Sesachacha Pond Annual Report
2002

Prepared for: Marine and Coastal Resource Department
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EXECUTIVE SUMMARY

Sesachacha Pond is a coastal eutrophic salt pond located on the northeast part of Nantucket Island. The unique physical characteristics of Sesachacha Pond could support high salinity conditions if the pond were properly flushed to the sea.

The pond must remain open to the ocean for at least 7 to 10 days to ensure a proper volumetric exchange of water. The spring opening lasted one day. The fall opening lasted two days. Neither the spring nor the fall openings successfully replaced enough ocean water with pond water to dilute nutrient concentrations, maintain marine fisheries, or increase salinity. The perpetual freshening of the pond due to poor openings and general precipitation is causing winter flounder and blue back herring to die.

Development in the pond's watershed has increased nutrient loading to the pond through groundwater and surface runoff. Nitrogen, a limiting nutrient, has reached high levels in the pond severely degrading water quality conditions. The lack of flushing during pond openings has resulted in higher concentrations of nutrients, low oxygen events, phytoplankton blooms, and fish kills.

If nitrogen continues to increase over time, there will be a shift from nitrogen to phosphorus as the limiting nutrient. Phosphorus concentrations were very high in the summer months indicating enriched nutrient conditions. Secchi depths were extremely low all year not just in the warmer months complimenting high nutrient levels. Water clarity is half the depth this year as it was in 2001. Fish biodiversity has decreased as a result of poor water quality conditions.

Water quality is continuing to degrade over time. Sesachacha Pond has been placed on the 1998 Massachusetts 303D list for impaired water bodies. Sesachacha Pond does not meet the standards for the direct consumption of shellfish due to pathogens. Department of Environmental Protection is the governing agency for impaired water bodies. Sesachacha has been placed on DEP Estuaries Project. This program will determine the total maximum daily load allowed for the pond.

INTRODUCTION:

Sesachacha Pond has been monitored since 1980 for water quality conditions by a variety of agencies. Historically, Sesachacha was opened to the ocean seasonally to enhance marine fisheries. Pond openings were discontinued for ten years during the 1980s. The absence of the openings resulted in the degradation of water quality and marine fisheries.

In spring 1991, Sesachacha Pond was opened to the sea. Due to inadequate opening practices, water quality in the pond did not improve in 1991 and 1992. In 1993, pond-opening methodology was revised. In 1993, water quality and marine fisheries in Sesachacha began to improve. Water quality conditions improved and stabilized through the most of the 1990s. However due to inadequate pond openings once again, water quality has continued to decline since 1998.

Increased development to the north of Sesachacha Pond has increased nutrient loading into Sesachacha Pond. Surface runoff and groundwater carry nitrogen and phosphorus to the pond changing water chemistry. This accelerated eutrophication process has made pond openings more critical in maintaining good water quality. A proper exchange of nutrient latent pond water with alkaline-rich ocean water is important in maintaining good water quality for marine life.

Due in part to the watershed to pond ration, water quality conditions in Sesachacha Pond are a reflection of the success or failure of pond openings. For the past five years, Sesachacha has had poor water exchange with the ocean during the bi-annual pond openings. Water quality has degraded resulting in fish kills, phytoplankton blooms and poor water clarity.

PHYSICAL FEATURES:

The drainage basin of Sesachacha Pond covers approximately 800 acres. The watershed to pond ratio is low (3:1). The surface area of the pond during “normal conditions” covers 266 acres. The “flooded conditions” of the pond covers 279 acres. The approximate pond volume for “normal” and “flooded” conditions is 2183 acre-ft and 3129 acre-ft, respectively.

Sesachacha Pond experiences a periodic fluctuation in water level as a result of pond openings. Theoretically, water level reaches maximum prior to a spring opening, and minimum after the pond has established equilibrium with the ocean. Shortly after this balance is reached, the channel closes and the pond surface area begins to increase. At minimum, or equilibrium pond level the surface area is 266 acres with a volume of 2183 acre-ft or 710 million gallons. At the maximum flooded condition, the pond has a surface area of 279 acres with a volume of 3219 acre-ft or 1 billion gallons. This represents a change of approximately 341 million gallons of water during a “good” pond opening.

The mean and maximum depths during equilibrium conditions are 8.2 and 18 ft, respectively. Mean and maximum depths during flooded conditions are 11.5 and 21 ft, respectively. The pond has two deep basins; one located on the east side with a maximum depth of 21ft and the other on the west side with a maximum of 18ft. The water depth between the two basins average 14 ft.

SURFACE DRAINAGE BASIN:

Sesachacha Pond's water quality if directly related to its watershed characteristics. The important physical properties of the watershed are drainage basin size, soil permeability, erosion qualities, and vegetative cover.

Drainage basin: The watershed area is approximately 800 acres and the pond is 266 acres. The watershed to pond area ratio is 3:1. Therefore, disturbances within the watershed should have minimal affects to pond water quality. However, pond water lost to the ocean during openings takes longer to replace by surface and groundwater flows.

Soil permeability and erosion qualities: The Plymouth-Evesboro association surround 80% of Sesachacha Pond. Plymouth-Evesboro is a gently sloping excessively drained, sandy soil formed in glacial till and in outwash deposits. Medisaprists-Berryland Variant association surround 20% of Sesachacha Pond to the southwest. This association is nearly level, very poorly drained muck soil formed in organic deposits; sandy soil formed in outwash deposits. Sand and cobble are found along the shoreline and extend to the 12ft contour. Organic muck is found in deeper contours.

Most of the development around Sesachacha Pond is located in the Plymouth-Evesboro Association. The permeability of this soil is rapid. Septic tanks placed on the downward slope to the pond will increase seepage of effluent into the pond and groundwater. Nutrients are entering Sesachacha Pond though groundwater infiltration.

Vegetative cover: A wetland is to the northwest of the pond contributes to Sesachacha Pond's ecosystem. The wetland produces peat, which stabilizes sediment during flooded conditions. Peat is the result of recycled nutrients and organic matter from a wetland system. Peat provides structural biomass to the ecosystem. Nitrogen becomes mineralized in the sediment and can be used for plant growth. Bulrush grows in the "intertidal area" of the pond. Spartina grows along the peripheral upland of the bulrush. North of the spartina, woody vegetation exists. The change in upland vegetation is a result of underlying sediments. As organic material accumulates, the elevation around the pond increases. Phragmites and cattails are growing along the wetland border.

SOURCES OF CONTAMINATION:

Sesachacha Pond has the following sources of contamination to water quality: septic systems, stormwater overflow pipe entering beneath Polpis Road, wetland, paved roads,

precipitation and deposition, internal recycling, underground storage tanks, fertilizer applications.

Groundwater entering Sesachacha Pond has increased in nitrate concentrations due to septic system leachates. The leaching field effluents of a conventional septic system contain 40 to 60 mg/l of nitrogen and 8 to 38 mg/l of phosphorus. Effluents contain a large number of pathogenic bacteria and viruses. Virus inactivation times in groundwater are approximately 120-200 days.

The direct discharge pipe that drains the adjacent wetland entering beneath the road is a contamination source. The organic that are carried by the pipe provide a food source for bacteria. Wetlands by nature provide habitat for a variety of animals that contribute many bacteria strains as well as nutrient concentrations.

During storm events, surface runoff carry heavy metals from roadways, volatile organic compounds, oils and grease from cars; pathogenic bacteria and viruses from septic systems; suspended solid, nutrients, pesticides and herbicides from lawns and the golf course. The possible location of the surface water divide encompasses part of the Sankaty Golf Course causing additional water quality problems during storm events.

Sampling Procedures and Equipment

Sampling sites shown on Figure 1 and defined as:
Site 1: near Quidnet village approximately 1000 ft from shore
Site 2: deep water off shack approximately 1000 ft from shore to northwest
Site 3: near boat launch approximately 100 ft from shore
Site 4: deep water to southeast approximately 1200 ft from shore

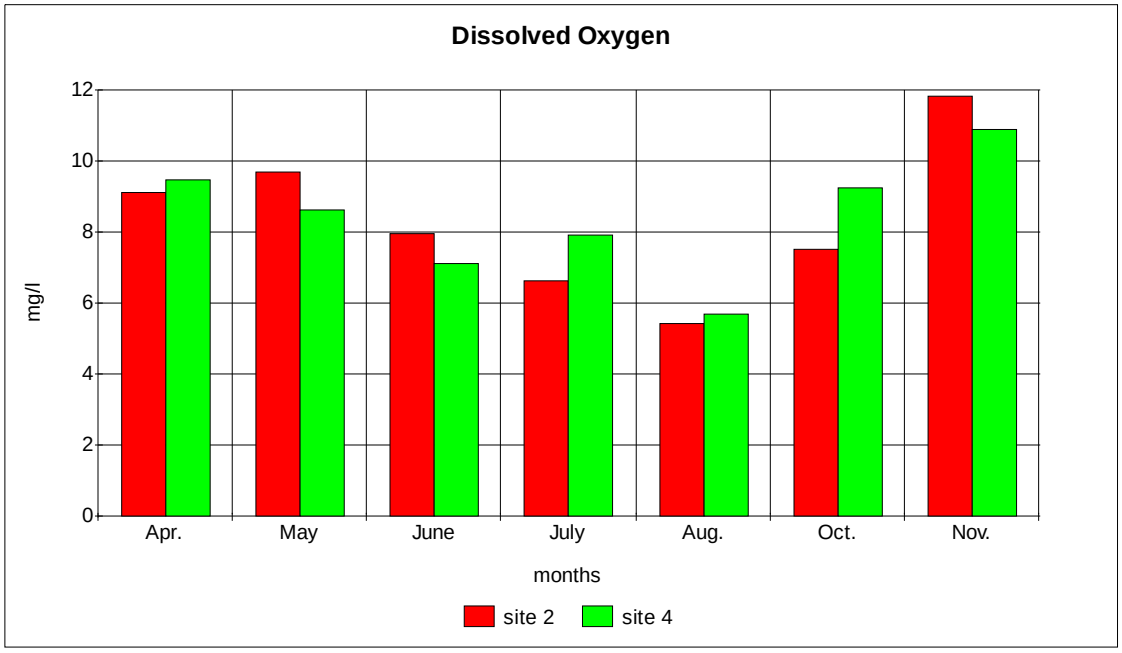
Sampling protocol:
Sesachacha is sampled beginning in April through November. Temperature and dissolved oxygen were measured using a WTW Oxi 340. Salinity was measured with a YSI 30. Measurements were recorded every 3-ft. Secchi depth was measured with a white secchi disk. A van dorhn was used to collect water at mid depth for nutrient analysis. Envirotech analyzed nitrogen and Phosphorus, a state certified laboratory in Sandwich. Phytoplankton was collected using a WildCo 47-E phytoplankton net and analyzed upon arrival to the office.

RESULTS AND DISCUSSION:

Dissolved Oxygen

The water column was saturated in April. Dissolved oxygen remained high in May with the exception of site 4, which was 4.67ppm at 15ft. The low oxygen or hypoxic layer covered the entire bottom of the pond in June and July. This layer separates from other oxygenated layers in the pond forming a low oxygen bubble on the bottom.

The following is a chart of the average dissolved oxygen concentrations. August contained the lowest concentrations of dissolved oxygen for the year. High water temperatures in July and August result in lower dissolved oxygen concentrations naturally.

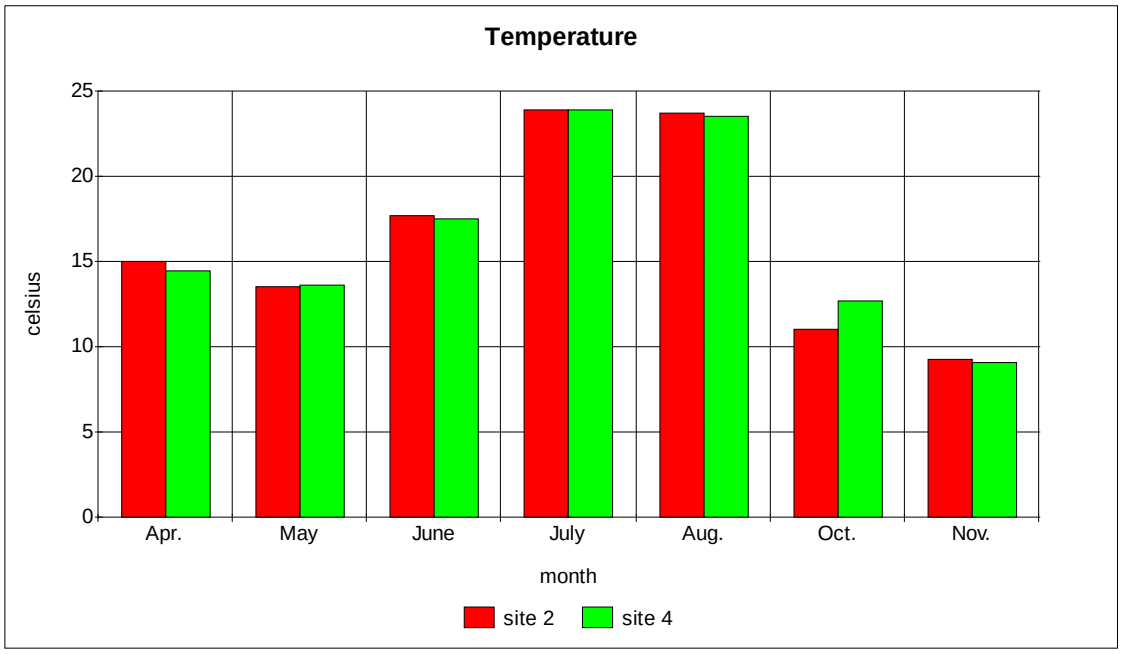


The addition of excess nutrients in combination with increased hours of daylight caused algal blooms. Algal bloom increased dissolved oxygen during the day and reduced available oxygen at night. The fluctuating oxygen concentrations could not support some fish species. Winter flounder and river herring were observed coming ashore in August as a result of low oxygen and high water temperatures.

Dissolved oxygen levels increased in the fall. In the fall water temperatures decreased and wind increased, oxygenating the water column through mixing. A phytoplankton bloom was noted in November. Overall, dissolved oxygen levels were not stable this year.

Temperature

Water temperature ranged from 14 – 15 C in April. Temperature decreased to 13.8C in May. Water temperature increased through the summer peaking at 24C in July. Temperature remained high in August (23.7C). Water temperature was generally warmer at the surface than at the bottom.

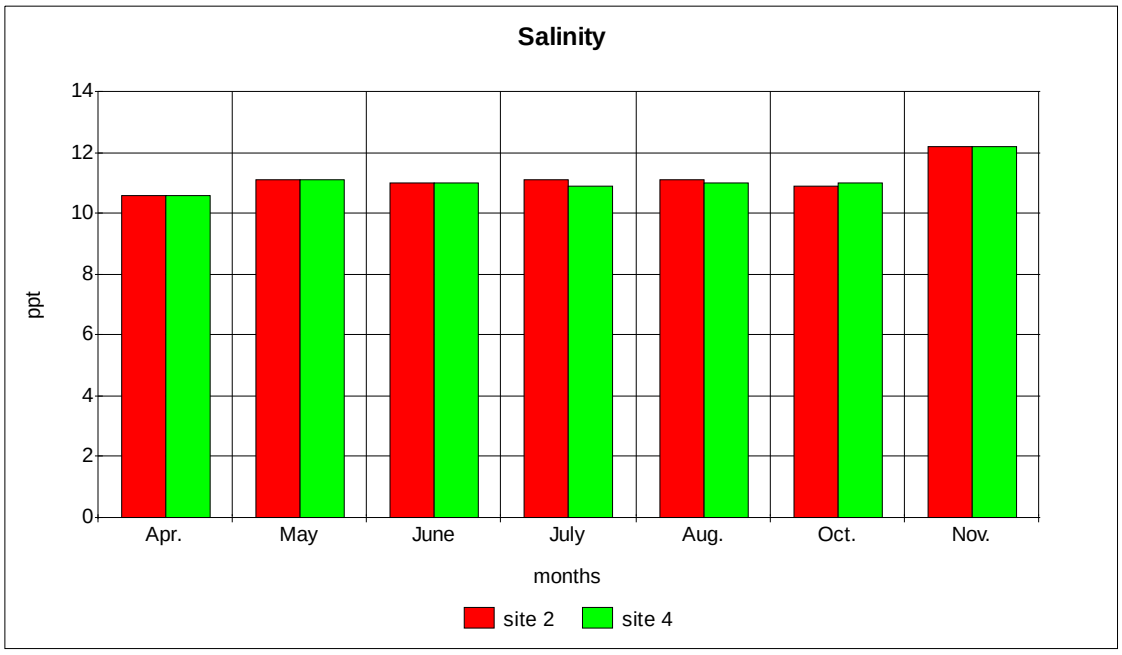


High water temperature 24C contributed to a winter flounder fish kill this year. Winter flounder can generally survive up to 25C. However, low dissolved oxygen episodes in addition to high ammonia may have caused the flounder's immune system to be compromised. In their weakened metabolic state, high water temperature may have contributed to their early death. Water temperature cooled slowly in the fall and reached low temperatures in early winter. December's cold air temperature should be enough to allow fall overturn, a complete gas exchange, to take place.

Salinity

The overall salinity in Sesachacha Pond ranged from 10.6 ppt to 12.2ppt, two parts per thousand less than last year. Salinity tended to be stable vertically and horizontally in the water column. Salinity increased by 0.5ppt as a result of the spring opening and 1.3ppt after the fall opening.

The salinity in Sesachacha has reached a concentration that no longer supports adult winter flounder. Although winter flounder eggs can survive in a salinity range of 10ppt to 30ppt, there will be no adults left to spawn in the pond. As a result of precipitation, poor pond openings, and groundwater infiltration, the pond can no longer support a variety of fish species. As the pond changes from saltwater to brackish, the biodiversity of fish will be reduced over time.

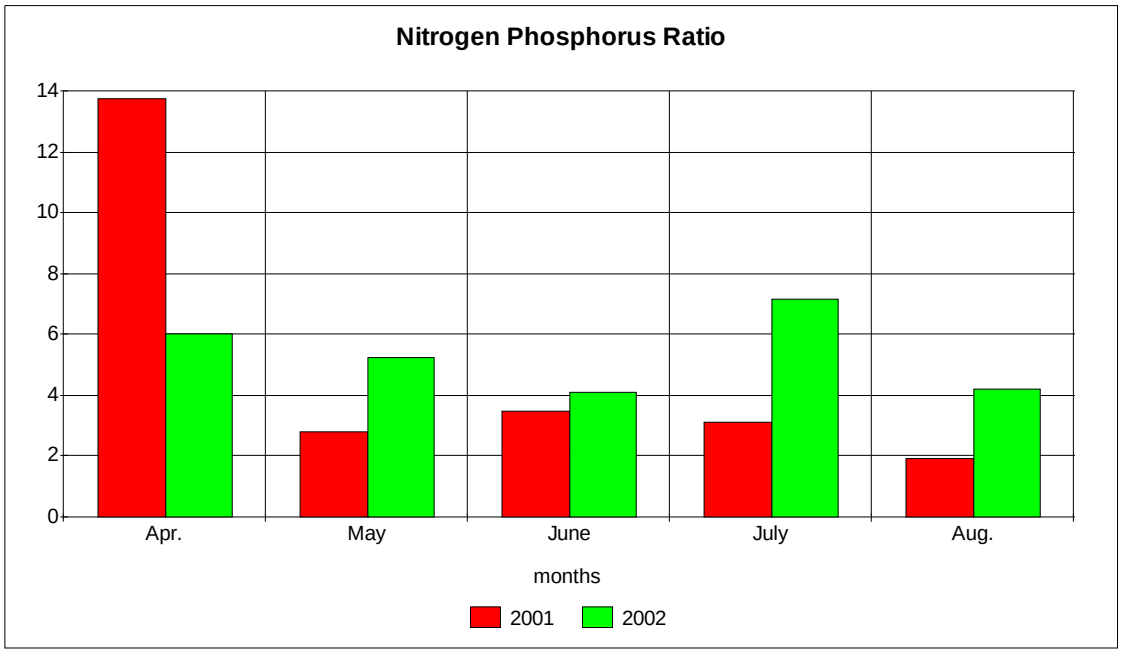


Nitrogen/Phosphorus Ratio

It is important to determine which nutrient may be in shortest supply in relation to the needs of plants (phytoplankton or rooted aquatic plants). For it is the relative abundance of this nutrient which will control or "limit" primary production in the water body. An increase in the amount of the limiting nutrient should result in a proportional amount of additional production, and vice versa. This limiting nutrient concept or "Law of the Minimum" is an important principle because it explains the response of a waterbody to increases in watershed pollution, but also indicates the priority of which elements should be reduce to effect a change in the pond conditions.

Nitrogen and phosphorus both provide the food source for phytoplankton growth. The ratio of nitrogen to phosphorus is necessary to determine which is the limited nutrient. Phytoplankton requires approximately 16 parts of nitrogen to 1 part of phosphorus to grow. Nitrogen is considered “limited” in Sesachacha Pond.

The concentration of nitrogen in the marine environment dictates phytoplankton production. However, an overabundance of either nutrient will result in a shift of phytoplankton species population.

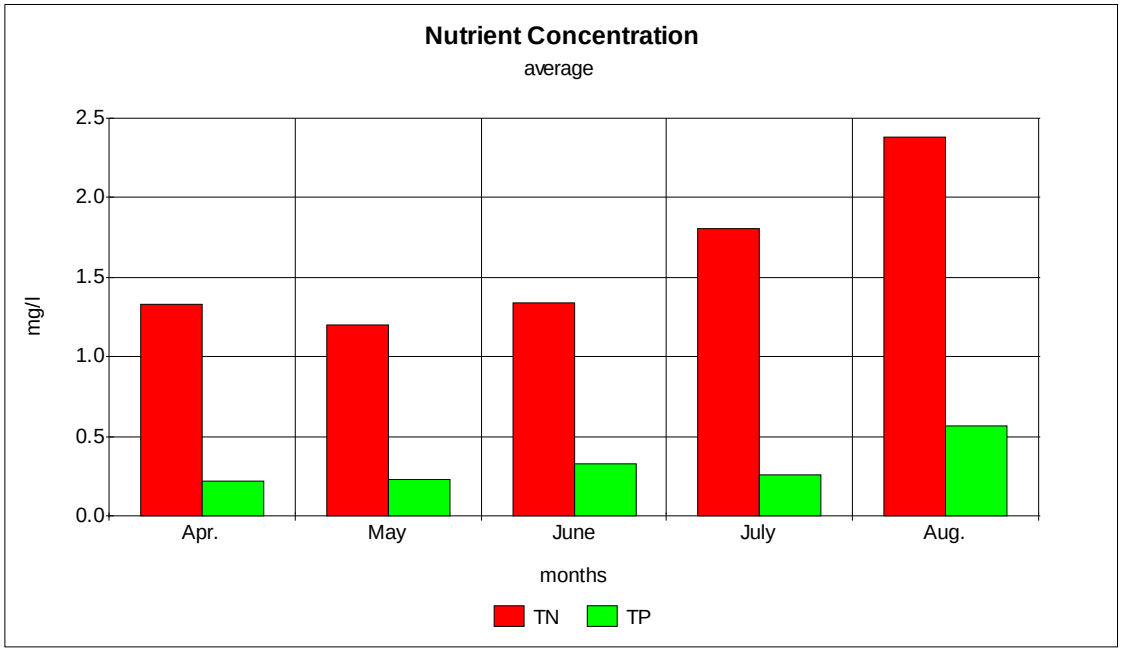


The nitrogen phosphorus ratio chart displays with the exception of April, nitrogen has increased since last year. Nitrogen, when limiting, controls the ability of phytoplankton to reproduce. As nitrogen increases so does the number of phytoplankton cells in the water column. Phytoplankton blooms cause fish kills. As nitrogen increases each year, as a result of poor openings, nitrogen may no longer be limiting in the future.

Nutrient ratios alone do not provide conclusive proof of limiting factors. Other considerations such as light, the movement of water, internal recycling or microbial processes are also reviewed. When reviewing these other possible factors of nutrient loading, Sesachacha Pond has severely degraded water quality conditions.

Nutrients

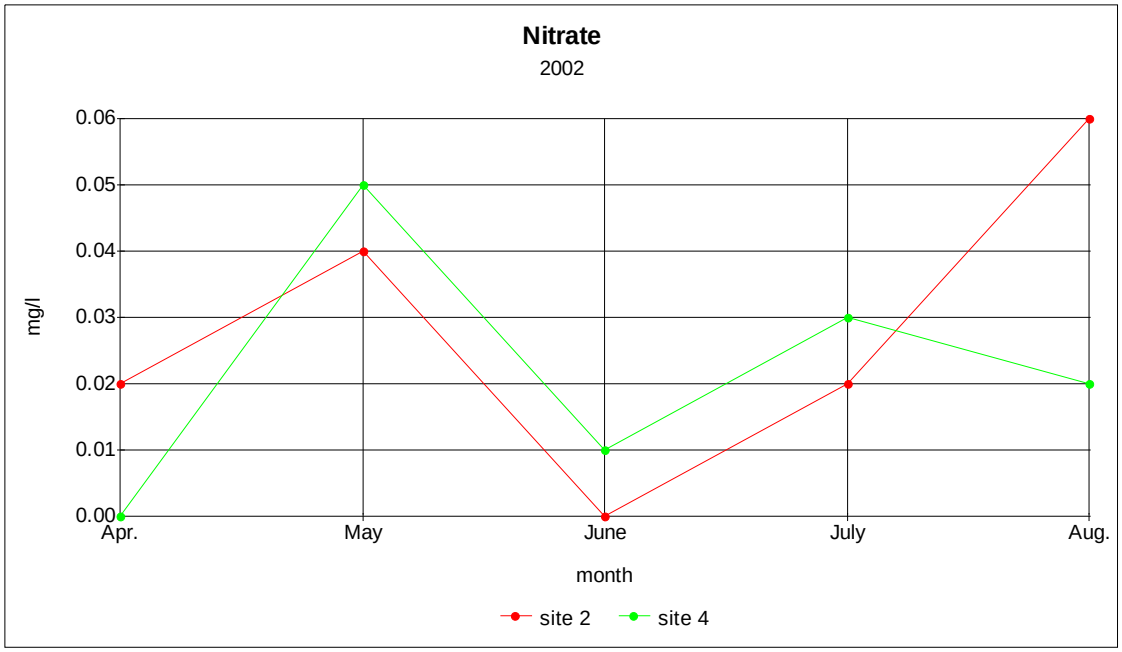
Total nitrogen levels recorded this year were high ranging from 1.2ppm to 2.38ppm. Total nitrogen concentrations, which exceed 0.7 mg/l, indicate enriched conditions. All sites had double the recommended concentration of nitrogen. Phosphorus levels exceeding 0.05 mg/l indicate enriched conditions. Sesachacha had higher than recommended phosphorus in August. Sesachacha Pond is a severely degraded ecosystem.

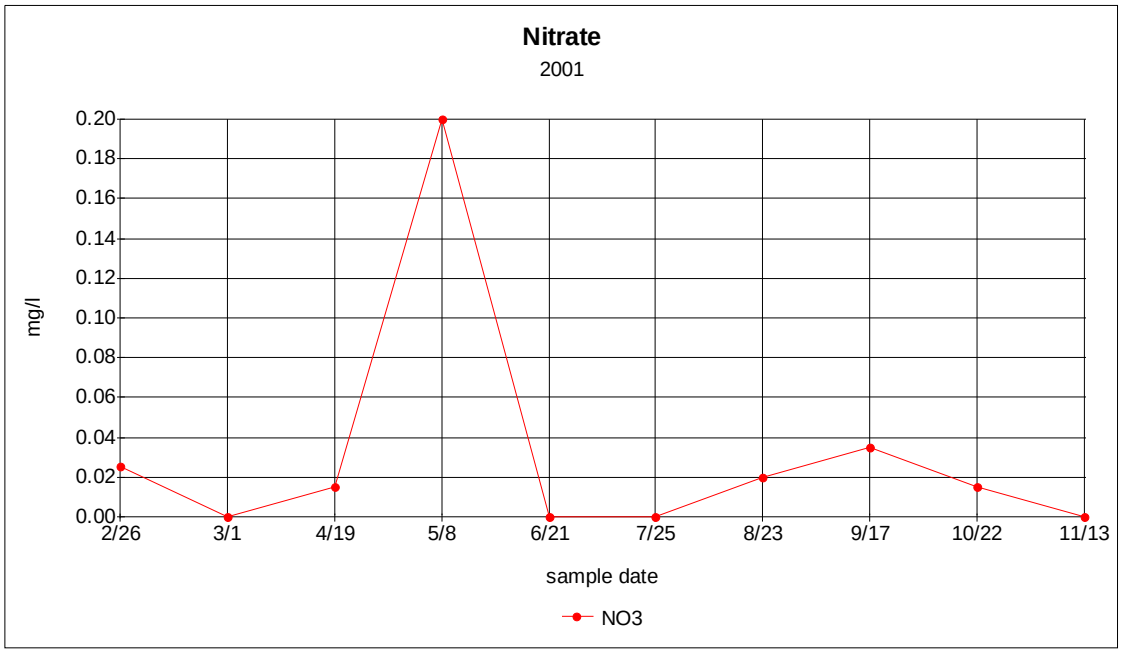


Nitrogen occurs in three major forms in aquatic systems (ammonia, nitrate and organic compounds). Nitrite is a fourth form; but due to its instability it exists for very short periods of time during the conversion between other forms. Nitrate and ammonia are readily available for uptakes by plants. Both forms can cause toxicity problems at high concentrations.

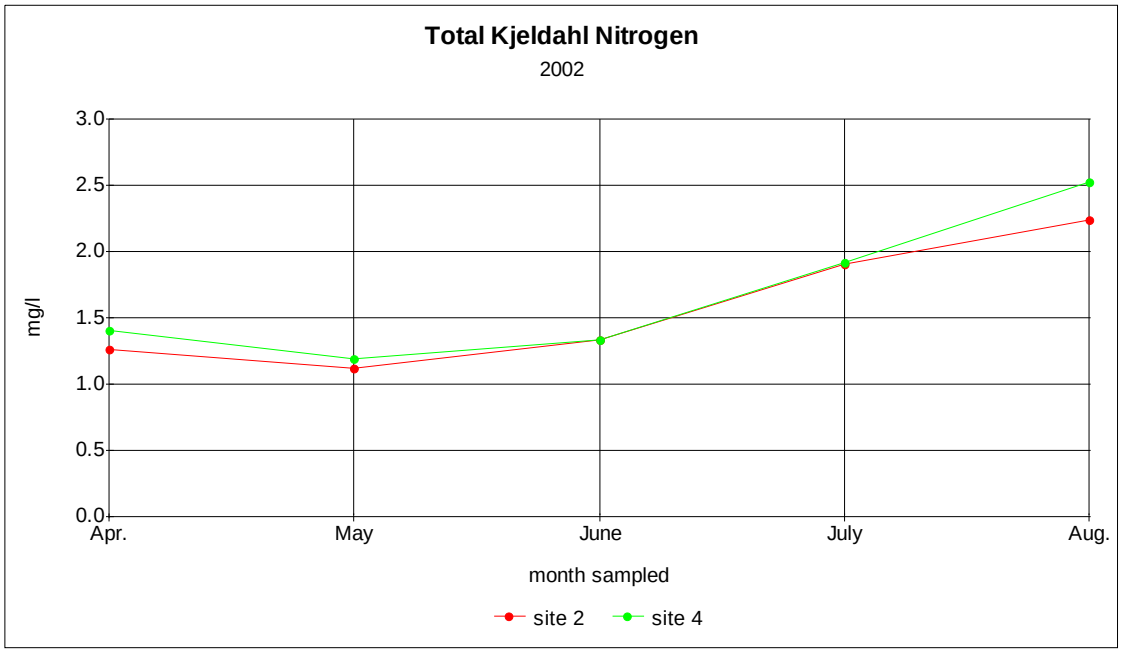
Nitrogen is limited in Sesachacha Pond and limits primary production of aquatic plants. As nitrate levels increase, phytoplankton, macroalgae (seaweed), epiphytes (plants that attach) reproduce. The greater the concentration of nitrogen in the water column, the more plants will grow. When these plants die, bacteria use dissolved oxygen from the water column to decompose the organic plant matter. This can result in ecosystem stress, due to oxygen depletion.

Nitrate concentrations increased in May after the pond opening. This may be due to nutrient rich groundwater filling the pond after the draining. Nitrogen is accumulating in Sesachacha Pond. Nitrogen concentration has tripled in the last two years. Every year the pond is not properly opening, nitrogen concentration may double again.





In June during both years, there is no detectable concentration of inorganic nitrogen or nitrate. Nitrate has been incorporated into plant material. The TKN chart below depicts organic nitrogen. Organic nitrogen increased throughout the summer months. November was not sampled for nutrients this year. However, the algal bloom observed at the pond in November would represent very low nitrate in the water column.



Secchi Depth

The average secchi depths were lower than last year. Secchi depth ranged from one to two feet. This is extremely low for Sesachacha Pond. Secchi depth is a general indication of available dissolved oxygen in the waterbody. There is generally enough dissolved oxygen for fish survival at three times the secchi depth. This means only half of the pond is suitable for fish habitat.