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ABSTRACT

This field studies manual, developed by biology students in the 1971 Georgia Governor's Honors Program, was designed for collection of data pertinent to freshwater and estuarine habitats. In addition to the various methods of sampling the ecosystem and for quantification of the data, instructions for dividing the field study into three logical phases: the pre-trip, on-site, and post-trip and included. Three appendices are also included: (1) Centigrade-Fahrenheit Scales Comparison, (2) Guidelines for Evaluating a Research Article, and (3) Finagles Laws. (CP)

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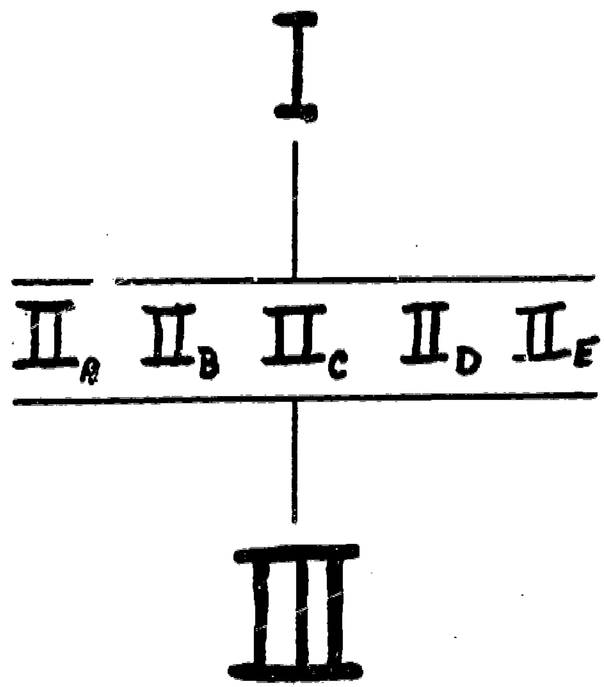
# FIELD STUDY MANUAL

# TO

# FRESHWATER AND ESTUARINE HABITATS




PREPARED BY: STAFF AND STUDENTS
GOVERNOR'S HONORS PROGRAM - 1971

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## INTRODUCTION

The planning of a field trip for students should probably be divided into three phases, pre-trip, in-progress and post-trip. The phases should be carefully considered and specific objectives formulated for each of them.

The pre-trip phase should be planned around selected reading, practice with taxonomic keys, construction of model profiles which might resemble the on-site situation, the definition of specific on-site tasks and the checking of equipment for the trip. Therefore, before leaving on the trip, the student should have done all the following things:

1. Read Chapter 9 of BSCS Green Version
2. Read selected protions of Odum's Principles of Ecology and other books if possible.
3. Constructed an ecological profile of an ecosystem similar to the one to be visited.
4. Practiced with taxonomic keys for on-site identification.
5. Have, in hand, an on-site job description.
6. Have all equipment to be used securely packed and in good repair.

The in-progress phase should be clearly understood by the student for this is where he will gather most of his information for the third phase. The data sheets are for use at this point. They embrace three major areas, water, land and mapping of sites. Teams of one to three students should be selected to do the several data collection tasks.

Water sampling is a relatively simple task but requires careful attention on the part of the students as to location and other salient facts about the collection spot. The collection of water should be done by a team of no less than three. One will act as a runner to bring the water samples to testing sites. The other two will remain in the water. Never allow anyone to be left alone in the water. The tests which can be run on the water at the testing sites are described on the data sheets. Each test described in the following materials can be done by one or more students operating singlely or in teams.

Water samples will have to be collected, stored and brought back to the laboratory for salinity tests, biomass and identification of plankton.

Collection of field data requires the staking of quadrats and sampling of biota on sandy beaches, mud flats and tidal pools. Pairs of students can generally be used for most of these samplings.

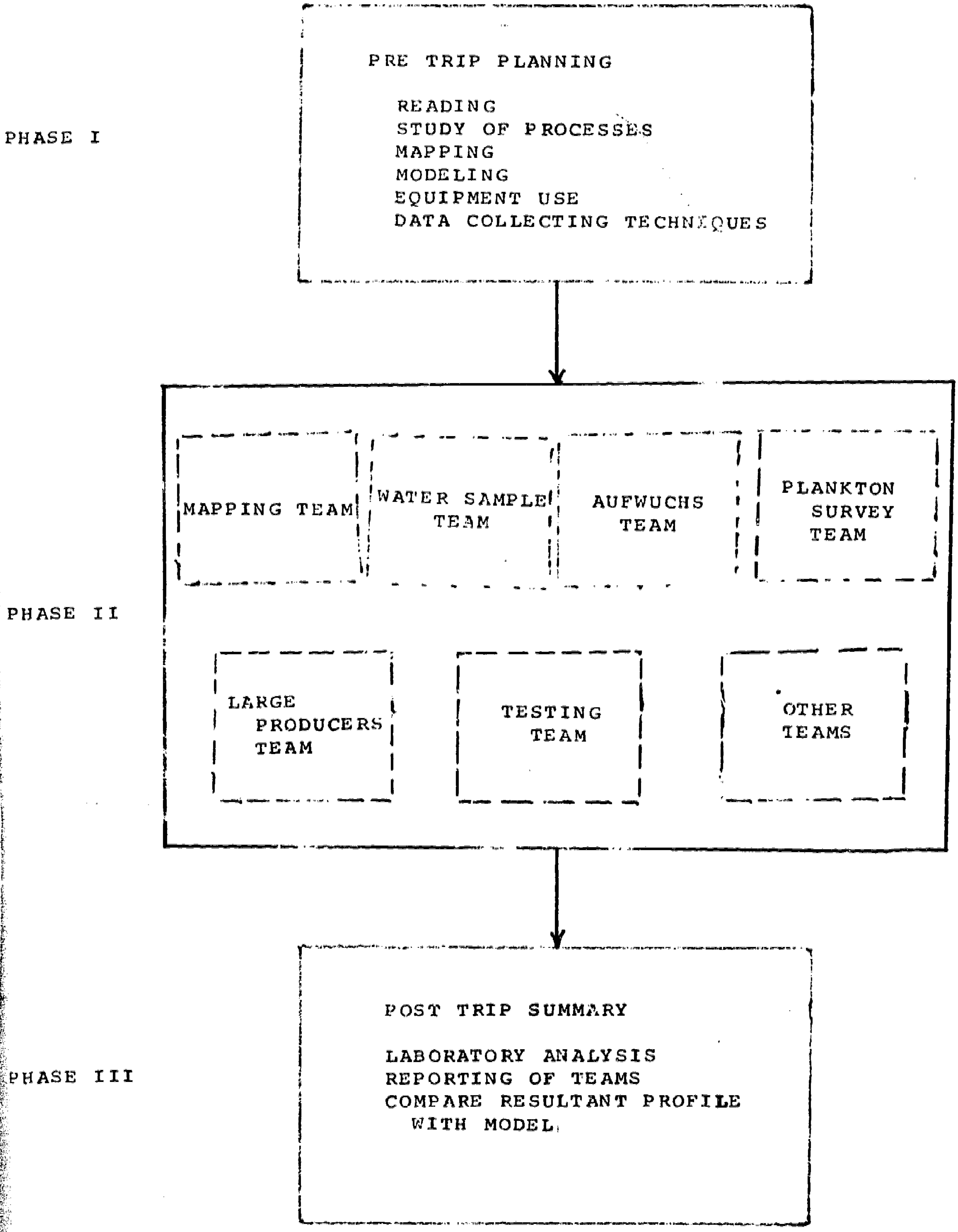
Mapping of an area is most important for future identification of sites This can be done simply or with rather sophisticated equipment if it is available.

In progress objectives should include a thorough understanding of a task and the diligent application of the student to the task.

A post trip summation allows the student a chance to share what he has learned with the rest of the group. Each student should be able to:

1. Describe fully a field technique or a sampling technique, giving its purpose, procedure and possible results.
2. Report findings based on use of the technique described.
3. Relate the techniques used and the data collected to a description of the ecosystem.
4. Construct a profile of an actual site and compare it with his model from the pre-trip planning.

The data sheets for the field trip were developed by the students in biology at the Georgia Governor's Honors Program, 1971. They encompass what they construed as information which would enable them to better understand estuarine and freshwater ecosystems.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LABORATORY ANALYSIS
REPORTING OF TEAMS
COMPARE RESULTANT PROFILE WITH MODEL

MARINE ECOSYSTEMS

## Before Beginning

Before beginning the collection of marine organisms, each student should become familiar with the following precautions:

1. Always work in pairs--never alone.

2. Beware of slipping on alga-covered rocks. One of the gravest dangers is slipping and falling on a jar or knife. Be extremely careful with these items.

3. Never go barefoot. The most dangerous "species" normally encountered are broken bottles, rusty, cans, boards with nails, and fishhooks.

4. Collect unfamiliar animals with caution. Bites and stings are painful and may be dangerous.

5. Do not put your hand into a dark cave or deep holes among rocks and expect to get it back in the same condition.

6. Do not disturb the environment more than is absolutely necessary. Fill in any holes left in the sand or mud after digging. Replace all rocks and driftwood.

As far as possible, organisms collected should be studied in the field while still alive. Marine organisms are difficult to transport alive to a laboratory. If you find organisms that you wish to identify more carefully than field conditions will permit, make sketches of them in your data book. If you wish to take preserved specimens back to the laboratory, place such specimens in small jars which contain 7 parts of 40% formaldehyde solution to which you are to add sea water to fill.

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WATER COLLECTION AND TEST MATERIALS MAY BE PURCHASED FROM MOST SCIENTIFIC SUPPLY HOUSES. ONE MANUFACTURER IS:

EDUQUIP, INC.
1220 ADAMS STREET
BOSTON, MASSACHUSETTS 02124

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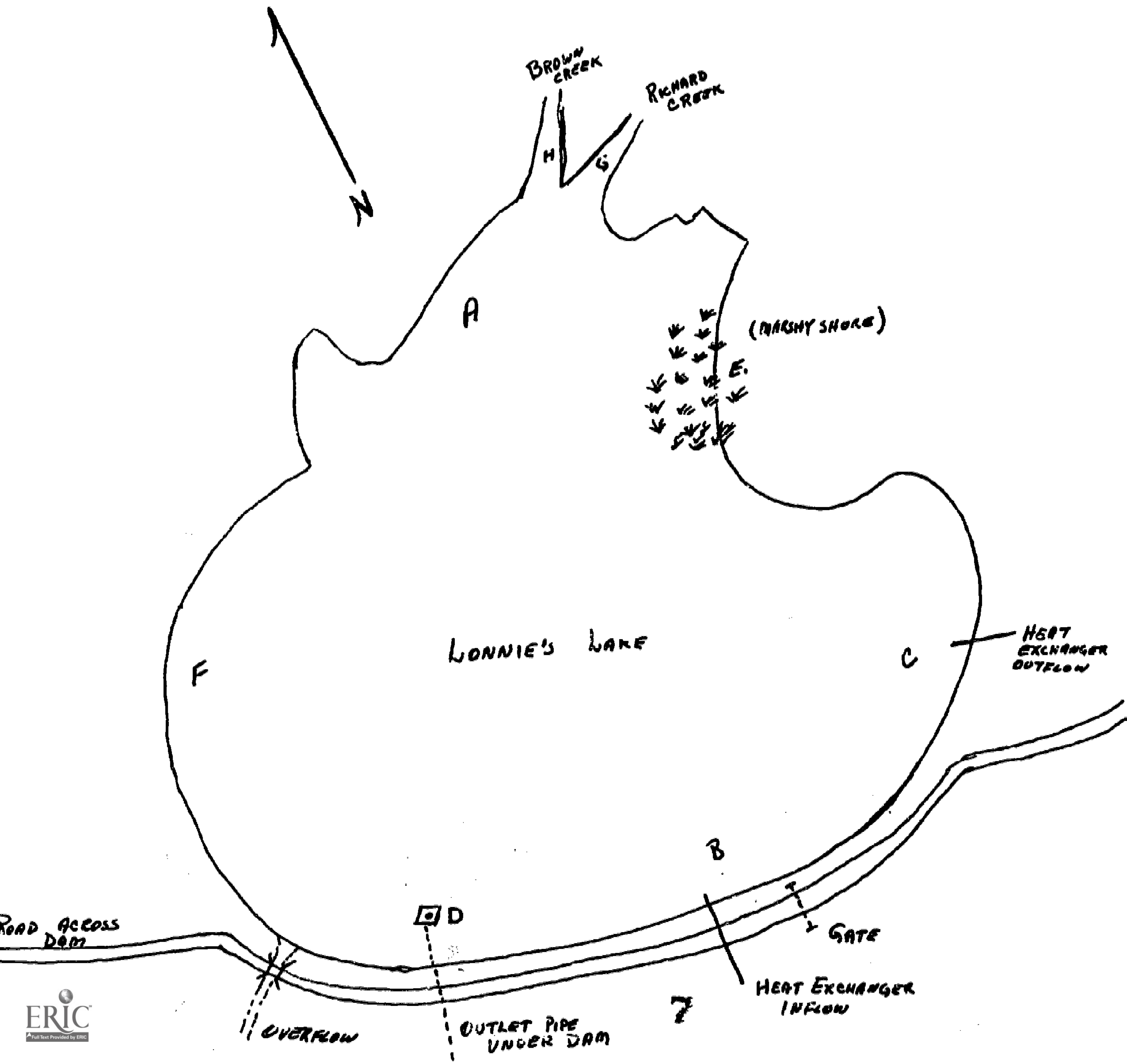
# MAP EXAMPLE

A general outline of each study site should be mapped first. The site of each sample taken should be added as the samples are made along with other significant observed data.



DATA SHEET: PRODUCER SAMPLING (ALGAE)

INSTRUCTIONS: Make a map of the shore area from which you are sampling. Mark all sampling sites on this map and number them. Record water temperature and air temperature of each site. Record general description of each site including time collected, distance from shore and depth of water.

I. Collect rock algae by scraping it off and placing in a bottle of seawater. Label and store.

II. Collect algae on pilings by above procedure, making sure to sample algae that is always underwater and algae that is sometimes exposed to the air.

III. Collect any shells that are algae encrusted and place in a bottle of seawater.

IV. Collect samples of bottom dwelling algae by the above procedure.

V. Collect samples of freefloating algae by filling bottles with seawater.

Examine algae with a hand lens and record description of each species found.

| | Air temp. | water temp. | time | dist. from shore | depth |
|---|---|---|---|---|---|
| Site A | | | | | |
| Site B | | | | | |
| Site C | | | | | |
| Site D | | | | | |
| Site E | | | | | |

Partial species list:

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WATER SAMPLING

TOTAL INFORMATION

One team should work on one side of the coastal island or estuary with one set of tests and then they should switch sides.

Five different places should be tested on each side of the island or estuary. It should be possible to conduct the nitrate, phosphate, pH, and silica tests with one sample of water. This will save time and reduce the number of samples necessary. Dissolved oxygen will take an entire sample, but it should be possible to conduct the $CO_2$, total hardness, and calcium hardness tests with one sample.

Information for each sample should be listed as follows:

Location of sample ____________________
Time ____________ Temperature: Air ________ Water ____________
Depth ____________________ Distance from shore ____________
$O_2$ conc. ____________________ $CO_2$ conc. ____________________
pH ____________________ phosphates ____________ nitrates ________
Silica ____________ Hardness: total ____________________
Calcium hardness ____________________ Mg hardness ____________

For some tests, salt water should be diluted. If the sample is diluted, it should be stated and in what ratio.

## Salinity Test

Site of sample ______________________________

Date ________________ County ________________ Time ____________

After making sample, use a 10ml pipette to draw out exactly 10ml of water. Weigh out about 1 gram of $AgNO_3$ (silver nitrate) and add it to the sample while observing reaction. Continue adding carefully measured small amounts of $AgNO_3$ until no precipitate is formed. The precipitate is AgCl (silver Chloride). The AgCl may be filtered out of the solution by using a funnel, filter paper, and a vacuum flask. Before filtering the solution, the filter paper should be weighed to determine the mass. While filtering the solution, be careful to wash down all of the AgCl into the filter paper. Several washings may be required. The filter paper must then be dried (may be left over night if no oven is available. After the paper is completely dried, including the precipitate, it must be weighed again. The mass of the AgCl may be determined by subtracting the original mass of the filter paper from the mass of the paper containing the AgCl. The mass of the AgCl is the number of grams of AgCl per liter of solution. When this is complete, divide the number of grams per liter by the molar weight of AgCl (143.4g). This will give you the number of moles of AgCl formed. The number of moles of AgCl formed will be the same number of moles of NaCl present in the water. This number may be multiplied by the molar weight of NaCl to find the number of grams of NaCl per liter of water. (the molar weight of Na Cl is 58.8g). To get the number of parts per million of NaCl, multiply grams per liter by 1000. This can be compared to an average to determine the accuracy of the test.

Grams of NaCl per liter of water ____________ ppm NaCl ________________

### Math

Mass of filter paper and AgCl − mass of filter paper = grams of AgCl per 10ml of water

$$\frac{\text{g AgCl}}{\text{10ml}} \times 100 = \frac{\text{g AgCl}}{\text{Liter}}$$

$$\frac{\text{Grams AgCl}}{\text{liter}} \div \text{molar mass of AgCl} = \text{moles AgCl per liter}$$

moles AgCl=moles NaCl

$$\frac{\text{moles of NaCl}}{\text{liter}} \times \text{molar mass of NaCl} = \frac{\text{grams of NaCl}}{\text{liter}}$$

$$\frac{\text{grams of NaCl}}{\text{liter}} \times 1000 = \text{ppm NaCl}$$

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DATA SHEET: DETERMINATION OF pH

Sample No. ____________ Site ______________ Date ____________________
Ocean/Estuary

Recorded by ______________________________________________

| | Time | Depth | Distance From Shore | pH |
|---|---|---|---|---|
| Site A | | | | |
| Site B | | | | |
| Site C | | | | |
| Site D | | | | |
| Site E | | | | |

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DATA SHEET: PHOSPHOROUS AND NITROGEN CONTENT

NAME OF BODY OF WATER ______________________ DATE ______________

COUNTY ______________________ TIME ______________________

RECORDED BY ______________________________________________

| | DEPTH | DISTANCE FROM SHORE | N CONC. | P CONC. |
|---|---|---|---|---|
| SITE A | | | | |
| SITE B | | | | |
| SITE C | | | | |
| SITE D | | | | |
| SITE E | | | | |

NOTES:

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DATA SHEET: CONSUMERS ON SANDY BEACH

INSTRUCTIONS: Stake out large area that would include shallows and extend some distance up the beach. Make water sample for zooplankton. Observe organisms in water and sand (also include birds in area). Determine number of different species; describe or identify by scientific name (if possible) each one. Tell where each was found or sited.

Size of area_______________________ Time of day_______________

Water sample: Time taken_______________ Temp of water__________

Number of species______________________________________________

Description:

DATA SHEET: STUDY OF AUFWUCHS

SITE: (DESCRIPTION) ________________________________________

INSTRUCTIONS: STAKE OUT PLOT 2 METERS BY 2 METERS IN AREA OF VEGETATION. RECORD THE FOLLOWING DATA:

SKETCH PLOT AND MARK IN LOCATION OF LARGE PRODUCERS.

RECORD NUMBER OF SMALL ORGANISMS FOUND ON EACH LARGE PRODUCER.



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DATA SHEET: PLANKTON SAMPLING

SITE____________________ SITE AIR TEMP ____________ DEPTH __________

TIME____________________ DISTANCE FROM SHORE___________ RECORDED BY___

INSTRUCTIONS: Make a map of the area from which your samples are made. Take samples at intervals of about 20 meters moving outward from the shore at 3 ft. intervals. Mark sample sites on map. Use bottles supplied to store samples and make sure each bottle is labeled as the above blanks indicate. After the bottles have been brought back, the samples may be centrifuged and measured to determine the biomass. A hand lens may be used to distinguish different species of plankton. Describe each kind of plankton found and sketch examples when possible.

NOTES:

DATA SHEET: LARGE PRODUCERS

DATE ________________ TIME ______________ RECORDED BY ________________

SITE: 10 m x 5 m Quadrat.

DISTANCE FROM SHORE ________________________________________________

INSTRUCTIONS:

1. Draw diagram of quadrat and locate producers on diagram.

2. Describe terrain, including soil conditions, degree of light, slope of land, etc.

3. Identify producers and determine density ($d = N/S$) where N is the number of producer organisms counted and S is the area of the quadrat.

NOTES:

DATA SHEET: BIOMASS

DATE______________ NAME OF BODY OF WATER ______________________________

COUNTY______________________ RECORDED BY ______________________________

| | AIR TEMP | DIST. FROM SHORE | DEPTH | WATER TEMP | TIME |
|---|---|---|---|---|---|
| SITE A | | | | | |
| SITE B | | | | | |
| SITE C | | | | | |
| SITE D | | | | | |
| SITE E | | | | | |

PROCEDURE: FILL WATER BOTTLES. AFTER BOTTLES ARE COMPLETELY FILLED, PULL UP AND POUR OUT INTO CONTAINERS. CAP TIGHTLY AND LABEL WITH SITE AND SAMPLE #.

DATA SHEET (FRESH WATER ECOSYSTEMS)

WATER BOTTLE SAMPLE (REVISED)

SAMPLE NO.__________ DATE____________ NAME OF LAKE_________ COUNTY_______

TIME _______________ RECORDED BY _________________________________________

| | SITE 1 | SITE 2 | SITE 3 | SITE 4 | SITE 5 | Site 6 |
|---|---|---|---|---|---|---|
| AIR TEMP. | | | | | | |
| WATER TEMP. | | | | | | |
| DEPTH OF SAMPLE | | | | | | |
| DISTANCE FROM SHORE | | | | | | |
| OXYGEN CONC. | | | | | | |
| $CO_2$ CONC. | | | | | | |
| pH | | | | | | |
| PRODUCER NO. | | | | | | |
| BIOMASS | | | | | | |
| PIGMENT DENSITY | | | | | | |
| PARTIAL SPECIES LIST | | | | | | |

NOTE: THIS WILL REQUIRE 3 SAMPLES TO BE TAKEN AT THE SAME SITE. ONE FOR THE D. $O_2$: ONE FOR THE $CO_2$ AND pH: AND THE THIRD FOR THE BIOMASS TESTS



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DATA SHEET: DISSOLVED OXYGEN TEST (REDEAL-STEWART MODIFIED WINKLER TEST)

Glass bottles with tight-fitting glass stoppers and having a capacity of 250 cc are used. Make certain all glassware used is clean. Special water samplers are available to secure water without introducing atmospheric oxygen. If a sampler is not available, the water should be obtained in such a manner as to avoid splashing or bubbling the water. Siphons are often of use in such a procedure. Temperature of the water should be recorded at the time and place the water is collected. If water is then transferred from the sampler to the bottle, the water should be allowed to overflow the 250 cc. bottle 2-3 times to flush out atmospheric oxygen. When the stopper is replaced, no air bubble should remain.

Now proceed to analyze the water as follows: (Steps # 1-5 the reagents should be added quickly and the bottle restoppered to prevent oxygenation from the atmosphere.

1. To the water sample, add:
   a glass bead (to aid mixing)
   0.35 cc. conc. $H_2SO_4$
   0.5 cc. potassium permanganate solution

2. Shake. A pale violet to pink color should appear and persist. If it does not, add a few cc. more of $KMnO_4$ solution. Allow to stand at least 40 minutes after the color is established.

3. Add: 0.5 cc. potassium oxalate. Let stand until color disappears.

4. Add: 0.5 cc Manganous sulfate solution
   1.5 cc. hydroxide potassium iodide solution
   Shake. A yellow precipitate will form. Allow it to partially settle and then shake again.

5. Add 0.5 cc of conc. $H_2SO_4$, shake. The precipitate should dissolve. If it does not, add 0.5 cc. more of $H_2SO_4$. A yellow color will remain, which represents the iodine that replaced the oxygen dissolved in the water. At this point, the analysis may be suspended for several hours, allowing completion in the laboratory.

6. Measure out 100 cc. of the sample, and titrate with N/100 sodium thiosulfate solution. MAKE SURE YOU READ THE LEVEL OF THE SODIUM THIOSULFATE BEFORE YOU START TITRATING. <u>WRITE IT DOWN</u>.

7. Titrate until a very pale yellow color is reached, then add starth indicator (about 2 cc.). The sample will turn blue.

8. Continue titrating until the sample becomes clear. The clearness should persist for several seconds under agitation.

9. Read the new level of the sodium tionsulfate, and calculate the amount used in titration.



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10. Multiply this amount by 2. This will give (roughly) the parts per million of dissolved oxygen in the water.

REAGENTS

(All water used should be distilled. Salts are usually dissolved in small quantities of $H_2O$ first, then diluted.)

Potassium permanganate solution: 6.32 g. $KMnO_4$ in 1 liter $H_2O$

Potassium oxalate solution: 20 g. $K_2C_2O_4 \cdot H_2O$ dissolved in $H_2O$ Add: 4 g. NaOH, then dilute to 1 liter with $H_2O$.

Manganous sulfate solution: 480 g $MnSO_4$ per liter of $H_2O$

Hydroxide - potassium iodide solution: 500 g NaOH and 135 g. NaI, diluted to 1 liter with water.

Sodium thiosulfate (N/100): dissolve 25 g. sodium thiosulfate and 2-3 g. borax in $H_2O$ and dilute with cooled boiled water. This normality is fairly stable. When to be used, make N/100 by diluting 1 part N/10 to 9 parts $H_2O$.

Starch indicator: 3 g. potato starch, ground with $H_2O$. Place in 500 cc. freshly boiled H O. Allow to stand overnight, then use only the clear fluid.

DATA SHEET

Lake Bottom Sample

Sample No. ________ Station No. ___________ Date ______________________________

Name of Lake _________________ County _______________ Type of Bottom __________

Temp: Air _______________ Depth _______________________________________________

Water _____________ Vegetation ______________________________________

Time ______________ Distance from shore ______________________________

Wet wt. of food __________ Recorded by _________________________________________

| Order | Total No. | Stage LNPA | Per Cent | Remarks |
|---|---|---|---|---|
| Molluscs | | | | |
| Ephemeroptera | | | | |
| Diptera | | | | |
| Oligochaetes | | | | |
| Coleoptera | | | | |
| Neuroptera | | | | |
| Crustacea | | | | |
| Miac. | | | | |
| Totals | | | | |

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DATA SHEET

Habitat Description

Date ________________ Name of Lake or Pond ____________________________

Area: ________________ in $m^2$ Natural or Artificial ____________________

Height of dam ________________

Character of shore line ______________________________________________

Character of watershed ______________________________________________

Approximate depth 100' from shore ________________ 200' from shore ______

Shoal areas 20' or less ____________________________% of lake

Bottom condition ____________________________________________________

Temperatures: Surface ____________ Air ________ Beneath Surface ____________

Depth ________________

Hour ________________ Weather ________________ Color ________________

Turbidity ___________________________________________________________

Sketch of area:

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DATA SHEET

Habitat Description: page 2

Higher Plants (show location on map):

Emergent:

Submerged:

Algae (floating)

Vertebrates:

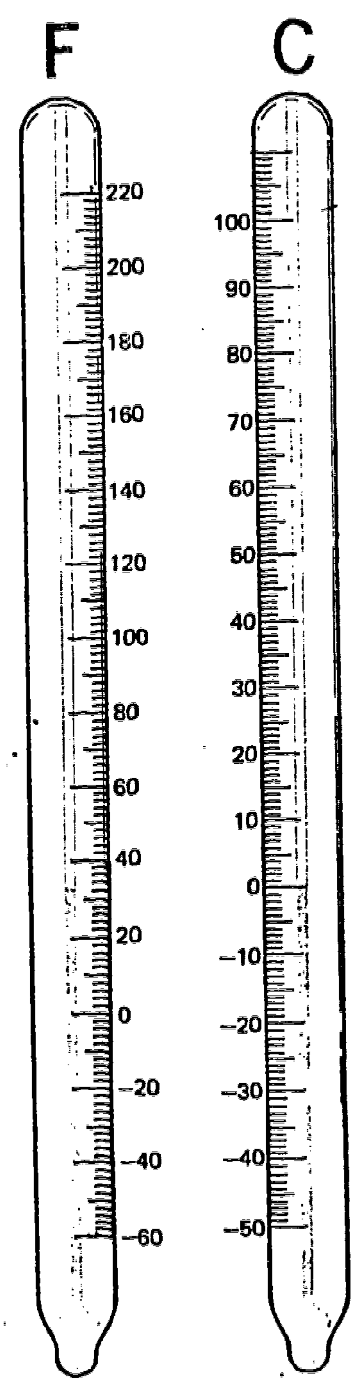
Invertebrates:

Shore: (approx. no. per sq. ft.):

APPENDIX I

Celsus - Fahrenheit Comparison

All measurements on the field trip will be taken in metric units. The Celsus and Fahrenheit temperature scales are shown for comparison only, since students not familiar with the Celsus readings may have some difficulty knowing whether a Celsus reading should feel "warm" or "cool" to touch.



APPENDIX II

GUIDELINES FOR EVALUATING A RESEARCH ARTICLE

When a question refers to a specific statement in the text of a report, (for example, the problem, hypothesis, independent variable, etc.), place in the margin of the article, near the statement, a notation to show the question in the guideline to which the statement applies.

| | NA | YES | NO | UNCERTAIN (Specify) |
|---|---|---|---|---|
| I. Problem | | | | |
| A. Was the problem clearly defined? | ( ) | ( ) | ( ) | ( ) |
| B. Was the hypothesis (hypotheses) present testable? | ( ) | ( ) | ( ) | ( ) |
| C. Was the hypothesis (hypotheses) logically deduced from some theory or problem? | ( ) | ( ) | ( ) | ( ) |
| D. Was the independent variable (s) clearly defined? | ( ) | ( ) | ( ) | ( ) |
| E. Was the independent variable (s) under the manipulative control of the experimenter? | ( ) | ( ) | ( ) | ( ) |
| F. Was the dependent variable (s) clearly defined? | ( ) | ( ) | ( ) | ( ) |
| II. Medthodolgy--Instrumentation | | | | |
| A. Is the instrumental procedure a commonly used one? | ( ) | ( ) | ( ) | ( ) |
| B. Is it an acceptable procedure? | ( ) | ( ) | ( ) | ( ) |
| C. Is the apparatus described in sufficient detail? | ( ) | ( ) | ( ) | ( ) |
| D. Is the apparatus reliable? | ( ) | ( ) | ( ) | ( ) |
| III. Experimental Design | | | | |
| A. Was the population from which the Ss were drawn specified? | ( ) | ( ) | ( ) | ( ) |
| 1. Would this satisfy the requirements dictated by the problem? | ( ) | ( ) | ( ) | ( ) |
| B. Was the number of Ss used specified? | ( ) | ( ) | ( ) | ( ) |
| 1. Would this satisfy the requirements dictated by the problem? | ( ) | ( ) | ( ) | ( ) |

| | | NA | YES | NO | UNCERTAIN |
|---|---|---|---|---|---|
| C. | Was a control condition necessary? | ( ) | ( ) | ( ) | ( ) |
| D. | If a control condition was necessary, was it employed? | ( ) | ( ) | ( ) | ( ) |
| E. | Was the procedure given in sufficient detail for replication of the study? | ( ) | ( ) | ( ) | ( ) |
| IV. | Data Analysis | | | | |
| A. | Was sufficient data presented to evaluate the hypothesis (hypotheses)? | ( ) | ( ) | ( ) | ( ) |
| V. | Conclusions | | | | |
| A. | Were the conclusions consistent with the types of independent variable used in the study? | ( ) | ( ) | ( ) | ( ) |
| B. | Was there sufficient control of other variables which might influence the results? If not, list the variables not controlled. | ( ) | ( ) | ( ) | ( ) |
| C. | Were the conclusions consistent with the results? | ( ) | ( ) | ( ) | ( ) |
| D. | Could the results have been due to a poorly measured dependent variable? | ( ) | ( ) | ( ) | ( ) |
| E. | Were generalizations confined to the population from which the sample was drawn? | ( ) | ( ) | ( ) | ( ) |
| VI. | Context of Research | | | | |
| A. | Were the alternative explanations of the results possible? | ( ) | ( ) | ( ) | ( ) |
| B. | Were they mentioned? | ( ) | ( ) | ( ) | ( ) |



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APPENDIX III
FINAGLES LAWS

## LAWS OF EXPERIMENT

First Law

If anything can go wrong with an experiment or test, it will.

Second Law

Everything goes wrong at one time.

Third Law

Experiments must be reproduceable; they should fail in the same way each time.

Fourth Law

Build no mechanism simply if a way can be found to make it complex and wonderful.

Fifth Law

No matter how an experiment or test proceeds, someone will believe it happened according to his pet theory.

Corollary One- No matter what the result is someone will misinterpret it.

Corollary Two- No matter what results are anticipated, someone will try to fake them.

## Laws of Mathematics

First Law

In any collection of data, the figures that are obviously correct, beyond all checking, contain the errors.

Corollary One- No one whom you ask for help will see the errors.

Corollary Two- Everyone who stops by with unsought advice will see it immediately.

Second Law

If, in any problem, you find yourself doing a transfinite amount of work, the answer can be obtained by inspection.

Corollary One- If inspection fails to yield results, Judicious application of one of the methods outlined in the text following may be in order.

## LAW OF SYSTEMS

When a system becomes completely defined and all avenues of inquiry and expansion are explored, an uninformed, independent experimenter will discover something which will either abolish the system or expand it beyond all recognition.

## LAW OF THE LOST INCH

In designing any type of construction, no overall dimension can be totaled correctly after 4:30 p.m. on Friday.

Corollary One- Under the same conditions, if any minor dimensions are given to sixteenth of an inch they cannot be totaled at all.

Corollary Two- The correct total will become self-evident at 8:15 a.m. on Monday.

## LAWS OF REVISION

First Law

Information necessitating a change of design will be conveyed to the designer after, and only after, the plans are complete.

Corollary One- In simple cases, presenting one obvious right way versus one obvious wrong way, it is often wiser to chose the wrong way to expedite subsequent revisions.

Second Law

The more innocuous the modification appears to be, the further its influence will extend and the more plans will have to be redrawn.

Third Law

If when completion of design is imminent, field dimensions are supplied as they are, instead of as they were meant to be, it is always simpler to start all over.

Fourth Law

It is usually impractical to worry beforehand about interference; if you have none, someone will supply some for you.

## LAWS OF THE UNIVERSAL PERVERSITY OF MATTER

First Law

Any mechanical or electrical device is most likely to fail the day after the manufacturer's guarantee expires.

Second Law

Any mechanical or electrical device with any malfunction short of a complete breakdown will function perfectly in the presence of a trained serviceman.

Third Law

Matter will damage in direct proportion to its value.

Corollary One- If a mechanism is accidently dropped, it will fall in such a way that the maximum damage will occur.

Corollary Two- Things fall at right angles.

## MURPHY'S LAWS

1. In any field of scientific endeavor, anything that can go wrong, will go wrong.
   BULLOCKS COROLLARY: There will always be someone to say "I told you so."
2. Left to themselves, things always go from bad to worse.
3. If there is a possibility of several things going wrong, the one that will go wrong is the one that will do the most damage, if they all don't go wrong.
4. Nature always sides with the hidden flaw.
5. Mother Nature is a bitch.
6. If every thing seems to be going well, you have obviously overlooked something.

## GUMPERSON'S LAW

The innate animosity of inanimate objects.