Executive Summary:

Lyngbya majuscula, a filamentous blue-green alga, became established in portions of King's Bay in the mid-1980s. It has since replaced hydrilla as the dominant plant in some areas of the bay. Lyngbya grows on the bottom of the bay, and also forms large floating mats. These surface mats have several negative effects: they impair navigation and recreational uses of the water body, and decay of the algae produces a foul, musty odor. Portions of these algal mats may wash up on banks and canals, further impairing the aesthetic quality of Kings Bay.

This project was initiated in March 1989 to find the causes of the Lyngbya infestation, and to identify possible management actions to control the growth and expansion of this alga in King's Bay. The first year of this three-year project was funded by a U.S. Environmental Protection Agency 205J Grant, administered by the Florida Department of Environmental Regulation (FDER). The remainder of the project is supported by the Southwest Florida Water Management District's Surface Water Improvement and Management (SWIM) Program, funded by the State of Florida, and administered by the FDER.

The project is comprised of three elements: 1) Southwest Florida Water Management District study of the water quality of Kings Bay/Crystal River and an estimate of the nutrient loading to Kings Bay; 2) population dynamics of Lyngbya in King's Bay/Crystal River and the response of Lyngbya to nutrient enrichment, study performed by Dr. Bruce Cowell, Department of Biology, University of South Florida; and 3) water motion and retention times in King's Bay, a study undertaken by the United States Geological Survey (USGS). The project is to be completed in March 1992. This report details the findings of project cooperators for the first year of the study, in fulfillment of 205J Grant requirements.

Water Quality

Increased loading of nitrogen and phosphorus due to development of the watershed is a suspected cause of infestations of hydrilla and Lyngbya in King's Bay. It has been well documented that the nutrients nitrogen and phosphorus most commonly limit the growth of aquatic macrophytes and algae in fresh water ecosystems (Hutchinson 1973, Dillon and Rigler 1974, Canfield 1983). There are four major sources of these nutrients entering King's Bay: 1) the springs discharge; 2) the city sewage treatment plant which discharges treated effluent into the northeast quarter of the bay; 3) stormwater runoff from residential and commercial developments, roads, and parking lots; and 4) leachate from septic tank systems and package plants in the vicinity of King's Bay.

Springs in King's Bay contribute a large proportion of the total nutrient loads of both total nitrogen and total phosphorus to King's Bay. However, King's Bay is tidally affected through its entire length, and is a flowing water system. Tidal cycle affects the residence time of water in canals and bays, the current velocity, direction, and patterns of water motion in the bay, as well as head differences between surficial groundwater and bay waters. Water motion and water retention times vary throughout the bay, which affects whether nutrients are flushed from, or accumulate in areas of King's Bay. Point discharges such as the sewage treatment plant, stormwater outfalls, and to some extent septic system leachate, most likely have their greatest potential for impacting water quality in the immediate areas of their discharge.

Treatment Plant is discharged into Cedar Cove, a small area (approximately 40 acres) of King's Bay. Mean concentrations of ortho-phosphate and total phosphorus were significantly greater in Cedar Cove than for other King's Bay stations. The highest mean concentrations of nitrate-nitrite were associated with stations in Cedar Cove and a larger area extending outside of Cedar Cove. It can be concluded that ambient concentrations of nitrate-nitrite, ortho-phosphate, and total phosphorus in the vicinity of Cedar Cove are impacted by the discharge from the city sewage treatment plant.

The network of canals in the City of Crystal River convey stormwater runoff directly into King's Bay. Water samples collected from the canals typically had higher concentrations of nitrogen and phosphorus than receiving waters. No direct evidence was found that suggested the canals had an impact on nutrient concentrations in King's Bay. However, no King's Bay water samples were collected during rainstorms, and regular sampling stations were not in the immediate areas of stormwater outfall. It is likely that the canals impact nutrient concentrations in the immediate areas of their outfall, particularly during periods of rainfall and in receiving waters that are not well-flushed.

Septic tank systems are poorly suited to waterfront developments built on King's Bay and adjoining canals, due to severe soil limitations for septic systems and the extremely shallow depth (< 5 feet) to tidally-influenced groundwater. Nitrate, and to a lesser extent ortho-phosphate from septic tank/package plant systems ultimately enter the bay, though nutrient contamination from these sources is more diffuse than point sources and may, therefore, be difficult to detect.

Factors Affecting the Growth of Lyngbya

Large benthic mats and surface mats of Lyngbya were observed in Cedar Cove, suggesting a relationship between the sewage treatment plant effluents and nuisance biomasses of Lyngbya. However, nutrient-Lyngbya relationships were not revealed by multiple regression methods (Dr. Bruce Cowell, Attachment A). Cowell found specific conductivity and the abundance of hydrilla accounted for 61.8 percent of the variability in the biomass of Lyngbya (dry weight) in King's Bay. Other variables only accounted for an additional 4 percent of the total variability of Lyngbya biomass. Hydrilla biomass (dry weight) in King's Bay was negatively related to total phosphorus and the presence of Lyngbya and other macrophytes. Lyngbya biomass and total phosphorus together explained 40.7 percent of the total variability of hydrilla biomass. The addition of other variables caused only small increases (1.1 to 2.9 percent) in the proportion of the variability explained by the respective models. Neither hydrilla biomass nor Lyngbya biomass seemed to be significantly affected by nutrient concentrations, with the exception of the negative relationship between hydrilla biomass and total phosphorus. Finally, Dr. Cowell suggested that changes in substrate composition and redox potential may inhibit the establishment and growth of more desirable aquatic macrophytes.

Water Motion and Retention Time

The U.S. Geological Survey have completed development of a preliminary model of King's Bay, and have collected much of the necessary data for calibrating a final model. Preliminary results estimate that particles take from 3 to 7 weeks to flush from King's Bay, depending upon the area in the bay where the particle is introduced. A preview of the preliminary model in May 1990 revealed that Cedar Cove may be somewhat isolated from the general flow of water out of the bay due to the action of currents and eddies which form at the mouth of the cove. This may result in greater flushing times, and the possible accumulation of nutrients in the cove. The model will be completed and a report issued in March 1992.

Management Considerations

Recommendations for the improvement of water quality in King's Bay include:

1) Diversion of the City of Crystal River Sewage Treatment Plant effluents from King's Bay. Overland spraying of effluent, if outside the immediate watershed, would reduce ambient concentrations of nutrients in Cedar Cove.
2) Disposal of treatment plant sludge outside of the immediate watershed. Sludge is currently stored in piles on the banks of the discharge canal. Nutrient-rich leachate from these piles on the banks of the discharge canal.
3) Appropriate pre-treatment of stormwater runoff would reduce nutrient and organic sediment loading to outfall areas in King's Bay.
4) Residences utilizing septic tank/package plant systems should be sewered to a regional facility. If this is not feasible, mounded drainfield systems might be utilized to ensure that adequate drainfield depth exists for the effective treatment of effluents. A regular program of inspection would ensure that systems are properly maintained and operating at optimum efficiency.

Dr. Cowell's recommendations for the management and restoration of Lyngbya-infested areas include:

1) Remove benthic Lyngbya mats.
2) Prevent the influx of rafting Lyngbya mats.
3) Hydraulic dredging of sediments, and planting of new macrophytes. An investigation of Crystal River sediment, funded by the District's SWIM Program is currently underway to document the extent of this problem, and identify areas in King's Bay which have been adversely impacted by increased sediment loading.