

BRISBANE SOUTH MARINE STUDIES PROJECT



MARINE STUDIES SERIES

UNIT 7

ESTUARINE CHEMISTRY

written by

R.D. MOFFATT

B.Sc., Dip. Ed.,

Grad. Dip. Ed. Admin., M.A.C.E.

"TO GREAT DAYS AT THE ALEX"

Australia's coastline forms a special place in our environment because over 90% of us live there. Due to different Ecological, Economic, Social and Recreational interests many conflicts arise over the use of our Estuaries, Beaches and Barrier Reefs. Sand Mining, High Rise development, Longline Fishing, Low water Land sales, Resort Development and Oil Pollution are but a few of the real issues that face us now. There is an urgent need for all Australians to develop an attitude towards sensible resolution of these conflicts. This set of notes is one in a series that hopefully will give students the skills necessary to become involved in these issues and make sensible contributions to coastal environmental decision making. In doing so I hope that the coastline may be managed in such a way that future Australians will derive as much pleasure out of it as I have.

My thanks must go to STAQ for providing the financial backing and support to start this project. Thanks also to my Mother and Father who deciphered and typed my bad writing; and to Len Zell of the Great Barrier Reef Marine Park Authority who read and criticised the draft and for making many useful contributions. As this is a first draft any comments would be gratefully acknowledged.

© 1985 R.D. Moffatt

NATIONAL LIBRARY OF AUSTRALIA
CATALOGUING-IN-PUBLICATION

MARINE CHEMISTRY

R.D.Moffatt

ISBN 0 9589813 6 1

For further information contact:

R.D. MOFFATT
Benowa State High School
Mediterranean Drive
BENOWA
GOLD COAST MAIL CENTRE, Q, 4217

First Printed: 1984 Draft copies by S.T.A.Q. publications

Second Printing: 1985 Benowa Marine publications

Third Printing: January 1986



Published by

BENOWA MARINE

Mediterranean Drive
Benowa, Qld. 4217

P.O. Box 5733
Gold Coast Mail Centre. 4217
Telephone : (075) 39 4222

ESTUARINE CHEMISTRY

written by

R.D. Moffatt

This module has 3 sections:

Section 1	Laboratory Methods.....	12 - 18
Section 2	Salt Water Chemistry.....	19 - 37
Section 3	Field Methods.....	Unit 5

This module is compatible with the Syllabus Topics:

- * The Nature of Science *
- * Matter and Materials *

Students, teachers and parents are referred to the Multistrand Science Syllabus, Board of Secondary School Studies (Qld), Spring Hill, Brisbane.

Acknowledgements:

The author acknowledges J.C. Happs and his book WATER POLLUTION AND ITS MEASUREMENT from which the Standard Water Analysis Techniques are taken. He would also like to thank the Schools Commission for providing the funds necessary to develop many of the original material, especially a boat. Thanks also to:

Allistair Martin (M.S.C. Tas.); David Kopelke (B.I.F.S.C. Qld); Jim Redfield (C.S.I.R.O.); Roy Jenkins (F.U.S.E.); Dennis Bridger; Ann Kenny; Graham Mitchell; Greg Martin; Steve Hall (G.S.H.S.); Sue Oates; Meran Kilgour (B.S.H.S.); Ian Griffiths; and the Departments of Harbours and Marine, Fisheries, Oceanography, Great Barrier Reef Marine Park Authority, The Beach Protection Authority and The Brisbane Education Centre for all their help.

WHY STUDY THIS UNIT

The Estuary provides an excellent place for students to study the Nature of Science. Firstly it got students into the field to experience the difficulties in research and the time it takes to collect data. They should also come to the conclusion that scientific discoveries do not occur overnight and that hypothesis conferences and scientific generalizations take a long time to become a reality.

NATURE OF SCIENCE

Science is a human activity involving us all as we attempt to understand the world around us. The empirical mode of thought embodied in science provides one way of viewing our world. Students should experience this empirical approach and be encouraged to develop a thoughtful, logical, and thorough approach to everyday life. To do this they should examine various views about the nature of science, its methods and processes.

Many aspects of this topic could be undertaken in conjunction with studies in other core topics or optional areas. An alternative approach could be the development of an introductory unit based on this topic.

MATTER AND MATERIALS

We are surrounded by an immense diversity of natural materials some of which man has adapted for his benefit. In addition he has developed new materials and applied these to the service of man. This interaction between man and his environment is crucial to our way of life.

Students should have an understanding of the structure, properties and uses of a range of materials both natural and synthetic. He should relate the materials, through a knowledge of their properties, to their everyday usage. The student should appreciate the reasons man chooses particular materials for specific usages. He should have a knowledge of some of the technologies involved and the impact of these technologies. As a consequence of the study of this topic the student should acquire a better appreciation of man's adaptation of these materials.

These aims may be achieved by a variety of teaching approaches e.g. by a traditional geological and chemical development or by a thematic study of a particular natural resource being transformed into a finished article. Irrespective of the approach pursued, the laboratory should form a focus for the treatment of the topic and students should acquire hands-on experience with a range of materials being studied.


The materials studied should include examples from each of the following three groups: ores, metals and alloys; non-metallic elements and inorganic compounds; organic compounds and polymers.

Special Note: *Students must be given the opportunity to do Field Work in an estuary for this process, skill and affective objectives to be achieved.*


ESTUARINE CHEMISTRY

<p><u>PRACTICAL ACTIVITIES</u></p> <ol style="list-style-type: none">1. Salinity Titration2. CO₂ and O₂ Titrations3. Acid/Base Titrations4. Separation of Dissolved and Undissolved Solids in Sea Water5. Prepare Chromic Acid Cleaning Solution6. Observe Abiotic Data	<p><u>RESEARCH ASSIGNMENTS</u></p> <ol style="list-style-type: none">1. The Chemical Composition of Sea Water2. Mining the Sea3. Materials for Ships and Small Boats
<p><u>MATTER AND MATERIALS</u></p> <p><i>THE NATURE OF SEA WATER - (salinity, dissolved particles, characteristics.</i></p> <p><i>MARINE SAMPLING MATERIALS - (glass, rope, nylon, plastic, stainless steel, aluminium, fibreglass, perspex.</i></p> <p><i>FIELD METHODS - (construction of sampling devices.</i></p>	
<p><u>DIRECTED TOPICS</u></p> <ol style="list-style-type: none">1. The Nature of Sea Water2. Chemical Tests on Sea Water3. Materials Resistant to Corrosion4. Making equipment from Non-Corrosive Materials5. Visit to a shop selling Marine Equipment	<p><u>AUDIO VISUAL</u></p>


CONTENT OBJECTIVES: The student should have a knowledge of:

- a) The natural origin of some of the materials studied.
- b) Correct safe procedures in the laboratory. 
- c) Common laboratory apparatus used.
- d) Some methods used to obtain or prepare materials selected from the listing above.
- e) Some chemical and physical properties of a range of natural and synthetic materials.
- f) The link between properties and uses of a range of separate materials; and
- g) The need for recycling of materials.


PROCESS OBJECTIVES: The student should be able to:

- a) Identify observations that indicate a chemical reaction.
- b) Distinguish between pure substances (elements and compounds) and mixtures.
- c) Arrange substances into groups by use of properties. 
- d) Recognise the limitations of measurements; and
- e) Apply knowledge of macro properties of materials to choices in everyday life.

SKILL OBJECTIVES: The students should be able to

- a) Use appropriate safe procedures in the laboratory.
- b) Use the appropriate laboratory apparatus for experiments.
- c) Separate the components of mixtures. 
- d) Make measurements using laboratory equipment.
- e) Prepare compounds representing different types of materials.
- f) Observe physical and chemical phenomena and accurately report observations.

AFFECTIVE OBJECTIVES: The student should have an opportunity to

- a) Recognise that man uses many criteria to choose a substance for a particular use.
- b) Value the role of a range of substances in our lives.
- c) Respect and care for laboratory apparatus.
- d) Value the everyday importance of chemistry. 
- e) Recognise the limitations of science as well as its successes; and
- f) Develop a personal position with respect to the use of non-renewable resources.

OBJECTIVE STATEMENT (TEACHER/STUDENT)

CONTENT AREA: The students should have knowledge of:

- a) Natural origin of sea water.
- b) Correct and safe procedures in using acids, bases, indicators, other inorganic and organic compounds in the laboratory to determine physical and chemical characteristics of sea water.
- c) A burette, analytic balance, reagent bottles, spatulas, conical flasks, beakers, bunsins, test tubes, filter paper, funnels, volumetric flasks and other general equipment.
- d) The method used to prepare a chromic acid solution and silver nitrate solution.
- e) Some of the chemical and physical properties of sea water and non-corrosive materials used to make marine sampling devices (eg. plastics, glass, aluminium, stainless steel, fibreglass etc)
- f) The link between (i) non-corrosive properties and plastics
(ii) silver nitrate and chlorinity
(iii) acids and base titrations
- g) The need to save old wine flagons for water sampling devices and plastic scraps for making cheap equipment.

PROCESS AREA: The students should be able to:

- a) Identify the end point in a silver nitrate, sea water titration.
- b) Distinguish between the atoms sodium and chlorine, the compound sodium chlorinate and the mixture sea water.
- c) Arrange the material described in content objective (e) into groups by use of their properties.
- d) Recognise the limitations of titrations and weighing of sea water.
- e) Apply knowledge of sea water to choosing materials for use in the sea.

SKILLS: The students should be able to:

- a) Work safely in the laboratory with acids, base and other reagents.
- b) Use the appropriate apparatus for titrations, weighing and filtrations
- c) Filter sea water
- d) Measure salinity, oxygen, carbon dioxide concentrations
- e) Make a fibreglass mould to cast a plastic sampling component
- f) Observe physical and chemical changes in sea water and report the changes

AFFECTIVE: The students should have the opportunity to:

- a) Recognise that many things must be considered when choosing materials for use in the sea.
- b) Value that we have a choice in the materials we can use.
- c) Respect and care for laboratory equipment.
- d) Value the importance of chemistry.
- e) Recognise the limitations of science in the sea.
- f) Develop a personal position with respect to non-renewable resources in the sea.

STUDENT MATERIALS:

Most materials are described in the Notes but a range of plastics, fibreglass, glass, stainless steel products from a local shipyard or sailing shop could be handy.

PRE EXPOSURE:

Students who had visited a Marina or Shipyard would have an appreciation of the corrosive nature of sea water.

REFERENCE/RESOURCES/NOTES:

Students should be encouraged to make their own sampling equipment. Most Manual Art departments have the tools to work plastics and students should be encouraged to design equipment. For the non-chemistry student who has difficulty working the matter part of this unit, this part should be more rewarding. No attempt has been made to go into atomic structure and this has been deliberate so as to encourage teachers and students to take a wholeistic view of matter. It is hoped that students, while not understanding fully the subtlety of titrations, can use the data they collect to make rational judgements about sea water.

EXCURSION:

A $\frac{1}{2}$ -day or day trip to a shipyard, sailing ship or boat builders workshop would enlighten students into the topic. Shipwrights would also be able to talk to students about the finer details of materials used.

ESTUARINE CHEMISTRY

PRACTICAL ACTIVITIES

1. Introduction to Glassware
2. Introduction to Apparatus
3. Laboratory Balances
4. Laboratory Burettes
5. Microscopes
6. Making Chromic Acid
7. Environmental Effects of Temperature
8. Making Salt Water
9. Sediments and Turbidity
10. Dissolved Oxygen and Carbon Dioxide
11. Acidity, Alkalinity
12. Biological Oxygen Demand

STUDY ASSIGNMENTS

1. Research into Oceanographic Field Methods
2. Designing Field Study of Local Estuary
3. Building Equipment for Study of Local Estuary
4. Writing Reports on Field Study

NATURE OF SCIENCE

LABORATORY METHODS - (glassware, apparatus, balances, burettes, correct use of glassware, cleaning solutions, oceanographic units and their measurement)

SALTWATER CHEMISTRY - (limits of tolerance, temperature, salinity, sediments, turbidity, oxygen, carbon dioxide, trace elements)

FIELD STUDY TECHNIQUES - (sampling, working, living in the field)

DIRECTED TOPICS

1. Laboratory Methods
2. Marine Environmental Limits
3. Laboratory Methods to Study Limits
4. Field Methods to Study the Limits
5. Designing Experiments
6. Formulating Hypothesis about Estuarine Salinity

AUDIO VISUAL

1. Professor Klandlestein Looks at Apparatus, Glassware.

SYLLABUS OBJECTIVE

CONTENT OBJECTIVES: *The student should have knowledge of:*

- a) The difference between observation and interpretation.
- b) The distinction between qualitative and quantitative data.
- c) The role that indirect observation can play in obtaining data.
- d) The need for standards in measurement.
- e) The concept of measurement by comparison with a standard.
- f) The limitations in accuracy of measurements.
- g) The fact that to increase the overall accuracy of an experiment one needs to improve the accuracy of the least accurate measurement or procedure.
- h) The need for the use of a control situation in many experimental designs.
- i) The need for control of variables in the conduct of many experiments.
- j) The traditional approach to scientific investigations.
- k) The role of insight or chance in some scientific achievements; and
- l) The limitations imposed by available instrumentation and technology.

AFFECTIVE OBJECTIVES: *The student should have the opportunity to:*

- a) Appreciate that the division of science into separate disciplines is done by man for his convenience.
- b) Value co-operation between scientists, since the solution to a problem draws knowledge from several interrelated areas which no one individual can know completely.
- c) Value the need for quantitative data.
- d) Value the essential role of detailed, accurate, recorded observations.
- e) Develop a predisposition to proceed with an experiment in a systematic fashion and with purpose; and
- f) Value the need for care and maintenance of laboratory equipment.

OBJECTIVE STATEMENT (TEACHER/STUDENT)

CONTENT AREA:

- a) The difference between the reading on a burette and a table of salinities determined by titrations.
- b) The distinction between salinity measured by taste and titration or water temperature measured by feel and thermometer.
- c) The role that observing weather patterns, current directions and time of day can play in obtaining data.
- d) The need for standard salinity tables or standard oxygen tables.
- e) The concept of measurement of water acid with standard acidity colours.
- f) The limitations of accuracy of acidity with burette compared with meters.
- g) The fact that to measure oxygen accurately, in the laboratory then accurate field methods are demanded and that the accuracy of one is dependent on the other.
- h) The need for a control in B.O.D. experiments.
- i) The need to control other variables in B.O.D. experiments.
- j) The traditional approach of observe, hypothesise, measure, record, generalise, and re-test in determining salinity in estuaries.
- k) The role of insight or chance in making discoveries about the chemistry of the sea.
- l) The limitations imposed by weather, boats, sea conditions, money, available instruments in Marine Research.

AFFECTIVE AREA: *The student should have the opportunity to:*

- a) Appreciate that the division of Marine Science into separate divisions is convenient for Government Authorities (CSIRO), Universities, and other institutions.
- b) Value the co-operation that a marine expedition demands.
- c) Value the need for quantitative data in Marine Chemistry.
- d) Value the essential role of detailed, accurate, recorded observations in estuarine field work and the hardships and personal sacrifice that hard-won data affords.
- e) Value the need to be careful with expensive field and laboratory equipment

PROCESS OBJECTIVES: The student should be able to:

- a) Research the meaning of terms in the popular press used to describe scientific activities.
- b) Make accurate observations in a variety of situations.
- c) Suggest ways by which indirect observations may be made on systems which cannot be viewed directly.
- d) Select the appropriate number of significant figures in a measurement and in the answer, to a calculation based on that measurement.
- e) Select which measurement determines the overall accuracy of an experiment.
- f) Analyse an experimental design to identify sources of error and to suggest how to reduce the overall errors.
- g) Record data in tabular form.
- h) Use graphical techniques to present data.
- i) Interpret data presented in tabular and graphical form.
- j) Use graphical techniques to generate new information by interpolation and extrapolation.
- k) Use scientific reasoning to generate an hypothesis.
- l) Modify an hypothesis in the light of new evidence.
- m) Design simple experiments to demonstrate the control of variables; and
- n) Communicate information by writing reports and presenting verbal accounts.

MANIPULATIVE SKILLS: The student should be able to:

- a) Demonstrate care in the use of and respect of a variety of laboratory equipment.
- b) Demonstrate the application of appropriate safety procedures throughout an experiment.
- c) Use simple instruments to make quantitative measurements.
- d) Select, assemble and use glassware appropriate to a particular experiment.
- e) Use a microscope; and
- f) Carry out field studies using appropriate equipment and techniques.

PROCESS: The student should be able to:

- a) Research the meaning of the terms B.O.D. and parts per million in the Courier Mail or Australian.
- b) Make accurate observations in the experiment on Sea water in a laboratory, a field station and on a boat.
- c) Suggest ways that probes can be used to make indirect observations of deep sea environments.
- d) Select the appropriate significant figure in titration experiments.
- e) Select the measurement which determines the accuracy in S‰, O₂ and CO₂ concentration determinations.
- f) Analyse an experimental design of how an estuary's salinity concentration could be found so as to identify, sources of error and suggest ways to reduce that error.
- g) Record data on temperature, S‰, O₂, CO₂, light, current from a variety of sampling sites at a variety of depths in a table.
- h) Graph (g) above.
- i) Interpret (g) above.
- j) Use (g) above to predict salinities, temperature at different tides and different times.
- k) Use (g) above to generate hypothesis about salinity and temperature.
- l) Modify (k) above from other group data (e.g. previous years)
- m) Design experiments to validate (k) above using control stations.
- n) Write a report on the salinity and temperature of an estuary and present the report in a seminar using data and photographs.

MANIPULATIVE SKILLS: The students should be able to:

- a) Demonstrate care in the use of a burette, bucket thermometer, pipette, electrical probes, associated glassware and reagents.
- b) Demonstrate the application of safety procedures by making chromic acid.
- c) Use thermometers, balances, burettes, salinity/temperature probes and associated equipment to make quantitative measurements.
- d) Select, assemble and use glassware appropriate to a silver nitrate/sea water titration.
- e) Use a microscope to compare filtrates from waters of different turgidity.
- f) Carry out a field study to a local estuary by setting up a temporary field station and work out of boats or off a pontoon to collect data.

STUDENT MATERIALS:

All materials are described in the Notes, students enjoy making their own equipment and this should be encouraged.

PRE EXPOSURE:

A basic understanding of chemical reagents and safety is important.

REFERENCES/RESOURCES:

A good supply of burettes is required or access to a salinity/temperature probe however these are expensive and do not afford the hands-on philosophy of the course. Students should come to grips with sound laboratory techniques in this unit and good supplies of standard glassware and chemical sets are required. All experiments are standard but an excellent reference is found in "Water Pollution and its Measurement" a practical guide for use in schools by John C. Happs. The Jacaranda Press

TIME REQUIRED:

Depending on the type of student and his/her background 10-15 hours could be minimal.

EXCURSION:

An essential component of the course. Jacobs Well Field Study Centre (Brisbane area) and Boyne Island Field Study Centre (Gladstone area) are two excellent sites. However a temporary field station could be set up using boats and camping gear. It is important not to be too ambitious and to concentrate on things capable of students. Much can be achieved with good depth, salinity, temperature readings in the form of experimental design data collection and hypothesis formation, testing and generalization.

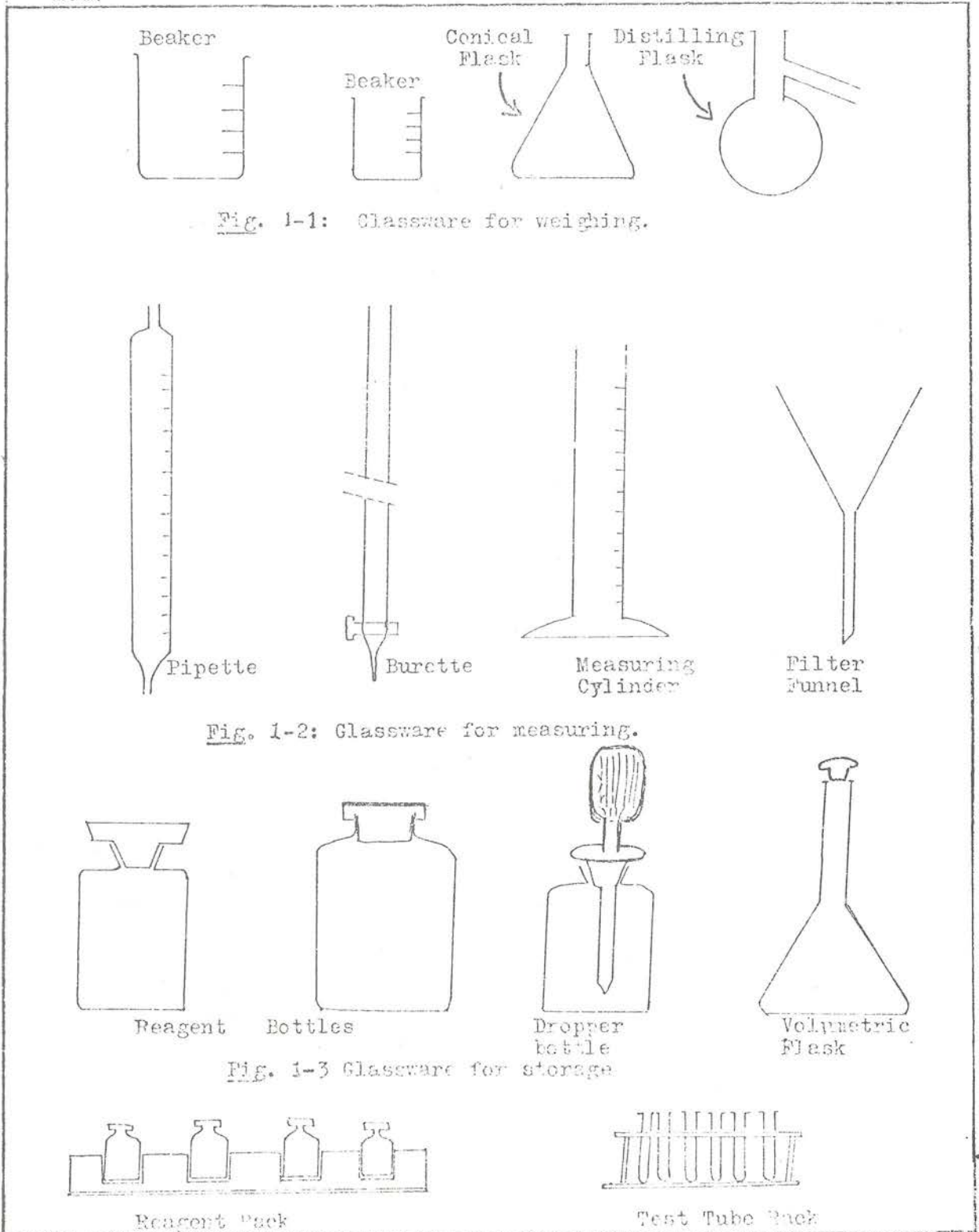
SECTION A

LABORATORY METHODS

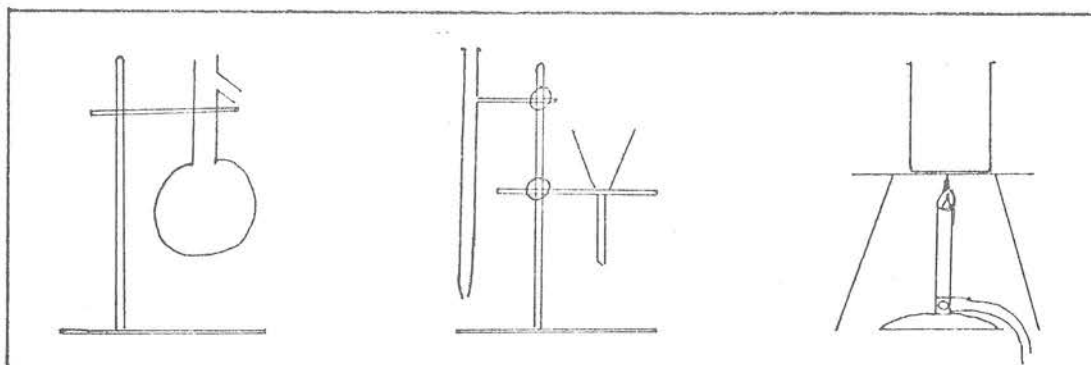
1.1 Glassware

You may have used some of the glassware that will be described here before. If you have, then this Chapter will be a simple revision, but for those of you who have not, an oceanographer's laboratory contains many valuable pieces of glassware which must be correctly used and stored safely.

Here is some of the equipment drawn in side view that you will use.



1.2 Apparatus for holding Safety Glassware



Pick out the following:

RETORT STAND, CLAMP, BOSS HEAD, DISTILLING FLASK, BUNSEN BURNER, FILTER FUNNEL, BURETTE, TRIPOD STAND, BEAKER, RING STAND, AIR PORT.

Fig. 1-4: Apparatus for holding equipment safely

I.3 Apparatus for Weighing the Balance:

Before you start you must ZERO the balance. This is done by placing the balance pan on the scale and moving the ZERO ADJUSTMENT KNOB until the Line on the balance arm lines up with the Zero Point.

Measuring of Masses:

Suppose you wanted to weigh out 162.5 g of starch.

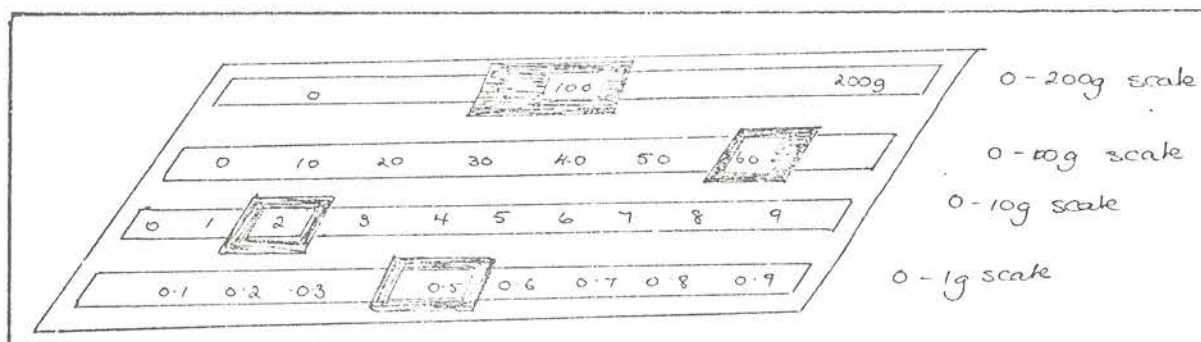


Fig. 1-5: Scale Balance arms.

Readings:

	100.0	(0-200 g scale):
+	60.0	(0-100 g scale):
+	2.0	(0-10 g scale):
+	0.5	(0- 1 g scale):
<hr/>		
	162.5	← <u>Desired Weight</u> :

1. Start off with all the sliding masses on the ZERO position and ZERO the BALANCE.
2. Place a piece of filter paper on the scale and weigh it by moving the 0-1 g scale.
3. Add this to your desired weight.
4. Set the scale.
5. Add starch until the scale balances.

1.4 Burettes

A Burette is an invaluable instrument in titrations of one chemical into another. Such titrations will tell you how much OXYGEN, SALT, ACID, and CARBON-DIOXIDE is in a water sample.

What to do:

- * Fill the Burette at (A) with a labelled filter funnel.

Always use the same burette with the same solution.

If not enough burettes exist, rinse out the burette with CHROMIC ACID and then rinse out the burette with the solution that is to be used NEXT.

Don't mix filter funnels when filling.

- * The Stop Cock (E) is a delicate piece of glassware. It is TURNED by lightly pushing the handle (F) IN.

The Stop Cock is lightly greased on both sides of the ground glass, but not to the point where grease plugs up the small hole.

A CIRCLIP (G) holds the Stop Cock on.

- * DO NOT REMOVE THE STOP COCK - leave this for the Laboratory Assistant or your teacher.

- * Read the INITIAL VOLUME from the bottom of the MENISCUS at (B) with your eye in line with the MINISCUS.

Similarly at (D) - FINAL READING.

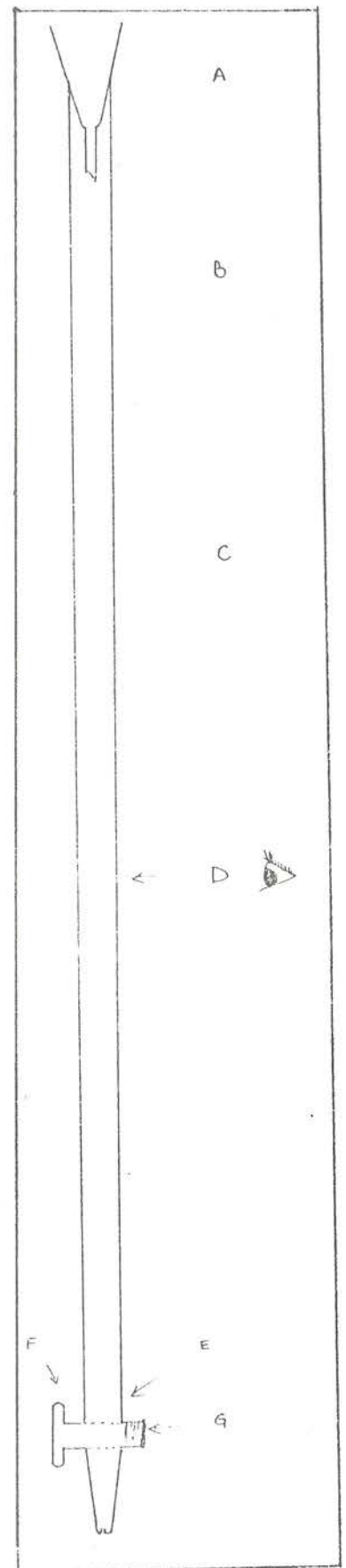


Fig. 1-6: Burette

1.5 Correct use of Laboratory Glassware

Observing the following guidelines will ensure that you treat all laboratory glassware correctly. You will obtain the best possible results from your equipment when it is kept in good condition.

1. Scratched or etched glassware should never be heated, since scratches and etches are zones of weakness and may cause the glass to break.
2. Water and concentrated acids should not be mixed inside a measuring cylinder, since the resulting heat may crack the base.
3. Never place hot glassware on either cold or wet surfaces as the sudden change in temperature may cause the glass to break.
4. Always use tongs or a similar lifting device to remove hot glassware from the heat, otherwise unpleasant skin burns may result.
5. Allow all heated items of glassware to cool slowly, since forced cooling may lead to shattering.
6. Heat liquids in glass vessels slowly and with rotation to avoid overheating any particular area.
7. Any item of glassware that has been used to hold chemical solutions should be washed as soon afterwards as possible. The longer such items are left, the more difficult they are to clean.
8. Take great care when washing measuring cylinders, burettes and pipettes, since it is easy to accidentally break these items on sinks or water taps.
9. Always watch evaporation procedures very carefully so that the vessel may be removed from the heat the moment that evaporation is finished. Otherwise the vessel may crack.
10. Individual items of glassware should always be stored in their correct racks, cupboards or drawers, with no two pieces in contact with each other and none in danger of being broken.
11. Separate burette stopcocks, ground joints, flask stoppers, etc. when storing, to prevent sticking.
12. Place thermometers in the middle of the DESK and be careful how you take them out of their containers.

Before you begin the next part of the notes, go through the following checklist:

I CAN

- | | |
|---|--------------------------|
| (a) Decant a liquid | <input type="checkbox"/> |
| (b) Wash a precipitate | <input type="checkbox"/> |
| (c) Dilute an acid | <input type="checkbox"/> |
| (d) Evaporate with a water bath | <input type="checkbox"/> |
| (e) Use a burette | <input type="checkbox"/> |
| (f) Heat a liquid | <input type="checkbox"/> |
| (g) Recognise, a test tube, a burette, a tripod stand, a bunsen, conical flask, beaker, volumetric flask, balance, gauze mat, retort stand, boss head, clamp, filter paper, pipette, pipette bulb, dropper bottle, reagent bottle, thermometer, test tube rack, graduated measuring cylinder, wash bottle | <input type="checkbox"/> |

1.6 Some Practice

THE CLEANING OF LABORATORY GLASSWARE

1. Preparation of chromic acid cleaning solution

WARNING!

Chromic acid solution can be very dangerous if it is used incorrectly. If any is spilled, the area must be immediately washed with a solution of sodium bicarbonate. Any acid that is spilled on your clothing or skin must be washed off with large quantities of water.

You will need:

- * distilled water
- * potassium dichromate
- * concentrated sulphuric acid
- * 100ml beaker
- * glass rod
- * 60ml bottle with glass stopper
- * 1 or 5ml pipette

* *Be careful of the reaction*
* *Pour the acid very carefully*

Procedure:

1. Pipette 1ml of distilled water to a 100ml beaker.
2. Weigh out about 0.7g of potassium dichromate and dissolve this in the distilled water.
3. Carefully add 50ml of concentrated sulphuric acid to the beaker.
4. Stir in the solution carefully, making sure that all of the potassium dichromate dissolves.
5. Carefully pour the chromic acid solution into a suitable container and seal with a glass stopper.
6. Label this bottle "CAUTION! CHROMIC ACID".

2. Using the chromic acid cleaning solution

You will need:

- * chromic acid solution
- * detergent
- * distilled water
- * sampling bottle (to be cleaned)

Procedure:

1. Transfer about 15ml of the chromic acid solution into the sampling bottle.
2. Slowly swirl the liquid in the bottle so that the chromic acid solution covers the inside of the bottle with a thin film.
3. Leave the bottle for about 2 minutes and then wash it out with a large quantity of water.
4. Wash out the bottle with hot water and detergent.
5. Rinse again with cold water and finally with distilled water. Your bottle is now ready for sampling.



1.7 Oceanographic Units and Measurements

VOLUME:

Millilitres - expressed as Mls : 1000mls = 1 litre
 Litres - expressed as L.

Use a BEAKER, MEASURING CYLINDER, PIPETTE OR BURETTE.

e.g. A 100ml measuring cylinder will hold 100mls to the MARK. It may hold a bit more, but is so called because of its MAXIMUM VOLUME MARK.

MASS:

Kilogrammes - expressed as Kg.
 Grammes - expressed as g. : 1000mls = 1 Kg.

Use a Triple Beam Balance: Express weight as 94.2 g. or 49.62 g. LIMIT OF ACCURACY is 0.01 g.

TEMPERATURE:

Water boils at 100° C. and freezes at 0° C. at standard atmospheric pressure.

Queensland sea air temperature ranges from 12° C. to 25° C. and water temperature from 16° C. to 22° C.

There are exceptions.

Use a hand Lens to measure to 0.1° C. accuracy, and use a 0-50° C. range thermometer.

EXTINCTION COEFFICIENT

Secchi Disc = $\frac{1}{2}$ L where L = length of rope under water in metres.

SPEED:

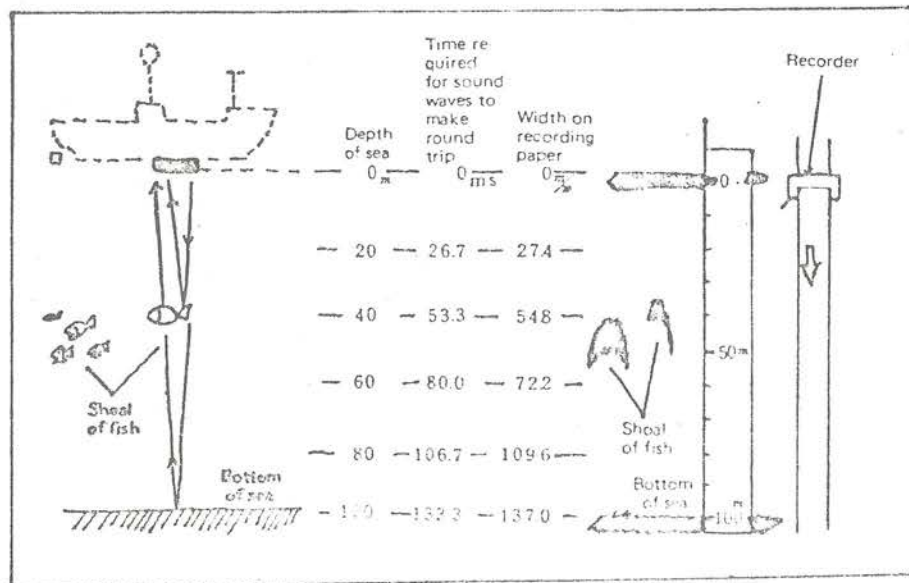
Knots: 1 Knot = 1 Nautical Mile per hour.

Used for speed of vessel and wind and current speed.

Km/hr = Kilometres per hour - Air speeds, Current speeds.

TIME:

Hours, minutes, seconds - used in Navigation.



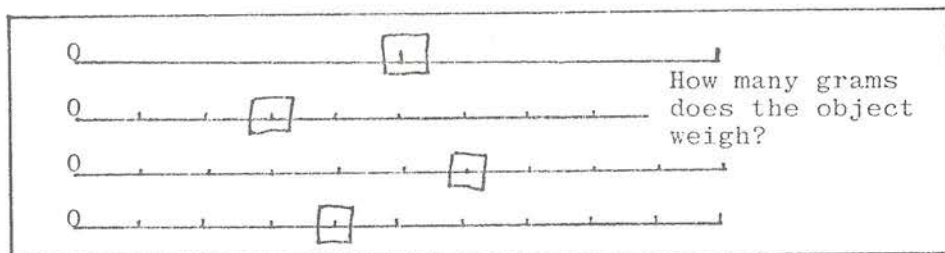
Principles of sounding machine

MAIN IDEAS

1. In a chemical laboratory there is a place for everything and everything in its place.
2. Burettes need special care.
3. Chronic acid is used to clean glassware.
4. As in all sciences, each measurement has a set of units.
5. A Laboratory Balance is a delicate scientific piece of apparatus and not a toy.

REVIEW QUESTIONS

1. How many significant figures are there in each of the following quantities?
 - (a) 37.2 m
 - (b) 0.000 076 sec
 - (c) 301.5 kg
 - (d) 56.02 m
 - (e) 5.00 m
 - (f) 0.000 000 000 97 m
 - (g) 0.05 m
2. A triple beam balance as follows



3. List the dangers with acids and alkalis.
4. What precautions must be taken when using and making chronic acids?
5. How do you care for a burette?
6. How do you care for a balance?
7. Name 9 pieces of glassware.
8. How should liquids be poured? How should the pipette bulbs be used?



SECTION 2

SALT WATER CHEMISTRY

2.1 Limits of Tolerance

When studying the chemistry of sea water, we should not study it as a study of its own. The results and observations you learn about in this chapter will drastically affect the organisms that inhabit the estuaries.

An animal's survival is often limited by the factor with the narrowest tolerance. The limits of tolerance describe a range of living conditions specific to each organism and each living or non-living factor affecting it. Every species of animal and plant has a range of tolerance for each factor which determines its survival. There are tolerances for food, predation, shelter, breeding conditions, temperature, salinity, water clarity, light, pressure, oxygen, depth, and other factors that affect its surroundings at any stage of a life cycle. An animal's survival is often limited by the factor with the lowest tolerance.

TABLE 2-1

The Limit of Tolerance

Lower Limits of Tolerance	Living Conditions	Upper Limits of Tolerance
		Light
		Oxygen
		Depth
LIMITING FACTOR		Temperature
		LIMITING FACTOR Salinity
		Water Clarity
		Food

Let us study now how each is recorded:

2.2 Temperature in Estuaries

Water with high salinities tends to sink and therefore will be colder than water with lower salinities. It seems reasonable therefore to suggest that the bottom layers of an estuary will be colder and denser compared with the top layers.

Water temperatures in estuaries can often change quite dramatically due to floods, droughts, location of heavy industry or meat works. An increase in the heat content of water can have a serious effect on the life in an estuary.

Power stations, for example, use VAST quantities of water in cooling processes. This water is returned to an estuarine waterway a lot hotter than the surrounding water. Also, evaporation at the surface can cause the water temperature to be colder than at the middle layers.

Investigation 2-1: Environmental Effects of Temperature

You will need:

PART A : Effect of Pollutants

- * Sea water sample. (From investigation)
- * 3 test tubes
- * Test tube rack
- * Dilute sulphuric acid
- * 0.50°C. Thermometer
- * 250ml beaker

PART B.

- * 3 x 250ml measuring cylinders
- * Hydrometer or Salanometer
- * Hot water
- * Cold water
- * Urn (if hot water supply not available)

PART C.

- * Graph paper

What to do:

PART A.

1. Set up 3 test tubes half full of water and read the temperature in each to the nearest 0.1°C.

Record in data table.

2. Add drops of bleach, acid and iron filings to each of the test tubes.

Record the temperature change in each to the nearest 0.1°C.

CARE : Do not add too much acid or you will break the thermometer. ALWAYS add acid to water.

PART B.

Fill 3 X 250ml measuring cylinders with cold, warm, and hot water.

Record the hydrometer reading and temperature in each.

PART C.

Examine the data table below on temperature and dissolved oxygen content in parts per million.

Temperature °C	Dissolved oxygen
0°C	13 PPM
5°C	10 PPM
10°C	8 PPM
15°C	6 PPM
20°C	5 PPM
25°C	4 PPM

Plot a Graph of the Data

Analysing the results:

1. In which test tubes in PART A did the temperature increase the greatest?
2. Which water pushes up the hydrometer the most?
HOT or COLD?
Is cold water more or less dense than Hot Water? WHY?
3. How could acids, bleach, or iron filings enter an estuary?
4. Predict the dissolved oxygen in sea water at 22.5°C and 28°C.

Drawings:

Try this : Try dissolving an alka-seltzer tablet in hot water.

5. Make pencil line drawings of the experimental equipment used in PARTS A and B.

The environmental effects of temperature are many. Fish can die or move elsewhere if temperatures change. Rainbow trout cannot live if the temperature rises above 15 C, or perch above 24 C. Each of these species can only tolerate a temperature rise of only 5 C.

Poisoning by chemicals such as acids or heavy metals can be increased dramatically if temperatures in estuaries increase by 10 C.

The amount of oxygen decreases rapidly as temperature rises. This can effect the type of fish that breed in estuaries or the survival rate of their young.

2.3 Salinity

Estuaries are places where fresh water from the land mixes with ocean water. Salinity is a measure of the amount of dissolved salt in the water. Water which has a less amount of salt in it, not equivalent to oceanic water, is called brackish water.

Investigation 2-2: Making Sea Water

You will need:

- * A salinometer (or Beer Hydrometer)
- * An empty 2 litre wine flagon + cap
- * OR 1 X 1 litre measuring cylinder
- * 70g of salt (35g if using a 1 litre cylinder)
- * Triple Beam Balance
- * Spoon or large Spatula

What to do:

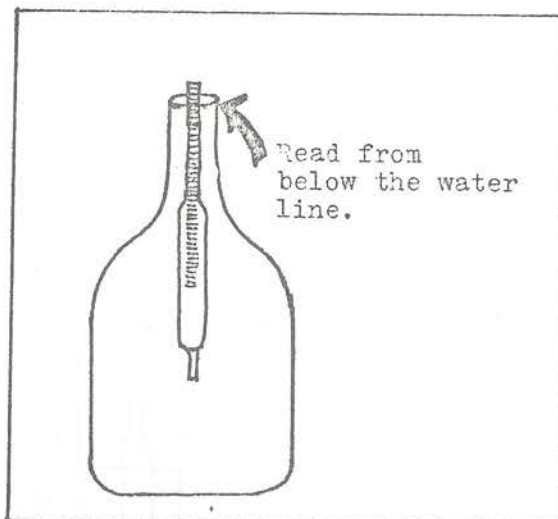


Fig. 2 - 1: Hydrometer in Wine Flagon.

1. Fill the wine flagon almost to the top with water (This represents water from the land) and place the salinometer in and top up.

Read and record the salinity from under the water line.

2. Now weigh out 10g. salt (5g. if you use a 1 lt. cylinder). Take out the salinometer, pour in the salt, screw the cap of the wine flagon on, and shake. Replace the salinometer and top up again if necessary.

Read and record the salinity. What has happened?

3. Repeat this 7 times until 70g. of salt has been added, recording the salinity each time.

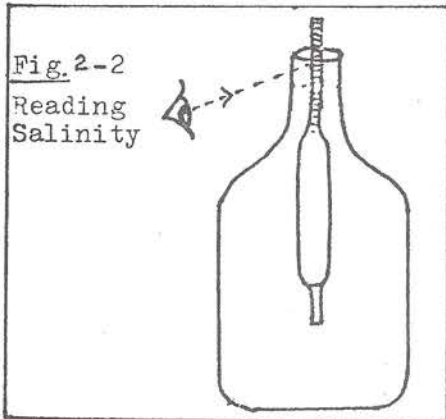
4. Plot a graph of SALINITY versus GRAMS OF SALT. This will serve as a very useful calibration curve in field work and should be plotted carefully and accurately, and covered with clear contact if necessary, AND

KEEP YOUR SALT WATER NOW FOR FURTHER EXPERIMENTS.

Questions:

1. What happened as you added the salt?
2. What did you do to the water to make this happen?
3. When you had added 70 grams of salt to 2,000mls of water, what % salt was in the water?
4. Extrapolate the curve and predict the salinity reading when 9.5 grams of salt was added.

The saltiness of sea water is called SALINITY and is measured in parts per thousand (PPT). In the ocean, the salinity is usually 35 PPT, or if you took a litre of sea water and boiled it all away you would be left with 35g. of salt.



In 2 litres of water you added 70 grams of SALT.

This is equivalent to adding 35 grams in 1 litre.

This is approximately the salinity of sea water and is written as

35%

35 parts per thousand.

The salinity of ocean waters anywhere in the world is usually between 34-36 PPT. In estuaries the salinity can be much less than the ocean because water in the rivers, mixing with the ocean water, dilutes it. The salinity can be as high as 35 PPT or as low as 10 PPT.

In Northern Queensland estuaries the salinity varies from time to time due to seasonal rains. In Summer, when there is a lot of rain, there is a tremendous flow of water into the rivers. When this occurs the salinity drops to 10-12 PPT. In the Winter, when there is little or no rain, the level of the rivers drops and the amount of fresh water reaching the sea is not as great. This is when the salinity of the estuary increases.

The salinity varies also with tides. Depending on the size of the local tides, a gradual influx of water into the estuary can change the salinity.

Let us look at this more closely. Investigation proved that salty water pushed the hydrometer up. This was because of the increase in density of the salt water.

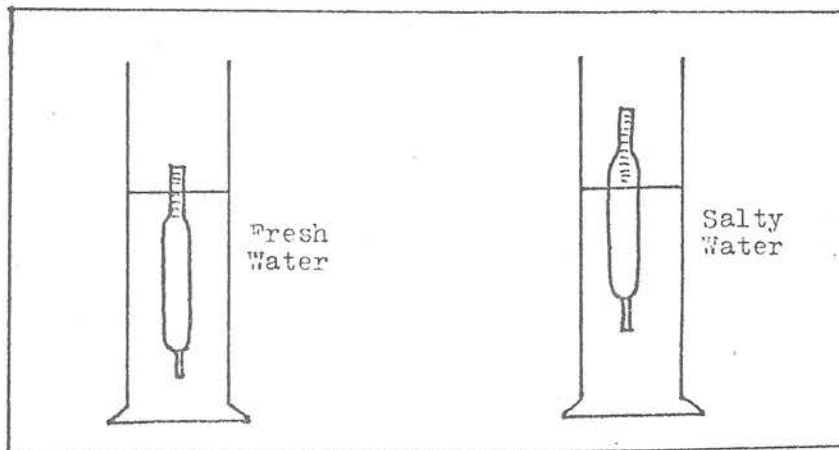
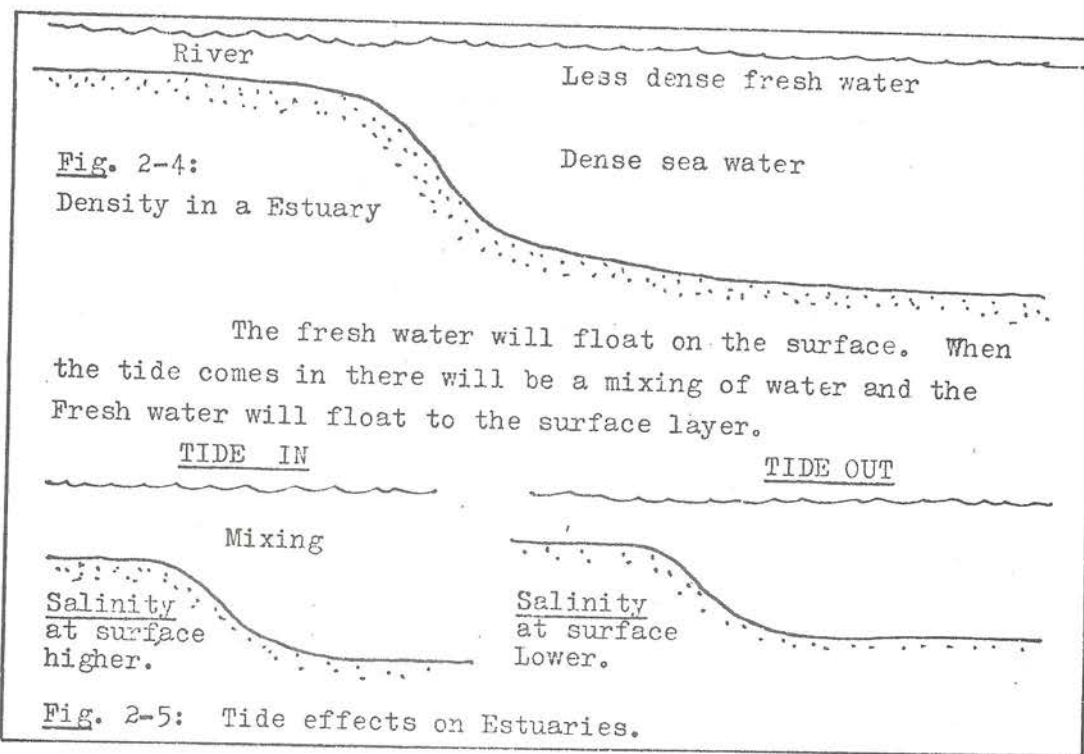


Fig 2 - 3:
Comparing Salt and Fresh water

Salt water is said to be denser and therefore will tend to sink, whereas fresh water will tend to float.

Consider now an estuary from the side:



Investigation 2-3: Measuring Salinity of a Sea Water Sample

You will need:

- * Burette
- * Silver Nitrate solution (fresh) 100mls
- * 10mls filtered sea water sample
- * 1ml pipette and dropper
- * 50ml conical flask
- * Potassium chromate indicator
- * Small funnel (for filling Burette)

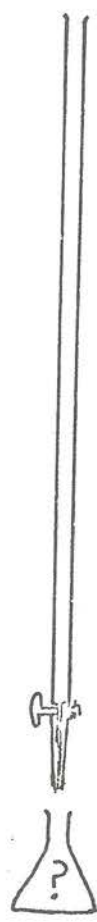
Notes on Solutions:

Silver Nitrate solution : Weigh out 0.497g of dry silver nitrate crystals and make up one litre of solution in a volumetric flask. It is very important that these solutions are made up accurately.

When the solution has been made up, a clean, dry, brown glass bottle should be labelled suitably and the solution transferred to it, since direct sunlight tends to break down silver nitrate solution.

Potassium chromate indicator : Weigh out 5g of potassium chromate and dissolve this in 90ml of distilled water in a 250ml beaker. When all of the potassium chromate has dissolved, add a few drops of silver nitrate solution until a red precipitate forms. The solution is then filtered into a clean, suitably labelled bottle.

This solution of AgNO_3 is cheap, as large amounts are required for Field Work.



*What to do: Note - If you have not mastered the stop-cock yet, fill the Burette with water and practice.

1. Fill the burette with silver nitrate solution.
2. Pipette 1ml of filtered sea water into a 50ml conical flask.
3. Add 1 drop of potassium chromate indicator.
4. Run the silver nitrate into the conical flask, taking care as you approach the end point which is indicated by a red colour.
5. Repeat or use class set results to obtain average.

*Sample Calculation

Each milligram 0.001g of chloride in the sea water uses .1ml of silver nitrate solution.

Initial Burette reading = 0.00ml
 Final Burette reading = 60.00ml
 Volume of Silver Nitrate used = 60.00 - 0.00mls
 = 60mls

IF 0.1mls ^{uses} 0.001g.
 THEN 60. mls x' grams

$$0.1x = 0.001 \times 60$$

$$\frac{x}{10} = \frac{60}{1000}$$

$$x = \frac{600}{1000} = 0.6g$$

To get PPM x 1000

$$\therefore \text{PPM of chloride} = \frac{0.6 \times 1000}{10} = 600 \text{ PPM}$$

Questions:

1. Often in estuaries the salinity is higher near the bottom than the top. Why?
2. You wish to measure salinity at 4 depths at 3 times during the day. How much silver nitrate would you need?
3. Study the table below. Plot a graph of Salinity v's Latitude.

SALINITY %	LATITUDE
32.0	80° N
33.0	70° N
32.6	60° N
33.5	50° N
35.0	40° N
35.8	30° N
35.3	20° N
34.5	10° N
35.0	0°
35.5	10° S
35.7	20° S
35.5	30° S
34.5	40° S
34.0	50° S
33.9	60° S
33.9	70° S
34.0	80° S

4. What relationships exist between the PLIMPSOL line on Ships and SALINITY?

2.4 Sediments and Turbidity

During rainy seasons river heights rise washing off topsoil from their banks. This soil becomes dissolved or suspended in the river water and is washed into estuaries. Mud can cause problems for the animals and plants that live nearby, or it can provide an excellent hiding place.

Because water is such an excellent solvent, many compounds dissolve in it easily. It is expected that all water bodies will contain a certain amount of dissolved material since chemical compounds are constantly being weathered out of rock and soil, and the T.D.S. content of a river increases rapidly as it approaches the sea. T.D.S. can also be increased by industrial effluent, sewage disposal and irrigation, which washes salts from the land.

It has been realised that for many years, that a number of dissolved solids in the sea water can have a harmful effect. Every now and then you hear of oyster poisoning or mercury poisoning. The increasing use of metallic elements (mercury, lead, zinc and cadmium, is of concern when these elements end up in waterways.

Factors that can contribute to increasing include :

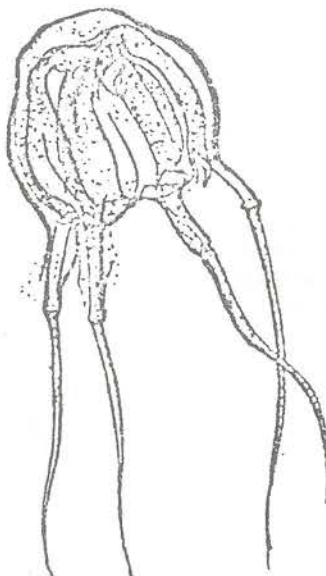
1. Industrial effluent.
2. Irrigation - a process that dissolves huge quantities of fertilisers that end up in estuaries.
3. Ocean inundations by other areas containing dissolved particles.

About 97% of all the world's water is found in the sea. Less than 1% is actually fresh water. In estuaries there is a mixing of water.

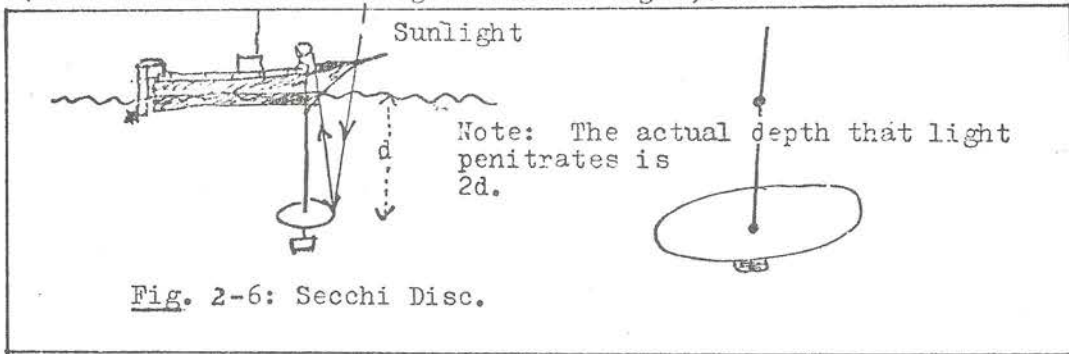
Through weathering and erosion, chloride compounds in rocks and soils eventually find their way into streams and rivers, and therefore we would expect all natural waters to contain some chloride ions. However, we should realise that aquatic life cannot exist if the chloride concentration becomes too high. (For example, freshwater species cannot survive if the water becomes saline).

The chloride concentration of water may increase significantly where industrial wastes containing chlorine compounds enter the water body, or where certain mining projects allow rain and wind to move chloride-bearing wastes into nearby waterways.

Irrigation dissolves chloride compounds from the topsoil and transports them into rivers and lakes. Evaporation may concentrate the dissolved salts to extremely high levels in some lakes in dry areas - for example, the Dead Sea and Lake Eyre.



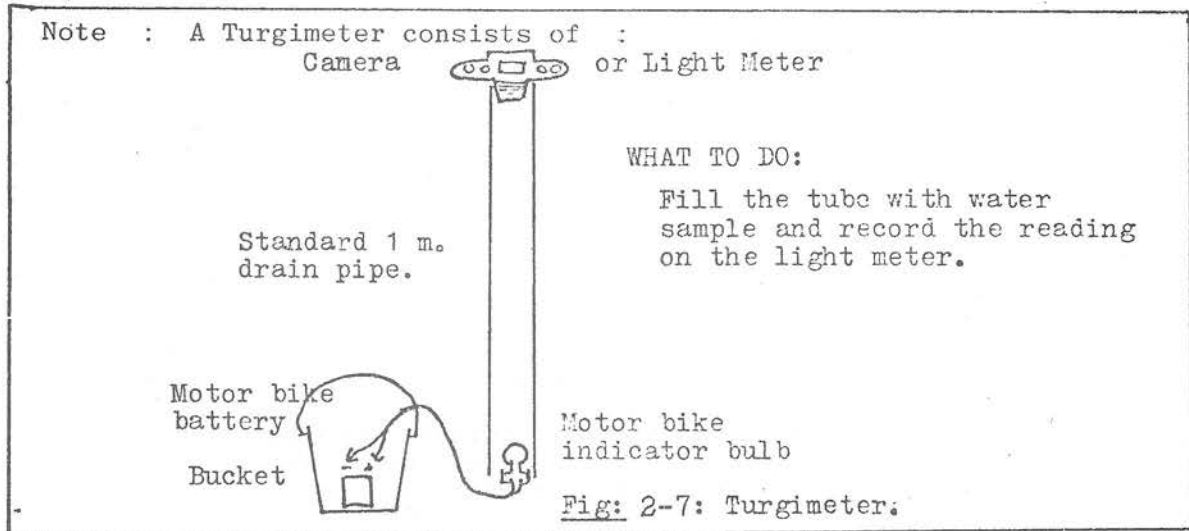
Turbidity of water clarity is measured with a secchi disc. This disc is lowered over the side of the boat. A record of depth is kept when the white disappears. This is multiplied by 2 (because we are observing reflected light).



The value obtained is called the *EXTINCTION COEFFICIENT* and is used world wide as an accepted measure of Turbidity. The zone that light penetrates in the ocean is called the *Photio Zone*.

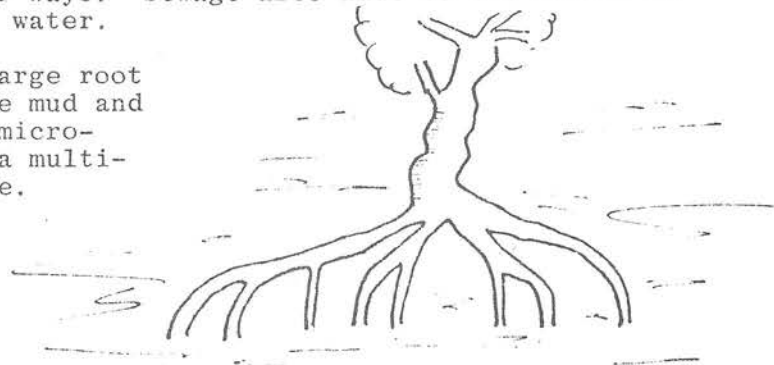
Extinction Coefficient	Water Content
$\frac{1}{2}$ metre	Very muddy
1 metre	Much suspended particles
5 metres	Few suspended particles
10 metres	Very clear

ADDITIONAL METHOD: Turgimeter



Man causes high *TURBIDITY* in estuaries by clearing land of trees and vegetation, so that grass and root systems no longer bind, (together) the top soil. Both wind and water transport this material to water ways. Sewage also adds to the amount of suspended material in water.

Mangroves have large root systems which trap the mud and provide an excellent micro-environment in which a multitude of organisms live.



Investigation 2-4: Measuring the total suspended solids T.S.S. and total dissolved solids T.D.S. in a sea water sample.

You will need:

- * Triple Beam Balance or (Analytic Balance)

PART A. T.S.S.

- * 3 x 250ml sea water samples containing different solids. You will have to make them up (Clear, Some, Lots)
- * 3 filter papers
- * 3 filter stands or tripod stands
- * 3 filter funnels
- * 6 x 250ml conical flasks
- * Balance (second day)
- * Drying lights or oven
- * 100 or 250ml measuring cylinder
- * Wash bottle

PART B. Total Suspended Solids

1. Make up 3 different 250ml sea water solutions by adding some soil to the sea water sample in 3 x 250ml conical flasks. Add 0.5g., 1g. and 5g. approximately.
2. Set up 3 filter funnels with 3 more 250ml conical flasks. Weigh the filter papers to the nearest 0.02g and then fold, and place in the funnels.
3. Measure out 100mls of sample and filter this so that sea water (the filtrate) passes through, leaving the residue trapped in the filter paper.
4. After all the 100mls has filtered through, dry the filter paper in an oven or under lights overnight.

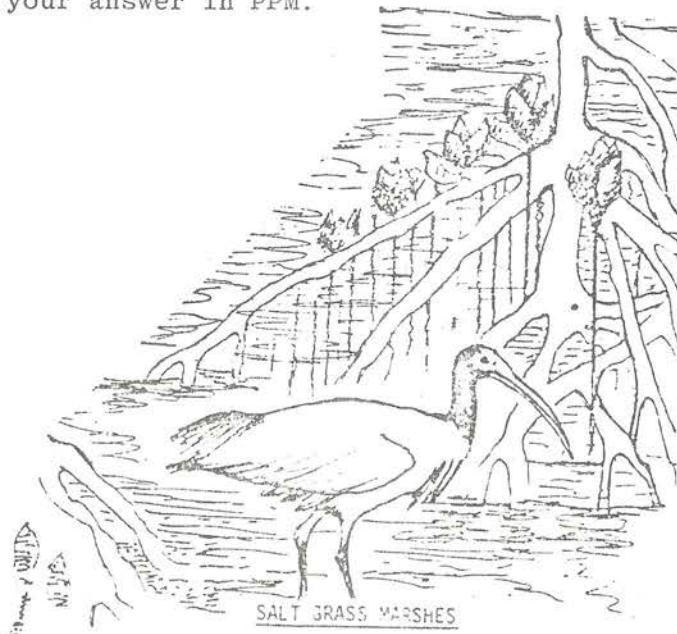
NEXT DAY - Carefully weigh the dried filter papers with the same balance you used.

Calculate the number of grams of residue :

Mass of filter paper = x grams
 Mass of filter paper + residue = y grams

∴ Mass of residue. = y-x grams

Express your answer in PPM.



SALT GRASS MARSHES

NOTE : Calculate part per million ; Note 1ml = 1 gram

If 100mls contains 0.01g.

Then 1,000,000mls contains x gr.

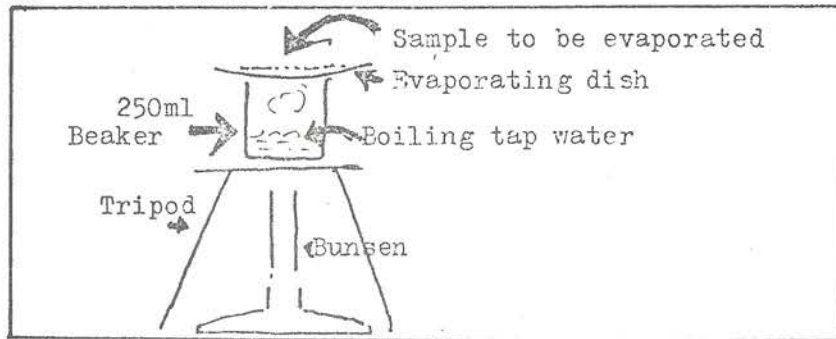
Cross multiplying:

$$\begin{array}{cc}
 100 & \searrow & 0.01\text{g} \\
 & \times & \\
 1,000,000 & \nearrow & \text{x g}
 \end{array}$$

$$\begin{aligned}
 100 \text{ x} &= 0.01 \text{ x } 1,000,000 \\
 \text{x} &= \frac{0.01 \times 1,000,000}{100} \\
 &= 0.01 \times 10,000 \\
 &= \underline{10 \text{ grams per million}} \\
 \text{OR} &= \underline{10 \text{ PPM}}
 \end{aligned}$$

PART B. Total Dissolved Solids

Set up a water bath as follows :



1. Weigh out 3 numbered clean evaporating dishes and record their weights to the nearest 0.01g.
2. Add 5mls of filtered water sample to each, and evaporate off all the water.
3. Place in a Dessicator overnight.

NEXT DAY

4. Weigh the numbered evaporating basins on the *same balance*.

Record the change in weight
 Calculate the PPM of each sample

$$\begin{aligned}
 \text{Mass of Basin} &= \text{a.grams} \\
 \text{Mass of Basin + TDS} &= \text{b.grams} \\
 \text{Mass of TDS} &= (\text{a-b})\text{grams}
 \end{aligned}$$

If 5mls contains (a-b)g. of dissolved solid
 Then 1,000,000mls " a.grams

$$5x = (a-b) \times 1,000,000$$

$$x = \frac{(a-b)g \times 1,000,000}{5} \quad \text{PPM}$$

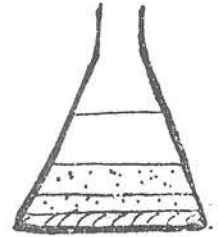
RESULTS : Produce a data table to summarize your findings in PART A and PART B.

QUESTIONS:

1. How did your results compare with the expected results?
2. Why is it necessary to use the same balance all the time?
3. Why did you place the evaporating basins in the dessicator overnight?
4. Why are parts per million used?
5. Write a paragraph explaining the effects of dissolved soil particles on fish in an estuary.

25 Turbidity and Oxygen

If you let your dirtiest sea water sample settle overnight you will see that the sediment will settle out. Shake it again and we see it becomes dirty, or it has what we call *High Turbidity*. The turbidity is due to the mud which you know consists of dissolved and suspended materials.

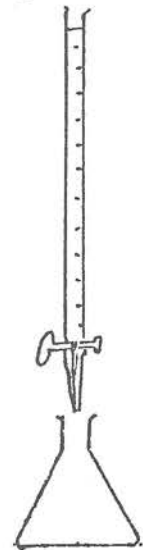


Turbidity prevents light from reaching plants below the surface. It is only when plants get sunlight that they can build up a store of food by the process called *photosynthesis*. If light is prevented from reaching them by high turbidity, photosynthetic rates decrease and the amount of oxygen will decrease. Mangrove swamps are characterised by characteristic odours. Lack of oxygen is a contributing factor.

Investigation 2-5. Measuring the Dissolved Oxygen Content of Sea Water

You will need: Freshly made solutions of

- * Starch solution
- * Concentrated sulphuric acid
- * Manganese II sulphate solution
- * Alkaline Iodide solution
- * Sodium Thiosulphate solution
- * 250ml conical flask and stopper
- * 500ml conical flask
- * 3 x 2ml droppers, OR 3 x 2 ml pipettes with filter bulbs
- * 250ml measuring cylinder
- * Burette

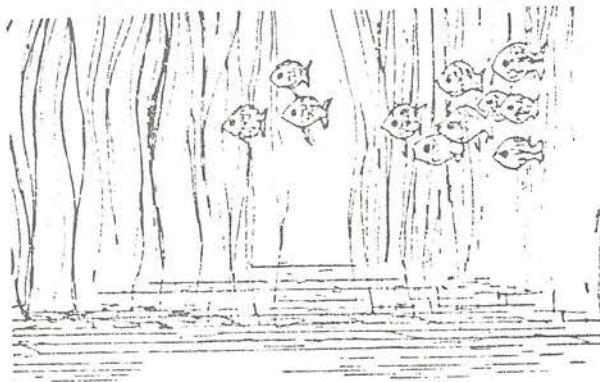


- NNB. 1. 2ml samples must *NEVER* be pipetted using a *MOUTH* pipette. These chemicals are extremely *POISONOUS*.
2. For each 2ml added, use a separate pipette or dropper, i.e. name one for manganese sulphate, one for alkaline iodide, and one for sulphuric acid.

Teachers Note - keep these from year to year.

What to do:

1. Fill a burette with water and drain the burette in short spurts - adjust the stop-cock so that it will give you drops. Practice this a few times.
2. Take a 250ml sample of water to be tested and place in a conical flask. (Note : If this is to be done in the field later, use a tube to add the water to the bottom of the sample bottle to avoid air bubbles which may increase the D.O. of the sample Steps 3-5 must then be done immediately). Add 2mls of Manganese sulphate.



What to do: (cont)

3. Steps (i) to (v) should be done immediately. The subsequent titration may be delayed several hours to be done in a Laboratory. Steps (ii) to (v) should be done on a surface which cannot be harmed by the overflow.
- (i) Take a 250ml sample of water to be tested. Place this in a conical flask. Use a tube to add water to the bottom of the sample bottle to avoid air bubbles, which may increase the D.O. of the sample.
 - (ii) Add 2ml of Manganese sulphate below the level of the sample, again to avoid air bubbles.
 - (iii) Add 2ml of alkaline iodide solution below the surface.
 - (iv) Replace stopper carefully in bottle, shake vigorously, and allow precipitate to settle.
 - (v) Add 2ml of conc. sulphuric acid above the water level, replace the stopper and shake.
 - (vi) Transfer 200ml of the solution to a 500ml conical flask using a 250ml measuring cylinder.
 - (vii) Titrate with standardized sodium thiosulphate solution, using starch indicator for the end point (blue colour just disappears). The D.O. in mg/l, i.e. PPM, is the number of mls of sodium thiosulphate used to reach the end point.

NNB. 2ml samples of chemicals *MUST NOT* be pipetted using a mouth pipette. These chemicals are extremely dangerous.

ALSO NOTE : For each 2ml added, use a separate pipette or dropper, i.e. nominate one dropper for the manganese sulphate, one for the alkaline iodide, and one for the sulphuric acid.

4. Calculations:

Initial Burette reading	=	0.02mls
Final Burette reading	=	5.02mls
Volume of Thiosulphate used ...	=	Final reading-Initial reading
	=	5.02-0.02mls
	=	5.00mls

The dissolved oxygen, or D.O., in mg/litre is the number of mls of sodium thiosulphate used to reach the end point.

So, in our sample there are 5 PPM of dissolved O₂

RESULTS:

For really accurate calculations, class averages must be taken, or repeat your titration three times. You may want to heat one of your samples and calculate the dissolved oxygen.

5. Questions:

- 1. What exactly is the end point?
- 2. List safety precautions with sulphuric acids. What first aid procedures should be adopted if acid spills in the eye? On the body?
- 3. What effect does heat have on dissolved oxygen?
- 4. Write a paragraph on the relationship that you might expect between oxygen, light, temperature and fish.

Solutions required:

Use as freshly made as possible.

* Manganese II sulphate :

Make 100g of $MnSO_4 \cdot 2H_2O$ to 250ml solution
Or 120g of $MnSO_4 \cdot 4H_2O$ to 250ml solution

* Alkaline Iodide solution :

Either (a) 100g NaOH + 27g Na_2I + 10g sodium azide
Make up to 200ml solution
OR (b) 140g KOH + 30g K_2I + 10g sodium azide
Make up to 200ml solution

(Note : Sodium azide prolongs the life of the solution)

.025M $Na_2S_2O_3$: 3.95g per litre of solution
Or 6.2g of $Na_2S_2O_3 \cdot 5H_2O$ per litre of solution

* Starch Indicator :

Mix 1g of soluble starch in water to a fluid paste.
Transfer to 100ml boiling water. After cooling, add
0.5ml of 40% formalin. (Formalin may be omitted if
used fresh).

* Concentrated H_2SO_4 : Standard 18m

2.6 The Importance of Oxygen

Although some forms of bacteria can live in water that contains no dissolved oxygen, no other animal life can survive in these conditions. Obviously, it is very useful to be able to measure the oxygen levels of water samples. The following guide relates oxygen levels to possible life forms.

Less than 1 PPM of oxygen

This water would not support any life other than anaerobic bacteria. It is bacteria of this type that releases the gases that may be detected in swampy areas, such as methane and hydrogen sulphide.

Between 1 PPM and 5 PPM of oxygen

A few animals, such as worms and shrimps, may survive in this water, although there is not enough oxygen for fish.

More than 5 PPM of oxygen

A large variety of animal life can live in this water.

Oxygen dissolves in water to only a slight extent. It usually enters the water from the atmosphere or be being released by green plants growing beneath the surface. The amount of dissolved oxygen depends on water temperature and altitude (that is, atmospheric pressure). At 20 C and at sea level pressure, a value as high as 9 PPM can be expected whereas high mountain lakes may contain up to 40% less dissolved oxygen at the same temperature. The dissolved oxygen content falls with increase in temperature.

The main cause of water de-oxygenation is the presence in the water of substances known as oxygen-demanding wastes, that is, materials that are readily broken down in the decaying process produced by bacterial activity, with resulting depletion of dissolved oxygen. Most oxygen-demanding wastes are organic compounds, which commonly occur in sewage, industrial wastes from food-processing plants, paper mills and tanning plants, and slaughterhouse effluents. Since the characteristic element in these organic materials is carbon, an obvious reaction (and one encouraged by bacterial activity) is the oxidation of carbon to carbon dioxide: $C + O_2 \rightarrow CO_2$. Any available carbon will require almost three times its mass of oxygen to react. For example, one drop of oil will react with all the dissolved oxygen in 4.5 litres of water.

2.7 Biological Oxygen Demand

Water that contains organic waste usually also contains bacteria, which break down the waste material and in the process consume dissolved oxygen. The amount of oxygen that is used up in this process is a good measure of the amount of organic waste in the water sample and is known as the *biochemical oxygen demand*.

Some Typical B.O.D. Levels

Source of Sample	B.O.D. (PPM)
Untreated municipal sewage	100 - 400
Runoff from farmyard	100 - 10 000
Food-processing wastes	100 - 10 000
SOURCE : C.H. Wadleigh, Wastes in Relation to Agriculture and Forestry; U.S. Department of Agriculture miscellaneous publication No. 1065 (Washington D.S: U.S. Government Printing Office, 1968) pp. 41-44.	
Aerobic conditions	Anaerobic conditions
C - CO ₂	C - CH ₄
N - NH ₃ + HNO ₃	N - NH ₃ + amines
S - H ₂ SO ₄	S - H ₂ S
P - H ₃ PO ₄	P - PH ₃
SOURCE : L. Klein, River Pollution. Vol. 2 (London: Butterworth, 1962) pp. 37-38.	

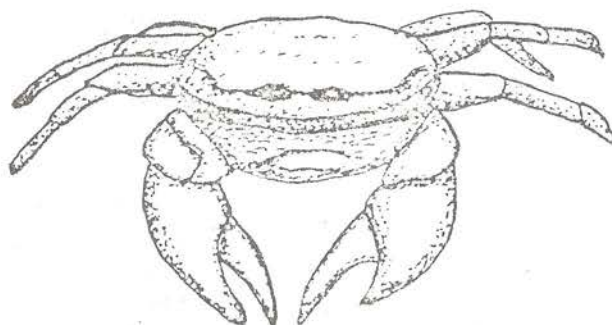
Aquatic life may disappear when oxygen is removed from water, because it has died of oxygen starvation or because it has moved to more favourable areas. A further result of oxygen depletion is an increase in the number of anaerobic organisms, which, in contrast to aerobic organisms, thrive in the absence of oxygen. Some products of decomposition may be summarized as in the table.

Methane (CH₄), often called "marsh gas" is odourless and flammable. Amines have a fish smell. Hydrogen sulphide (H₂S) is evil smelling and toxic. Some phosphorous compounds also have unpleasant odours. Obviously, a change from aerobic to anerobic conditions is most undesirable where water is to be used for human consumption, and also where water is used for recreation.

Investigation 9-6. Measurement of Biological Oxygen Demand - BOD

BOD is the measure of dissolved oxygen used during the aerobic decomposition of organic matter present in the water. This is often used as an organic pollution indicator. The greater the amount of organic matter present, the higher the BOD.

Chlorinated water should not be tested for BOD as chlorination destroys the organisms which decompose the organic matter.



You will need:

- * Water sampler -
- * 250ml measuring cylinder
- * 3 x 2ml pipettes with filter bulbs or
3 x 2ml droppers
- * 2 x 500ml conical flasks with stoppers
- * Burette and stand
- * 2 beakers
- * Length of polythene or rubber tubing
- * At least 5 x 500ml flasks with stoppers
- * An incubator or dark water bath which can
be set at 20°C.

Solutions:

As for
In sufficient quantity for at least 1 titration per day
for 5 days.

What to do:

1. Collect 5 samples of water and place each in a flask
and stopper tightly. Do not shake.
2. Incubate 4 of these flasks at 20°C in the dark to
preclude any photosynthesis which might occur.
3. Test 1 flask (as shown in for dissolved oxygen.
4. Each day for the next four days, test one flask for
dissolved oxygen.
5. Set up table, e.g.

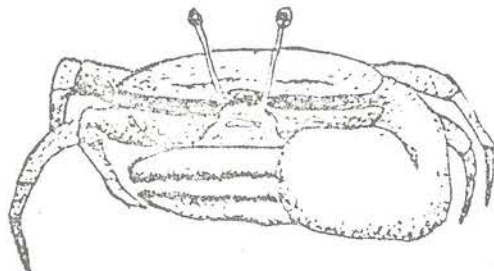
DAY	1	2	3	4	5
DISSOLVED OXYGEN					

6. Express the BOD as: mg l^{-1} (PPM) oxygen original, minus
minus PPM oxygen final, over 24 hour, 48 hour, 72
hour, 96 hour, and 120 hour periods.
This gives a reading in mg l^{-1} of the amount of oxygen
oxygen used during each time period, and so
indicates the amount of organic material in your
sample.

2.8 Other Chemical Aspects of Sea Water

There are many other chemical tests for carbon dioxide,
acidity, etc. If you have time you may like to try them.
They are listed below :

Carbon Dioxide: Water bodies tend to contain dissolved
carbon dioxide because this gas dissolves in rain droplets as
they fall through the atmosphere. The amount of carbon dioxide
present in a water sample will affect the pH because the product
of carbon dioxide solution in water is carbonic acid:



Acidity: In this topic we use the pH value to indicate whether or not a water sample is acidic or basic. Neutral samples have a pH of exactly 7.0; acidic solutions have a pH less than 7.00; alkaline solutions have a pH greater than 7.0. If a body of fresh water has a pH value outside the range of 6.0 - 8.0, it is possible that pollutants are entering the water at some point. Common materials that can easily disturb the natural pH of water are fertilizers, industrial effluent, detergents and insecticides.

The most productive fresh natural waters contain concentrations of the carbonate ions that result in a pH of between 6.5 and 8.5. Such a system can readily absorb small quantities of acidic or basic materials without significant changes in pH. However, if large amounts of strong acid or base are allowed to enter the system, then the natural "buffering" ability of the water is overcome, resulting in drastic changes of pH. Consider some of the possible consequences.

1. A water body with a pH as low as 6.0 can cause excessive corrosion of plumbing, boats and metal structures in the water, such as piers.
2. All vertebrates, most invertebrates and the majority of microorganisms die at pH values below 4.0. In fact, only bacteria and a few species of algae can tolerate such levels of acidity.
3. Agricultural crop damage will almost certainly result if the pH of irrigation water falls below 4.5. This level of acidity in water causes iron, aluminium and magnesium salts to dissolve more readily than usual and the resulting high concentrations can become toxic to crops.

Investigation 2-7. Measuring the acidity or alkalinity of Sea Water

You will need:

- * Water samples
- * pH paper
- * Universal indicator
- * Phenolphthalein solution
- * 0.02 M sodium hydroxide solution
- * 0.01 M sulphuric acid
- * pH meter (if available)
- * Burette
- * 3 x 250ml conical flasks
- * 25ml pipette

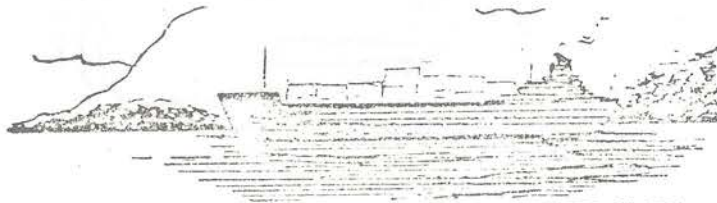
What to do:

Approximate measurements of pH can readily be obtained using inexpensive pH paper or universal indicator solution. It would be an excellent idea to test the pH of a number of household detergents, insecticides, etc. before going on to test your water samples.

A pH meter will give a more accurate result, though not all students may have access to this relatively expensive piece of equipment.

Alternative method:

We can determine the alkalinity of a sample of water by using a burette, a 25ml pipette and phenolphthalein indicator. Note that phenolphthalein is colourless in the presence of acids but gives a pink colour in alkaline solution.



Measure 25ml of your water sample into a 250ml conical flask and add about two drops of phenolphthalein solution so that a pink colour develops. Titrate to a colourless end point by adding 0.01 M sulphuric acid from the burette.

In this technique we use 0.01 M sulphuric acid to give a direct measure of the alkali concentration of your water sample as parts per thousand in a 25ml sample. Multiplying by 40 gives the result in parts per million alkali.

If the volume of sulphuric acid added to the 25ml sample is x ml, then :

$$\text{alkalinity} = x \times 40 \text{ (PPM alkali)}$$

This technique is useful to compare sample pH values that are too close to be distinguished using universal indicator solution.

It is possible to use a similar method and the same apparatus to determine the acidity of a water sample. The titration is carried out with 0.02 M sodium hydroxide solution, using phenolphthalein as indicator, until a faint pink colour appears.

For a 25ml sample:

$$\text{acidity} = \text{number of ml NaOH added} \times 40 \text{ (PPM acid)}$$

Results:

Tabulate your results for yours and the class data - and estimate the average pH of the class sample.

Discuss:

The possible effects of low and high pH values on animals and plants in the sea.

NNB: You must learn how to clean the Burette and grease the Tap. Failure to do this will *SPOIL ALL YOUR RESULTS* and will lead you to frustration. A Burette is a delicate piece of glassware, which must be treated with *RESPECT*.

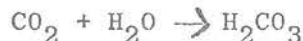
Investigation 2-8. Measuring the carbon dioxide concentration

Aim:

To calculate the CO₂ concentration in PPM for a sea water sample.

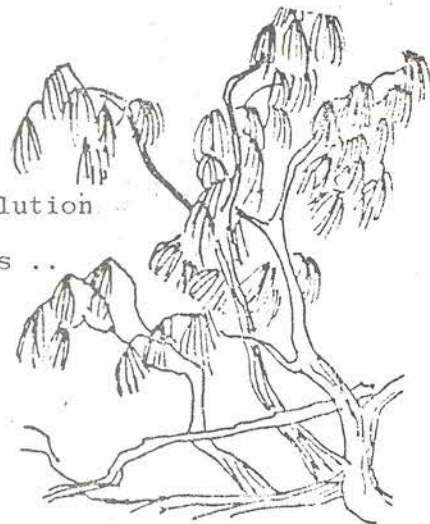
Introduction:

Water bodies tend to contain dissolved carbon dioxide because this gas dissolves in rain droplets and they fall through the atmosphere. The amount of carbon dioxide present in a water sample will affect the pH because the product of carbon dioxide in water is carbonic acid.



You will need:

- * Water samples
- * 100mls 0.0227 M sodium carbonate solution in a stoppered volumetric flask
- * Phenolphthalein indicator in bottles ..
- * 100ml Measuring Cylinder
- * Boss head clamp and stand
- * Distilled water
- * Burette (clean)
- * 3 x 250ml conical flasks
- * Pipette



What to do:

A standard 0.0227 M solution of sodium carbonate is made up by dissolving 2.406g of sodium carbonate in 1 litre of distilled water that has been boiled and cooled immediately before preparing the solution. Then take 100mls of this and add to 900mls of distilled water. Pour into stoppered volumetric flask.

Using a pipette, transfer 100ml of water sample to a conical flask. Add about ten drops of phenolphthalein indicator solution. Then run the sodium carbonate solution from a burette into the water sample, until the solution in the flask turns from colourless to pink. Use some filter paper under the flask.

Take care to avoid excessive shaking of the water sample, since this could easily lead to more carbon dioxide dissolving. Because of this possibility, the analysis should be carried out as soon as possible after sampling.

Calculate the carbon dioxide concentration using this formula:
1ml of 0.0227 M sodium carbonate used = 10 PPM carbon dioxide.

Results: (Alter results and calculations X 10).

Present yours similar to those below:

Sample No.1
Initial burette reading 0.00ml
Final burette reading 2.50ml
Volume of 0.0227 M sodium carbonate used
= final reading - initial reading
= (2.50 - 0.00)ml
= 2.50ml
1ml sodium carbonate = 10 PPM CO₂
. . . 2.5ml = 25 PPM CO₂

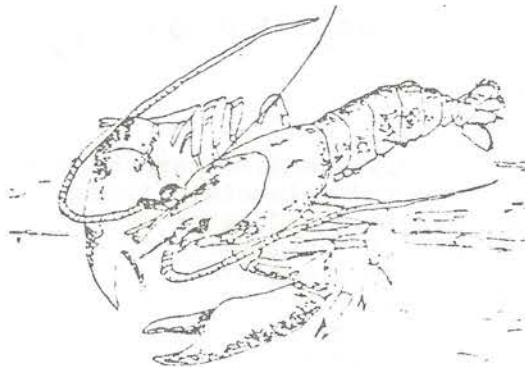
. . . carbon dioxide concentration in sample No.1 - 25 PPM.

Your results will be more meaningful if you compare the results obtained from prepared samples. One of the prepared samples should be distilled water, or recently boiled water, which contains no carbon dioxide. To make a second sample, pass carbon dioxide (from a Kipp's generator) through a sample of distilled water to saturate it with carbon dioxide. In this way you can obtain upper and lower limits with which to compare the results from the samples you have collected from natural water bodies.

Discuss:

The effect of CO₂ on pH.

Your results in relation to class results.



MAIN IDEAS

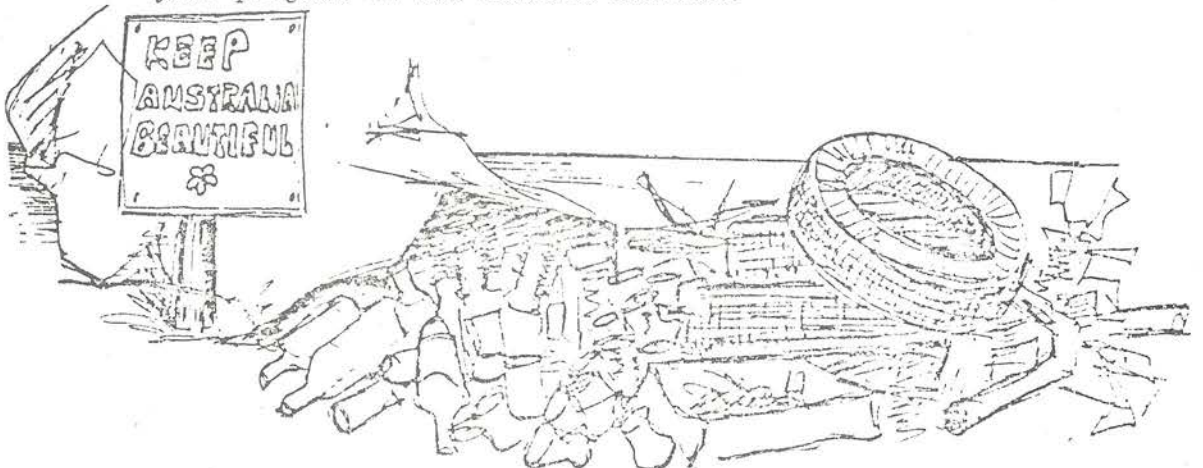
1. We study the characteristics of ocean water to understand marine ecology.
2. Ocean minerals are brought to the ocean by land.
3. Salinity refers to the amount of dissolved salts in the sea. Seawater is $3\frac{1}{2}\%$ salt or 35% .
4. Seawater is heavier than freshwater because of its dissolved salts.
5. The chief gases of the sea are CO₂ and O₂.
6. Cold water is heavier than warm water.
7. Ocean water is transparent and lets light penetrate in the photic zone.

REVIEW QUESTIONS

1. Why is sea water heavier than salt water?
2. Why do you find cold water near the ocean bottom?
3. How does the nature of ocean water help us to understand ecology?
4. How far does light penetrate in the sea? What is this zone called? What instrument measures it?
5. In warmer parts of the world salinities would be high or low. A ship setting out from India to Antartica would have to take what ballast precautions?
6. What is BOD? What does it measure? How important is it?
7. Why is the photic zone important?

STUDY ASSIGNMENTS

1. Write to A.I.M.S. in Townsville and ask them about their experiments with a floating temperature, pH, oxygen probe.
2. Ask your local garage to show you how a hydrometer is used. Write a report on it.
3. Find out the world health standards (W.H.O.) for BOD, O₂ content.
4. Try flame tests for salt, calcium or potassium.
5. Carry out a small research project on a local stream. Enter your project in the science contest.





BENOWA HIGH SCHOOL PARENTS & CITIZENS ASSOCIATION

PRESIDENT: Roger Brewster

Ph. 381 755 Bus.
501 660 A.H.

SECRETARY: Leslie Ponti

Ph. 323 782

17th July, 1986

Mr. R. Moffatt,
Benowa State High School,
Mediterranean Drive,
BENOWA. QLD. 4217

Dear Bob,

On behalf of the P & C Association and the students of the school, I would like to express our deep appreciation for your personal commitment and untiring efforts in relation to the Marine Studies program.

The P & C Association has benefitted financially from your generous loan of the copyright over the Marine Studies classroom notes. The sale of notes to other schools has defrayed the costs of establishing the Marine Studies program here at Benowa as well as assisting many other schools in Queensland to begin their school programs.

This letter acknowledges the return of the copyright over the following classroom notes to yourself as owner:

Navigation, snorkelling, coastal physics, fisheries biology, estuarine chemistry, oceanography, science of diving, field methods, boating and marine radio.

The P & C Association will continue to be able to sell copies of the sea notes which will continue to operate under the Marine Studies Sub Committee. The Association acknowledges that these notes were produced in school time and therefore remain the property of the Education Department.

Finally, we are very pleased that the inaugural Castrol Sea Safety Award was made to you. It is a fitting tribute and worthy honour to your entrepreneurial achievement.

Yours faithfully,

ROGER J. BREWSTER
PRESIDENT

MARINE STUDIES SERIES

OTHER UNITS :

There are two types of Classroom Note : Practical & Applied

(a) Practical Notes

- | | |
|----------------------|--|
| Unit 1 : Navigation | : Features of the Coastline, Navigation Methods, Practical, Weather, Pilotage, Tides, Exam. |
| Unit 2 : Snorkelling | : Physiology, Techniques, First Aid, Dangerous Marine Animals, Safety, Certificate. |
| Unit 3 : Radio | : Components, Features, Discipline, Types, Practice Exercises, Certificate. |
| Unit 4 : Boating | : Buying a Boat, Safety, Seamanship skills, Handling, Maintenance, Licence. |
| Unit 5 : Camping | : Types of, Equipment for Camping with a boat, Campsites, Practical Conservation, Safety, Leadership Skills. |

(b) Applied Notes

- | | |
|------------------------------|---|
| Unit 6 : Fisheries Biology | : Plankton, Nekton, Benthos, Fishing Methods, Protected Species, Fisheries Management |
| Unit 7 : Estuarine Chemistry | : Laboratory Methods, Pollution, Salinity, Temperature, Ph, and other parameters. |
| Unit 8 : Coastal Physics | : Waves, Tides, Beach Erosion, Beach Protection, Coastal Management, Local Coast Management |
| Unit 9 : Diving Science | : Boyles Law, Charles Law, Effects of Pressure on Diver, Marine Medicine. |
| Unit 10 : Sampling Methods | : Marine Technology in Scientific sampling apparatus, student project, collection methods. |

