REPORT ON THE LAKE GEORGE INSHORE CHEMICAL MONITORING PROGRAM

Submitted to

The Lake George Association Fund

by

Lawrence W. Eichler, Research Scientist

Timothy B. Clear, Research Assistant

&

Dr. Charles W. Boylen, Director

Rensselaer Fresh Water Institute
Rensselaer Polytechnic Institute
Troy, New York 12180-3590

February, 1992

RFWI 92-2

REPORT ON THE LAKE GEORGE

INSHORE CHEMICAL MONITORING PROGRAM

Submitted to

The Lake George Association Fund

by

Lawrence W. Eichler, Research Scientist

Timothy B. Clear, Research Assistant

&

Dr. Charles W. Boylen, Director

Rensselaer Fresh Water Institute
Rensselaer Polytechnic Institute
Troy, New York 12180-3590

February, 1992

RFWI # 92-2

TABLE OF CONTENTS

Executive Summary

The Inshore Chemical Monitoring Program was instituted in 1986. The goals of this program are to evaluate near-shore water quality and quantify the effects of various land uses on near-shore water chemistry. Sampling locations were selected to be representative of predominant land uses within the basin; including areas with high residential population density, high density commercial use, marina operations, and little or no human impact (undeveloped). Completion of analysis of this years samples and this report represents the sixth year of the Inshore Chemical Monitoring Program.

Results from this program have shown that inshore waters have higher levels of phosphorus than mid-lake sites. Soluble silica concentrations were less at inshore sites while other nutrient levels (nitrogenous compounds) and chlorides were generally comparable to offshore levels.

Comparison of inshore sites shows that undeveloped areas continually have lower total phosphorus concentrations in near shore waters, while developed land use areas show higher levels. At sites with some level of development (residential, commercial and marina), phosphorus levels varied, with concentrations not significantly different between the development activities monitored. Nitrogen containing compounds, namely nitrate and ammonia, varied in concentration across all types of sites with little discernable relationship to shoreline levels of development. Total suspended solids measurements varied greatly between sampling times and no consistent influx of particulates from any of the sites was observed by fixed time interval sampling. Chloride levels were also similar among land use types in 1991, but an overall increase over the past five years has been detected. This increase coincides with data obtained from the Offshore Program showing that increases in lakewide chloride concentrations are occurring.

One of the primary concerns of this continuing study is to compare the impacts of the lakeshore development, whether forested or developed to some degree. This study design has shown that concentrations of nutrients (primarily phosphorus containing compounds) of undeveloped areas have consistently been lower than more developed areas. Only undeveloped sites provide a comparatively complete forested shoreline. The forest cover and the permeable soils underneath provide protection from stormwater runoff and disturbance from incident precipitation. Water that does collect is allowed to infiltrate the soils where adsorption and bacterial activity remove nutrients before runoff waters enter the lake. The forest cover decreases the effect precipitation has on loosening soil and allowing it to move into the lake (erosion). This type of shoreline cover also acts to secure soil at the water's edge to prevent shoreline erosion. Maintenance of a vegetative cover at the lakeshore is critical to reducing erosion and nutrient additions from runoff waters.

INTRODUCTION

This report marks the conclusion of the sixth year of the Lake George Inshore Chemical Monitoring Program. This program's initial, and continuing, purpose is to compare terrestrial impacts on nearshore water quality from various types of land uses found within the Lake George Basin. Four types of common land uses were identified and monitored in this study. These types included marina operations, high usage commercial areas, high density residential areas, and undeveloped shorelines. Samples were collected in close proximity to the shoreline (shallow waters) in order to reduce the effects of dilution and to better quantify the terrestrial effects on water quality.

Since the start of this program (1986), nearshore waters have consistently shown higher concentrations of essential nutrients for algal and macrophyte growth (nitrogen and phosphorus) than found at open water sites (Eichler, Clear and Boylen; 1989; 1990). The established sites in the Bolton Bay area have shown that the unimpacted or largely undeveloped areas have the lowest concentration of nutrients and contaminants when compared to nearshore waters of developed shorelines (Eichler, Clear and Boylen; 1989a; 1990a). Elevated nutrient concentrations associated with certain shoreline types have been attributed to resuspension of shallow sediments due to heavy recreational usage, the inflow of applied yard care products such as fertilizers, and inputs from faulty or overloaded septic systems. Other possible inputs include terrestrial runoff of highway deicing materials and other pollutants associated with motor vehicles. Petroleum and corrosion products are deposited on road surfaces and become incorporated into stormwater runoff which, if not allowed to infiltrate the soil, eventually enter the lake.

In 1990, for the first time, the Inshore Program used an event-based sampling design in order to determine terrestrial inputs at times of increased runoff associated with rainfall. Although this sampling design provided information about increased short-term chemical inputs, it proved to be time and cost prohibitive. The timing and scheduling around events, and manpower restraints did not allow for the continuation of event-based sampling beyond 1990. The 1991 Program returned to a fixed-time sampling regime as used in previous years. This sampling design provides quantification of the ambient concentrations of chemical constituents over the course of the sampling period. The fixed time sampling method allows for a more comprehensive view of the changes in nearshore water chemistry as compared to the open water conditions.

In addition to a return to fixed-time interval sampling, other cost containment measures were implemented in order to provide the maximum amount of information while remaining on budget. Total filterable phosphorus, pH, and specific conductance analyses were discontinued in 1991 since results from previous years' programs showed that these analyses provided the least information of those measurements included in the program.

METHODS

The sites chosen sampled during the 1991 Inshore Program remained the same as those chosen in 1987; selected to be representative of various types of shoreline usage found within the Lake George basin. The four land use types identified here include:

* marina operations,
* areas of high commercial usage,
* high density residential areas, and
* those lands that appear to have very low human impact (i.e. undeveloped, forested shoreline).

Table 1 gives a listing and brief description of each site. Figure 1 is a map of the sample area pinpointing specific sampling locations.

Sampling for the 1991 Inshore Program was conducted bi-weekly beginning June 8 and continuing through September 26. A total of eight sampling events were carried out during this period of summer thermal stratification. At each site, grab samples were collected at a point out from the shoreline where water depth first reached 0.5 meters. Samples were analyzed for:

* total phosphorus,
* orthophosphorus,
* nitrate,
* ammonia,
* chloride,
* silica, and
* chlorophyll _a_.

Sample preparation and analytical techniques have been discussed at length in previous reports (Eichler and Boylen, 1986). A list of analytical techniques used for this study is included as Appendix A.

Table 1. Sampling Site Names and Locations. All sites are located in the Town of Bolton.

Site Name	Type	Location
Bolton Landing	C,HD MARINA	West shore of Bolton Bay, 250 meters south of the Green Island Bridge. Adjacent to a marina operation with high density commercial uses.
Sweetbriar Bay	C, HD MARINA	West shore of the bay on the property line of a marina and a restaurant. Moderate sized paved areas drain into the lake in this area.
East Huddle Bay	R, HD	East shore of Huddle Bay, 200 meters north of the southeast corner of the bay. A vegetated zone (lawn and trees) is maintained along the shoreline.
Stewart Brook	R, HD	West shore of Bolton Bay, 150 meters south of the Town of Bolton Pier. An area of moderate to high density residential development.
West Huddle Bay	C, MD	West shore of Huddle Bay, 50 meters north of the mouth of Huddle Bay Brook. Moderate commercial (motels) and residential use.
West Bolton Bay	C, MD	West shore of Bolton Bay, in a small bay with moderate commercial use (motels). A shallow slope with large lawn and paved areas.
Green Island	U	West shore of Green Island approximately 100 meters north of the DEC facility. This section of the island has a maintained trail system but no habitation.
Clay Island	U, LD	Northwest tip of the island. Relatively undisturbed land with a flat slope and no vehicular traffic or pavement.

R = Residential; C = Commercial; U = Undeveloped; HD = High Density; MD = Moderate Density; LD = Low Density.

RESULTS AND DISCUSSION

Precipitation data, both daily and cumulative over the course of the sampling period, and in relation to times of sampling, is given in Figure 2. This precipitation data was collected at the Bolton Landing RFWI site and cross-referenced with NOAA data collected at the Warren County Airport (NOAA, 1991). The months of June and July received less than normal amounts of precipitation, -1.81 and -0.43 inches respectively. On the other hand, August (+0.55), and September (+0.46) both received above average amounts of precipitation. The September 26th sampling followed a day of 1.49 inches of precipitation. The June 18th sampling followed precipitation on the 15th and 16th, both of which received approximately 0.50 inches. All other samples were collected at least three days following any precipitation event. No sampling event occurred on a day receiving precipitation.

There were large variations among the total phosphorus (TP) averages, for the summer, within and also among the land use types. Figure 3 gives the total phosphorus averages by land use type. The two undeveloped sites had the lowest average TP (4.6 ug P/L) of any land use type. The three other land use types showed little similarity within each group; for example, among commercial sites average TP at W. Bolton Bay was 4.8 ug P/L, while the TP concentration at W. Huddle Bay was 7.9 ug P/L. It was also W. Huddle Bay that had the greatest average TP. The highest single TP measurement was found at Sweetbriar Bay (11 ug P/L) in early July.

The fact that the least developed or impacted areas show the lowest concentration in total phosphorus in the nearshore waters is not unexpected. Previous years' data from this program have consistently shown this to be true (Eichler, Clear & Boylen, 1989, 1990). Figure 4 shows the average TP concentrations for each land use designation for the past five years. The undeveloped areas have always shown the lowest average TP while the other three land use designations have varied in relative level of TP concentration. Figure 5 shows the average TP for all Inshore sites from the period of 1987-1989 and 1990, while Figure 6 shows the average TP concentrations for each land use designation over the same time period. These composite graphs omit the 1990 data because the sampling design for 1990 was rainfall event-based while for all other years, it was fixed time interval. The comparison of data from studies of this nature with varying methodologies is not considered prudent in this context. In the case of both Figures (5 & 6), the undeveloped sites showed the lowest TP for all sites and all land use designations. This trend over the past five years is most likely due to the characteristics of the drainage areas at each site. The relatively undisturbed vegetative cover of shoreline adjacent to undeveloped sites restricts direct runoff entering the lake, mainly due to the forest cover and the lack of impermeable surfaces along the shoreline. This prevents or at least slows direct input of terrestrial debris, whether phosphorus containing or not, from entering the lake.

Figure 5 shows that the W. Huddle Bay site had the highest average TP of all sites for the time period of 1987-1989 and 1991 with a concentration of 7.9 ug/l. This site in particular may consistently have high TP, as well as other nutrients and chemical constituents, because of a number of factors. Firstly, its position near the outlet of Huddle Bay Brook may reflect, in part, the chemistry of the stream. The boat slip where the sample point is located collects floating debris from the lake, accounting for increased TP concentrations as a result of decay products and/or leaching from organic matter.

Orthophosphate (OP) concentrations appeared to be relatively stable over the course of the sampling period, with no single sample exceeding 3 ug P/L. W. Huddle Bay showed the highest average OP concentration of 2.1 ug P/L (also the greatest average TP 7.9 ug P/L). All other sites showed average OP concentrations below 2.0 ug P/L. There was no discernable trend concerning orthophosphate between land use types.

Chloride concentration averages over the course of sampling showed nominal variation and remained within the range of 8 to 10 mg/L (Figure 7). Chloride concentrations at inshore sampling sites were similar to mid-lake concentrations found throughout the southern basin of Lake George (Eichler, Clear and Boylen, 1991; 1990). The sample with the highest concentration of chloride (10.4 mg/L) was obtained at a marina site, Sweetbriar Bay, that also had the highest average chloride concentration of 9.2 mg/L.

The relatively narrow range of chloride concentrations found in this study is typical of inshore areas in Lake George. Nearshore waters sampled as a part of the Offshore Monitoring Program (Eichler, Clear and Boylen, 1991) show a substantial increase in chloride levels in the Spring, presumably from snowmelt and the salts applied on area roads for deicing purposes. During the early summer (June) chloride levels decrease then stabilize as summer progresses (July and August); this appears to be the part of the cycle observed during the months of June to September. The 1990 Inshore Program, with its rainfall event-based sampling design, showed that changes of 1.0 mg Cl/L can occur around Summer and Fall storm events, but that concentrations decrease to pre-storm levels soon after precipitation stops (Eichler, Clear and Boylen, 1991a).

Figure 8 gives the average chloride concentrations for the four land use designations. Chloride concentrations have increased steadily in the nearshore water from 1987 to 1991. This observation is consistent with recent findings in the Offshore Monitoring Program showing a general lakewide increase in the concentrations of chloride (Eichler, Clear and Boylen, 1990). Large amounts of highway deicing materials applied during the winter months are mainly chloride containing and thus the lake receives large inputs during times of runoff. These inputs on a yearly basis most likely account for the year to year accumulation of chloride in the nearshore waters, and thus the entire lake. Increasing chloride concentrations have been related to the conservative characteristics of this ion. Chloride is highly water soluble and is present in the water column in concentrations greatly exceeding the needs of primary producers. Thus chlorides which are added to the lake system are not readily removed by aquatic organisms and only leave the system through discharge of lake waters at the outlet.

Average ammonia (NH_4) concentrations for all sites are given in Figure 9. The two marina sites showed the highest average ammonia concentrations with 0.04 mg N/L. Commercial sites and residential sites showed concentrations of 0.01 and 0.02 mg N/L respectively. The undisturbed shoreline sites had varying average amounts of ammonia present where Clay Island showed 0.03 mg N/L and Green Island showed 0.01 mg N/L.

The last sample collection, September 26, showed a substantial increase in ammonia concentrations at four of the eight sampling locations. It was this collection that immediately followed the single largest precipitation event of the summer, 1.49 inches. The two marina sites, one residential (J) , and one undisturbed (M) site each showed an increase in ammonia of 10-20 times the average concentration of the previous seven samples. The average of the previous seven samples at each of these sites was less than 0.02 mg N/L. Sources of ammonia in runoff include human and animal wastes and precipitation. Attributing the cause of the observed ammonia increases to only one of these sources would be highly speculative and beyond the scope of currently available data.

Nitrate (NO_3) levels were determined for all sites and results showed that the average concentrations were at or below the laboratory detection limit of 0.01 mg N/L. No single sample exceeded 0.03 mg N/L, and only 3 of the 64 samples analysed in this program showed concentrations this high.

Average soluble silica concentrations are given in Figure

10. The commercial site West Huddle Bay had the highest average silica levels of all sites, 0.85 mg Si/L. All other sites showed levels between 0.6 and 0.7 mg Si/L with little variation.

Figure 11 gives the average soluble silica concentration for each of the land use designations from 1987 to 1991. The silica levels have varied at these sites from year to year and do not show either an increasing or decreasing trend. Average levels have remained less than 1.0 mg Si/L at these sites, and evidence of significant loading or recycling of silica in the nearshore waters involved in this study is limited.

Figure 12 shows the average total suspended solids (TSS) detected at each land use type for each sampling time. Great variation occurred between land use types over the sampling dates. The was no distinction between areas of high or low TSS. The overall averages for each land use designation showed essentially identical values. Marina and Residential sites had a mean TSS of 1.1 mg/L, while Commercial and Undeveloped areas had a mean of 1.2 mg/L. The site with the greatest mean TSS was W. Huddle Bay (1.5 mg/L), and Stewart Brook recorded the lowest average TSS of 0.7 mg/L. Particulate matter suspended in the water column can originate from a number of sources, including both aquatic and terrestrial. Aquatic sources of particulates can be attributed to resuspension of sediments, planktonic organisms, aquatic plant fragments, or decaying organic matter among others. Terrestrial sources include either water or wind driven soil, plant products or other debris.

Results from this study indicate there is no consistent influx of particulate matter from any of the sampling sites, given the highly variable results from each site over the course of the study. The sample collection that immediately followed a large storm event (September 26) showed no substantial increase in TSS. When high levels of TSS were found, precipitation appeared not to be a factor since many days had elapsed since the last storm event.

Substantial variation in chlorophyll a concentrations, the prominent energy fixing pigment in most green algae, occurred among the sites as well as among land use types. The maximum average concentration of chlorophyll a was 1.27 ug/L at the residential site E. Huddle Bay. The minimum was found at Green Island (0.69 ug/L), an area of undeveloped shoreline. Average chlorophyll a concentrations for each land use type from 1987 to 1991 are given in Figure 13. Levels of chlorophyll a have remained moderate since the origin of this study. All concentrations have remained less than 2.0

ug/l, a level consistent with other nearshore areas within the Lake George basin (Eichler, Clear & Boylen, 1991).

In addition to 1991 data, this report contains compilations of information gathered over the past five years, the period over which identical sites have been used for the Inshore Chemical Monitoring Program. This composite data shows that some consistent variation exists between certain sites that may be a part of similar land use designation. Significantly, no two sites will behave in exactly the same manner, thus analysis of composite data that distinguishes trends and aids in the possible explanation of these trends.

One of the primary concerns of this continuing study is to compare the impacts of the lakeshore development, whether forested or developed to some degree. This study design has shown that concentrations of nutrients (primarily phosphorus containing compounds) of undeveloped areas have consistently been lower than more developed areas. Only undeveloped sites provide a comparatively complete forested shoreline. The forest cover and the permeable soils underneath provide protection from stormwater runoff and disturbance from incident precipitation. Water that does collect is allowed to infiltrate the soils where adsorption and bacterial activity remove nutrients before runoff waters enter the lake. The forest cover decreases the effect precipitation has on loosening soil and allowing it to move into the lake (erosion). This type of shoreline cover also acts to secure soil at the water's edge to prevent shoreline erosion. Maintenance of a vegetative cover at the lakeshore is critical to reducing erosion and nutrient additions from runoff waters.

Given the extent of existing development in the Lake George basin, stormwater management practices utilizing both natural and "man-made" detainment and infiltration structures are necessary. The preservation or construction of natural stormwater management zones, i.e. a "greenbelt"; is now being practiced on a national scale for the protection of large and small waterways including rivers and lakes. Education of property owners regarding the advantages of maintaining a vegetated shoreline and best management practices for doing so should be a priority. In the Lake George basin, stormwater management plans and structures are required by law for all new construction. Studies are currently underway to determine the feasibility and applicability of retrofitting existing construction within the Lake George basin with stormwater management devices. Local and regional support for these efforts should be encouraged.

ACKNOWLEDGMENTS

We wish to again thank the Lake George Association Fund for its financial support which makes the continuing study of the chemical water quality of Lake George possible. Thanks also go to the Lake George Association, its office staff, members and leadership for their support of our efforts to monitor and study Lake George.

David Neils, Robert Bombard, and Adolf Eiling aided in the data collection and analysis. Dr. Charles W. Boylen, Director of the RFWI does, of course, have ultimate responsibility for the monitoring program and this report.

REFERENCES

Eichler, L.W. and C.W. Boylen. 1986. Final report on the Lake George chemical monitoring program. (April 1985 - December 1985). Fresh Water Institute Technical Report No. 86-4, Rensselaer Fresh Water Institute, Rensselaer Polytechnic Institute, Troy, NY.

Eichler, L.W., T.B. Clear and C.W. Boylen. 1989. Report on the Lake George chemical monitoring program. January 1988 - November 1988. Fresh Water Institute Technical Report No. 89-3, Rensselaer Fresh Water Institute, Rensselaer Polytechnic Institute, Troy, NY.

Eichler, L.W., T.B. Clear and C.W. Boylen. 1989a. The Lake George inshore chemical monitoring program. Fresh Water Institute Technical Report No. 89-4, Rensselaer Fresh Water Institute, Rensselaer Polytechnic Institute, Troy, NY.

Eichler, L.W., T.B. Clear and C.W. Boylen. 1990. The Lake George inshore chemical monitoring program. Fresh Water Institute Technical Report No. 90-3, Rensselaer Fresh Water Institute, Rensselaer Polytechnic Institute, Troy, NY.

Eichler, L.W., T.B. Clear and C.W. Boylen. 1990. Report on the Lake George chemical monitoring program. January 1989 - November 1989. Fresh Water Institute Technical Report No. 90-2, Rensselaer Fresh Water Institute, Rensselaer Polytechnic Institute, Troy, NY.

Eichler, L.W., T.B. Clear and C.W. Boylen. 1991. Report on the Lake George chemical monitoring program. January 1990 - November 1990. Fresh Water Institute Technical Report No. 91-2, Rensselaer Fresh Water Institute, Rensselaer Polytechnic Institute, Troy, NY.

Eichler, L.W., T.B. Clear and C.W. Boylen. 1991a. Report on the Lake George inshore chemical monitoring program, June - October, 1990. Fresh Water Institute, Technical Report No. 91-5, Rensselaer Fresh Water Institute, Rensselaer Polytechnic Institute, Troy, NY.

NOAA. 1991. Glens Falls FFA data reported in Climatological Data, New York Monthly Summaries. National Oceanic and Atmospheric Administration. National Climatic Data Center. Ashville, North Carolina.

APPENDIX A. ANALYTICAL METHODS

Analyte	Method	Instrument
Chloride	Ion Chromatograph (EPA Method 300)	Dionex QIC
Nitrate	Ion Chromatograph (EPA Method 300)	Dionex QIC
Ammonia	Automated Phenate (EPA Method 350.1)	Technicon Autoanalyzer II
Total Phosphorus	Colorimetric (EPA Method 365.2)	Bausch & Lomb Spec 710
Ortho Phosphorus	Colorimetric (EPA Method 365.2)	Bausch & Lomb Spec 710
Soluble Reactive Silica	Automated Molybdate (Technicon Method)	Technicon Autoanalyser II
Chlorophyll *a*	Methanol Extraction	Bausch & Lomb Spec 710

APPENDIX B. **FIGURES**

Below is a list of site code designations used for the sites in this study; these codes are used in the following figures.

Site Name	Land Use Type	Code
Sweetbriar Bay	Marina	O
Bolton Landing	Marina	B
West Huddle Bay	Commercial	I
West Bolton Bay	Commercial	E
East Huddle Bay.....	Residential	J
Stewart Brook	Residential	P
Clay Island	Undeveloped	M
Green Island	Undeveloped	N

Figure 1. Map detailing shoreline and locating Inshore sampling sites.

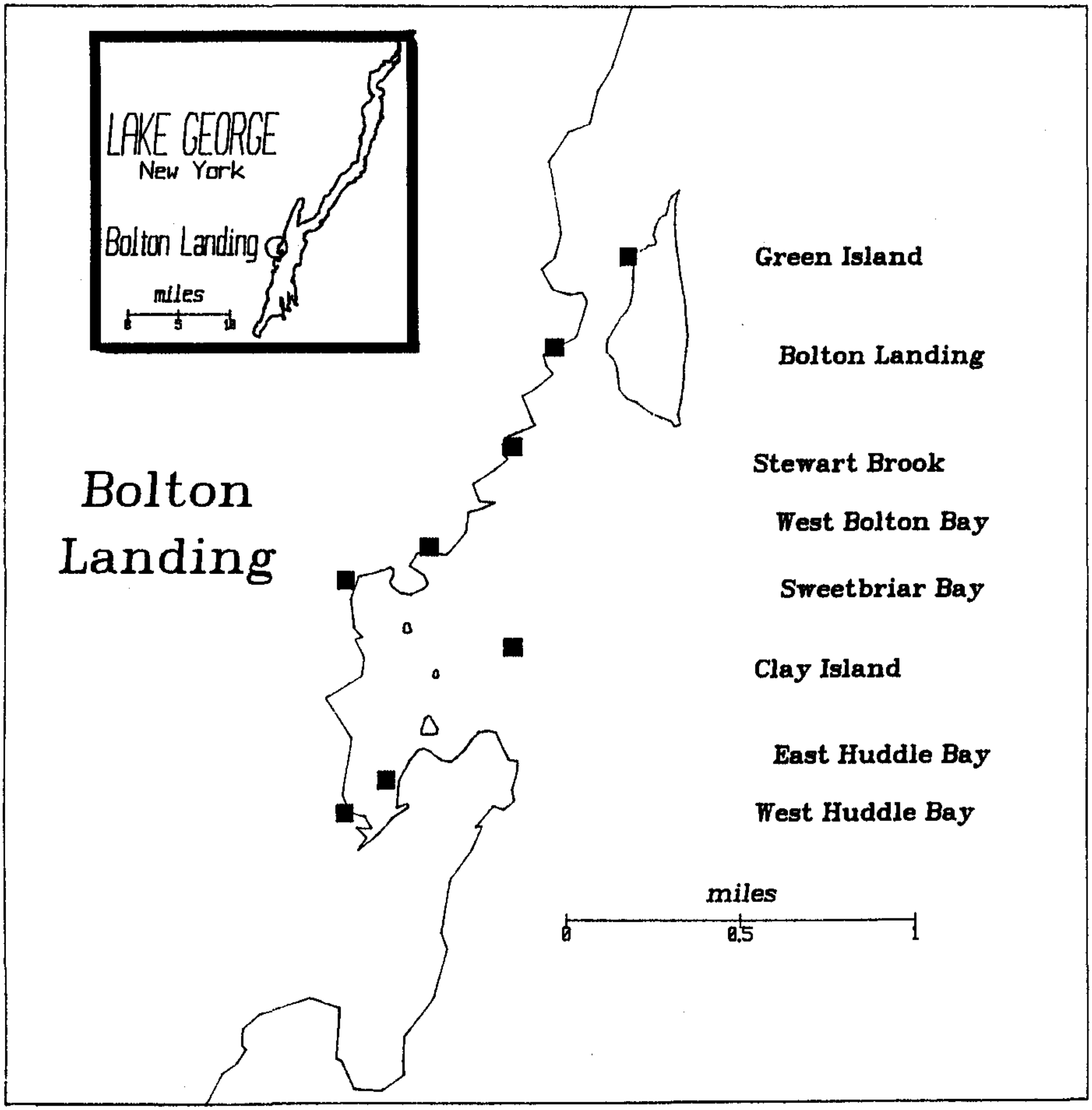
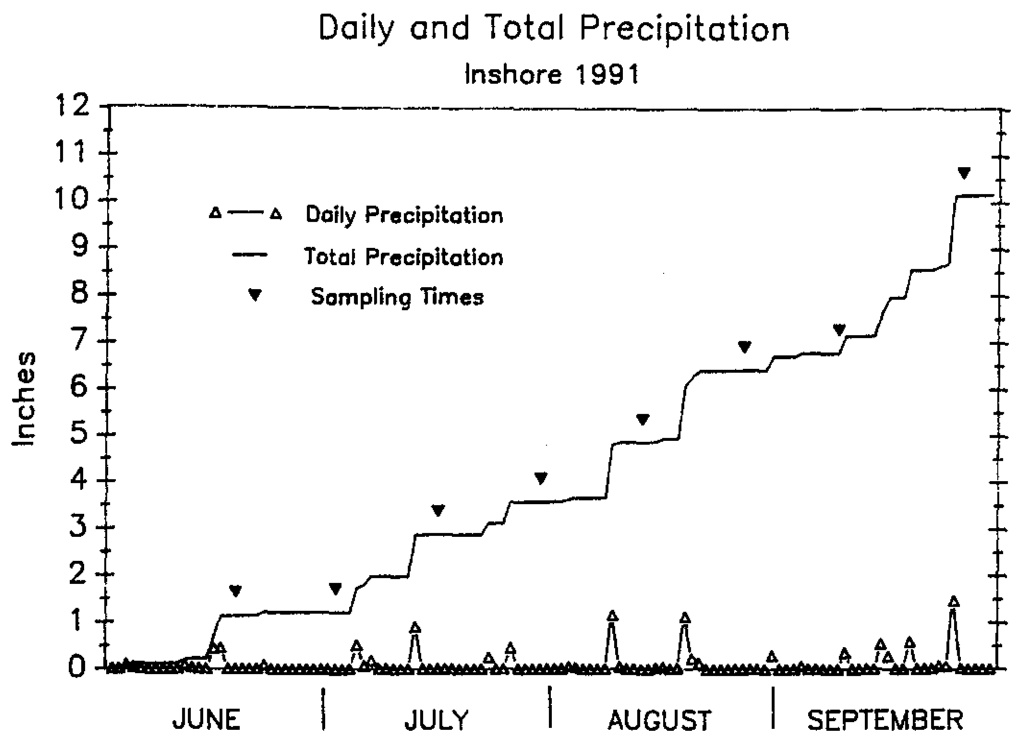


Figure 2. Daily and accumulative precipitation at the RFWI Bolton Landing facility.



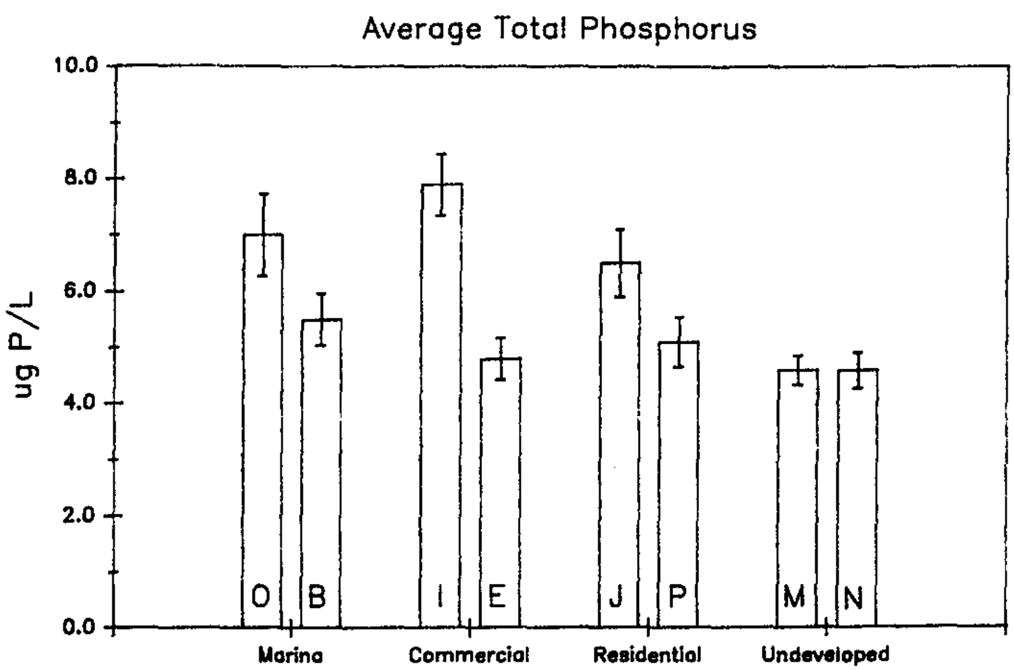


Figure 3. Average Total Phosphorus concentrations for all Inshore sites for 1991. Error bars are standard error of the mean (n=8).

Figure 4. Average Total Phosphorus concentrations for each land use type for each year from 1987 through 1991.

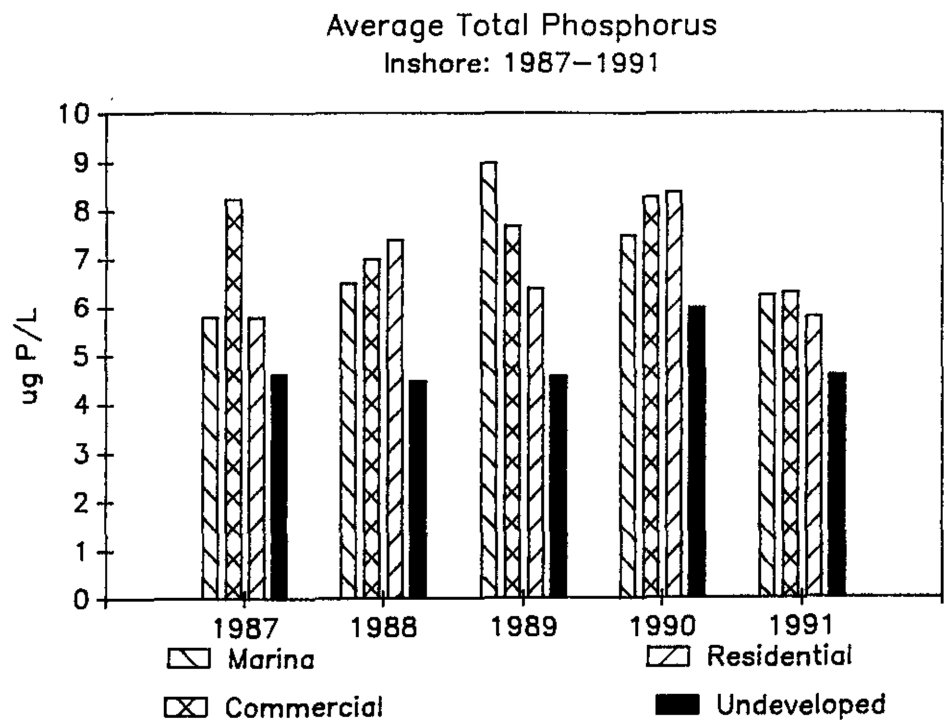
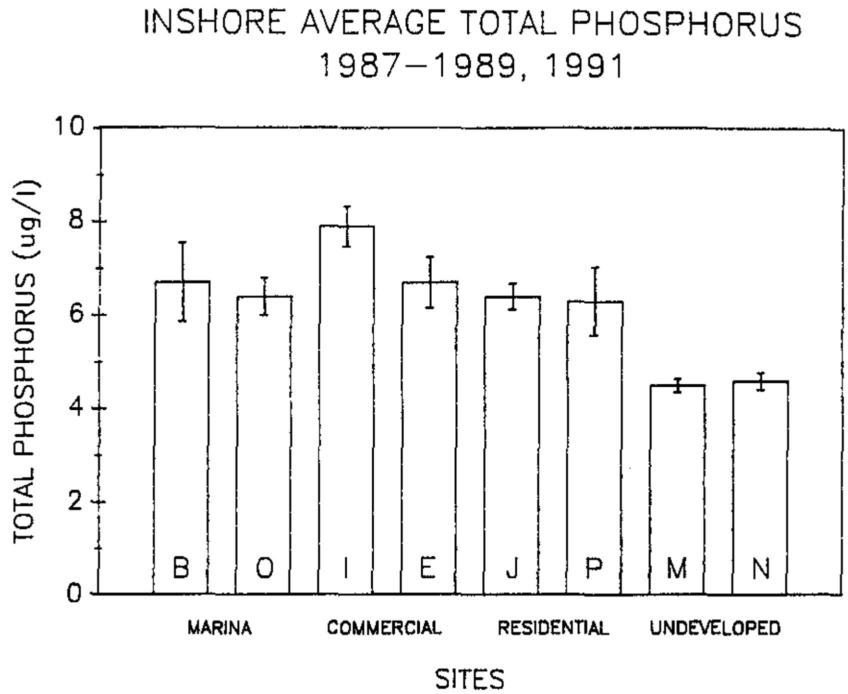


Figure 5. Average Total Phosphorus concentrations by site for 1987-1989 and 1991. Error bars are standard error of the mean (n=8).



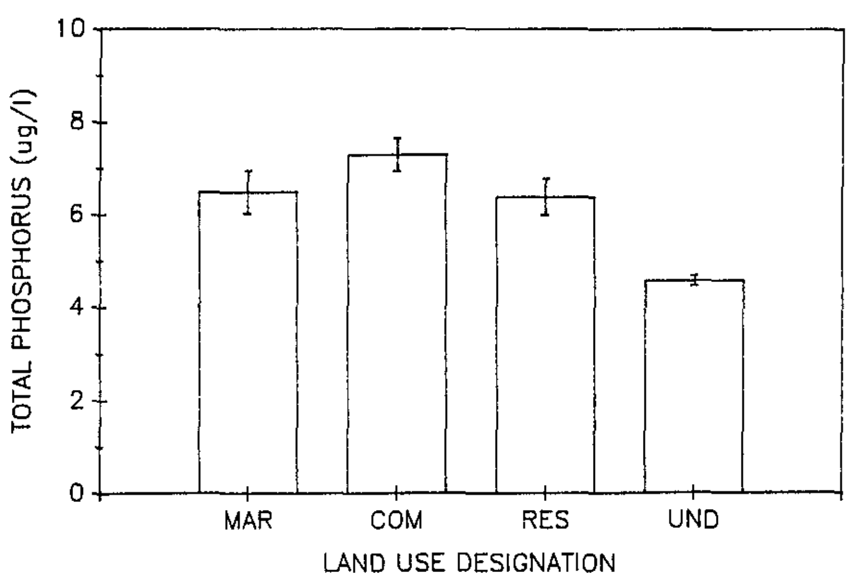
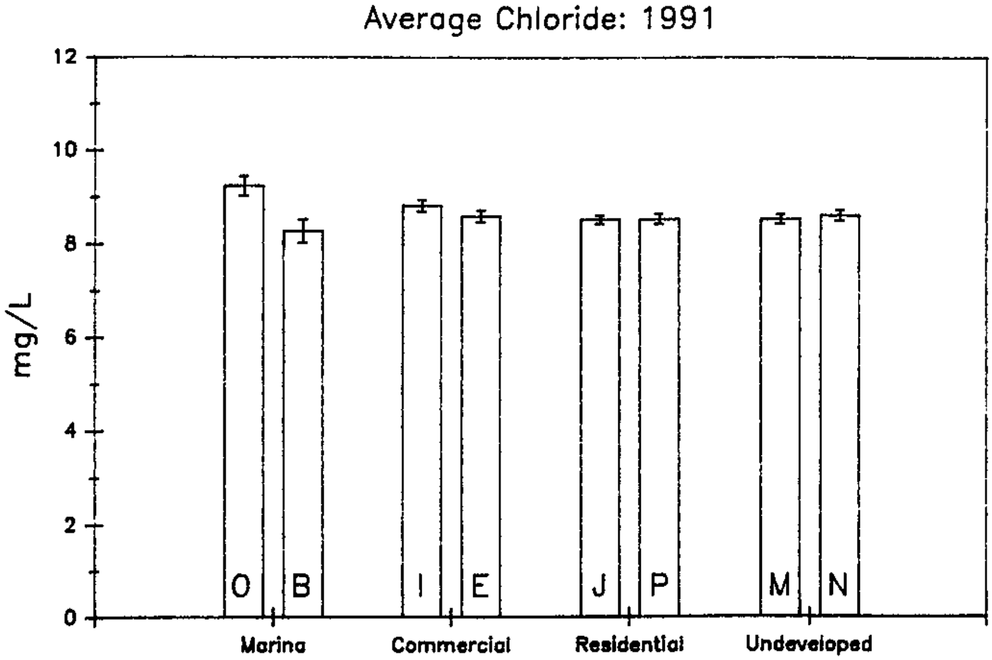


Figure 6. Average Total Phosphorus concentrations by land use designation. Data presented includes 1987, 1988, 1989 and 1991 sample results. Error bars are standard error of the mean (n=8).

Figure 7. Average Chloride concentrations for each Inshore site. Error bars are standard error of the mean (n=8).



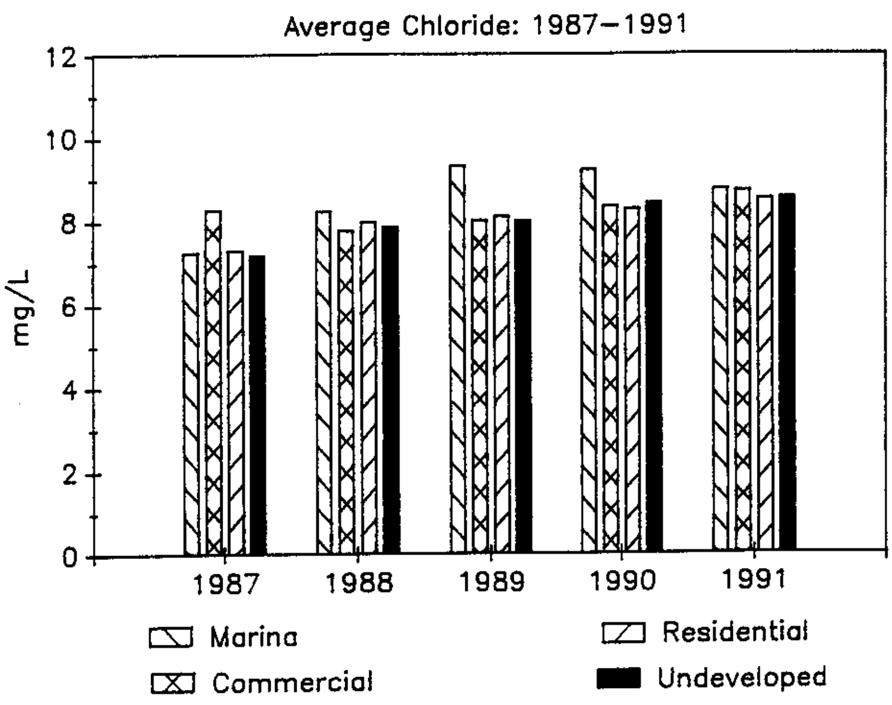
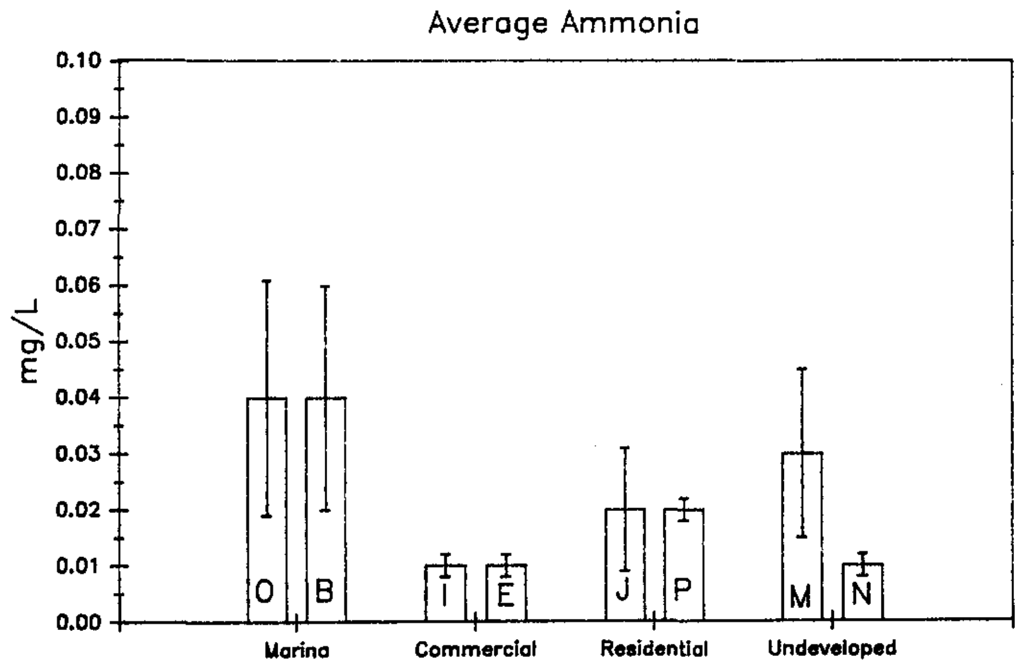


Figure 8. Average Chloride concentrations for each land use type from 1987 to 1991. Data for 1990 was collected on a rainfall event basis and is not directly comparable to the other years. It is presented for continuity.

Figure 9. Average Ammonia concentrations for each Inshore site. Error bars are standard error of the mean (n=8).



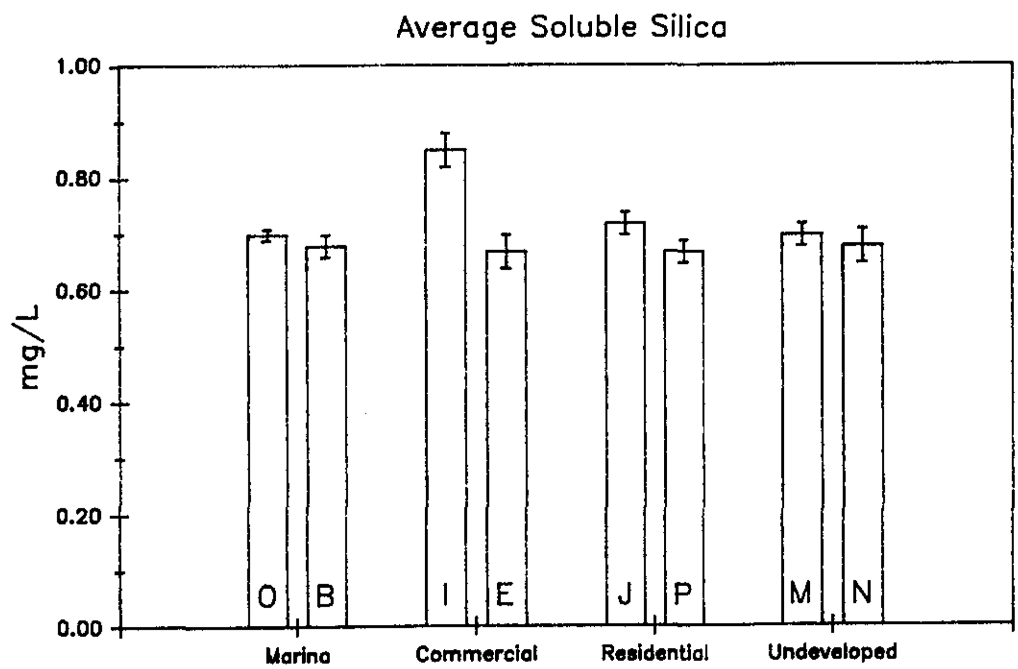
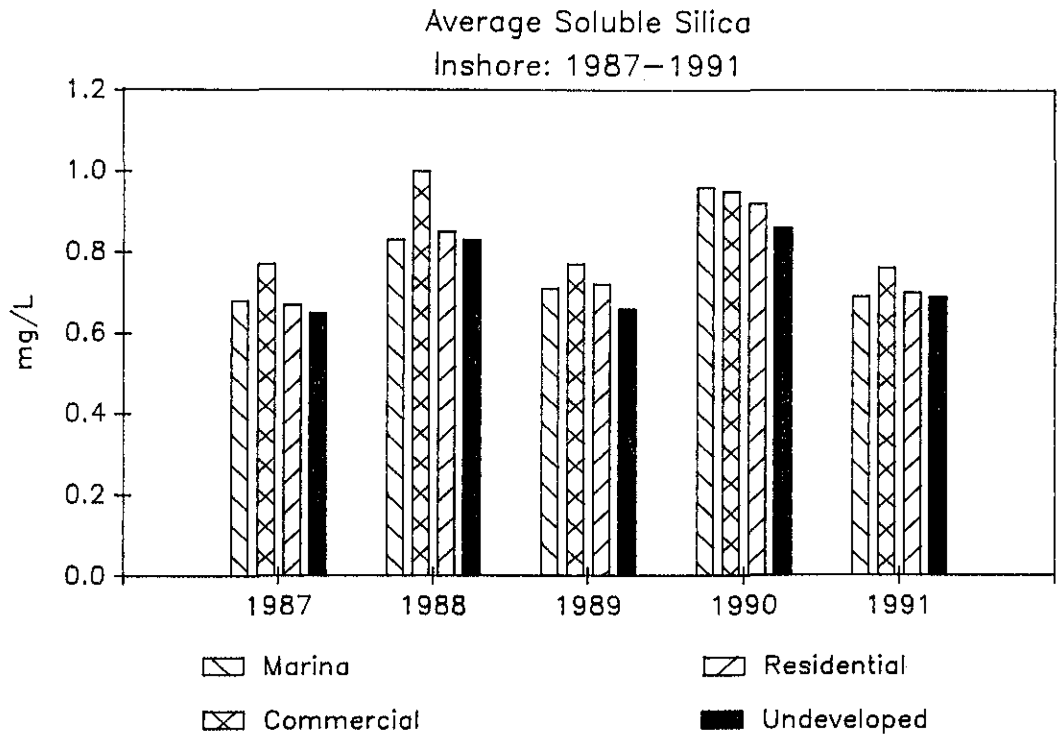


Figure 10. Average Soluble Silica concentrations for each Inshore site. Error bars are standard error of the mean (n=8).

Figure 11. **Average Soluble Silica concentrations for each land use type from 1987 to 1991. Data for 1990 was collected on a rainfall event basis and is not directly comparable to the other years. It is presented for continuity.**



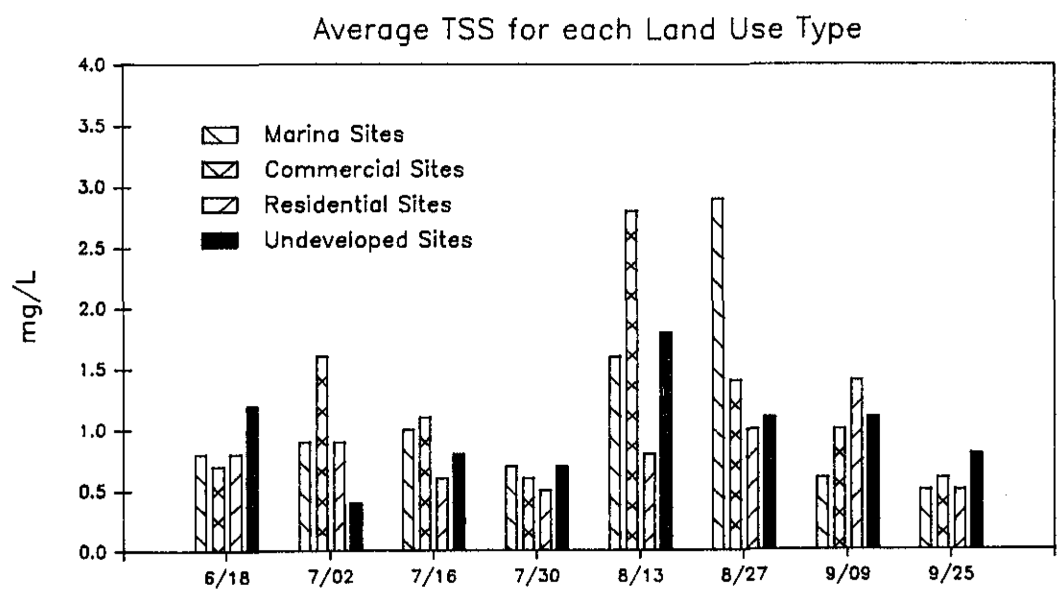
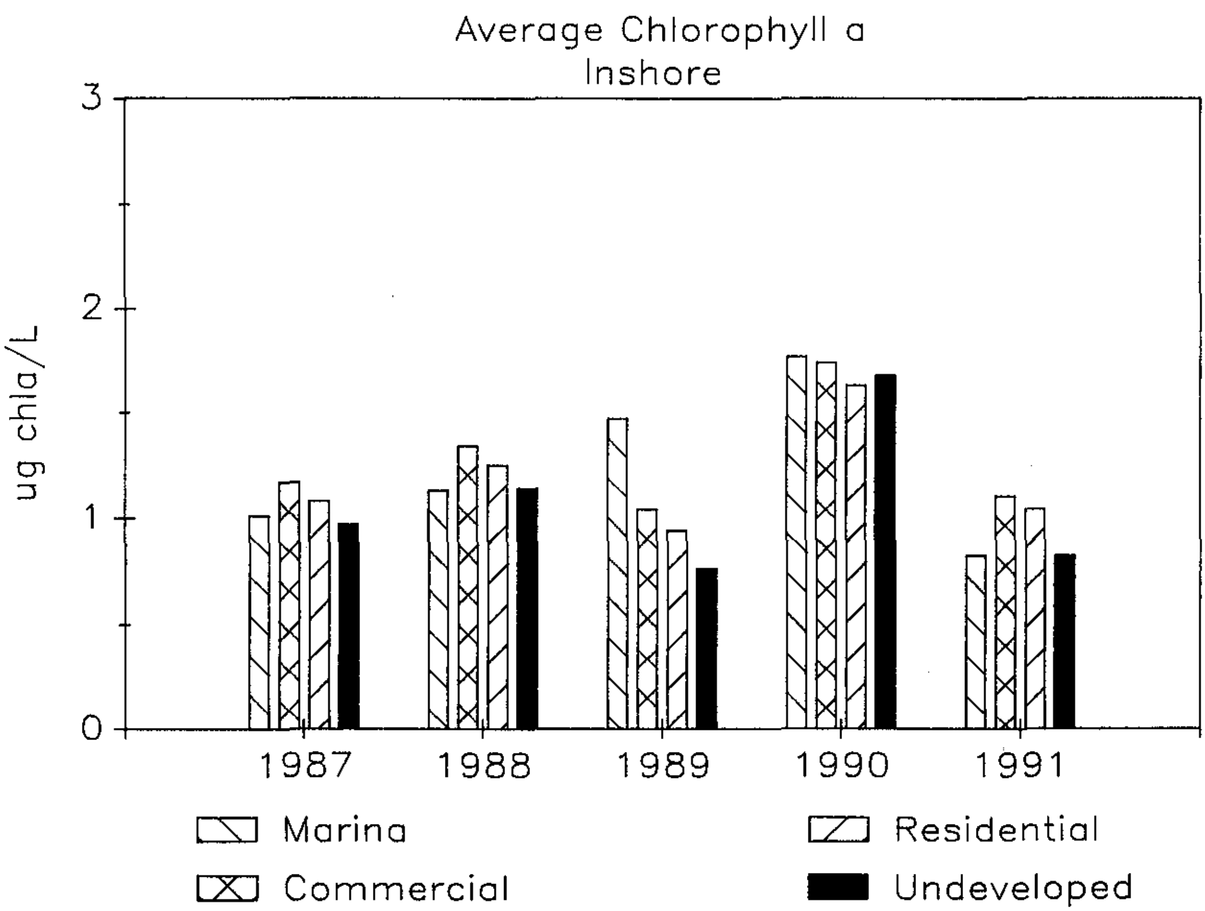


Figure 12. **Total Suspended Solids concentrations for each land use type and each sampling date.**

Figure 13. Average Chlorophyll a concentrations for each land use type from 1987 to 1991. Data for 1990 was collected on a rainfall event basis and is not directly comparable to the other years. It is presented for continuity.



APPENDIX C. TABLES

1991

Cl (mg/1)

Site	Depth	6/18	7/02	7/16	7/30	8/13	8/27	9/09	9/26
Bolton Landing	0.5	8.6	8.4	8.5	8.6	8.3	8.4	8.9	6.6
Sweetbriar Bay	0.5	8.8	9.9	10.4	9.0	8.9	8.8	9.2	8.9
West Bolton Bay	0.5	8.6	8.7	8.5	8.7	8.2	8.1	9.0	9.1
West Huddle Bay	0.5	8.8	8.8	8.7	8.8	8.7	8.3	9.5	9.0
East Huddle Bay	0.5	8.6	8.6	8.9	8.5	8.3	8.0	8.7	8.7
Stewart Brook	0.5	8.5	8.5	8.6	8.7	8.1	8.1	8.8	9.0
Clay Island	0.5	8.6	8.7	8.6	8.7	8.2	8.0	8.7	8.7
Green Island	0.5	8.6	8.5	8.5	8.7	8.2	8.3	9.0	9.1

****** : indicates no data available

1991

NO3 (mg/1)

Site	Depth	6/18	7/02	7/16	7/30	8/13	8/27	9/09	9/26
Bolton Landing	0.5	-0.01	-0.01	-0.01	-0.01	0.01	-0.01	-0.01	0.01
Sweetbriar Bay	0.5	-0.01	-0.01	0.01	-0.01	-0.01	-0.01	-0.01	0.01
West Bolton Bay	0.5	-0.01	-0.01	-0.01	-0.01	0.01	-0.01	0.02	-0.01
West Huddle Bay	0.5	-0.01	-0.01	0.01	-0.01	0.03	0.02	0.02	0.01
East Huddle Bay	0.5	-0.01	-0.01	0.01	-0.01	0.01	0.01	0.01	-0.01
Stewart Brook	0.5	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.03	-0.01
Clay Island	0.5	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Green Island	0.5	-0.01	-0.01	-0.01	-0.01	-0.01	0.01	0.03	-0.01

****** : indicates no data available

1991

NH4 (mg/l)

Site	Depth	6/18	7/02	7/16	7/30	8/13	8/27	9/09	9/26
Bolton Landing	0.5	-0.01	0.02	0.01	-0.01	0.02	0.02	0.02	0.19
Sweetbriar Bay	0.5	-0.01	0.02	0.03	-0.01	0.02	0.02	0.02	0.21
West Bolton Bay	0.5	0.02	0.01	0.01	-0.01	0.02	0.01	0.02	-0.01
West Huddle Bay	0.5	-0.01	0.02	0.02	-0.01	0.02	0.01	0.01	0.01
East Huddle Bay	0.5	-0.01	-0.01	0.01	-0.01	0.02	0.02	0.02	0.11
Stewart Brook	0.5	-0.01	0.01	0.02	0.02	0.02	0.02	0.02	-0.01
Clay Island	0.5	-0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.14
Green Island	0.5	0.01	-0.01	-0.01	0.01	0.02	0.02	0.02	******

****** : indicates no data available

1991

Total phosphorus (ppb)

Site	Depth	6/18	7/02	7/16	7/30	8/13	8/27	9/09	9/26
Bolton Landing	0.5	7.	7.	6.	5.	4.	7.	4.	6.
Sweetbriar Bay	0.5	5.	11.	8.	7.	7.	7.	7.	4.
West Bolton Bay	0.5	4.	7.	5.	4.	4.	5.	6.	4.
West Huddle Bay	0.5	7.	9.	8.	7.	10.	9.	8.	5.
East Huddle Bay	0.5	4.	8.	6.	7.	7.	9.	7.	6.
Stewart Brook	0.5	4.	7.	5.	4.	7.	6.	4.	5.
Clay Island	0.5	4.	4.	5.	4.	6.	4.	5.	6.
Green Island	0.5	4.	6.	4.	4.	5.	6.	4.	4.

****** : indicates no data available

1991

Si (mg/l)

Site	Depth	6/18	7/02	7/16	7/30	8/13	8/27	9/09	9/26
Bolton Landing	0.5	0.69	0.62	0.64	0.83	0.64	0.74	0.75	0.69
Sweetbriar Bay	0.5	0.68	0.67	0.69	0.73	0.67	0.88	0.72	0.76
West Bolton Bay	0.5	0.69	0.62	0.47	0.69	0.63	0.75	0.77	0.75
West Huddle Bay	0.5	0.79	0.71	0.88	0.85	1.00	0.81	0.92	0.83
East Huddle Bay	0.5	0.75	0.62	0.69	0.73	0.77	0.67	0.72	0.79
Stewart Brook	0.5	0.71	0.62	0.63	0.66	0.63	0.66	0.72	0.76
Clay Island	0.5	0.72	0.60	0.66	0.68	0.71	0.75	0.71	0.78
Green Island	0.5	0.70	0.63	0.64	0.66	0.63	******	0.67	0.82

****** : indicates no data available

1991

Orthophosphate (ppb)

Site	Depth	6/18	7/02	7/16	7/30	8/13	8/27	9/09	9/26
Bolton Landing	0.5	1.	1.	1.	1.	1.	2.	-1.	-1.
Sweetbriar Bay	0.5	1.	3.	2.	1.	3.	3.	2.	-1.
West Bolton Bay	0.5	1.	1.	1.	1.	1.	2.	1.	1.
West Huddle Bay	0.5	2.	2.	2.	2.	3.	3.	2.	1.
East Huddle Bay	0.5	1.	1.	1.	1.	2.	2.	2.	1.
Stewart Brook	0.5	1.	1.	2.	1.	1.	2.	1.	1.
Clay Island	0.5	1.	1.	1.	-1.	1.	2.	1.	1.
Green Island	0.5	2.	1.	2.	2.	2.	3.	-1.	-1.

****** : indicates no data available

1991 Chl-a (ppb)

Site	Depth	6/18	7/02	7/16	7/30	8/13	8/27	9/09	9/26
Bolton Landing	0.5	0.57	0.85	0.44	0.85	0.16	0.60	1.26	1.26
Sweetbriar Bay	0.5	0.41	0.85	0.57	0.79	1.20	1.17	1.01	1.05
West Bolton Bay	0.5	0.98	1.36	1.61	0.28	0.41	1.01	1.67	0.83
West Huddle Bay	0.5	0.89	0.63	1.49	0.70	1.39	0.30	2.39	1.52
East Huddle Bay	0.5	0.53	1.39	0.73	0.89	1.58	1.33	1.33	2.36
Stewart Brook	0.5	1.33	0.63	0.19	0.57	0.32	1.04	1.20	1.14
Clay Island	0.5	0.25	0.35	1.01	1.01	0.76	1.01	1.20	2.06
Green Island	0.5	0.76	0.19	0.63	0.51	0.63	1.01	0.89	0.89

****** : indicates no data available