environment. In general, toxics that have been monitored in the past have declined throughout the Bay system, largely due to better treatment practices by industry and increased regulation and enforcement. Nevertheless, ***hot spots*** (areas where toxics exist at high levels) remain in areas of the Bay, and still need to be addressed. For example, the Texas Department of Health (TDH) has issued a seafood consumption advisory for blue crabs and all catfish landed from the Houston Ship Channel and Galveston Bay north of a line from Red Bluff to Houston Point. Women of childbearing age and children, as well as people with immune system disorders, should not eat these species taken from these areas. Other, healthy adults are advised to eat no more than one eight-ounce meal per month consisting of these seafoods. For more information, call the TDH Seafood Office at (512) 719-0215.

Oxygen Demanding Substances

The amount of oxygen required for the decomposition of organic material, such as that found in wastewater, is called ***biochemical oxygen demand*** (BOD). High BOD is one reason organic materials are removed from sewage and industrial discharges. When the BOD is greater than the available oxygen in the water, the resulting low DO level can cause fish kills. BOD in the Galveston Bay System is generally the highest in the upper Houston Ship Channel and in regions of runoff and wastewater discharge. Open bay waters have the lowest values of BOD.

The good news is that BOD is decreasing over time due to a combination of improved wastewater treatment, changes in land use, and dams on rivers.

Bacterial Contamination

Several types of ***pathogens*** (disease-causing microbes) are harmful to humans, and can sometimes be found in the waters of Galveston Bay when conditions are hospitable for them. Fecal coliforms are not necessarily pathogenic, but are useful indicators of sewage pollution and potential health risks. Traditionally, fecal coliform bacteria counts, measured in colonies per 100 milliliters (ml), have been used by the Texas Department of Health seafood office. The current maximum level for shellfish harvesting waters is 14 colonies per 100 ml. For contact recreation (swimming, etc.), the maximum is 200 colonies per 100 ml. However, low levels of fecal coliform bacteria do not necessarily mean there are no pathogens in the water column, just lower risk! For example, species within the genus *Vibrio* are not detected using the standard bacteriological tests and have caused a few people to become ill from eating contaminated raw or undercooked shellfish and/or from infection of cuts and wounds from exposure to Bay water and/or fish. Viruses cannot be detected using the standard fecal coliform test. Contamination by animal wastes also yields positive fecal coliform results. It is generally agreed that a better sewage pathogen indicator is needed.

Nutrients

Nutrients are naturally-occurring chemical elements or compounds essential for plant and animal growth. Excess nutrients (fertilizers from lawns, soap from washing cars, etc.) in urban runoff frequently cause pollution. Water and chemicals running down storm drains do not flow into a water treatment plant—these liquids flow directly into bayous, streams and into the Bay. Nutrients commonly measured include ammonia, organic nitrogen, nitrate nitrogen and total phosphorus. Because nitrogen is present in low concentrations compared to other nutrients, it is the amount of nitrogen that limits the growth of plants in the Bay system. Since passage of the Clean Water Act, nitrate and phosphate concentrations throughout the Bay have declined, except in Armand Bayou, where they continue to increase.

What Does it all Mean?

While most of the Bay's water quality has improved, industrial and municipal wastewater treatment plants, urban run-off and past wastewater disposal practices have contributed to hot spots in the Bay. Many tributaries continue to have problems with low DO, nutrients and toxics. The lasting effects of habitat loss and human population growth require unified management and restoration efforts to ensure continued improvement, and to prevent further declines.

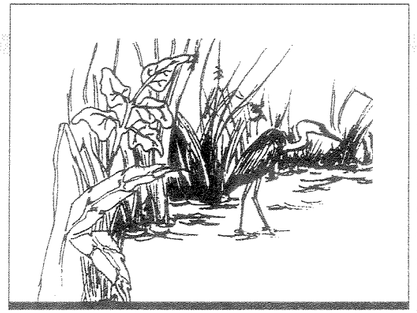
This fact sheet is one of a series produced through a cooperative agreement between the Galveston Bay Foundation and the U.S. Fish and Wildlife Service. The information in this series was developed by authors from the Galveston Bay Foundation, National Marine Fisheries Service, Sea Grant College Program, Texas Natural Resource Conservation Commission, Texas Parks and Wildlife Department, Texas Water Development Board and the U.S. Fish and Wildlife Service.

The Galveston Bay Foundation is a nonprofit organization whose mission is to preserve and enhance the Bay for its multiple uses through education, conservation, research and advocacy. The mission of the U.S. Fish and Wildlife Service is to conserve, protect and enhance the nation's fish and wildlife and their habitats for the continuing benefit of the American people.

For more information, contact the Galveston Bay Foundation at 17324-A Highway 3, Webster, Texas 77598, or call 713-332-3381.

Water Quality in Galveston Bay

Sustaining multiple resources and multiple uses



Can I safely eat the fish I catch in the Bay? Can I safely swim in the Bay? These are common questions, with the answers rooted in water quality. Water quality is an excellent indicator of the health of the Galveston Bay ecosystem because nearly everything that happens in the watershed—man-made and natural—affects water quality.

Because the open waters of Galveston Bay are shallow and well-flushed by wind, tides and freshwater inflows, the open Bay has historically maintained good water quality. The most serious water quality problems have occurred near the greatest concentration of industry and urban development.

The Texas Natural Resource Conservation Commission (TNRCC) has designated many portions of the Bay as having the following uses: 1) high quality aquatic habitat, 2) shellfish waters and 3) contact recreation. Water quality standards vary within each designation. The TNRCC and many certified citizen monitors evaluate water quality through regular testing. The TNRCC also conducts inspections and monitors reports on ***point source discharges*** (permitted discharges from industrial and municipal wastewater treatment plants) to ensure compliance with discharge permits.

Water Quality Parameters

Water resource managers use water quality data to make management decisions. Testing for general water quality requires collecting data on several specific parameters which can, over time, indicate the general health of a water body.

Salinity

Galveston Bay is an ***estuary***, a body of water where fresh water from rivers and streams mixes with salty sea water, in this case that from the Gulf of Mexico. The resulting ***brackish*** water is extremely important to the juvenile finfish and shellfish that use the estuary as a nursery area.

Salinity is an important physical variable which influences the life cycles of various estuarine organisms. Salinity is directly influenced by freshwater inflow, both natural and artificial (i.e., point source discharges).

There is a wide variety of inorganic substances or dissolved solids, like sodium, chlorides, sulfates, calcium, nitrates, phosphates, iron, magnesium, etc., in water that may affect salinity. These dissolved materials in normal proportions and concentrations are essential for aquatic life, and all have the ability to carry electrical current (***conductivity***). These substances affect the movement of materials in and out of the cells of organisms living in the water. They may also be used as energy sources for certain organisms. Finally, they serve as the parts of molecules necessary for building new cells.

The salinity of Galveston Bay gradually decreases from near full strength sea water--3.5% or 35 parts per thousand (ppt) salt--at the mouth of the passes into the Gulf to totally fresh water in the upper Trinity River delta. This salt ***gradient*** is formed by the interaction of two opposing forces: 1) A diluting effect caused by freshwater inflow from the Trinity and San Jacinto Rivers and runoff from local rainfall, and 2) Increased saltiness resulting from on-shore winds, rising tides and ***density currents*** (salty water displacing less dense fresh water in deep channels).

Extremes in salinity threaten the survival of many estuarine organisms. These extremes may occur during drought, interruption of natural freshwater inflow by dams or levees, or during prolonged flooding.

Pollution can be caused by fluctuating levels of dissolved solids, or ***conductivity,*** as seen in a number of activities. Wastewater discharges that are high in salts are one example. Discharges of ***brine*** or ***produced water*** (concentrated salt water associated with oil and gas production) in the Bay cause salinity hot spots which are also detrimental to estuarine life.

Dissolved Oxygen

Dissolved oxygen (DO) is essential to the growth, development and survival of the creatures in any aquatic ecosystem, and is one of the most important indicators of water quality for aquatic life.

Oxygen is transferred from the atmosphere into the surface waters by the aerating action of the wind through a process called ***physical aeration*** or diffusion. It is also added at or near the surface as a by-product of plant ***photosynthesis*** (the incorporation of solar energy into carbon compounds by green plants). As a result, floating and rooted aquatic plants increase DO levels through the process of photosynthesis, which is the opposite of respiration, and removes carbon dioxide (CO_2) from the atmosphere or water. Since the existence of green plants depends on the availability of light, oxygen-producing processes only occur near the surface or in shallow waters.

The amount of oxygen that water can hold decreases as the temperature and salinity of the water increases. Aquatic organisms take up dissolved oxygen through their gills or body surfaces. Extremely low DO levels are stressful or even fatal for aquatic life.

DO levels in Galveston Bay are generally high, with the exception of places where the water doesn't move, or flush well, such as sluggish bayous, dead-end canals and marinas.

Within heavy industrial and shipping areas of the Bay system, spills occasionally depress or consume available dissolved oxygen. This can result in fish kills. Dissolved oxygen concentrations are also decreased by warm temperatures and by discharges from ***point sources*** (permitted facilities) and ***non-point sources*** (rainwater runoff), both of which may contain oxygen-consuming contaminants. The upper Houston Ship Channel is the main water body in the Galveston Bay system that consistently exhibits low DO levels during summer months, although that has improved in the past 10 years.

Overabundant numbers of plants and animals in an aquatic environment can consume most of the oxygen in the water. This consumption can be most damaging at night and on very cloudy days when photosynthesis, producing new oxygen, does not occur. Excessive growth of algae, especially from fertilizer run-off and sewage effluent, also contributes to night time depletion of oxygen. This, too, can result in fish kills.

pH

pH (potential of Hydrogen) is a measure of how acidic or basic (alkaline) a solution is. The pH scale ranges from 0 to 14, with a pH of 7.0 (distilled water) considered neutral. An acidic pH is less than 7.0 (wine, 3.2, or battery acid, 0.3), and a basic, or alkaline pH is greater than 7.0 (drinking water, 7.8, or lye, 13.7). Full-strength sea water has a pH of about 8.1. Generally, the ability of estuarine organisms to complete a life cycle greatly diminishes as pH becomes greater than 9.0 or less than 6.0. Water's ability to resist changes in pH, or its ***buffering capacity***, is critical to aquatic life.

There are several activities in water that can severely affect the pH. Mineral substances are dissolved, aerosols and dust from the air are picked up, and man-made wastes are dumped into the water. The pH of Galveston Bay can fluctuate to lethal levels in areas affected by spills of acidic or alkaline substances from ships or on land.

One naturally-occurring effect on pH is photosynthesis, which removes CO_2 from the water, increasing its alkalinity. In very still waters with an abundance of plant life (including algae), an increase in pH can be expected during warm, sunny afternoons.

Temperature

Temperature may be one of the easiest measurements to perform, but it is also one of the most important parameters to be considered. The temperature of the water helps determine how much DO the water can carry, and, as already seen, DO is essential for aquatic creatures to survive. Water holds less oxygen at higher temperatures, and temperatures in excess of 89°F are generally considered poor.

Warmer temperatures can also affect pH, as described above.

Water temperature varies within the Bay system, and from season to season. With increasing depth the water generally becomes colder. This resulting ***thermal stratification*** creates layers of varying temperatures and differences in water density. During the spring and summer months, surface waters are warmed by the sun. In the fall, as surface water cools, it increases in density. Once it becomes colder and heavier than the water below it, it begins to sink and ***vertical mixing*** occurs. This mixing action brings ***nutrients*** (materials essential to the growth of organisms) up from the bottom and into higher water levels.

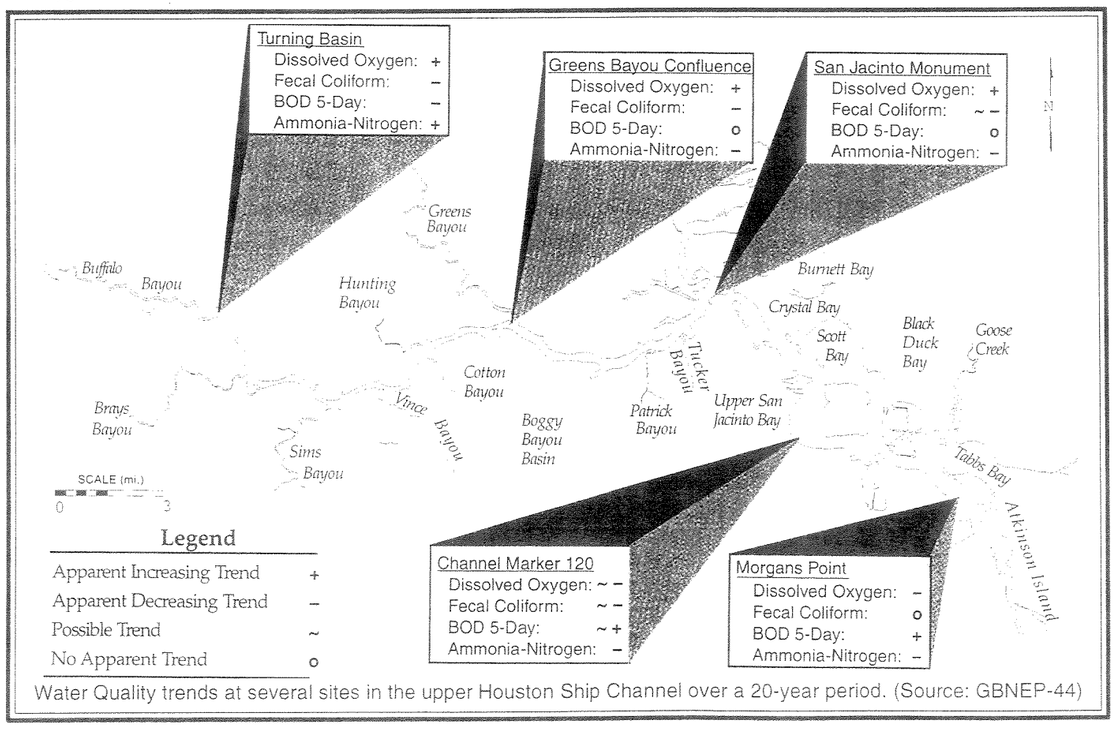
Bay water temperature is also affected by tidal fluctuations, by freshwater inflows from rivers and by discharges of water from industry and power plants, as well as by the depth of the water.

While estuarine organisms grow more rapidly during warm summer months, local temperature fluctuations above 95°F can occur near the outfalls of power plants, and can be fatal to aquatic organisms. However, during the coldest winter months, large numbers of fish can be found congregated near some power plant discharge canal outfalls because of the warmth.

Turbidity

When the water is cloudy or muddy-looking, it is called ***turbid.*** Turbidity is caused by material suspended in the water—it can be sediments or plankton. Galveston Bay is normally turbid, largely because the Bay bottom and the contributing watersheds are made up of fine sediment which is easily re-suspended. Turbidity varies widely in many parts of the Bay and at different times of the year. For instance, in summer, plankton plays an important role, as these organisms are growing and multiplying rapidly in warm, sunlit, nutrient-enriched water. Heavy rains increase turbidity by increasing runoff from the land into tributaries and the Bay. Turbidity is greatly affected by disturbances of the sediments on the Bay's bottom, which can be either natural (rainfall, fish movements, winds, currents) or man-made (boat traffic, shrimping, dredge disposal). Decaying plant matter also influences water color and water clarity. Waters colored brown by these high concentrations of naturally-occuring tannins will not be transparent.

Too much turbidity over long periods of time reduces light essential for photosynthesis. Only plant life close to the surface would have adequate light to turn CO_2 to O_2. Seagrasses that normally grow from the Bay bottom may not survive in highly turbid water. In addition, large amounts of suspended matter can clog the gills of fish and kill them directly by suffocation. Suspended particles may provide a place for harmful microorganisms to lodge, and affect the visibility of fish feeding below the surface.



Water Quality trends at several sites in the upper Houston Ship Channel over a 20-year period. (Source: GBNEP-44)

Contaminants

Contaminants affecting water quality are too numerous to mention individually. A few general categories are discussed below.

Toxics

Heavy metals and organic compounds can be toxic, and are in Galveston Bay as a result of the uses of the Bay and tributary waters for commercial, industrial and domestic purposes. Toxic substances (or simply ***toxics***) have been found in the vicinity of various industrial and municipal discharges and in areas receiving large amounts of non-point source runoff.

Many of these compounds can ***bioaccumulate*** to higher concentrations in finfish which provide food for man. Bioaccumulation occurs when toxics enter the water in very low, seemingly harmless amounts and then accumulate in the tissues of animals that ingest them. However, the exact risks of eating these fish are constantly debated, and more research needs to be done to determine the effects on humans and the