CITIZENS' WATER QUALITY MONITORING MANUAL

THE FRIENDS OF CASCO BAY'S

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43 Slocum Drive
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ACKNOWLEDGEMENTS

Much of the information in this manual was adapted from the Citizen Monitoring Manuals of the NY/NJ Harbor BayKeeper Program and the Alliance for the Chesapeake Bay, Inc. We would particularly like to thank the Alliance, which was chiefly responsible for compiling the information and instructions presented in both of these manuals.

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Many thanks are also owed to Esperanza Stancioff of the University of Maine Cooperative Extension. Her manual *Clean Water: A Guide to Water Quality Monitoring* was invaluable, especially in providing information on fecal coliform monitoring. The publication of *Clean Water* was supported by the University of Maine Cooperative Extension and by the University of Maine/University of New Hampshire Sea Grant College Program. Copies are available at $7.50 each (without shipping) or at $10.50 each (including shipping and handling) from:

Sea Grant Communications
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Finally, we'd especially like to thank the Casco Bay Estuary Project for their encouragement and guidance in sponsoring and funding this program.

Copies of this manual are available at $10.00 each, including shipping and handling, from:

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INTRODUCTION

This manual is designed to assist Casco Bay volunteer monitors in conducting surface sampling only. The sections start with a **Discussion of the Parameters Being Monitored**. For each parameter, the manual covers **Background** and **Methods**. **Background** gives some information about the relevance and importance of the parameters to be measured. **Methods** describes the methods we'll be using to measure these parameters and gives a bit of information about why these methods work. The **Methods** segments are set off by double-rimmed boxes - if you're allergic to chemistry and technotalk, feel free to skip them.

After the opening discussion, the manual goes on to detail the **Preliminary & General Sampling Procedures** and the **Step-by-Step Field Procedures** involved in surface sampling..

The appendices include a statement of our monitoring policy, a list of monitoring stations, a map of the station locations, and the current sampling schedule, plus a variety of charts and tables to assist you in collecting data.

Don't be daunted by the size of this manual - we were trying to create something which would cover a range of interests and answer the many questions that we've been asked by people interested in water quality monitoring and in the Bay. Many volunteers will only be involved in surface sampling using LaMotte tidal water quality monitoring kits. If that's you, please be sure to read Sections 1A, 1B, and 1C - the other sections are optional.

The material in this manual was developed specifically for use by the Friends of Casco Bay's Citizens' Water Quality Monitoring Program. The Coordinator for this program is the Citizen Stewards Coordinator, Peter Milholland , who can be reached at:

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We welcome your comments and suggestions. We'd also like to thank everyone who's volunteered for their interest, time, and support. In these times of financial crunch, volunteer monitoring plays an increasingly important role in collecting the data needed to make wise decisions about the future of our environment. The data we

collect can be used by federal and state agencies, town managers, and local groups. All of you involved in the monitoring program are making a real contribution to improving and protecting the environmental health of the Bay.

We also urge you not to consider yourselves "just volunteers." The methods and techniques we use are scientifically sound. With the aid of this manual and the training sessions, you will be able to collect and analyze water samples in a professional manner and produce scientifically credible data. We all care about the Bay and we're all doing something positive to help. Congratulations on being a Professional Steward of Casco Bay!

SURFACE SAMPLING

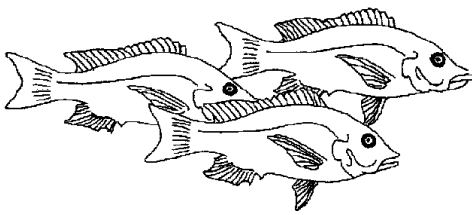
SECTION 1A.

DISCUSSION OF THE PARAMETERS BEING MONITORED: BACKGROUND & METHODS

SURFACE SAMPLING

SECTION 1A. DISCUSSION OF THE PARAMETERS BEING MONITORED: BACKGROUND & METHODS

"Surface sampling" refers to sampling from the top meter of water. We'll be collecting these samples by bucket and analyzing them for water temperature, dissolved oxygen, pH, and salinity. We'll also be measuring water clarity.



WATER TEMPERATURE

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BACKGROUND

Although temperature may be one of the easiest measurements to perform, it is one of the most important parameters to be considered. It dramatically affects the rates of chemical and biological reactions within the water. Many biological, physical, and chemical processes and activities are temperature dependent. Here are some of the most common:

- The rates of photosynthesis and plant growth both increase in warmer water. It's important here to understand the connection between the processes of photosynthesis and respiration. In photosynthesis, plants use sunlight, carbon dioxide, and water to create organic molecules they need to grow. In the process, the plants release oxygen. Respiration is the opposite of photosynthesis. When no light is available, plants respire - that is, they take in oxygen and break down the stored organic molecules to get energy, releasing carbon dioxide.

  An increase in plant growth and photosynthesis means that more oxygen is produced, but it also means that more oxygen is consumed through
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plant respiration. The balance between photosynthesis and respiration depends on the availability of sunlight. Especially in summer, when the days are longer, there's a net production of oxygen. Another factor is that when the plants die, oxygen is consumed in the process of bacterial decay.

≫ Individual organisms living in the water are healthiest when temperatures stay within their range of tolerance. The metabolic rates of organisms increase in warmer water and in many organisms, increased metabolism means an increased oxygen demand. Even if there's enough dissolved oxygen to supply the greater demand, under extreme high or low temperature conditions marine organisms become stressed and are more vulnerable to toxic chemicals, diseases, and parasites. The requirements of any one organism change as it goes through different stages of life. For example, fish larvae and eggs usually have a narrower tolerance range than adult fish; conditions that would have been tolerable for the adults may kill off the larvae before they have a chance to reach adulthood.

SALMON & TEMPERATURE

As an example of how temperature changes and their effect on marine organisms can affect human activities, consider salmon aquaculture. Like all fish, salmon are cold-blooded. Their body temperature depends strongly on the temperature of the water around them. When the water temperature gets below -0.7°C (30.7°F), some of the chemical reactions taking place in the salmon's bodies as part of their life processes simply stop. There's no longer enough heat to make the reactions go, so the salmon die.

In practical terms, this means that in early March 1993, Maine salmon farmers had to worry about the effect of unseasonably cold temperatures on their "herds." Earlier that same year, the Swan's Island Salmon fishery lost 60,000 fish worth almost $200,000 to the cold.

Salmon are more tolerant of high temperatures - **if** the rise occurs gradually. However, if a salmon suddenly swims into a "thermal plume" several degrees warmer than the surrounding water,

- Temperature affects the distribution of various types of organisms because different organisms have different temperature requirements and different ways of responding to changes in temperature. Motile organisms - those capable of moving on their own, such as fish - may be able to escape unfavorable temperature conditions by migrating elsewhere. Sessile (immobile) organisms such as algae and slow-moving organisms such as anemones stay to be weakened or even to die.

- Gases such as oxygen are more soluble in cool water than in warm water - in other words, cool water can hold more dissolved oxygen. Solids, on the other hand, are usually more soluble in warm water. For example, heavy metal compounds deposited in sediments at cooler temperatures can be released at warmer temperatures. First, the compounds already existing in the sediments become more soluble; second, as the concentration of oxygen decreases, the metals react chemically to form new and even more soluble compounds. Once the metals are released from the sediments into the water, they can be taken up by marine life.

- The rates of chemical reactions generally increase with increasing temperature.

- The density of seawater decreases with increasing temperature. This variation of density with temperature affects inversions, mixing, and current movements.

Because significant portions of the Casco Bay Estuary are naturally shallow, like Maquoit Bay, the capacity of these parts of the estuary to store heat for long time periods is relatively small. As a result, water temperatures fluctuate considerably over time and by location. However, they **don't** vary much by depth. In shallow areas, tides, currents, and wind tend to minimize temperature differences between surface and subsurface water.

In deeper areas, the temperatures of surface and subsurface water often differ. Generally, deeper water is colder water and therefore, denser water. The vertical temperature profile of the water column follows a fairly predictable annual cycle. In spring and summer months, the surface waters are warmed by the sun; the bottom waters remain much cooler. In the fall, the sun gets lower in the sky, the days get shorter, and the air gets cooler. The surface waters also cool, increasing in density. When the surface water is colder and denser than the bottom water, it begins to sink, and vertical mixing occurs. Wind speeds up the process. This annual turnover creates an upwelling of nutrients and minerals from the bottom that are newly available to the

phytoplankton and other inhabitants of the surface waters. (For more on phytoplankton, see the box on page 9.) During the remaining winter, the water temperature becomes nearly constant from surface to bottom. Then, in early spring, the radiation of the sun again warms the surface waters. The top layer warms and the bottom remains cool, until the next fall when turnover and upwelling occur again.

A FEW BIOLOGICAL DEFINITIONS

The term **plankton** refers to the plants and animals, generally microscopic, which spend their lives floating and drifting in either salt or fresh water. Some do have their own means of locomotion, but because of their size they're pretty much at the mercy of the water currents. Plankton can be very primitive one-celled organisms or they can be composed of many cells to form complex cellular systems. **Marine** plankton constitute the greatest source of organic matter in the sea. For this reason, nearly all other marine life is dependent on them for food, either directly or as part of the food web. Some of the species of whales which travel through the Gulf of Maine live on plankton - and reach 50 to 70 feet in length. The basking shark, a visitor to Casco Bay which reaches lengths in excess of 35 feet, also depends exclusively on plankton.

Zooplankton are planktonic animals. Many zooplankters spend their entire lives floating and drifting. However, some species are only planktonic at certain stages of development. Zooplankton include the larvae of fish, lobsters, crabs, clams, and many other species. Plankton can also include jellyfish, some species of which can be up to a meter (about 40 inches) across.

Phytoplankton are planktonic plants. Most marine phytoplankton possess chlorophyll and are therefore capable of photosynthesis, producing a major portion of the oceans' oxygen. Phytoplankton also represent the bottom level of the food web on which all the other levels depend. Most zooplankton in particular depend upon phytoplankton as a food source.

The term **algae** refers to a group of plants which have no true roots, stems, leaves, or flowers and which are found in water and in damp places. Seaweed, kelp, and pond scum are types of algae, as are phytoplankton. Many types of algae

(Continued from previous page)

Not all marine plants are algae, however. Eelgrass is a common green plant found growing in shallow water in calm areas around Casco Bay. It's the only plant that grows underwater in the Bay that is not algae - eelgrass is a flowering plant which blooms underwater in the spring and produces seeds in July and August. It has true roots, as land plants do, rather than the "hold-fast organs" of some seaweeds. Eelgrass beds play an important role in the Casco Bay ecosystem. When the beds are sufficiently dense, they provide protection for fish, shellfish, and other animals. The beds are also an important habitat and food source for ducks and geese. Eelgrass beds reduce current velocities and trap sediments leaving and entering subtidal flats. It is estimated that two-thirds of all species that

METHODS

Temperature will be measured using a familiar instrument: a thermometer. Most liquids expand with increasing temperature. A thermometer consists of a reservoir of a known liquid in the bulb - in our case, a mineral spirit mixed with dye - and a narrow-bore tube into which the liquid expands. Measuring the height to which the liquid has expanded in the tube gives the temperature.

Temperatures will be reported in degrees Celsius, the standard temperature unit for scientific data. On the Celsius scale, originally proposed by the Swedish astronomer Anders Celsius in 1742, **fresh** water boils at 100°C and freezes at 0°C. (Because of this 100° spread, the Celsius scale is one type of **centi**grade scale.) Seawater freezes at a somewhat lower temperature depending on its salinity.

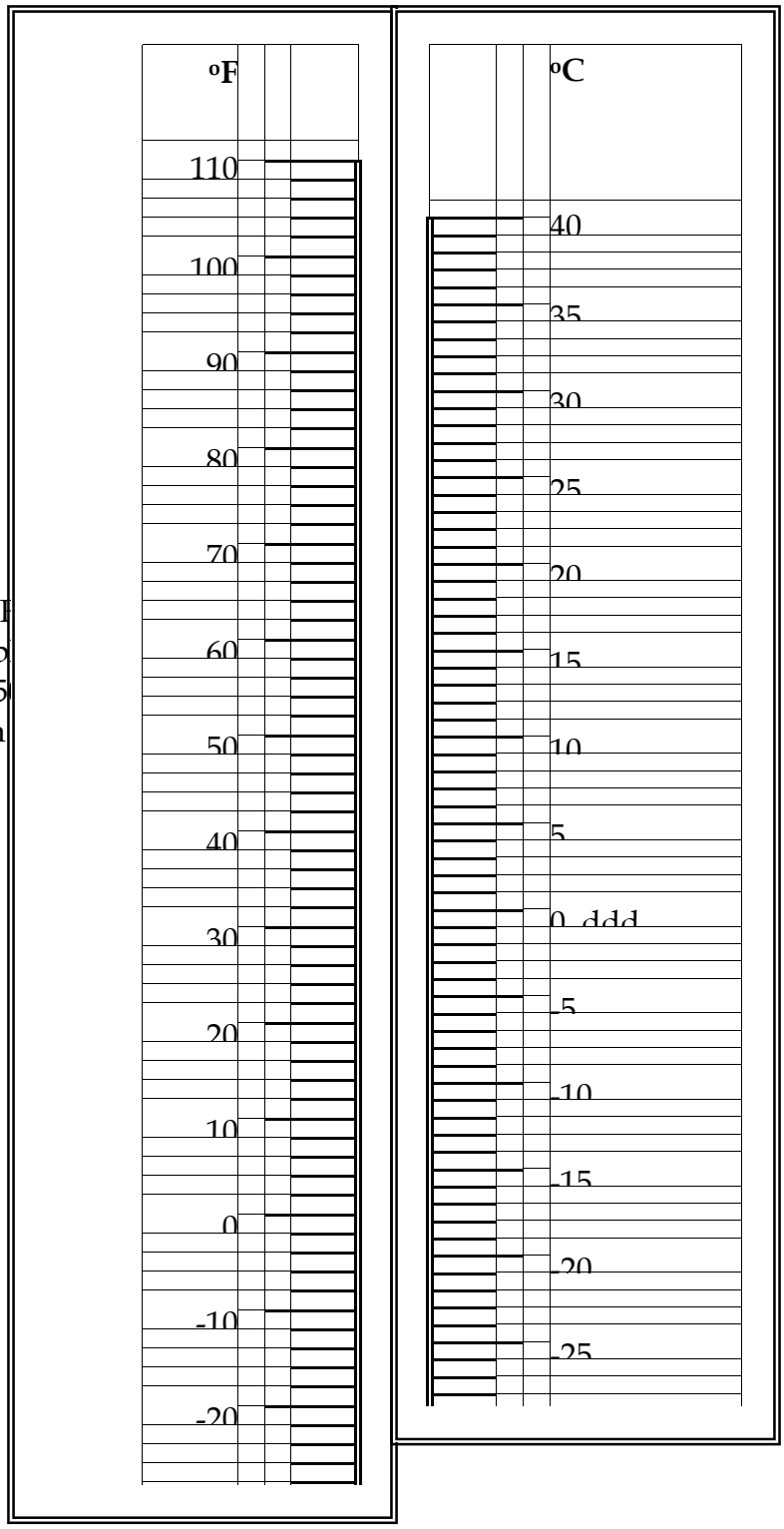
In the scientific world - and in most of the world in general - the Celsius scale has largely replaced the Fahrenheit scale (devised by the German physicist Gabriel Daniel Fahrenheit during the period from 1707 through 1736). Foreign tourists sometimes find American weather reports rather confusing because of the difference in temperature scales! The following formulas may be used to convert from Celsius to Fahrenheit:

To convert from °F to °C:

$$°C = (°F - 32) \times (5/9)$$

To convert from °C to °F:

Use this chart to compare the F
and Celsius scales. For examp
air feels to you like it's about 5
thermometer ought to read an
temperature of 10ºC.



DISSOLVED OXYGEN

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BACKGROUND

Dissolved oxygen (DO) is one of the most important indicators of the quality of water for aquatic life. It is essential for the basic metabolic processes of animals and plants inhabiting our coastal waters. Dissolved oxygen is measured in **m**illi**g**rams per **l**iter (mg/l). When oxygen levels fall below about 3 to 5 mg/l, fish and many other marine organisms are stressed and some can not survive. Dissolved oxygen is a particularly sensitive constituent because other chemicals present in the water, certain biological processes, and physical factors such as temperature and water clarity exert a major influence on its availability throughout the year.

The maximum amount of oxygen water can hold depends a great deal on its temperature and salinity. A DO test (using a meter or chemical kit) tells you how much oxygen is dissolved in the water, but it does not tell you how much oxygen the water is **capable** of holding at the temperature and salinity at which it was tested. Warmer water holds less dissolved oxygen; as water approaches its boiling point, it can hold almost no oxygen. Dissolved oxygen also decreases with increasing salinity. When water holds all the dissolved oxygen that it can at a given temperature and salinity, it is said to be 100 percent saturated with oxygen. If water holds only half that amount of DO at the same temperature and salinity, it is said to be 50 percent saturated. The table below shows this relationship for various temperatures and salinities.
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TEMPERATURE	SALINITY			
°C	fresh water 0 ppt	brackish water 5 ppt	outer Casco Bay 32 ppt	open ocean 35 ppt
0	14.6	14.1	11.6	11.3
5	12.8	12.4	10.3	10.1
10	11.3	11.0	9.2	9.0
15	10.2	9.9	8.4	8.3
20	9.2	9.0	7.6	7.5
25	8.4	8.2	7.0	6.9
30	7.6	7.4	6.2	6.1

Potential dissolved oxygen levels in milligrams per liter (mg/l) at sea level

Consider a shallow bay like Maquoit Bay on a hot August day. At that time of year, stream levels are low, so less fresh water is flowing into the bay and the salinity is relatively high. The average water temperature in Casco Bay is also relatively high (by Maine standards) - and it gets higher locally as the tide comes in over a clam flat that's been baking in the sun. Both the higher salinity and the higher temperature lower the water's ability to hold oxygen. Any events that increase the oxygen demand - e.g. a pogey run, or an influx of nutrients that causes a plankton bloom followed by a die-off - can push the local ecosystem over the edge and cause serious problems.

One of the largest sources of dissolved oxygen is oxygen transferred from the atmosphere into surface waters by the reaerating action of wind and waves. A second major source is oxygen produced by aquatic plants (including phytoplankton) during photosynthesis. Photosynthesis requires sunlight, so it's limited by depth. In the open ocean, most photosynthetic activity occurs in the upper 80 meters (260 feet), with some activity continuing up to 600 meters (1,970 feet). In coastal areas, the depths at which photosynthesis can occur are more variable and more influenced by activities on land.

Once in the water, oxygen is consumed by marine organisms. Like land animals, fish and other marine species need oxygen for respiration. When no light is available, plants also need oxygen. Bacteria consume oxygen as they decompose dead plants and animals.

Oxygen shortages occur when consumption outstrips the available oxygen resources. Oxygen levels may be reduced because the water is over-heated, as it might be near a power plant; warmer water simply can't hold as much oxygen as cooler water. If water clarity decreases - that is, the water becomes turbid - due to an influx of silt, organic matter, etc., less sunlight will reach the photosynthesizing plants, and they will be less able to produce oxygen.

Large amounts of organic matter in the water can not only decrease oxygen production, but also increase consumption as bacteria work on breaking down and decaying the matter. When run-off from the land or the addition of sewage effluents provides excessive amounts of nutrients such as nitrogen (in salt water near the coast) or phosphorus (in fresh water), a phytoplankton bloom can occur. The availability of extra nutrients allows the reproductive rate of these microalgae to zoom; the population of some species can double every twenty minutes. The phytoplankton bloom blocks sunlight from reaching other types of plants. Even worse, when the extra nutrients are gone, the bloom dies off, and huge amounts of oxygen are "sucked up" in its decay. A massive phytoplankton bloom can result in die-offs of fish and shellfish in coastal waters.

METHODS

For surface sampling, dissolved oxygen will be measured using a method called the Winkler titration (after Lajos Wilhelm Winkler, a Hungarian chemist who first published this method in 1888). One of the immediate problems involved in measuring the concentration of oxygen dissolved in a water sample is to prevent any of the oxygen from escaping. To achieve this, two solutions are added to the sample. One contains manganous ions (Mn^{2+}) and the other hydroxyl ions (OH^-). Because of its high concentration of hydroxyl ions, the second solution is described as "alkaline." Together, these ions react to form manganous hydroxide, which is fairly insoluble in water and forms a white, fluffy floc. Immediately, the oxygen molecules in the water react with the floc to convert it from mangan**ous** hydroxide to hydroxides of various mangan**ese** ions with charges higher than +2 (e.g., +3, +4, and +7). These new hydroxides give a brownish color to the floc.

At this point, the oxygen molecules are no longer floating around in the water. Instead, they've been entirely used up in the conversion of the manganese ions. The manganese ions in turn are safely tied up in the floc that settles to the bottom of the sample bottle. If you're sampling in messy weather or from an unstable surface, you can take the treated sample to some more convenient place to finish the procedure. (Protect the sample from light and heat, and finish the procedure within **eight** hours.)

The next step is to add a strong acid to the sample to dissolve the hydroxides. As the manganese ions are freed from the floc, they react with the iod**ide** ions (I^-) contained in the alkaline solution added earlier and form manganous ions (the same kind you started with) and iod**ine** molecules (I_2). Because of the iodine, the sample turns a yellow-brown color.

A carefully measured portion of the treated sample is "titrated" with thiosulfate ions ($S_2O_3^{2-}$) - that is, sodium thiosulfate solution is added drop by drop to determine the **exact** amount necessary to consume all of the iodine in a reaction that produces iodide and tetrathionate ions ($S_4O_6^{2-}$). In order to make it easier to see the exact point at which all the iodine is consumed, a starch indicator is added

(Continued from previous page)

The whole point of this sequence is that **all** of the oxygen molecules are consumed in the conversion of the manganese ions, but **all** of the manganese ions are converted back to manganous ions by the iodide ions. The net result is that two iodine molecules are produced for each of the oxygen molecules you started with. Each iodine molecule then converts two thiosulfate ions to one tetrathionate ion.

The titration procedure measures the volume of a sodium thiosulfate solution of known concentration needed to consume all of the iodine in a titration sample of known volume. Multiplying the volume of thiosulfate solution used by its concentration gives the number of thiosulfate ions that were consumed. The number of iodine molecules involved is twice this, and the number of oxygen molecules originally dissolved in the titration sample is twice this again. Dividing the number of oxygen molecules by the volume of the sample gives the dissolved oxygen concentration. In the procedure we're following, a syringe holding 1 milliliter of sodium thiosulfate solution and divided along its length into ten units

pH

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BACKGROUND

pH is a measure of how acidic or basic a solution is. Pure distilled water has a pH of 7.0 and is said to be **neutral** - but pure distilled water is rarely found in nature. The pH values of natural waters are controlled by the salts and gases dissolved in them. Seawater typically has a pH of 8.1 to 8.3. Because its pH is **greater than 7.0**, it is said to be **basic** or **alkaline** (the two terms are synonymous). The pH of seawater is fairly stable because it's highly **buffered** - that is, the water contains pairs of ions which react to damp down changes in pH (for more information on buffers, see the box on page 19).

The strong buffering and constant motion of seawater tend to minimize variations in pH. Short-lived, local variations may be caused by intense phytoplank-ton blooms, or at locations where industrial discharges and sewer outflows enter the ocean, or where there are large influxes of fresh water. Natural fresh water typically has a lower pH than seawater. Rain water usually has a pH of 5.6 to 5.8. Because its pH is **less than 7.0**, even unpolluted rain water is said to be **acidic**. So-called "acid rain" has an even lower pH due to atmospheric pollutants.

pH is defined as the **negative** logarithm of the concentration of hydrogen ions; the higher the concentration, the lower the pH. In any given aqueous solution, a certain proportion of water molecules dissociate to form hydrogen (H^+) and hydroxyl (OH^-) ions:

$$H_2O \rightleftharpoons H^+ + OH^-$$

In neutral solutions (pH = 7.0), the concentrations of hydrogen and hydroxyl ions are equal. Acidic solutions (pH < 7.0) contain more hydrogen than hydroxyl ions. Basic or alkaline solutions (pH > 7.0) contain more hydroxyl than hydrogen ions.

The term "pH" was proposed in 1909 by Søren Peter Lauritz Sørensen, a Danish chemist, in articles published in French and German. The "p" stands for power (French pouvoir, German Potenz) and the "H" refers to the chemical symbol for hydrogen. Sørensen was investigating methods for determining hydrogen ion concentrations by measuring electromotive force (that is, potential difference or voltage). The higher the concentration of hydrogen ions, the more "power" they
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Because the pH scale is logarithmic, pH does not increase or decrease in a simple linear fashion. Instead, the increases are in powers of 10. For example, at a pH of 5 there are ten times more H^+ ions than at a pH of 6:

pH 6: $[H^+] = 1 \times 10^{-6} = 0.000001$

pH 5: $[H^+] = 1 \times 10^{-5} = 0.00001$

A solution with a pH of 3 is not merely **twice** as acidic as one with a pH of 6, but

When gases and salts dissolve in water, they can affect its pH. Rain water is somewhat acidic because it reacts with carbon dioxide (CO_2) in the atmosphere to produce hydrogen and bicarbonate (HCO_3^-) ions:

$$CO_2 + H_2O \rightleftharpoons HCO_3^- + H^+$$

As water travels through the watershed, a number of factors affect its pH:

- Leaching of soil and rock outcrops, especially during periods of heavy rain or snowmelt.
- Human-generated wastes (e.g. industrial discharges, sewer overflows, lawn runoff).
- Aerosols, dusts, and gases picked up from the air.
- Photosynthesis by aquatic plants, which consumes carbon dioxide and raises the pH.

The pH of the water flowing into the Bay depends on where the water's been and on what it's carrying.

Once water reaches the Bay, local variations tend to be homogenized, partly by the motion of currents and tides, but also due to the strong buffering of seawater. Local pH values can increase during intense phytoplankton blooms, as the phytoplankton consume carbon dioxide in photosynthesis. A pH of 10 was recorded during a 1983 phytoplankton bloom in the Potomac River Estuary. However, this kind of variation is usually short-lived and affects relatively small areas.

The resistance of water to changes in pH is critical to aquatic life because it determines the range of pH that organisms have to adapt to in order to survive. Generally, the ability of aquatic organisms to complete a life cycle greatly diminishes as pH becomes more than 9.0 or less than 5.0. However, the ideal range for aquatic life in general - including both fresh water and salt water species - falls between 6.5 and 8.2. Marine organisms in the open ocean are usually exposed to an even narrower pH range of 8.1 to 8.3. When water with a low pH value comes in contact with certain chemicals and metals, the acidity of the water may cause these substances to become more soluble or more toxic than normal, increasing the load on the Bay. (Think of the dissolved oxygen procedure described on page 15, in which sulfuric acid is added to dissolve the hydroxide floc and release manganese ions into the solution.) Fish that can stand a slightly acidic pH may die at a more neutral pH if low concentrations of iron, aluminum, lead, or mercury are present. Phytoplankton blooms can play an interesting role here; as a bloom dies off, chunks of it sink to the bottom and decompose. The decomposition process produces organic acids which can lower the pH and react with the sediments to release metals and other toxins into the water.

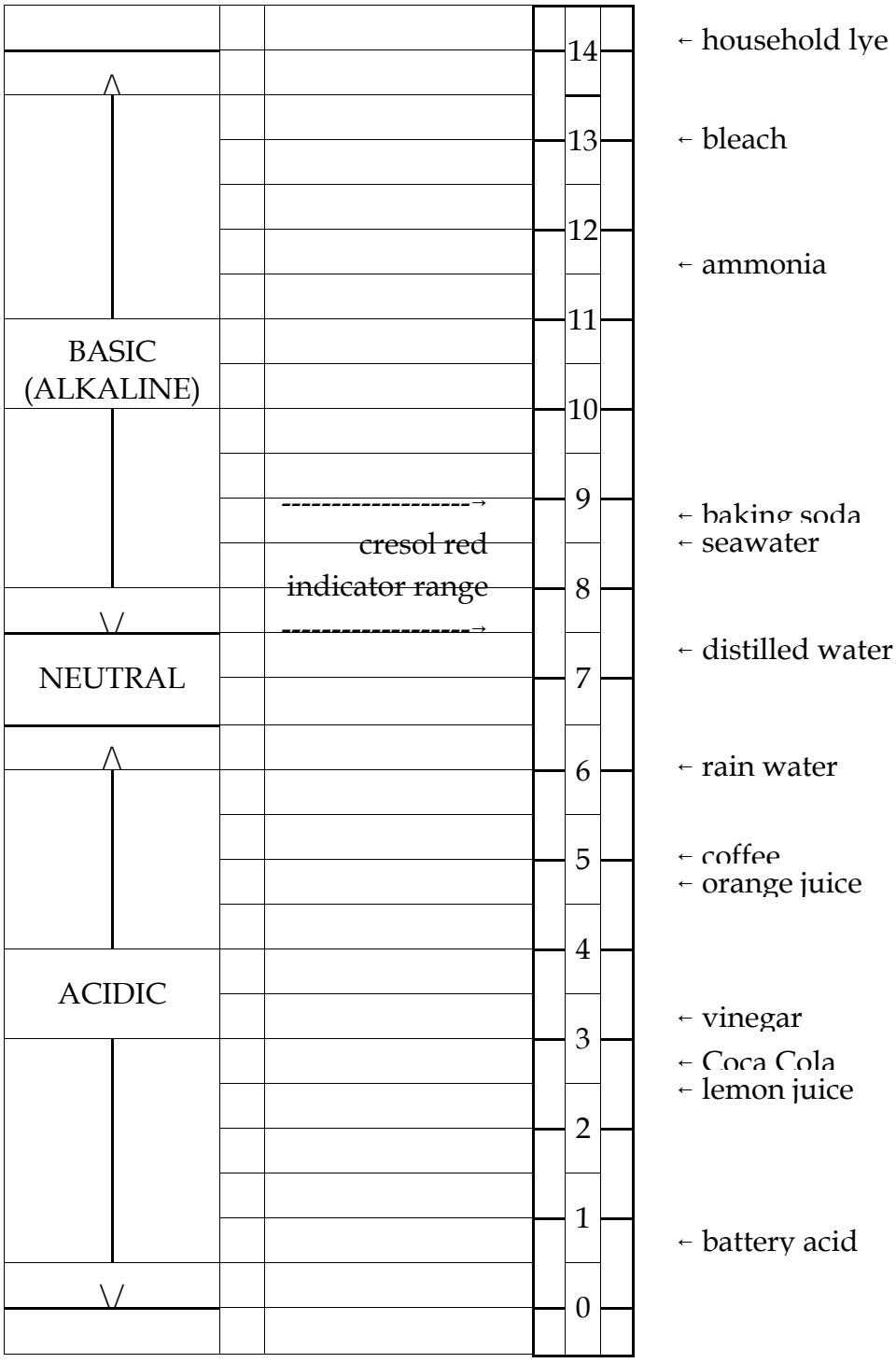
BUFFERS

Seawater contains both bicarbonate ions (HCO_3^-), which can consume excess hydroxyl ions, and carbonate ions (CO_3^{2-}), which can consume excess hydrogen ions:

$$HCO_3^- + OH^- \rightleftharpoons CO_3^{2-} + H_2O$$

$$CO_3^{2-} + H^+ \rightleftharpoons HCO_3^-$$

The ratio of carbonate to bicarbonate ions present in seawater **buffers** its pH to a fairly stable value of 8.1 to 8.3. The ratio of borate ions ($H_2BO_3^-$) to boric acid



THE pH SCALE & pH VALUES FOR SOME COMMON SUBSTANCES

METHODS

One of the easiest ways to measure pH is to use an indicator solution. Most indicators are organic molecules which have a hydrogen ion they can easily gain or lose and which happen to change color when this occurs (making the reaction easy for us to observe). Cresol red is a convenient indicator to use for measuring pH values in the range typically found in seawater. Below a pH of 7.2, **concentrated** solutions of cresol red are yellow. As the concentration of hydrogen ions decreases and the pH rises, the cresol red molecules begin to give up their hydrogen ions, and the color of the concentrated solution gradually shades from yellow to orange to red. By the time the pH reaches 8.6, all the cresol red molecules have lost their "detachable" hydrogen ions. The concentrated solution is red, and it stays that way even if the pH continues to rise - the cresol red molecules have no more hydrogen ions to give up! If the pH is lowered again (the hydrogen ion concentration is raised), the color of the concentrated solution changes back to yellow as the molecules regain their hydrogen ions. At a pH of 7.2, all the molecules have been satisfied, and the solution is as yellow as it's going to get.

In the procedure we're using, 8 drops of cresol red indicator are added to 5 milliliters of the water sample, creating a **dilute** cresol red solution. The compartments in the narrow-range octet comparators are filled with dilute cresol red solutions of known pH values ranging in steps from 7.2 to 8.6. Because these known solutions are dilute, their colors vary from yellowish to pinkish to violet, according to their pH values. The pH of the water sample can be measured by comparing the color of the solution prepared from the sample to the known solutions in the comparator.

SALINITY

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BACKGROUND

Salinity is a key factor affecting the physical make-up of an estuary. It's defined as the concentration of dissolved salts in the water, usually expressed in **p**arts of salt **p**er **t**housand parts of water (ppt). Seawater averages 35 ppt (3.5% by weight) in the open ocean and 27 to 33 ppt (2.7 to 3.3% by weight) in coastal waters. Fresh water contains few salts - drinking water usually has a salinity of less than 0.5 ppt. A liter of Casco Bay water would typically contain 28 to 34 grams of dissolved salts. In other words, a quart would contain about an ounce of salts.

The surface salinity levels within the Bay, especially near the coast, vary with many factors, including the tides and the volume of fresh water flowing into the Bay. Salinity tends to decrease in the spring when heavy rainfall, the release of groundwater, and melting snow combine to greatly increase the amount of fresh water flowing in. In late summer and fall, particularly during periods of drought, higher levels of salinity may extend farther up some reaches of the estuary as the fresh water flow decreases. Some decreases in salinity can be attributed to human activities which reduce the water-holding capacity of the land (such as paving or removal of vegetation) or directly accelerate fresh water discharge (such as storm sewers). On the other hand, excessive withdrawals of water from the fresh water portion of a tributary (for agricultural use, drinking water, etc.) can elevate salinity near the mouth of this tributary.

Salinity levels also vary vertically from top to bottom. In general, salinity increases with depth. The fresh water coming down river is less dense than the heavier seawater, so the entering fresh water tends to float on top of the seawater and may not mix immediately. The volume of entering fresh water is also the greatest closest to land. The net result is a wedge of lighter fresh water lying over the heavier seawater, with poorly defined edges that are continually mixed by wind, waves, and tides. In shallow waters, the mixing of top and bottom layers can obscure this "wedge" completely.
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Perhaps the most important aspect of the estuary's salinity gradient is its effect on the distribution and well-being of the biological population that inhabits the Bay. Some species of fish, such as alewives, require the fresh water portion of the estuary to spawn, but live the rest of their lives in the marine portion. Other species, such as the American eel, do the exact opposite. Some organisms are extremely tolerant of the changes in salinity and are found everywhere from the open sea to waters with only the slightest tinge of salt. Sessile (immobile) bottom-dwellers such as oysters are tolerant of salinity variations, but salinity does affect their growth and spawning.

The solubility of heavy metals also increases with increasing salinity. Consider the example of Maquoit Bay in August (page 14). The higher temperature, higher salinity, and lower dissolved oxygen levels will all tend to release into the water heavy metals previously deposited in the sediments. To make the situation worse, this is the season when bottom-dwelling and burrowing organisms are at their most active in turning over sediments and exposing them to react with the water.

METHODS

There are many methods of measuring salinity. Most of them depend on measuring some other property which is directly affected by salinity. In this program, we'll be measuring the specific gravity of the water using a hydrometer and converting the specific gravity readings to salinities. The specific gravity of a substance is its density divided by the density of pure water at 4°C - easy enough to do, since the density of pure water at 4°C is 1 gram per milliliter.

If you've done any maple sugaring, then you might have used a hydrometer to measure the density of the sap and determine when it had cooked down enough. A hydrometer placed in a liquid will always displace its own **weight** of liquid, so the denser the liquid is, the less **volume** of liquid is displaced and the higher the hydrometer floats. Measuring the point at which the hydrometer stem breaks the surface of the liquid gives the liquid's specific gravity.

The specific gravity of water changes with temperature. Pure water reaches its maximum specific gravity at 4°C. At temperatures above 4°C, the specific gravity of pure water decreases with increasing temperature. As salts are dissolved in the water, the temperature of maximum specific gravity both decreases and becomes closer to the freezing point. At 25 ppt salinity, the two temperatures intersect. For solutions with salinities above 25 ppt, such as seawater (typically 35 ppt), the specific gravity **always** decreases with increasing temperature.

Because of the dependence of specific gravity on temperature, a sample's temperature has to be measured at the same time as its specific gravity. A table

WATER CLARITY

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BACKGROUND

Water clarity is a quick and easy measurement that pulls together many important features of an aquatic system. Any material mixed and suspended in water will reduce its clarity and make the water turbid - that is, muddy and cloudy. Such materials can come from many sources. In early spring, the water may become more turbid as silt is carried into the estuary with the spring run-off. At any time of year, silt-laden surface water can be seen flowing into the estuary from tributaries and storm outfalls during periods of heavy rain and associated runoff. In late spring through early fall, turbidity could be caused by plankton as they grow and multiply rapidly in warm, sunlit, nutrient-rich water.

In shallow areas, wind-generated waves and boat wakes can stir up sediments from the bottom. As waves generated by wind and passing boats break on the shore, they also increase the turbidity. Upstream construction activities - or any activity which erodes the soil - release sediment to tributaries of the Bay and increase turbidity. In Casco Bay, we've seen Secchi depths from 0.8 meters (2.6 feet) at the Southern Maine Technical College dock to 5.5 meters (18 feet) at the Quahog Lobster Pound at Pinkham Point.

Turbidity affects fish and aquatic life in many ways:

- High turbidity levels interfere with the penetration of sunlight. Submerged aquatic vegetation (SAV) needs light for photosynthesis. If suspended particles block out light, lower rates of photosynthesis produce less oxygen. SAV, like the eelgrass in many areas of Casco Bay, provides habitat for a diverse community. These are critical areas where many species including shellfish, waterfowl, and fish can find essential food and shelter. If light levels get too low, photosynthesis can stop all together and the vegetation will begin to die off.

- Large amounts of suspended matter clog the gills of some species of fish, reducing oxygen transfer.

- Fish can't see well in turbid water and may have difficulty finding food. (On the other hand, small fish may have an advantage in turbid water, which makes it easier for them to hide from predators.)
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- Large amounts of suspended matter clog the feeding apparatus of bottom-dwelling animals and may even smother them completely.

- Suspended particles may provide a place for harmful bacteria and microorganisms to settle and grow. The particles can also carry pesticides and excess nutrients down tributaries into the estuary. Suspended particles near the water surface absorb additional heat from sunlight and can raise the surface water temperature.

SURFACE SAMPLING

SECTION 1B.

PRELIMINARY & GENERAL SAMPLING PROCEDURES

SURFACE SAMPLING

SECTION 1B. PRELIMINARY & GENERAL SAMPLING PROCEDURES

THE MONITORING STATION

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Monitoring stations are located at approximately 85 sites(1994) around Casco Bay. Monitoring stations, primary monitors, and alternate monitors are listed in Appendix 2 on page 125.

The best sites for monitoring stations are bridges, piers, bulkheads, floats, jetties, docks, etc. where there is at least 15 feet of water at low tide. This minimum water depth requirement would allow a Secchi disk reading to be taken at almost any tide stage. However, because of the limited number of ideal spots, a number of stations will be sampled by wading-in from shore. The disadvantage is that Secchi disk readings won't be taken. The advantage is that nearshore areas can be close to important nursery areas as well as providing habitat and a food source for adult marine organisms. These areas are also more likely to show the effects or presence of pollution from shoreline point and non-point sources. A few monitoring stations will be sampled from volunteers' boats.

Additional sites will be considered as the network of monitoring stations is expanded. If you have suggestions for sites, please let us know. The site need not be on your own property as long as the owner is agreeable.

Once you have been assigned as a station coordinator or team member, the team should decide on the **exact** location of its monitoring station. For example, if your team is going to sample at a marina, you should choose a specific slip to work at. It is important to ensure that samples are taken from exactly the same location for each sampling session. Make sure that the site has a reasonable depth to allow sample collection - at least 15 feet at low tide is good **if** you can get it. (Obviously, "wading-in" sites won't meet this requirement.)

When you have determined the exact location of your sampling station, write a full description of the site and its location. Mark the location on a topo map or navigational chart. A few photographs would also be good. Send copies of the description and the map or chart with the photographs to the Monitoring Program Coordinator for entry in the Station Description Log. An initial station description should be written at or before your first sampling session. After this, the description
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should be updated at least seasonally to document any long term changes in the location (e.g., erosion, flooding, development). You should also send in descriptions of sudden changes which might alter your site (e.g., encroachment, fires, construction). The Station Description Log will serve a number of purposes:

- Allowing accurate mapping of the data we collect.
- Allowing us to follow the "history" of each site and to see how local changes affect the water quality.
- Allowing alternate monitors to locate the site and sample for you in the event that you're not available to show them.

SAMPLING EVENTS

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The sampling schedule is given in Appendix 4 on page 129. Sampling must be done at 7:00 AM and 3:00 PM (± ½ hour). Some of the parameters we'll be measuring depend on the amount of sunlight available. As of spring 2005, the sampling window has changed in order to collect water quality data morning and afternoon in order to capture primary productivity throughout the Bay. This program has also incorporated the collection of dissolved inorganic nutrients being collected at each sampling events at select locations.

The dates given in the schedule are all Saturdays. Please don't complete part of a session one day and finish it up the next. If you need to break off a session (due to weather, injury, etc.), **all** procedures should be repeated on the next attempt. We're trying to get a data "snapshot" of the conditions at your site at a particular date and time.

The quality of the data collected by our program depends on regular and consistent monitoring. If you anticipate missing an event (for example, if you're going on vacation), it is **your** responsibility to make arrangements with a **trained** alternate. If your alternate isn't on your monitoring team, make sure they know the **exact** location of the site. If none of the trained alternates are available, or in an emergency, please contact the Program Coordinator at (207) 799-8574. Please do not try to give a novice a quickie training session and then send them out on their own. (But feel free to bring them to our next "official" training session - we're always looking for new recruits!)
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FILLING OUT THE WATER QUALITY MONITORING DATA SHEETS

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All data should be recorded on the standardized data sheets provided by the Program Coordinator (see pages 34 and 35 for an example). Please keep an ample supply of these sheets at home and use a fresh one for each sampling event at each site. If you're running low, just call (207) 799-8574!

Data should be entered using a fine-point "Sharpie" or other indelible marker. If the data sheet is wet and the Sharpie won't write, use a #2 pencil and go over it with a Sharpie when the sheet dries. If you make a mistake - and who doesn't occasionally? - draw **one** line through the characters in question, enter the new characters to the immediate right of the lined-out entries, and initial the change immediately after the new characters.

It may not always be easy under field conditions, but try to write as legibly as possible, especially when entering numbers. All numeric data should be entered in the appropriate spaces, using the decimal places provided on the form. When entering temperatures, please remember to specify if they're negative. All letters and words should be **printed**. Boxes should be marked with a ✓ or **X**.

Record **all** of your observations and test results **as you go along**; don't rely on memory!

The **first** data you record on your data sheet should be the names of the monitors, the name and number of the station, the date, and the time. Times should be entered on a 24-hour (or so-called "military") basis - for example, 1:00 PM would be 13:00, 3:00 PM would be 15:00, etc.

The second section of the data sheet describes air temperature, wind, and weather conditions. Page 46 gives instructions on how to measure the air temperature. In light, unsteady winds, you may have trouble judging wind direction - try tying a piece of ribbon or yarn to a pole or other upright object at your site. Record the wind direction as N, NE, E, SE, S, SW, W, or NW. Read the wind speed from the Beaufort Wind Scale in Appendix 6 on page 131 and record the **range** you observe at your site in **mph**. Check off the appropriate boxes for weather conditions and rainfall. ("Rainfall" refers only to precipitation that soaks into the ground, such as rain, freezing rain, or sleet. Snow doesn't count.) Record the number of consecutive days these weather conditions have persisted, including today.
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The third section of the data sheet describes the tidal stage and general observations about the condition of the water. Use the 1994 tide charts in Appendix 7 (page 133) and the Tidal Stage Guide in Appendix 8 (page 137) to determine what tidal stage you should enter. Check off the appropriate water surface description and as many of the indicators as you observe at your site. Use the "please elaborate" space on Side 1 and the "remarks" space on Side 2 to write down general observations and comments about your site - don't be shy about noting anything that looks interesting or odd to you! Comments might include:

- Observations of recent changes at your site (erosion, nearby construction or demolition, etc.).
- Observations about the weather, the sea, strange odors, objects floating by, plant and animal activity in the area, etc.
- Any human activity in the area, either on land or in boats.
- Any problems you had with sampling procedures or equipment (including the data sheets themselves). Suggestions for improvement are always welcome!

Procedures for filling in the fourth section of the data sheet are given in Section 1C, which starts on page 43.

Finally, don't forget to **sign** the data sheet at the bottom!

THE FRIENDS OF CASCO BAY CITIZENS' MONITORING PROGRAM
WATER QUALITY DATA SHEET (SIDE 1 OF 2)

Site name/number: _____ Collection date (mo/dy/yr): ___/___/___

Monitor name(s): _____ Time (military): _____ hours

_____

Air temperature: . °C

Wind direction:

Wind speed: _____ mph

Weather (check one) ☐ clear ☐ snow ☐ overcast ☐ fog/haze
☐ drizzle ☐ downpour ☐ partly cloudy

Rainfall in previous 24 hours (check one):
☐ none
☐ light (___ inches)
☐ heavy (___ inches)

Number of days with similar weather: _____ days

Tidal stage (check one):
☐ high ☐ low
☐ high ebb ☐ low flood
☐ ebb ☐ flood
☐ low ebb ☐ high flood

Water surface (check one): ☐ calm ☐ ripple ☐ waves ☐ whitecaps

Indicators (check all that apply):

☐ fishkills ☐ dead crabs ☐ oil on surface ☐ debris
☐ erosion ☐ foam ☐ bubbles ☐ odors
☐ abnormal color ☐ birds ☐ animals ☐ other

Please elaborate on the above: _____

_____

Continue on the other side if needed

Water temperature: ___.___ °C pH: ___.___ N W (circle one)

Specific gravity: __._____ read at temp of ___.___ °C

Salinity: ___.___ ppt

Dissolved oxygen: Test 1: ___.___ mg/l Test 2: ___.___ mg/l

Test 3: ___.___ mg/l Avg: ___.___ mg/l

Fecal coliform colonies: per 100 ml Exact sample volume: ml

Lab analysis by: _____/_____ Time: _____

Monitor signature(s):

_____

Return to:

THE FRIENDS OF CASCO BAY CITIZENS' MONITORING PROGRAM
WATER QUALITY DATA SHEET (SIDE 2 OF 2)

WATER COLUMN PROFILE DATA		TEMPERATURE (°C)		SALINITY (ppt)		DISSOLVED OXYGEN (mg/l)	
Model number of meter							
Serial number of meter							
Depth (m):	0		.		.		.
	1		.		.		.
	2		.		.		.
	4		.		.		.
	6		.		.		.
	8		.		.		.
	10		.		.		.
	12		.		.		.
	14		.		.		.
	16		.		.		.
	18		.		.		.
	20		.		.		.
	22		.		.		.
	24		.		.		.
	26		.		.		.
	28		.		.		.

REMARKS: _____

_____

_____

_____

WHERE TO SEND YOUR RESULTS - & HOW THIS DATA WILL BE USED

Please send in your data sheet(s) **biweekly**, as soon as possible after the data

have been collected. This will help us keep our database up to date and alert the Program Coordinator to the development of potential problems. Before mailing, please **make a copy** of the sheet for your own files. After the data have been entered on our database program, we'll be sending you printouts to check for errors, so you'll need copies of the original data. The copies will also be lifesavers if the original sheets get lost in the mail. If you're bringing the sheet in yourself, you can get a copy made on our office copier. Data sheets can be mailed in the stamped, pre-addressed envelopes provided or in any envelope addressed to:

Friends of Casco Bay
Water Quality Monitoring
2 Fort Road
South Portland, ME 04106

Please write your return address on the envelope.

All data will be entered into a database program which is currently being developed. If you've got access to a computer which meets minimum requirements for the program, you'll be able to enter the data yourself and send us **both** the data sheet and a data disk. (We'll return the disks - please make sure to label them with your name and address.) Once the program is completed, we'll be creating data printouts using both graph and report formats every three months. All monitors will get copies of the printouts of data from their stations so that they can review them and report any errors to the Program Coordinator - and also so that they can see what's going on and what kind of data we're accumulating. Data disks including everyone's data will be sent to the Maine Department of Environmental Protection and to the Casco Bay Estuary Project.

If any of your data meet the criteria for "Test Values Requiring Special Response" as described in Appendix 5 on page , please phone (207) 799-8574 **immediately**.

BAYKEEPER CITIZEN MONITOR'S EQUIPMENT LIST

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LaMotte tidal water monitoring kit:

- Armored thermometer with twine & paper clip or butterfly clip
- Weighted black & white Secchi disk attached to line marked in 0.1 meters
- Bait bag for holding Secchi disk weights(rocks etc)
- Hydrometer (range: 1.000 to 1.070 specific gravity)
- 500-ml plastic cylinder
- Narrow-range pH kit
- Hanna Model HI 98128 Waterproof pH Tester with replaceable electrode
- Micro-Winkler dissolved oxygen titration kit with three collecting bottles
- Magnifying glass
- Clothespin

Five-gallon bucket

One-gallon plastic waste jug with kitty litter

Safety glasses

Wristwatch

Piece of ribbon or yarn for judging wind direction

Clipboard

Fine-point Sharpies & #2 pencils

Supply of data collection sheets on write-in-the-rain paper

Pre-addressed stamped envelope

Friends of Casco Bay's Citizens' Water Quality Monitoring Manual

Compass (optional)

Wind meter (optional)
~~~~~~

Field guides (optional)

Towel (optional)

SAFETY & MAINTENANCE

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BEFORE YOU GO:

- ⋙ Make sure all your equipment is ready. Read all instructions and familiarize yourself with the procedures of the tests you're going to run. Note any precautions in the instructions.

- ⋙ This would be a good time to calibrate your pH meter.

- ⋙ Read the label on each LaMotte reagent prior to use. Some containers include precautionary notices or antidote information on the back of the container.

  In the event of an accident or suspected poisoning, immediately call the Poison Center (1-800-442-6305 for Maine Medical) listed in the front of your local telephone directory or call a physician. Be prepared to give the name of the reagent in question and its LaMotte code number (4 digits on the side of the bottle). LaMotte reagents are registered with POISONDEX, a computerized poison control information system available to all local poison centers. Also located in Appendix 7 are Material Safety Data Sheets (MSDS) for all chemicals included in this kit.

  Keep all equipment and reagent chemicals out of the reach of children and pets.

- ⋙ Check your reagent solutions for cloudiness or the formation of precipitates. If any of your reagents look odd, call the Program Coordinator at (207) 799-8574 to get more. **Postpone** your sampling session until you get the new reagents.

- ⋙ Check your thermometer to make sure that the red fluid inside hasn't separated, as separation will cause inaccurate readings. If your thermometer fluid has separated, call the Program Coordinator for a new one.

- ⋙ Dress properly. Remember that you're going to be outside, sitting fairly still, for 40 to 60 minutes. You're probably also going to slosh water on yourself. Layered clothing, gloves, and boots are important in colder
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weather. Wool and polypropylene are the best fabrics to wear to retain body heat when wet.

Don't wait until the last minute to check your reagents and your equipment. If you discover any problems, you'll have to postpone your sampling session until you can get new equipment and chemicals from the Program Coordinator.

In particular, separation of the thermometer fluid is often a problem if the thermometer has been subjected to extremes of heat or cold. If you think there's a good chance your thermometer fluid might have separated, check it well in advance of your next sampling session.

Avoid storing any equipment or reagents in your car for long periods of time when outside temperatures are extremely hot or cold. At home, avoid storing equipment and reagents in areas that may get extremely hot or cold. For example, don't use garages and

AT THE MONITORING SITE:

- Use common sense in approaching your site. Getting samples is important, **but not at the risk of injury**. We're not in the Army and we don't get Purple Hearts. If your site has potentially hazardous conditions - slippery or icy rocks, deep mud, strong currents - bring a buddy. Your buddy doesn't have to be a trained monitor - in fact, this might be a good way to "recruit" a friend!

- Try to find a place to set out your equipment and chemicals where they won't be sitting in strong, direct sunlight. On windy days, beware of small containers being blown into the water.

- As you work, avoid contact between reagent chemicals and your skin, eyes, nose, and mouth. If you do get chemicals on your skin - especially the sulfuric acid in the DO kit - don't spread them around by wiping. **Blot** the chemicals off, and then rinse immediately with **lots** of water.
- Wear safety glasses when handling reagent chemicals.

- Use the caps and stoppers, not your fingers, to cover test tubes and bottles during shaking and mixing.

- When dispensing a reagent from a plastic squeeze bottle, hold the bottle vertically upside-down (not at an angle) and **gently** squeeze it. If a gentle squeeze does not suffice, check the dispensing cap or plug to see if it's clogged.

- If you spill any of the reagents, rinse the area with salt water.
- If you pour out an excess amount of a reagent, discard it. Never return excess portions of reagents to the main supply. If there's any dirt, grease, or other contaminant on the container the reagent was poured into, you risk contaminating your entire supply by returning the excess.

- Tightly close all reagent containers immediately after use. Do not interchange caps.

- Do not mix chemicals indiscriminately.

- Place all liquid waste into the one-gallon jug filled with kitty litter. When the kitty litter is no longer capable of holding more liquid, notify the Monitoring Program Coordinator to obtain a new waste jug and turn in the filled one.

- Thoroughly rinse jars, bottles, test tubes, etc. before and after each test by pouring water from the sample bucket in to and over them. **Don't dunk!** (You risk contaminating the entire bucketful of water.) Dry your hands and the **outside** of the jars, bottles, tubes, etc.

WHEN YOU GET HOME:

- Rinse everything that was in contact with salt water or chemicals in fresh water. Dry everything thoroughly.

- If you're running low on any reagents, or if any of them look funny, contact the Program Coordinator at (207) 799-8574 for a fresh supply. Also contact the Program Coordinator if any of your equipment has been acting oddly.

- Store your equipment and reagents in the black plastic "suitcase" to protect them from excess exposure to light. Keep the suitcase in a dry place protected from extremes of heat and cold. Don't leave it in your car, which can get pretty hot in the summer and pretty cold in the winter. Chemicals may also freeze if kept in a garage or breezeway.

- Make sure that children and pets can't get at the equipment and reagents.

> Next to the handle of the "suitcase," there's a hole about 0.2 inches in diameter drilled through the top and bottom halves of the case. If you have especially inquisitive children, you might want to use this hole to **lock** your case with a small padlock.

SURFACE SAMPLING

SECTION 1C.

STEP-BY-STEP FIELD PROCEDURES

SURFACE SAMPLING

SECTION 1C. STEP-BY-STEP FIELD PROCEDURES

FIELD PROCEDURE CHECKLIST

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1) Set the blue thermometer equilibrating with the air.

2) Start filling out the data sheet: site name, monitor's name, date, time, weather conditions, tidal stage, water surface, etc.

3) Read the air temperature and record it on the data sheet.

4) Rinse the sample bucket three times and then collect the water sample.

5) Set the Hanna pH meter equilibrating with the bucket of water.

6) Rinse and fill the dissolved oxygen sample bottles. Add the manganous sulfate and alkaline potassium iodide azide solutions (reagents #1 and #2) to the samples and set them aside to allow the floc to settle out. After the first settling, the floc should be shaken up and allowed to settle out a **second** time.

7) Read the water temperature and record it on the data sheet.

8) Read the pH of the water in the sample bucket.

9) Measure and record the salinity of the water in the sample bucket.

10) Take Secchi depth and bottom depth readings; record them on the data sheet.

11) Titrate the dissolved oxygen samples and record the results.

12) Sign your data sheet!
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AIR TEMPERATURE & BASIC OBSERVATIONS

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The air temperature has to be taken while the thermometer is **completely** dry, so do that first. Hang the thermometer somewhere where it's not leaning against any solid object and where it's protected as much as possible from direct wind and sunlight. You might find it convenient to set the handle of your sample bucket upright, clip it in place with a clothespin, and hang the thermometer from there.

The thermometer will take at least five minutes to equilibrate. It might take longer if it has to adjust for large changes in temperature - for example, if you've been carrying it in a warm car on a frosty day. If you've waited the five minutes but the reading looks warmer or cooler than you expected, wait another minute and see if the reading changes. Keep checking at one-minute intervals until the reading comes up the same twice in a row - it shouldn't take longer than ten minutes for this to happen. Once the thermometer has equilibrated, read the air temperature to the nearest 0.5°C (a magnifying glass may be helpful) and record it on your data sheet.

> The thermometers we're using go down to -5°C (23°F). Water will freeze long before it gets that cold, but at the beginning and end of the sampling season, the air temperature could be **colder**. If this happens to you, record the air temperature on your data sheet as "< -5°C."

While you're waiting for the thermometer to equilibrate, you can fill in most of your data sheet: the site name, your name, the date and time, the weather conditions, and site observations such as tidal stage and water surface. (See page 32 for more information on filling out the data sheet.)
~~~~~~

COLLECTING THE WATER SAMPLE

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A few yards **away** from your exact sampling site, rinse the bucket three times with the water to be sampled. Now go over to your site, lower the bucket **gently** into the water, and fill it to the level of the holes drilled in the side. If the water at your site is more than an arm's length away, your bucket should have a rope tied to the handle. After securing the **other** end of the rope to something solid, fill the bucket by turning it upside down and dropping it straight down into the water. This will help avoid the futility of having the empty bucket floating all over the surface and refusing to fill. If you're working in very shallow water, don't disturb the bottom while collecting the sample.

Be careful not to artificially increase the dissolved oxygen content of the water you're sampling. This can happen if you splash the water around too much before you sample it - that's why you should rinse your bucket a few yards away from your sampling site. Once you've got the sample, handle it **gently**. Avoid jostling the bucket or sloshing the water around.
~~~~~~

WATER TEMPERATURE

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As soon as you pull the bucket out of the water, the water in it will begin to equilibrate with the temperature of the air. After about five minutes, the equilibration can cause inaccuracies in your water temperature reading. The way to avoid this problem is to take the water temperature immediately after collecting the water sample in the bucket.

Put the bucket somewhere where it's protected from direct wind and sun as much as possible. Set the handle of the bucket upright and clip it in place with a clothespin. Hang the Hanna pH meter from the handle so that it sits in the middle of the bucket and sits in the middle of the bucket and is roughly upright (not flat on the surface of the water). The waterline should be somewhat between the "C/F" markings on the meter. Turn on the meter by pressing and releasing the "Power/Mode" button. Give the pH meter at least three minutes to equilibrate, but don't let it sit for more than five minutes.

> HINT:This is a good point at which to take your dissolved oxygen samples, treat them, and set them aside to allow the precipitate to settle - see page .

Read the pH and temperature with the meter still immersed in the water (tilt it so that you can see it – use a magnifying glass if you find it helpful). The pH is the top value on the meter and the temperature is the bottom value (See Figure 1). Record these values in the appropriate places on your data sheet, and circle "MTR" next to the pH value. Once these values have been recorded, turn off the meter by holding the "Power/Mode" button until "OFF" is displayed, then release. Please be sure to rinse the meter thoroughly with tap water.
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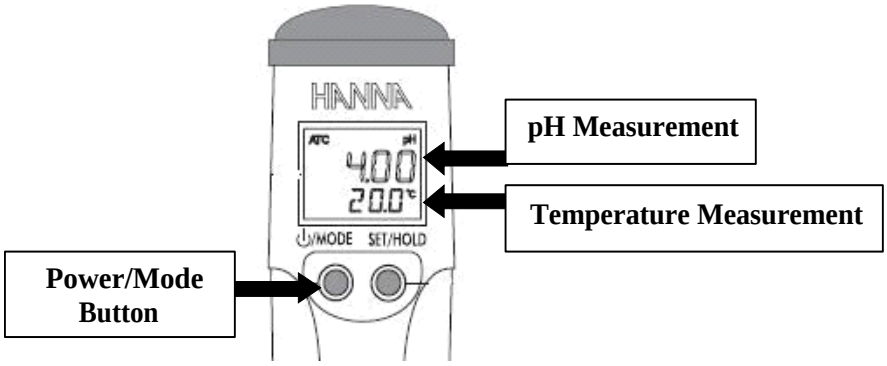
Figure 1.



Read the temperature with the meter still immersed in the water (put your hands in and tilt it so that you can see it - use a magnifying glass if you find it helpful). Record the value to the nearest 0.1°C on your data sheet.

pH Meter Maintenance and Troubleshooting

The electrode on the pH meter must be kept damp all the time. Please inspect the electrode and cap regularly to be sure that it has not dried out. There is a small sponge in the cap that should be kept wet with tap water and several drops of the storage solution.

The pH meter will turn off automatically after eight minutes of use. If this happens simply press the Power/Mode button to restart.

DISSOLVED OXYGEN (DO)

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As you work through the DO titration procedure, you'll notice the emphasis on avoiding trapping any air bubbles in the sample and even on splashing it around too much. The point is to avoid changing the amount of oxygen dissolved in the water by contact with the oxygen in the air.

To guard against problems, three samples will be prepared for titration. If the difference between the first and second titrations is less than 0.6 mg/l, the third sample does not have to be titrated. If the difference is 0.6 mg/l or greater, titrate the third sample. Record the results of all titrations (even the one you suspect is wrong) and the average of the two closest.

STEP 1: Rinse each of the three 60-ml sample bottles with small amounts of water from the bucket three times. Don't dunk the bottles - pour the water into them through the hole in the bucket. Rinse the outsides of the bottles and the caps as well.

STEP 2: Tightly cap the mouth of one of the bottles. Holding the bottle sideways, submerge it to mid-depth in the sample bucket, and remove the cap to allow the bottle to fill.

STEP 3: Turn the submerged bottle slowly to a vertical position (mouth up) and tap the sides with the cap to dislodge any air bubbles clinging to the inside. Replace the cap while the bottle is **still submerged**.

STEP 4: Retrieve the bottle and examine it carefully to make sure that no air bubbles are trapped inside. Once a satisfactory, bubbleless sample has been collected, repeat Steps 2 through 4 with the other two bottles.

STEP 5: Uncap all three samples. Add 8 drops of manganous sulfate solution (reagent #1) to each sample; then add 8 drops of alkaline potassium iodide azide (reagent #2) to each sample. Be sure to add the manganous sulfate **first.** Drop the solutions in **gently** to avoid splashing and mixing in air. Hold the reagent bottles vertically, and don't allow the dropper tips to touch the sample.
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Cap each sample bottle carefully and mix by inverting **vigorously** and **repeatedly** (give your wrists a good workout!). A fluffy, white to brownish precipitate will form. Set the bottles in their holes in the LaMotte monitoring kit; the styrofoam will help keep the samples at a constant temperature. Allow the precipitate to settle a third of the way down the bottles, so that it fills only the bottom two-thirds. Settling may take as long as an hour at cooler temperatures (e.g. in early spring and late fall), but will usually be faster. Invert the bottles vigorously several more times, and allow the precipitate to settle again.

The dissolved oxygen in your samples is now bound up in the floc. As long as you keep the samples cool and in the dark, you can complete the analysis any time in the next eight hours.

At this point, go back to page and read the water temperature. Then go on to page and get your pH, salinity, Secchi disk depth, and bottom depth measurements while you're waiting for the precipitate to settle. (Take a break from the other tests to reinvert the DO sample bottles so the precipitate can settle a **second** time.)

The settling can take a while, especially in cold weather, and it's better to allow too much time than too little. Once you've got your other measurements done and the precipitate is settled from the **second** inversion, continue with Step 6 of the DO procedure if you're going to complete this procedure on-site. In inclement weather, you

After your samples have been shaken and allowed to settle twice, return to the DO procedure at this point:

STEP 6: Add 8 drops of sulfuric acid (reagent #3) to the bottle marked "1." Cap the bottle and mix by shaking vigorously until the precipitate has dissolved. If a rusty or dark-brown, gelatinous-looking, "gloppy" precipitate remains, add 1 more drop of acid, cap, and shake. Continue to add acid one drop at a time(maximum of 12 drops) capping and shaking between each drop, until the gloppy precipitate dissolves completely. (Do not confuse the gloppy precipitate with dark, **solid-looking** grains of organic matter or sediment which refuse to dissolve, but which can be ignored.) Depending on the oxygen content of the sample, a clear yellow to brown-orange color will develop as the precipitate dissolves.

You may choose to add the acid to all three sample bottles at this time, if you feel comfortable doing that. Once the acid has been added, the rest of the procedure must be completed within 45

STEP 7: Rinse a 25-ml graduated cylinder three times with **small** amounts of the solution from the sample bottle, and then fill it to the 20-ml line. (You'll notice that the upper surface of the solution in the cylinder may curve up or down slightly; this curving upper surface is known as the **meniscus**. It's the **center** of the curve that should be level with the 20-ml mark, not the portion near the walls of the cylinder.) Rinse a titration tube three times with small amounts of solution from the sample bottle, capping the tube each time so that the inside of the cap is rinsed as well. After rinsing, shake out as many droplets as possible from the tube.

Pour the measured solution carefully from the cylinder into the tube, being sure not to spill any and to leave as little as possible in the graduated cylinder. Cap the tube and set it aside. (Don't worry if the solution isn't level with the 20-ml line on the **titration tube**, as this line is not accurate. The 20-ml line on the **graduated cylinder** provides an accurate volume measurement.)

STEP 8: Depress the plunger of the direct-reading titrator (the thing that looks like a small syringe) to expel air. Holding the plunger tightly down, insert the titrator into the plastic fitting of the bottle of **sodium thiosulfate solution**. (This bottle is slightly larger than the others and does **not** have a dropper tip. The sodium thiosulfate solution is **colorless**.) Invert the bottle and withdraw the plunger **slowly** until the bottom of the plunger is about half an inch **past** the zero mark on the titrator scale.

As you start to withdraw the plunger, inspect the solution filling the syringe for air bubbles, especially at the tip of the plunger or in a silvery rim **around** the tip. If bubbles appear while you've only got a **small** amount of solution in the titrator, pump the solution back into the thiosulfate bottle, pressing the plunger down quickly and firmly. Bubbles tend to be a particular problem when the dry titrator is filled for the first titration of the day. It may be necessary to pump the solution back and forth several times to get the plunger surface wetted.

Once you've gotten a small amount of sodium thiosulfate solution into the titrator without bubbles, continue to inspect for bubbles as you slowly withdraw the plunger. If you spot a bubble when the titrator is nearly full, remove the titrator from the thiosulfate bottle, hold it over your kitty litter jug, and press the plunger down until the bubbles are expelled. Reattach the titrator to the thiosulfate bottle and continue.

In an ideal world, you would **never** squirt solution back from the titrator into the bottle of thiosulfate. If there were contaminants on the inside of the titrator, you would risk contaminating your entire supply of reagent. In reality, it's almost impossible to get rid of bubbles without pumping **small** amounts of solution back and forth. You should **minimize** the risk of contaminating your reagent supply

Turn the thiosulfate bottle upright and remove the titrator. Push the clear plastic tip **firmly** onto the titrator, but don't **jam** it on or it will be difficult to remove later without breaking the titrator. Press the plunger slowly downward until the clear plastic tip is full and the **lowermost rim** of the black rubber shoulder (**not** the tip) is opposite the zero mark. Inspect the titrator carefully for air bubbles.

See diagram next page.

STEP 9: Insert the titrator with its plastic tip into the central hole of the titration tube cap until it snaps into place. Add 1 drop of sodium thiosulfate and **swirl** the tube (with the titrator still attached) to mix it. Continue this titration process one drop at a time until the yellow-brown solution in the tube **just** begins to fade or get lighter. The solution should be a pale yellow color - about the shade of pale straw.

STEP 10: Remove the titration tube cap with the titrator still attached. **Be very careful** not to change the position of the plunger or to shake any fluid loose from its tip.

Add 8 drops of starch indicator solution to the titration tube. The solution should turn from pale yellow to dark blue.

> If you're unsure of the exact point at which to add the starch solution, it's better to do it a little early than too late.

STEP 11: Replace the cap with the titrator carefully on the titration tube and swirl until the solution turns a uniform blue. Continue the titration process described in Step 9. **Be sure to swirl after each drop.** Continue the titration until the solution **just** turns from blue to clear - the **first** complete disappearance of the blue color is the endpoint of the titration. (If the solution turns blue again a moment later, ignore it.) Hold the solution against a sheet of white paper (for example, your data sheet) to check the color.

If your sample has a really high oxygen content, you may have to refill the titrator in order to reach the endpoint. **Do not** completely empty the titrator into the titration sample. The plunger should be lowered **only** far enough that the lowermost rim of the black rubber shoulder is level with the 10-unit mark on the scale. If you reach this point without hitting the endpoint of the titration, remove the titrator from the titration tube. Refill the titrator as described in Step 8 and continue the titration.

STEP 12: Read the **total** number of units of sodium thiosulfate used in the titration from the scale opposite the lowermost rim of the black rubber shoulder. The divisions are in 0.2 units, but you should be able to read the results to the nearest 0.1 units.

If you had to refill the titrator, remember to add in the ten units from the first filling. The number of units used equals the milligrams per liter (mg/l) of oxygen dissolved in the water. Record this figure on your data sheet to the nearest 0.1 mg/l.

STEP 13: Carry out Steps 6 to 12 on the sample bottle marked "2.". If the two titrations differ by 0.6 mg/l or more, you must titrate bottle "3" as well. If the two titrations are within 0.6 mg/l of each other, you have the option of titrating bottle "3". Record the results of all titrations and the average of the two closest on your data sheet to the nearest 0.1 mg/l. Discard the contents of the sample bottles in the kitty litter jug.

THE DISSOLVED OXYGEN TITRATION TIP SHEET

The DO titration is easily the most complicated field procedure we'll be doing. Here are a few tips to help you get through it more efficiently and accurately:

- Be sure your sample bottles are clean and rinsed **three** times with water from your sample bucket.

- Remember to keep the bottle cap on when you first immerse the bottle in the bucket in order to minimize surface scum from contaminating your bottle.

- After filling a sample bottle, check it carefully for bubbles - the oxygen trapped in the air bubbles will throw your results off.

- Hold the dropper bottles vertically when adding the manganous sulfate (reagent #1) and alkaline potassium iodide azide (reagent #2) solutions. Try to avoid splashing that may introduce air into the sample. Be sure to add the manganous sulfate **first**.

- Since the sample bottle is supposed to be completely filled, without any air space, some of the sample may overflow as you add the reagents. Don't worry about this.

- The manganous sulfate and alkaline potassium iodide azide solutions are added in excess. The precise number of drops is not critical as long you add enough manganese to bind up all the dissolved oxygen and enough iodide to mop up all the manganese. Try for 8 drops, but if you accidentally add 9 drops instead, that's okay. If you lose count and are not sure whether you've added 7 drops or 8, add an extra one.

- The manganous sulfate and alkaline potassium iodide azide solutions should be added to the samples **as soon as possible** after collection. Once these reagents have been added, the samples can be held for up to 8 hours before finishing the analysis. They should be protected from light and kept at the temperature of the water they were collected from.

- Allow enough time for the fluffy, white to brownish precipitate (the floc) to settle a third of the way down the bottle after each of the **two** mixings. Impatience may result in an incomplete reaction and false low results.

- The sulfuric acid (reagent #3) is also added in excess - try for 8 drops, but 9 are okay. Adding the acid should dissolve all of the fluffy or "gloppy" precipitate. If 8 drops don't do the trick, continue to add acid one drop at a time until the gloppy precipitate dissolves. You may find that your sample contains dark, **solid-looking** grains of organic material or sediment that do not dissolve. Ignore these; they will not affect the test results.

- It is **critical** that the amount of sample to be titrated is measured out carefully. The **center** of the meniscus (the curved surface of the liquid) should be level with the 20-ml mark on the graduated cylinder used for measuring. **All** of the titration sample must be transferred from the graduated cylinder to the titration tube with as few droplets as possible remaining in the cylinder.

- It is **critical** that the titration be performed carefully. Before starting, check that the syringe plunger moves smoothly. If it seems to be sticky, lubricate it with a bit of sodium thiosulfate solution. (Remember to rinse it with fresh water when you get home.) If the problem persists, report it to the Program Coordinator.

- Make sure that the plastic tip is attached firmly. Using this tip **doubles** the precision of your titration because it produces smaller drops. However, do not **jam** the tip on or it will be difficult to remove without breaking the titrator.

- Check the titrator and plastic tip carefully for air bubbles after filling. The volume taken up by the bubbles will produce inaccurate readings of the volume of thiosulfate solution used in the titration. Do not proceed with the titration until your titrator is **bubbleless**.

- The amount of thiosulfate solution used in the titration is **critical**. At the start of the titration, the **lowermost** rim of the black rubber plunger shoulder should be level with the 0-unit mark on the titrator scale. Handle the titrator carefully after filling it, taking special care not to move the plunger inadvertently. Moving the plunger accidentally downwards will expel solution; moving it upwards will draw air into the syringe.

- If your sample contains more than 10 mg/l dissolved oxygen, you will have to refill the titrator during the titration. This is especially likely to happen if you're sampling water that can hold more oxygen - i.e., cool water (less than 10^{o}C or 50^{o}F) or water with an unusually low salinity. One tip-off that you've got high oxygen levels is that when you add the sulfuric acid, the solution turns a brown-orange color as **lots** of iodine is created.

- As the plunger approaches the bottom of the titrator, be sure not to depress the lowermost rim of the black rubber shoulder below the 10-unit mark on the titrator scale. If you depress the plunger further, you're adding an **unknown** volume of thiosulfate to your titration sample. When the lowermost rim reaches the 10-unit mark, remove the titrator from the titration tube and refill the titrator.

- Exactly when and how much of the starch indicator solution is added is not critical. The important thing is that the sample turns blue. If you have a sample with low oxygen levels, adding the sulfuric acid may cause it to turn a pale yellow or pale straw color before you've added any thiosulfate at all. In this case, you'll want to add the starch indicator **before** you start the titration. It's always better to add the starch a bit too early than too late.

- Once you've reached the pale-yellow color and added the starch indicator, proceed with the titration slowly and carefully so that you don't overshoot the endpoint.

- If the sample fails to turn blue when you add the starch, this means that you've already added too much thiosulfate and overshot the endpoint. If this happens, or if you overshoot after adding the starch, **discard** the results of this titration. Measure out a second titration sample from the same sample bottle and repeat the procedure.

- The first complete disappearance of the blue color is the endpoint. If you see the solution turn blue again a moment later, ignore it! The "rebluing" effect is caused by the interference of other chemical compounds in the sample.

pH COMPARATOR METHOD

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STEP 1: Rinse one of the sample test tubes and tube caps supplied with the pH kit **three** times with small amounts of water from the sample bucket by pouring water out from the bucket.

STEP 2: Pour water from the bucket into the tube to fill it to the mark. Pour out any excess water.

STEP 3: Add **8** drops of the **narrow-range** (cresol red) indicator to the sample tube. Hold the dropper bottle vertically (not tilted) to dispense uniformly-sized drops.

STEP 4: Cap the test tube and invert several times to mix thoroughly. Wipe any drops off the outside of the tube.

STEP 5: Insert the test tube into the narrow-range comparator and match the sample color to the closest color in the comparator.

> HINT:Hold the comparator up so that light enters through the special light-diffusing screen in the back, but avoid viewing the comparator against direct sunlight or an irregularly lighted background.

The pH values of the narrow-range comparator solutions change by 0.2 pH units at a time. If your sample appears to be right between two comparator solutions (for example, 8.0 and 8.2) take the average (in this example, 8.1). Read the pH of the solution in the test tube to the nearest 0.1 pH units and record it on your data sheet. Circle **N** for narrow, **W** for Wide Range, **O** for Other, or **Mtr** for Meter.
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STEP 6: **If** the sample appears to match the lowest or highest solution in the narrow-range comparator, there's a chance that it might in fact lie beyond the range of this comparator (7.2 to 8.6 pH units). pH readings of 7.2 or 8.6 should be checked using the **wide-range** indicator and comparator; this comparator has a range of 3.0 to 10.0 pH units.

If necessary, repeat Steps 1 through 5. Use **10** drops of the wide-range indicator for the sample tube in Step 3, and check the tube against the wide-range comparator in Step 5. The pH values of the wide-range comparator change by 1.0 units at a time. Read the pH of the solution in the test tube to the nearest 0.5 pH units and record it on your data sheet. Circle **W** for wide.

It may happen that the narrow-range comparator gives you a reading of 7.2 or 8.6, but the wide-range comparator gives you a reading that appears to be **within** the narrow range - e.g., 7.5 or 8.5. This apparent discrepancy is due to the lower precision of the wide-range comparator. In this case, record the **narrow-range** reading on your data sheet and circle N.

If the pH readings at your site **consistently** fall outside the range of the cresol red comparator, be sure to let the Program Coordinator know so that (s)he can order an indicator more suitable for your site.

STEP 7: Discard the contents of the sample tube in the kitty litter jug.

HANNA pH METER METHOD

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The pH meter must be calibrated before every sampling event, preferably at home.

Calibration Procedure:

STEP 1: Remove the cap from the pH meter, then dry the pH meter thoroughly with a soft tissue such as a Kim Wipe or toilet paper being mindfull not to scratch the glass electrode.

STEP 2: Cut open the top of the calibration buffer packet (Sachet) with scissors carefully so as not to spill the solution.

STEP 3: Turn on the pH meter by pressing the "Power/Mode" button

STEP 4: Insert the pH meter all the way into the calibration buffer packet and swish the meter up and down a bit making sure the electrode is fully immersed.

STEP 5: Press and hold the "Power/Mode" button so the meter goes off and then until the word "CAL" appears, then release the button.

STEP 6: pH meter will display "7.01" and "USE" and then "REC" while it is calibrating

STEP 7: When pH meter displays "4.01" and "USE", push and release the "Power/Mode" button; meter should briefly display OK 1

Meter is now calibrated. Check the "OK" box under pH Calibration on the Data Sheet. It is okay now to turn off the meter while you travel to your site. Turn off the meter by holding the "Power/Mode" button until "OFF" is displayed, then release. Calibration buffer packet can be clipped shut and kept for another calibration during the same day (later that afternoon), but must be discarded after one day.
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SALINITY

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STEP 1: Rinse the clear plastic hydrometer jar (the 500-ml cylinder) three times by pouring **small** amounts of water from the sample bucket. Then, fill the hydrometer jar to within an inch of the top with water poured from the bucket.

STEP 2: Hang the thermometer in the jar so that it's totally immersed.

STEP 3: Insert the hydrometer into the jar and give it a slight twist to remove bubbles. Take care that the hydrometer doesn't hit the bottom hard (it might break), and that drops of water don't splash on to the hydrometer stem above water level. Allow the hydrometer to float **freely**. (If the hydrometer is resting on the bottom of the jar you need more water.)

> The accuracy of the hydrometer depends on its having exactly the same weight as when it was calibrated in the factory. Anything that changes that weight - dried salt from previous use, grease from fingerprints, water droplets on the portion of the stem that's not submerged - will throw the results off.
>
> To avoid the fingerprint problem, handle the hydrometer as little and as lightly as possible. This almost sounds like a contradiction - it's fragile, so you don't want to drop it, but neither do you want to get a choke hold on it. Think of the way you would handle a photograph - carefully and by the edges.
>
> When you get home, be sure to rinse the hydrometer in **fresh** water

STEP 4: Wait until 3 minutes have gone by since Step 2. Read the temperature of the water in the jar to the nearest 0.5^{o}C and record it on your data sheet in the space next to the specific gravity reading. (You may find it helpful to use a magnifying glass here.) Remove the thermometer to allow the hydrometer a bit more room to float freely.
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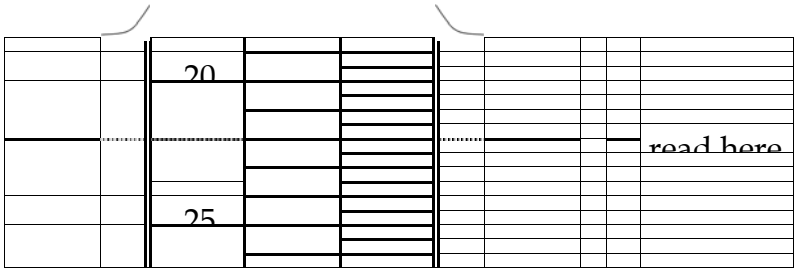
Don't worry if the water temperature you read in the hydrometer jar is different than the one you measured previously in the sample bucket. The whole point of measuring the temperature in the jar is that the bucket's been sitting out for a while by now, and the temperature has **probably** changed. Furthermore, the temperature of the water in the jar will change as you work!

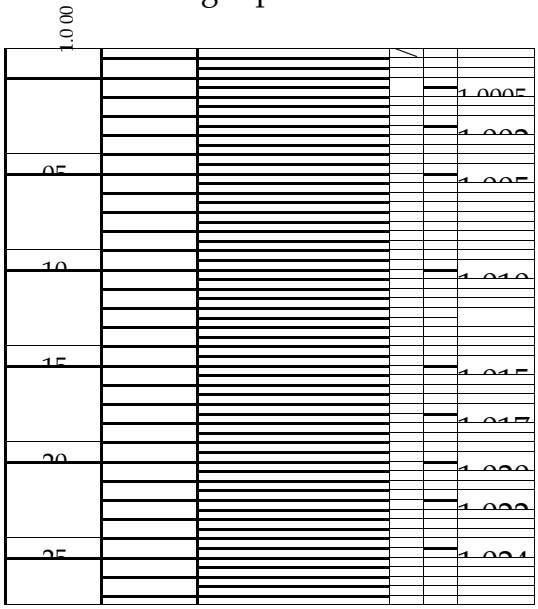
The relationship between specific gravity (what the hydrometer measures) and salinity (what we're trying to get at) is **very** temperature dependent, so it's important to know the exact

STEP 5: Read the specific gravity from the scale on the hydrometer stem to the nearest 0.0005 and record it on your data sheet. Be sure to take the reading:

- ⋙ Without touching the hydrometer.
- ⋙ With your eyes at the same level as the water surface in the hydrometer jar. Viewing the scale up or down at an angle can give an incorrect reading.
- ⋙ At the point where the flat water surface would cross the hydrometer stem. You'll notice that the water curves up slightly right next the wall of the stem. (This curve is the meniscus. It's the same effect as you saw when measuring out the DO titration samples - see page 51.) You want to measure from the **bottom** of the curve, not the top.



The hydrometer scale can be a little tricky to read at first. Make sure you get all your zeros in the right places!



READING THE HYDROMETER SPECIFIC GRAVITY SCALE

STEP 6:Use the hydrometer table on pages 139 and 140 to convert your specific gravity reading to salinity in parts per thousand. Run horizontally across the table until you find the column for the temperature at which you took the reading. Then run down the column until you get to the row for the specific gravity you read.

EXAMPLE: Say that you've taken a reading of 1.0220 at 20.0°C. Looking at the 4th column from the left on page 140 and running down to the 24th row, you find that this corresponds to a salinity of 29.8 ppt.

If the temperature at which you read the specific gravity falls between two of those listed in the table, split the difference, **always rounding to the even number**.

EXAMPLE: Say that you've read a specific gravity of 1.0220 at 10.5°C. Split the difference between 27.4 ppt (from the 10.0°C column) and 27.7 ppt (from the 11.0°C column), and record the salinity as 27.6 ppt.

WATER CLARITY ("SECCHI DISK DEPTH") & BOTTOM DEPTH

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STEP 1: Take the reading without sunglasses and with the sun at your back to minimize interference from reflections on the water. Always take the reading from the same position, whether it's standing, kneeling, or lying on the dock. The closer you get to the water the better, but the most important requirements are that you have a good view of the disk and use one position consistently. If you're on a boat, take the reading on the shaded side and away from any agitation caused by the engine or propeller.

HINTS:Always take your Secchi disk and bottom depth readings from exactly the same spot so that they'll be comparable from reading to reading.

It's a good practice to always tie the end of the Secchi disk line to something solid if you're working from a dock or a boat.

It's important that the line hang straight as you lower the Secchi disk. If you're working in an area with strong currents, you may have to add some weights in a bait bag attached to the loop below your disk. Improvise the weights from anything available at your site - rocks, tools from your car, etc.

If the water surface is especially choppy, you might have trouble determining exactly where it intersects the line. There's not much you can do about "natural" chop, but if the chop is due to a boat going by, you'll want to wait a couple of minutes before taking your reading.

If you're more than a foot or two above the water surface, you might
~~~~~~

STEP 2: Lower the disk into the water until it **just** disappears from sight. Read the point at which the surface of the water intersects the Secchi disk line marked in 0.1-meter intervals. Now lower the disk a bit more, and then slowly raise it until it **just**, barely perceptibly reappears. Read the point at which the water surface intersects the marked line. This reading should be within 0.4 m of the first one. If the readings differ by more than 0.4 m, repeat the measurements. The average of the two readings is the **Secchi disk depth**. When you have a reliable figure, record it on your data sheet to the nearest 0.1 m.

STEP 3: Continue to lower the disk until you see or feel the line go slack. Pull the line up gently just enough to straighten it out. Read the point at which the water surface intersects the marked line. This is the **bottom depth**. Record it on your data sheet to the nearest 0.1 m.

> If you're working at a shallow site, especially at low tide, the Secchi disk may hit bottom before it vanishes from view. If this happens, record **Bottom SV** (Still Visible) on your data sheet.

APPENDICES

APPENDIX 1

MONITORING POLICY

1) Each site will have at least one primary monitor and one alternate. If the primaries are a couple, a third person must be assigned as alternate to provide coverage for vacations, etc.

2) The alternate for one site may be a primary **or** an alternate monitor at **not more than one** other site. Try to avoid having primary monitors at any pair of sites act as each other's alternates because if both get sick or go on vacation, that will leave us two sites to cover. It would be better if a third person could be assigned as alternate for at least one of the sites.

3) All primary and alternate monitors will be at least 16 years old. People under 16 are welcome to attend training and QA/QC sessions and to **assist** monitors at the sites.

4) All primary and alternate monitors will attend initial training sessions and **at least** one of the two QA/QC sessions held each year. For monitors working in couples, **both** monitors must attend **both** the training and QA/QC sessions (although not necessarily the same session).

5) All primary monitors will have their own kits. Monitors working in couples may share a kit. All primary monitors will be responsible for maintaining their kits and for notifying the Program Coordinator of any problems with their equipment. Monitors will be responsible for requesting new supplies of reagents on a timely basis (i.e., well in advance of the old supplies running out). Primary monitors will bring their kits to all QA/QC sessions.

6) Alternate monitors who are primaries for other sites may use their own kits at any site. Otherwise, alternate monitors standing in for primaries will use the primaries' kits. The alternates are responsible for reporting equipment problems, reagent shortages, etc. to the primary owners of the kits for further action. If an alternate is not able to get hold of the primary monitor's kit, the alternate should contact the Program Coordinator to make arrangements, preferably in advance of the sampling session.

7) All alternate monitors will stand in for the primaries at least once every two

months to maintain familiarity with the equipment, the procedures, **and** the site itself.

8) All primary and alternate monitors will have the option of joining an "alternate pool" in addition to their responsibilities for specific sites. The pool will provide coverage when the regular alternate is not available at a given site. Only trained primary and alternate monitors may join this pool.

9) All primary and alternate monitors will be responsible for the quality and completeness of the data they themselves collect and for submitting this data to the Program Coordinator on a timely basis. Monitors will be responsible for maintaining an ample supply of standardized data sheets at home.

10) Primary monitors will be responsible for arranging for coverage of their sites by **trained** personnel. If the regular alternate for the site is unavailable for a particular sampling session, the primary should call members of the alternate pool until someone agrees to cover the site for that session. The primary should not ask the alternate or one of the pool members to call the other pool members. As a **last** resort, the primary should call the Program Coordinator.

11) The Program Coordinator will be responsible for the overall quality of the data collected by the program. If problems arise with the data collected by any particular monitor, the Program Coordinator will work with the monitor to resolve these problems.

APPENDIX 2

MONITORING STATIONS & TEAMS

APPENDIX 3

MAP OF ESTUARY & MONITORING STATIONS

APPENDIX 4

APPENDIX 5

TEST VALUES REQUIRING SPECIAL RESPONSE

Routine water monitoring at any one monitoring station will establish what parameter values are "normal" for that station and how these values change with the seasons and with periodic events such as storms. However, monitoring may also detect values which fall outside the established "norm." Such readings may signal episodic events or short-lived phenomena which are worthy of response or further analysis. On the other hand, oddball readings may indicate that there's something wrong with your equipment.

If you detect values in the ranges shown below, report the situation to the Monitoring Program Coordinator as soon as possible by calling (207) 799-8574. If you speak to a person, be sure to get their name. If you get the answering machine, please leave a message including a description of the problem you've found. Depending upon the circumstances, you may be directed to repeat a measurement, collect and forward a sample, or participate in a further investigation, perhaps offshore or upstream.

WATER TEMPERATURE:	0°C or less; 25°C or greater
DISSOLVED OXYGEN:	5 mg/l or less; 12 mg/l or greater
pH:	7.5 or less; 8.5 or greater
SALINITY:	10 ppt or less; 32 ppt or greater
WATER CLARITY:	Secchi disk depth of 1 meter or less
OTHER:	call (207) 799-8574!

APPENDIX 6 - BEAUFORT WIND SCALE

Beaufort Number or Force	Wind Speed			World Meteorological Organization Description	Estimating Wind Speed		
	knots	mph	km/hr		Effects Observed at Sea	Effects Observed near Land	Effects Observed on Land
0	under 1	under 1	under 1	calm	Sea like a mirror	Calm	Calm; smoke rises vertically
1	1-3	1-3	1-5	light air	Ripples with appearance of scales; no foam crests	Small sailboat just has steerage way	Smoke drift indicates wind direction; vanes do not move
2	4-6	4-7	6-11	light breeze	Small wavelets; crests of glassy appearance, not breaking	Wind fills the sails of small boats, which then travel at about 1-2 knots	Wind felt on face; leaves rustle; vanes begin to move
3	7-10	8-12	12-19	gentle breeze	Large wavelets; crests begin to break, scattered whitecaps	Sailboats begin to heel and travel at about 3-4 knots	Leaves and small twigs in constant motion; light flags extended
4	11-16	13-18	20-28	moderate breeze	Small waves 2-4 feet high, becoming longer; numerous whitecaps	Good working breeze; sailboats carry all sail with good heel	Dust, leaves, and loose paper raised up; small branches move
5	17-21	19-24	29-38	fresh breeze	Moderate waves 4-8 feet high taking longer form; many whitecaps; some spray	Sailboats shorten sail	Small trees in leaf begin to sway
6	22-27	25-31	39-49	strong breeze	Larger waves 8-13 feet high forming; whitecaps everywhere; more spray	Sailboats have double reefed mainsails	Larger branches of trees in motion; whistling heard in wires

7	28-33	32-38	50-61	near gale	Sea heaps up; waves 13-20 feet high; white foam from breaking waves begins to be blown in streaks	Boats remain in harbor; those at sea heave to	Whole trees in motion; resistance felt in walking against wind
8	34-40	39-46	62-74	gale	Moderately high waves (13-20 feet) of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks	All boats make for harbor if near	Twigs and small branches broken off trees; progress generally impaired
9	41-47	47-54	75-88	strong gale	High waves (20 feet); sea begins to roll; dense streaks of foam; spray may reduce visibility		Slight structural damage occurs; slate blown from roofs
10	48-55	55-63	89-102	storm	Very high waves (20-30 feet) with overhanging crests; sea takes a white appearance as foam is blown in very dense streaks; rolling is heavy and visibility is reduced		Seldom experienced on land; trees broken or uprooted; considerable structural damage occurs
11	56-63	64-72	103-117	violent storm	Exceptionally high waves (30-50 feet); sea covered with white foam patches; visibility still more reduced		Very rarely experienced on land; usually accompanied by widespread damage

12	64 and over	73 and over	118 and over	hurricane	Air filled with foam; waves over 50 feet high; sea completely white with driving spray; visibility greatly reduced		

APPENDIX 7

TIDE CHARTS FOR PORTLAND, MAINE

APPENDIX 8

GUIDE TO TIDAL STAGES

0	1	2	3	4	5	6	7	8	9	10	11	12	HRS
	LOW FLOOD	<------	FLOOD	------>	HIGH FLOOD		HIGH EBB	<------	EBB	------>	LOW EBB		
LOW						HIGH						LOW	

For example, if high tide were at 14:00 (2:00 PM) and you were sampling two hours earlier at 12:00 noon, the tidal stage would be "flood." If you were sampling **one** hour earlier, the stage would be "high flood"; one hour **later** would be "high ebb" and **two** hours later would be simply "ebb." Only the period from 13:30 to 14:30 would be considered "high."

You may find this tidal stage guide easier to use in "clock" form:

APPENDIX 9

HYDROMETER TABLE

APPENDIX 10

SAMPLE S-C-T METER CALIBRATION LOG

DATE / CONDUCT STANDARD CALIB DATE	SERIAL NUMBERS		PRE-CAL CHECK WITH CONDUCTIVITY STANDARD					POST-CAL CHECK WITH CONDUCTIVITY STANDARD					PASS-FAIL (W/IN 5% OF STD)		
			TEMPERATURE (°C)		CONDUCTIVITY (µmhos/cm)			TEMPERATURE (°C)		CONDUCTIVITY (µmhos/cm)					
	YSI S-C-T MODEL 33	THERM OM-ETER	THERM OM-ETER	YSI READ ING	CALCUL ATED VALUE	YSI READ ING	YSI READIN G -0.6%	THERM OM-ETER	YSI READ ING	CALCUL ATED VALUE	YSI READ ING	YSI READIN G -0.6%	PR E PO ST	/	INI T INI T
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APPENDIX 11

CALIBRATION VALUES FOR THE YSI MODEL 58 DO METER

These values are to be used when calibrating the meter in water-saturated air. See page 85, 87 for the complete procedure. After the meter has been zeroed and set to the % air saturation mode, and the probe has stabilized, the O_2 CALIB control should be unlocked and set to the CALIB VALUE indicated below.

ALTITUDE							CALIB
feet			meters				VALUE
-14	to	14	-4	to	4		100.0
14	to	42	4	to	13		99.9
42	to	70	13	to	21		99.8
70	to	97	21	to	30		99.7
97	to	125	30	to	38		99.6
125	to	153	38	to	47		99.5
153	to	181	47	to	55		99.4
181	to	209	55	to	64		99.3
209	to	236	64	to	72		99.2
236	to	264	72	to	81		99.1
264	to	292	81	to	89		99.0

APPENDIX 12

SAMPLE DO METER CALIBRATION LOG

[CALIBRATION LOG BEING DEVELOPED.]

APPENDIX 13

SAMPLE FECAL COLIFORM FILTRATION LOG

PAGE # _____ FROM _____ TO _____

SAMPLE #	DATE/TIME SAMPLED	DATE BUFFER MIXED	INCUBATOR TEMP.	DATE/TIME FILTERED	DATE/TIME READ	COMMENTS	RESULTS	INITIALS

APPENDIX 14

TROUBLESHOOTING FECAL COLIFORM ANALYSES

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APPENDIX 15

EMERGENCY TELEPHONE NUMBERS

[GET AN INTERN OR VOLUNTEER TO DEVELOP THIS LIST?]

[INCLUDE POISON CONTROL NUMBERS.]

APPENDIX 16

MARINE MAMMAL STRANDING

CALL NE AQUARIUM OR ALAN LISHNESS AT GOM AQUARIUM FOR ORIGINAL POSTER.