of plants and animals in the marsh and to demonstrate techniques used for collection.

When walking in a marsh use care so as not to trample more plants than necessary. A true marsh is a tenuous environment - this can be shown by having everyone stand still then one person's jump should send vibrations of the ground out for 10 to 15 meters. This indicates

DESCRIPTION OF SHORE-SIDE ACTIVITIES (cont.)

E. Marsh plant and animal observation and collection (40 minutes)

that there is not a film foundation under the marsh and that the shoreline has indeed been extended by growing plants.

The diversity of the plants is easily observable. A few terrestrial plants will be collected and placed in a plant press. At least one submerged plant will be collected by floating the plant onto some heavy paper and allowing it to partially dry on the paper before being placed in a plant press.

The animals will be harder to spot. Look for holes in the mud near the edge of the water and watch to see if there is any activity. You are looking for mud crabs, fiddler crabs or worms. Also look in the shallow water for minnows or other swimming organisms. Look for racoon footprints and bird activity because these are the predators for this environment. Try to identify any plants and animals you see by using the references available.

II. In the lab

A. Identification of fish, plankton and other orgaisms using keys (60 minutes)
The purpose of this exercise is to demonstrate the diversity of the organisms in the water. The plankton identification would include the knowledge as to whether or not that particular organism is a phytoplankton or zooplankton and if it is a zooplankton whether it is holoplankton or meroplankton. This classification will separate the plankton according to the roles each type has in the eco-system.

The fish and other larger organisms play various roles also. Their roles may be determined by the presence of teeth, gills, claws or shells.

B. Convection experiment (set-up time 10 minutes)
The purpose of this exercise is to demonstrate that the density of water is keyed to salinity and temperature.

Set out four 400 ml beakers 2/3 filled with room temperature water. Chill approximately

B. Convection experiment (set-up time 10 minutes)

100 ml of water in an additional container with ice and color it with a few drops of food coloring. Also prepare two containers of salt water by adding one teaspoon of table salt to another 200 ml of room temperature water. Color the two mixtures of salt water with two different colors of food dye. Take note of the color of the three different mixtures.

Take a funnel stuck into a large portion of approximately 5" of flexible bubble tubing and place it diagonally in one of the 400 ml beakers. Carefully pour about 25 ml of the cold water into the funnel and tub so that no bubbles are formed in the tube which cause mixing of the water. The colored cold water should be on the bottom of the beaker. Repeat with the cold water. Then carefully place one of the cold water beakers on a cold hot plate. Turn it on and observe the differences between the heated beaker the the control. Meanwhile, set up the the two concentrations of salt water in a similar manner. Place the two beakers carefully on a cold hot plate. Turn on the hot plate and note the differences in the times until complete mixing takes place in the two different salinities.

C. Absorption experiment (set-up time 5 minutes let sit for 1½ hours)
The purpose of this exercise is to show the differences between soil and water in the absorbance and the reflectivity of heat.

Set up an infra-red heat lamp about 18" above the table. Place two 9 x 13 x 2" pans equally underneath the light. One pan will have at least an inch of water in it and a thermometer. The other pan will have a comparable depth of soil with a thermometer at the bottom.

D. Dissection of a fish and an oyster (45 minutes)
The purpose of this exercise is to acquaint you with the inner workings of these organisms to show how they are adapted to their environment.

The directions for dissection of these organisms plus any others depending upon the haul in the seine will be found in reference books found in lab.

WORKSHOP EQUIPMENT CHECK LIST FOR RESEARCH VESSEL

Beckman Induction Salinometer Readout
- cable and sensor
- protective plastic milk crate
- weights
- plastic bucket
- data sheets

Photometer Readout
- cable and sensor
- deck cell
- data sheets

Current meter and cable in box
- readout unit
- data sheets

YSI Dissolved Oxygen Meter Readout
- cable, sensor and circulator
- battery for circulator
- portable aerator
- calibration container
- calibration tables
- data sheets

Water Sample Bottles
- Nansen bottle
- Sea Gear bottle
- Martek bottle
- messengers
- plastic tubing for drawing sample
- plastic sample bottles
- grease pencil

Secchi Disk

Enviroeye for backup

Envirotrans for backup

Dissolved Oxygen by Titration (2 kits)
- all reagent bottles full, empty sample bottle
- instructions with kit

Salinity by Titration (2 kits)
- all reagent bottles full
- instructions with kit

Refractometer

Geology
- grap sampler
- corer
- small portable wash down table with C-clamp
- trough
- screens

Biology
- small sample jars
- Formalin
- trawl
- plankton net
- bushel basket
- wide-mouth plastic jug
- hand lens

Position Fixing
- sextant
- hand held bearing compass
- 3 arm protractor
- charts
- dividers

Bucket Thermometer

Weather
- sling psychrometer
- anemometer
- deionized water

Calculator (personal equipment)

Tide Tables

"Fishes of the Bay"
Field Oceanography Lab Manual
The Chesapeake Bay in Maryland, An Atlas of Natural Resources

Polaroid Camera and film

Note: A checklist of activities will be posted on board the research vessel to help you be certain that you have accomplished all activities.

TECHNIQUES OF DATA SAMPLING

The emphasis of field experiences portion of this workshop is on the equipment and techniques for marine data sampling. A variety of equipment will be used that is representative of physical, chemical, geological and biological data sampling areas. Where necessary, equipment operation will be demonstrated and operating instructions provided. All pieces of equipment chosen for the workshop have been selected because they are easy to operate.

Preparations

Before embarking on any field trip or research cruise, many important preparations must be made. A very complete equipment, support equipment and backup equipment check-off list needs to be compiled and used. Such a list has been included in this workshop booklet. All equipment must be working properly. Since most field equipment is battery operated, fresh batteries should be in place and extra batteries at hand. For data to be useful, it must be traceable to a standard. The process of calibrating an instrument is to insure traceability of data to a standard.

Basics of data taking

All data will be taken at a physical location; from the shore, a bridge, pier or deck of a research vessel. This physical location must be recorded on the data sheet as a latitude and longitude. Positions are found with respect to landmarks using either a sextant, three-position plotter, hand-bearing compass, radar or Loran C.

Data is also taken at a time location. Date and time of observation must also be recorded on the data sheet. Other data sheet information that needs entering is the wet and dry bulb temperature, wind velocity and direction, general weather, the observer's name and surface water temperature taken with a mercury in glass thermometer.

The person recording the data should put his name in the comments column and make sure that all column headings indicate the variable and units being measured.

Most marine environmental data taken at a specified location or station is recorded at different depths at the surface and proceeding downward. Depth data in meters is recorded in the appropriate data sheet column. Measurement of the depth at which the instrument is located can be done two ways. Some instruments have a depth transducer included with the primary transducer. Depth measurements are most often made by measuring the amount of cable paid out. This is done by passing the cable over the sheave of a pulley and counting the number of turns the sheave makes as cable pays out. The sheave with counter is called a meter wheel and reads directly in meters of cable paid out. To calibrate the meter wheel, the sensor is lowered to a point just below the water surface and the meter wheel pointer turned by hand until it points to zero depth.

Note: Operating procedures for all equipment will be demonstrated.

SIMPLIFIED OPERATING INSTRUCTIONS

1. Beckman Salinometer

The Beckman RS5-3 is a portable, battery-operated salinometer designed to make measurements of temperature, electrical conductivity and salinity in situ (in place). It covers the following ranges:

Salinity: 0-40 ‰ (parts per thousand)
Conductivity: 0-60 Millimhos/cm
Temperature: 0-40 degrees C

The operation principles are based on:

a. An induced electric current is proportional to the conductivity of sea water.
b. Temperature measurements can be made using the temperature resistance relation of a semi-conductor called a thermistor.
c. Salinity is a known function of electrical conductivity and temperature.

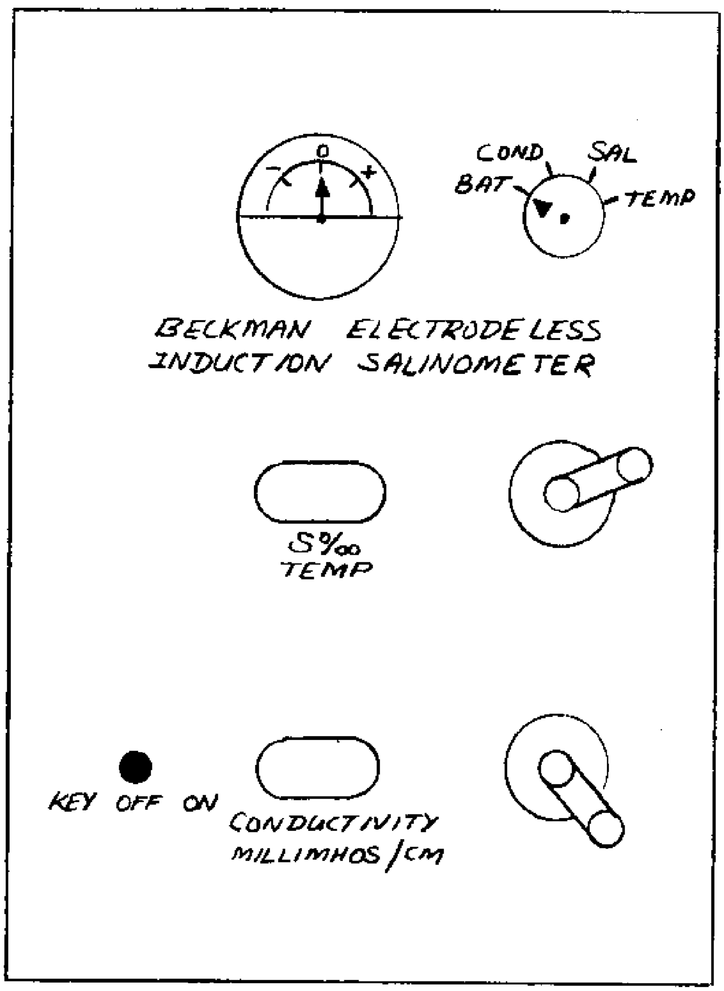
Thus, conductivity is measured by producing a current with an oscillator, and picking up the induced current, which is proportional to the conductivity, by means of a transformer. A wheatstone bridge circuit allows rapid determination of the conductivity.

Salinity is determined from conductivity and automatic compensation for temperature changes, and temperature measurements are made by manually balancing thermistor inputs on a bridge circuit.

Operation:

a. Always set "ON", "OFF", "KEY" toggle switch to "OFF" when equipment is not in use to conserve the batteries
b. Lower sensor into water to desired depth. Sensor may be secured to weight attached to winch, as long as sensor is removed from conductivity material by about 1 foot and no strain is placed on sensor cable.
c. Turn toggle switch "ON".
d. Rotate selector switch to "CONDUCTIVITY".
e. Crank "CONDUCTIVITY" knob until meter needle has zero deflection (mid-scale position).

f. Without further adjustment, read and record conductivity from appropriate scale.
g. LEAVE CONDUCTIVITY SETTING until all readings at this depth are completed.
h. Rotate selector switch to "SAL" (salinity) position.
i. Using crank knob next to window marked "SALINITY" set meter needle to zero
j. Read and record salinity.
k. Set selector switch to "TEMP" (temperature).
l. Again set meter needle to zero (mid-scale) position, using the crank knob near "SALINITY/TEMPERATURE" window.
m. Read and record temperature
n. Turn toggle switch to "OFF" position.
o. Measurement at a certain depth is completed. Go to next depth and repeat, or retrieve and secure sensor.

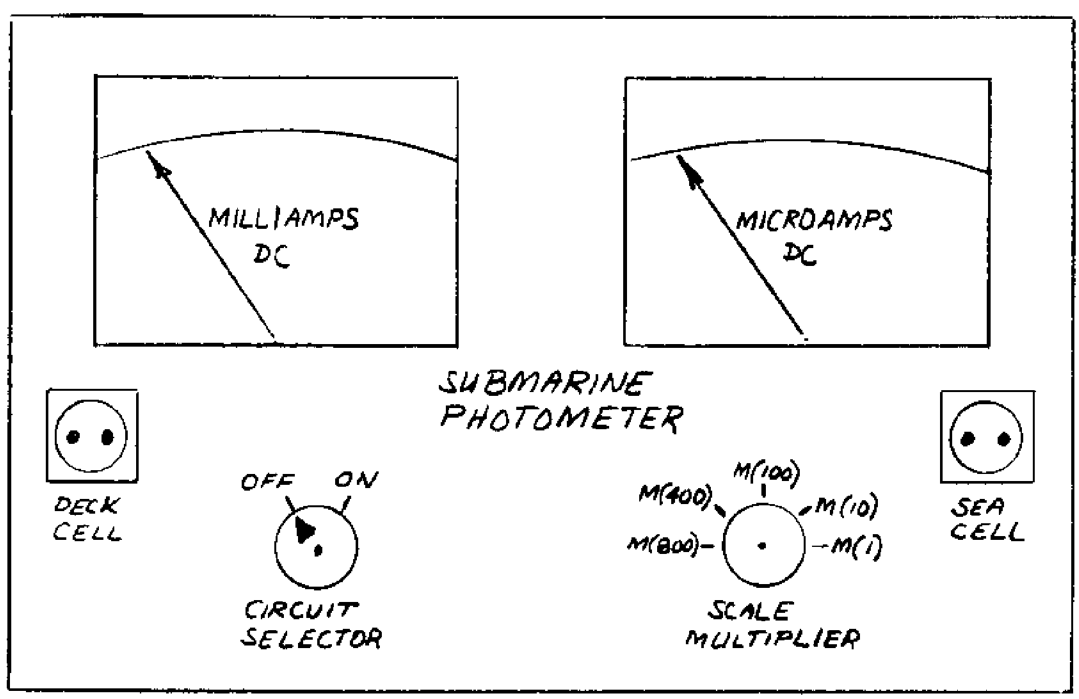


2. Photometer

The rate of absorption or EXTINCTION of sunlight in the water column is measured with a PHOTOMETER. It consists of a light sensitive photocell lowered from a cable which in turn is connected to a deck control unit and read-out box. This deck unit has two sensitive ammeters, measuring 0-25 microamps (1 microamp = 10^{-6} amps) for the underwater cell and 0-25 milliamps (milli = 10^{-3}) for measurements above the surface. The latter is not used.

To extend the range of the photocell a multiplier is provided. Depending on multiplier setting, scale reading may be multiplied by x1, x10, x100, x400, x800.

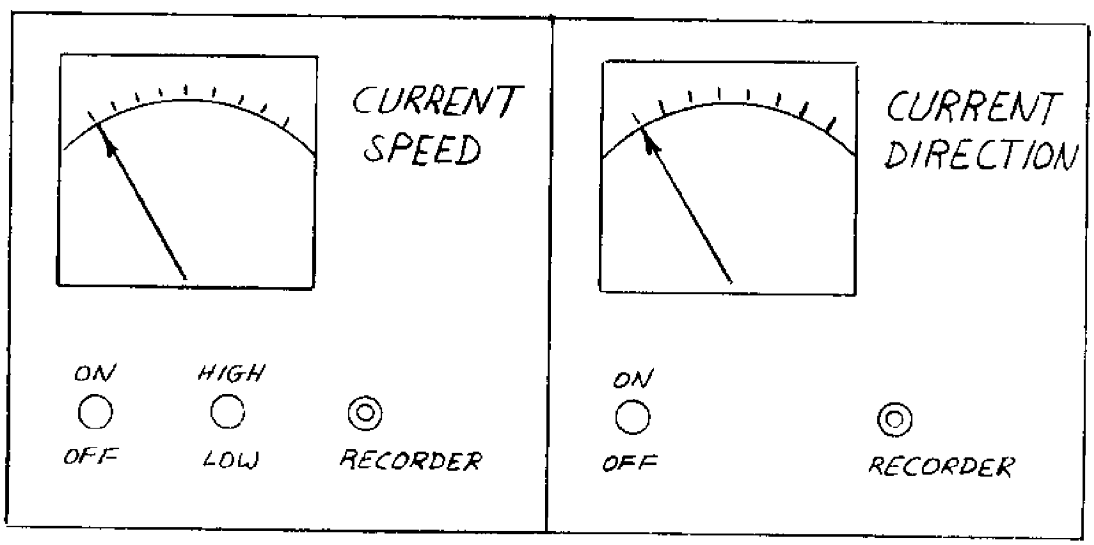
a. Remove protective shorting plugs from cable connectors, and connect cables to deck control unit.
b. Lower unit until photocell is just below surface.
c. Set circuit switch to "ON".
d. Set scale multiplier until needle deflection is approximately midscale.
e. Record reading, multiplier setting, depth.
f. The surface value obtained will be taken as the 100% light level.
g. Lower meter to next depth.
h. If needle deflection is small, change multiplier setting to obtain higher, preferably mid-range, deflection.
i. Record as in step 5.
j. Upon completion, raise unit to surface, turn circuit switch "OFF".



3. Current Meter

The Bendix-Savionus Rotor Current Meter is designed for measurement of current speed and direction in oceans and estuaries, where low speeds prevail and many different depth need to be sampled. The current spins a rotor assembly, rotation is sensed by a magnetically coupled reed-switch, and internal circuits transform the pulse inputs into steady state velocity output. A vane and compass similarly provide directional information. Both speed and direction are displayed at the deck read-out box, speed ranges are from 0-1 and 0-7 knots, and direction is shown for 360 degrees with a 15 degree accuracy. Detection threshold is .05 knot.

a. Connect signal cable to read-out unit.
b. Set range switch to 0-7 knot scale.
c. Lower current meter to desired depth.
d. Turn current speed sensor and directional indicator "ON".
e. Select speed range consistent with optimum needle deflection.
f. Allow 15 to 30 seconds for stabilization.
g. Read and record current direction and speed.
h. Lower unit to next depth or retrieve.
i. Turn sensor read-out "OFF" to conserve batteries and secure equipment.



4. Water Sampling Bottles

A great many measurements and analyses cannot be performed in situ (in place), therefore, water samples have to be brought aboard ship from surface layers down to great depths. Most water sampling bottles have been devised for lowering with valves or openings in the open position. Then a messenger is used to trigger, or trip the bottles so the valves will close, trapping the water inside. The open valves allow flushing during the descent, although it is still necessary to allow a few minutes at sampling depth to flush the bottles at the depth sampled.

Among the different types are the Nansen bottle, the oldest among present types and its variants, the Van Dorn, and Nisken bottle. The Kammerer water sampler has been used by limnologists in lake work, but has not become popular for deep-sea work. The Nansen bottle holds about 2 liters (1 liter = 1 quart), is made of brass and stainless steel parts, usually teflon lined inside. Its metal has made it unsuitable for work on trace analysis, hence all plastic bottles are used, such as the Van Dorn and Nisken bottle. Both have large openings closed by rubber or plastic lids held by rubber tubing. Sizes vary, Nisken bottles go from 2 liters to 30 liter capacity.

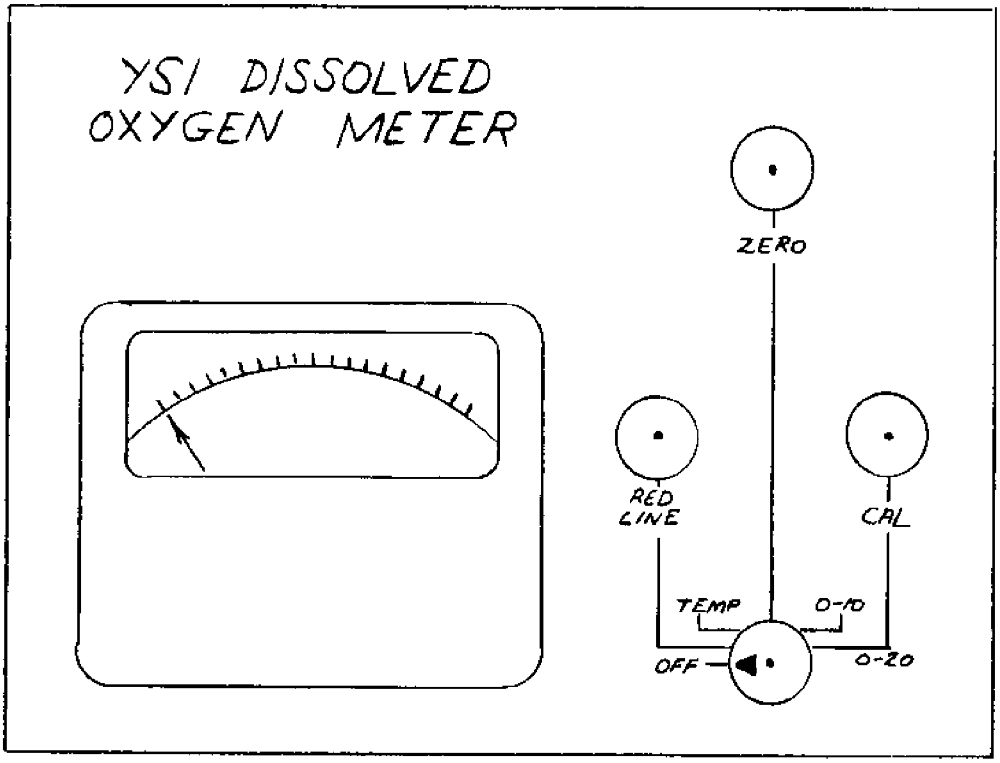
The Martek water sampler is a metal bottle of small capacity, suitable for hand-lowering and easy to operate. On all bottles, an air relief valve is provided for ease of withdrawing the water sample and to minimize mixing and bubbling air into the sample. The last must be avoided when accurate determination of dissolved gases in the water are desired. On large ship, deep sea operations water samplers are mounted on a circular platform along with conductivity and temperature sensors. Bottles are actuated electrically when platform is at desired depth. The entire assembly is called a rosette sampler.

5. YSI Model 54 Oxygen Meter

This is a portable battery-operated instrument for in situ measurements of dissolved oxygen and temperature to 50 foot depths in fresh or salt water. The dissolved oxygen sensor is combined with a temperature sensor which compensates for temperature effects on the D. O. sensor membrane permeability and oxygen solubility in water. Dissolved oxygen pressure is indirectly measured by the D. O. sensor. Inside the sensor are two electrodes, an anode and a cathode, immersed in an electrolyte. A teflon membrane separates the marine environment from the electrolyte. Oxygen diffuses through the membrane and is electro-chemically consumed at the cathode. This reaction produces a current which is directly proportional to the dissolved oxygen level.

When you use the instrument the following preliminary checks will have been made.

a. Condition of the teflon membrane on the D. O. sensor.
b. Condition of the electrolyte inside the D. O. sensor.
c. Checkout of stirrer and read-out batteries.
d. Calibration of the D. O. sensor.
e. Installation and connection of probes and stirrer to read-out meter.
f. Warm-up of electronics.



Operation:

a. With instrument turned off check the mechanical zero of the meter. Adjust with the screw on the meter case and recheck when the position of the instrument is changed.
b. Switch to the RED LINE position and adjust the meter to red line using fron panel control.
c. Switch to the ZERO position and adjust the meter to zero using the the ZERO control.
d. Switch to the TEMP position and read the temperature when the meter is steady (in equilibrium with environment).

e. Switch to the 0-10 or 0-20 ppm (parts per million) position and read dissolved oxygen level. Allow sensor to equilibrate with D. O. of the environment. This may take up to 30 seconds.
f. After taking data at one depth, lower to the next depth making sure stirrer is operating.

6. Dissolved Oxygen Determination by Titration

The amount of dissolved oxygen in water can be determined by chemical methods. Special chemicals of known concentration are added to the sample reacting with the dissolved oxygen. The reactants are then titrated with a solution; the end point of the reaction being noted by a color change. The amount of dissolved oxygen in the sample is related to the amount of titrating solution needed to reach the end point of the titration.

Operation:

a. Collect the water sample in the sample bottle without introducing atmospheric oxygen. Fill completely to the top and cap.
b. Uncap and add 8 drops of Manganese Sulfate solution.
c. Add 8 drops of Alkaline Potassium Iodide Solution.
d. Cap and mix gently by inverting several times.
e. Allow precipitate to settle below shoulder of bottle.
f. Uncap and add one measure (0.5 ml) of Sulfuric Acid.
g. Cap and mix until precipitate dissolves.
h. Fill titration flask to 50 ml. line with sample.
i. Fill microburette with Sodium Thiosulfate solution.
j. Titrate sample until brown color nearly disappears.
k. Remove microburette and add several drops of starch solution. Sample will turn blue.
l. Replace microburette and continue titrating until blue color disappears. This completes titration.
m. Each major division on the burette is equivalent to 0.2 ppm D. O., each minor division = 0.04 ppm D. O.
n. Count the major and minor divisions and calculate the D. O. of the sample.

7. Grab Samplers and Corer

These types of marine sampling equipment are easy to use. Grab samplers are selected according to the types of sediments being collected, the amount being collected, the depth of water in which collecting is being done, currents and wave motion in the area being sampled, and finally the equipment available for handling the grab sampler. Samplers can be closed either by contact with the bottom or by tripping with a messenger.

Grab samplers and the corer used in this workshop are selected knowing that the sediments are soft mud, the water is less than 150 feet deep, tidal currents may be strong, the boom and winch do not have a large lifting capacity, the vessel being used is small.

The corer used consists of a weight, a barrel for punching into the sediments, a bracket for attachment to a lowering cable, and a suction device for holding the core material in the tube.

Operation of Corer:

a. Assemble corer selecting weight depending on consistency of sediment being sampled.
b. Attach corer to lowering cable.
c. Lower corer to within 10 feet of bottom.
d. Allow to free fall to bottom.
e. Retrieve corer and remove core.

8. Plankton Nets

Plankton nets are a common method of sampling the microscopic plant and animal plankton. The net consists of a metal hoop, a towing bridle, a fine mesh conical net attached to the hoop, and a small collecting container at the end of the net cone. Mesh size should be selected according to the size of the organism desired.

Operation:

a. Attach sampling bucket and make sure draining tube is closed.
b. Attach towing bridle to towing line.
c. Make sure towing line is attached to vessel.
d. With vessel proceeding forward, lower net into the water and control its streaming aft by paying out towing line.
e. Make sure line out, vessel speed and weight on net are adjusted so that net is towed at desired depth.
f. Collect for a specified length of time.
g. Retrieve net.
h. Release contents of sample bucket into sample bottle for later identification or counting.

9. Salinity Determination by Titration

a. Fill the Salinity Titration Tube (0648) to the mark with the chloride-free water. Distilled or demineralized water is recommended, however, tap water with no chloride content can be used.
b. Using the 1 ml. syringe (0808) measure 0.5 ml. of the water to be tested and add this to the Salinity Titration Tube.
c. Add three drops of Salinity Indicator Reagent A (7460) to the contents of the titration tube. Insert the titration tube cap and gently shake the tube to mix the contents.
d. The Microburette is filled with Salinity Titration Reagent B (7461) in the manner described in the instruction manual. Insert the Microburette in the center hole of the titration tube cap.
e. Add the Salinity Titration Reagent B in small amounts, agitating the titration tube between additions, until the yellow color is permanently changed to a pinkish-brown color. The results of the titration are read from the scale on the Microburette. Each numbered division is equal to 1.0 part per thousand (ppt.) and each minor division is equal to 0.2 parts per thousand (ppt.).

Salinity Corrections (Harvey, 1963)

Salinity, S ^{o}/oo found	Correction to be applied	Salinity, S ^{o}/oo found	Correction to be applied
40	-0.15	22	+0.22
38	-0.08	20	+0.23
36	-0.03	18	+0.23
34	+0.03	16	+0.23
32	+0.07	14	+0.19
30	+0.11	12	+0.16
28	+0.15	10	+0.15
26	+0.17	8	
24	+0.20		

PRECAUTION:

Silver Nitrate solutions will cause a dark stain where it contacts the skin. Therefore, care should be taken to avoid spillage when handling the Salinity Titration Rg. B.

THINK ABOUT AND LOOK FOR

BIOLOGICAL SAMPLING

1. While you were doing geological sampling you were also obtaining biological samples. What type of organism or habitat is sampled with a grab sampler? When you sieve the mud sample are many living organisms found?

2. What characteristics would you list for the sub-bottom mud habitat? How much dissolved oxygen is there? Can you smell hydrogen sulfide? With hydrogen sulfide present is there likely to be any dissolved oxygen present?

3. As the otter trawl is towed behind the research vessel how close to the bottom is it? Are all organisms sampled bottom dwelling only? How can you explain the presence of other nektonic organisms?

4. Your data taking and knowledge of an estuarine tells you to expect low and variable salinities. What can you say about the tolerance to salinity changes of organisms in the otter trawl.

5. Would some preserved samples of the small organisms be useful in your classroom. Small glass jars and formalin are available for preserving and keeping specimens.

6. Do you have a salt water aquarium back at the classtoom that could benefit from small live Bay organisms?

7. After towing the plankton net at the surface was there an abundance of plankton in the net? What environmental variables could change the amounts of plankton found? At what level of the food chain are these organisms? At what levels of the food chain are the other organisms you sampled?

GEOLOGICAL MEASUREMENTS

1. Most of the bay bottom is covered with very fine grain silt containing a high percentage of organic material. Your sediment samples are likely to contain typical Bay mud. Why is this the predominant Bay sediment?

THINK ABOUT AND LOOK FOR

GEOLOGICAL MEASUREMENTS

2. If your grab or core samples contain coarser sediments such as sand what might be the reason? Is your data taking station close to a source of sand? You may be near an eroding bank or bluff? In the presence of high current velocities which grain sizes will be swept away first?

3. In the core samples why are the deeper sediments harder than the surface sediments? Is there a color change and odor change from surface to bottom? What is the cause of the odor?

4. When you sieve the sediment samples do you find mostly fine or coarse grain sizes. How long do you think it would take to accumulate 0.1 meters of sediment? Do you have any ideas on how the sedimentation rate could be measured?

5. Would taking some sediment samples back to your class be helpful? Whirl packs are available for keeping samples.

6. Looking across the water what type of shoreline do you see? Is it primary or secondary type? Is it being modified by marine processes?

WEATHER MEASUREMENTS

1. Wind and the waves it generates are a major cause of shallow water mixing. Is the wind velocity sufficient and the direction appropriate to cause much mixing at your data taking station?

2. Is the air temperature measured with the dry bulb thermometer likely to be lower or higher than an air temperature measured 20 miles inland? What are some reasons for the difference?

3. Would you expect differences between over land and over water temperatures to be great enough to cause convection and the resulting sea breezes in the region?

4. Dry bulb and wet bulb air tempertures are used to determine humidity. Is the humidity going to be greater over water than over land?

THINK ABOUT AND LOOK FOR

WEATHER MEASUREMENTS

5. No current precipitation measurements are being made, however, if you consider rainfall during the previous two weeks what effect could it have on surface salinity, turbidity and dissolved nutrients?

DISSOLVED OXYGEN MEASUREMENTS

1. Measurements of the amount of oxygen dissolved in water can be made electronically or by chemical titration. As you use the equipment consider its adaptability to teaching your students. How could the data be used to teach about estuarine mixing, adaption to habitats and water quality?

2. Your dissolved oxygen levels should be maximum at the surface and decrease with increasing depth. What are the reasons for this decrease? What is the source of dissolved oxygen at the greatest depth, near the bottom?

3. Low dissolved oxygen levels at the surface can indicate poor water quality. Eutrophication is a situation related to low dissolved oxygen. What are the causes of eutrophication?

4. Organisms adapt to specific habitats with dissolved oxygen levels being an important characteristic of habitats. Can you identify some habitats with different levels of dissolved oxygen?

5. Why are dissolved oxygen levels greatest at the surface? How does mixing due to wind and wave action affect dissolved oxygen levels? Phytoplankton have what role in supplying dissovled oxygen?

CURRENT MEASUREMENTS

1. Current velocity and direction data is being taken at various depths using the Savonius Rotor Current Meter. How does the data compare with expected directions and velocities? What use could you make of the data?

2. What is the predominant current direction? It should be aligned with the estuary's centerline since the estuary shoreline is functioning like the banks of the river.

THINK ABOUT AND LOOK FOR

CURRENTS MEASUREMENTS

3. What is the major cause of water flow in this estuary? Is tidal action more important than fresh water inflow? Tidal Current Tables can be used to predict velocities and directions for selected locations in Anne Arundel County estuaries.

4. Do current velocities decrease as the sensor nears the bottom? Water flowing through a pipe or an open channel is slowed down by friction caused by the pipe walls or channel sides.

5. Sewage treatment plant liquid waste gets dumped into estuaries. How could you use current information data to determine the "best" location to dump this waste?

TEMPERATURE MEASUREMENTS

1. While taking the data pretend you are a scientist. Why do you need this information? How can data taken along the surface and at various depths be used? Are the temperatures what you would expect them to be? Surface water should be relatively warm and get colder as the sensor is lowered to greater depths.

2. If there is little change in temperature from surface to depth could this mean the water is well mixed? Convection is movement of heated masses of fluid. Could the mixing also be due to winds and tidal currents?

3. If there is a substantial temperature difference from surface to depth this could mean that there is little mixing taking place. The water could be in layers with the salty, cold, dense layer at the bottom and a fresh, warmer, less dense layer at the top.

4. How does the surface water temperature compare with land surface temperatures? Is it warmer or cooler? Water has a different reflectivity value than soil so you would expect some differences.

5. Do the water temperatures you are measuring have any effect on other environmental variable? Does oxygen dissolve move easily in cold water than

THINK ABOUT AND LOOK FOR

TEMPERATURE MEASUREMENTS

5. warm? What do cold temperatures do to metabolic activities? Would plant plankton grow more quickly in warm water than cold?

SALINITY MEASUREMENTS

1. What variation in salinity does your salinometer sensor show when lowered from the surface to greater depths? Is this the expected variation for an estuary where fresh water inflow is mixing with salt water supplied by the ocean?

2. What causes the surface salinity to be less than in the ocean? How much freshwater inflow is there? Have precipitation amounts been above or below average for the year? Is this estuary close to or far away from the ocean?

3. Would your instruments show surface salinities decreasing as you move closer and closer to the head of the estuary?

4. What is the dominant mixing force between fresh and saltier water? Will density difference cause the mixing or are external forces such as winds and tidal currents more important?

LIGHT MEASUREMENTS

1. As you use the underwater photometer and the secchi disk think about the usefulness of the data to your teaching. Consider ways that variations in turbidity could be shown in the classroom and what might cause these variations in the natural environment.

2. As the photometer is lowered from surface to depth does the amount of light it receives diminish? If you did this experiment during the winter would the light levels diminish less rapidly? What causes differences in water clarity between summer and winter?

3. Phytoplankton, the microscopic plant plankton found in water need adequate amounts of sunlight for photosynthesis. Would you expect an abundance of phytoplankton at depths where there are low light levels?

THINK ABOUT AND LOOK FOR

LIGHT MEASUREMENTS

4. During the week preceding your light measurements has there been alot of rain? What affect on turbidity would substantial rain and land runoff have? Have you ever noticed the effects of shoreside development and its associated land clearing and grading on water turbidity?

EXPERIMENTAL TECHNIQUES

1. We take data using instruments to learn about the world around us. You are using several different instruments and techniques to learn about the marine environment. Why is it important to know where and when the data is being taken?

2. When using instruments how can we be sure they are producing accurate data? How is the dissolved oxygen meter accuracy checked? Do you consider accurate data taking in classroom experiments?

3. What is the difference between qualitative and quantitative sampling? Can you give some examples of both types?

4. Weather data by itself is useful and interesting but when taken along with other marine environmental data what purpose does it have?

5. Marine environmental data is expensive to acquire so it is always kept on file but often is found plotted in graphical form and included in reports. What uses could you make of this data in the classroom? Do you have any classroom experiments that emphasize first taking data then displaying it for interpretation?

SELF-STUDY DEBRIEFING SESSION

Budgeted Time: 6 hours

OBJECTIVES

1. To provide participants with an opportunity to apply information gained in the self-study session and field-experiences session.

2. To direct the application of that information to marine science teaching situations.

DATA PLOTTING

1. Attached is a sample graph of dissolved oxygen data.

2. Note how the dissolved oxygen and depth axes are drawn on the graph paper.

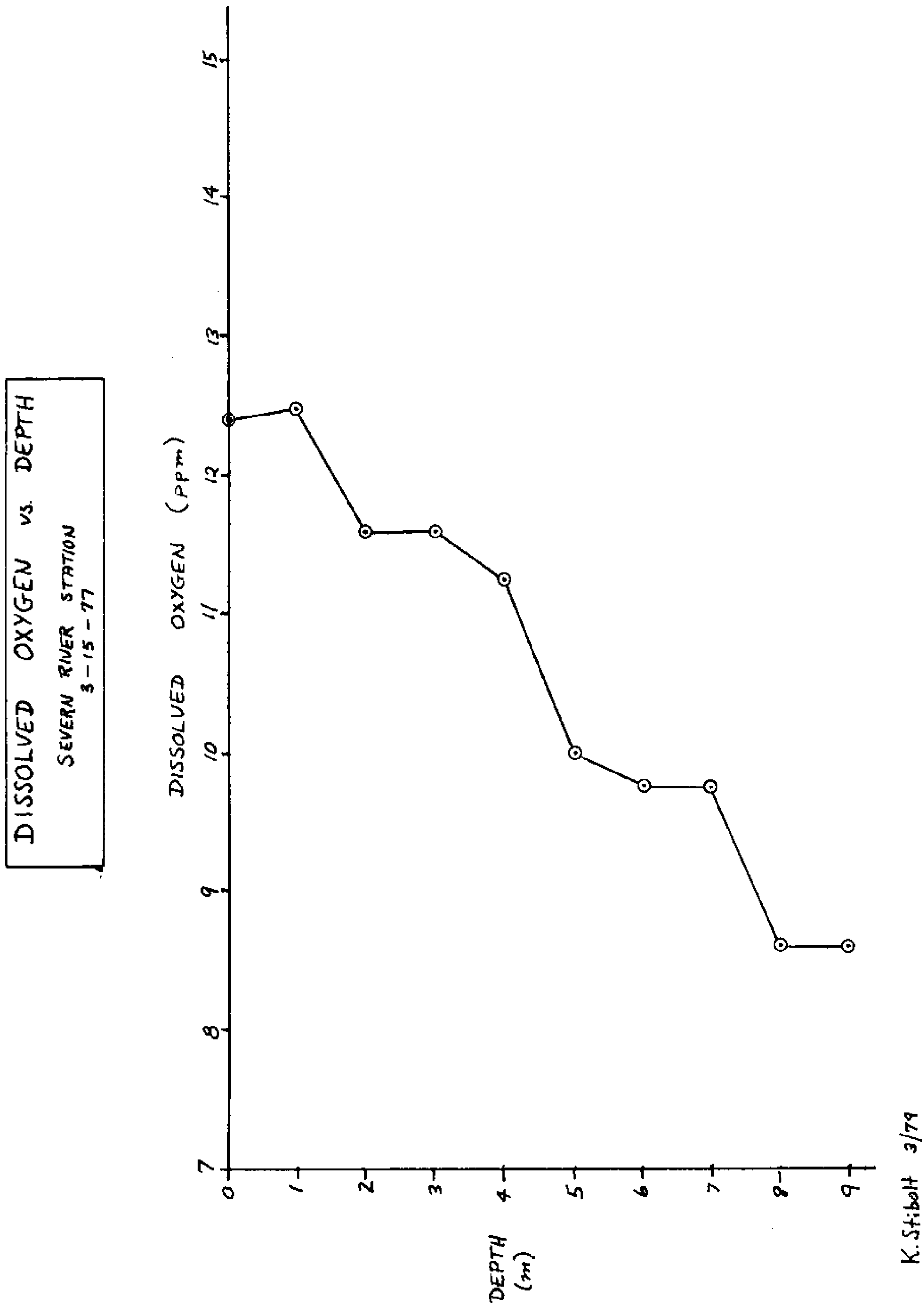
3. The depth axis is vertical and the 0.0 depth is at the top of the page. The axis is labeled as DEPTH and the units, meters, shown in parenthesis (meters). The scale must be selected to accommodate the maximum depth reached and be easy to read. Readability is accomplished by considering that for ordinary decimal graph paper where each main division is divided into 10 subdivisions, the value of each main division should be restricted to 1, 2 or 5 and their multiples by any power of 10.

4. All comments about the vertical axis apply to the horizontal axis, except that the horizontal axis is labeled with a dependent variable such as temperature or salinity and increases from left to right. The scale does not have to start at 0.0 particularly if the dependent variable change with depth is small and you want to emphasize that change.

5. Note how the data points are circled and the data trends shown by drawing straight lines from data point to data point but that the lines are not drawn inside the circle.

6. Note the graph title.

7. During the field experiences session you recorded temperature, salinity, dissolved oxygen, current velocity and direction and light loss versus depth. Plot the temperature and salinity data following the techniques mentioned in 2-6. Graph paper will be provided. Bring results to follow-up session.


DISSOLVED OXYGEN vs. DEPTH
SEVERN RIVER STATION
3-15-77
DISSOLVED OXYGEN (ppm)
7
8
9
10
11
12
13
14
15
DEPTH (m)
0
1
2
3
4
5
6
7
8
9
K. Stibolt 3/79

STATION LOG SHEET

TIME 1055 – 1130 OBSERVER Stibolt

OPERATION Severn River Summary Cruise STATION 7 LAT. 39° 00' 58" LONG. 76° 31' 12"

SHIP R/V Bottle nose Depth 9 meters Weather Sunny Clear

DATE 3 – 15 – 77 Wind 320° 4 Knots

Air Temp.

BUCKET TEMP 10.5 °C Dry Bulb 58 F ° Wet Bulb 51 °F

Depth (m)	Salinity ‰	Temp. °C									Remarks
0	6.64	9.26									
1	6.78	9.30									
2	7.20	9.27									
3	7.18	9.10									
4	7.32	8.84									
5	7.54	8.46									
6	7.96	7.78									
7	8.54	7.36									
8	8.80	7.08									
9	8.94	6.90									

QUESTIONS ABOUT FIELD ACTIVITIES

Short answer on a separate page and bring to follow-up session.

1. What is the significance of noting physical and time location of a marine data taking activity?

2. What is the purpose of taking meteorlogical data when the primary interest is to obtain marine data?

3. What purpose does obtaining an accurate temperature with the bucket thermometer serve?

4. What is the basic difference between geology samples taken with the grab sampler and with the corer?

5. Of all the water sampling bottles used and observed which one flushes most easily?

6. Can you suggest a method for using the otter trawl for quantitative sampling?

7. The only instrument calibrated during the workshop was the D.O. meter. Can you assume there are methods of calibrating the salinometer, current meter and photometer?

8. For the following three instrument sets, compare the advantages and disadvantages considering such items as: ease of use, accuracy, portability, cost, ability to take data at any depth, and adaptability to use by students that you teach.

   a. Salinometer versus salinity titration kit.
   b. D.O. meter versus D.O. titration kit.
   c. Photometer versus Secchi disk.

9. What types of problems did you encounter in taking current data? What is the reason for the problems?

10. Comment briefly on your interpretation of the salinity and temperature data you graphed. What usefulness is there in visually presenting marine environmental data?

APPLICATION OF WORKSHOP INFORMATION TO UNIFIED SCIENCE PROGRAM

This workshop has been designed to not only convey information about the reasons and techniques for environmental data sampling but also to improve the participants' familiarity with marine science subjects covered in the Unified Science Program.

Where possible, the workbook, self-study readings, field experiences and demonstrations, self-study debriefing and follow-up session provide information applicable to the selected marine-oriented Proficiency Levels, Proficiency Level Objectives, and Educational Objective Statements listed in this booklet.

Participants are asked to give two examples of where workshop derived information can be used in teaching the Unified Science Program, high school science courses or any other non-science course. The examples should refer to lecture teaching situations. Write them on a separate page and bring to follow-up sessions.

DESIGN OF A MARINE SCIENCE TEACHING ACTIVITY

One effective method of teaching a marine science concept is to have students participate in an activity where things instead of just words are used to explain that concept.

Participants are asked to design such an activity suitable for the grade level they are teaching. Make sure the design can be accomplished and actually used. That means you must consider such constraints as time, facilities, equipment, budget, group size, etc. Write the designed activity limiting the description to one page. Please write it on the ditto master.

FOLLOW-UP SESSION

Budgeted Time: 3 hours

PLAN

1. Discussion of self-study debriefing session.
    a. results of data plotting
    b. discussion of questions
    c. discussion of how workshop information can be used in Unified Science Program
    d. discussion of marine science teaching activities (Items c. and d. will represent a sharing of individual ideas with the group. Participants have been asked to write their teaching activity ideas on a ditto master for distribution to other interested group members. (1.5 hours)

2. Workshop evaluation: This workshop is developed under a grant from the National Sea Grant Program. Evaluation is being done to optimize the workshop program by soliciting participant's suggestions and incorporating them in future revisions. See following sheet. (0.5 hours)

3. Marine education (science or other) resource material display. (0.5 hours)
    a. Participants are asked to bring with them any marine education resource material they think may be of interest to the rest of the group.
    b. Workshop instructor will display resource material he is aware of.
    c. National Marine Education Association (NMEA) and Mid-Atlantic Chapter of NMEA.

WORKSHOP EVALUATION

Please comment on the following topics:

1. Length of workshop:

a. Self-study session:

b. Field experiences session:

c. Self-study debriefing session:

d. Follow-up session:

2. Workshop level: too advanced or too basic

3. Usefulness of study guide: Any particular parts that rate high or low?

4. Appropriateness of emphasizing techniques and equipment for environmental data sampling:

5. Relationship of workshop material to Unified Science Program material:

6. Method of workshop presentation:

7. Workshop administration:

8. Would you recommend workshop to your colleagues?

9. Do you have any suggestions for ways of providing your students with a marine science field experience?

INTRODUCTION

People of all ages are interested in the Chesapeake Bay. Certainly the group includes Marylanders and Virginians but it may also include people from states such as Pennsylvania. Those Marylanders with the strongest interest in the Bay are likely to be living in one of the fifteen counties that borders on the Bay proper or one of its tidal tributaries.

There are many sources of information about the Bay. Television and newspapers have an important role in the informing process as do people's recreational activities on the Bay. Formal education provided by schools is another important information source. Such marine education activity has been increasing throughout the United States. It is evidenced by such activities as the increasing availability of literature about marine subjects, by the establishment of national and regional marine education associations and by efforts to develop a national statement on the importance of marine education.

There are reasons for the activity. Primary among them are educator's realization that the marine environment has a substantial influence on people's lives. Our marine environment is an important resource providing food, recreation, transportation avenues, waste disposal sites, oil, gas and other minerals. It needs careful management and utilization by people trained with special marine competencies supported by a public that is aware of the importance of the marine environment.

There are many reasons for the Anne Arundel County Board of Education to direct more attention to marine education. The enclosed site map, Figure 1, shows the county's Bay shoreline. Such a location with about 430 miles of Chesapeake Bay shoreline results in a close economic and recreational association with the Bay.

The Chesapeake Bay is the largest estuary in the contiguous U.S. being 180 miles long with about 8,000 miles of shoreline. It is an important recreational, food, shipping and waste disposal resource.

The extensive county shoreline results in several important public problems: erosion and siltation. Waterfront property being in great demand is very expensive to purchase. Only 2% of the shoreline is in public ownership and there are only three public facilities.

A tremendous amount of boating activity occurs on county waters. There are 130 commercial marinas and a substantial number of community docks resulting in 6,100 slips and about 14,700 boats in the water. It is not surprising that Annapolis is known as a boating capital and is the site of an annual in-the-water sail and power boat show. Two other marine activities, Chesapeake Appreciation Days, and the Clam Festival are held at Sandy Point State Park near Annapolis.

Several marine resource conservation and management activities are located in or near to Annapolis. The Department of Natural Resources has a Water Resources Administration and a Coastal Zone Management program headquartered there. Bay environmental problems are the concern of the Chesapeake Bay Foundation and the Smithsonian Chesapeake Center for Environmental Studies. The Naval Academy focuses National attention on Annapolis. Two marine trade interest groups, the Maryland Watermen's Association and the Maryland Petroleum Institute have their offices in Annapolis.

There is a substantial marine education and marine research activity in the county. Johns Hopkin's Chesapeake Bay Institute is involved primarily in Bay research. Power Squadrons and Coast Guard Auxiliaries offer safe boating instruction. In the County Board of Education's Unified Science Program there is some marine emphasis at elementary, middle and high school levels. An Environmental Protection Agency field office is located in Annapolis. The Naval Ship Research and Development Laboratory is located across the Severn River from the Naval Academy.

Northern Anne Arundel County is influenced by the Port of Baltimore's cargo handling activity, ship building activity and hopefully by its revitalization.

Within the Baltimore-Washington-Annapolis triangle there are many other types of marine-oriented establishments. A recently prepared sabbatical report by Ken Stibolt, Professor, Marine Technology, Anne Arundel Community College, and principal investigator for this workshop project lists 930 marine-oriented establishments in Maryland. Two hundred thirty five of the establishments are located in Anne Arundel County. Marine-oriented industry is the third largest employer in the county according to Augie Levero, Associate Professor and Director of Retail Management, Anne Arundel Community College.

As workshop participants from the Anne Arundel County School System you will benefit directly and the students you teach, indirectly, from the information learned in the workshop.

There are about 78,000 public school students in the county none living more than 12 miles from the Chesapeake Bay or one of its tributaries. These young people are swimming, boating, crabbing and fishing on and in the Bay within a county that has a boat for every 20 people. They are exposed to many marine issues through newspapers, radio and television including such subjects as: shipping, dredging, oil refineries, shoreline development, waterway crowding, boating safety, oyster harvesting, crab catches, kepone, and waste disposal. One vehicle for learning about the scientific aspects of some of these issues is through the County Board of Education's Unified Science Program.

Oceanographers are considered to be the people practicing oceanography. This study of the oceans includes several scientific disciplines including physics, chemistry, biology and geology. Thus, an oceanographer is likely to be a physicist, chemist, biologist or geologist first and an ocean scientist second. General oceanography as a subject includes a survey of all the sciences of the ocean including physics, chemistry, biology and geology.

The marine environment includes not only the open oceans and seas but also the coastal waters, bays, rivers, and creeks up to the limits of tidal influence. The aquatic environment is usually considered to include fresh water. Oceanography is one of the few words that defines the study of marine and aquatic environments. Unfortunately, it focuses attention of the open oceans when most people are more directly concerned with coastal marine and inland aquatic environments.

The Chesapeake Bay is a coastal marine environment, an estuary. It is more probable that a marine scientist practicing a marine version of physics, chemistry, biology or geology is studying the Bay than an oceanographer.

An estuary is a semi-enclosed body of water that has a definite connection with the open sea and that is characterized by mixing of fresh water derived from river flow with salty water of the sea.

Examples in the U. S.:	Others:
Chesapeake Bay	Firth of Forth, Scotland
Delaware Bay, Del.	Yangtze Estuary, China
Puget Sound, Wash.	Rio de la Plata, Brazil
Laguna Madre, Texas	
Cook Inlet, Alaska	
San Francisco Bay, Calf.	

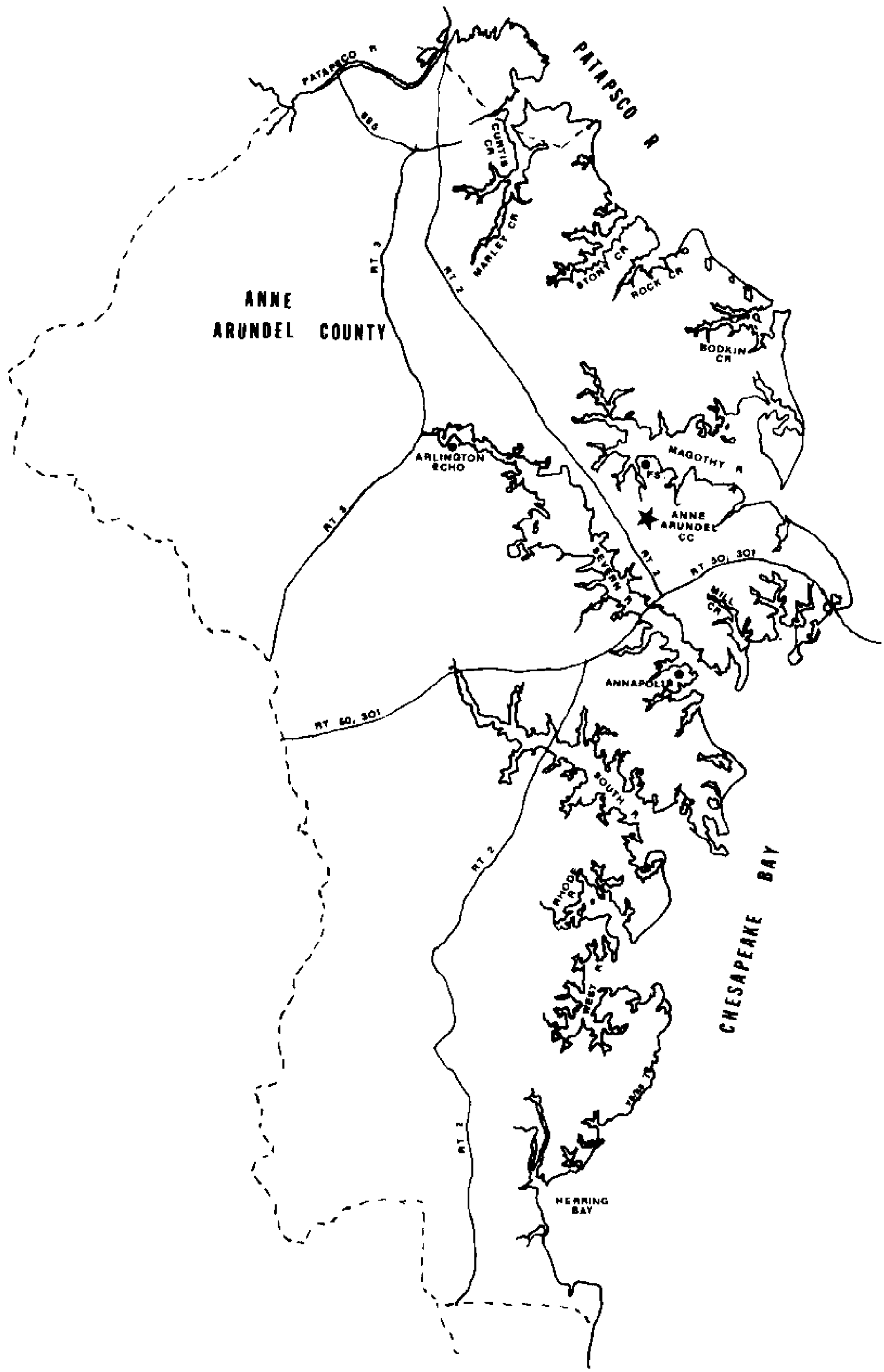
The Bay is the largest estuary within the contiguous U. S. It is 180 miles long (155 n.m.) and 5 to 30 miles wide. Its average depth is only 27 feet, although the deepest spot is 175 feet deep. Interestingly, this spot is within 2 miles of Bloody Point at the southern tip of Kent Island. The total shoreline length is estimated at 8,000 miles, 4,000 of which are within Maryland. Total surface area is about 4,400 square miles. The drainage basin (watershed) of the Bay and its tributaries is approximately 74,000 square miles. The Susquehanna drains 42% of that area. In 1973, approximately 2.3 million people lived within 20 miles of the Bay and its tributaries. Certainly another good example of why there is a marine education interest.

Developer wants to build a 930 slip marina on the already overcrowded Magothy River. Those facts will concern anyone interested in environmental quality. Battle lines are drawn, developers on one side, concerned local citizens on the other and public agencies in the middle. Any project of that magnitude needs an EIS (environmental impact statement) drafted to assess potential changes to the environment resulting from the project. A marina project is under the jurisdiction of the Army Corps of Engineers so they hire an environmental consulting company to draft the statement.

What is the source of the scientific data used in the statement? Where do the environmental scientists obtain their physical, chemical, biological and geological data? Physical data about current velocities and directions, and turbidity may be needed. The existing water chemistry may be desired. Habitats for organisms living in the water and on the bottom where the marine will be built must be determined. There may be active oyster beds or an endangered species habitat in the area. Changes in wave patterns or tidal currents may cause sediments to move to undersired locations. When possible, existing data sources will be used because it is less expensive than collecting new data.

Whatever the current data source, you can be certain that originally field data had to be collected using marine data sampling techniques. Such data gathering whether it be simple visual observations or electronic monitoring of dissolved oxygen versus depth is crucial to our knowledge of the marine environment. This workbook emphasizes the techniques that scientists and engineers use to monitor the environmental status of the Chesapeake Bay. It will focus first on the why, then the how of measuring marine physical, chemical, biological and geological variables.

Figure 1


PATAPSCO R
PATAPSCO R
CURTIS CR
MARLEY CR
STONY CR
ROCK CR
BODKIN CR
ANNE ARUNDEL COUNTY
RT 3
RT 2
ARLINGTON ECHO
MAGOTHY R
ANNE ARUNDEL CC
SEVERN R
RT 50, 301
MILL CR
ANNAPOLIS
SOUTH R
RHODE R
WEST R
CHESAPEAKE BAY
HERRING BAY

AIR-SEA INTERACTION

When scientists and engineers are engaged in marine environmental data gathering, they are not only learning about the hydrosphere but also about the atmosphere.

At data taking stations or locations on the Bay, basic weather data such as wind speed and direction, wet and dry bulb temperatures, cloud types, precipitation and fog occurrences will be taken.

Some basic explanations of the causes of some types of weather phenomenon and their effects on the Bay's hydrosphere follow.

The sun, the energy source

The Atmosphere interacts with the hydrosphere which means that the air sphere affects the water sphere and vice versa. Before looking at the physical, chemical, biological and geological characteristics of the hydrosphere we should know something about fluid motion in the atmosphere and what causes it.

Engines convert heat to produce motion. Both the hydosphere and atmosphere can be considered as global scale engines with their energy supplied by the sun. Energy transfer by radiation is the mechanism by which the sun's energy arrives at the earth's upper atmosphere.

Uneven heating

When this energy passes through the atmosphere some is absorbed. Forty-seven percent of what started at the upper atmosphere is actually available for absorbtion at the earth's surface. The amount of energy being absorbed per square meter is different at different locations on the earth's surface. Causes for the differences can be classified as either global or regional. In the global category are the earth's spherical shape accounting for less incident sun energy per square meter at the poles than at the equator. Another global scale cause is the tilt of the earth's axis of rotation with respect to its plane of rotation. This phenomena results in the seasons. Regional types of uneven heating occur at the earth's land or water surface and are due to different thermal properties of earth surface materials.

Absorbtivity is a thermal property that tells how much energy will be absorbed compared to the amount incident on a surface. Reflectivity, or albedo effect, tells how much energy will be reflected compared to the amount incident. Specific heat is another thermal property that tells how much energy a given quantity of fluid must absorb to change temperature a specified amount. On a regional scale these thermal properties are different for land and water surfaces.

Density differences

Atmosphere and hydrosphere movement is very dependent on this uneven heating. When a fluid, liquid or gas, is heated it expands and becomes less dense than the cool fluid around it. This less dense fluid will rise up through the surrounding cool fluid and "float" at the "top". Other cool fluid will flow into the volume vacated by the rising warm fluid. What has been described is convection, the movement of heated volumes of a fluid, in this case air, due to density differences.

Fluid density differences can also be the cause of cold dense fluids "sinking" to the "bottom" through warmer less dense fluids. Standing with bare feet while opening the refrigerator door is a good way to experience this phenomenon.

Heat transfer in the marine environment can occur either of two ways. Conduction is heat transfer by transfer of molecular activity from one molecule to another. When the spoon you put in a cup of hot coffee gets too hot on the end it is because heat has been conducted through the spoon. Heat conduction in water is of minor importance because it is a fluid and not a solid.

Being a fluid warm parts of it can move from one area to another by convection. This is the most important heat transfer method in the marine environment results from density differences which in turn are due to salinity and temperature differences.

Wind patterns

Global scale atmosphere density differences due to global uneven heating can be shown to cause global scale wind patterns. These wind patterns can then be used to explain the causes of global scale ocean currents. While ocean current systems are important to the subject of general oceanography, this course is focusing on the Bay and therefore on air - Bay surface interaction effects.

The most obvious air - Bay surface interaction is wind and the waves it generates. There are often true regional wind patterns found certainly along the sea coast and perhaps where the Bay is wide. These convective wind patterns, often referred to as sea breezes, are caused by daytime heating of the land faster than the water. Warm air heated over the land rises to be replaced by cool air from over the water resulting in daytime horizontal landward breezes. The winds peak in early afternoon producing good sailing as well as substantial waves for the small boat.

Understanding convective sea breezes does not require much knowledge of meteorology. To understand the source of most Chesapeake Bay winds does require some knowledge of meteorology. Course participants wanting to learn how winds, as well as precipitation and air temperature are related to high and low pressure systems, air masses, weather fronts and frontal weather and storms read a basic text on meteorology such as Weather for the Mariner by William J. Kotsch, Naval Institute Press.

Wind effects

Wind, whether it be a result of regional or global uneven heating, has an important and easily viewed effect on the hydrosphere. Wind generated wave height will depend on the wind velocity, how long the wind has been blowing, and the distance over which it has blown, or its fetch. Wave action mixes air with the upper layers of the hydropshere providing an important source of dissolved oxygen. Mixing also equalizes water temperatures in the upper layers. When waves break on the shore they dissipate their energy. When this energy dissipation becomes great, shore erosion can result. Such erosion is a serious problem along many Bay shorelines making bulkheading and other erosion prevention structures necessary.

Another interesting wind effect is due to long-term, one direction wind usually from the northwest. The friction of the wind blowing over the water drags the water along and out of bays on the western shore. This water must go someplace and tends to be pushed down the Bay and toward the eastern shore. When this phenomonon is occurring, western shore residents notice abnormally low tides. As soon as the wind stops blowing, the drag force is removed and the bay water level will return to normal.

To measure wind velocity on the research vessel, a hand-held anemometer will be used. Wind direction will be estimated from its direction relative to the vessel's compass heading.

Temperature effects

The most significant effect of air temperature level is its effect on surface water layer temperatures. Air temperature can act to either heat or cool the water. Air temperatures are simply measured with a dry bulb thermometer. At the same time, another thermometer with a wick wetted bulb can measure a wet bulb temperature. Combined wet and dry bulb temperatures can be used to determine the humidity or the amount of water vapor in the air. For any specified temperature there is a definite limit to the quantity of moisture that can be held by the air.

This limit is known as the saturation point. The proportion of water vapor present relative to the maximum quantity is the relative humidity, expressed as a percentage. Atmospheric relative humidity can change two ways. Evaporation from a nearby water body will increase it as will a drop in air temperature. When air temperature drops the air is less able to hold water vapor. For a given body of air, as its temperature drops the relative humidity increases. It may increase to 100% or the saturation point. Any further cooling will cause water vapor to condense and form dew, fog or frost. This temperature at which the air is fully saturated and below which condensation normally occurs is the dew point.

Steam fog is often seen over the Bay rivers in the fall when water temperatures are still high but air temperatures are 18 degrees F. or more cooler than the water. Water evaporating from the surface oversaturates the cold air and forms fog. Because the water surface is warm, convection of the fog is upward so that the steam fog looks like tufts of whirling smoke coming out of the water.

PHYSICAL FACTORS

Data presentation

Marine environmental data can often be presented in one of three graphical methods. Salinity is an ideal variable to use in explaining the three methods. The simplest data presentation is a surface map of salinity at many different locations for a certain time of the year. This type of data for the Bay would take several years to accumulate because the Bay is so large. Figure 10 is an example of such a surface map. The lines of constant salinity are drawn by connecting individual locations having the same surface salinity.

The next most simple type of data presentation is based on taking salinity measurements versus depth at just one location. This data is plotted on graph paper and the result is shown in Figure 5.

When salinity versus depth data is taken at many different locations along a well defined plane, the diagram as shown in Figure 11 is the result. What has been done is to show salinity versus depth and location along the center line of the Bay from its headwaters on the left and its entrance on the right. Location and depth points with the same salinity have been connected to give the lines of constant salinity.

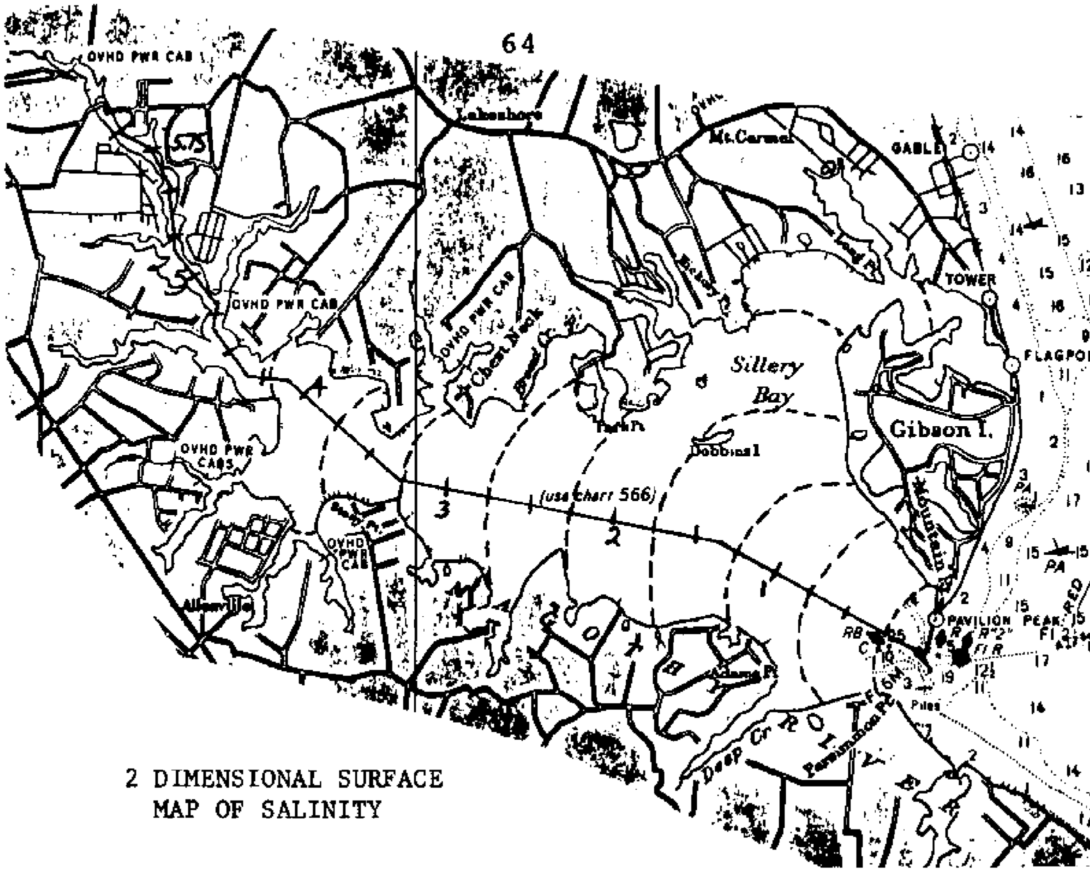
Figure 2 is a composite diagram showing the three data presentation methods for the Magothy River.

Temperature distributions

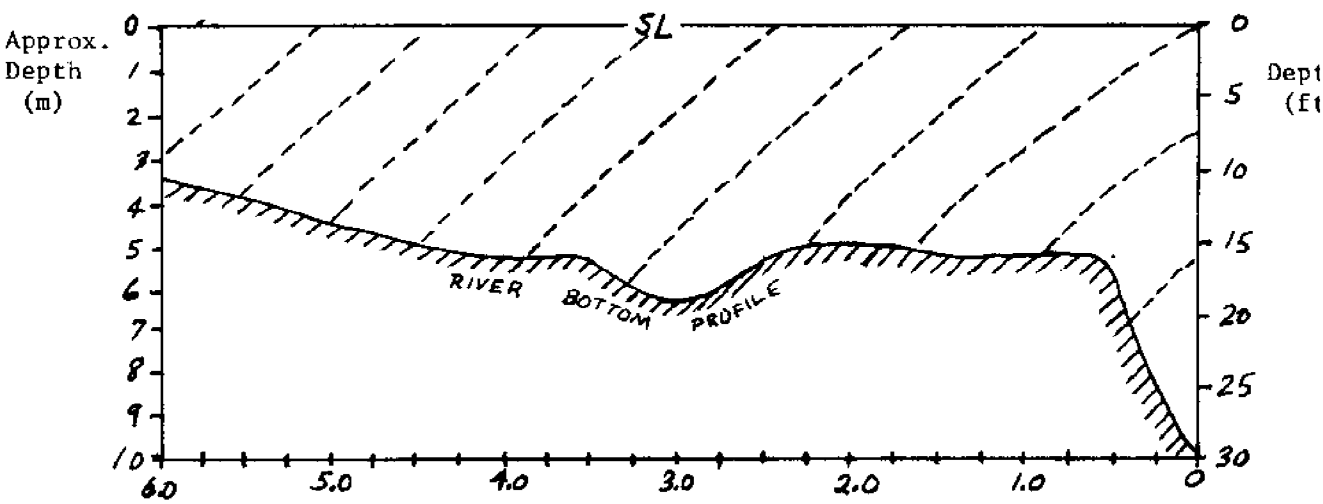
As previously mentioned, the simplest type of temperature data presentation would be a surface map. Because of the shallow nature of the Bay (average depth is 27 feet) the temperature of the waters are subject to large seasonal changes. Summer surface maximum is about 25 degrees C (75 degrees F) in open Bay waters, and can reach near 30 degree C (90 degrees F) in marshes and shallow creeks on hot, windless days.

Winter minimum often approaches 0 degrees C in upper Bay waters, where ice forms for short periods, whereas the lower bay almost never experiences freezing, temperatures rarely falling below about 5 degrees C (40 degrees F).

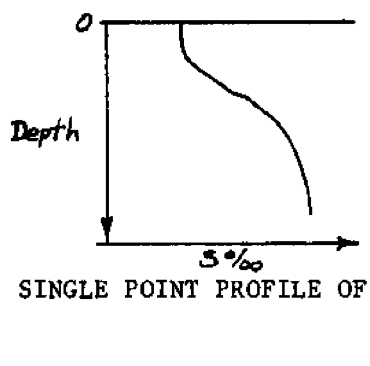
The distribution of Mean temperature vs. depth is different for esturaries than for marine or fresh water



2 DIMENSIONAL SURFACE MAP OF SALINITY

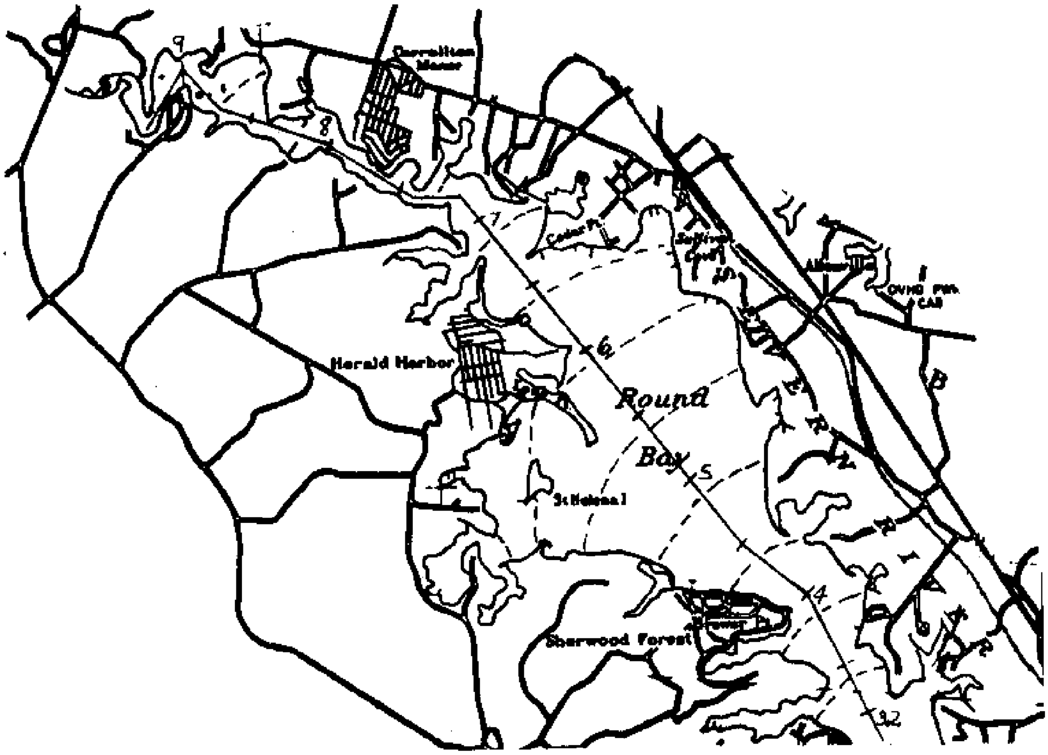


2 DIMENSIONAL SUBSURFACE PROFILE OF SALINITY

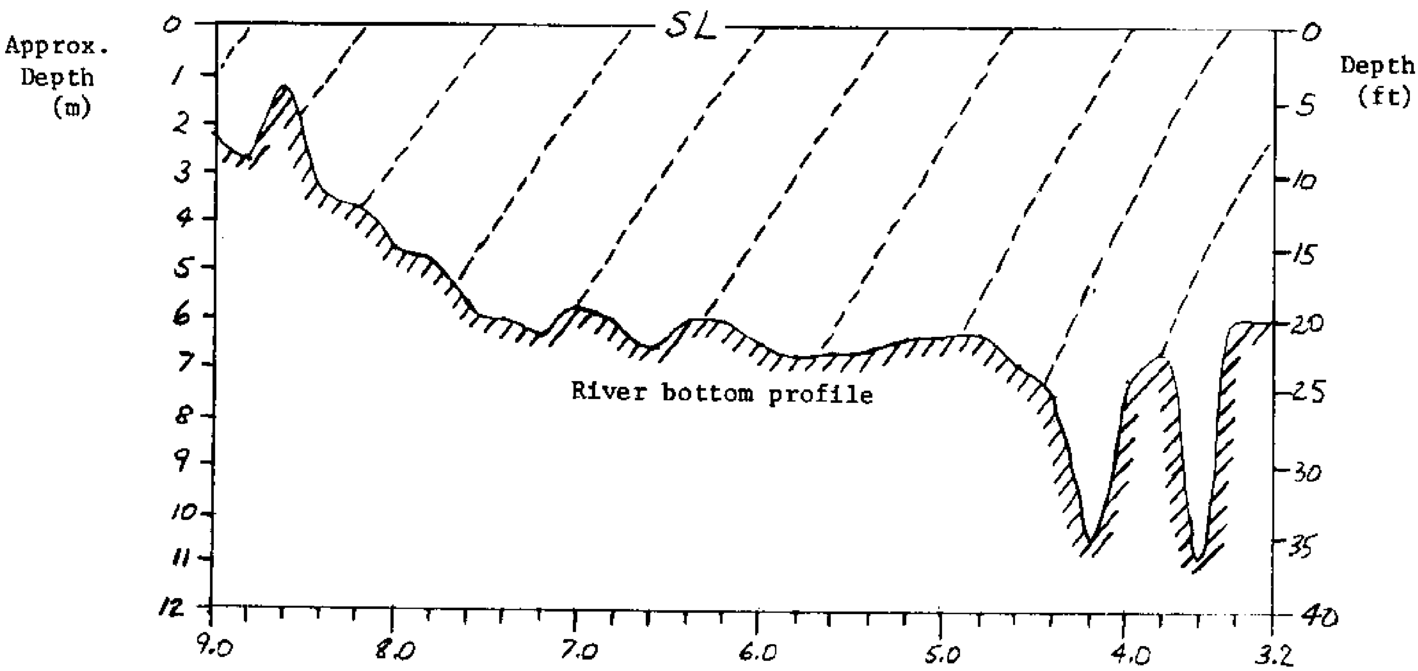


SINGLE POINT PROFILE OF SALINITY

Figure 2



2 DIMENSIONAL SURFACE
MAP OF SALINITY



Distance from Chase Creek (miles)
2 DIMENSIONAL SUBSURFACE PROFILE OF SALINITY

Figure 2a

regions because of the stable density stratification which have both salt and freshwater regimes.

The following Figures 3 and 4 shows a typical summer profile characterized by a very warm surface layer above a much cooler, heavier, more saline layer. These vertical temperature profiles are strongly influenced by heating at the surface either by radiant energy from the sun or by air temperature. Sometimes several layers are discerned from the temperature profile. The regions where the temperature changes rapidly with depth are called thermoclines.

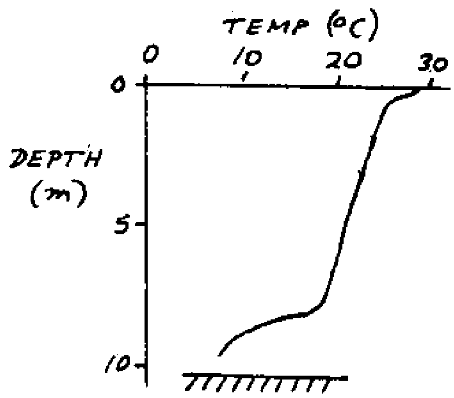


Figure 3

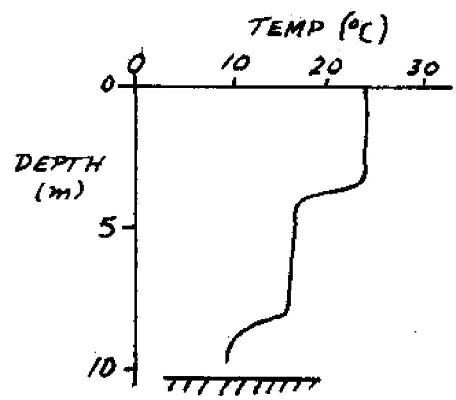


Figure 4

In winter, surface layer water cooling takes place due to reduced radiant energy from the sun or lowered air temperatures. This lowers the temperatures of the upper layers <u>below</u> the temperature of the deeper layers. Because the density of the upper layers still does not exceed that of the more saline deep waters, a stable condition with <u>positive temperature gradients</u> exists. See following Figure 5.

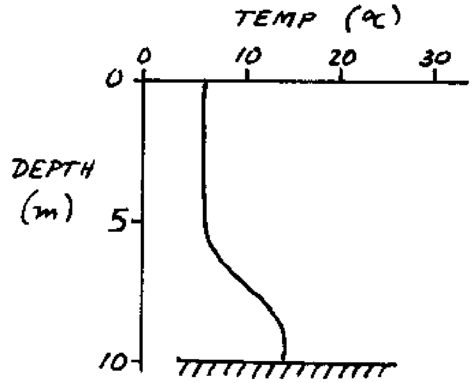


Figure 5

The distinct temperature profiles tend to be disturbed by mixing either at the surface due to wave action or throughout the total water column by tidal currents.

The two dimensional temperature distribution along the center line of the Bay for summer and winter are shown in Figures 6 and 7.

Why measure temperature?

There are many reasons why scientists would be measuring the Bay temperature. One important reason that is more related to open-ocean oceanography than it is to Bay studies is in the determination of water density at the sampling location and depth. Sea water density is dependent on the water's temperature, salinity and depth. Depth effects on density in the Bay are small and are neglected. Therefore, to calculate the density of a Bay water sample you would measure its temperature and salinity. Figures 3 and 4 shown water layers defined by their temperature structures. Polluntants with a certain density dumped into Bay waters may sink to a layer defined by the temperature structure and having a similar density. Fish can be located by finding areas with appropriate temperatures. Scientists may be interested in determining the extent of a hot water plume being discharged into the Bay from a power plant. Temperature structures in the marine environment can be an indicator of convection. Warm surface water moved down or away from a source - such as current. Cold deep water moving up in a region of upwelling. For instance, Gulf Stream boundaries can be determined by measuring surface temperatures.

Methods of measurement

Water surface temperatures are measured simply by obtaining a bucketful of water and quickly obtaining the temperature with a mercury thermometer. Temperature at depth is measured with reversing thermometer, a thermistor probe on a cable, or a bathythermograph. A reversing thermometer is a mercury thermometer so designed as to remain at the temperature of water when it is overturned (reversed). Thermistors are most often combined with other sensors and lowered from a single cable also carrying the necessary conducting wires. Abbreviations such as TDC (Temperature, Depth, Conductivity) recorder are used to designate such devices. A bathythermograph was devised to quickly measure temperature as a function of depth; it is a mechanical device combining a Xylene filled tube as temperature sensor with a simple diaphragm type pressure sensor, which act together to produce a trace on a gold coated glass slide.

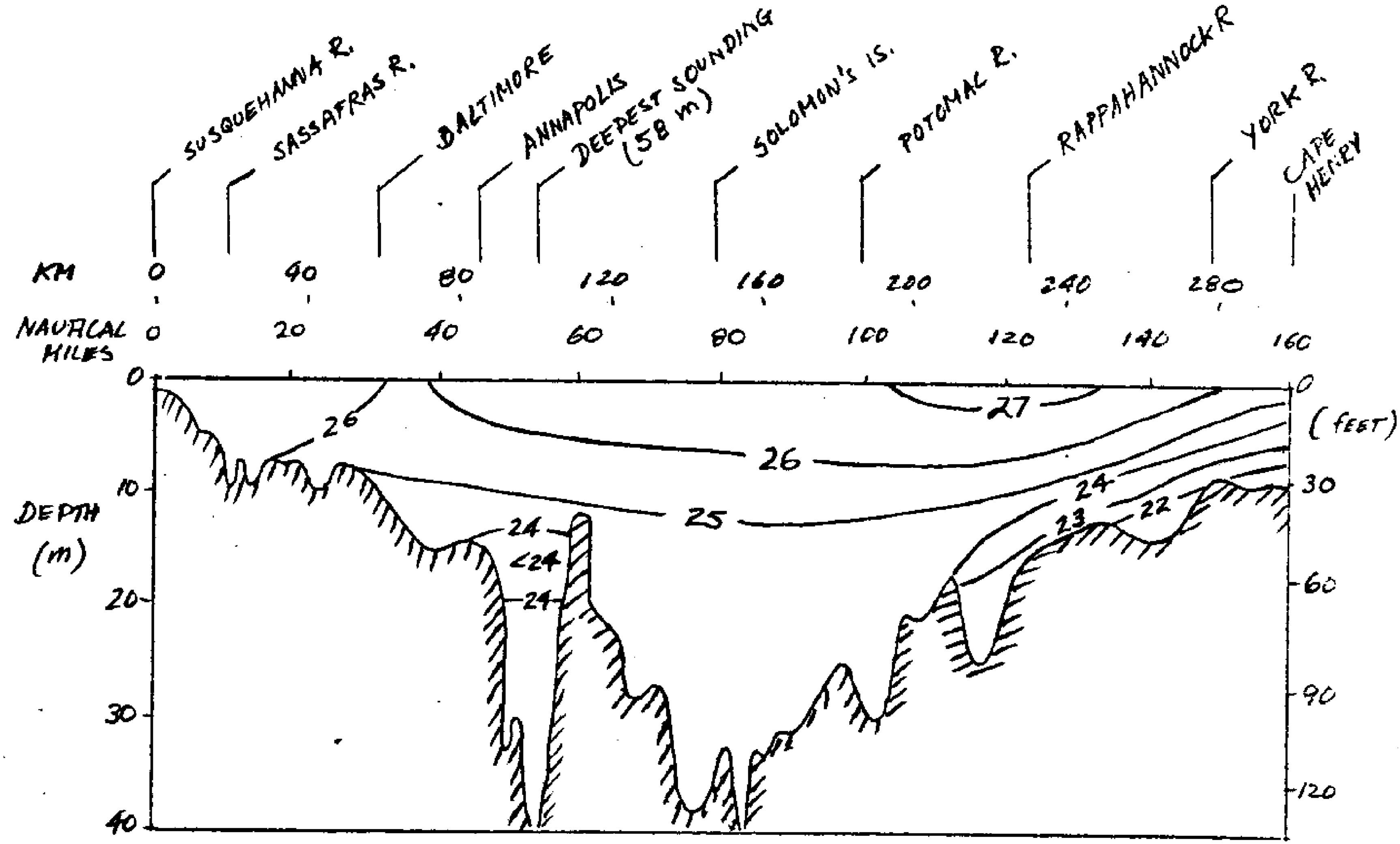


Figure 6

TEMPERATURE DISTRIBUTION - SUMMER

°C

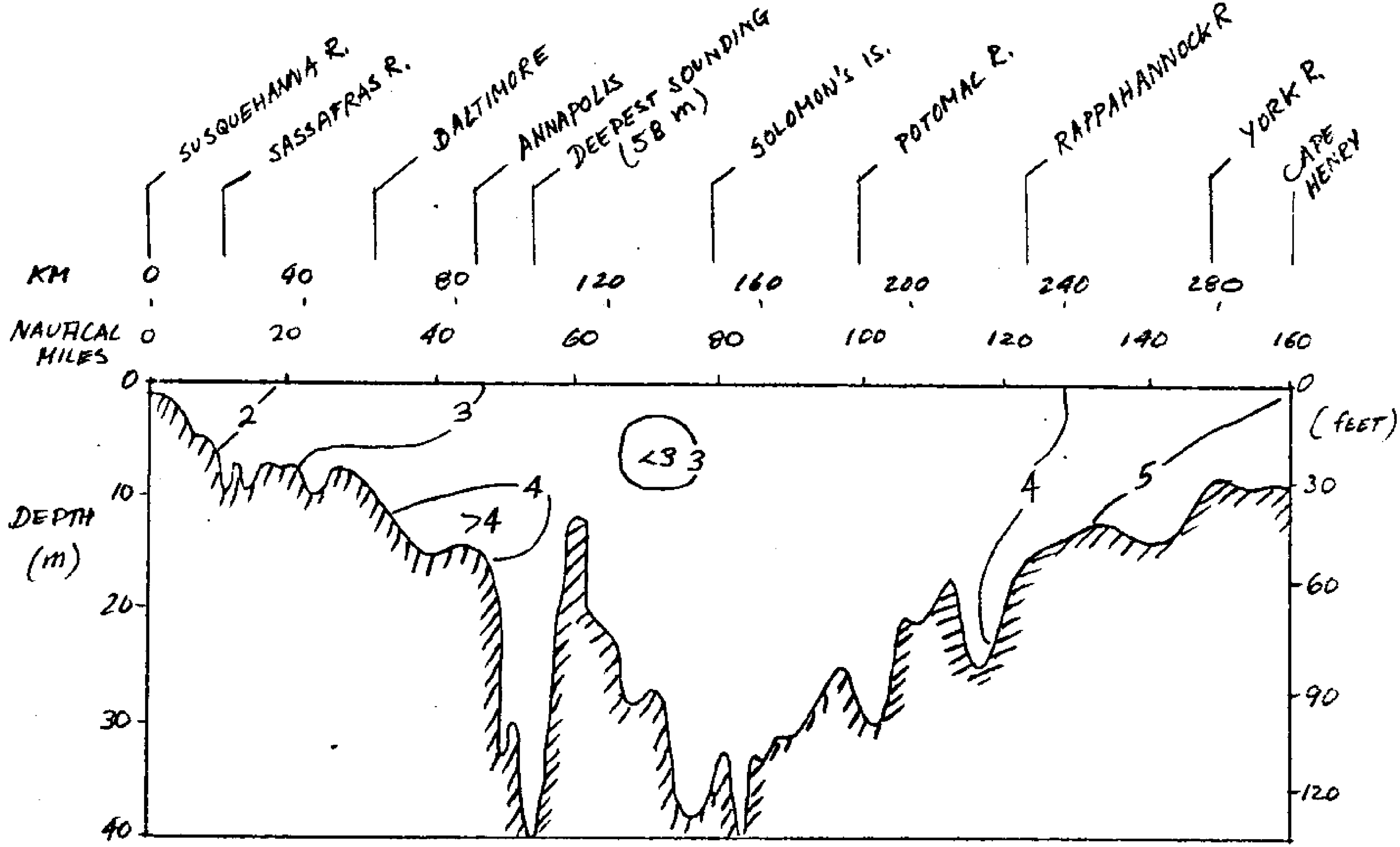


Figure 7

TEMPERATURE DISTRIBUTION °C - WINTER

<u>Salinity distribution</u>

Salinity is often written as $S^0/00$. The definition of salinity is the total amount of dissolved solids per 1000 units of solution. Percent or parts per 100 is shown as $^0/0$ whereas salinity parts per 1000 is shown as $^0/00$. Typical open-ocean salinities are about $34.8^0/00$. Bay salinity off Annapolis in the fall is about $13^0/00$.

In the definition of the estuary we spoke of the mixing of river-derived fresh water with the salty water from the sea. It must be noted that this mixing is not nearly as complete as might be expected. This can be seen by the surface salinity chart, Figure 10, which shows that salinity decreases with distances from the mouth of the Bay. The decrease is not uniform, however. It varies seasonally because river flow varies with run-off, it also varies as a function of depth and it varies as a result of the coriolis acceleration which affects water motion.

Just how the Bay salinity is affected by evaporation and precipitation is shown by the hydrological cycle. This shows evaporation of Bay and other waters to vapor, transport of that vapor over land, its condensation to precipitation which returns to the Bay as run-off. Bay salinities will usually be increasing if evaporation exceeds precipitation induced run-off and decreasing if run-off exceeds evaporation.

The next diagram, Figure 8, shows salinity as a function of depth:

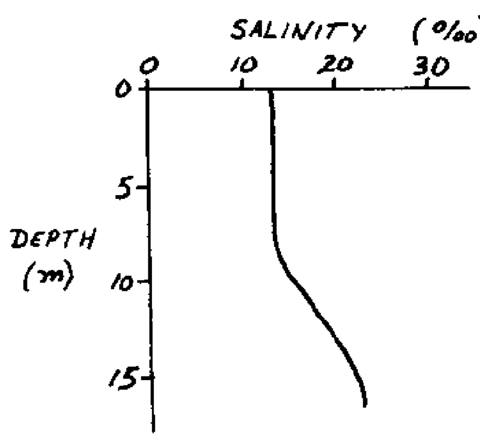


Figure 8

The diagram illustrates that mixing is minimized because of the density differences of fresh and salty water. The salty, heavier water tends to stay near the bottom, while the less saline, brackish to fresh water tends to remain near the surface. It is this natural stability that tends to slow down and modify the mixing process. Figure 11 is another vertical salinity profile.

The effect of coriolis acceleration is to deflect moving objects to the right in the northern hemisphere. It should be realized that the effect is very small, however. For example the coriolis acceleration amounts to only about .000015g on a 2-knot current, g being the force of gravity.

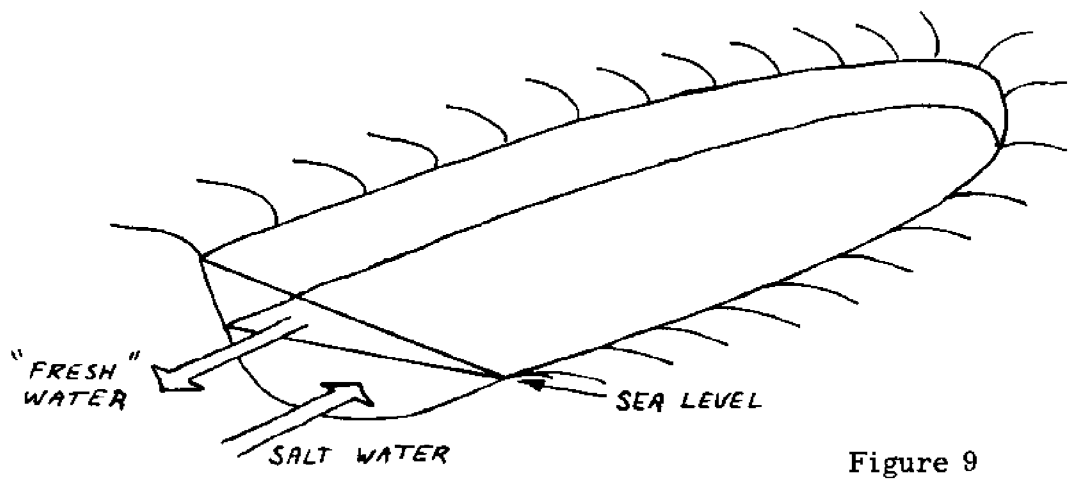


Figure 9

This leads to lowering of the depth of the fresh water layer on the western (right-hand side facing the mouth) side of the Bay, while the salty layer, moving up the Bay (albeit slowly) comes closer to the surface on the eastern side (right-hand side facing the headwaters). Such a structure is difficult to determine experimentally.

Figure 10 shows a surface map of summer salinity values. Winter salinities will be lower.

<u>Why measure salinity?</u>

Measurements of salinity along with temperature have already been mentioned as necessary for determining seawater density. Knowing the salinities tells a

SURFACE SALINITY - SUMMER

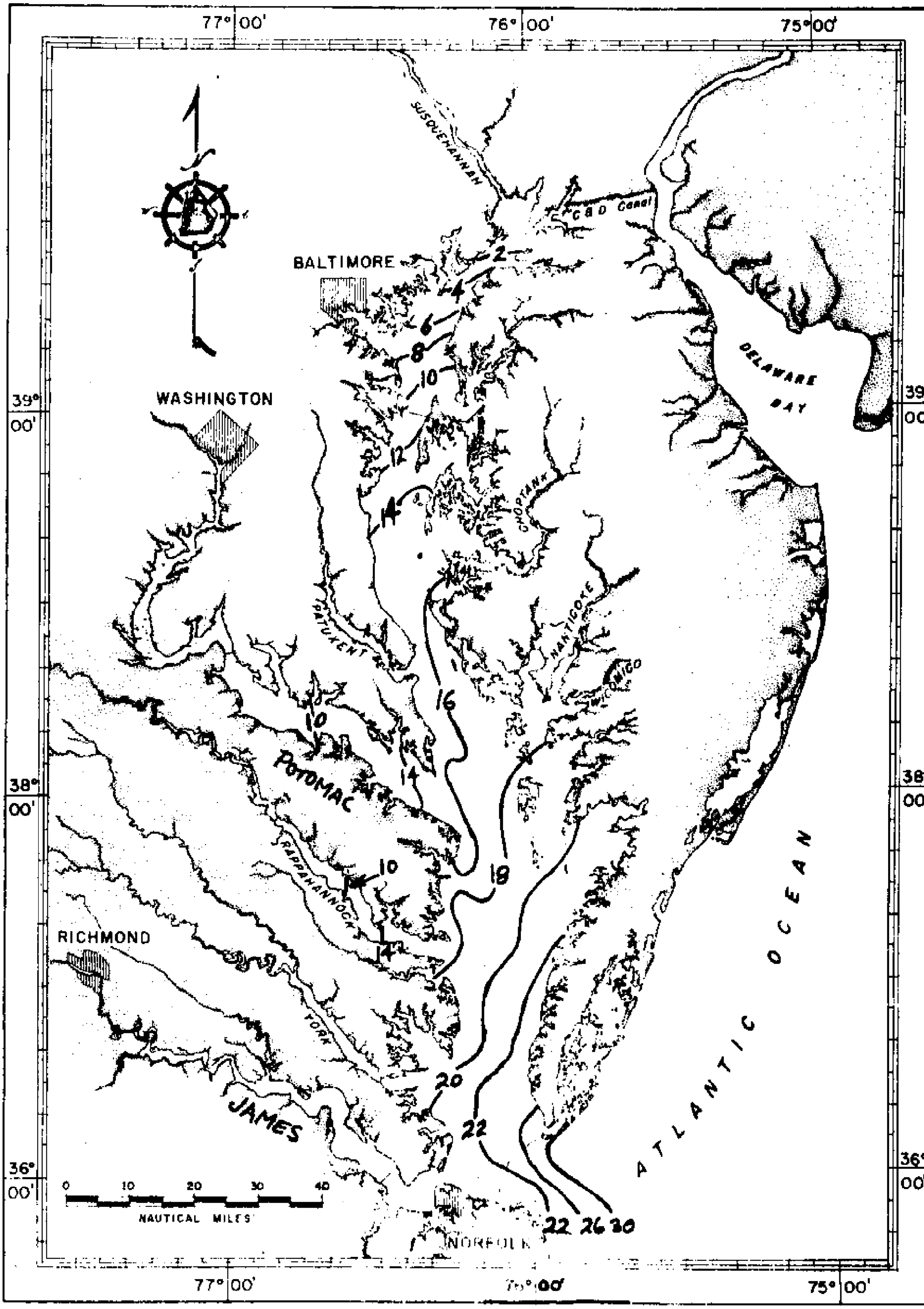


Figure 10

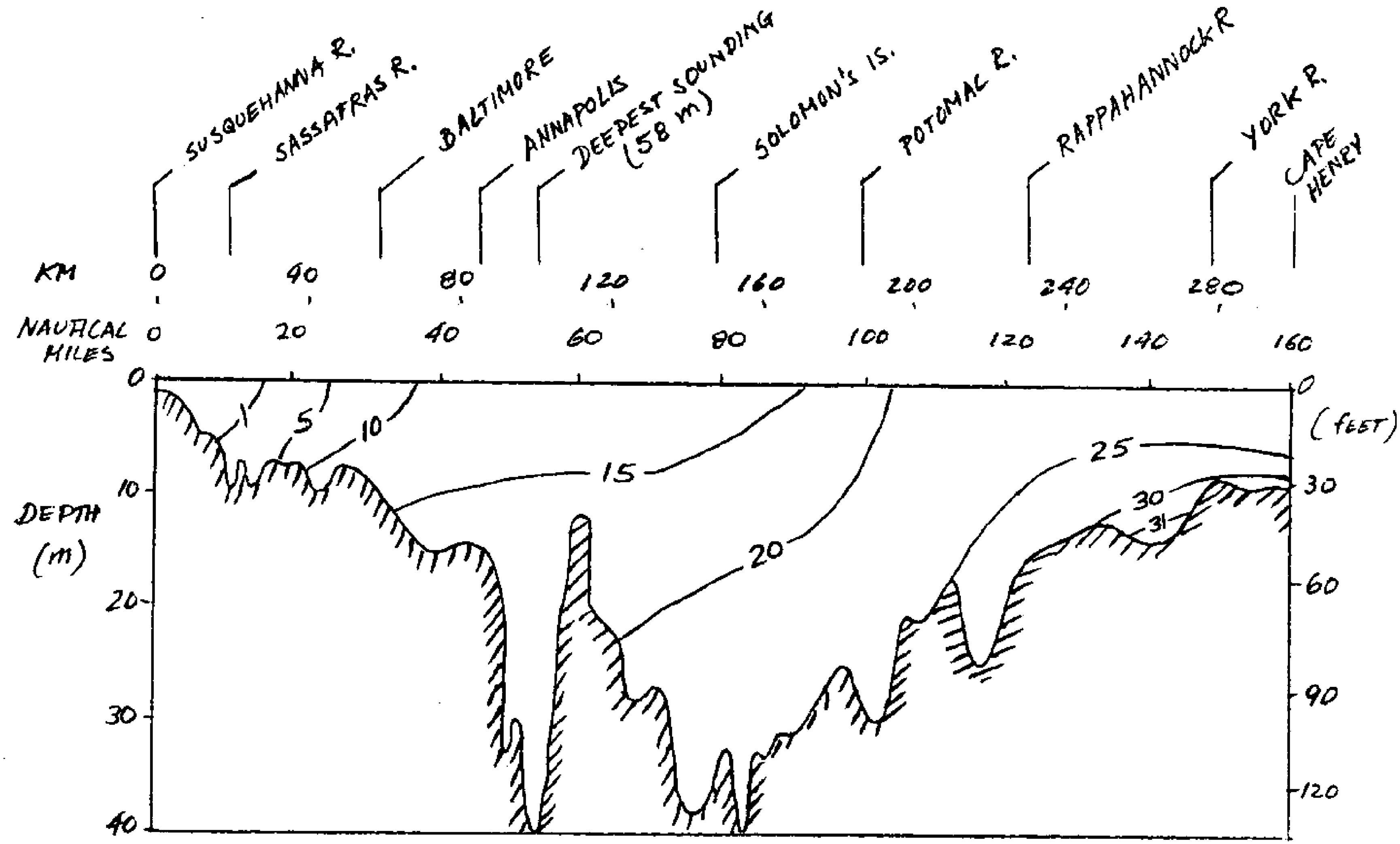


Figure 11
SALINITY DISTRIBUTION ‰-SUMMER

scientist about the relationships between evaporation and run-off. Marine biologists interested in oyster management are concerned with salinity because of its effect on the oyster's growth and spawning as well as the presence of the oyster drill which lives in saltier habitats. Many fish are andromodous which means that they lay their eggs in fresh water (heads of creeks and inlets) and spend the rest of their lives in saltier water, for example rockfish. Blue crabs on the other hand lay their eggs in the saltier region and spend the rest of their lives in the fresher regions of the Bay.

Methods of measurement

Salinity, which is a measure of the total weight of dissolved solids in the water, is measured in several ways. The most important way relies on the fact that the electrical conductivity of seawater is proportional to the amount of dissolved solids. A measure of the conductivity will allow rapid determination of salinity, if temperature changes are accounted for. The other technique is to measure the chloride ion concentration by chemical means and relate that to the total salinity by an equation known as Knudson's equation. These two techniques are most important both historically and presently. Other techniques relate salinity to readily measured parameters such as the index of refraction, or the speed velocity of the water.

Light penetration

Material that becomes mixed and suspended in water to reduce its clarity makes the water turbid. Materials contributing to this turbidity are varied. In the summer, an important constituent are the plankton. These organisms are growing and multiplying rapidly in the warm, sunlit, nutrient rich water. During periods of heavy run-off, silt-laden surface water can be seen flowing into the Bay. In shallow areas, wind-generated waves and boat wakes interact with the bottom to stir up sediments. Wind and boat generated waves breaking on shore also contribute to turbidity. In the water, the zone illuminated sufficiently by sunlight to allow photosynthesis is called EUPHOTIC ZONE. Where light levels drop off, either at great ocean depths, or only a few meters or tens of meters down in turbid estuarine waters, we speak of the APHOTIC ZONE.

Why measure light penetration?

An understanding of the distribution of sunlight in the water is a requirement in order to assess or measure primary productivity. Primary productivity is a biologist's term referring to the amount of inorganic materials converted into living matter in the process of photosynthesis. Only plants are able to do this, because they possess the necessary pigment, chlorophyll. While the steps involved are quite complex, we summarize as follows:

$$CO_2 + H_2O \xrightarrow[\text{photosynthesis}]{\text{sunlight}} C_6H_{12}O_6 + O_2$$

This chemical equation says that in the presence of sufficient sunlight the primary producers convert carbon dioxide and water into simple sugars (carbohydrates) and oxygen. In the sea the primary producers are planktonic algae called phytoplankton, seaweeds, rooted aquatic plants and grasses. Phytoplankton, tiny drifting organisms, are of greatest importance. So the amount of light is proportional to the productivity. Because of this the amount of turbidity is also measured as an indicator of water quality.

Methods of measurement

We see now how a determination of the light intensity below the surface is very important when measuring primary productivity. The most commonly used tool is a submarine photometer. A submarine photometer consists of a photocell lowered into the water and connected to a read-out device, a millivoltmeter, on deck. By setting the light intensity at the surface - actually just below the surface - to 100%, a series of measurements at different depths quickly establishes the data curve from which the EXTINCTION coefficient can be calculated. A typical profile of % light intensity VERSUS depth might look like this for Chesapeake Bay waters:

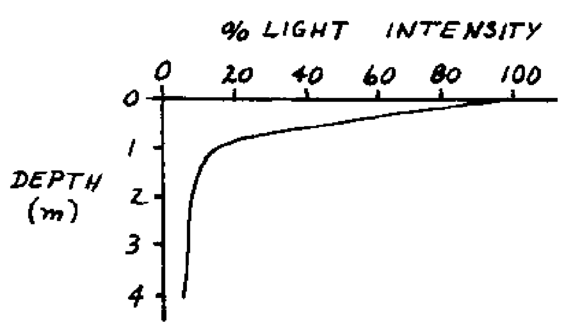


Figure 12

Such a curve is typical of an exponential absorption (extinction) process, which is indeed the case for light absorption in water. When such a curve is plotted on a semi-log scale, a straight line results:

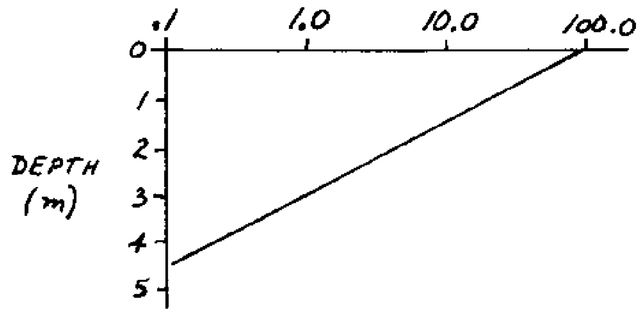


Figure 13

The slope of the line is the extinction coefficient, while the depth where the light intensity is between 1% and 3% is the bottom of the euphotic zone. In the Chesapeake Bay this depth is often 1 or 2 meters during the summer, but may be 5 meters or so in some locations during the winter.

The submarine photometer uses the sun as its light source. Therefore, it cannot be used at depths where sunlight cannot penetrate. In these situations, a transmissometer which is similar to the photocell but carries its own light source with it is used.

An older, less reliable technique relates light extinction to the depth at which a white disc, about 30 cm across and called a SECCHI DISK, disappears from view. This technique is quick, simple and uses inexpensive equipment, and results can be compared to many previous measurements so that some useful information is generally obtained.

Currents and tides

Currents are the horizontal movement of water. In the Chesapeake Bay, currents are produced by tidal forces, river discharges and run-off, and short-term perturbations of sea level called seiches. This is in contrast to the open ocean where the forces causing major ocean currents come primarily from the winds and from unequal heating and cooling of ocean waters.

River discharges are most easily analyzed. River flow is not nearly as much as may be guessed at first glance. The Susquehanna River supplies 40% of the total water influx into the Chesapeake Bay, the Potomac River about 18% and the James 15%. The rivers of the western shore, having sources in the Shenandoah Mountains and other nearby regions contribute far more than the rivers of the eastern shore, which drain rather small basins. If river discharge were solely responsible for currents in the Bay, velocities would probably never exceed ½ knot (a knot is the speed of one nautical mile/hour). This would be most likely in the spring, when heavy rainfall combines with meltwater from mountains to increase riverflow to nearly ten times the flow during the end of the relatively dry summer-autum season. For example, average flow of the Potomac River is around 11,000 cfs (cubic feet per second). Flood stages may raise flow to 120,000 cfs, while hurricane Agnes increased flow to nearly 200,000 cfs.

Tidal forces produce currents with much higher velocities, the net flow, however, is nearly nil. The rise and fall of sea level known as the tide results from gravitational interactions of the earth-moon and the earth-sun system. The moon, while only a tiny fraction of the sun's size, accounts for 54% of tidal force, because it is so much closer than the sun (approximately 350,000 mi compared to 93,000,000 mi for the sun). In the Chesapeake Bay the tide behaves like a progressive wave traveling up from Cape Henry, the mouth of the Bay. High water level with slack (zero) currents respresents the crest of the wave, while low water (also slack currents) represents the trough. Crest and trough travel north at a speed determined by the average water depth; this speed is nearly 20 mph. The enclosed charts, Figures 14 and 15, show how this tidal wave travels, and the direction of the currents during the ebb and flood stages. Maximum currents rarely exceed 2 knots, and diminish in the upper Bay to about 1 knot. Similarly, the height of the tide in the Bay is just over 3 feet in the lower Bay and diminishes to about 1 foot in the Bay. Interestingly, the channeling effect on the tide in rivers is to increase the height of the tide. Thus, at the mouth of the Potomac the tide range is 1½ feet, while near Chain Bridge in Georgetown, D.C. the tide range is nearly 4 feet.

Seiches are oscillations in water level produced by standing waves and are caused by meteorological disturbances, such as severe winds, occurring in part of the Bay. A standing wave is produced in a teacup when it is jarred and oscillations are produced. The period of these oscillations, that is the time between successive high (or low) water levels depends on the length, width, depth and shape of the basin, as well as its connection with the sea, if any. Periods may be only a few minutes or several hours, changes in level a few centimeters or several meters. Because periods are generally short and changes in sea level small, currents are produced in harbors (not on the Chesapeake) such currents can become considerable and are known as surges.

To determine tidal currents, you would need Tidal Current Tables (year of interest), Atlantic Coast of North America published by the National Oceanic and Atmospheric Administration. First look in the index for the place of interest and its station number. For this example, we will use the Severn River Cedar Point station 2128. Then look in Table 2 for either the station number, 2128, or the place, Cedar Point. The times (hours and minutes) of slack water or minimum current and maximum current are given referenced to the times for Baltimore Harbor approach. Those times as a function of date are given in Table 1 of the same publication.

Why measure currents?

Navigation needs are an important reason for knowing about currents. Captains of vessels moving about on the Bay want to know the directions and velocities of currents. They want this information so they can plan their travels with the currents instead of against them and so they can avoid dangerous cross currents in areas where there is much boat traffic.

Another reason for studying currents is their effect on movement of pollutants. No one would want to build a sewage outfall where there are no currents to mix and disperse the discharge. Current measurements would therefore be made as part of the design project.

When building a bridge that is supported by underwater pilings, engineers will want to know current velocities near the piling locations. They will need this information to determine if there is a possiblity of sediment erosion or scour around the pilings.

Geologists are interested in current information as it affects sediment movement either in deep water or along the shoreline.

TIDAL CURRENTS — SLACK WATER AT CAPE HENRY

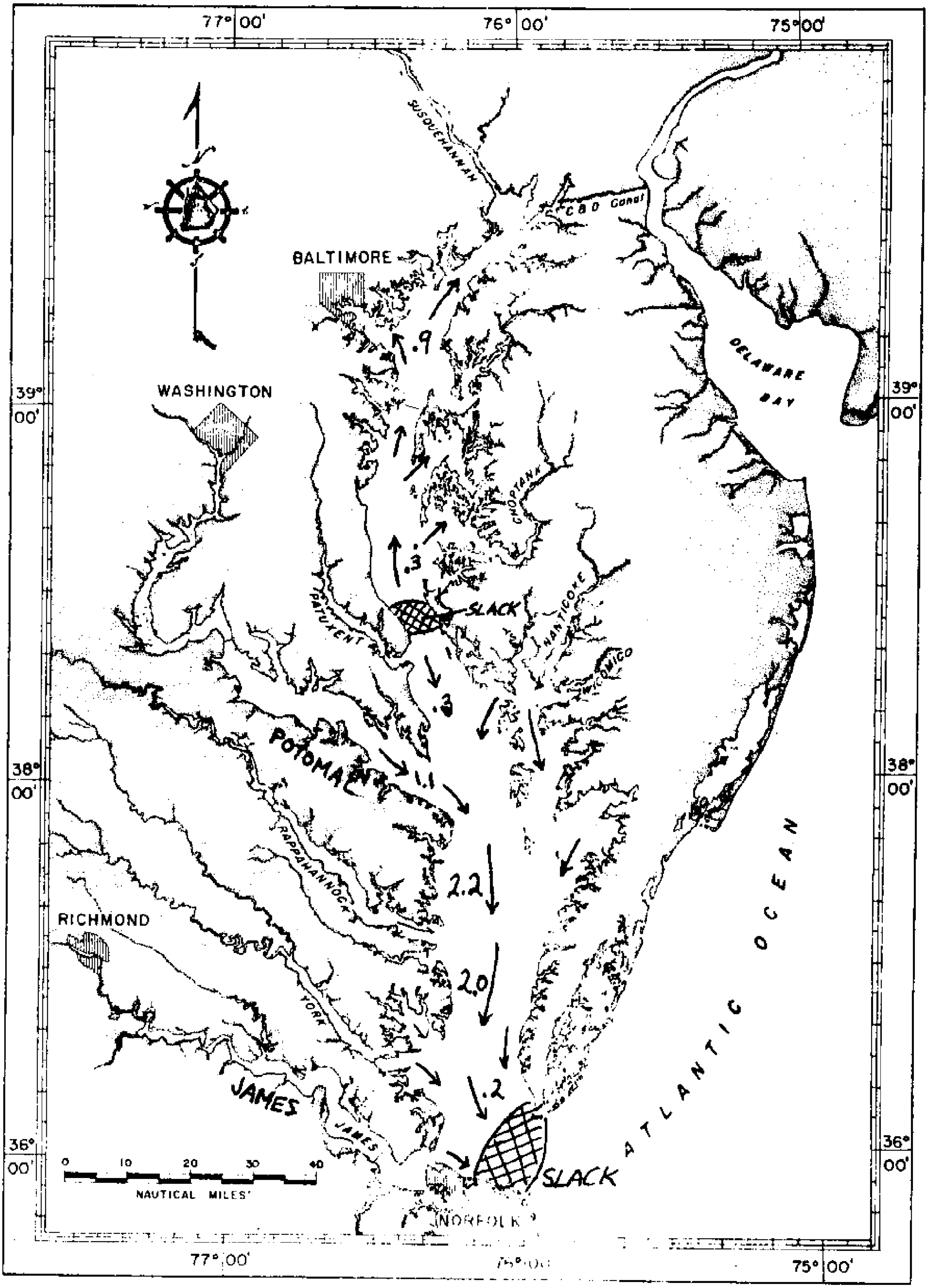


Figure 14

TIDAL CURRENTS - 2 hrs. AFTER SLACK AT CAPE HENRY

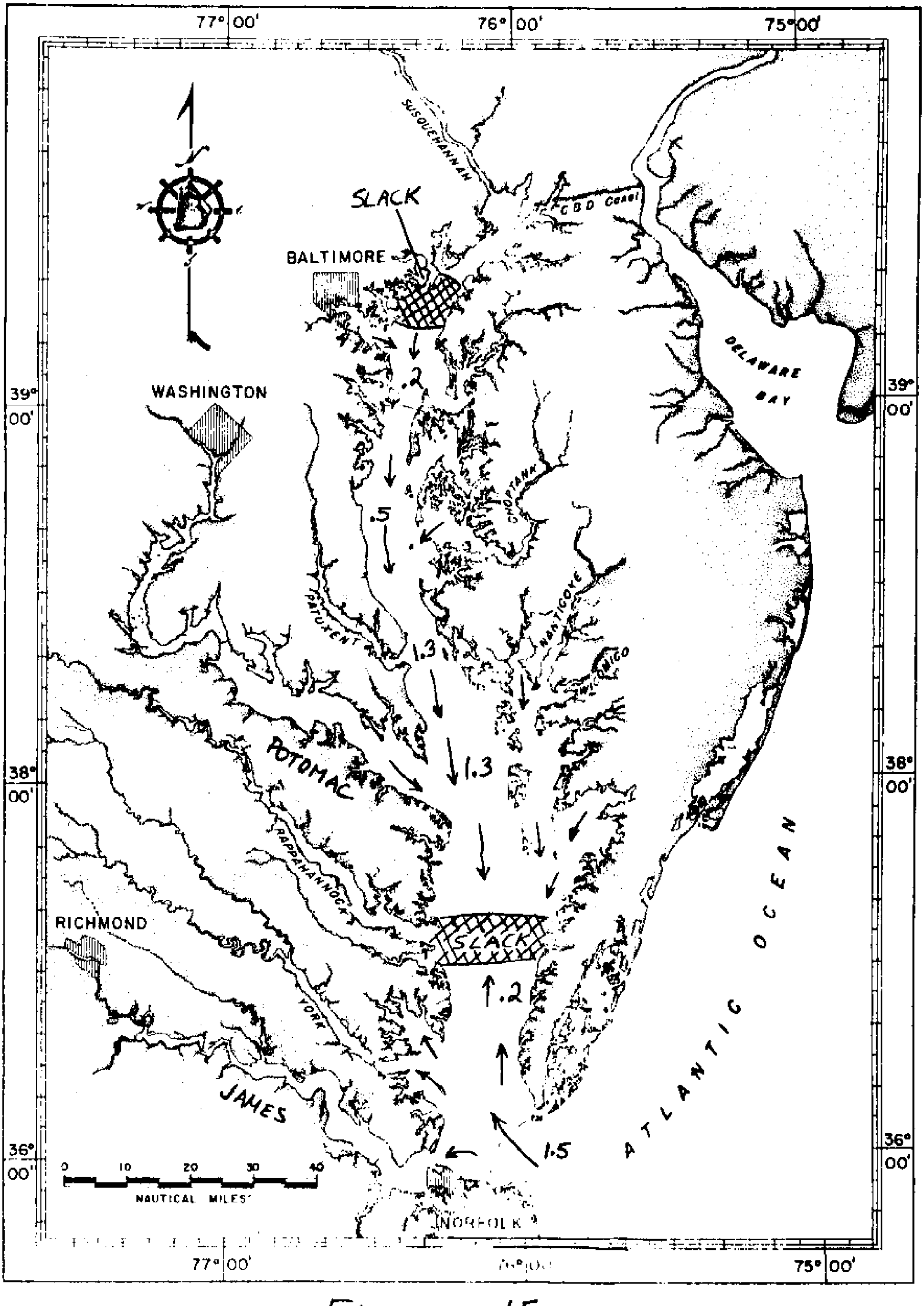


Figure 15

Tidal currents in the Bay tend to distort temperature and salinity profiles. Occasionally, currents, especially in the ocean, are responsible for carrying unfamiliar organisms into a region.

Methods of measurement

Tides are most simply measured with a tide staff, nothing more than a graduated rod set in the water. Unfortunately, it requires continuous or frequent observations. A tide recorder relieves one of this burden. A tide recorder may consist of a pressure sensor mounted in the water just below the extreme low water level, connected to a recorder with a clock drive or electrically driven. A pressure sensor may be mechanical, a diaphragm or bourdon tube, or electromechanical such as pressure transducer. Another technique uses a float in a tube connected with a small opening to the sea with a recording pen writing on a suitable recorder. The opening to the sea must be so as to dampen oscillations in the level produced by waves.

Tidal and other currents are measured by two major techniques. In one, the current moves a wheel, propeller, or rotor connected to a recorder or read-out unit. The assembly must be fixed firmly in position and suitably calibrated. The other technique is to measure the time over which an object floats in the current over a known distance.

Speed = Distance/Time.

Suitable objects may be bottles or cards weighed to float nearly submerged, drogues made of plywood or parachutes, or seabed drifters which drag along barely off the bottom. Recovery of the last few is a chancy business, of course. On the Chesapeake Bay, current meters employing a rotor or propeller are most easily used, although suitable positioning may be difficult.

CHEMICAL FACTORS

In this study guide, chemical factors are being discussed separately even though they have a close relationship with physical, geological and biological factors in the marine and estaurine environments.

Salinity

This subject can be considered a chemical factor. It has, however, already been discussed.

Dissolved gases

The movement and distribution of some dissolved gases is very important in understanding the biological environment. Carbon dioxide is widely distributed in the water and closely associated with the amount of carbonates in the sea. Hydrogen sulfide is very toxic to most living things, it is often produced when dead organisms decay in the absence of oxygen. This often happens in sediments underlying high stratified waters, and can be noticed in Chesapeake marshes and ponds. (The smell is like rotten eggs).

Dissolved oxygen

Most living organisms require oxygen for respiration although the photosynthetic plants produce more oxygen then they use. Oxygen is poorly soluble in water, roughly 10 ppm (parts per million) at 0 - 2 degrees C compared to almost 1700 ppm for carbon dioxide at the same temperature. When oxygen levels fall below about 3 - 5 ppm fish and many other marine organisms cannot survive. These low levels of dissolved oxygen may be due to:

1. the over heating of the water (eg. near a power plant)
2. the addition of decaying matter which stimulates growth of bacteria which utilize oxygen in respiration
3. the addition of sewage or other nutrients which over-stimulates the algae production which initially increases the oxygen but later the respiration of too much algae causes oxygen depletion at night.

Distribution

In general, oxygen levels at the surface are near saturation (the maximum level sustained at the temperature), and fall off with depth. Only in very deep water will oxygen levels increase, this is because the high pressure increases solubility. A typical profile in the Chesapeake may be as shown in Figure 16.

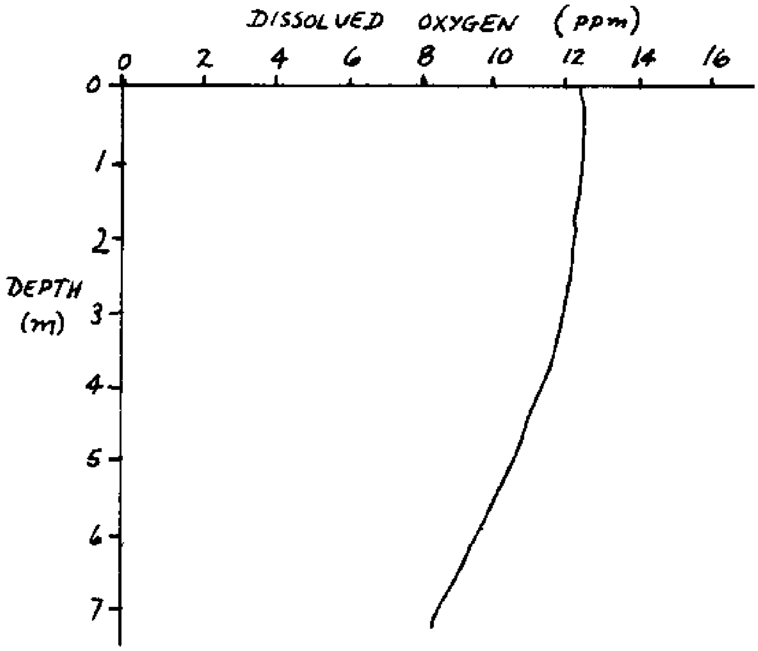


Figure 16

Why measure dissolved oxygen?

Dissolved oxygen is often measured because of its relationship to plant productivity in water. The procedure is to take two samples of water in identical bottles except that one bottle is transparent to light and the other opaque. Starting dissolved oxygen levels are measured in each bottle then the bottles are placed in a temperature bath at the same temperature as the sampled environment. In the opaque bottle, the same thing is happening in addition to oxygen production by plants photosynthesizing. At the end of a specified time span, dissolved oxygen levels in both bottles is measured and the difference related to productivity.

Dissolved oxygen levels are an indicator of water quality. Bodies of water which have low amounts of dissolved oxygen also have poor balance between the animals and plants. Eutrophication is the term describing this condition where there is an excess of phytoplankton compared to zooplankton so the ecological balance is upset and the result we see is fish kills.

Methods of measurement for dissolved oxygen

The older and still somewhat more precise technique of measuring oxygen concentration is called the WINKLER TITRATION. Here a water sample is chemically treated to combine the oxygen with a substance called manganous hydroxide. The resulting chemical is reacted with another such that a color change indicates when all oxygen has chemically reacted. After a few calculations, the oxygen concentration in milligrams/liters is obtained.

Much easier, but not quite as reliable, is the dissolved oxygen meter. Here oxygen penetrates a teflon membrane in the sensing probe and changes the conductivity is measured by the read-out box and indicates the amount of dissolved oxygen in the water.

pH

pH is a measure of hydroxide ions (OH^-) in a solution. The pH number is the log of the number of ions in a mole of solution if a solution has a pH of 8 there are 10^8 OH^- per mole. Water molecules (H_2O) can disassociate into hydrogen (H^+) and hydroxide (OH^-) ions, if the water is distilled then there will be an equal number of H^+ and OH^-, the number of each type of ion will be 10^7. The pH of pure water than is 7 which is nuetral. If the pH is higher than 7 then the solution is basic or alkaline; if the pH is lower than 7, then the solution is acidic. The range of pH is from 1 (concentrated sulphuric acid, stronger than battery acid) to 14 (concentrated sodium hydroxide, contained in Drano.) Seawater has a pH of 7.4 to 8.2 so it is slightly alkaline.

Why measure pH?

pH of less than 5 or greater than 9 is taken to mean that water is seriously polluted, such as from mine acid water discharge, a problem in West Virginia rivers, or industrial discharges. Some deep basins isolated from the open sea have pH values of 3-5 from naturally arising conditions.

Methods of measurement

The most convenient method for accurately measuring pH is electronically. In this method, electrodes are placed in the water sample that are designed to produce an electrical signal in the presence of hydrogen (H+) and hydroxide (OH-) ions.

Reagents can be added to a water sample that change color depending on the pH of the sample. The color can then be compared visually to some standard colors to determine the sample pH. A spectrophotometer that shines light through a filter and the sample with added reagent and then measures the resulting light intensity can also be used to determine pH.

Other dissolved substances

In estuaries such as the Chesapeake other dissolved substances are of interest chiefly as an indication of the health of the Bay's water. We may distinquish 2 types of substances - NUTRIENTS AND TOXINS. Surprisingly, even nutrients may be harmful when available in excess as discussed under dissolved oxygen. Chief offenders are nitrates and phosphates. Sources may be natural such as sediments and substances in river discharge, or man-made such as agricultural fertilizers, sewage sludge and detergents containing phosphate.

Unfortunately, toxins are primarily man-derived being the by-products of advanced industrialization. They may be radioactive or organo-halogens which are carcinogenic (cancer causing), pesticides and herbicides, heavy metals such as cadmium, arsenic, lead, cooper, etc., or hydrocarbons, solvents, acids, and caustics. Some are bio-degradable, evaporate, or oxidize and so pose only a short-time hazard, others are long lasting, non-destructible and can be concentrated by organisms once they enter the food chain. Sometimes concentrations must be in the ppt (part per thousand) range before they become harmful, sometimes as little as a few ppm (part per million) constitute a hazard. Plutonium, said to be the most toxic substance known to man, is hazardous at a fraction of a ppb (part per billion).

The study of the concentration, fate, dispersion, and methods of removal or prevention of dissolved substances must be an ongoing process and of concern even to the layman.

Methods of measurement

Sampling the marine environment to obtain enough water for analysis is relatively easy. Dipping a bucket of water or filling a bottle by hand could be the technique used. To obtain a sample from below the surface, someone could use a sampling bottle that can be lowered to the desired depth in an open position and then closed remotely by sliding a messenger down the lowering cable. An electrically powered submersible seawater pump could be attached to a hose and lowered to the desired depth to pump up the sample. Measuring the concentration of dissolved substances in place (or in situ) is done by electrodes connected to a read-out with sufficient waterproof cable to allow lowering the electrodes to the desired depth.

Once a sample has been obtained, analysis for dissolved substances remains to be done. Desired accuracy of results and place of analysis are two factors affecting the type of analysis equipment to be used. It is the area of dissolved substance analysis that has the greatest variety of instruments. Probably because the analysis is actually quantitative chemistry. Field analysis of samples when accuracy is not critical is often done with kits where reagents are added to the sample and a color change noted either by eye or with a battery powered spectrophotometer. Other devices that are used in analysis work are flourometers and gas chromatographs.

GEOLOGICAL FACTORS

Structure of the Bay

If we move back through time we would find that the sea level was about 375 feet lower. The Bay at its deepest point is 180 feet. It should be evident that at lower sea levels the Bay as we know it would have been empty. In its place was a long, broad valley formed by the Susquehanna with local tributaries such as the Magothy River, the Severn River and the Patapsco River also forming valleys.

When the glaciers melted the result was a rise in the sea level, drowning of the Susquehanna River and the formation of the Bay and its irregular, tree-branch shaped shoreline. Marine geologists classify the Bay shoreline as primary or youthful, one that is formed by the sea meeting land masses shaped by terrestrial processes. The other category is secondary: a shoreline shaped by marine or biological processes. An example of the marine would be the Ocean City shoreline with its barrier beach which was built by wave action. Examples of biological changes to a shoreline would be coral reefs, mangrove swamps or here in the Bay, salt marshes where the plants trap sediment and build out more land.

Sediment types

Bay bottom sediment types when the Bay was first flooded consisted of weakly compacted sands and clays deposited during earlier glacial periods. The original sediments were rapidly covered and continue to be covered by sediments carried into the Bay via the many rivers and creeks. Flowing water will carry and move sediment depending on its volocity and sediment size. Fast moving water can carry large size sediment, slow moving water can carry only small size sediment. Consider the large amount of land area draining into the Bay (74,000 square miles) and the soft soil types near the Bay. Both contribute to large amounts of sediments flowing into and being deposited in the Bay.

The result is that you will find large areas of the bottom covered with fine sediments consisting of much organic material. Near natural sand sources, and at fast moving stream entrances one should find coarse sediments. Oyster bars represent a third frequently found sediment type. Occasionally interesting sediments are found that correlate with their sources.

Fossil shells, bones and shark teeth in the vicinity of the Calvert County cliffs is expected. When an Anne Arundel Community College geological sampling cruise found two sharks teeth in sediments off Ulmstead Point in the Magothy River, it was totally unsuspected. Examination of a geological formation map for the area shows sediments that are the probable source of the teeth.

Why obtain marine geology data?

The engineer working in the Bay, building bridges and piers will want marine sediment information so he can design adequate foundations for these structures. He will want to know the sediment type, the amount of entrained water, the load-bearing capacity and sediment deposition or erosion in a given location.

Biologists are interested in marine geology information because the type of bottom dwelling organism found in a particular location is often related to the sediment type. Information on sedimentation rates is needed to predict whether erosion or deposition is taking place at a particular location. Either phenomena could have a detrimental effect on a biological population. Oysters are a good example of this situation. That they cannot survive where sedimentation rates are excessive is one reason for the decline of oysters in certain areas.

Individuals concerned with marine pollution might be interested in the rates of marine sedimentation as indicative of excessive land erosion. Water pollutants will precipitate or adsorb on the surface of other particles and settle to the bottom sediments. These sediments are therefore a fertile area to investigate for marine pollutants.

Methods of taking marine geological data

Data sampling methods can be categorized by where the sampling is done and whether or not an actual geological sample is retrieved.

In situ (in place) sampling might be done by a scuba diver or a small research submarine. Remote sampling is the most frequently used method and is usually done by lowering equipment from a ship to the bottom.

Often a marine sediment sample is actually retrieved by dragging it from the bottom with a dredge, or scooping it from the bottom with a grab sampler or coring it with a corer. Sometimes the marine geological information will be obtained by photographing, by probing below the bottom with sound energy or by using magnetic sensors.

The marine geology sampling methods used in this workshop are the most frequently used methods and are categorized as remote sampling with actual retrieval of a sample.

BIOLOGICAL FACTORS

The Bay as a bio-system

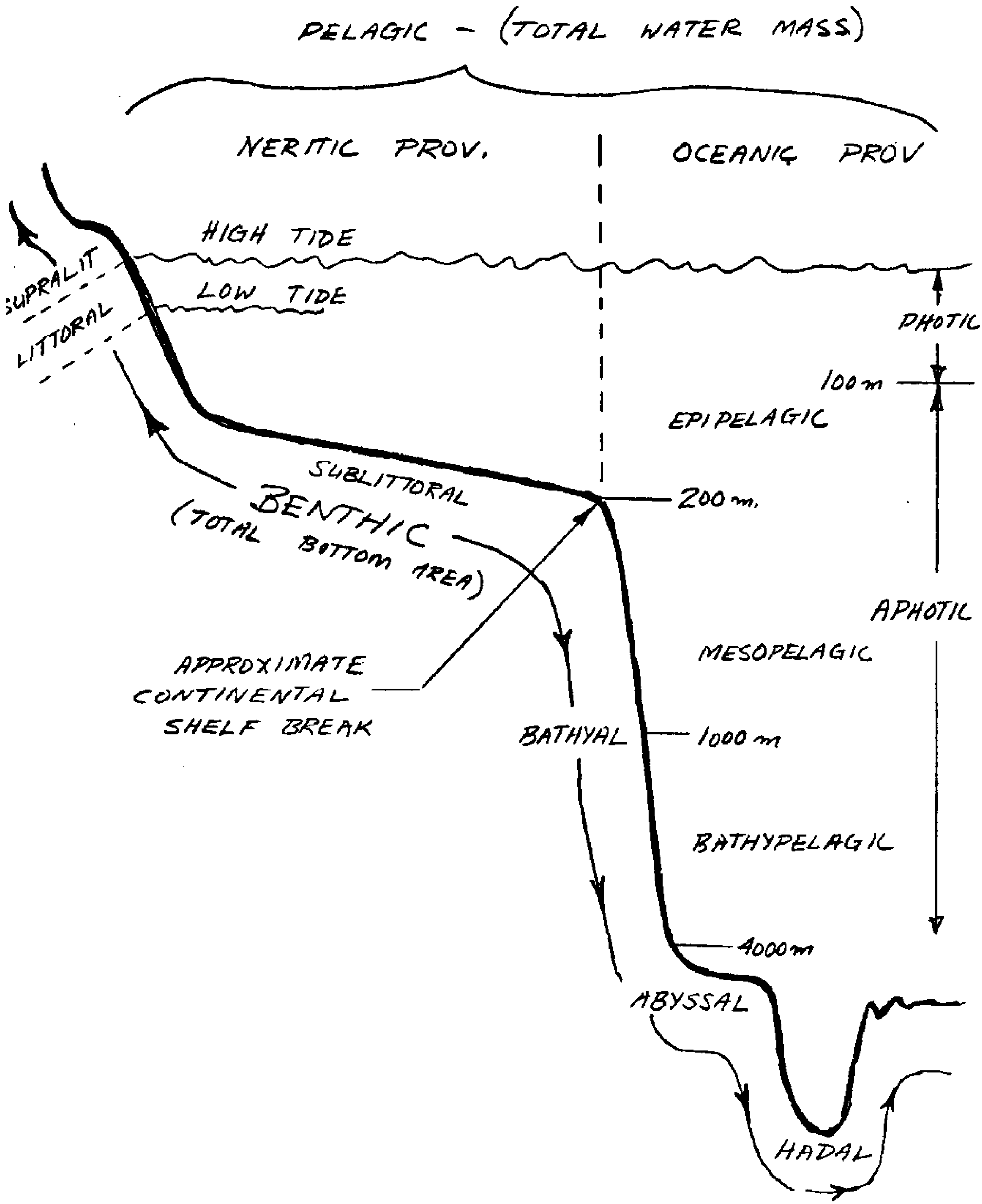
As humans we can study the Bay and learn that it is a system. A system that is complex, where one component is affected by and also affects other components. The moxt complex interrelationships occur between biological organisms and their surroundings. Some of these would include relationships between: food chain levels, between organisms and water quality, between organisms and dissolved gases, and between organism and the bottom topography. A salt water aquarium containing Bay organisms is an excellent method of watching and learning about such a system. Water quality can be monitored, organism behavior and feeding preferences observed.

Sampling areas

The types of organisms that can be sampled in the Bay will depend on the area being sampled. Whatever the area, organisms will likely be typical of an estuarine environment where salinities are constantly changing, where temperatures vary over wide ranges and where dissolved oxygen may drop to low values. There are divisions of the marine environment that we can establish and use to categorize the Bay waters and bottom. The basic subdivision of the marine environment as shown in Figure 17, is into the pelagic region including the entire water mass and into the benthic region including the bottom sediment dwelling areas. Divisions of the pelagic region are the neritic province including shallow water out to the continental shelf bread and the oceanic province including deep water beyond the shelf break. Bay waters are classified under the neritic province. The benthic region includes all those bottom areas from above the high tide line out to the greatest depths of the ocean. Our primary interest is in the Bay so we will look at only the littoral system. The supralittoral area includes those areas above high tide; the littoral area, those areas between high and low tide lines; and the sublittoral area that area below the low tide line.

Types of organisms

Organisms that can be sampled in the Bay can be categorized according to type of movement: free swimming, free floating and bottom dwelling. These categories can further be subdivided according to kingdom, phylum, order, class, family, etc.



BIOLOGICAL ZONES
Figure 17

The strong swimmers, nekton, can be found in the open water and near the bottom. The most important phylum is the chordata including primitive fish, cartilaginous fish, bony fish, reptiles, and mammals. Examples of these in the are Rockfish, eels, menhaden, turtles, water snakes and rays. We have no good examples of nekton which are mammals or invertibrates in the Bay.

Bottom dwelling plants and animals are the benthos. Their mode of existence is creeping or swimming about, firmly attached to something or burrowed in the sediment. Examples of benthic organisms in the Bay are crabs, oysters, worms, sponges, milifoil and Horned Pondweed.

Small free floating or weak swimming organisms are called plankton. Phytoplankton are the photosynthetic organisms. Many of these organisms are difficult to classify as either plants or animals because they have characteristics of both. The genus Euglena is a perfect example of this classification problem. It does photosynthesize and have a cellulose cell wall, so it is plant like. On the other hand it moves around with its flagella, some species can survive in the dark if provided with certain vitamins and close relatives injest other organisms, so it is also animal like. The final proof is that both the botanists and the zoologists claim it as their own! Most taxonomists these days avoid the issue by separating out the one-celled organisms by calling them Protists.

The phytoplankton are producers since they are photosynthetic and are the base of the food pyramid or the first trophic level in the water biomes. This means that all the organisms within that biome depend directly or indirectly on this food production. The zooplankton are the organisms which graze upon the phytoplankton. They may be organisms which complete their entire life cycles as plankton, the holoplankton, such as Copepods and small Crustaceans. Other zooplankton may be only "passing through" as it were during certain stages of their life cycle. These organisms are called meroplankton. Examples of these in the Bay would be crab larvae (zoea), oyster larvae, barnacle larvae and juvenile fish.

Larger free floating or weak swimming organisms such as the sea nettle are called macroplankton.

Food chains and trophic levels

When the phytoplankton photosynthesize the light energy of the sun is changed to chemical energy in the form initially of glucose. This glucose may be used to form larger molecules such as cellulose or starch or the glucose may be broken down again during respiration to obtain energy for cellular functions. Photosynthesizing organisms are producers.

When an organism eats the phytoplankton it is a primary consumer. Only the glucose which has been stored by the phytoplankton may be used by that consumer which then breaks down the glucose during respiration obtaining energy on which to live. Such as: energy to look for food, reproduction, defense and maintenance. Again some of this energy is stored as chemical energy.

When a secondary consumer eats the primary consumer only the energy which has been stored as complex chemicals can be used by this animal.

This will go on and on until the top carnivore probably an Osprey here in the Bay eats a large fish.

The final stage though, is that the decomposers, mainly bacteria, break down the remains and wastes of organisms into simpler subtances which act as nutrients for the phytoplankton.

The photosynthesizers or producers make up the first trophic level. About 1% of the available energy from the first trophic level is used by the primary consumers on the second trophic level. About 10% of the energy from the second trophic level is used by the secondary consumers or the third trophic level. The approximate 10% rate continues on up the food pyramid. Pyramids most often use biomass as a measure of energy flow in an ecosystem. Biomass is the weight of the organisms over a certain area.

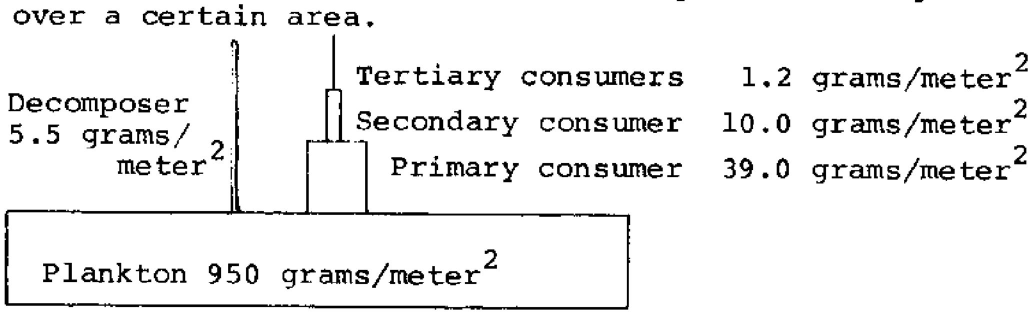


Figure 18 Biomass pyramid

Why obtain marine biological data?

Early marine biology consisted primarily of collecting, identifying and classifying organisms into a taxonomy or classification system. This type of work is still being done but there are other uses for marine biological data of greater interest to the environmental scientist.

Biological populations, whether they be plankton, or juvenile or adult marine organisms can be determined by sampling a known water volume and counting the specimens. Knowledge of juvenile populations can be used to predict adult populations.

Biomass data can be used to predict success of the carnivores given typical energy flow in these ecosystems.

Marine pollutants can be monitored by noting their effects on organisms. Useful drugs may be derived from marine organisms. There is increasing interest in aquaculture, the farming of marine organisms. Scientists are striving to learn about the diseases afflicting some marine organisms.

Types of sampling

Marine biological data from the field is most frequently obtained by sampling. The sampling method depends on the organism and the marine environment from which it is being sampled. There are two main categories of sampling, qualitative and quantitative. Sampling to determine what organisms are present is qualitative sampling. Quantitative measurement means counting organisms in a specified water volume or bottom area.

Qualitative plankton sampling is done by pulling a fine meshed net through the water or by pumping water through the net. In quantitative sampling, the volume of water sampled and the number of organisms would be determined. A Clark-Bumpus Meter is a specially designed plankton net with a volume flow meter mounted in its entrance.

Benthos are usually sampled by dredging, trawling or grab sampling the sediment. Dredging consists of dragging a frame attached to a metal or rope net along the bottom. Sometimes the bottom edge of the frame will have raker teeth to cut below the sediment-water interface. The type of dredge is determined by several factors such as the organisms being sampled and the sediments in the sample area. Grab sampling for benthos is done by lowering a clam shell type device that closes and grabs a sediment sample for retrieval to the surface. Sediment samples being examined for organisms are often washed through selectively sized screens.

Nekton are sampled primarily with trawls but the same method can be used for benthos. Trawls are designed to "swim" at certain levels in the water column depending on the desired sampling areas. These areas may be at the surface, at mid-depth, or on the bottom. Since bottom dwelling fish are often of commercial importance, trawling for these organisms is often down with bottom swimming trawls. Hook and line, trapping, gill netting, poisoning and using SCUBA equipment are other selective methods of nekton sampling.

POLLUTION PROBLEMS

Many of the previously mentioned reasons for obtaining physical, chemical, geological and biological data are applicable to pollution research. Likewise, the techniques of obtaining the data are used frequently in pollution studies. In fact, the importance of instrumentation must be stressed. Without it we would have few tools to learn about the marine environment.

Point and non-point sources

In any county some people are going to be concerned with water pollution, whether it be of lakes, ponds, rivers, streams, estuaries, the ocean or below ground water. Sources of pollution are considered to be point or non-point. An example of a point source is a sewage outfall. Non-point sources are represented by run-off from the land such as a farmer's recently manured field.

In Anne Arundel County, there are examples of both types of sources. Point sources are represented by treated sewage outfalls or treatment plant and pumping station overflow pipes. Storm drain discharges pipes and the well-defined mouths of creeks and rivers could be considered point sources. Industrial wastes, particularly near Baltimore, are discharged through point sources into county waters.

Non-point sources are represented by the run-off from fields recently fertilized or treated with herbicide. Seepage of faulty septic systems could be considered as a non-point source. Erosion of recently graded areas into streams is non-point source pollution of that stream.

Pollution constituents

Point source pollution constituents are represented by:

--treated discharges from sewage treatment plants including nutrients and high levels of bacteriacides such as chlorine

--untreated discharges from sewage treatment plants and pumping stations including organic solids and dangerous bacteria and virus

--industrial discharges including all types of organic and inorganic chemicals

--storm drain discharges including land run-off, street run-off and overflows from other discharge lines. This discharge could include sand, silt, hydrocarbons, fertilizers, pesticides, organic wastes and many others.

Non-point source pollution constituents are represented by whatever is on the land and may enter the marine environment as run-off.

--fertilizers, herbicides and pesticides can be harmful

--the land itself in the form of inorganic sediments causes problems

--antifouling materials from boat hulls leaching into the water may present problems in a confined basin

--the resuspension of marine sediments by boat wakes and propeller turbulence is a good example of a non-run-off source of non-point source pollution

Effects of pollutants

There are many factors that will determine the effect of pollutants. One factor whose influence is easily understood is the type of pollutant. What follows is a brief overview of the general effects of some more common pollutants. An over-abundance of nutrients causes overgrowth of plant plankton and possible eutrophication. Herbicides will kill aquatic plants. Pesticides can become incorporated in the tissues of marine organisms. As organisms low in the food chain are eaten by higher level organisms the pesticides can become concentrated to dangerous levels. Hydrocarbons can poison and smother marine organisms as well as foul surfaces of boats and beaches. Raw sewage adds nutrients and harmful bacteria and viruses to the marine environment closing areas to water-related recreation and making marine organisms such as oyster unfit for consumption. Land run-off sediments silt in the headwaters of creeks changing habitats and degrading boat oriented sports.

Pollution prevention

The key to reducing or preventing pollution is education followed by laws discouraging pollution and enforcement to make sure the laws are obeyed. Public attitudes about the desirability of a clean natural environment can be changed through education. After this attitude change is made, the public will be willing to pay the increased price of pollution control. Without such education, laws to discourage pollution will not be enacted nor will the public support the cost of enforcement of these laws.

High technology societies are going to generate wastes that will pollute the environment if they are not disposed of properly. In a sense, pollution cannot be eliminated without a drastic change in our standard of living away from high technology. This pollution can be controlled through technology provided there is economic incentive to do so. As previously stated, the public can be educated to bear the cost of pollution control and provide that economic incentive.

Some examples of technology that are helping to control water pollution are sewage treatment plants, industrial discharge treatment systems and oil spill containment booms.

Examples of legislation that helps control pollution is: the sediment control law, and the prohibition against use of certain pesticides.