PRINCE EDWARD ISLAND ESTUARINE WATER QUALITY MONITORING PROGRAM

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Executive Summary

Twenty estuaries on Prince Edward Island were selected to be included in the introduction of an estuarine water quality monitoring program. These estuaries were sampled in July and August 1998 in order to determine locations and time of year which would provide the earliest indications of eutrophication. Chlorophyll *a*, dissolved oxygen, total nitrogen and total phosphorous are the parameters used as indicators of eutrophication. Historical data, along with 1998 data, was used for sample station selection for those estuaries for which it was available. A fixed upper, middle and lower station was selected for each estuary separately. Suggested station locations for each estuary are included and the suggested time of year for sampling in subsequent years is the first two weeks of August. An internet website and a yearly estuarine water quality bulletin are suggested for reporting ongoing results of the monitoring program.

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Introduction

Estuaries are highly productive systems and typically contain a large biomass of algae, sea grasses and phytoplankton (McComb 1995). The estuaries of Prince Edward Island (PEI) are generally small, narrow, shallow bodies of water. Many empty into coastal embayments, thus have limited exchange with coastal waters and are known as ‘trap areas’ for nutrients (P. Lane and Associates 1991). The nutrient enrichment of estuaries can lead to the generation of large masses of macroalgae which reduce opportunities for contact recreation and may lead to nauseous odors and the production of toxins (McComb 1995).

P. Lane and Associates (1991) address eutrophication on PEI as follows:

> “Nutrient enrichment of estuaries may lead to protracted periods of intense growth of phytoplankton and macroalgae. As the phytoplankton becomes senescent, a constant rain of organic matter cascades through the water column. This is in addition to attached macroalgae that is also contributing to the organic load. Aerobic microbial and animal consumption of this material depletes dissolved oxygen concentrations faster than it can be replaced by either physical or biological mechanisms. Depending on the frequency and intensity of water column mixing, dissolved oxygen concentrations in the lower layers of the estuaries may be totally exhausted. Anaerobic continuation of organic degradation results in the generation of noxious odors. Resident fish and shellfish suffocate and their carcasses litter the shores and bottom of the estuaries further contributing to the problem. This suite of phenomena, collectively known as “eutrophication” occurs on a fairly regular basis every summer in several Prince Edward Island estuaries.”

Nutrients can be lost into waterways through processes such as soil erosion and leaching. Of these nutrients, phosphorous and nitrogen contribute most to eutrophication (Fertilizer Industry Federation of Australia 1994). Meeuwig et al (1997) identified strong patterns between chlorophyll *a* and total nutrients in PEI estuaries, indicating that phytoplankton biomass is correlated to bottom-up nutrient factors. Taylor et al. (1995) showed that nitrogen is the nutrient most limiting to productivity and biomass in marine lagoons of northeast United States. In Stege Bay, Denmark, nitrogen was also reported to limit phytoplankton and macroalgae production (Lyngby and Mortensen, 1997). If a nitrogen limited system is supplied with high levels of nitrogen, phytoplankton and macroalgae

production may significantly increase (Osmond et al 1995). When nitrogen levels are high, excess phosphorous will trigger eutrophic conditions (Osmond et al 1995).

Koster et al. (1997) report that concentrations of chlorophyll *a* and inorganic nutrients increased from the outer to the inner parts of a shallow coastal inlet. They also found that chlorophyll *a* concentration and oxygen consumption increased with increasing levels of eutrophication. Oxygen losses readily occur when water temperatures rise, when plant and animals respire, and when microbes aerobically decompose organic material (Osmond et al 1995). Therefore monitoring chlorophyll *a* and dissolved oxygen concentrations at specific locations throughout an estuary could provide indications of levels of eutrophication.

The objective of this survey is to provide a methodology for an ongoing estuarine water quality monitoring program on Prince Edward Island. Included in this recommended methodology are sampling locations, sampling dates, sampling methods and reporting mechanisms.

Methods

Twenty of the larger estuaries throughout PEI were selected to be included in the monitoring program: **Boughton, Brudenell, Cardigan, Covehead, Dunk, Foxley, Grand, Hillsborough, Kildare, Mill, Montague, Murray River, New London, North, Orwell, Rustico, Southwest, St. Peter's, Tracadie, and West.** The first sampling station in each estuary was sited as far upstream as was accessible by boat. The concurrent stations were run downstream to represent the seaward salinity gradient. This methodology often resulted in 3 to 5 stations in the upper estuary area. Where possible, sample stations were located in the channel. The number of sampling stations per estuary varied according to the size of the estuary and ranged from 6 to 11.

At each station, temperature (°C), conductivity (mmho), and salinity (ppt) readings were taken using a Beckman Salinometer. Dissolved oxygen (DO) readings were taken with a YSI; Model 55 DO meter. The DO meter was not available every sampling day, so no

DO readings were taken in Brudenell, Covehead, Montague, and Rustico. Water was sampled in 250 ml Nalgene bottles for chlorophyll *a* (chl *a*) analysis and in 40 ml plastic vials for total nitrogen (TN) and total phosphorous (TP) analysis. Field readings and water samples were taken at both the surface (0.3 m from the surface) and the bottom (0.3 to 0.5 m from the bottom substrate) at each station. Bottom water samples were collected with a vertical Kemmerer Bottle. UTM coordinates for each station were recorded with a handheld GPS 2000 XL. Station depth was also recorded. All estuaries were sampled between July 16 and August 19, 1998.

Chlorophyll *a*, TN and TP analyses were carried out at the P.E.I. Analytical Laboratories. All statistical analysis was completed using Systat 7.

Historical data is available for Boughton River, Cardigan River, Hillsborough River, Mill River, New London Bay (Trout River), St. Peter's Bay and West River. Historical sampling locations, that corresponded to 1998 stations, were examined for chl *a* and DO values. Only data collected within the same time frame as the 1998 sampling was used. The historical sampling station numbers were changed to their corresponding 1998 station number to aid the reader. In order to determine the best two weeks of the summer months for subsequent sampling, historical chl *a* and DO values from the upper estuary stations were plotted against time. The point in time which yielded the highest chl a values and lowest DO values was determined.

All plots were created using Systat 7 and maps were created using MapInfo.

Results and Discussion

The 1998 data was examined to determine if permanent sampling locations should be selected by a specific salinity or by station location. Figures 1 and 2 show the relationship between salinity and chl *a* and DO respectively. Although chl *a* concentrations are slightly higher at salinities of 18-20 ppt (Figure 1) and DO readings are slightly higher at salinities above 23 ppt (Figure 2), the overall range of salinities observed was not represented by all 20 estuaries. Many of the estuaries were not sampled at salinities less

than 23 ppt. The lack of distinct pattern and variation in salinity range prevents choosing sampling locations for all estuaries based on a specific salinity range.

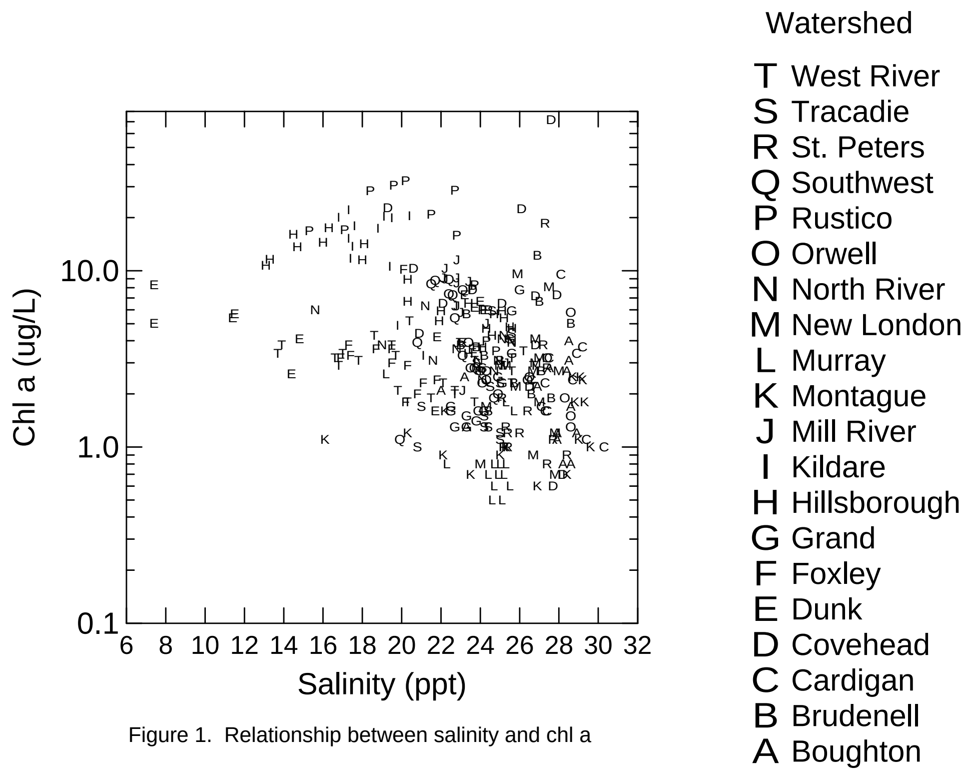


Figure 1. Relationship between salinity and chl a

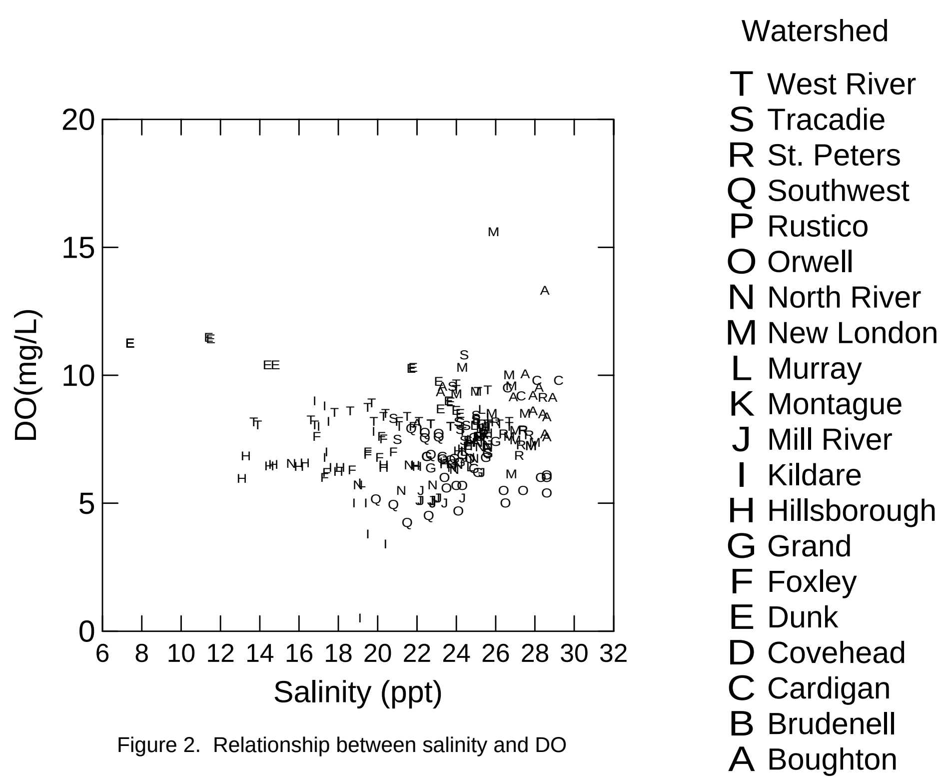


Figure 2. Relationship between salinity and DO

Little relationship exists between salinity, chl *a* and DO values. A specific location is representative of a wide range of salinities over time, especially in the upper estuary. Conversely a specific salinity can be found over a large geographical distance. The utility of using a specific salinity to identify sample locations, which indicate levels of eutrophication, is weaker than use of fixed stations.

Figures 3 and 4 show the relationship between station location (upper to outer estuary) and chl *a* and DO respectively. The large range of chl *a* and DO values for each location indicates that the overall trend is not representative of each individual estuary. Sample station locations should therefore be assessed for each estuary individually.

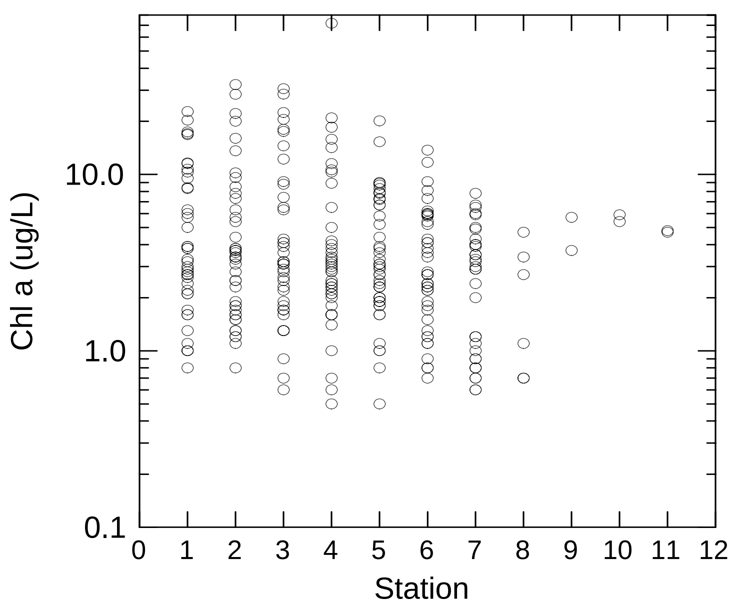


Figure 3. Relationship between station and chl a

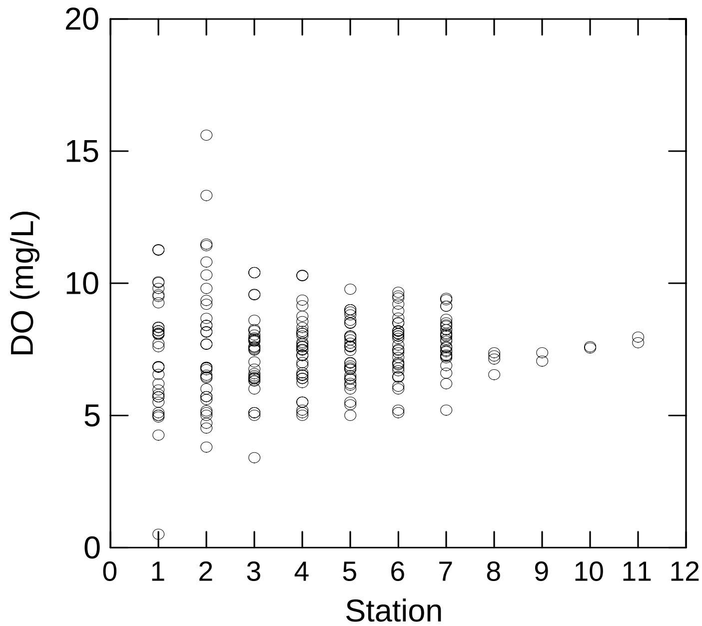


Figure 4. Relationship between station and DO

Boughton River

Historical chl *a* and DO values for Boughton River from 1988 and 1989 are shown in Figures 5 and 6 respectively. Only data obtained between July 21 and August 4 was used. Station 4 produced higher chl *a* values than Station 1 and lower DO values than Station 1.

In 1998, Station 4 produced the highest chl *a* values and low DO values relative to other station locations (Figure 7). **Station 4 is the suggested upper estuary sampling location. Stations 6 and 7 are recommended as middle and lower stations respectively.**

Historical results indicate that late July is the best time of year for finding a combination of high chl *a* and low DO values in the upper estuary (Figure 8). Figure 9 is a map of the 1998 Boughton River sampling locations.

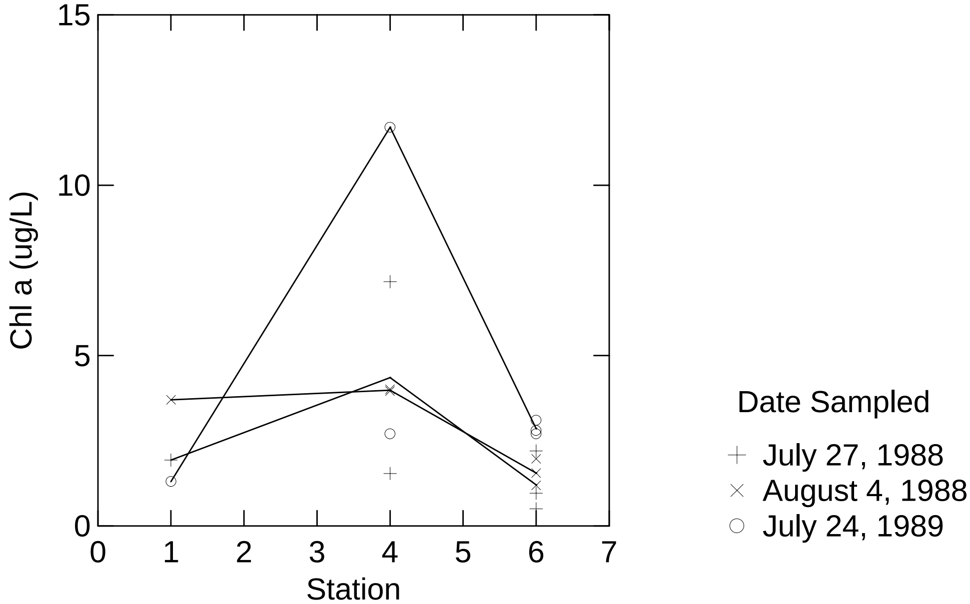


Figure 5. Relationship between historical stations and chl a values in Boughton River

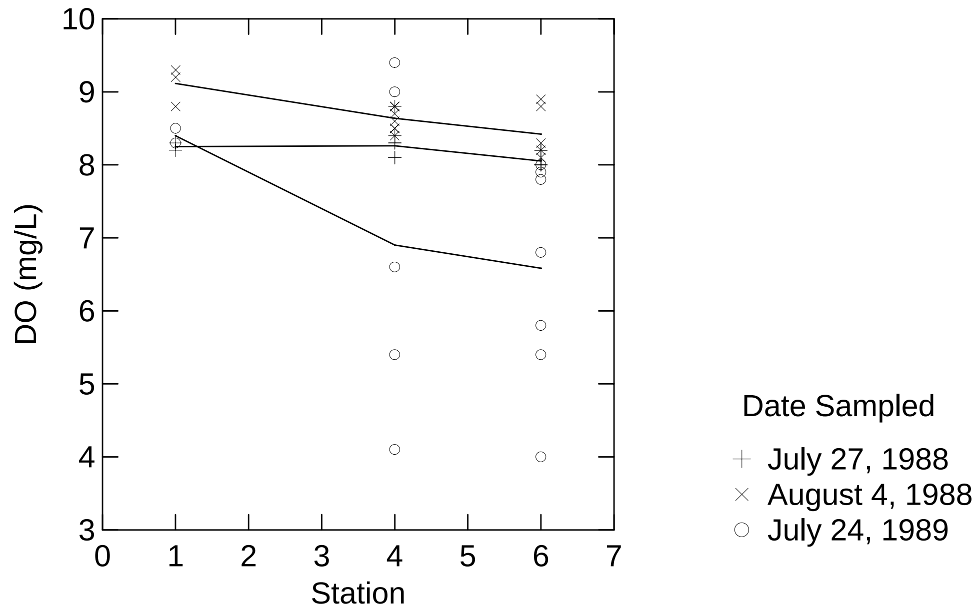


Figure 6. Relationship between historical stations and DO values for Boughton River

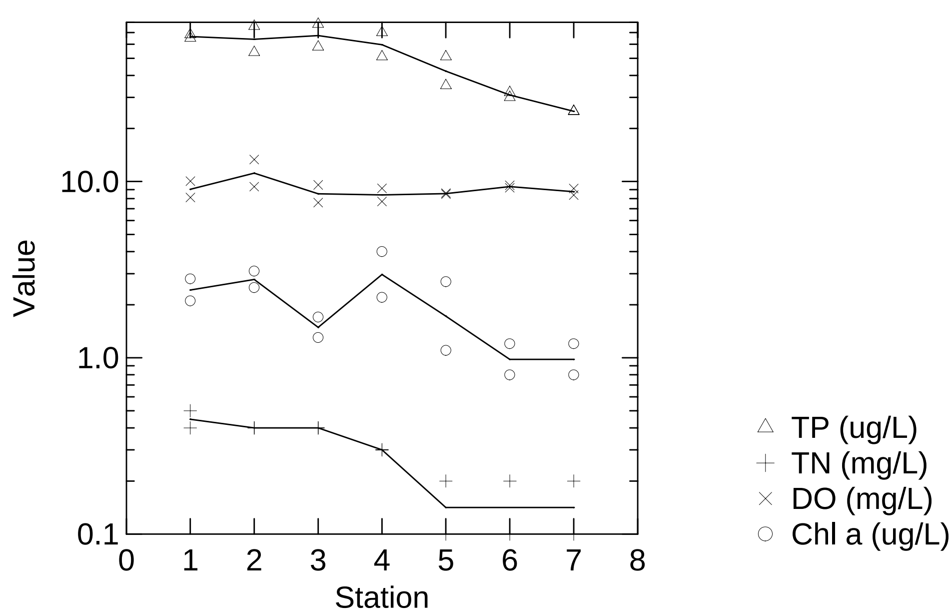


Figure 7. Relationship between 1998 stations and chl a, DO, TN and TP values in Boughton River

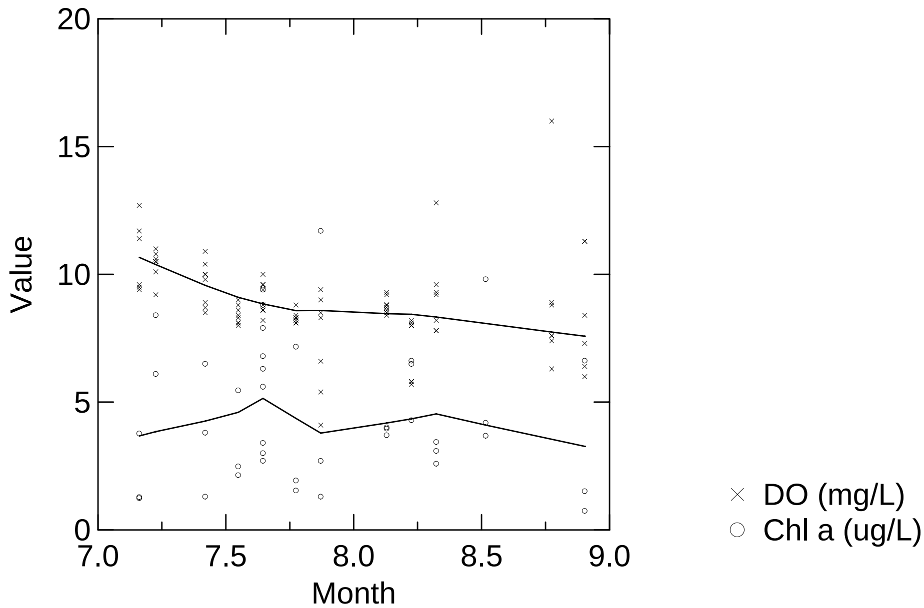


Figure 8. Relationship between month and historical chl a and DO values in upper Boughton River

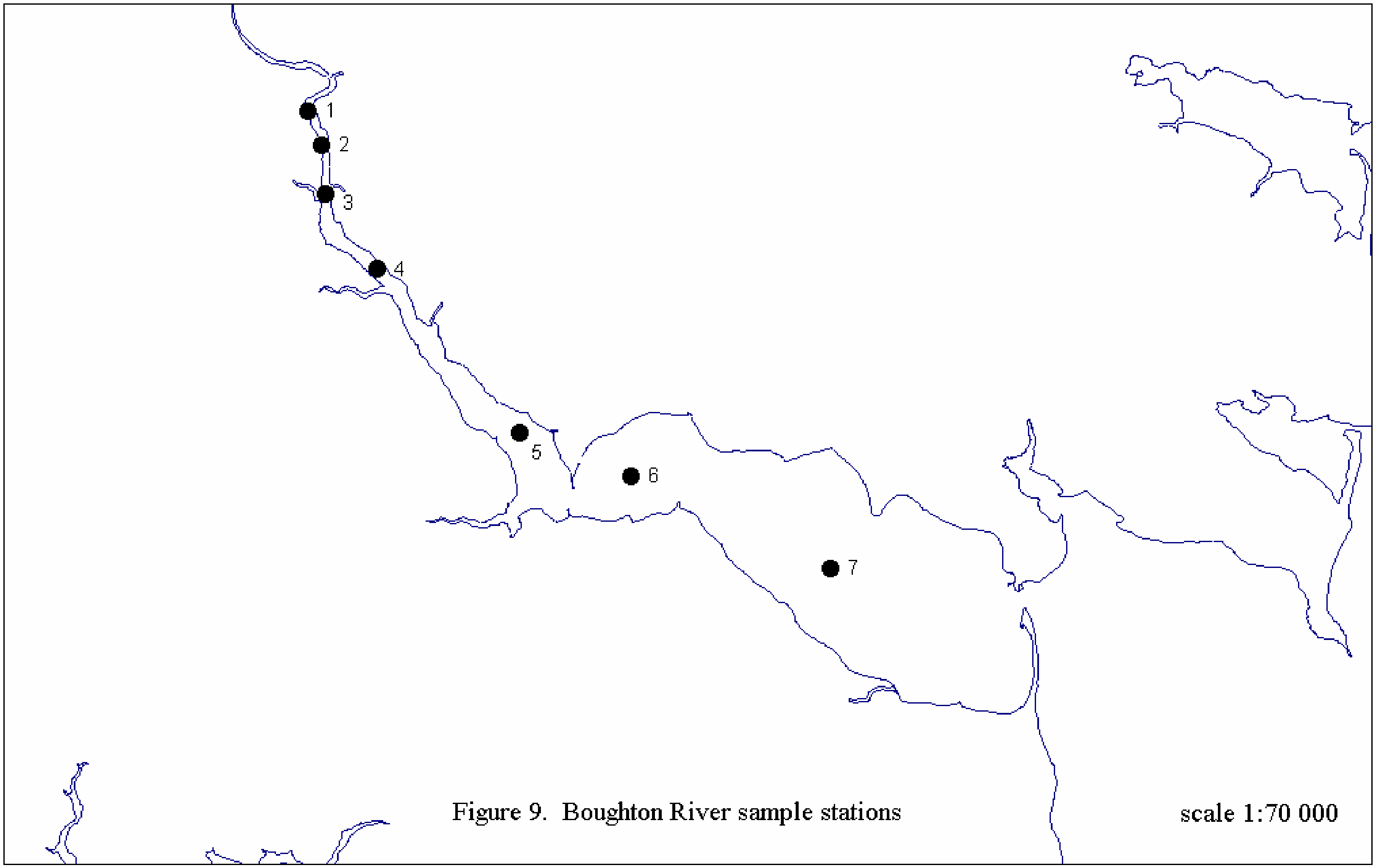


Figure 9. Boughton River sample stations

Brudenell River

No historical or 1998 DO data for Brudenell River is available. Station 3 produced the highest chl *a*, TN and TP concentrations (Figure 10). **Station 3 is the suggested upper estuary sampling location. Stations 5 and 6 are the recommended middle and lower stations respectively.** Figure 11 is a map of Brudenell River sampling locations.

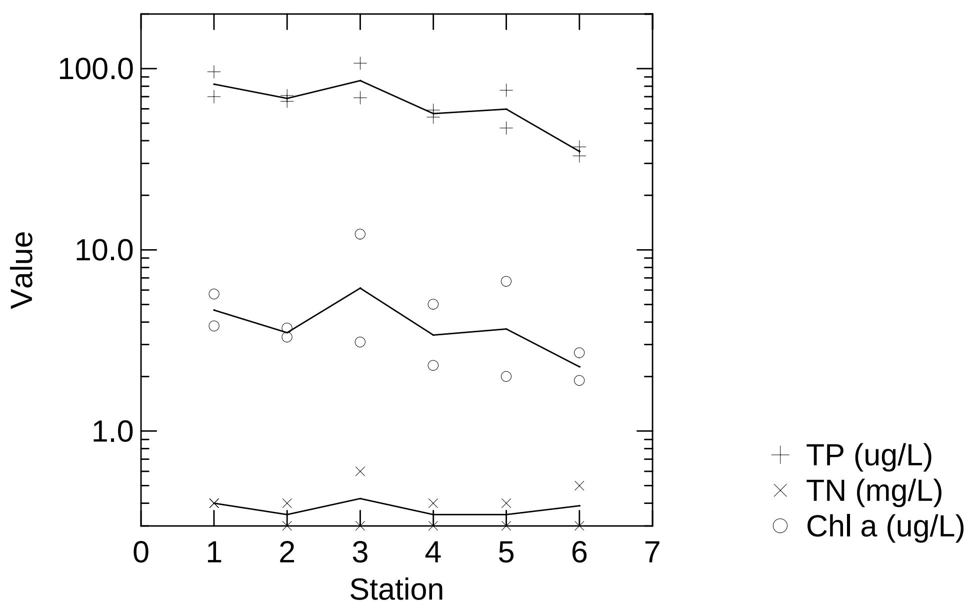


Figure 10. Relationship between 1998 stations and chl a, TN and TP values in Brudenell River

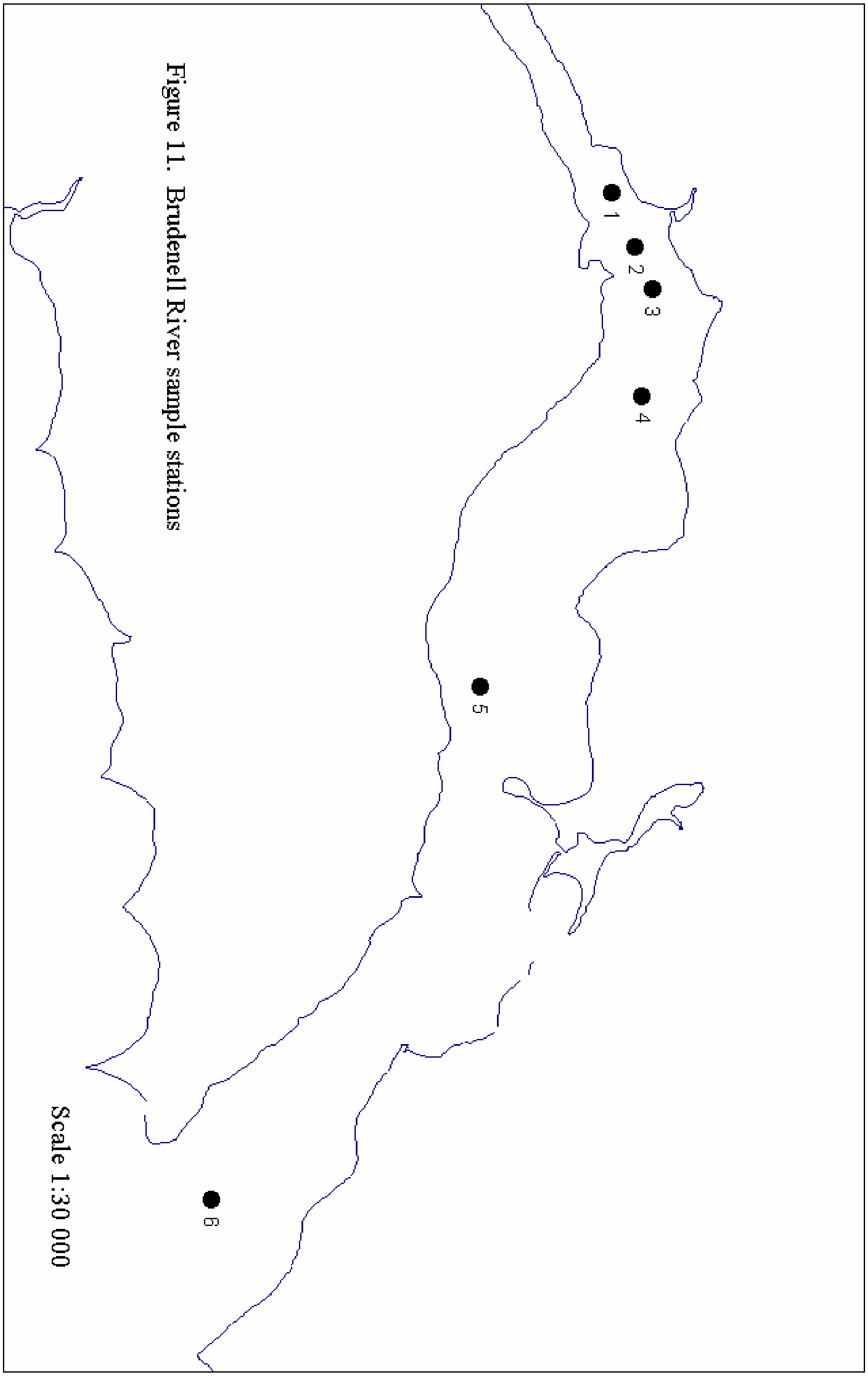


Figure 11. Brudenell River sample stations

Cardigan River

Historical chl *a* and DO values for Cardigan River from 1988 and 1989 are shown in Figures 12 and 13 respectively. Only data from between July 16 and July 30 was used. Station 3 produced higher chl a values than Station 6 on two of three sample dates (Figure 12). On two of three sampling dates, Station 3 had higher DO values than Station 6 (Figure 13), however Station 6 is not an upper estuary station (Figure 16).

DO readings were only available for Stations 1 and 2 in 1998. Station 1 produced the highest chl a, TN and TP values (Figure 14). **Station 1 is the suggested upper estuary sampling location. Stations 5 and 6 are recommended as middle and lower stations respectively.**

Historical results indicate that mid August is the best time of year for finding a combination of high chl *a* and low DO values in the upper estuary (Figure 15). Figure 16 is a map of 1998 Cardigan sampling locations.

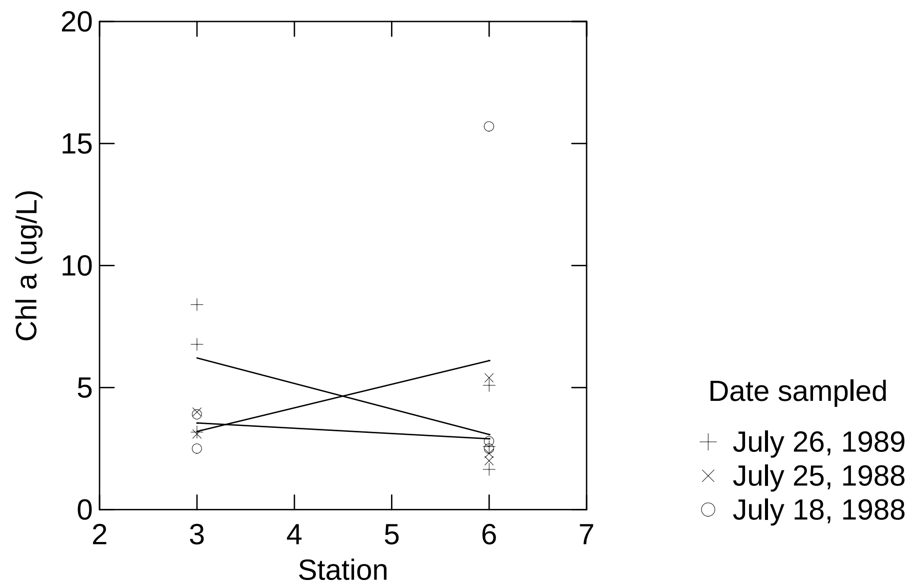


Figure 12. Relationship between historical stations and chl a values in Cardigan River

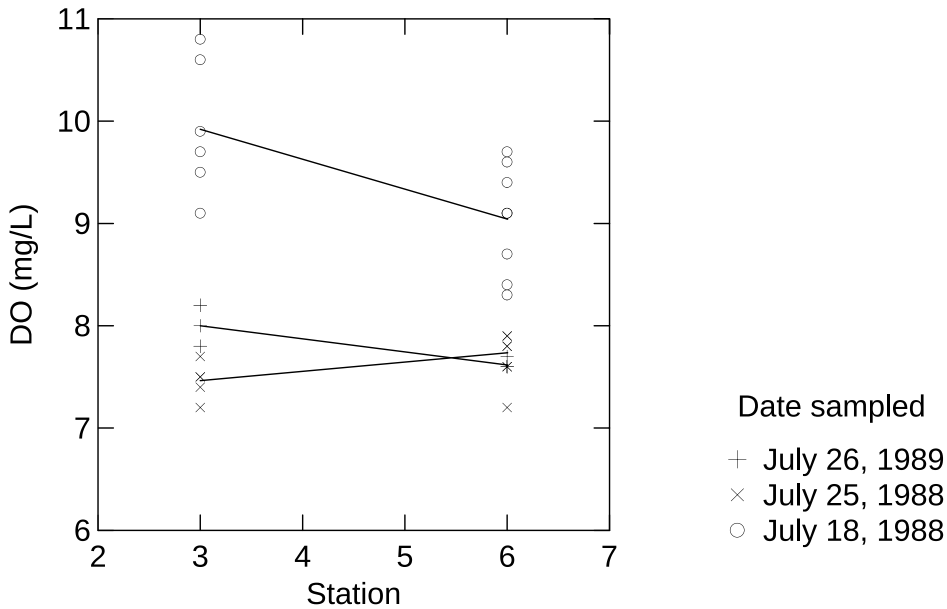


Figure 13. Relationship between historical stations and DO values in Cardigan River

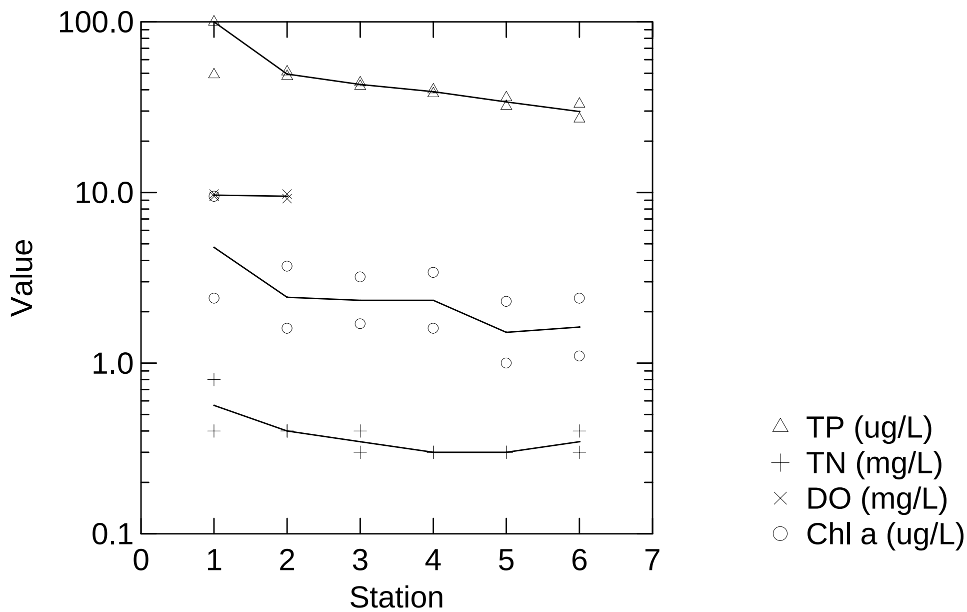


Figure 14. Relationship between 1998 stations and chl a, DO, TN and TP values in Cardigan River

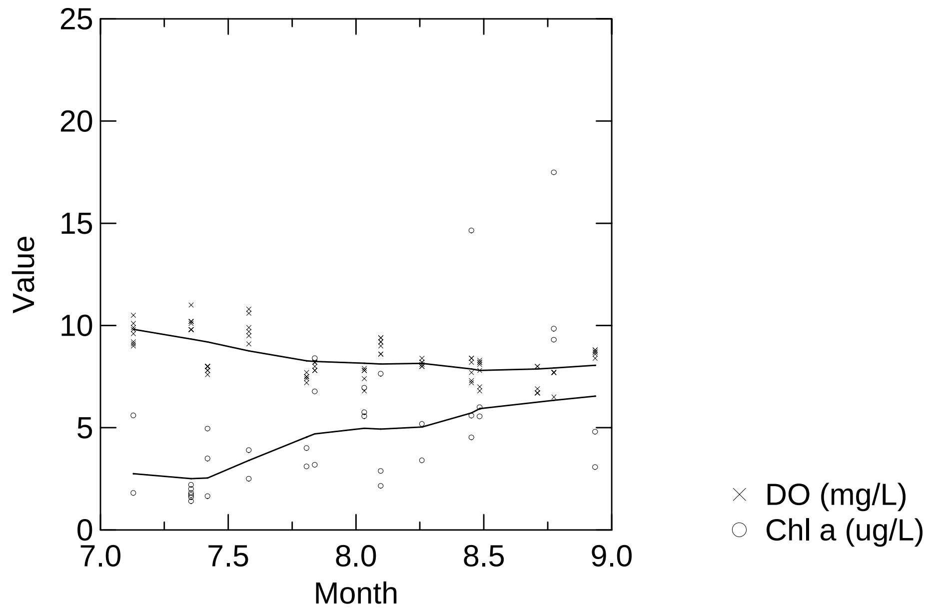


Figure 15. Relationship between month and historical chl a and DO values in upper Cardigan River

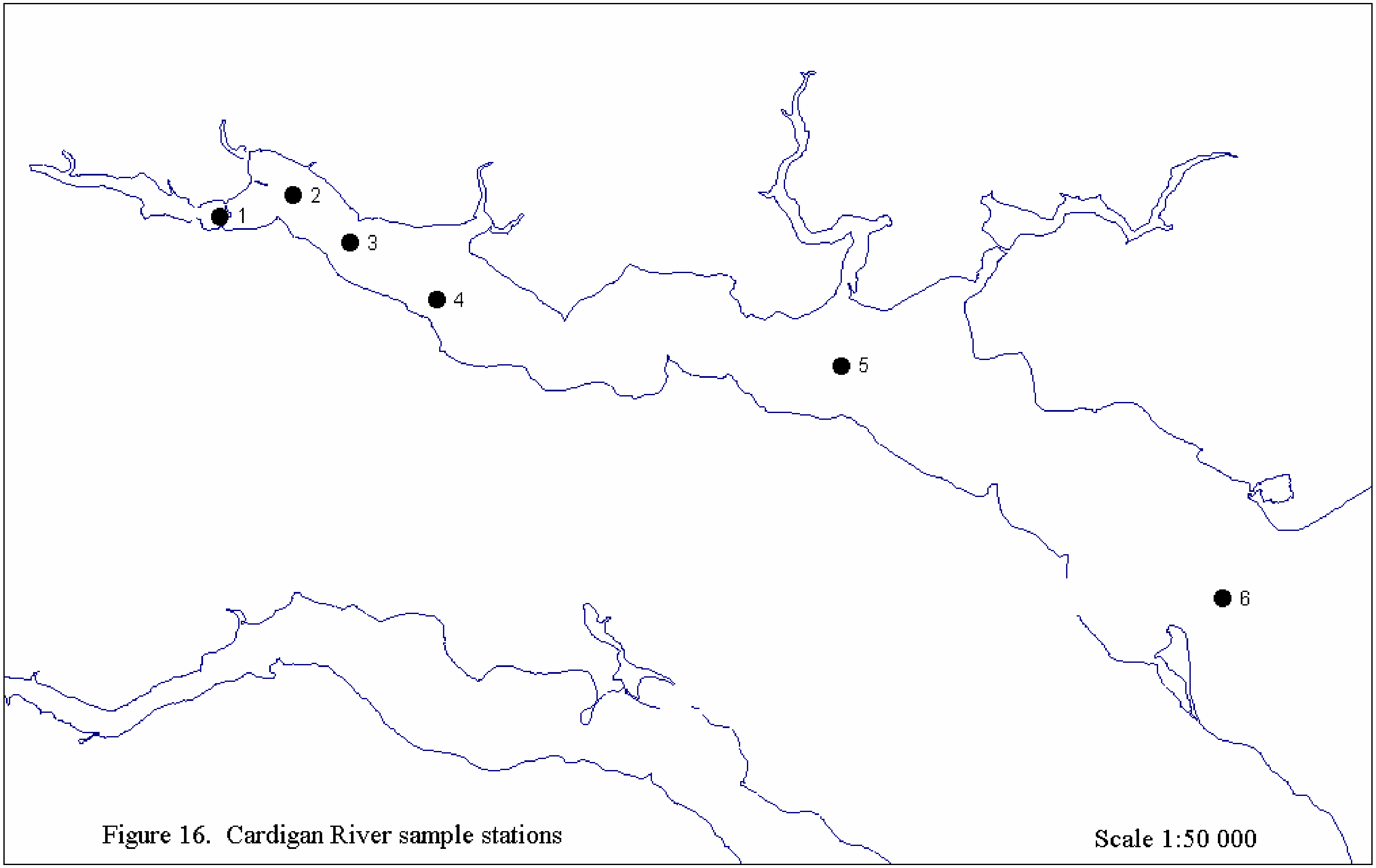


Figure 16. Cardigan River sample stations

Covehead Bay

No historical or 1998 DO data for Covehead is available. Station 4 produced the highest chl *a*, TN and TP readings (Figure 17). **Station 4 is the suggested upper estuary sampling location**. **Stations 6 and 7 are suggested as middle and lower stations respectively.** Figure 18 is a map of Covehead sampling locations.

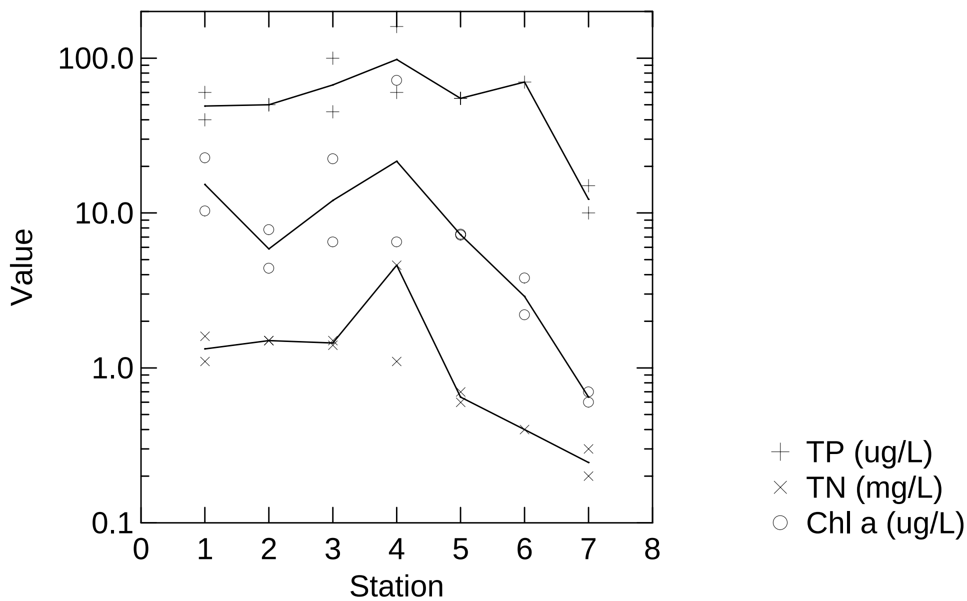


Figure 17. Relationship between 1998 stations and chl a, TN and TP values in Covehead Bay

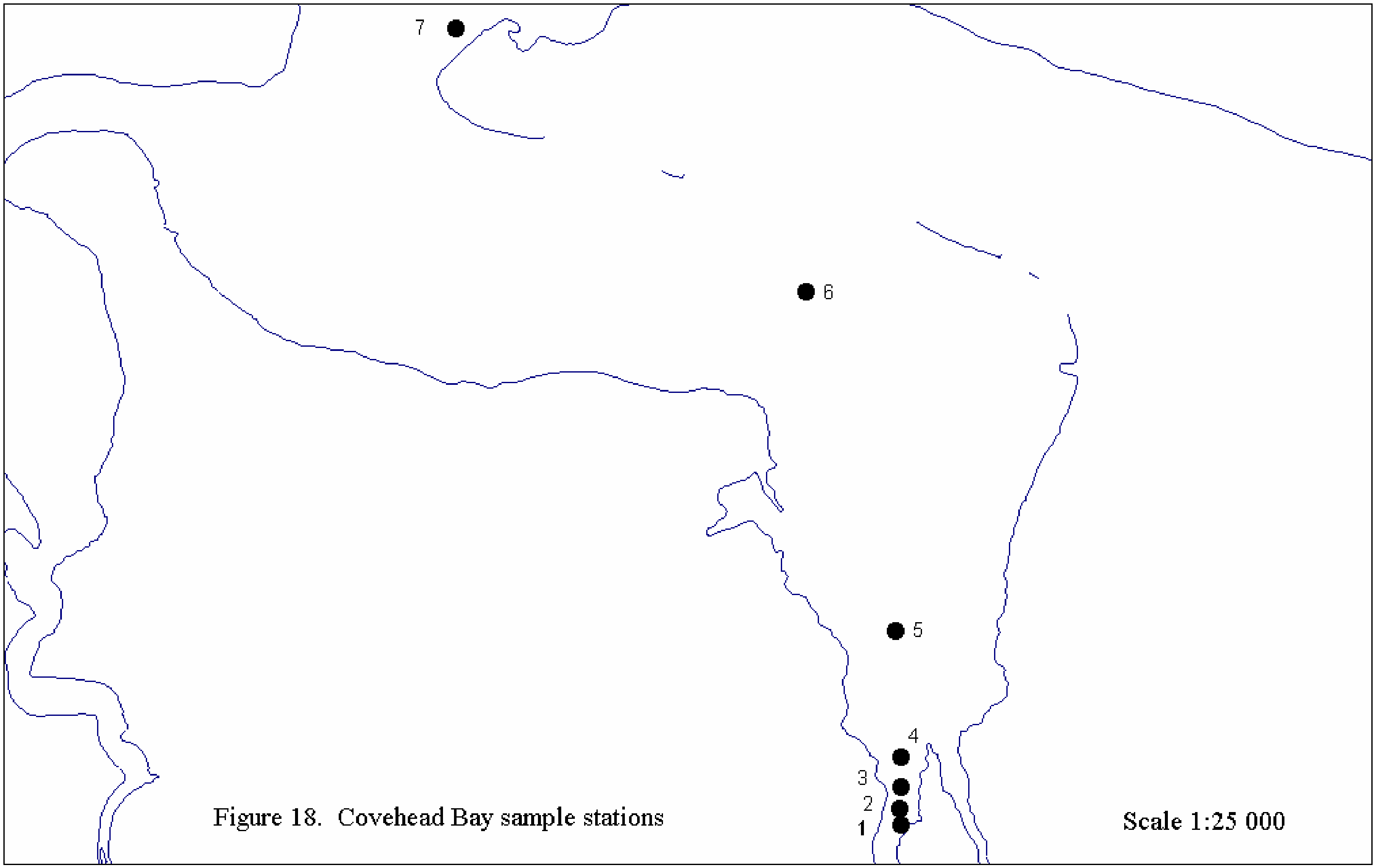


Figure 18. Covehead Bay sample stations

Dunk River

No historical data for Dunk River is available. In 1998 Station 1 produced the highest chl *a*, TP and TN values and DO readings were consistent throughout the upper estuary stations (Figure 19). **Station 1 is the suggested upper estuary sampling location**. **Stations 6 and 7 are suggested as middle and lower stations respectively.** Figure 20 is a map of Dunk River sampling locations.

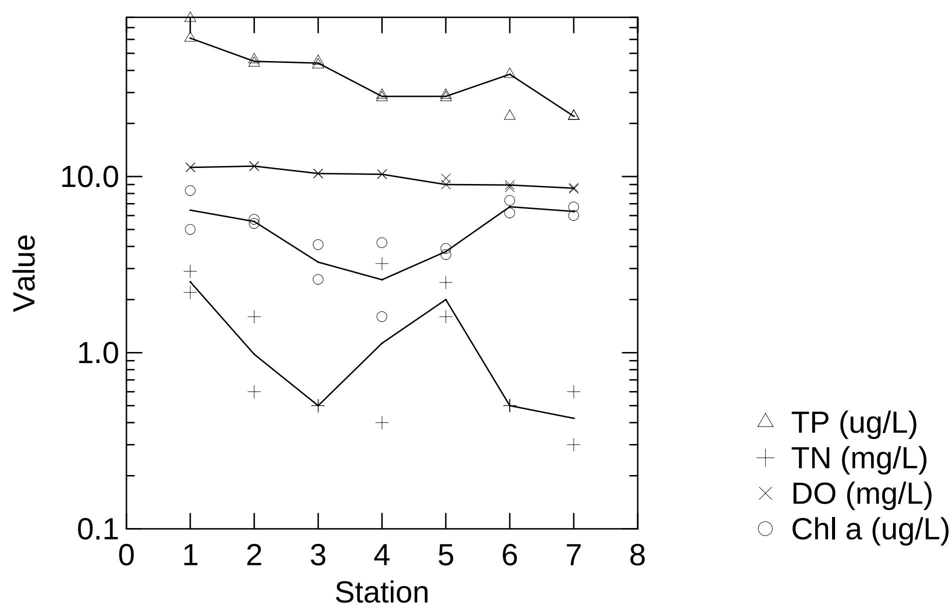


Figure 19. Relationship between 1998 stations and chl a, DO, TN and TP values in Dunk River

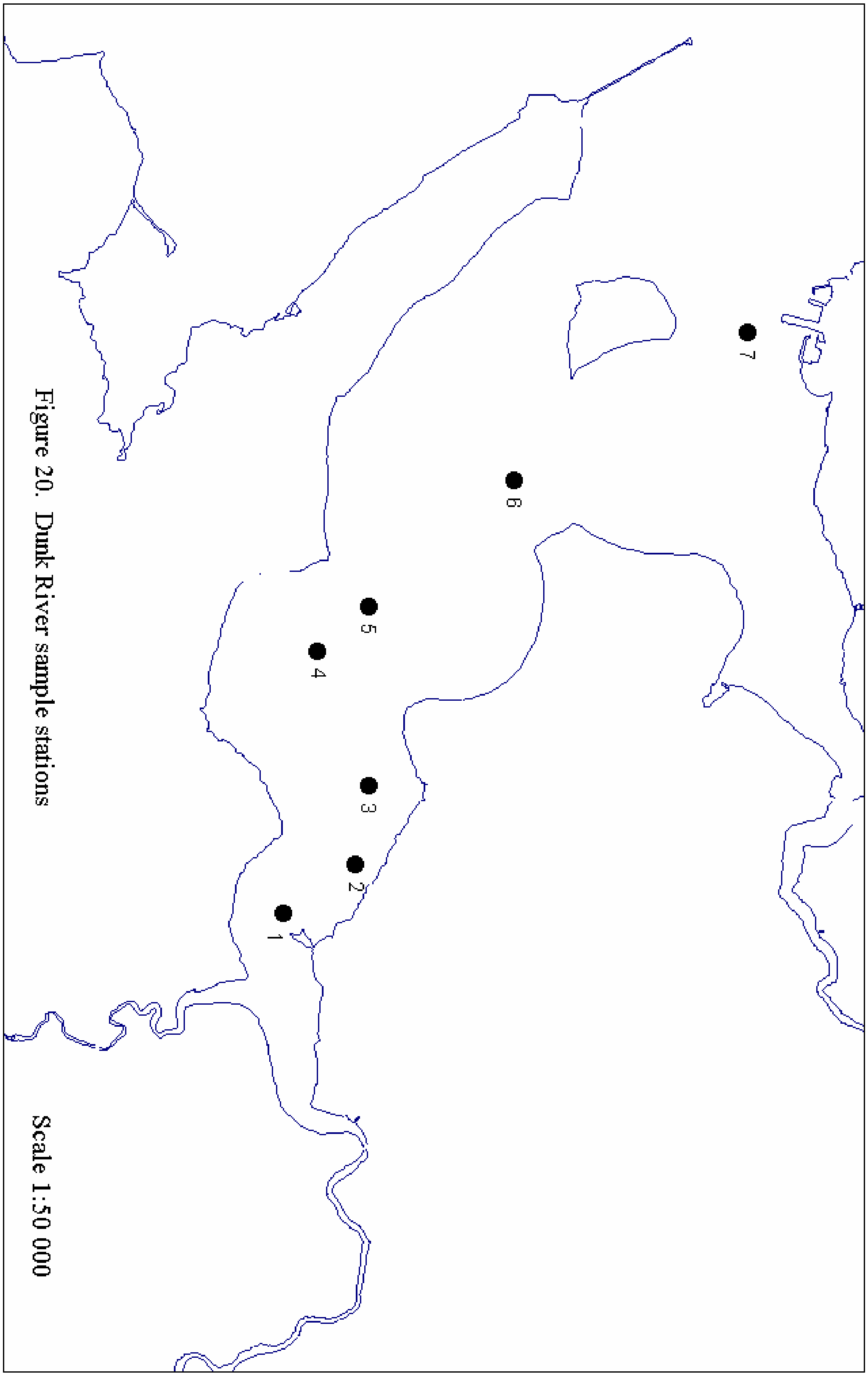


Figure 20. Dunk River sample stations

Foxley River

No historical data for Foxley River is available. In 1998 Station 2 produced the highest chl *a* readings and the lowest DO readings (Figure 21). **Station 2 is the suggested upper estuary sampling location**. **Station 4 and 6 are suggested as middle and lower stations respectively.** Figure 22 is a map of Foxley River sampling locations.

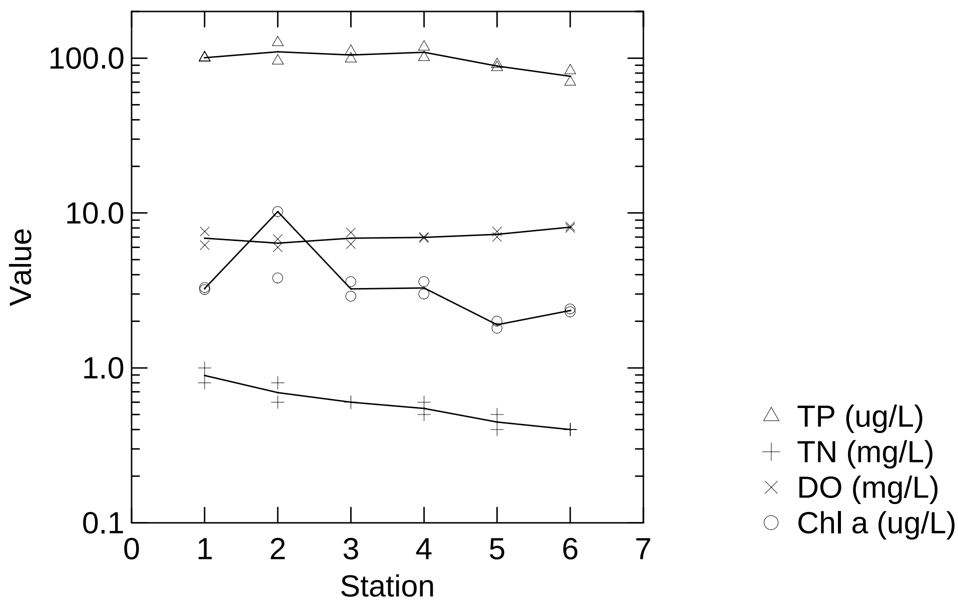
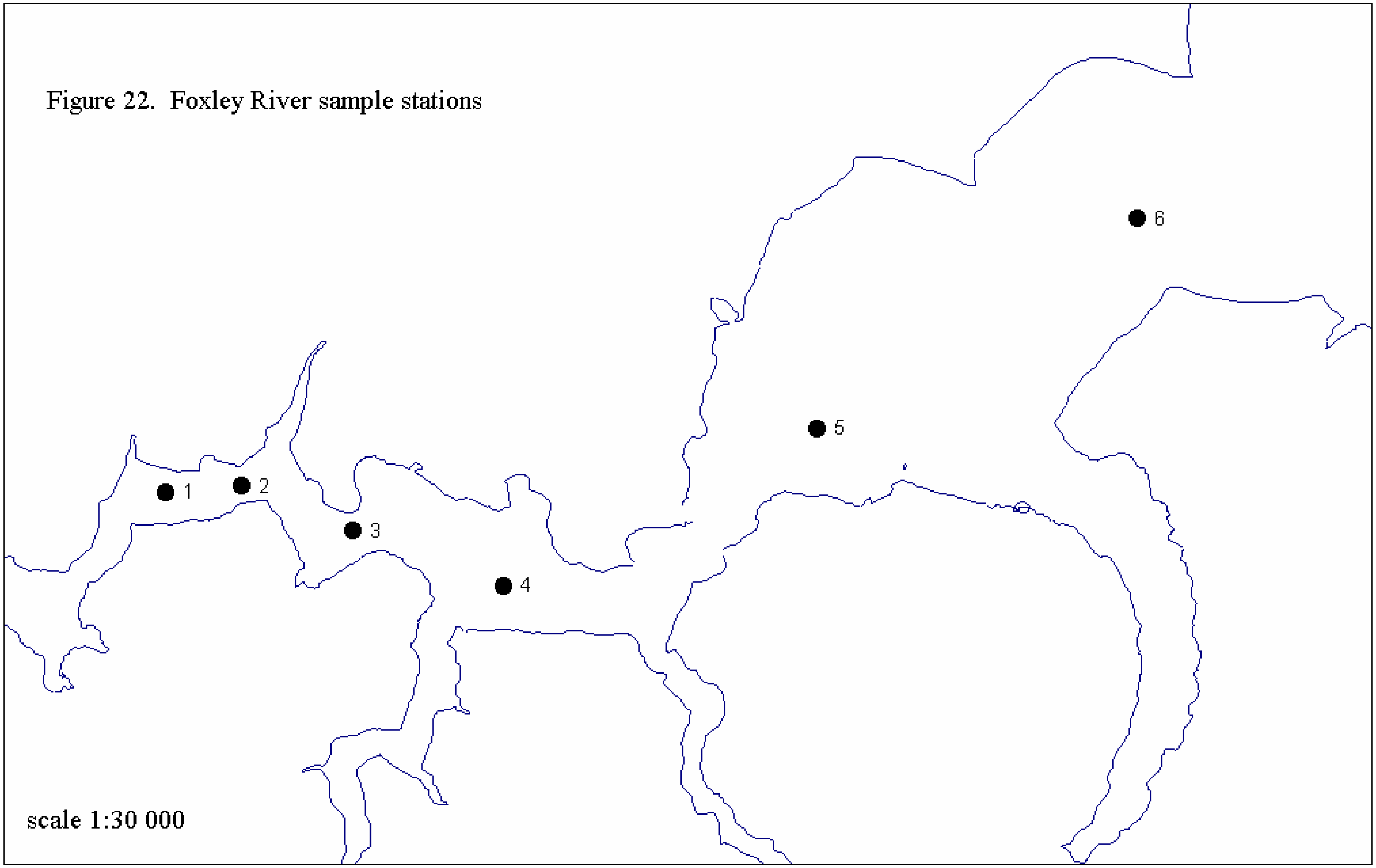


Figure 21. Relationship between 1998 stations and chl a, DO, TN and TP values in Foxley River

Figure 22. Foxley River sample stations



Grand River

No historical data for Grand River is available. Station 1 produced the highest chl *a* readings of the upper estuary samples (Figure 23). DO readings are consistent throughout the upper estuary stations (Figure 23). **Station 1 is the suggested upper estuary sampling location**. **Stations 5 and 7 are suggested as middle and lower stations respectively.** Figure 24 is a map of Grand River sampling locations.

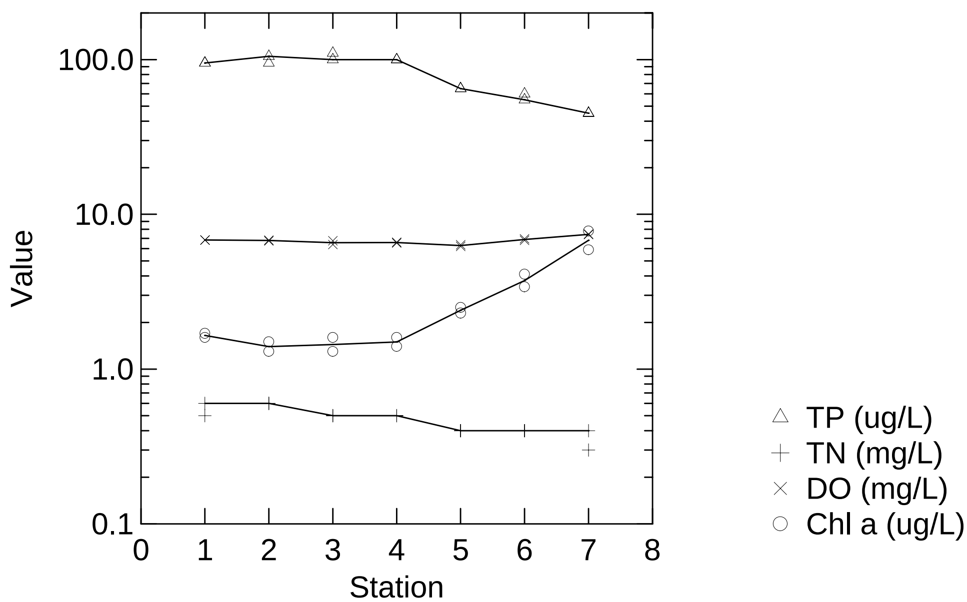
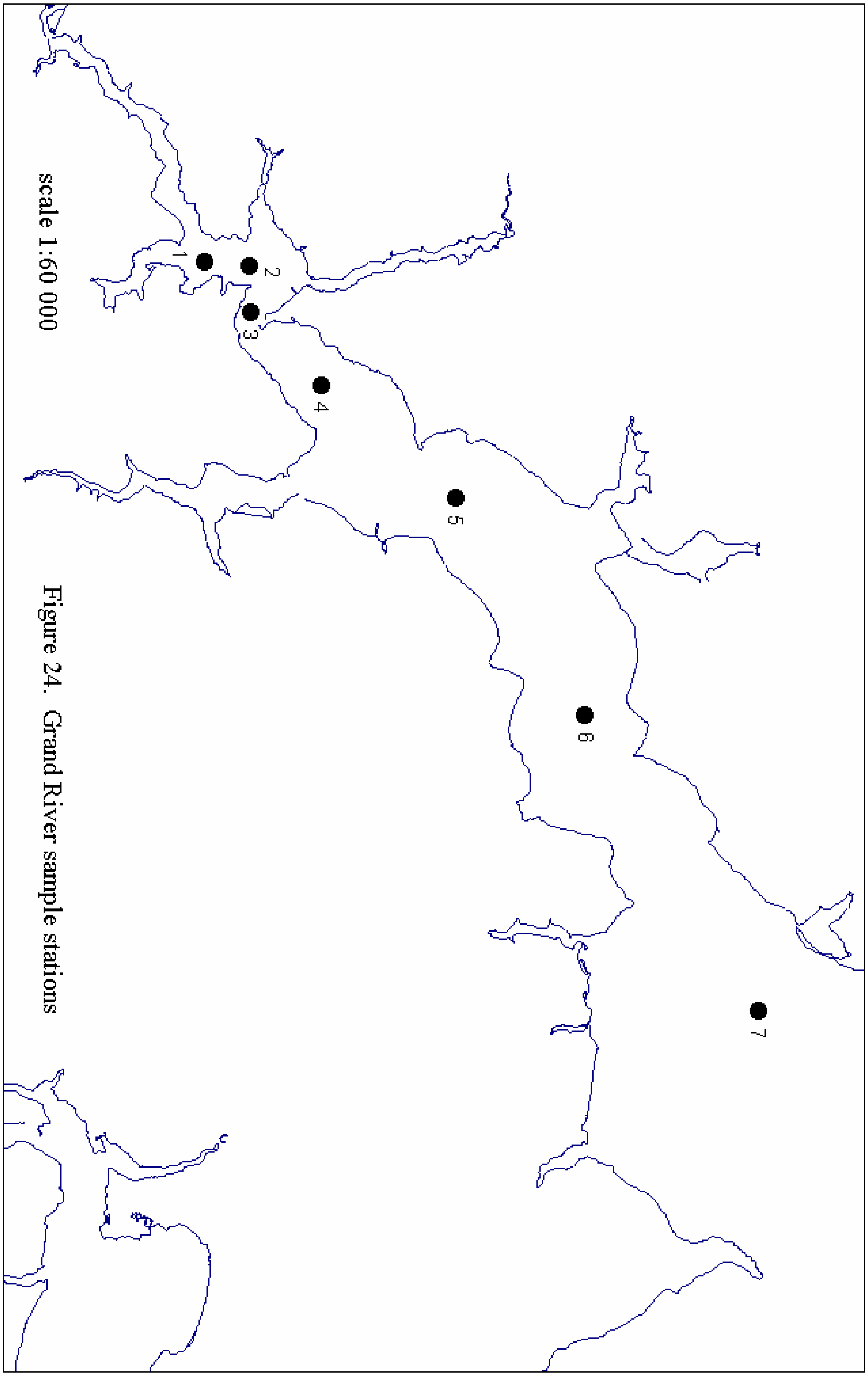


Figure 23. Relationship between 1998 stations and chl a, DO, TN and TP values in Grand River



scale 1:60 000

Figure 24. Grand River sample stations

Hillsborough River

Historical chl *a* and DO values for Hillsborough River, from 1989, 1990 and 1991, are shown in Figures 25 and 26. Only data from between August 4 and August 18 was used. Station 3 produced the highest chl *a* values on 3 of 6 sampling dates (Figure 25). On the other three sampling dates Station 3 had the second highest chl *a* values (Figure 25). The station which exhibited the lowest DO value varied with the date sampled (Figure 26).

In 1998, Station 3 produced the highest chl *a*, TN and TP values (Figure 27). DO readings were consistent throughout the upper estuary stations (Figure 27). **Station 3 is the suggested upper estuary sampling location. Stations 8 and 10 are suggested as middle and lower stations respectively.**

Historical results indicate that early August is best for time of year for finding a combination of high chl *a* and low DO values in the upper estuary (Figure 28). Figure 29 is a map of Hillsborough River sampling locations.

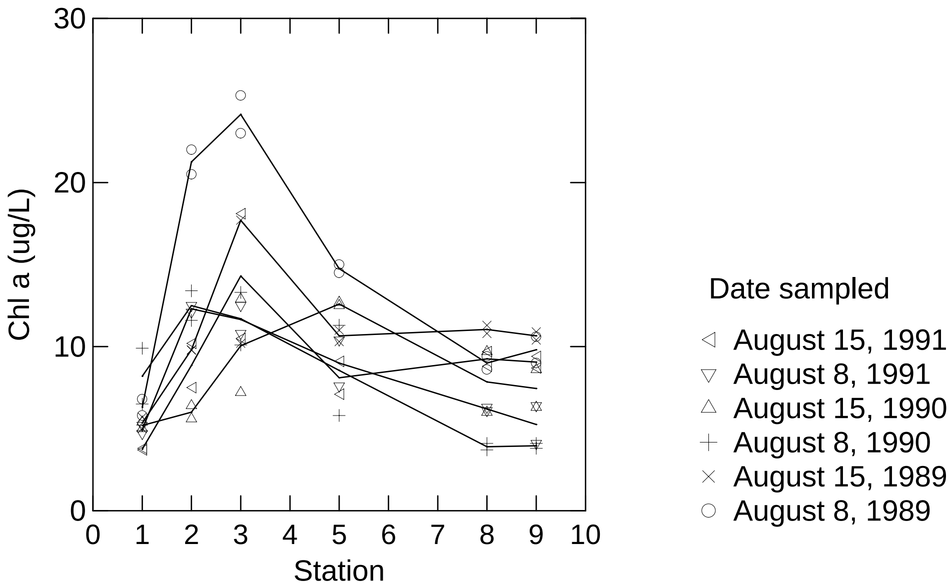


Figure 25. Relationship between historical stations and chl a values in Hillsborough River

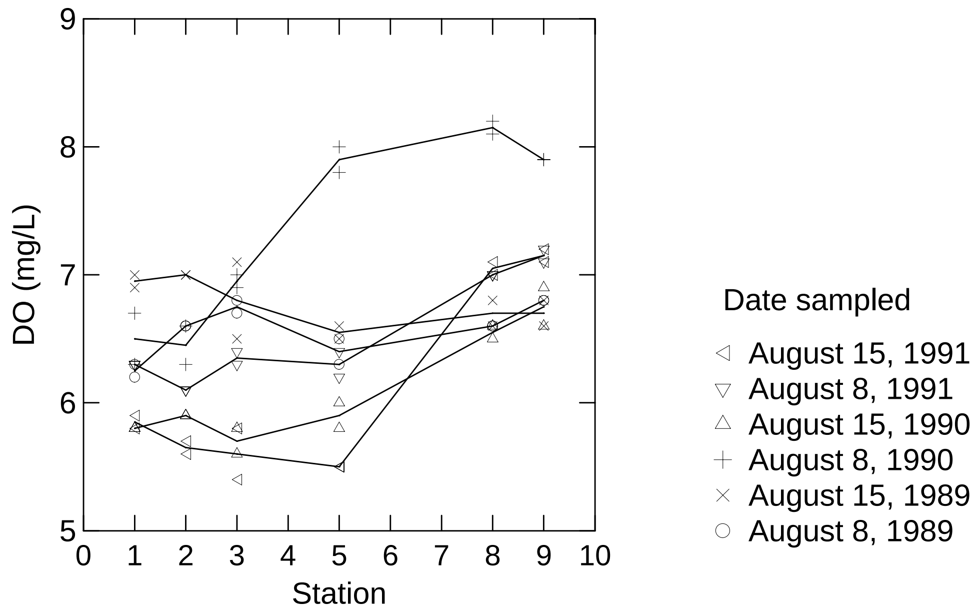


Figure 26. Relationship between historical stations and DO values in Hillsborough River

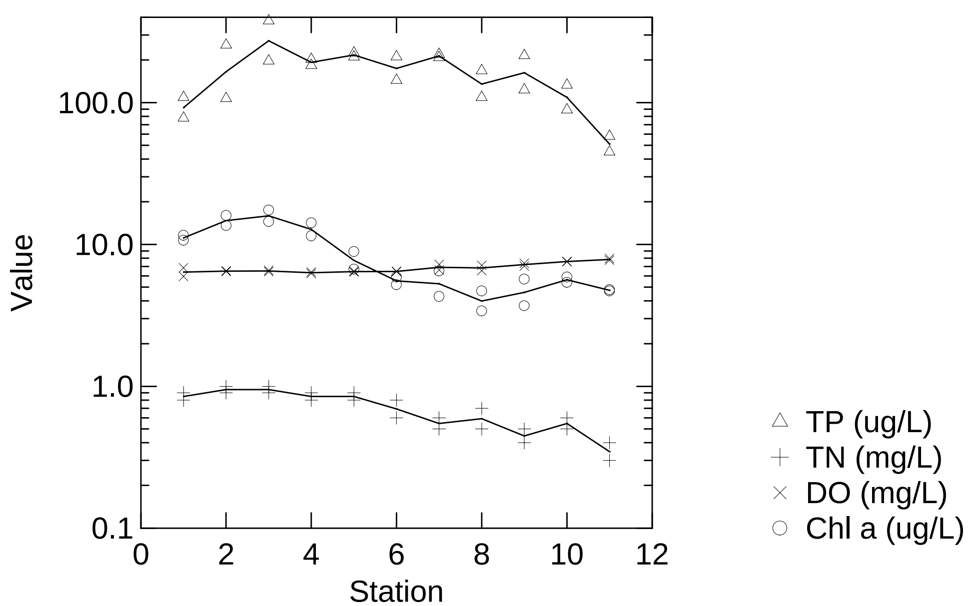


Figure 27. Relationship between 1998 stations and chl a, DO, TN and TP values in Hillsborough River

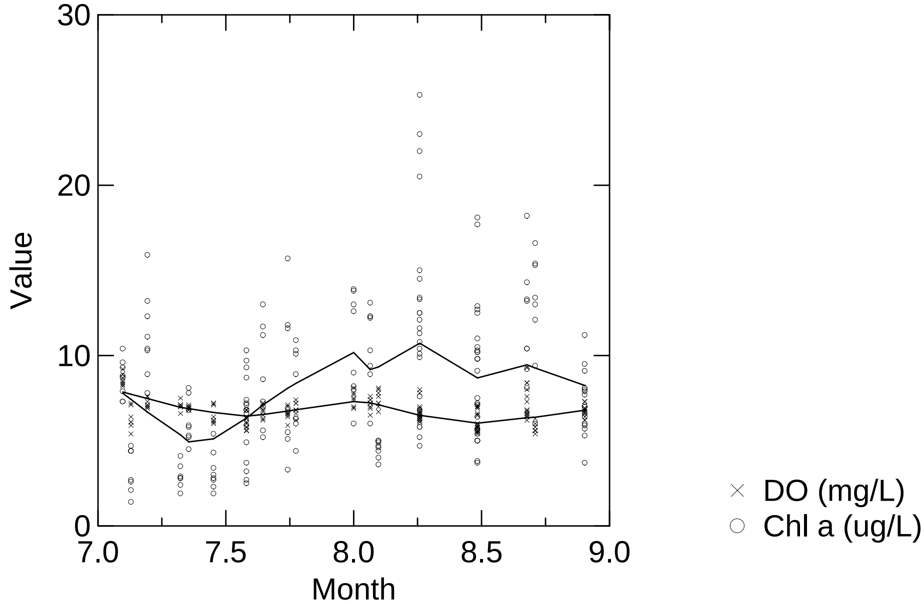


Figure 28. Relationship between month and historical chl a and DO values in upper Hillsborough River

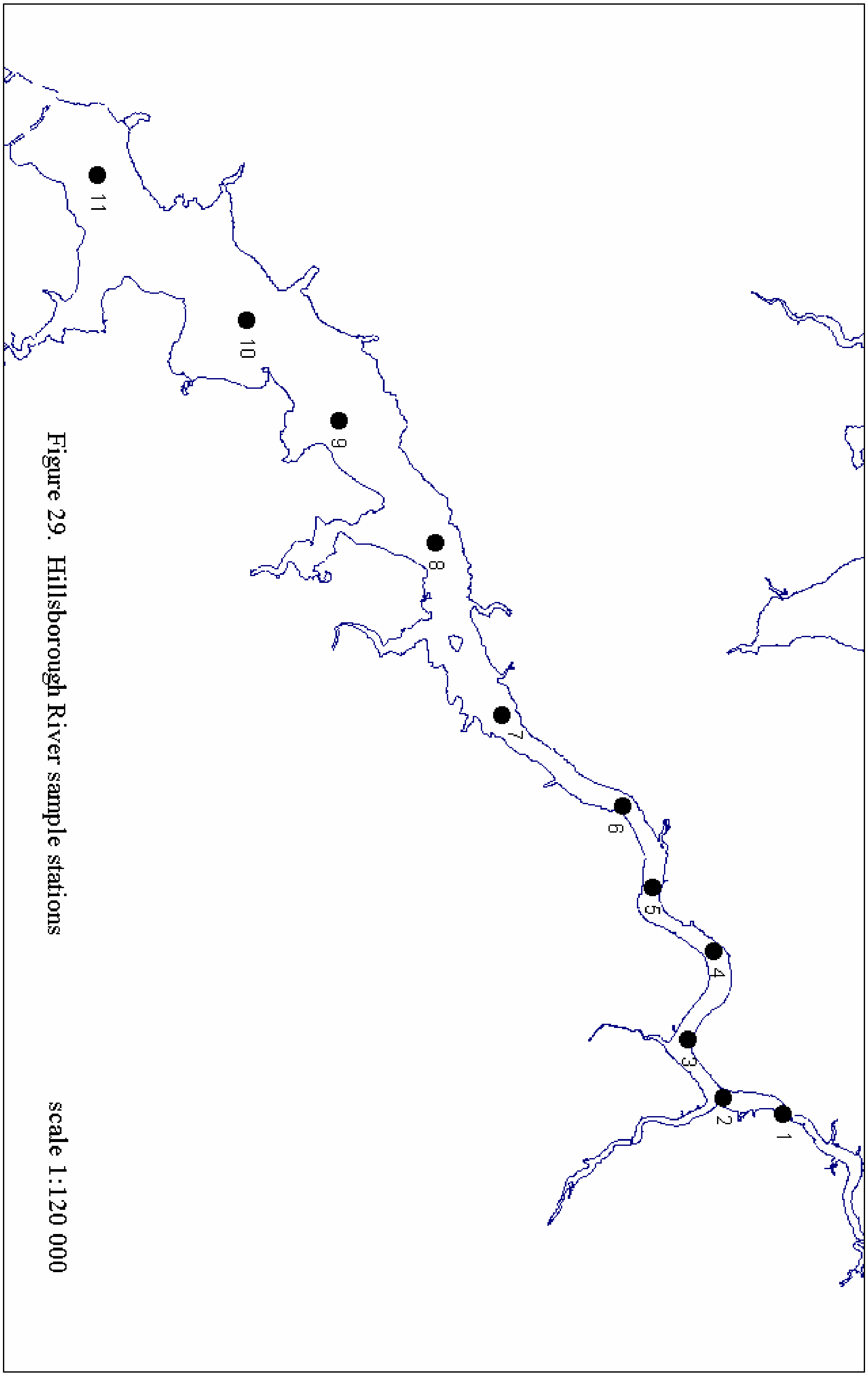


Figure 29. Hillsborough River sample stations scale 1:120 000

Kildare River

No historical data for Kildare River is available. In 1998 Chl *a* readings were consistent throughout the first three upper estuary stations and DO readings are lowest at Station 1 (Figure 30). **Station 1 is the suggested upper estuary sampling location**. **Stations 5 and 7 are suggested as middle and lower stations respectively.** Figure 31 is a map of Kildare River sampling locations.

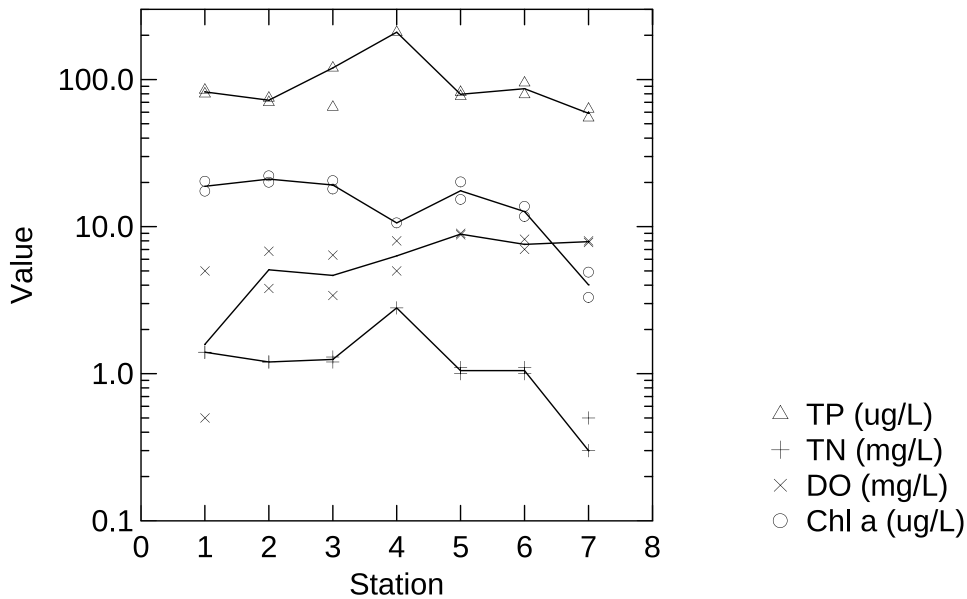


Figure 30. Relationship between 1998 stations and chl a, DO, TN and TP values in Kildare River

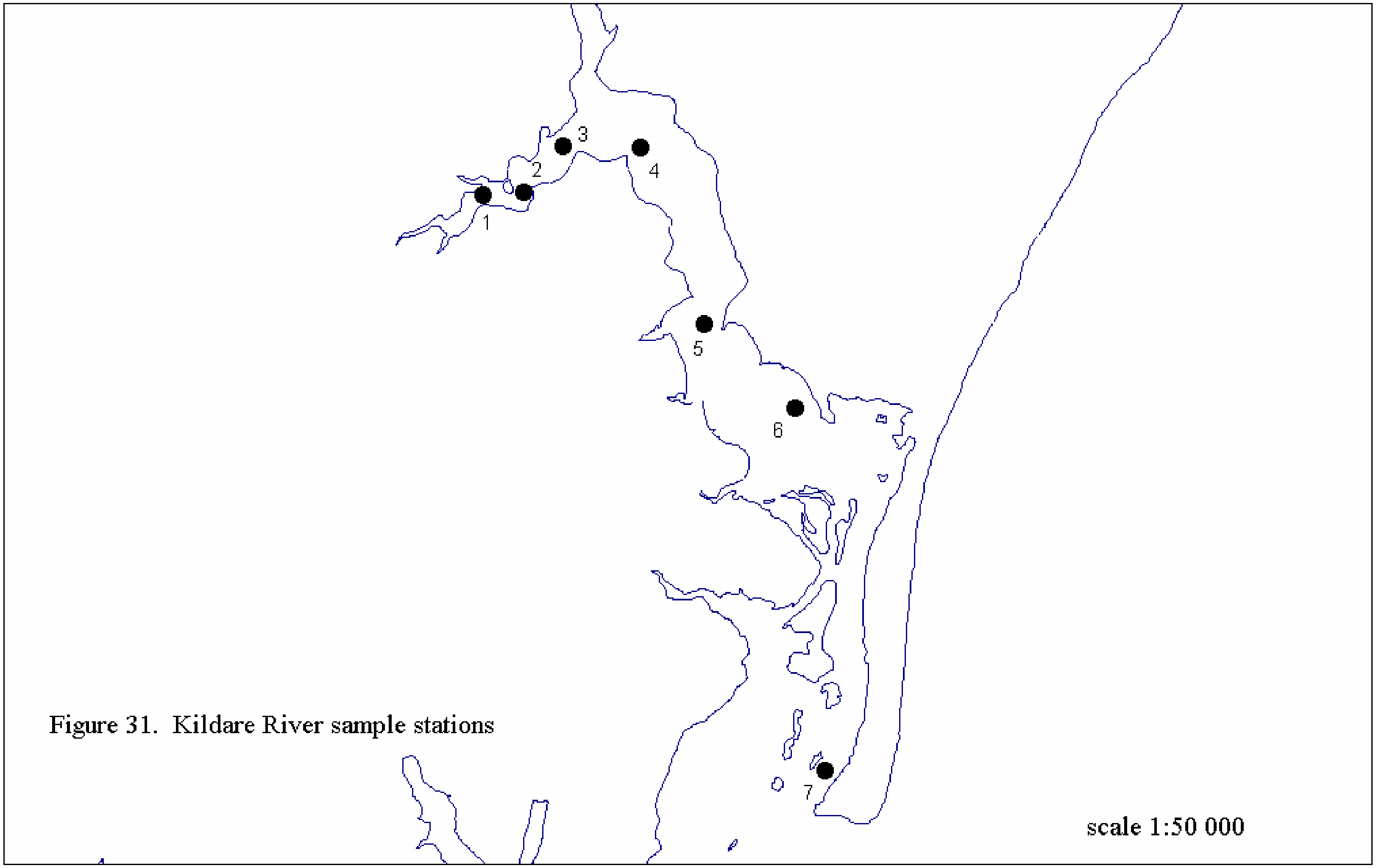


Figure 31. Kildare River sample stations

Mill River

Historical chl *a* and DO values for Mill River are shown in Figures 32 and 33 respectively. Only data which was sampled between July 14 and July 29 was used. Station 1 produced higher chl a values than Station 3 and lower DO values than Station 3.

Station 1 produced the highest chl *a*, TN and TP values in 1998 (Figure 34). DO readings are consistent throughout the upper estuary stations (Figure 34). **Station 1 is the suggested upper estuary sampling location**. **Stations 5 and 7 are suggested as middle and lower stations respectively.**

Historical results indicate that mid August is the best time of year for finding a combination of high chl *a* and low DO values in the upper estuary (Figure 35). Figure 36 is a map of the Mill River sampling locations.

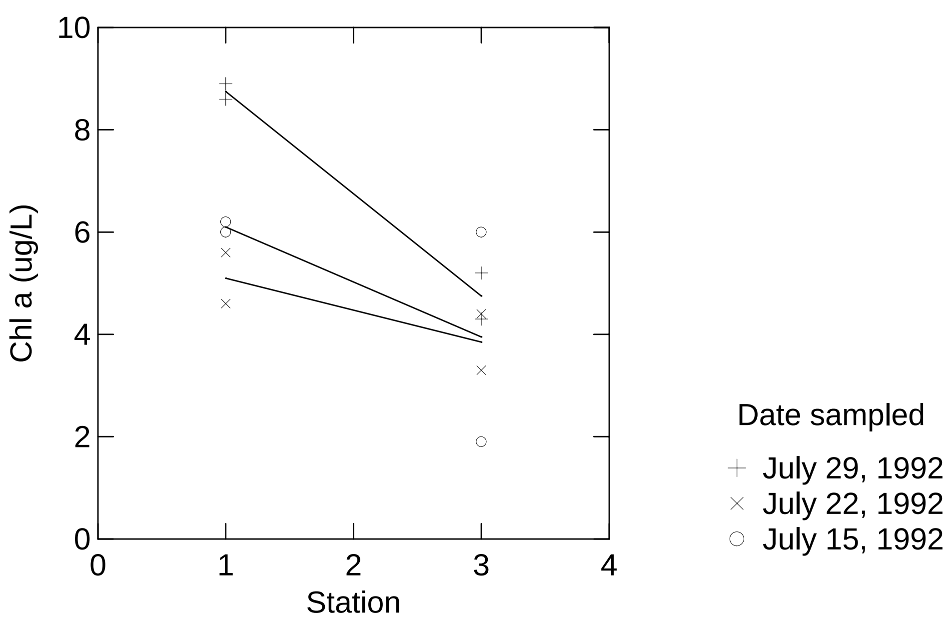


Figure 32. Relationship between historical stations and chl a values in Mill River

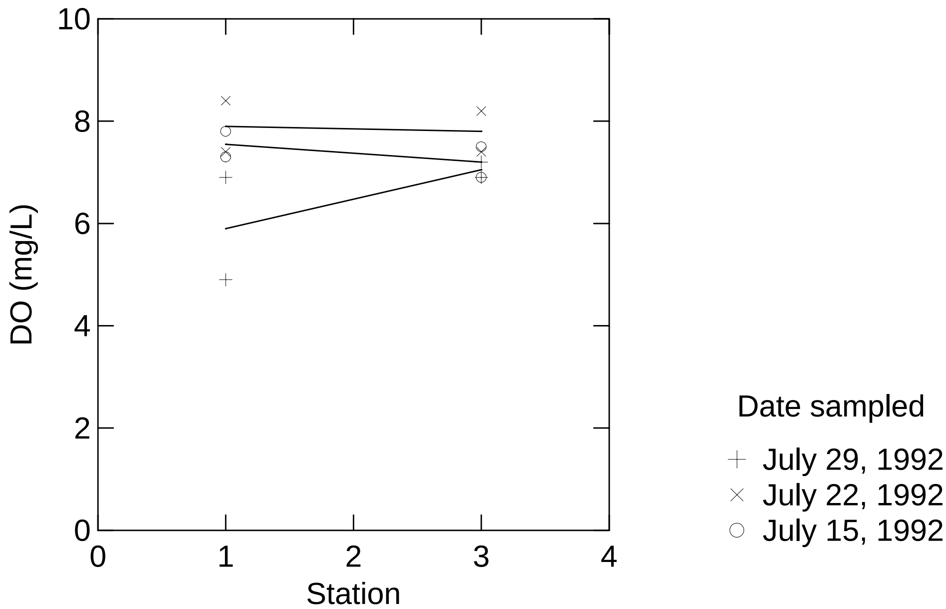


Figure 33. Relationship between historical stations and DO values in Mill River

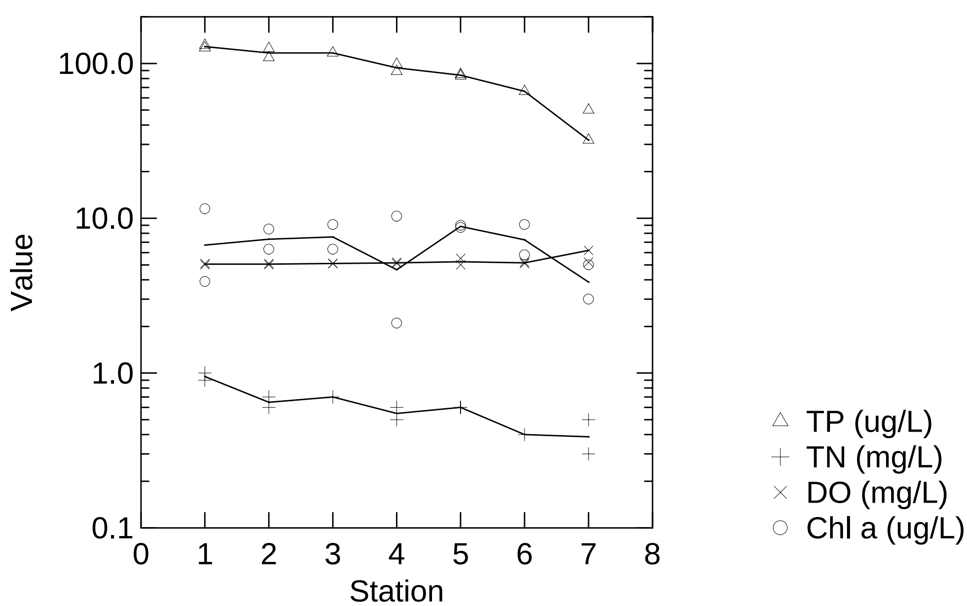


Figure 34. Relationship between 1998 stations and chl a, DO, TN and TP values in Mill River

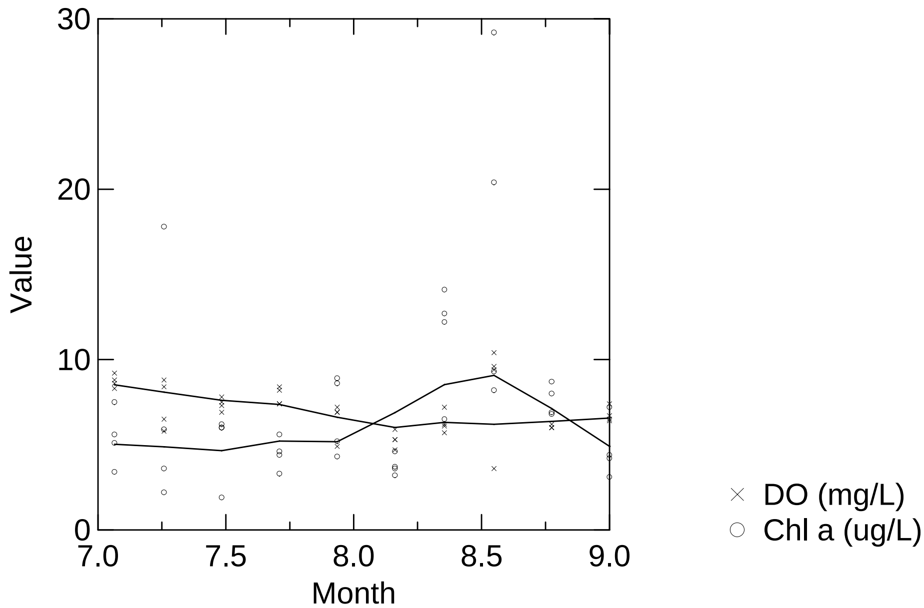


Figure 35. Relationship between month of year and historical chl a and DO values in upper Mill River

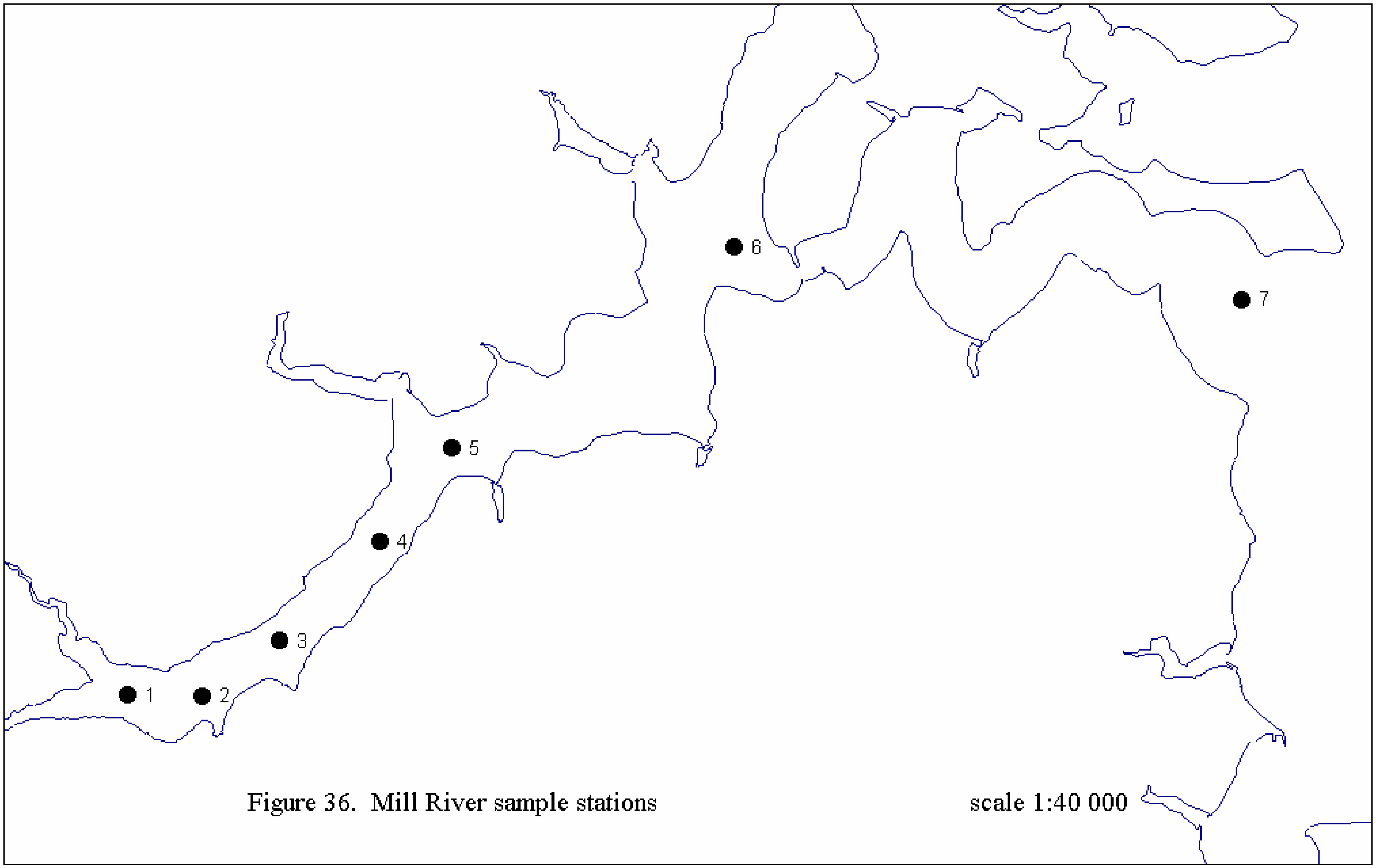


Figure 36. Mill River sample stations

scale 1:40 000

Montague River

No historical or 1998 DO data is available for Montague River. In 1998 Station 2 produced the highest chl *a* values along with high TN and TP values relative to other stations (Figure 37). **Station 2 is the suggested upper estuary sampling location**. **Stations 6 and 7 are the suggested middle and lower stations respectively.** Figure 38 is a map of Montague River sampling locations.

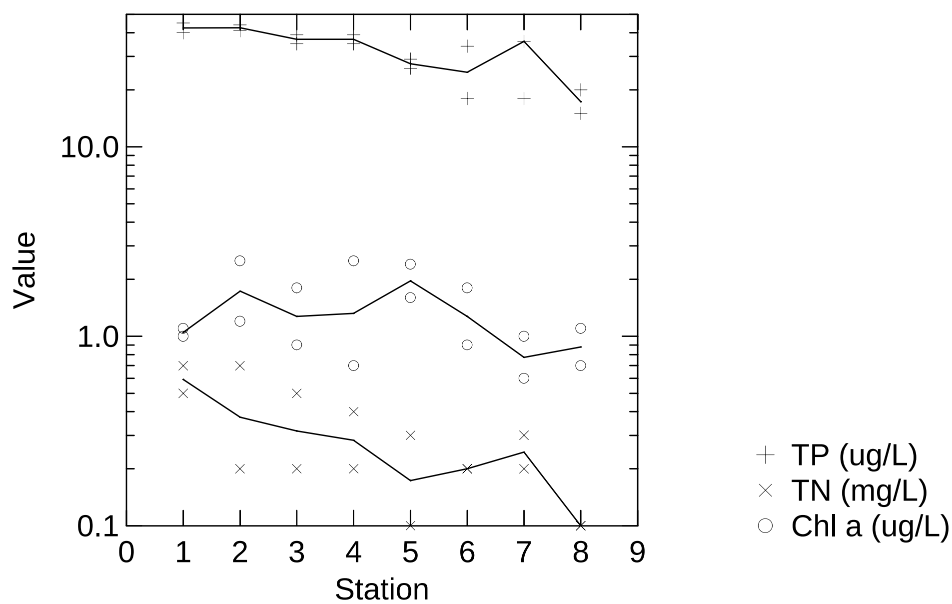


Figure 37. Relationship between chl a, TN and TP values for Montague River

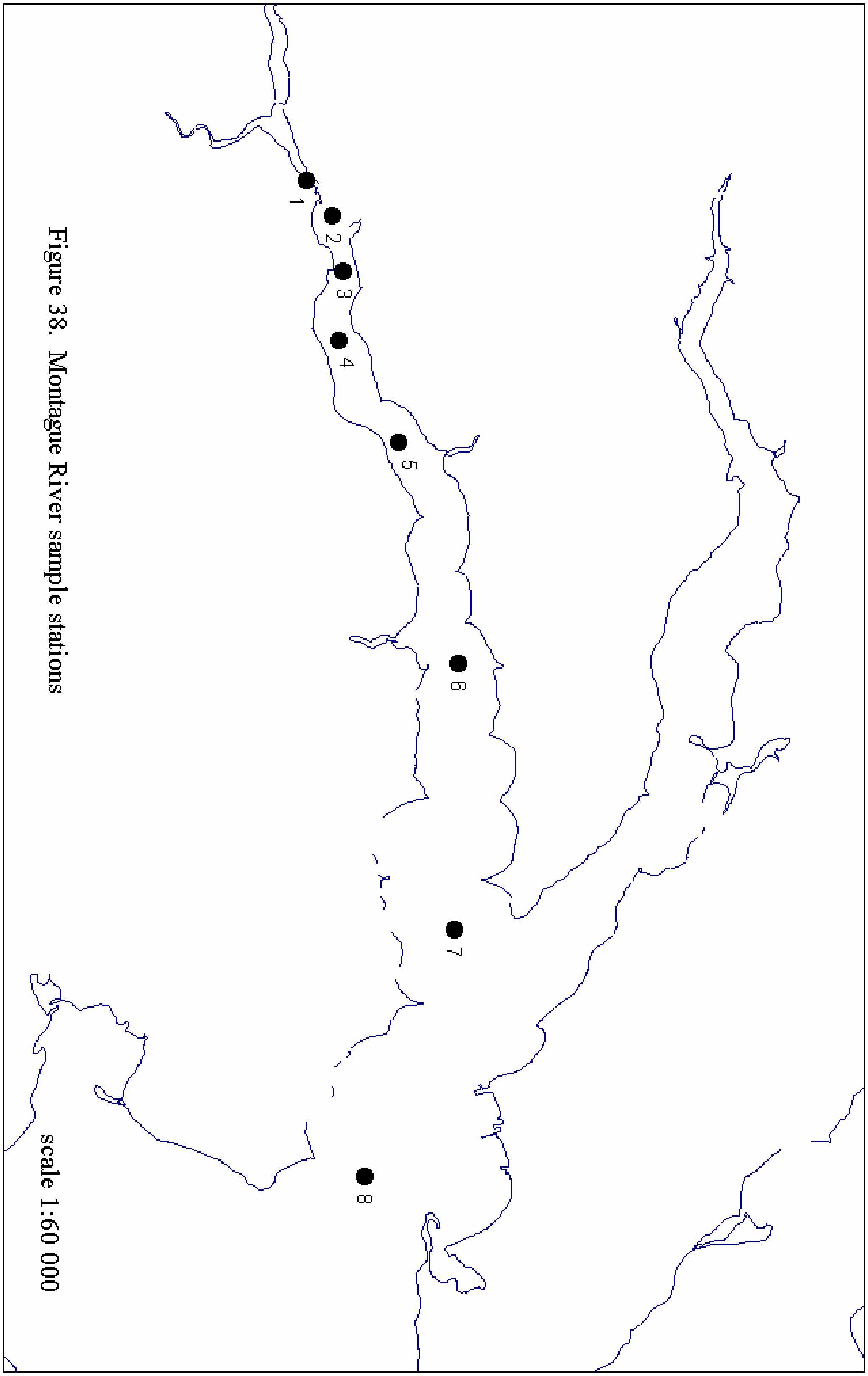


Figure 38. Montague River sample stations

Murray River

No historical data for Murray River is available. In 1998, Station 1 produced the highest chl *a* values along with high TN and TP values relative to other stations (Figure 39). DO readings were lowest at station 1. **Station 1 is the suggested upper estuary sampling location**. **Stations 5 and 6 are suggested as middle and lower stations respectively**. Figure 40 is a map of Murray River sampling locations.

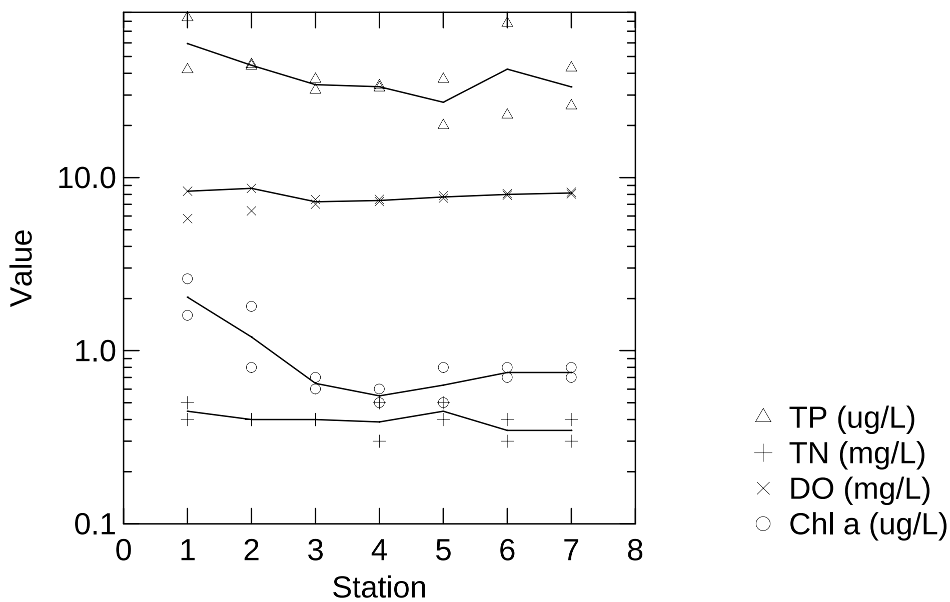


Figure 39. Relationship between 1998 stations and chl a, DO, TN and TP values for Murray River

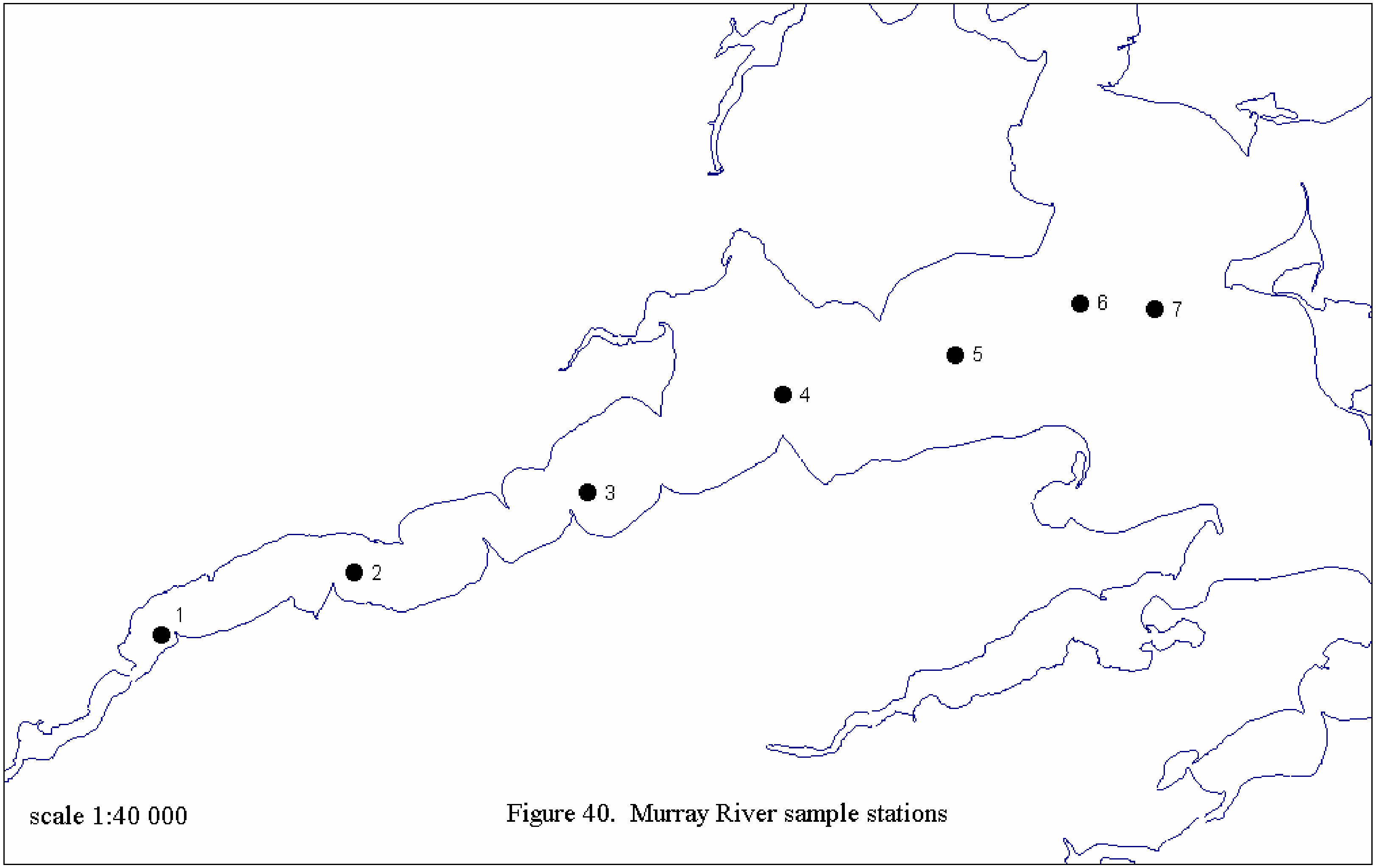


Figure 40. Murray River sample stations

New London Bay

The upper area of New London (Trout River) was not sampled during July and August so data from May 29, 1998 was used to identify a suggested upper estuary sampling location. Historical data was not available for locations which corresponded to the May, 1998 stations. Data from the two uppermost estuary stations, for which historical data was available, was however used to determine the best time of year for sampling.

In the May, 1998 sampling, Station 4 had the second highest chl *a* values and the lowest DO readings (Figure 41). Station 6 has the highest chl *a* values along with high TN and TP values relative to other middle and lower stations (Figure 42). **Station 4 is the suggested upper estuary sampling location. Stations 6 and 8 are suggested as middle and lower stations respectively.**

Historical results indicate that mid August is the best time of year for finding a combination of high chl *a* and low DO values in the upper estuary (Figure 43). Figure 44 is a map of New London sampling locations.

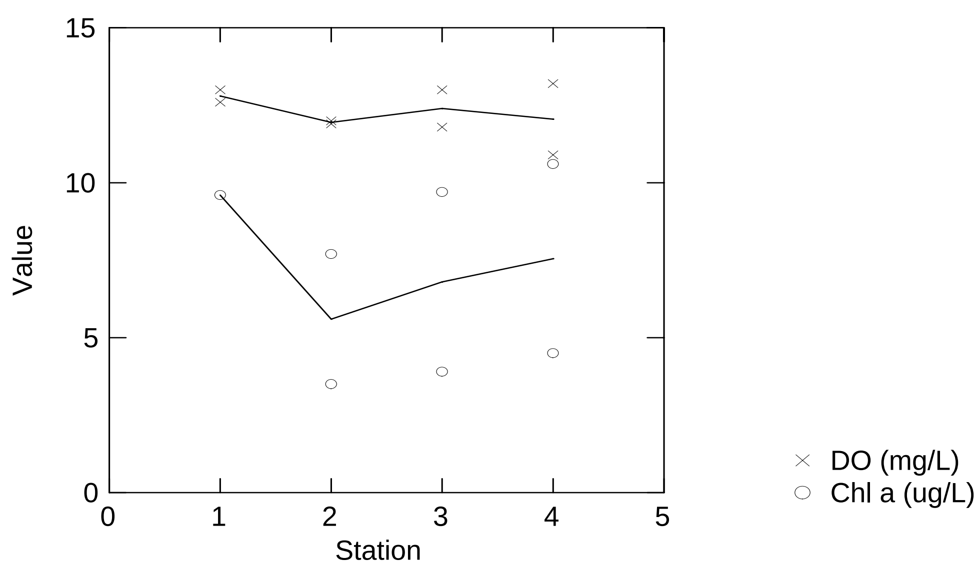


Figure 41. Relationship between 1998 stations and chl a and DO values in Trout River

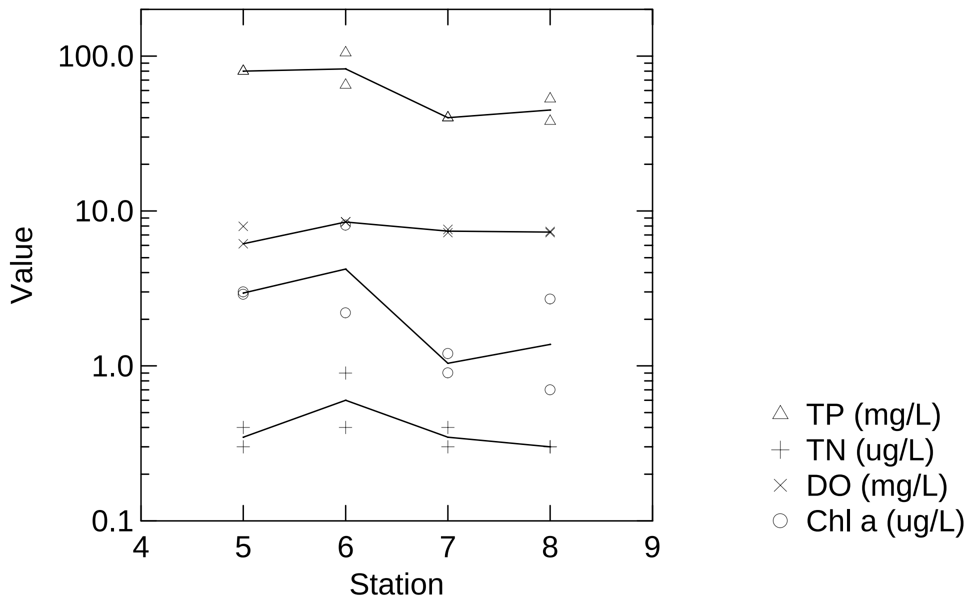


Figure 42. Relationship between 1998 middle and lower stations and chl a, DO, TN and TP values in New London Bay

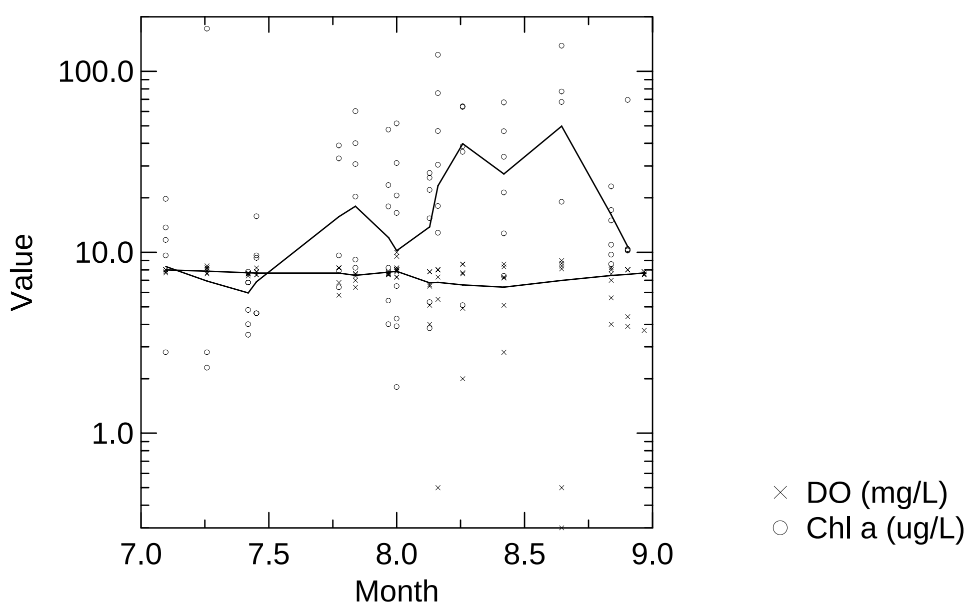


Figure 43. Relationship between month and historical chl a and DO values in upper New London Bay

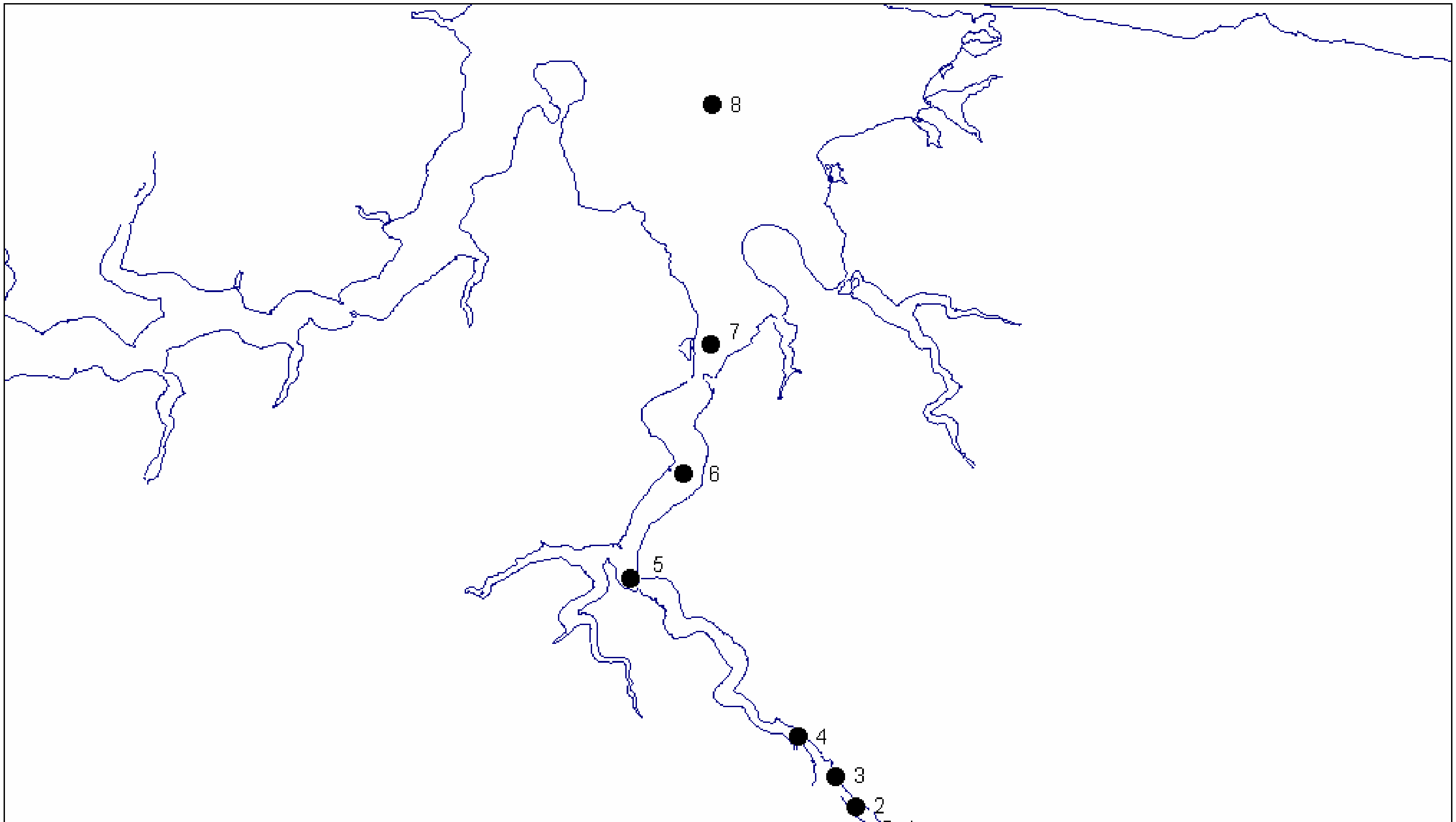


Figure 44. New London Bay sample stations

North River

No historical data for North River is available. In 1998, Station 1 produced the highest chl *a* values along with high TN and TP values relative to other stations (Figure 45). DO readings were also lowest at Station 1. **Station 1 is the suggested upper estuary sampling location**. **Stations 6 and 7 are suggested as middle and lower stations respectively**. Figure 46 is a map of North River sampling locations.

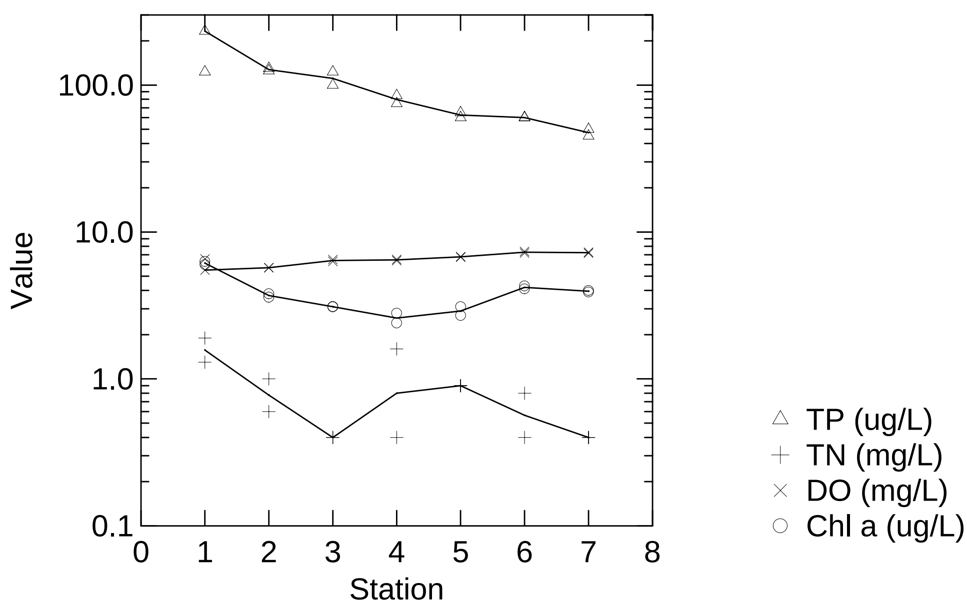


Figure 45. Relationship between 1998 stations and chl a, DO, TN and TP values in North River

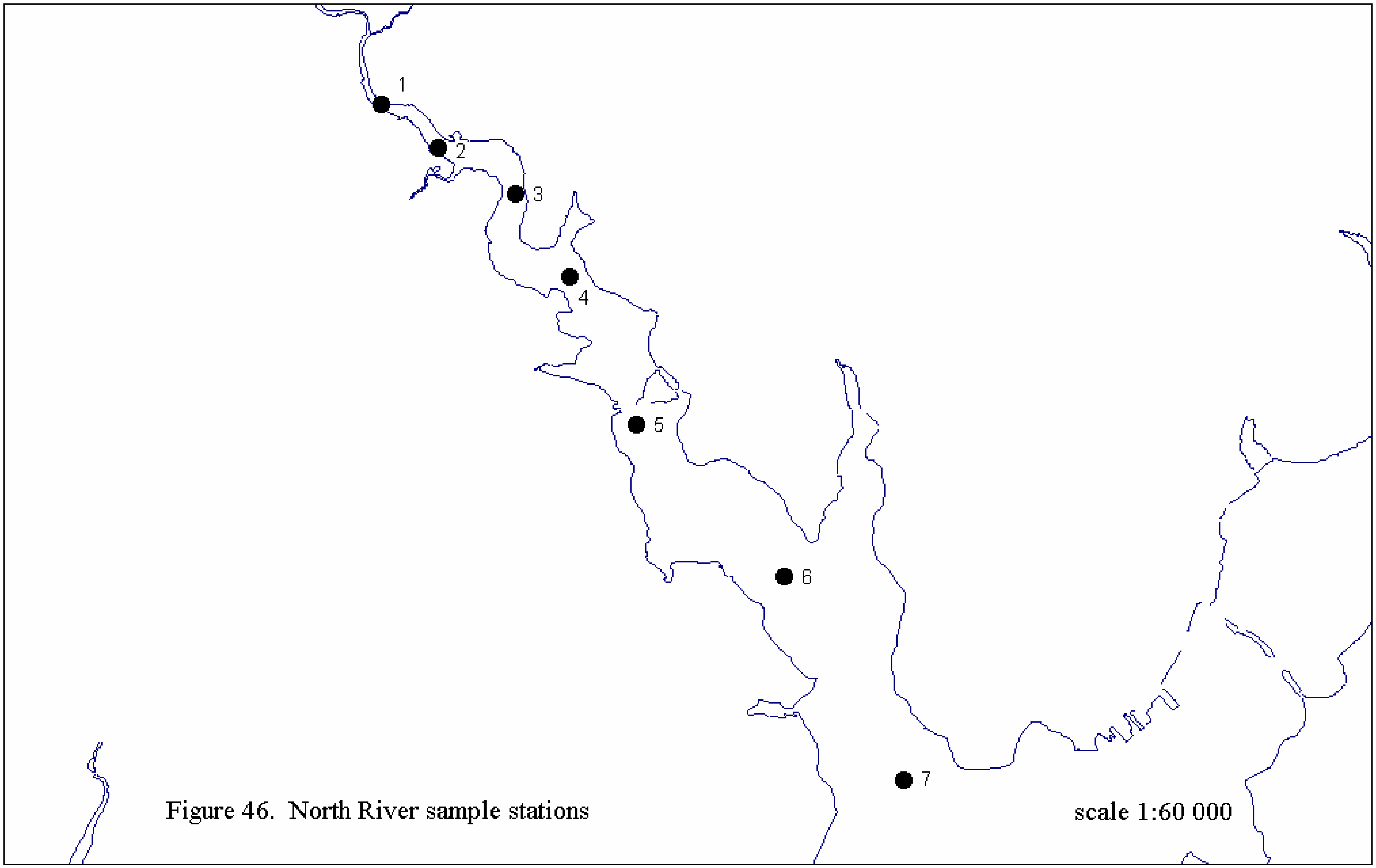


Figure 46. North River sample stations

Orwell Bay

No historical data for Orwell Bay is available. In 1998, Station 3 produced the highest chl *a* values and DO readings were consistent throughout the upper estuary stations (Figure 47). **Station 3 is the suggested upper estuary sampling location**. **Stations 5 and 6 are the suggested middle and lower stations respectively.** Figure 48 is a map of Orwell Bay sampling locations.

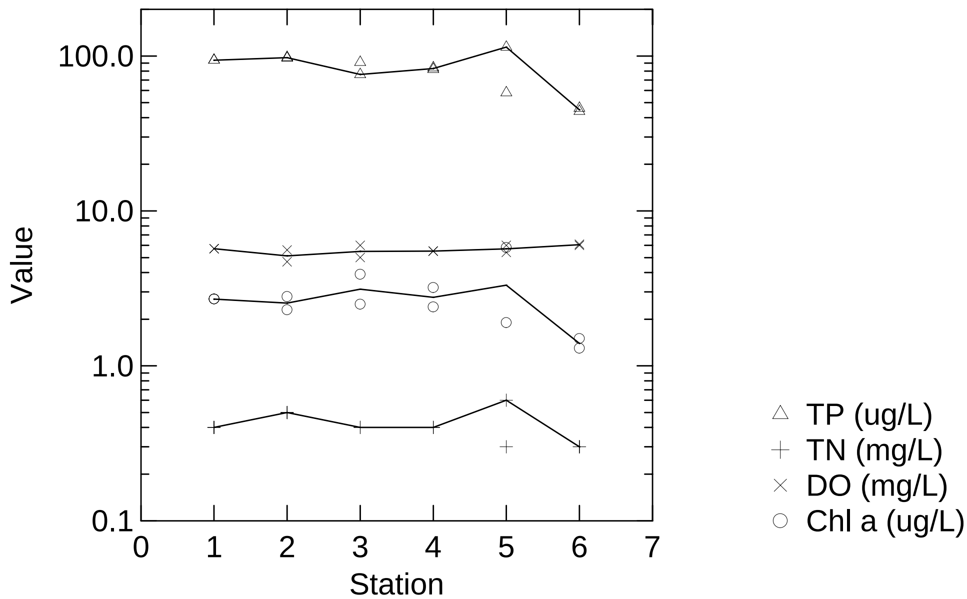


Figure 47. Relationship between 1998 stations and chl a, DO, TN and TP values in Orwell Bay

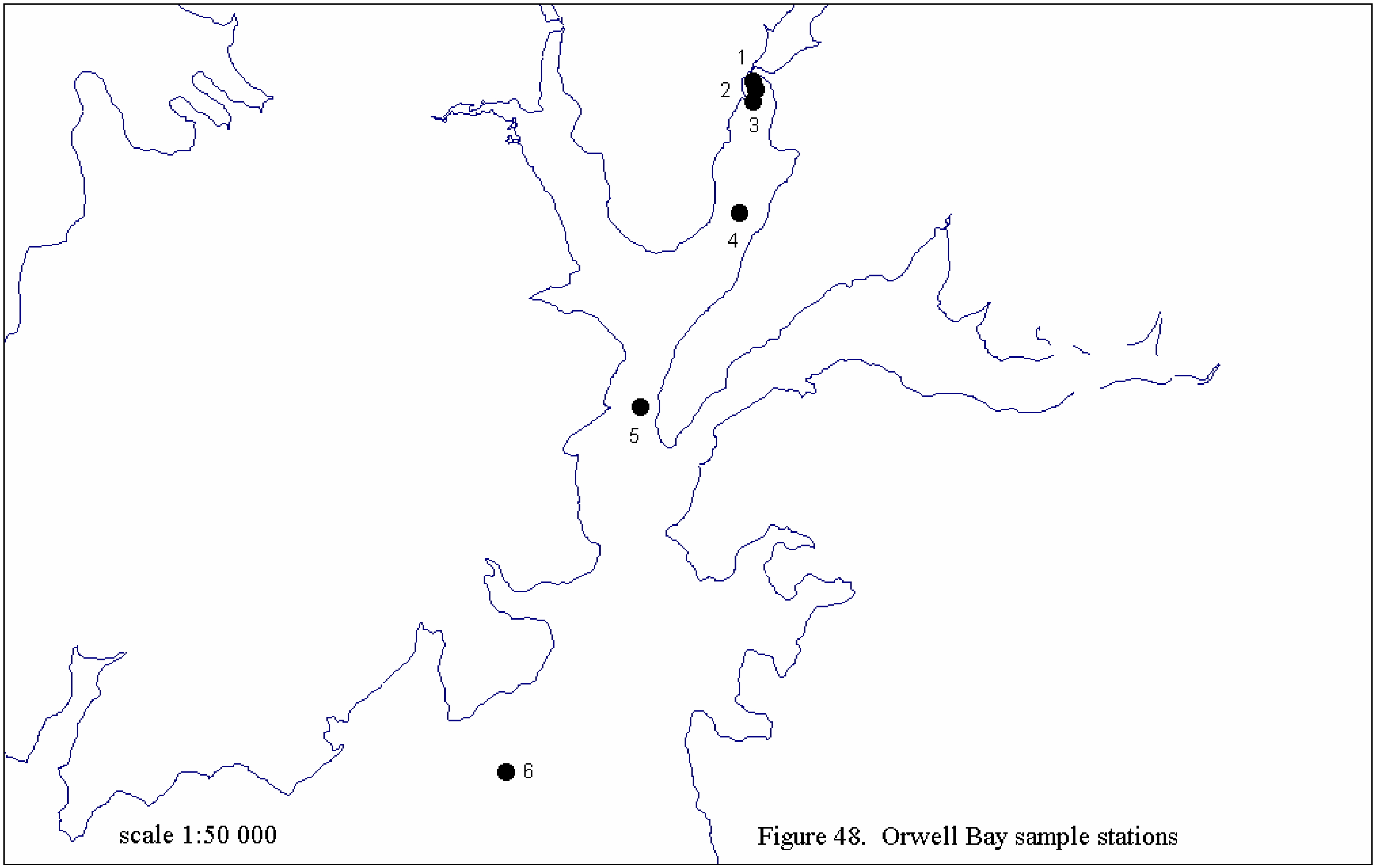


Figure 48. Orwell Bay sample stations

Rustico Bay

No historical data for Rustico is available. In 1998, Station 1 produced the second highest chl *a* readings and the lowest DO readings in the upper estuary stations (Figure 49). **Station 1 is the suggested upper estuary sampling location. Stations 5 and 7 are the suggested middle and lower stations respectively.** Figure 50 is a map of Rustico sampling locations.

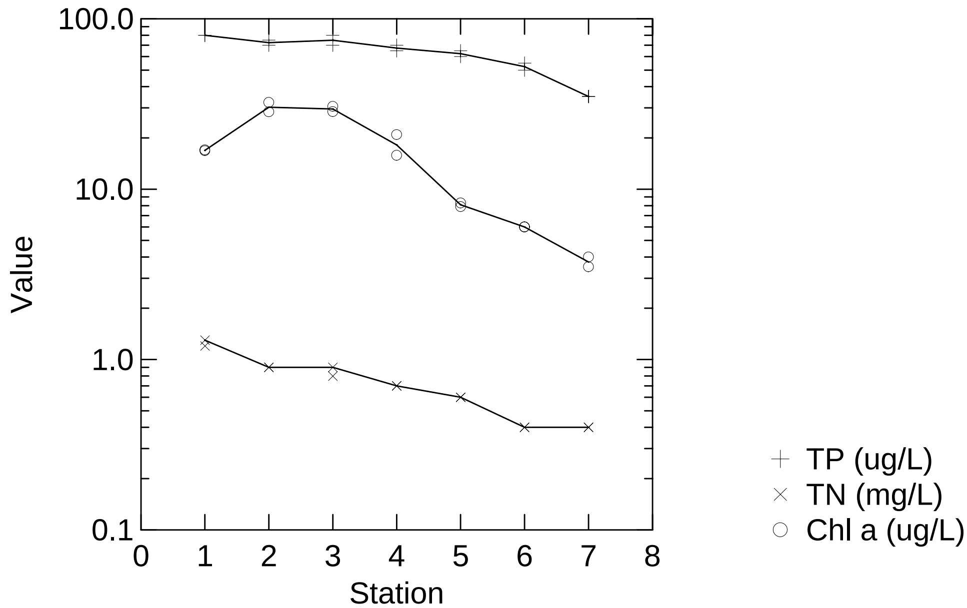


Figure 49. Relationship between 1998 stations and chl a, TN and TP values in Rustico Bay

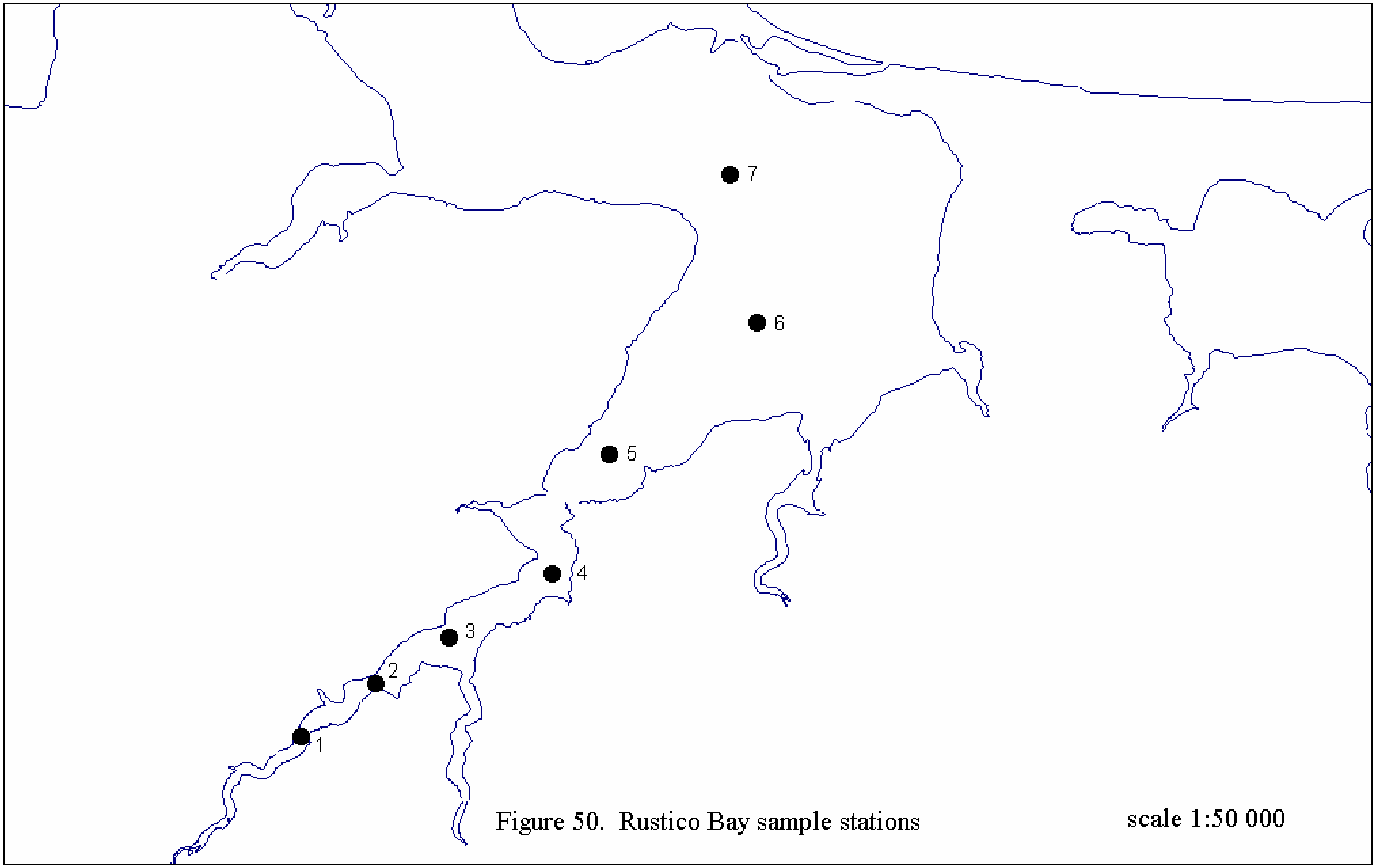


Figure 50. Rustico Bay sample stations

Southwest River

No historical data for Southwest River is available. In 1998, Station 3 produced the highest chl *a* readings followed by Station 2. DO readings are lowest at Station 1 (Figure 51). **Station 1 is the suggested upper estuary sampling location**. **Stations 5 and 6 are suggested as middle and lower stations respectively.** Figure 52 is a map of Southwest River sampling locations.

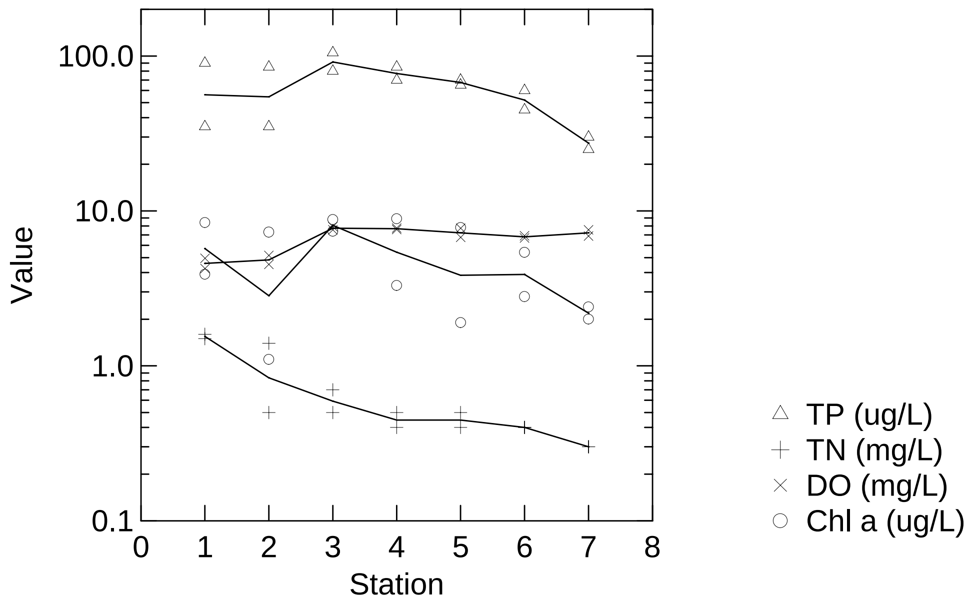


Figure 51. Relationship between 1998 stations and chl a, DO, TN and TP values in Southwest River

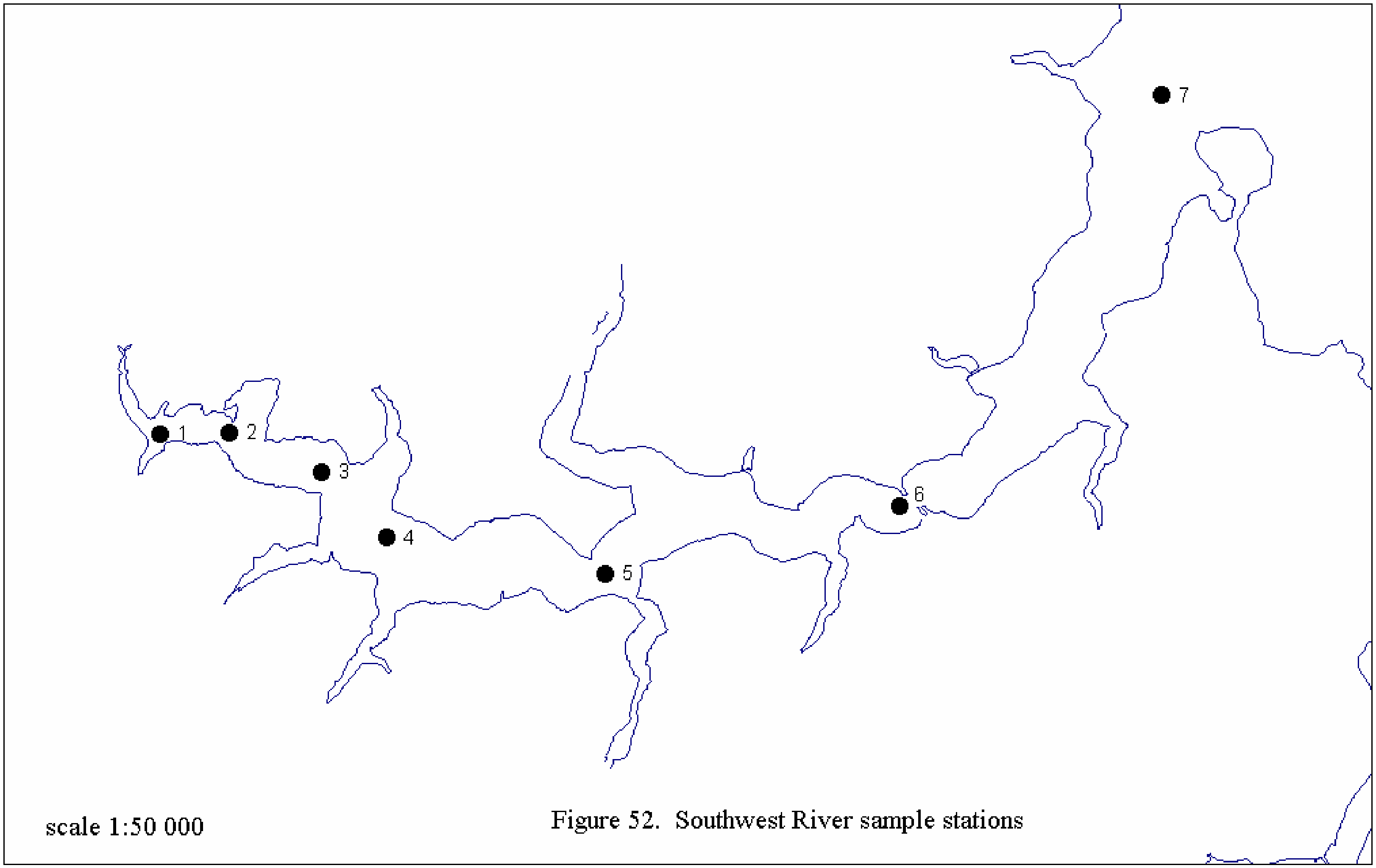


Figure 52. Southwest River sample stations

St. Peter’s Bay

Historical chl a and DO values for St. Peter’s, from 1988 and 1989, are shown in Figures 53 and 54 respectively. Only data obtained between July 20 and August 03 was used. Station 1 produced the highest chl *a* values (Figure 53) and Station 5 the lowest DO values (Figure 54). However Station 1 is the only station, for which historical data is available, which is also considered an upper estuary station.

In 1998, Station 4 produced the highest chl *a* values and the lowest DO readings in the upper estuary (Figure 55). **Station 4 is the suggested upper estuary sampling location. Stations 5 and 6 are suggested as middle and lower stations respectively**.

Historical results indicate that mid August is best for time of year for finding a combination of high chl a and low DO values in the upper estuary (Figure 56). Figure 57 is a map of St. Peter’s Bay sampling locations.

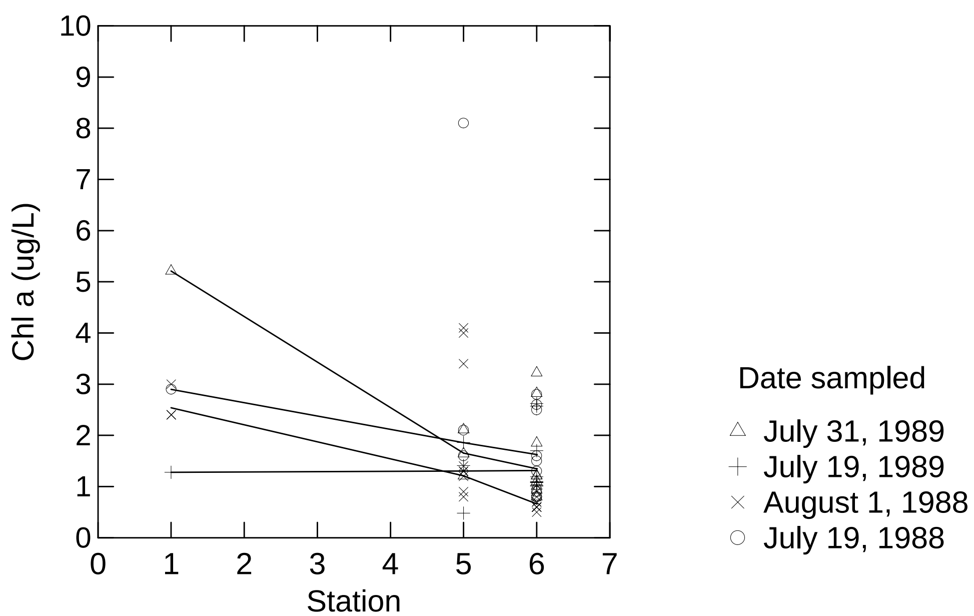


Figure 53. Relationship between historical stations and chl a values in St. Peter's Bay

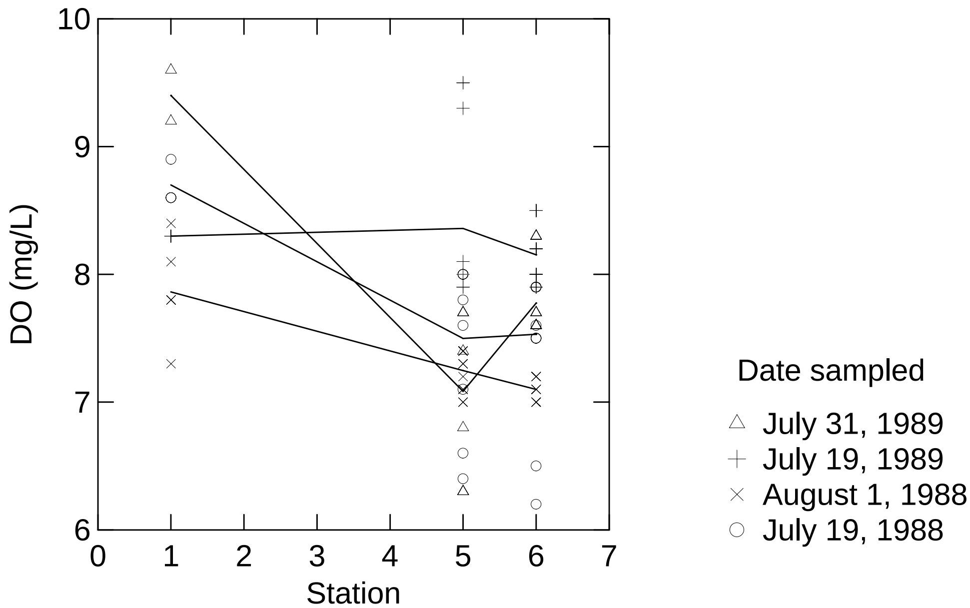


Figure 54. Relationship between historical stations and DO values in St. Peter's Bay

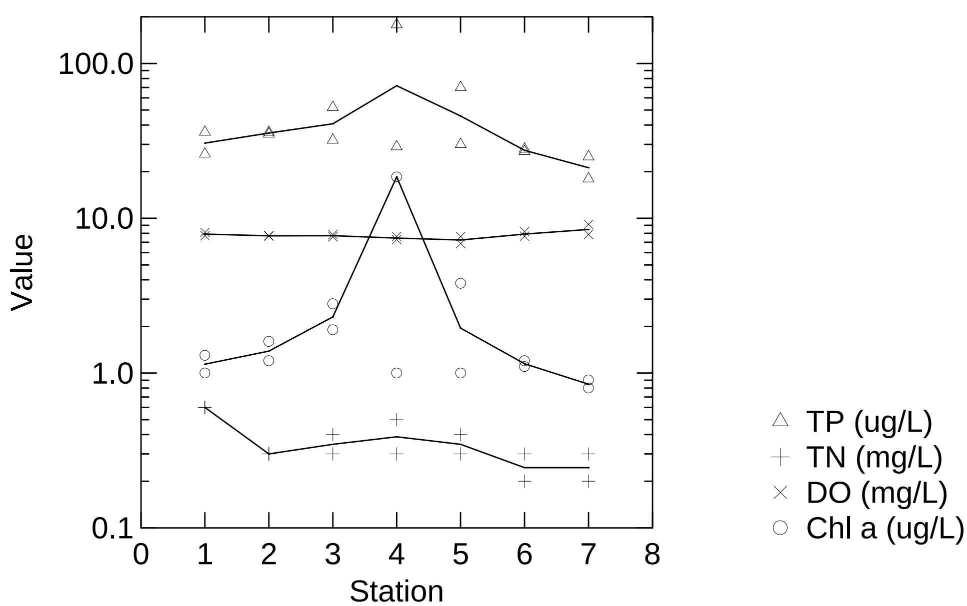


Figure 55. Relationship between 1998 stations and chl a, DO, TN and TP values in St. Peter's Bay

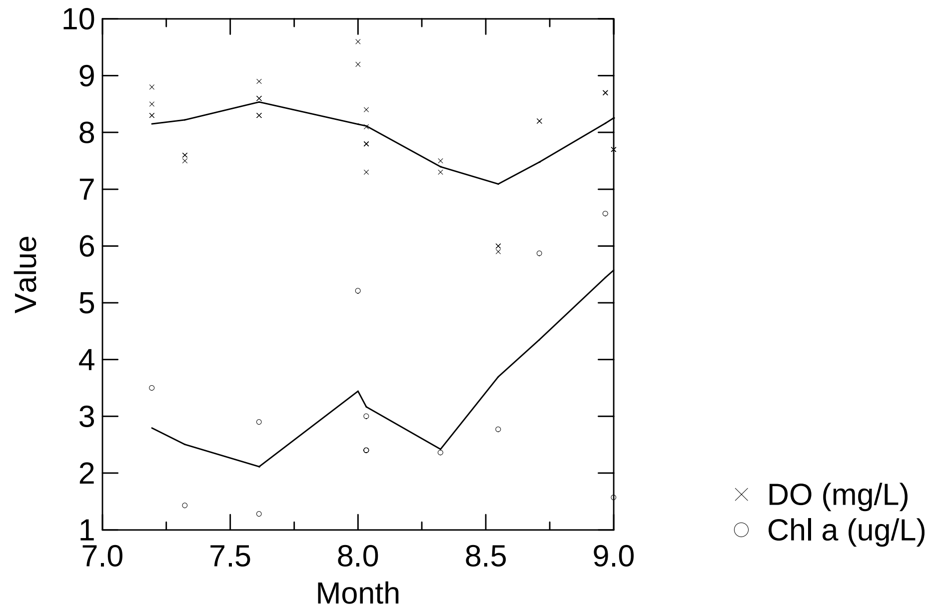


Figure 56. Relationship between month and historical chl a and DO values in upper St Peter's Bay

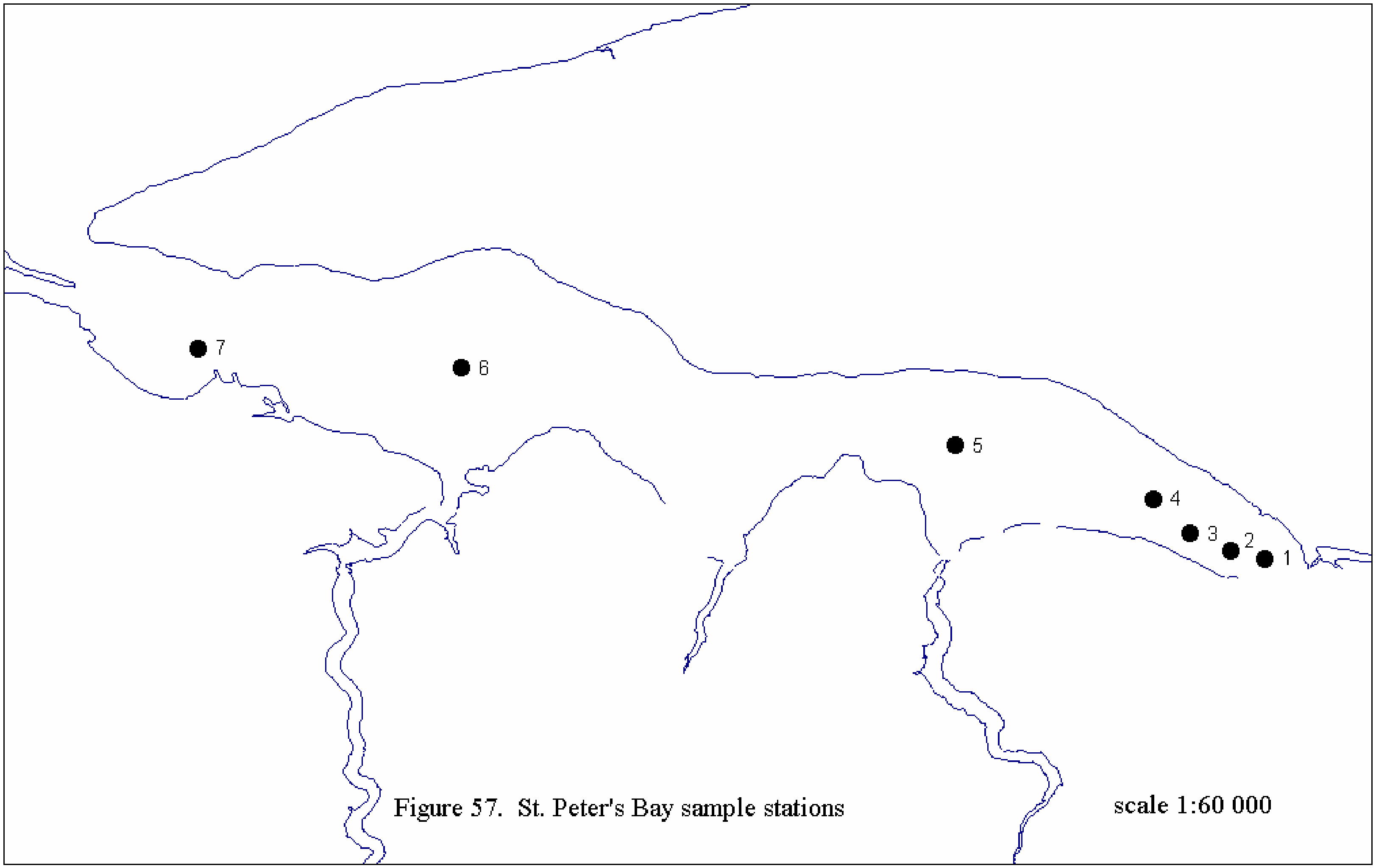


Figure 57. St. Peter's Bay sample stations

Tracadie Bay

No historical data for Tracadie Bay is available. In 1998, Station 4 had high chl *a* and TP values and DO readings were consistent throughout the upper estuary stations (Figure 58). **Station 4 is the suggested upper estuary sampling location**. **Stations 5 and 6 are suggested as middle and lower stations respectively.** Figure 59 is a map of Tracadie Bay sampling locations.

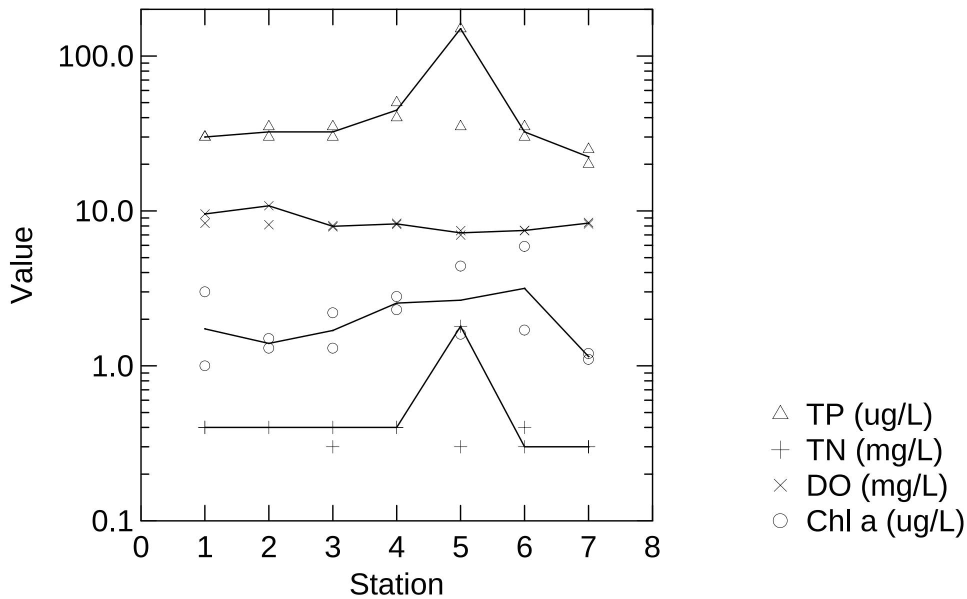


Figure 58. Relationship between 1998 stations and chl a, DO, TN and TP values in Tracadie Bay

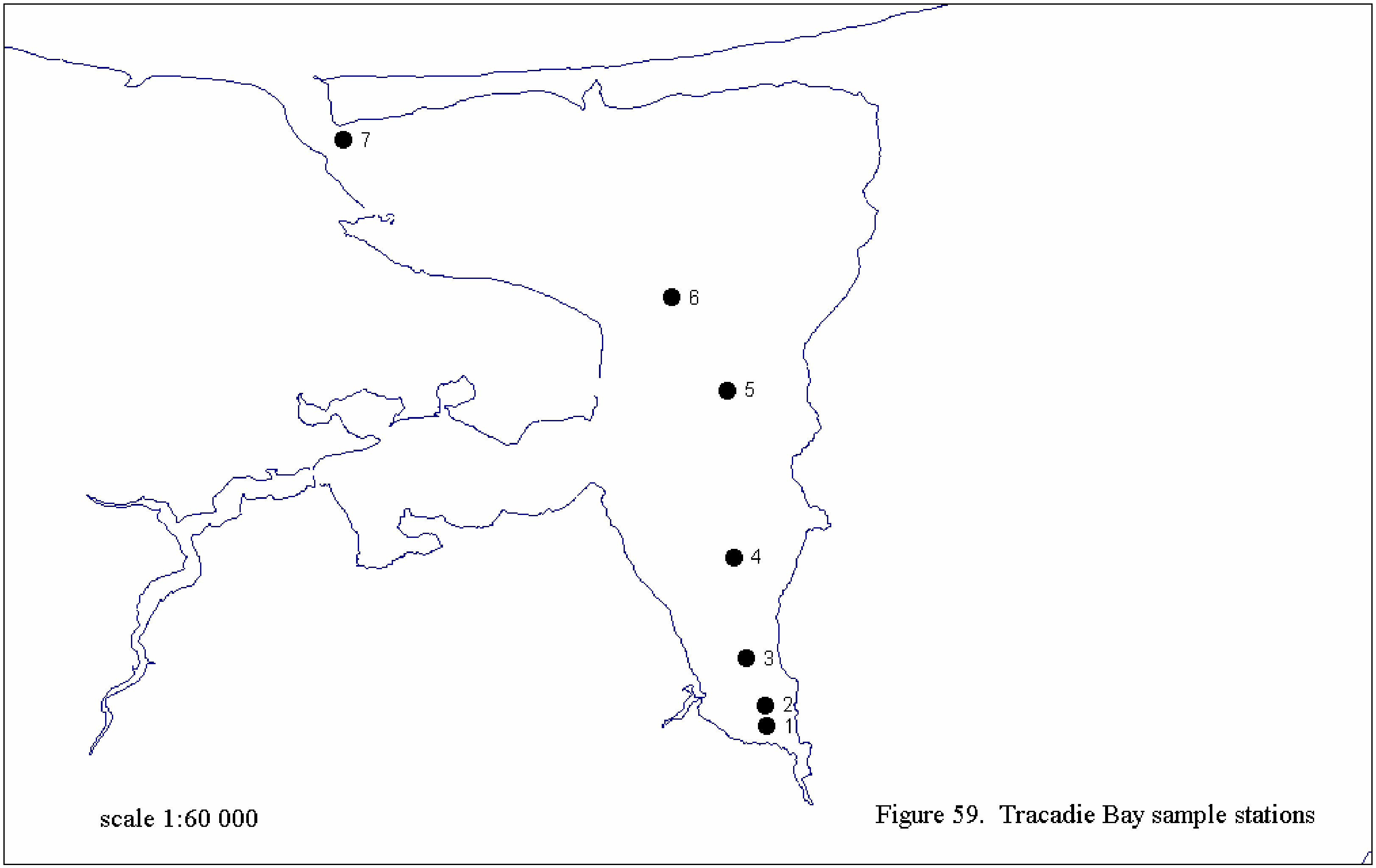


Figure 59. Tracadie Bay sample stations

West River

Historical chl *a* and DO values for West River are shown in Figures 60 and 61 respectively. Only data which was obtained between July 15 and July 21 was used. Station 1 produced the highest chl *a* values (Figure 60) and lowest DO values (Figure 61).

In 1998, chl *a* and DO values were consistent throughout the upper estuary, while Station 5 had slightly elevated chl *a* values and Station 1 had the lowest DO values (Figure 62). **Station 1 is the suggested upper estuary sampling location. Stations 5 and 6 are suggested as middle and lower stations respectively.**

Historical results indicate that early August is the best time of year for finding a combination of high chl *a* and low DO values in the upper estuary (Figure 63). Figure 64 is a map of West River sampling locations.

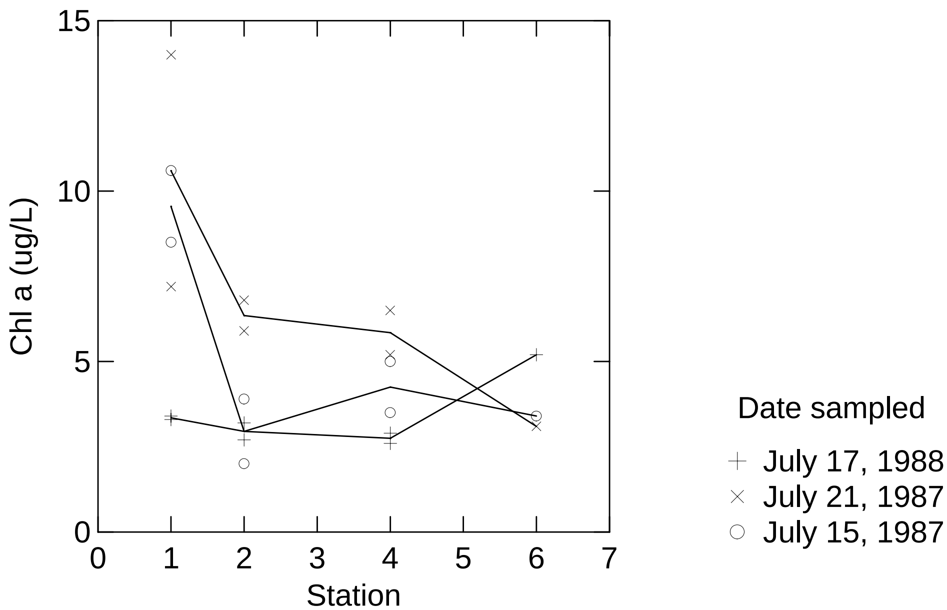


Figure 60. Relationship between historical stations and chl a values in West River

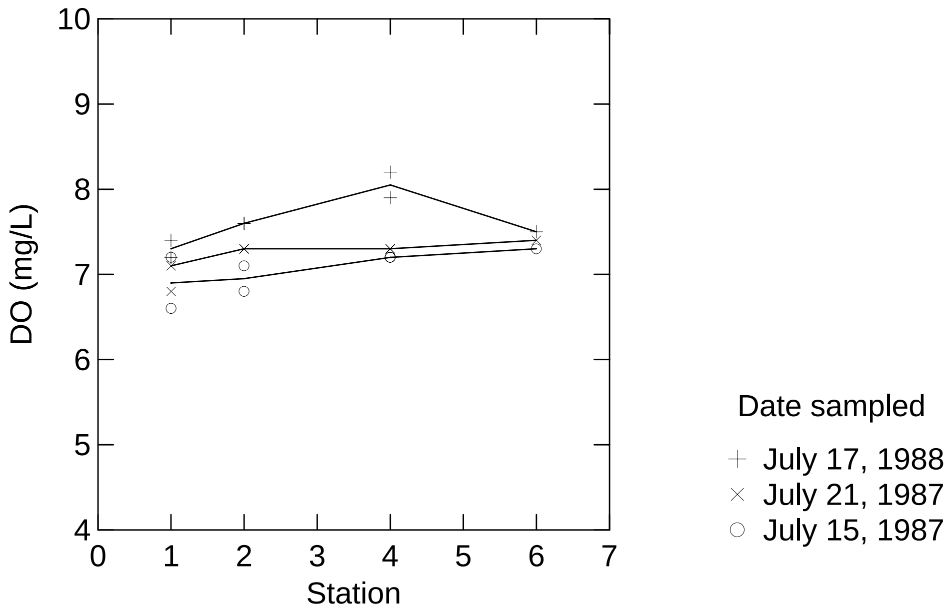


Figure 61. Relationship between historical stations and DO values in West River

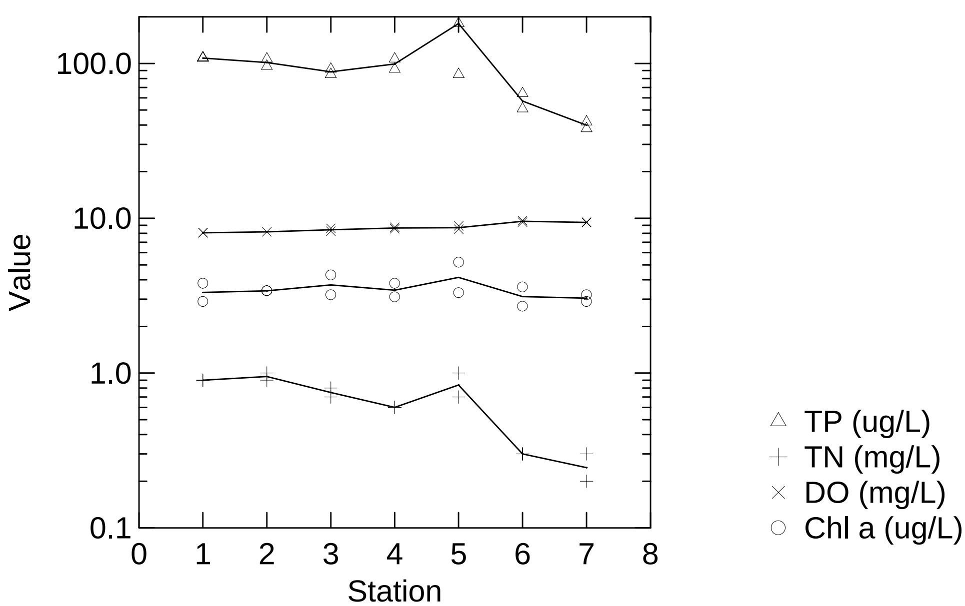


Figure 62. Relationship between 1998 stations and chl a, DO, TN and TP values in West River

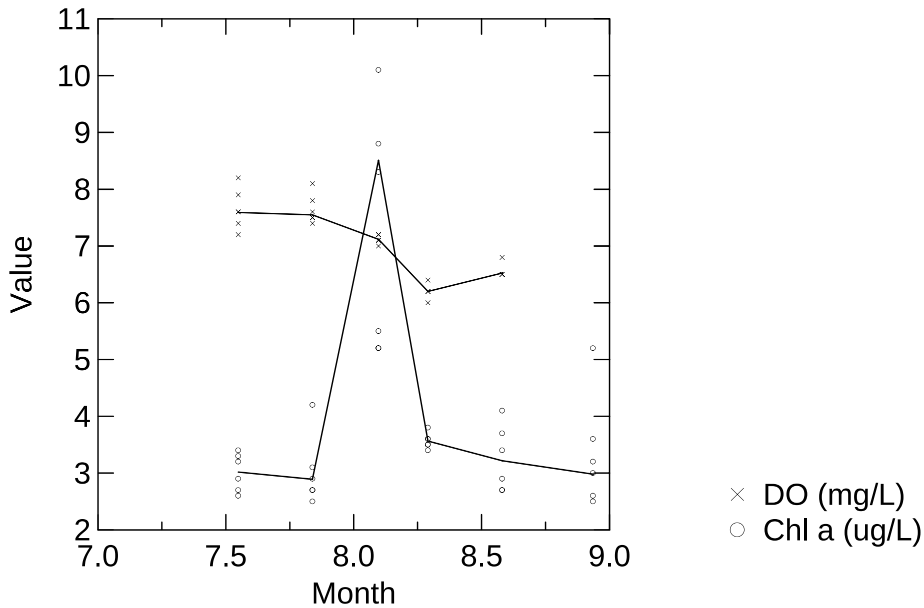


Figure 63. Relationship between month and historical chl a and DO values in upper West River

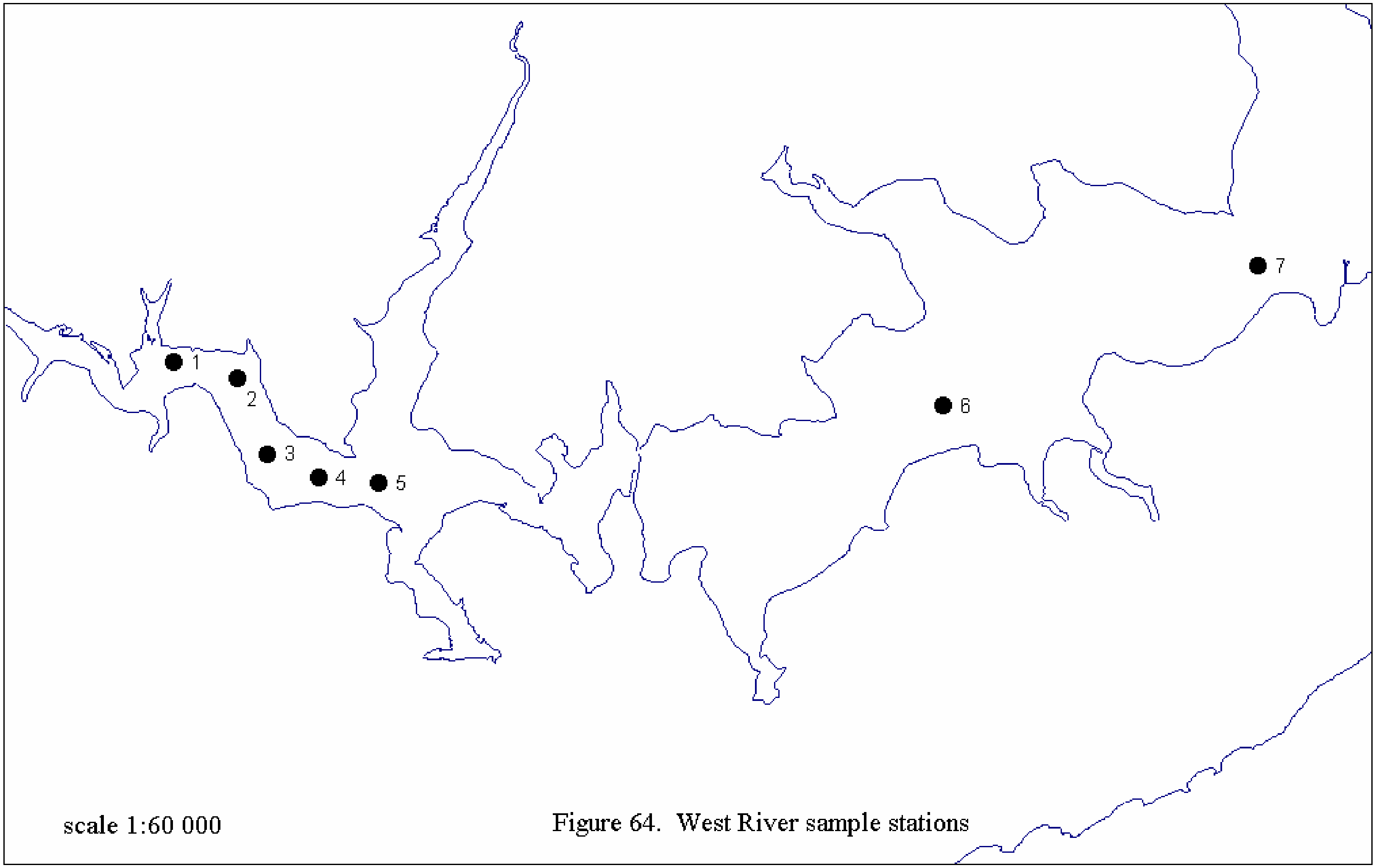


Figure 64. West River sample stations

Summary of Suggested Sample Locations

Table 1 is a summary of suggested upper, middle, and lower sample stations along with their corresponding UTM coordinates.

Table 1. Suggested sampling stations and UTM coordinates

Estuary	Station	Easting	Northing
Boughton			
Upper	4	537350	5126180
Middle	6	540120	5123920
Lower	7	542300	5122920
Brudenell			
Upper	3	530070	5116400
Middle	5	531930	5115590
Lower	6	534330	5114340
Cardigan			
Upper	1	529540	5119660
Middle	5	534390	5118500
Lower	6	537360	5116680
Covehead			
Upper	4	490310	5138350
Middle	6	489940	5140160
Lower	7	488580	5141190
Dunk			
Upper	1	443890	5133200
Middle	6	440520	5134990
Lower	7	439360	5136810
Foxley			
Upper	2	414000	5171900
Middle	4	415230	5171430
Lower	6	418190	5173150
Grand			
Upper	1	426830	5146530
Middle	5	429040	5148880
Lower	7	433840	5151710
Hillsborough			
Upper	3	508840	5132450
Middle	8	499550	5127720
Lower	10	495380	5124190

Table 1. (Cont./...)

Estuary	Station	Easting	Northing
Kildare			
Upper	1	418160	5188610
Middle	5	419880	5187600
Lower	7	420820	5184120
Mill			
Upper	1	410740	5177450
Middle	5	412770	5178990
Lower	7	417690	5177920
Montague			
Upper	2	527160	5112120
Middle	6	531680	5113530
Lower	7	536478	5112660
Murray			
Upper	1	530310	5095670
Middle	5	535260	5097420
Lower	6	536040	5097740
New London			
Upper	4	465710	5141140
Middle	6	464370	5144240
Lower	8	464710	5148580
North			
Upper	1	483480	5125320
Middle	6	487250	5120900
Lower	7	488370	5119000
Orwell			
Upper	3	509160	5113020
Middle	5	508280	5110640
Lower	6	507240	5107800
Rustico			
Upper	1	478510	5136670
Middle	5	480920	5138870
Lower	7	481860	5141050
Southwest			
Upper	1	454530	5146710
Middle	5	458000	5145620
Lower	7	462340	5149350
St. Peter's			
Upper	4	530680	5140720
Middle	5	528820	5141219
Lower	7	521730	5142130

Table 1. (Cont./...)

Estuary	Station	Easting	Northing
Tracadie			
Upper	4	500900	5135490
Middle	5	500830	5137048
Lower	6	500320	5137920
West			
Upper	1	477600	5116170
Middle	5	479510	5115040
Lower	6	484800	5115760

Suggested Sample Timing

The time of the summer which provides the highest chl *a* and lowest DO values is quite consistent across the seven estuaries for which historical data is available (Table 2). With the exception of Boughton River, chl *a* highs and DO lows are found in early to mid August. **It is thus suggested that the sampling for the monitoring program be conducted during the first two weeks of August.** It is also suggested that, as laboratory resources permit, triplicate water samples be taken at each station.

Table 2. Suggested time of sampling based on historical data from the upper estuary

Estuary	Time of summer
Boughton	late July
Cardigan	mid August
Hillsborough	early August
Mill	mid August
New London	mid August
St. Peter’s	early August
West	mid August

Suggested Reporting Methodology

The North Carolina State University Water Quality Group (1997) recommends the following guidelines for acceptable estuarine values:

- Lowest acceptable DO value for estuarine biota is **5.0 mg/L**
- TN limit for maximum estuarine diversity is **0.1 mg/L**
- TN limit for moderate estuarine diversity is **1.0 mg/L**
- TP limit for maximum estuarine diversity is **0.01 mg/L**
- TP limit for moderate estuarine diversity is **0.1 mg/L**

It is suggested that these guidelines be adopted for interpreting data generated by the subsequent Estuarine Water Quality Monitoring Program.

An internet web site for reporting the results of the monitoring program should be established. On the home page, the following links should be available: **Background, Sampling and Analytical Methods, Sampling Stations.**

The background section should be similar to the above introduction, containing a definition and the implications of eutrophication and the objective of the Estuarine Water Quality Monitoring Program.

Sampling methods can be taken from the Materials and Methods section of this report. A brief description of the analytical methods should also be included.

The twenty estuaries should be listed as links, or preferably displayed in a graphical map format. Each estuary should be listed separately as users will often be looking for information on specific estuaries only. By clicking on an estuary, a user should be presented with station number, station location (upper, middle, lower), station coordinates and a time series graph of the results from the four pertinent variables for each of the three stations in that estuary. The time series graphs should have time in years on the x axis and variable values on the y-axis. TN and TP should be expressed

with the same unit to eliminate the necessity of log format on the y axis. The above recommended acceptable limits could be indicated on the time series graphs to better demonstrate prolonged indications of eutrophic conditions.

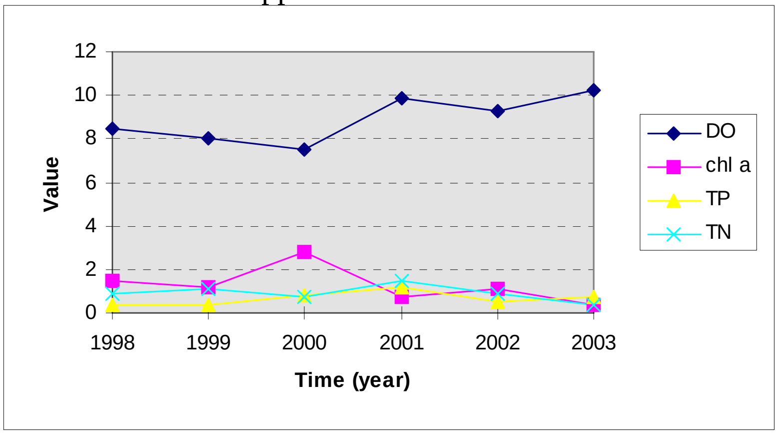
Figure 65 is an example of the suggested format for a results page for each estuary. **The results included in Figure 65 are not real values and were created for demonstration only**. The time series graphs are line graphs created using Excel.

The upper estuary results are especially significant because this area of the estuary is often the location of anoxic events. Therefore upper estuary results can provide an indication of "worst case" estuarine water quality at a specific point in time. Results from the three sampling stations may be pooled when assessing trends over time in each estuary. Estuary means from the three stations could be presented in a time series graph. These could be presented in lieu of, or in addition to, individual station time series graphs.

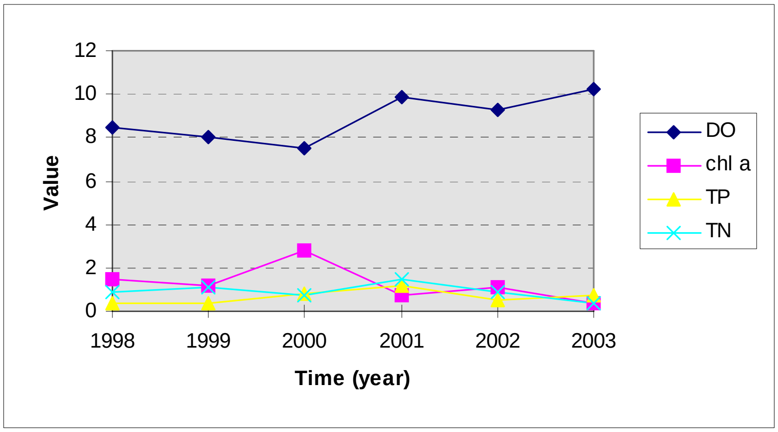
The production of a Water Quality Bulletin may also be beneficial to report the status of the Water Quality Monitoring Program. A similar format as the web page could be used, including the background, an introduction, and the objective of the program. In order to simplify, only the pooled time series graphs of estuary station means could be displayed, with reference to the website for the individual site results. Any relevant changes in the watersheds should be noted in the bulletin. These would include any developments which may potentially alter the nutrient input or outflow to and from the estuary. Potential nutrient input sources include livestock excrement, fertilizers, leaky septic systems, sewage treatment outfalls, reservoir bottom sediments, decomposing plant debris, and industrial products such as detergents and pharmaceuticals. Also the occurrence of any anoxic events in the watersheds should be reported in the bulletin. Sampling staff should be prepared to record general observations in the field which may be useful in preparing the yearly bulletin. Again the above guidelines for acceptable

Cardigan River

Station 1 Upper 529540E 5119660N



Station 5 Middle 534390E 5118500N



Station 6 Lower 537360E 5116680N

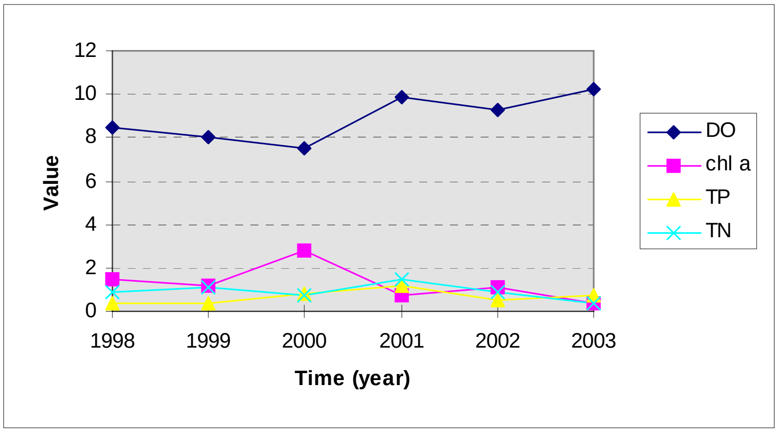


Figure 65. Suggested format for an estuary results web page

estuarine values could be included in the bulletin along with noting any stations which are non-compliant.

Conclusion

In subsequent years twenty estuaries on PEI are to be sampled within the first two weeks of August. Temperature, depth, conductivity, salinity and DO are to be measured in the field and water samples are to be collected for determination of chl *a*, TN and TP. If the necessary laboratory resources are available, triplicate water samples should be taken. Each estuary should be sampled in the upper, middle and lower areas at the stations recommended in Table 1. The UTM coordinates are available to facilitate returning to specific station locations with a hand held GPS unit. The recording of field notes is recommended to document any visible developments or changes in the watershed which may potentially alter nutrient input or outflow in the estuary. Ongoing results should be reported via an updated internet website and possibly also an annual Estuarine Water Quality Bulletin.

Literature Cited

Fertilizer Industry Federation of Australia. 1994. Eutrophication. http://www.fifa.asn.au/FIFA8.HTM

Koster M., S. Dahlke, L.A. Meyer-Reil. 1997. Microbiological studies along a gradient of eutrophication in a shallow coastal inlet in the southern Baltic Sea (Nordrugensche Bodden). *Mar. Ecol. Prog. Ser.* 152:27-39

Lyngby J.E. and Mortensen S.M.1997. Biomonitoring of eutrophication levels in shallow coastal ecosystems. European Marine Biology Symposium.

McComb A.J. 1995. Eutrophic Shallow Estuaries and Lagoons. CRC Press, Boca Raton Florida

Meeuwig. J.J., J.R. Rasmussen, and R.H. Peter's. 1997. Turbid waters and clarifying mussels: their moderation of empirical Chl:nutrient relations in P.E.I estuaries. McGill University.

Taylor D., S. Nixon, S. Granger, B. Buckley. 1995. Nutrient limitation and the eutrophication of coastal lagoons. *Mar. Ecol. Prog. Ser.* 127:235-244

Osmond, D.L., K.A. Bartenhagen, M.H. Turner. 1995. WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System, http://h2osparc.wq.ncsu.edu.

P. Lane and Associates Limited,. 1991. Prince Edward Island estuaries study Water quality in the Cardigan River, Boughton River and St. Peter's Bay. Halifax N.S.

APPENDIX A. FIELD AND LABORATORY DATA

Date	Watershed	Station	Easting	Northing	Depth (m)	TN (mg/L)	DO (mg/L)	TP (ug/L)	SAL (ppt)	TEMP (C)	Chl*a* (ug/L)	Cond (mmho)
27/07/9	Boughton	1	536600	5127900	3.0	0.4	10.1	68	27.5	21.7	2.8	39.6
27/07/9	Boughton	1	536600	5127900	0.2	0.5	8.1	65	22.0	23.0	2.1	33.5
27/07/9	Boughton	2	536740	5127530	2.5	0.4	13.3	76	28.5	21.5	3.1	40.3
27/07/9	Boughton	2	536740	5127530	0.2	0.4	9.4	54	23.2	23.1	2.5	34.6
27/07/9	Boughton	3	536790	5126990	3.5	0.4	7.6	78	28.6	20.1	1.7	39.8
27/07/9	Boughton	3	536790	5126990	0.2	0.4	9.6	58	23.3	23.2	1.3	35.0
27/07/9	Boughton	4	537350	5126180	4.0	0.3	7.7	70	28.5	20.1	4	39.5
27/07/9	Boughton	4	537350	5126180	0.2	0.3	9.2	51	26.9	22.2	2.2	38.6
27/07/9	Boughton	5	538910	5124390	6.0	0.2	8.5	51	28.4	18.7	2.7	38.6
27/07/9	Boughton	5	538910	5124390	0.2	0.1	8.6	35	27.9	21.4	1.1	39.5
27/07/9	Boughton	6	540120	5123920	3.0	0.1	9.5	30	28.2	21.3	0.8	40.0
27/07/9	Boughton	6	540120	5123920	0.2	0.2	9.2	32	27.9	20.8	1.2	40.1
27/07/9	Boughton	7	542300	5122920	8.0	0.2	9.1	25	28.9	17.2	1.2	37.8
27/07/9	Boughton	7	542300	5122920	0.2	0.1	8.4	25	28.6	20.6	0.8	40.1
23/07/9	Brudenell	1	529620	5116210	1.5	0.4		70	23.0	23.3	3.8	35.8
23/07/9	Brudenell	1	529620	5116210	0.2	0.4		96	23.3	23.6	5.7	35.9
23/07/9	Brudenell	2	529870	5116320	3.5	0.4		66	24.2	23.7	3.3	36.7
23/07/9	Brudenell	2	529870	5116320	0.2	0.3		71	23.8	23.3	3.7	36.0
23/07/9	Brudenell	3	530070	5116400	2.5	0.6		107	26.9	21.4	12.2	38.4
23/07/9	Brudenell	3	530070	5116400	0.2	0.3		69	25.0	22.5	3.1	37.0
23/07/9	Brudenell	4	530570	5116350	4.0	0.4		59	28.6	17.9	5	37.9
23/07/9	Brudenell	4	530570	5116350	0.2	0.3		54	25.7	21.8	2.3	37.8
23/07/9	Brudenell	5	531930	5115590	4.0	0.3		76	27.0	17.7	6.7	37.1
23/07/9	Brudenell	5	531930	5115590	0.2	0.4		47	26.6	22.7	2	38.9
23/07/9	Brudenell	6	534330	5114340	7.0	0.3		33	27.1	16.9	2.7	36.1
23/07/9	Brudenell	6	534330	5114340	0.2	0.5		37	27.6	21.1	1.9	39.8
23/07/9	Cardigan	1	529540	5119660	3.5	0.4	9.8	100	28.1	18.6	9.5	38.1
23/07/9	Cardigan	1	529540	5119660	0.2	0.8	9.5	49	26.6	19.1	2.4	36.5
23/07/9	Cardigan	2	530120	5119820	5.0	0.4	9.8	48	29.2	15.7	3.7	36.8
23/07/9	Cardigan	2	530120	5119820	0.2	0.4	9.2	51	27.3	20.5	1.6	38.5
23/07/9	Cardigan	3	530560	5119460	5.5	0.3		44	27.5	17.6	3.2	36.7
23/07/9	Cardigan	3	530560	5119460	0.2	0.4		42	27.1	20.2	1.7	39.0
23/07/9	Cardigan	4	531240	5119010	4.0	0.3		40	28.9	16.7	3.4	37.6
23/07/9	Cardigan	4	531240	5119010	0.2	0.3		38	27.4	20.4	1.6	39.2
23/07/9	Cardigan	5	534390	5118500	9.0	0.3		36	27.3	16.1	2.3	35.0
23/07/9	Cardigan	5	534390	5118500	0.2	0.3		32	30.3	17.2	1	39.1
23/07/9	Cardigan	6	537360	5116680	12.0	0.3		33	29.4	14.3	1.1	35.7
23/07/9	Cardigan	6	537360	5116680	0.2	0.4		27	28.7	19.7	2.4	39.9
28/07/9	Covehead	1	490310	5138080	1.0	1.1		60	20.6	21.5	10.3	30.6
28/07/9	Covehead	1	490310	5138080	0.2	1.6		40	19.3	20.6	22.7	28.6
28/07/9	Covehead	2	490310	5138150	1.0	1.5		50	23.6	21.4	7.8	35.0
28/07/9	Covehead	2	490310	5138150	0.2	1.5		50	20.9	21.2	4.4	30.9
28/07/9	Covehead	3	490310	5138230	1.0	1.5		100	26.1	20.9	22.4	37.7
28/07/9	Covehead	3	490310	5138230	0.2	1.4		45	22.1	20.8	6.5	32.1
28/07/9	Covehead	4	490310	5138350	1.5	4.6		160	27.6	21.1	71.8	39.4
28/07/9	Covehead	4	490310	5138350	0.2	1.1		60	25.1	20.7	6.5	36.3
28/07/9	Covehead	5	490300	5138840	2.5	0.6		55	27.9	20.2	7.3	38.9
28/07/9	Covehead	5	490300	5138840	0.2	0.7		55	26.8	20.7	7.2	38.0
28/07/9	Covehead	6	489940	5140160	5.0	0.4		70	26.8	19.7	3.8	38.5

Date	Watershed	Station	Easting	Northing	Depth	TN	DO	TP	SAL	TEMP	Chl*a*	Cond
					(m)	(mg/L)	(mg/L)	(ug/L)	(ppt)	(C)	(ug/L)	(mmho)
28/07/98	Covehead	6	489940	5140160	0.2				26.5	21.3	2.2	38.8
28/07/98	Covehead	7	488580	5141190	3.0	0.2		10	28.2	19.3	0.7	38.7
28/07/98	Covehead	7	488580	5141190	0.2	0.3		15	27.7	19.8	0.6	39.0
17/08/98	Dunk	1	443890	5133200	0.5	2.2	11.3	61	7.4	22.8	8.3	11.3
17/08/98	Dunk	1	443890	5133200	0.2	2.9	11.3	79	7.4	22.8	5	11.3
17/08/98	Dunk	2	443510	5133760	1.0	0.6	11.4	44	11.5	22.8	5.7	18.2
17/08/98	Dunk	2	443510	5133760	0.2	1.6	11.5	46	11.4	23.6	5.4	18.0
17/08/98	Dunk	3	442900	5133860	1.0	0.5	10.4	43	14.8	23.6	4.1	23.2
17/08/98	Dunk	3	442900	5133860	0.2	0.5	10.4	45	14.4	23.6	2.6	22.7
17/08/98	Dunk	4	441850	5133460	1.0	3.2	10.3	28	21.7	22.7	1.6	32.8
17/08/98	Dunk	4	441850	5133460	0.2	0.4	10.3	29	21.8	22.8	4.2	32.7
17/08/98	Dunk	5	441500	5133860	1.5	1.6	9.0	29	23.6	21.9	3.6	34.2
17/08/98	Dunk	5	441500	5133860	0.2	2.5	9.8	28	23.1	21.9	3.9	33.9
17/08/98	Dunk	6	440520	5134990	2.0	0.5	9.0	38	23.7	20.4	6.2	33.4
17/08/98	Dunk	6	440520	5134990	0.2	0.5	8.7	22	23.2	20.7	7.3	33.1
17/08/98	Dunk	7	439360	5136810	6.0	0.3	8.6	22	24.0	20.4	6.7	34.1
17/08/98	Dunk	7	439360	5136810	0.2	0.6	8.5	22	24.2	20.4	6	34.0
03/08/98	Foxley	1	413650	5171870	0.2	1	7.6	101	16.9	23.6	3.2	26.2
03/08/98	Foxley	1	413650	5171870	0.2	0.8	6.2	100	17.4	23.4	3.3	26.9
03/08/98	Foxley	2	414000	5171900	1.5	0.8	6.8	126	20.1	23.2	10.2	30.6
03/08/98	Foxley	2	414000	5171900	0.2	0.6	6.0	96	17.3	23.2	3.8	25.7
03/08/98	Foxley	3	414520	5171690	1.5	0.6	7.5	111	20.3	22.6	2.9	30.4
03/08/98	Foxley	3	414520	5171690	0.2	0.6	6.3	99	18.7	23.1	3.6	28.3
03/08/98	Foxley	4	415230	5171430	1.5	0.6	7.0	118	19.5	23.1	3.6	29.6
03/08/98	Foxley	4	415230	5171430	0.2	0.5	6.9	101	19.5	23.1	3	29.6
03/08/98	Foxley	5	416690	5172170	2.0	0.4	7.6	87	20.2	22.7	1.8	30.2
03/08/98	Foxley	5	416690	5172170	0.2	0.5	7.0	91	20.8	23.2	2	31.2
03/08/98	Foxley	6	418190	5173150	5.0	0.4	8.2	83	21.1	22.6	2.3	31.5
03/08/98	Foxley	6	418190	5173150	0.2	0.4	8.0	70	21.8	22.5	2.4	32.3
06/08/98	Grand	1	426830	5146530	1.0	0.6	6.8	95	22.5	23.9	1.7	35.3
06/08/98	Grand	1	426830	5146530	0.2	0.5	6.8	95	22.5	24.4	1.6	35.2
06/08/98	Grand	2	426870	5146950	1.5	0.6	6.8	105	23.3	24.1	1.3	35.5
06/08/98	Grand	2	426870	5146950	0.2	0.6	6.7	95	23.3	24.1	1.5	35.5
06/08/98	Grand	3	427310	5146960	1.5	0.5	6.8	100	23.9	24.1	1.6	36.4
06/08/98	Grand	3	427310	5146960	0.2	0.5	6.4	110	22.7	25.1	1.3	34.1
06/08/98	Grand	4	427990	5147620	2.0	0.5	6.6	100	24.2	23.5	1.6	36.1
06/08/98	Grand	4	427990	5147620	0.2	0.5	6.5	100	23.8	23.8	1.4	36.1
06/08/98	Grand	5	429040	5148880	4.0	0.4	6.4	65	24.9	22.6	2.5	36.9
06/08/98	Grand	5	429040	5148880	0.2	0.4	6.2	65	25.1	23.5	2.3	37.6
06/08/98	Grand	6	431080	5150090	4.0	0.4	7.0	55	25.6	22.0	3.4	36.9
06/08/98	Grand	6	431080	5150090	0.2	0.4	6.8	60	25.5	23.7	4.1	37.9
06/08/98	Grand	7	433840	5151710	6.0	0.4	7.4	45	26.0	20.9	7.8	36.7
06/08/98	Grand	7	433840	5151710	0.2	0.3	7.5	45	25.6	22.4	5.9	37.3
11/08/98	Hillsborough	1	510240	5134220	2.0	0.9	6.0	78	13.1	23.4	10.7	21.1
11/08/98	Hillsborough	1	510240	5134220	0.2	0.8	6.9	109	13.3	23.2	11.6	21.0
11/08/98	Hillsborough	2	509940	5133100	1.0	0.9	6.5	255	14.5	23.3	16	25.2
11/08/98	Hillsborough	2	509940	5133100	0.2	1	6.5	107	14.7	23.1	13.6	22.8
11/08/98	Hillsborough	3	508840	5132450	2.5	1	6.6	378	16.3	23.4	17.5	25.4
11/08/98	Hillsborough	3	508840	5132450	0.2	0.9	6.4	197	16.0	23.8	14.5	25.2

Date	Watershed	Station	Easting	Northing	Depth (m)	TN (mg/L)	DO (mg/L)	TP (ug/L)	SAL (ppt)	TEMP (C)	Chl*a* (ug/L)	Cond (mmho)
11/08/98	Hillsborough	4	507200	5132910	3.5	0.8	6.4	183	18.1	28.2	14.2	28.2
11/08/98	Hillsborough	4	507200	5132910	0.2	0.9	6.2	202	18.0	23.8	11.5	28.4
11/08/98	Hillsborough	5	506000	5131770	3.0	0.9	6.5	224	20.3	24.1	8.9	31.7
11/08/98	Hillsborough	5	506000	5131770	0.2	0.8	6.4	210	20.3	24.0	6.7	31.6
11/08/98	Hillsborough	6	504480	5131220	8.0	0.6	6.5	144	21.9	23.8	5.2	33.8
11/08/98	Hillsborough	6	504480	5131220	0.2	0.8	6.4	211	22.0	23.7	5.9	33.9
11/08/98	Hillsborough	7	502780	5128960	3.0	0.6	6.6	208	23.4	23.7	6.5	35.4
11/08/98	Hillsborough	7	502780	5128960	0.2	0.5	6.5	109	23.4	23.7	3.4	35.4
11/08/98	Hillsborough	8	499550	5127720	7.0	0.7	7.1	168	24.3	23.2	4.7	36.3
11/08/98	Hillsborough	8	499550	5127720	0.2	0.4	7.1	215	24.1	23.5	3.7	36.3
11/08/98	Hillsborough	9	497260	5125910	11.0	0.5	7.4	123	24.7	22.2	5.7	36.7
11/08/98	Hillsborough	9	497260	5125910	0.2	0.5	7.2	219	24.6	22.7	4.3	36.6
11/08/98	Hillsborough	10	495380	5124190	12.0	0.6	7.6	133	25.2	21.3	5.4	36.4
11/08/98	Hillsborough	10	495380	5124190	0.2	0.5	7.6	89	25.1	21.3	5.9	36.6
11/08/98	Hillsborough	11	492670	5121400	13.0	0.3	7.8	45	25.6	20.4	4.7	36.3
11/08/98	Hillsborough	11	492670	5121400	0.2	0.4	8.0	58	25.5	21.3	4.8	36.3
29/07/98	Kildare	1	418160	5188610	2.0	1.4	0.5	85	19.1	21.8	20.3	28.4
29/07/98	Kildare	1	418160	5188610	0.2	1.4	5.0	80	18.8	21.8	17.4	28.0
29/07/98	Kildare	2	418470	5188630	3.0	1.2	3.8	75	19.5	20.6	20	28.4
29/07/98	Kildare	2	418470	5188630	0.2	1.2	6.8	70	17.3	22.0	22.1	25.7
29/07/98	Kildare	3	418780	5188990	5.0	1.3	3.4	120	20.4	16.5	20.5	27.0
29/07/98	Kildare	3	418780	5188990	0.2	1.2	6.4	65	17.6	21.5	18	26.3
03/08/98	Kildare	4	419390	5188980	5.0	2.8	5.0	210	19.4	17.7	10.6	26.2
03/08/98	Kildare	4	419390	5188980	0.2		8.0		17.0	23.8		26.2
03/08/98	Kildare	5	419880	5187600	3.0	1.1	8.8	82	17.3	22.2	15.3	26.2
03/08/98	Kildare	5	419880	5187600	0.2	1	9.0	77	16.8	24.0	20.1	26.2
03/08/98	Kildare	6	420590	5186940	2.0	1	7.0	79	17.4	24.3	11.7	27.5
03/08/98	Kildare	6	420590	5186940	0.2	1.1	8.2	95	17.5	24.5	13.7	27.5
03/08/98	Kildare	7	420820	5184120	3.0	0.3	8.0	55	21.1	19.8	3.3	30.4
03/08/98	Kildare	7	420820	5184120	0.2	0.5	7.8	63	19.8	22.0	4.9	29.8
21/07/98	Mill River	1	410740	5177450	1.0	1	5.1	126	22.8	24.7	11.5	35.5
21/07/98	Mill River	1	410740	5177450	0.2	0.9	5.0	131	22.8	24.7	3.9	35.5
21/07/98	Mill River	2	411200	5177440	1.5	0.7	5.1	125	22.7	23.8	6.3	34.5
21/07/98	Mill River	2	411200	5177440	0.2	0.6	5.0	109	22.8	23.9	8.5	34.7
21/07/98	Mill River	3	411690	5177790	3.0		5.1		22.8	23.1	6.3	34.3
21/07/98	Mill River	3	411690	5177790	0.2	0.7	5.1	117	22.1	24.0	9.1	33.9
21/07/98	Mill River	4	412320	5178410	4.0	0.5	5.2	89	23.1	22.6	2.1	34.4
21/07/98	Mill River	4	412320	5178410	0.2	0.6	5.1	99	22.2	23.7	10.3	33.6
21/07/98	Mill River	5	412770	5178990	5.0	0.6	5.0	85	23.4	22.9	8.7	34.7
21/07/98	Mill River	5	412770	5178990	0.2	0.6	5.5	83	22.2	23.7	9	33.7
21/07/98	Mill River	6	414520	5180240	4.0	0.4	5.2	66	23.0	23.4	5.8	34.7
21/07/98	Mill River	6	414520	5180240	0.2		5.1		22.8	23.7	9.1	34.7
21/07/98	Mill River	7	417690	5179920	5.0	0.3	6.2	32	25.3	20.1	3	35.2
21/07/98	Mill River	7	417690	5179920	0.2	0.5	5.2	50	24.3	22.7	5	35.8
24/07/98	Montague	1	527160	5112120	2.5	0.5		40	25.3	17.5	1	34.2
24/07/98	Montague	1	527160	5112120	0.2	0.7		45	16.1	18.0	1.1	22.8
24/07/98	Montague	2	527490	5112360	4.5	0.2		44	28.7	15.7	2.5	36.6
24/07/98	Montague	2	527490	5112360	0.2	0.7		41	20.3	18.1	1.2	28.1
24/07/98	Montague	3	528010	5112470	6.0	0.2		35	28.8	15.3	1.8	36.6

Date	Watershed	Station	Easting	Northing	Depth	TN	DO	TP	SAL	TEMP	Chl*a*	Cond
					(m)	(mg/L)	(mg/L)	(ug/L)	(ppt)	(C)	(ug/L)	(mmho)
24/07/98	Montague	3	528010	5112470	0.2	0.5		39	22.1	19.0	0.9	30.9
24/07/98	Montague	4	528660	5112420	7.0	0.2		39	29.1	14.3	2.5	36.4
24/07/98	Montague	4	528660	5112420	0.2	0.4		35	23.5	20.2	0.7	32.8
24/07/98	Montague	5	529610	5112990	5.0	0.1		26	29.2	14.9	2.4	36.7
24/07/98	Montague	5	529610	5112990	0.2	0.3		29	22.2	19.7	1.6	31.9
24/07/98	Montague	6	531680	5113530	6.5	0.2		34	29.3	14.4	1.8	36.3
24/07/98	Montague	6	531680	5113530	0.2	0.2		18	25.0	20.1	0.9	35.5
24/07/98	Montague	7	534170	5113500	8.5	0.2		36	29.6	15.7	1	37.0
24/07/98	Montague	7	534170	5113500	0.2	0.3		18	26.9	20.4	0.6	38.9
24/07/98	Montague	8	536480	5112660	13.0	0.1		15	29.0	14.8	1.1	36.6
24/07/98	Montague	8	536480	5112660	0.2	0.1		20	28.4	35.0	0.7	39.7
14/08/98	Murray	1	530310	5095670	2.0	0.4	8.3	42	25.7	20.9	1.6	36.7
14/08/98	Murray	1	530310	5095670	0.2	0.5	5.8	84	19.2	20.6	2.6	28.2
14/08/98	Murray	2	531510	5096060	3.0	0.4	8.7	44	25.3	20.3	1.8	35.4
14/08/98	Murray	2	531510	5096060	0.2	0.4	6.4	45	24.7	20.6	0.8	35.0
14/08/98	Murray	3	532970	5096560	4.0	0.4	7.5	32	25.5	19.0	0.6	35.4
14/08/98	Murray	3	532970	5096560	0.2	0.4	7.0	37	24.4	19.6	0.7	34.2
14/08/98	Murray	4	534190	5097170	5.5	0.5	7.5	33	24.7	17.8	0.6	34.1
14/08/98	Murray	4	534190	5097170	0.2	0.3	7.3	34	24.6	19.3	0.5	34.7
14/08/98	Murray	5	535260	5097420	6.0	0.4	7.9	20	22.3	17.2	0.8	30.4
14/08/98	Murray	5	535260	5097420	0.2	0.5	7.6	37	25.1	19.0	0.5	34.6
14/08/98	Murray	6	536040	5097740	4.0	0.4	8.1	23	25.2	17.9	0.7	34.2
14/08/98	Murray	6	536040	5097740	0.2	0.3	7.9	78	25.3	18.4	0.8	34.4
14/08/98	Murray	7	536510	5097700	3.0	0.4	8.2	26	25.0	18.3	0.8	34.3
14/08/98	Murray	7	536510	5097700	0.2	0.3	8.1	43	24.9	18.4	0.7	34.2
31/07/98	New London	1	463020	5142590	2.5	0.7	10.0	105	26.7	21.8	2.7	26.7
31/07/98	New London	1	463020	5142590	0.2	0.9	9.3	30	24.0	22.2	0.8	36.1
31/07/98	New London	2	463260	5142500	1.0	0.4	15.6	75	25.9	23.7	9.6	38.7
31/07/98	New London	2	463260	5142500	0.2	1	10.3	25	24.3	21.9	1.7	36.3
31/07/98	New London	3	463310	5142200	3.0	0.6	7.8	90	27.0	22.7	3.2	39.2
31/07/98	New London	3	463310	5142200	0.2	0.5	9.6	55	26.8	22.7	4.1	38.3
31/07/98	New London	4	463310	5143150	5.0	0.3	7.5	65	27.0	21.2	1.8	38.9
31/07/98	New London	4	463310	5143150	0.2	0.4	9.4	55	25.0	21.9	2.9	36.9
31/07/98	New London	5	463750	5143000	6.0	0.3	6.1	80	26.8	20.9	3	38.8
31/07/98	New London	5	463750	5143000	0.2	0.4	8.0	80	25.3	22.1	2.9	37.0
31/07/98	New London	6	464370	5144240	6.0	0.9	8.5	105	27.5	20.7	8.1	39.0
31/07/98	New London	6	464370	5144240	0.2	0.4	8.5	65	25.8	22.0	2.2	37.7
31/07/98	New London	7	464700	5145750	3.0	0.3	7.2	40	27.8	20.4	1.2	39.4
31/07/98	New London	7	464700	5145750	0.2	0.4	7.6	40	26.7	21.6	0.9	38.9
31/07/98	New London	8	464710	5148580	5.0	0.3	7.4	38	28.0	20.2	2.7	39.4
31/07/98	New London	8	464710	5148580	0.2	0.3	7.3	53	27.8	20.9	0.7	39.4
19/08/98	North River	1	483480	5125320	1.0	1.3	5.5	233	21.2	21.1	6.3	30.7
19/08/98	North River	1	483480	5125320	0.2	1.9	6.6	123	15.6	19.0	6	22.3
19/08/98	North River	2	484010	5124910	1.5	0.6	5.7	125	22.8	21.2	3.6	33.3
19/08/98	North River	2	484010	5124910	0.2	1	5.7	130	19.0	20.0	3.8	27.5
19/08/98	North River	3	484740	5124480	2.0	0.4	6.3	100	23.9	20.2	3.1	33.5
19/08/98	North River	3	484740	5124480	0.2	0.4	6.5	123	21.6	20.0	3.1	30.1
19/08/98	North River	4	485250	5123700	2.0	1.6	6.5	75	24.1	19.8	2.4	33.7
19/08/98	North River	4	485250	5123700	0.2	0.4	6.4	85	23.8	19.7	2.8	32.9

Date	Watershed	Station	Easting	Northing	Depth	TN	DO	TP	SAL	TEMP	Chl*a*	Cond
					(m)	(mg/L)	(mg/L)	(ug/L)	(ppt)	(C)	(ug/L)	(mmho)
19/08/98	North River	5	485870	5122320	5.5	0.9	6.8	65	24.7	19.9	2.7	34.6
19/08/98	North River	5	485870	5122320	0.2	0.9	6.7	60	24.9	19.7	3.1	34.6
19/08/98	North River	6	487250	5120900	2.0	0.4	7.4	60	25.1	19.5	4.1	35.0
19/08/98	North River	6	487250	5120900	0.2	0.8	7.2	60	25.2	19.6	4.3	35.0
19/08/98	North River	7	488370	5119000	4.0	0.4	7.3	45	25.6	19.3	3.9	35.2
19/08/98	North River	7	488370	5119000	0.2	0.4	7.2	50	25.6	19.1	4	35.2
22/07/98	Orwell	1	509160	5113180	2.0	0.4	5.7	94	24.3	24.1	2.7	37.0
22/07/98	Orwell	1	509160	5113180	0.2	0.4	5.7	94	24.0	23.9	2.7	36.4
22/07/98	Orwell	2	509180	5113120	3.0	0.5	5.6	97	23.5	23.7	2.8	36.1
22/07/98	Orwell	2	509180	5113120	0.2	0.5	4.7	98	24.1	24.0	2.3	36.9
22/07/98	Orwell	3	509160	5113020	1.5	0.4	5.0	76	26.5	23.4	2.5	38.8
22/07/98	Orwell	3	509160	5113020	0.2	0.4	6.0	91	23.4	23.7	3.9	35.7
22/07/98	Orwell	4	509050	5112150	4.0	0.4	5.5	82	27.4	23.0	3.2	41.0
22/07/98	Orwell	4	509050	5112150	0.2	0.4	5.5	84	26.4	23.7	2.4	39.8
22/07/98	Orwell	5	508280	5110640	2.0	0.6	5.4	114	28.6	23.2	5.8	41.1
22/07/98	Orwell	5	508280	5110640	0.2	0.3	6.0	58	28.3	22.7	1.9	41.4
22/07/98	Orwell	6	507240	5107800	6.0	0.3	6.0	46	28.6	21.5	1.3	40.9
22/07/98	Orwell	6	507240	5107800	0.2	0.3	6.1	44	28.6	22.0	1.5	41.1
10/08/98	Rustico	1	478510	5136670	1.0	1.3		80	17.1	23.8	17	
10/08/98	Rustico	1	478510	5136670	0.2	1.2		80	15.3	23.1	16.8	
10/08/98	Rustico	2	479100	5137080	1.5	0.9		70	20.2	23.6	32.3	
10/08/98	Rustico	2	479100	5137080	0.2	0.9		75	18.4	24.0	28.4	
10/08/98	Rustico	3	479670	5137440	2.0	0.9		70	22.7	22.9	28.5	
10/08/98	Rustico	3	479670	5137440	0.2	0.8		80	19.6	23.8	30.6	
10/08/98	Rustico	4	480470	5137940	2.0	0.7		65	22.8	22.9	15.8	
10/08/98	Rustico	4	480470	5137940	0.2	0.7		70	21.5	23.7	20.9	
10/08/98	Rustico	5	480920	5138870	2.5	0.6		60	23.7	23.5	8.3	
10/08/98	Rustico	5	480920	5138870	0.2	0.6		65	23.6	23.1	7.9	
10/08/98	Rustico	6	482070	5139890	4.0	0.4		55	24.1	23.3	6	
10/08/98	Rustico	6	482070	5139890	0.2	0.4		50	24.4	23.6	6	
10/08/98	Rustico	7	481860	5141050		0.4		35	24.8	23.0	3.5	
10/08/98	Rustico	7	481860	5141050	0.2	0.4		35	24.3	23.1	4	
07/08/98	Southwest	1	454530	5146710	1.0	1.5	4.3	90	21.5	26.0	8.4	35.3
07/08/98	Southwest	1	454530	5146710	0.2	1.6	4.9	35	20.8	22.6	3.9	33.4
07/08/98	Southwest	2	455070	5146720	1.5	0.5	4.5	85	22.6	24.5	7.3	34.5
07/08/98	Southwest	2	455070	5146720	0.2	1.4	5.2	35	19.9	25.7	1.1	31.5
07/08/98	Southwest	3	455790	5146410	2.0	0.7	7.6	105	22.4	23.9	7.4	34.1
07/08/98	Southwest	3	455790	5146410	0.2	0.5	7.9	80	21.7	24.3	8.8	33.4
07/08/98	Southwest	4	456300	5145900	4.0	0.4	7.6	85	23.1	23.3	3.3	34.9
07/08/98	Southwest	4	456300	5145900	0.2	0.5	7.8	70	22.4	24.9	8.9	34.3
07/08/98	Southwest	5	458000	5145620	7.0	0.4	6.8	65	24.7	22.5	1.9	35.5
07/08/98	Southwest	5	458000	5145620	0.2	0.5	7.7	70	23.1	22.4	7.8	34.3
07/08/98	Southwest	6	460300	5146140	7.0	0.4	6.7	45	23.7	22.3	2.8	35.1
07/08/98	Southwest	6	460300	5146140	0.2	0.4	6.9	60	22.7	22.7	5.4	34.9
07/08/98	Southwest	7	462340	5149350	8.0	0.3	7.6	25	24.9	21.6	2	36.0
07/08/98	Southwest	7	462340	5149350	0.2	0.3	6.9	30	24.3	21.8	2.4	35.6
27/07/98	St. Peters	1	531720	5140160	2.0	0.6	8.1	36	25.3	22.2	1.3	37.2
27/07/98	St. Peters	1	531720	5140160	0.2	0.6	7.7	26	25.4	22.9	1	37.5
27/07/98	St. Peters	2	531400	5140230	3.5	0.3	7.7	35	26.4	20.7	1.6	37.5

Date	Watershed	Station	Easting	Northing	Depth (m)	TN (mg/L)	DO (mg/L)	TP (ug/L)	SAL (ppt)	TEMP (C)	Chl*a* (ug/L)	Cond (mmho)
27/07/98	St. Peters	2	531400	5140230	0.2	0.3	7.7	36	25.4	22.9	1.2	37.3
27/07/98	St. Peters	3	531020	5140390	5.0	0.3	7.8	52	27.4	19.5	2.8	37.5
27/07/98	St. Peters	3	531020	5140390	0.2	0.4	7.6	32	25.1	23.0	1.9	37.3
27/07/98	St. Peters	4	530680	5140720	5.0	0.3	7.3	29	27.3	18.9	18.5	37.5
27/07/98	St. Peters	4	530680	5140720	0.2	0.5	7.6	178	25.2	23.1	1	37.2
27/07/98	St. Peters	5	528820	5141220	6.0	0.4	6.9	70	27.2	19.3	3.8	37.6
27/07/98	St. Peters	5	528820	5141220	0.2	0.3	7.6	30	25.2	24.0	1	38.1
27/07/98	St. Peters	6	524200	5141940	5.0	0.2	7.7	27	27.7	19.9	1.1	38.8
27/07/98	St. Peters	6	524200	5141940	0.2	0.3	8.2	28	26.0	22.2	1.2	37.9
27/07/98	St. Peters	7	521730	5142130	3.0	0.2	9.1	18	28.4	19.9	0.9	38.9
27/07/98	St. Peters	7	521730	5142130	0.2	0.3	7.9	25	27.4	22.4	0.8	38.9
04/08/98	Tracadie	1	501210	5133910	1.0	0.4	9.6	30	23.8	24.0	3	36.3
04/08/98	Tracadie	1	501210	5133910	0.2	0.4	8.3	30	20.8	25.2	1	32.7
04/08/98	Tracadie	2	501200	5134110	2.0		10.8	30	24.4	22.8	1.3	36.6
04/08/98	Tracadie	2	501200	5134110	0.2	0.4	8.2	35	24.2	23.3	1.5	36.4
04/08/98	Tracadie	3	501010	5134540	3.5	0.4	8.0	35	24.5	22.6	2.2	36.4
04/08/98	Tracadie	3	501010	5134540	0.2	0.3	7.9	30	24.2	22.7	1.3	36.3
04/08/98	Tracadie	4	500900	5135490	4.0	0.4	8.3	50	25.0	21.2	2.3	36.2
04/08/98	Tracadie	4	500900	5135490	0.2	0.4	8.2	40	24.1	22.9	2.8	22.9
04/08/98	Tracadie	5	500830	5137050	4.5	1.8	7.0	150	25.6	20.8	4.4	36.1
04/08/98	Tracadie	5	500830	5137050	0.2	0.3	7.5	35	24.4	23.0	1.6	36.2
04/08/98	Tracadie	6	500320	5137920	4.5	0.3	7.5	35	21.0	21.0	1.7	25.0
04/08/98	Tracadie	6	500320	5137920	0.2	0.4	7.5	30	24.6	22.4	5.9	36.3
04/08/98	Tracadie	7	497240	5139390	4.5	0.3	8.4	25	25.0	22.4	1.1	36.4
04/08/98	Tracadie	7	497240	5139390	0.2	0.3	8.3	20	25.0	21.8	1.2	37.0
16/07/98	West River	1	477600	5116170		0.9	8.1	108	16.8	22.4	2.9	
16/07/98	West River	1	477600	5116170	0.2	0.9	8.1	109	13.9	21.9	3.8	
16/07/98	West River	2	478200	5116020		1		107	17.0	24.1	3.4	
16/07/98	West River	2	478200	5116020	0.2	0.9	8.2	96	13.7	22.7	3.4	
16/07/98	West River	3	478480	5115310		0.7	8.6	85	18.6	22.3	4.3	
16/07/98	West River	3	478480	5115310	0.2	0.8	8.3	92	16.6	22.5	3.2	
16/07/98	West River	4	478950	5115090		0.6	8.8	107	19.5	22.2	3.8	
16/07/98	West River	4	478950	5115090	0.2	0.6	8.6	92	17.8	22.5	3.1	
16/07/98	West River	5	479510	5115040		1	8.5	181	20.4	22.0	5.2	
16/07/98	West River	5	479510	5115040	0.2	0.7	8.9	85	19.7	22.5	3.3	
16/07/98	West River	6	484800	5115760		0.3	9.7	64	24.0	20.1	3.6	34.3
16/07/98	West River	6	484800	5115760	0.2	0.3	9.4	51	24.0	20.1	2.7	34.2
16/07/98	West River	7	487740	5117070		0.3	9.4	42	25.6	19.1	3.2	34.8
16/07/98	West River	7	487740	5117070	0.2	0.2	9.4	38	25.1	19.9	2.9	34.7