Productive Capacity Of Littoral Habitats In The Great Lakes: Field Sampling Procedures (1988 - 1995)

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PRODUCTIVE CAPACITY OF LITTORAL HABITATS IN THE GREAT LAKES: FIELD SAMPLING PROCEDURES (1988 - 1995)

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Abstract

Valere, B.G. 1996. Productive capacity of littoral habitats in the Great Lakes : Field sampling procedures (1988 - 1995). Can. Manuscr. Rep. Fish. Aquat. Sci. 2384: 50 p.

As part of the Productive Capacity of Fish Habitat project (Great Lakes Laboratory For Fisheries & Aquatic Sciences, DFO), field electrofishing and habitat surveys were conducted between 1990 and 1995. This report documents the areas that were surveyed and the protocols used for electrofishing, habitat sampling and data processing. Equipment and instrumentation utilized for field sampling are also described. Additional surveys completed in 1988 and 1989, that were not part of the Productive Capacity project are also documented. Catch data are summarized for all locations and years.

Résumé

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Le projet sur la capacité de production de l'habitat du poisson (Laboratoire des Grand Lacs pour les pêches et les sciences aquatiques, MPO) comprenait les études faites entre 1990 et 1995 sur la pêche à l'électricité et l'habitat. Le présent rapport porte sur ce qui suit : secteurs étudiés, protocoles de pêche à l'électricité, habitats échantillonnés et données traitées. Il décrit également l'équipement et les appareils qui ont servi à faire l'échantillonnage. Le rapport traite enfin des autres études qui ont été faites en 1988 et en 1989, mais qui ne font pas partie du projet sur la capacité de production. Les données sur les prises sont résumées pour tous les endroits et toutes les années.

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Introduction

Near shore habitats are a highly productive and important part of the Great Lakes ecosystem. Fish species composition and fish density varies spatially along the littoral zone, depending on localized habitat features such as temperature, substrate, wind exposure, macrophyte density, shoreline development, and water quality. Preliminary surveys of nearshore areas were conducted in Hamilton Harbour (1988) and Bay of Quinte (1989) with the main goal of providing fish community and abundance data in support of the existing Remedial Action Plans (Hartig and Thomas 1988). In 1990, a project was initiated to quantify the productive capacity (DFO 1986) of nearshore habitats in the Great Lakes. The objective of this project was to conduct detailed surveys in the littoral zone to determine fish community composition, richness and biomass in areas with different habitat features. Field surveys, based on sampling methods used in 1988 and 1989, were continued between 1990 and 1995. Fish and habitat data from the field would be used to develop analytical tools to link fish production with specific habitat features. The predictive tools will be useful to fish habitat biologists and managers for identifying critical habitats, for determining the productive capacity of an area, and for predicting the effects of habitat alteration on the productive capacity of the near shore habitats.

The goal of this report is to document the locations and dates of the preliminary field surveys completed in 1988 and 1989, and for the Productive Capacity project between 1990 and 1995. Sampling protocols used for collecting fish and habitat data, and procedures used for preparing and verifying the data files, are also described. Electrofishing catch data for all locations are summarized.

Sampling Chronology

Near shore surveys were carried out over 6 years, with different objectives each year. During the six years, near shore transects were surveyed at several different areas of Lake Ontario, Lake Erie and Georgian Bay (Fig. 1). Specific survey locations and dates are identified

below. Maps of the individual survey areas, showing the transect locations by area, are provided in Appendix 1.

Preliminary surveys:

Preliminary electrofishing surveys were conducted in Hamilton Harbour in 1988 and the Bay of Quinte, Lake Ontario in 1989. Specific objectives are outlined below. Survey designs developed during these programs were later adopted (with modifications) for the Productive Capacity project.

1. **Hamilton Harbour**: About 40 transects in Hamilton Harbour (Appendix 1a) were surveyed on a weekly basis from May to August in 1988. Data from the 1988 survey provided detailed information on spatial and temporal variability in the nearshore fish assemblages in the Harbour, before the restoration activities of the Remedial Action Plan were initiated. A subset of the 40 transects (usually 20) were also surveyed in 1990 (see 3. below), 1992, 1993 and 1995, as part of the Productive Capacity project.

2. **Bay of Quinte**: Thirty-two transects were surveyed in Bay of Quinte (Appendix 1b) during August, 1989 to provide data for the Bay of Quinte Remedial Action Plan. A subset of these transects (20) were resurveyed during 1990 as part of the Productive Capacity project (see 3. below).

Productive Capacity project:

3. **1990:** Surveys in 1990 were conducted at three Great Lakes Areas of Concern (IJC 1984), Hamilton Harbour and Bay of Quinte in Lake Ontario, and Severn Sound in southeast Georgian Bay. Water quality problems existed in all three AOC's, and shoreline alteration has occurred over many years because of urban and industrial development (e.g., infilling, shoreline hardening, marina construction). Habitat and water quality however varied spatially

within and between AOC's, and ranged from relatively undisturbed to highly degraded conditions (Randall et al 1993). The survey transects were selected to cover a range in macrophyte densities (absent, sparse, moderate and heavy), and represented a variety of habitat conditions (substrate, exposure to wind, shoreline conditions etc.). Transects were surveyed 2 to 3 times each, between May and August. Numbers of transects (sampled at least twice) were: Hamilton Harbour - 20 (Appendix 1a); Bay of Quinte: 20 (Appendix 1b); Penetang Bay - 29 (Appendix 1c); Hog Bay - 14 (Appendix 1d) and Matchedash Bay - 12 (Appendix 1e). Descriptions of the survey areas, and analysis of aspects of the fish data collected for the 1990 survey period are provided by Randall et al. (1993), Minns et al. (1993), Minns et al. (1994) and Randall et al. (1996).

4. **1992:** The objective was to collect additional data in the exposed outer reaches of Penetang Bay (6 transects; Appendix 1c), Hog Bay (6 transects; Appendix 1d) and throughout Sturgeon Bay (12 transects, Appendix 1f) in Severn Sound, and from the lower reaches of Bay of Quinte (24 transects; Appendix 1g). Preliminary analysis of the data collected in 1990 indicated that fish biomass was correlated with average seasonal phosphorus levels (Randall et al. 1993). The 1992 survey was designed to provide additional data from shoreline areas where phosphorus concentrations were lower. Other cofactors (location and exposure to wind, substrate, macrophyte density and temperature) were also considered.

5. **1994:** All data collected prior to 1994 were from Great Lakes Areas of Concern. The objective in 1994 was to collect additional near shore fish and habitat data from non-AOC areas. Surveys were conducted in Lake Ontario and Lake Erie, and represented natural wetlands, harbour breakwalls, and exposed lake shorelines. Site locations in 1994 included: in Lake Erie, inner Long Point Bay (9 transects; Appendix 1h), Port Dover (16 transects; Appendix 1i) and Port Colborne (22 transects, Appendix 1j); in Lake Ontario - Port Weller (3 transects, Appendix 1k), Port Dalhousie (14 transects, Appendix 1l), Burlington beach and waterfront (6 transects, Appendix 1m), Bronte Harbour (18 transects, Appendix 1n) and Presqu'ile (10 transects, Appendix 1o).

6. **1995:** Some additional data were collected from the north shore of Severn Sound. Nine transects were surveyed in the vicinity of Port Severn (Appendix 1p). Geologically, Severn Sound is a boundary area, and is divided between sedimentary rock on the south shore, and precambrian rock of the Canadian Shield on the north shore. All previous surveys in Severn Sound (1990 and 1992), were conducted at the south shore only. Data from Green Island provided information on fish assemblages in the Canadian Shield side of Severn Sound. In addition, 9 transects in Hog Bay were resurveyed in 1995 for comparison.

Areas surveyed annually, and the number of transects by area, are summarized in Table 1.

Electrofishing Surveys

1. Boat Specifications And Operation

A Smith-Root SR20E electrofishing boat (length=6.1 m, beam=1.9 m) was used to carry out research on fish communities in littoral habitats of the Great Lakes. Electric current is produced by a 16 Hp gas motor driving a 7.5 KW generator with the following output capacity (DC configuration): 170 - 1000 Volts DC in four steps; 30, 60 or 120 pulses per second (PPS); variable pulse width; maximum continuous output current of 10.4 A at 1000 volts DC and 120 PPS. Prior to 1992, the output ranged from 6.8 to 10.0 A, usually averaging between 8.0 and 9.0 A. After 1992, the output was standardized at 8.0 A. Electrode configuration consisted of two anodes (each with a terminal six wire umbrella array) extended out from the bow at about 25°, with the aluminum boat hull acting as the cathode.

The electrofishing crew consisted of four members, all trained in electrofishing procedures and safety, and possessing valid Cardiopulmonary Resuscitation (CPR) certificates. One member stationed at the console, was responsible for driving the boat and operating the electrofisher, two members stationed at the raised bow of the boat, were responsible for netting stunned fish using 10 foot long fibreglass dip nets and the fourth member was stationed at the livewell and assisted

the netters in emptying captured fish into the livewell. Each member was required to engage one of 4 "dead man" foot-switches which were connected in series (all four switches must be on to produce high voltage output) for safety.

2. Survey Design

A line transect survey design was used for electrofishing. Transects were 100 m long, parallel to shore and followed the 1.5m bottom contour (Figure 2). Transect locations were chosen based on depth, macrophyte abundance and wind exposure. End points for transects were marked on shore and were used to visually determine the beginning and end of each transect. Boat speed was kept as constant as possible but varied due to wind speed and direction as well as netting activity. Typical electrofishing times along each transect ranged from about 4 - 8 minutes. Sampling commenced in the late afternoon at approximately 1700 and concluded at approximately 0100.

3. Fish Sampling

All fish were held in an aerated, on-board holding tank of the electrofishing boat and processed after each transect was completed. Fish were identified to species. In rare cases, a species could not be identified in the field and one or two specimens were sacrificed and preserved in 10% formalin (or frozen) for subsequent identification following the key in Scott and Crossman (1973). Fish with a forked tail were measured for fork length (± 1 mm) and fish with truncated or rounded caudal fins were measured for total length as described in Balon and Noakes (1987). Fish were weighed individually up to a maximum of 20 fish per species at each transect. Where catches of a species exceeded 20, remaining fish of that species were counted and batch weighed. Small fish (< 3 kg) were weighed (± 1 g) on Sartorius digital balances (PT120, PT600, PT6) and larger fish (> 3 kg) were weighed (± 20 g) on a 15 kg Chatillon hanging dial scale. All field data were recorded on the electrofishing data sheet (Table 2) following completion of each transect.

4. Additional Measurements

Once fish were processed and released, the following physical and chemical measurements were recorded: date, start and finish time of electrofishing run, wind speed and direction, shock time, voltage, amperage output, surface water temperature, surface conductivity and Secchi disk depth (after 1990). Surface temperature and conductivity was taken at mid-transect with a YSI model 33 S-C-T meter. Dissolved oxygen (where applicable) and sub-surface temperature was taken using a YSI model 58 digital oxygen meter at both end points at 0.75 m depth and at 5 m depth at mid transect. A single Secchi disk measurement was recorded in the middle of the transect. If the disk was still visible on the bottom, Secchi depth was recorded as >1.5 m. Although a proper Secchi reading should be done at midday (Orth 1983), the purpose of this measurement was only to give a measure of visibility for seeing stunned fish in the 1.5 m water column.

5. Electrofishing Field Data Sheet

Biological and physical habitat measurements made during electrofishing surveys were recorded on field data sheets (Table 2). Data elements are described in detail in Appendix 2.

Habitat Sampling

Various habitat characteristics were measured to document micro and macro-habitat features which may have direct or indirect affects on fish abundance and/or species richness. Habitat sampling was typically done late in the summer or early fall. A global positioning system (GPS) was utilized to record transect co-ordinates so that they may be entered into a computerized global information system (GIS).

1. Macrophytes

Diving and Visual Surveys, 1990 and 1991

A subset of the transects was chosen for detailed macrophyte surveys in 1990 and 1991. Transects were located in the three AOC's - Bay of Quinte, Hamilton Harbour and Severn Sound. Plant species composition, plant height, stem density and biomass were measured by Scuba surveys. Percent bottom cover (% cover) was also estimated at the transects. Minns et al. (1993) described in detail the survey methodology, and the analysis of the littoral macrophytes at the AOC's. Percent cover was correlated with stem density and plant height, and Minns et al. (1993) concluded that percent cover provided a good measure of plant abundance, given sufficient standardization and sampling.

Visual and Echo Sounder Surveys, 1992 to 1995

Two methods were adopted for surveying macrophytes at the transects: a visual estimate of percent bottom cover, and echo sounder recordings. The methods are described below.

Visual Estimates of Percent Cover: A 100 m floating rope, marked at 10 m intervals, was extended along the 1.5 m contour directly out from the existing shoreline markers (Fig. 2) and anchored in place. A Boston Whaler was used to slowly move along the 100 m transect rope stopping at each 10 m mark (including beginning and end points, total sample was 11) where an estimate of percent bottom cover was made using a special viewer. The viewer was constructed from a 77L green plastic garbage can with the bottom removed and a panel of black cloth fastened around the circumference of the top of the can. To use the viewer, a person would put their head into the top of the can, with the black cloth draped over his/her head and shoulders to block any outside light. While bending over, the bottom of the can was placed into the water above the macrophytes and an instantaneous estimate of percent cover (percent of the circular viewing field occupied by macrophytes) was taken. All visual estimates were made on the shady

side of the boat. Secchi disk readings to determine water clarity were also made (see Water Quality below).

Dominant plant types along the transect were identified to genus. On rare occasions, if a plant could not be identified in the field, a sample was kept moist in a plastic sample bag for subsequent identification (Fasset 1966) in the lab. The most common plant genera encountered were : *Vallisneria* (wildcelery), *Myriophyllum* (watermilfoil), *Potamogeton* (pond weed), *Chara* (stonewort) and *Ceratophyllum* (coontail).

Echo Sounding: The second method used to estimate macrophyte abundance was echo sounding (Lowrance X-16 paper graph recorder with 20° cone angle transducer). This unit was suitable for graphing macrophytes in shallow (1.5m - 5.0m) water for the following reasons: depth range was adjustable in 1 m increments; the "GRAYLINE" feature separated macrophytes from the harder bottom and/or bottom debris; adjustable pulse width with 2.5 cm resolution; adjustable paper speed (allowed us to optimize the length of the echogram); and finally the unit produced a hard copy that could be interpreted at a later time. Settings on the unit were predetermined to optimize the length, resolution , depth range, and readability of the echogram (Table 3).

Prior to initiating the survey, floats and anchors were placed at the 5 m depth contour perpendicular to shore at the two end-points of the transect. The distances from each 5 m float to shore was measured using a 100 m measuring tape. Where distances were greater than 100 m, an optical range finder was used. We used a Boston Whaler (5.0 m) with a 70 HP outboard motor running at idle speed to record the echograms. Three echograms were taken for each transect (Fig. 2). One was taken along the 100 m transect on the 1.5m contour, parallel to shore, and the other two were taken perpendicular to the shoreline starting offshore in 5 m of water and travelling in to shore towards each end marker. The two perpendicular echo sounder transects provided information on how far offshore the macrophytes extended. Boat speed was kept constant by starting the boat far enough ahead of the start point that idle speed was achieved before recording commenced. Each echogram was marked at the start and end points, and a stopwatch was used to time the run. During the offshore runs, an additional mark was made on

the echogram as the boat (transducer) crossed the 1.5 m bottom contour and another at the point when the water became to shallow to operate the outboard motor. A temporary float and anchor was placed into the water at this point. The distance from the temporary float to the shore was measured using a 100 m tape.

2. Substrate

In 1991, substrate samples were collected at two locations on the 1990 transects, and at a number of locations adjacent to, onshore and offshore of the transect. The latter samples were collected to provide information on substrate characteristics in the proximity of the transect, and are not considered to be part of this study. Transect samples were retained, dried and sieved in the laboratory, to determine particle size. After 1991, in all subsequent sampling, particle size was determined visually, in the field, as described below.

For fine substrates, an Ekman sampler was used. Two substrate samples were taken 30 m in from each end point of the 1.5 m transect. Substrate categories were assigned based on average particle size as listed below (from Cummins 1962), with an additional category for organic debris (wood particles). Particle size assignments were done visually and by feel. For coarse substrates, visual observations only were made.

- silt (0.0039 mm to 0.0625 mm)
- sand (0.0625 mm to 2 mm)
- gravel (2 mm to 16 mm)
- pebble (16 mm to 64 mm)
- cobble (64 mm to 256 mm)
- boulder (>256 mm)
- bedrock
- organic

Heterogeneous samples were categorized as a combination of the two most dominant substrate types, with the least dominant type preceding the most dominant type. For example, a sample which was mainly sand (dominant) and silt (subdominant) was classified as silty sand. If

more than two subdominant categories appeared in a sample, the subdominant types were listed as being present.

3. Water Quality Measurement

As noted above, water temperature and Secchi depth were usually recorded at each transect on the electrofishing survey date. Following the methods outlined above in **Additional Measurements**, water quality measurements included: Surface temperature and conductivity at mid transect, Dissolved oxygen, sub-surface temperature and Secchi disk depth. Dissolved Oxygen measurements were usually only taken in Hamilton Harbour, where anoxia is known to be a problem, at times even in depths < 5 m (J. Fitzsimons, pers. comm.).

4. Geo-referencing of the Transect Locations

Transect locations were marked as accurately as possible using shore reference points on Ontario Base Maps, hydrographic charts (detailed harbour charts where available) or topographic maps. Shorelines and transects were digitized, and incorporated into a GIS database. Distances from transects to shore were measured for 16 compass points (i.e., 22.5 degree intervals). Littoral slope was calculated as 1.5 m/min*1000, where min was the minimum distance in km from the transect to the shore. Maximum wind exposure, was the maximum overwater distance from the transect to a shoreline. Effective fetch, based on the prevailing wind direction, was calculated for all transects (Randall et al. [1996]; J. E. Moore, pers. comm.).

In 1994 and 1995, a Magellan Nav5000 Pro hand held Global Positioning System (GPS), with differential beacon receiver (DBR) was used to record co-ordinates for both transect end-points. With the use of the DBR unit, accuracy was expected to be within 10 m (Magellan Systems Corp. 1993). Co-ordinates were taken with the boat anchored in place at each transect end-point. The following set-up parameters were used for the Nav 5000 Pro: map datum=WGS84; mask angle=10°; terrain setting=interupted; co-ordinate system=Universal transverse mercator (UTM). A compass bearing

from one transect end-point to the other was also recorded. GPS co-ordinates were used to help identify the transect locations for the GIS databases.

5. Habitat Field Data Sheet

Physical habitat measurements made at the transects were recorded on field data sheets (Table 4), including the information on macrophyte % cover and composition, settings of the echosounder, substrate, water quality and GPS coordinates. Data elements for the Habitat Field Data Sheet are described in detail in Appendix 3.

A summary of the habitat features recorded in each survey area are listed in Table 5.

6. Shoreline Survey

A shoreline survey (called Physical Habitat Integrity, developed by C.K. Minns, GLLFAS) was designed to complement the transect habitat surveys. The objective was to define conditions in general in a zone 200-300 metres on either side of the 100 metre shoreline strip parallel to the electrofishing transect along the 1.5 metre contour and reaching inland about 150-200 metres. Habitat features recorded for the shoreline survey are given in Table 6. Data fields are described in detail in Appendix 4.

Data Processing

1. Data Entry

All electrofishing data were entered into tables created in the RS1 database software (BBN Software Products Corporation, Cambridge, Mass.). A specific set of procedures for creating and editing RS1 tables was created by J. E .Moore (DFO, GLLFAS) and provided a consistent, standardized format for data storage from year to year.

2. Data Verification And Documentation

Following entry of each sheet of data, all numbers were compared and verified against the raw data. When the entry and verification process was completed for a season, a series of RS1 procedures (J. E. Moore, pers. comm.) were performed to prepare all data for subsequent analysis. These procedures performed the following checks: developed a list of species present; counted individuals for each species; checked data for missing weights and lengths; checked each individual species (if > 10 individuals) for length/weight outliers (≥ 2 SD); checked batch weights for weight outliers (deviation of batch weights from individual weights ≤ -30% or ≥ 15%). Questionable data (outliers) were again checked against the raw data and if an error was found, the value in question was replaced or deleted.

Fish Catch Data

A summary of catch data from all locations (1988 - 1995) is provided in Table 7. For each location, the table includes total catch by species, number of species caught, number of individual transects and number of transects sampled within the year. Over the 8 sampling years, 54 species and 2 hybrid crosses representing 21 different families were caught.

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References

Balon, E.K. and D.L.G. Noakes. 1987. Principles of Ichthyology. Supplements to lectures and laboratory exercises. Department of Zoology, University of Guelph. 4th revised edition.

Cummins, K.W. 1962. An evaluation of some techniques for the collection and analysis of benthic samples with special emphasis on lotic waters. Am. Midl. Nat. 67, 477-504.

DFO. 1986. The Department of Fisheries and Oceans Policy for the Management of Fish Habitat. Dept. Fisheries & Oceans, Ottawa, Ontario. 30p.

Fasset, N.C. 1966. A Manual of Aquatic Plants. University of Wisconsin Press. Madison, Wisconsin, USA. 405p.

Hartig, J.H. and R.L. Thomas. 1988. Development of plans to restore degraded areas of the Great Lakes. Environmental Management 12: 327-347.

IJC. 1984. Report on Great Lakes Water Quality. Great Lakes Water Quality Board, Windsor, Ontario, Canada.

Magellan Systems Corporation. 1993. User Guide and Installation Instructions for the Magellan Differential Beacon Receiver. Magellan Systems Corporation. San Dimas, California, USA.

Minns, C.K. , V.W. Cairns, R.G. Randall, A. Crowder and A. McLaughlin. 1993. Macrophyte surveys of littoral habitats in Great Lakes' Areas of Concern: The Bay of Quinte, Hamilton Harbour and Severn Sound - 1988 to 1991. Can. Tech. Rep. Fish. Aquat. Sci. 1936:viii+60p.

Minns, C.K., V.W. Cairns, R.G. Randall and J.E. Moore. 1994. An Index of Biotic Integrity (IBI) for fish assemblages in the littoral zone of Great Lakes' Areas of Concern. Can. J. Fish. Aquat. Sci. 51:1804-1822.

Orth, D.J. 1983. Aquatic Habitat Measurements. p.61-84. In: L.A. Nielsen and D.L. Johnson [ed.] Fisheries Techniques. American Fisheries Society. Southern Printing Company Inc., Blacksburg, Virginia.

Randall, R.G., C.K. Minns, V.W. Cairns, and J.E. Moore. 1993. Effect of habitat degradation on the species composition and biomass of fish in Great Lakes Areas of Concern. Can. Tech. Rep. Fish. Aquat. Sci. 1941. viii+37p.

Randall, R.G., C.K. Minns, V.W. Cairns, and J.E. Moore. 1996. The relationship between an index of fish production and submerged macrophytes and other habitat features at three littoral areas of the Great Lakes. Can. J. Fish. Aquat. Sci. 53 (Suppl. 1): in press.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. 184: 966 p.

Table 1. Electrofishing history from 1988 - 1995 showing survey locations, number of transects, and sampling dates.

Sampling Year	Location	Month	Dates	Number of Transects
Productive Capacity				
1990	Hamilton Harbour	May	23-25	25
		June	27-28	20
		July/Aug	30-3	40
	Bay of Quinte	June	21-25	19
		July	23-25	20
		Aug	20-22	20
	Penetang Harbour	June	5-7	26
		July	9-11	29
		Aug	7-9	29
	Hog Bay	July	16-17	14
		Aug	15	14
	Matchedash Bay	June	12-13	12(2)*
		July	18-19	12
		Aug	14	12
1992	Penetang Harbour	July	7-9	6
		Aug	5-6	6
	Hog Bay	July	6	3
		Aug	4	3
	Sturgeon Bay	July	7	12
		Aug	5	11
	Carnachan Bay	July	15	9
		Aug	11-17	8
	Hay Bay	July	14	9
		Aug	10-17	9
	Conway	July	16	6
		Aug	13-17	6
1994	Long Point	July	5-6	9
		Aug	16-17	9
		Sept/Oct	29-5	9
	Pt. Dover	June/July	28-4	16
		Aug	10-17	16
		Sept/Oct	22-4	16
	Pt. Colborne	July	11-19	22
		Aug/Sept	25-1	22
		Oct	6-13	22

* numbers in parentheses indicate replicate samples

Table 1 Continued

Sampling Year	Location	Month	Dates	Number of transects
	Pt. Weller	June	16	5
		Aug	5	5
		Sept	15	3
	Pt. Dalhousie	June	14-15	14
		Aug	2-18	14
		Sept	13-14	14
	Burlington	June	12-19	6
		July	21	6
		Sept	8-12	6
	Bronte Harbour	June	1-9	18
		July	14-20	18
		Sept	5-7	18
	Presqu'ile	June	22-23	10
		Aug	7-8	10
		Sept	19-20	10
1995	Pt. Severn	June	21-22	9
		Aug	9-14	9
		Oct.	3-4	9
	Hog Bay	June	28-29	9
		Aug	15-16	9
Other surveys				
1988	Hamilton Harbour	May/June	30-3	20
		June	5-9	31
		June	12-16	23
		June	20-21	6
		June	26-30	40
		July	4-7	40
		July	17-20	40
		July	24-28	39(7)*
		Aug	7-11	34
		Aug	15-18	38
		Aug	22	8
1992	Hamilton Harbour	May	14-22	46
		July/Aug	23-19	44
1993	Hamilton Harbour	July	12-13	8
		July/Aug	26-11	27
1995	Hamilton Harbour	May/June	30-15	31
		July/Aug	3-8	32
		Sept	18-21	24
1989	Bay of Quinte	Aug	2-10	32(2)*

* numbers in parentheses indicate replicate samples

Table 2. Electrofishing Field Data Sheet used for the electrofishing surveys. Data fields are described in Appendix 2.

ELECTROFISHING (1994)

SHEET#___OF___

DATE ___/___/94 TRANSECT_____ TIME S____F____ SHOCK(s)_____
WTEMP(OC) _____ SECCHI(cm)_____ AMPS_____ VOLTS_____
COND(µScm-1)_____ WIND(0-9)_____ W.DIR.(N=1,E=2,S=3,W=4) _____
DO1 (0.75m)_____ DO2 (O.75m)_____ DO3 (5m)_____
T1 _____ T2 _____ T3 _____

MEASURE MAX. OF 20 INDIVIDUALS/SPECIES. ABOVE 20, BATCH WEIGH.

#	SPP	FL(mm)	W(g)	SX	SCALE#	#	SPP	FL(mm)	W(g)	SX	SCALE#
1						21					
2						22					
3						23					
4						24					
5						25					
6						26					
7						27					
8						28					
9						29					
10						30					
11						31					
12						32					
13						33					
14						34					
15						35					
16						36					
17						37					
18						38					
19						39					
20						40					

BATCHES(>20)

SPP	NUMBER(#)	WEIGHT(g)	SPP	NUMBER(#)	WEIGHT(g)

NOTES: □ON BACK

Table 3. Settings for the Lowrance X-16 echosounder used for habitat surveys to record depth and macrophyte density.

Lowrance X-16 Setting	Electrofishing Transect	Offshore Transects
Sensitivity	Minimum	Minimum
Grayline	4	4
Print Intensity	1	1
Paper Speed	5 (2.1 in/min)	7 (3 in/min) or 5 (2.1in/min) †
Scale*	0-2 m	0-5 m
Pulse Width	30 µs (Dense vegetation)	30 µs (Dense vegetation)
	110 µs (Sparse vegetation)	110 µs (Sparse vegetation)
Suppression	0	0
Discrimination **	0 to 4	0 to 4
Surface Clutter **	1 to 7	1 to 7

† paper speed is dependant on the length and uniformity of each individual transect. For short transects (ie. ≤100m) or transects with rapid depth changes and/or underwater structures, a faster paper speed was used. Slower paper speeds were used for longer, more uniform transects, in order to shorten the echogram.

* scale of the echogram was chosen to optimize the size of the tracing. (ie. largest possible tracing, that still included the deepest part of the transect).

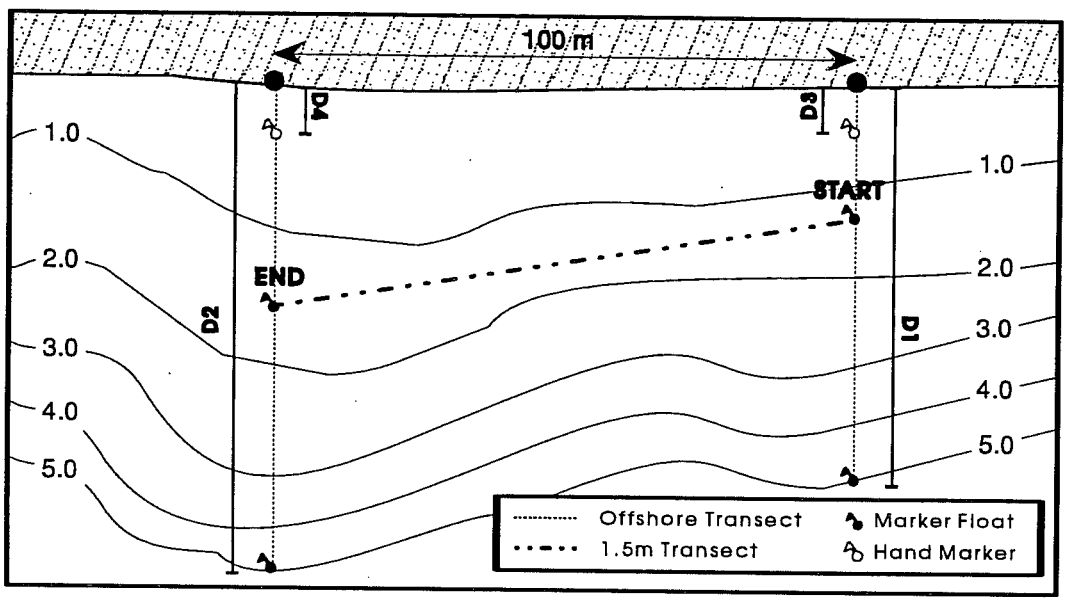
** these settings were set at minimum and increased accordingly to optimize the readability of the echogram. Conditions such as rough water, extremely abundant vegetation, bubbles under the boat, etc., may have warranted the increase of one or both settings.

Table 4. Habitat Field Data Sheet used for the habitat survey. Data fields are described in Appendix 3.

HABITAT SAMPLING (1994)

DATE ____/____/94 TRANSECT _____ TIME (24hrs) _____

WIND VEL. (km/h) _____ WIND DIR. (N=1,E=2,S=3,W=4) _____



SUBSTRATE _____ SUBSTRATE _____

D2_____ D4_____ D1_____ D3_____

	D2	TRANSECT	D1
ECHOGRAM TIME (s)	_____	_____	_____
PULSE WIDTH (μs)	_____	_____	_____
DISCRIMINATION (0-4)	_____	_____	_____
SURFACE CLUTTER (1-7)	_____	_____	_____
PAPER SPEED (0-7)	_____	_____	_____

UTM CO-ORDINATES FOR TRANSECT MARKERS

NORTHING _____ NORTHING _____

EASTING _____ EASTING _____

ZONE _____ ZONE _____

PERCENT COVER

OBSERVER:	0m	10	20	30	40	50	60	70	80	90	100m

DOM. VEG.: Chara sp. Vallisneria sp. Myriophyllum sp. Potamogeton sp. Ceratophyllum sp.

NOTES : ☐ on back

Table 5. Summary of the habitat features measured at each survey area . Habitat measures are described in detail in the text.

Area	Georeference	Transects	Macrophytes	Substrate	Shore	Water	Other
Hamilton Harbour	1, 2	54	1, 2	x	x	1, 2, 3	1, 2, 3
Penetang Harbour (AOC)	2	29	1, 2	x	x	1, 3	1, 2, 3
Penetang Harbour (Outer)	2	6	1, 2	x	x	1, 2, 3	
Hog Bay (AOC)	2	14	1, 2	x	x	1, 3	1, 3
Hog Bay (Outer)	2	3	1, 2	x	x	1, 2, 3	
Matchedash Bay	2	12	1	x	x	1, 3	1, 3
Sturgeon Bay	2	12	1	x	x	1, 2, 3	
Port Severn	1, 2	9	1, 2	x	x	1, 2, 3	
Bay of Quinte - Belleville	1, 2	9	1, 2	x	x	1, 3	1, 2, 3
Bay of Quinte - Big Island	1, 2	14	1, 2	x	x	1, 3	1, 2, 3
Bay of Quinte - Trenton	1, 2	10	1, 2	x	x	1, 3	1, 2, 3
Bay of Quinte - Hay Bay	2	9	1	x	x	1, 2, 3	
Bay of Quinte - Charn. Bay	2	9	1	x	x	1, 2, 3	
Bay of Quinte - Conway	2	6	1, 2	x	x	1, 2, 3	
Long Point	1, 2	9	1, 2	x	x	1, 2, 3	
Port Dover	1, 2	16	1, 2	x	x	1, 2, 3	
Port Colborne	1, 2	22	1, 2	x	x	1, 2, 3	
Port Weller	1, 2	3	1, 2	x	x	1, 2, 3	
Port Dalhousie	1, 2	14	1, 2	x	x	1, 2, 3	
Burlington Waterfront	1, 2	6	1, 2	x	x	1, 2, 3	
Bronte Harbour	1, 2	18	1, 2	x	x	1, 2, 3	
Presqu'ile	1, 2	10	1, 2	x	x	1, 2, 3	

Georeference
1 = GPS coordinates
2 = Chart reference

Transects
Number of transects

Macrophytes
1 = Echograms recorded, including offshore transects
2 = Visual survey

Substrate
x = Particle size recorded

Shore
x = Physical Habitat Integrity (PHI) survey completed

Water
1 = Temperature taken at time of electrofishing run
2 = Secchi disk depth taken at time of electrofishing run
3 = Conductivity taken at time of electrofishing run

Other
1 = SCUBA macrophyte survey
2 = Light extinction recorded
3 = Shoreline sediment survey

Table 6. Physical Habitat Integrity (PHI) data sheet. Data fields are described in Appendix 4.

PHYSICAL HABITAT INTEGRITY (PHI)				
CATEGORY	5	3	1	0
VEGETATION				
1 Wetland proximity	Present	Close by	Far off	Absent
2 Wetland size	V.Large	Large	Medium	Small
3 W 1st Spp dominance	30-70%	<30%	>70%	-
4 W Open water inter.	25-50%	<25%	>50%	-
5 Macrophyte abundance	Abundant	Common or	Sparse	Absent
6 M Height % of depth	30-70%	>70%	<30%	-
7 M 1st Spp dominance	30-70%	<30%	>70%	-
8 Plant types	Floating	Submerged	Elodea	
9 Riparian vegetation	Trees/Bushes	Shrubs/Tall	Turf/Lawn	Absent
SHORE SUBSTRATE				
1 1st,2nd, and 3rd dominants	1st 50%? ___	2nd 30%?	3rd 10%? ___	4th 10%? ___
2 Structure	Abundant	Common	Sparse	Absent
WATER QUALITY				
1 Turbidity (opacity/colour)				
2 Secchi Depth (cm)				
TOPOGRAPHY				
1 Onshore slope	Nil/Low	Shallow	Steep	V.Steep
2 Offshore slope	Nil/Low	Shallow	Steep	V.Steep
3 Exposure	Low	Medium	High	V.High
4 Fetch (wind exposure)	Nil/Low	Medium	High	V.High
5 Shoreline development	V.High	High	Medium	Nil/Low
TRANSFORMATION				
1 Impermeable land surfaces	<10%	10-30%	30-70%	100%
2 Buildings	None	Near by	Adjacent	Many present
3 Waterfront structures	None	Some	Rip-rap	Wall
4 Proximity to features	1st ____	2nd ____	3rd ____	4th ____
COLUMN SUM	___x 5 = ___	___x 3 = ___	___x 1 = ___	___x 0 = ___
PHI INDEX = ___				

Table 7. Electrofishing catch summary from 1988 - 1995 showing total numbers, number of species, number of transects and number of samples for each location. HAM = Hamilton Harbour; BOQ = Bay of Quinte; HOG = Hog Bay; PEN = Penetang Bay; MAT = Matchedash Bay; STG = Sturgeon Bay; BRON = Bronte Harbour; BURL= Burlington Waterfront; PDAL = Port Dalhousie; PRES = Presqu'ile; PWEL = Port Weller; PCOL = Port Colborne; PDOV = Port Dover; LONG = Long Point; PSEV = Port Severn..

	HAM88	HAM90	HAM92	HAM93	HAM95	BOQ89	BOQ90	BOQ92	HOG90
Petromyzon marinus									
Lepisosteus osseus	1	1				3	1		
Amia calva	1				2	4	6	3	4
Alosa Pseudoharengus	15515	2482	1110	847	1805	7	547	217	6
Dorosoma cepedianum	173	17	38	8	162	124	207	5	
Oncorhynchus kisutch									
Oncorhynchus tschawytsha	52	7	18		4				
Oncorhynchus mykiss		9	3		5				
Salmo trutta	3	1	14		6				
Salvelinus namaycush	2	1			2				
Osmerus mordax	4	22	8		4	2			
Esox lucius	9	9	6	1	7	32	41	21	3
Esox americanus vermiculatus									
Umbra limi							1		
Carpiodes cyprinus									
Catostomus commersoni	122	32	81	8	32	16	19	22	3
Erimyzon sucetta									
Moxostoma anisurum							1		
Moxostoma erythrurum									
Moxostoma macrolepidotum				1		1	4		
Moxostoma carinatum									
Moxostoma sp.									
Carassius auratus	52	10	4	1	2				
Couesius plumbeus									
Cyprinus carpio	784	110	111	52	75	18	34		7
Hybognathus regius									
Notemigonus crysoleucas						3	60	40	9
Notropis atherinoides	1157	792	302	24	114	1	15	13	
Luxilus cornutus						1			
Notropis heterodon									33
Notropis heterolepis									
Notropis hudsonius	205	6	58	9	45	90	125	30	
Pimephales notatus									6
Pimephales promelas									
Ameiurus nebulosus	5479	684	209	98	126	27	65	57	3
Ictalurus punctatus		1				1			
Anguilla rostrata	16	5	4	4	5	12	9	9	
Fundulus diaphanus									
Gasterosteus aculeatus					1				
Percopsis omiscomaycus	1		4						
Morone americana	1955	164	494	68	122	111	95	14	
Morone chrysops	53	2				2	2	2	
Ambloplites rupestris	4	2	11	8	23	81	118	45	18
Lepomis gibbosus	315	49	191	80	1059	108	180	121	729
Lepomis macrochirus		1	5	2	39	2	32		
Micropterus dolomieu	33	9	32	8	13	67	30		4
Micropterus salmoides	27	13	28	13	499	28	65	16	87
Pomoxis nigromaculatus	3	3	4	1	10	2	16		31
Perca flavescens	402	9	18	10	50	907	3116	473	441
Stizostedion vitreum vitreum			2			193	65	72	1
Etheostoma nigrum	1					2	2		
Percina caprodes			6	5	121	288	225		
Labidesthes sicculus					2		6		6
Aplodinotus grunniens	19	5	5	1	3	43	35	3	
Cottus cognatus									
C. auratus X C. carpio	6		6	7	3				
L. gibbosus X L. macrochirus				1					
Number of Transects	40	44	46	27	23	34	20	24	14
Number of Samples	326	85	90	35	87	34	59	47	28
Number of Species*	28	27	27	23	29	29	29	18	17
Number of Fish	26394	4446	2772	1257	4341	2176	5122	1163	1391

* Hybrid crosses included as separate species.

Table 7 continued

	PEN90	MAT90	HOG92	PEN92	STG92	BRON94	BURL94	PDAL94
Petromyzon marinus								
Lepisosteus osseus				1				
Amia calva	6	18			4			
Alosa Pseudoharengus	380	102		4	4	3873	280	151
Dorosoma cepedianum		13				4		49
Oncorhynchus kisutch						1		
Oncorhynchus tschawytsha		1				2	1	1
Oncorhynchus mykiss						10		2
Salmo trutta						13		4
Salvelinus namaycush							1	
Osmerus mordax	6			80		12	14	
Esox lucius	4	5			2	2		6
Esox americanus vermiculatus								
Umbra limi								
Carpiodes cyprinus	19	4						
Catostomus commersoni	118	43		1	4	320	26	33
Erimyzon sucetta								
Moxostoma anisurum	1							
Moxostoma erythrurum		1						
Moxostoma macrolepidotum	17			1				1
Moxostoma carinatum								23
Moxostoma sp.					4	3		
Carassius auratus	1	3						
Couesius plumbeus								
Cyprinus carpio	18	10	1			8	1	8
Hybognathus regius								
Notemigonus crysoleucas	8	49			7			
Notropis atherinoides	27					53	14	192
Luxilus cornutus						2		
Notropis heterodon	54							
Notropis heterolepis		1						
Notropis hudsonius	23	22		2	7	230	1	10
Pimephales notatus	65	2						
Pimephales promelas								
Ameiurus nebulosus	23	73	1		3	1		
Ictalurus punctatus								
Anguilla rostrata						7	1	46
Fundulus diaphanus	1							
Gasterosteus aculeatus						1		
Percopsis omiscomaycus	6						1	
Morone americana						3	1	
Morone chrysops	2	5						
Ambloplites rupestris	87	74		1	10	12		40
Lepomis gibbosus	897	330	38	5	189	22		7
Lepomis macrochirus								1
Micropterus dolomieu	91	1		5	2	48		137
Micropterus salmoides	64	46	1	1	19	3		10
Pomoxis nigromaculatus	38	152	2		20	1		
Perca flavescens	1480	846	34	10	128	17	6	9
Stizostedion vitreum vitreum	2	9						2
Etheostoma nigrum						1		
Percina caprodes		6				1		4
Labidesthes sicculus	4							1
Aplodinotus grunniens						1		4
Cottus cognatus						3		
C. auratus X C. carpio								2
L. gibbosus X L. macrochirus								
Number of Transects	29	12	3	6	12	18	6	14
Number of Samples	84	38	6	12	23	54	18	42
Number of Species*	27	24	6	11	13	27	12	24
Number of Fish	3442	1816	77	111	403	4654	347	743

* Hybrid crosses included as separate species. A fish that was identified to genus only (eg. Moxostoma sp.) but was known to be one of the species in the above list was not counted as a separate species.

Table 7 continued

	PRES94	PWEL94	PCOL94	PDOV94	LONG94	PSEV95	HOG95
Petromyzon marinus	1						
Lepisosteus osseus	1					1	
Amia calva	2		1	1	8	8	5
Alosa Pseudoharengus	50	178		5		43	
Dorosoma cepedianum	1	1	4	172		1	
Oncorhynchus kisutch							
Oncorhynchus tschawytsha							
Oncorhynchus mykiss							
Salmo trutta							
Salvelinus namaycush							
Osmerus mordax			2				
Esox lucius	16		55	1	22	12	4
Esox americanus	3				44		
Umbra limi							
Carpiodes cyprinus			1	1			
Catostomus commersoni	2	19	4	1		9	2
Erimyzon sucetta					15		
Moxostoma anisurum			3				
Moxostoma erythrurum							
Moxostoma macrolepidotum		1	11	8		12	
Moxostoma carinatum			3				
Moxostoma sp.							
Carassius auratus			1				
Couesius plumbeus							
Cyprinus carpio	1	1	21	27	4	3	13
Hybognathus regius							2
Notemigonus crysoleucas	101			15	71	53	13
Notropis atherinoides		8	1	53			
Luxilus cornutus							3
Notropis heterodon					108	4	47
Notropis heterolepis	8						
Notropis hudsonius	15	4	1	10		2	17
Pimephales notatus	1	2			2	5	3
Pimephales promelas							
Ameiurus nebulosus	92		10	4	28	22	5
Ictalurus punctatus				3			
Anguilla rostrata	3	2	4	1			
Fundulus diaphanus					3		
Gasterosteus aculeatus							
Percopsis omiscomaycus		1					
Morone americana		1				3	
Morone chrysops		1					
Ambloplites rupestris	12		134	75	48	25	14
Lepomis gibbosus	167		134	111	68	224	236
Lepomis macrochirus	6		26	87	274		
Micropterus dolomieu		2	49	16		2	2
Micropterus salmoides	15		58	103	172	26	52
Pomoxis nigromaculatus	1		2	7	19	55	18
Perca flavescens	585		57	27	224	463	189
Stizostedion vitreum vitreum	4	1				2	
Etheostoma nigrum							
Percina caprodes				1		1	
Labidesthes sicculus	79		3	200	53	20	1
Aplodinotus grunniens		5	26	8	4		
Cottus cognatus							
C. auratus X C. carpio			1	1			
L. gibbosus X L. macrochirus							
Number of Transects	10	3	22	16	9	9	9
Number of Samples	30	9	66	48	27	27	18
Number of Species*	23	15	25	25	18	23	18
Number of Fish	1166	227	612	938	1167	996	626

* Hybrid crosses included as separate species.

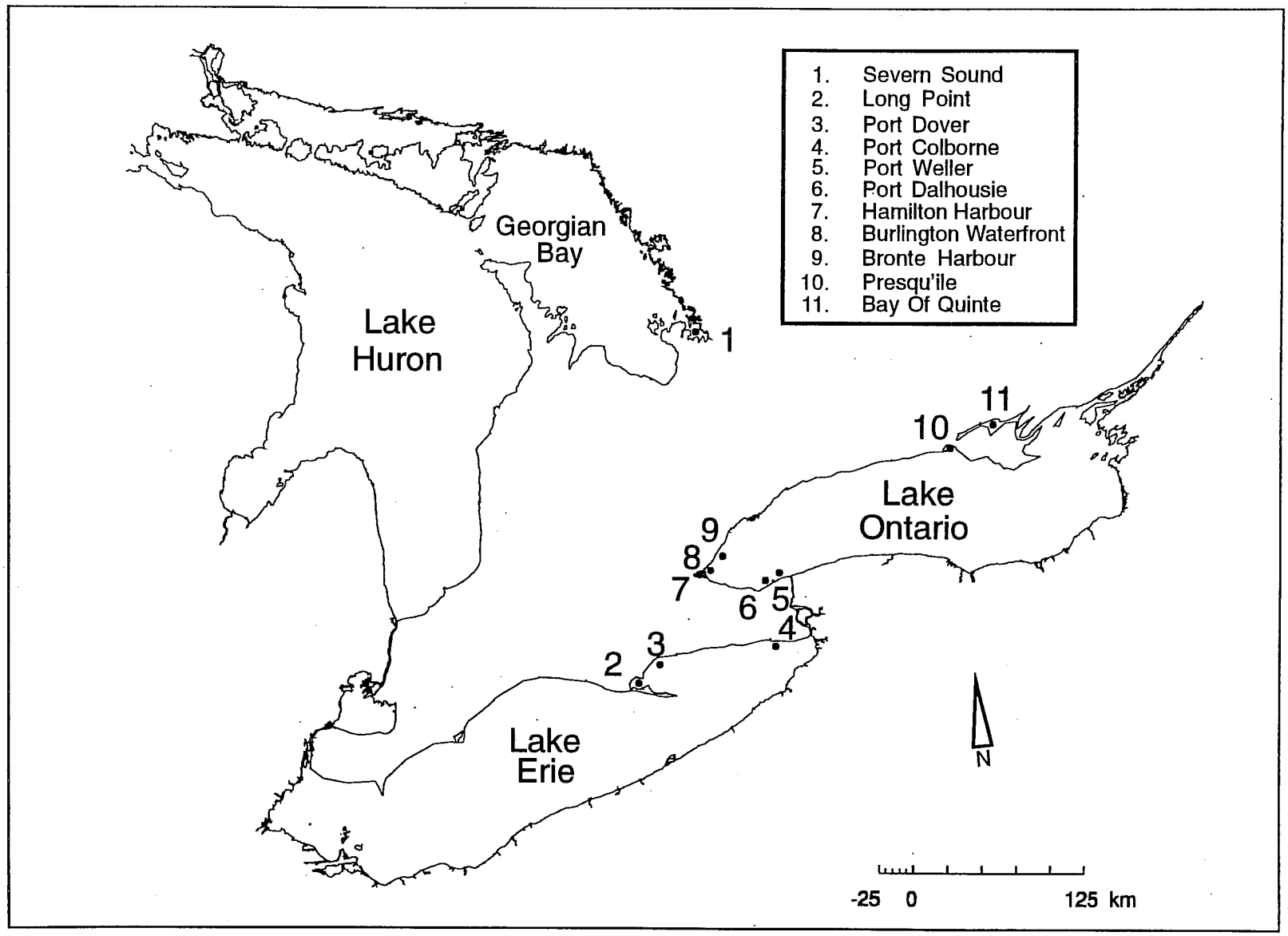


Fig. 1 Map of Great Lakes showing the general survey locations. Detailed maps of each survey area are given in Appendix 1.

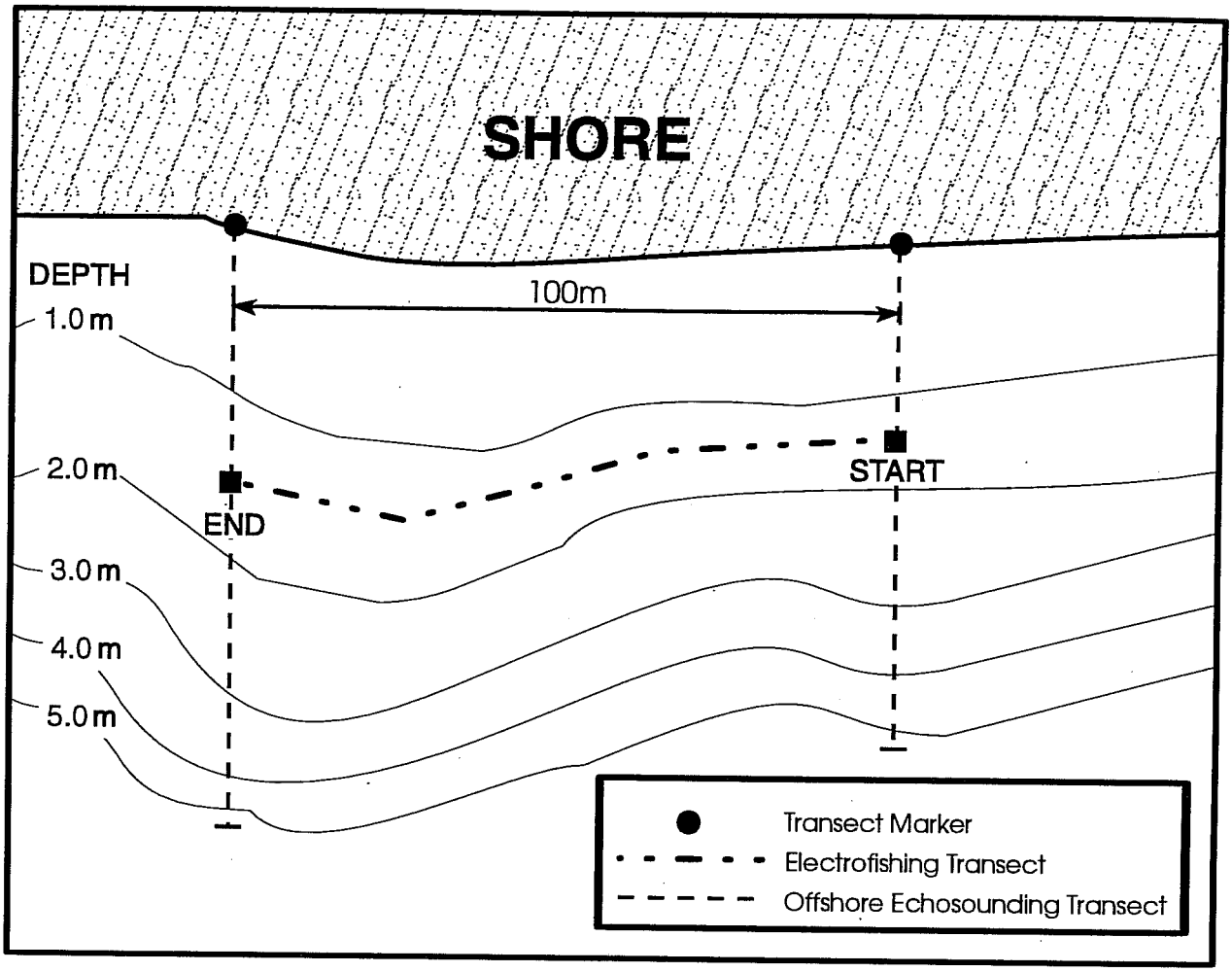
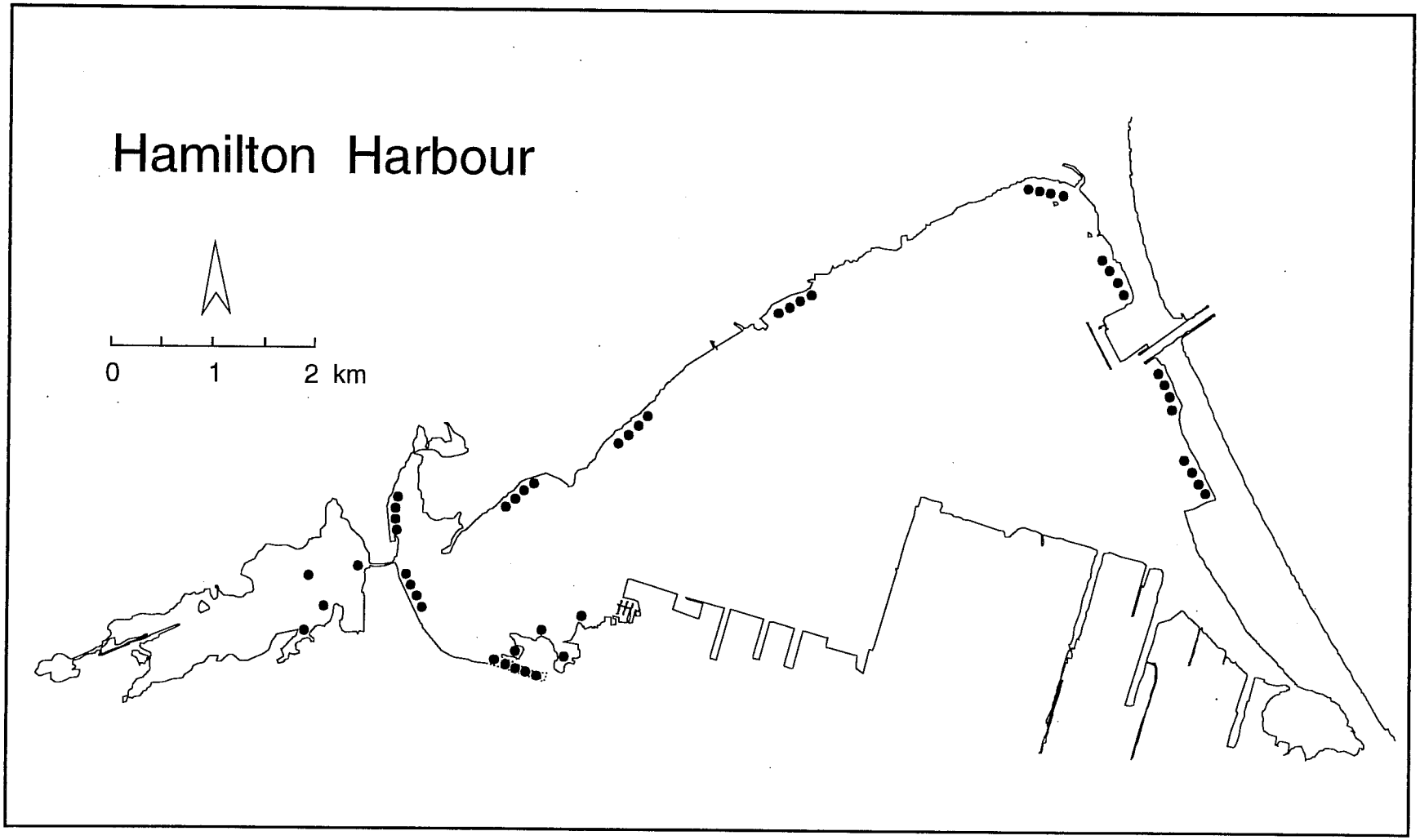
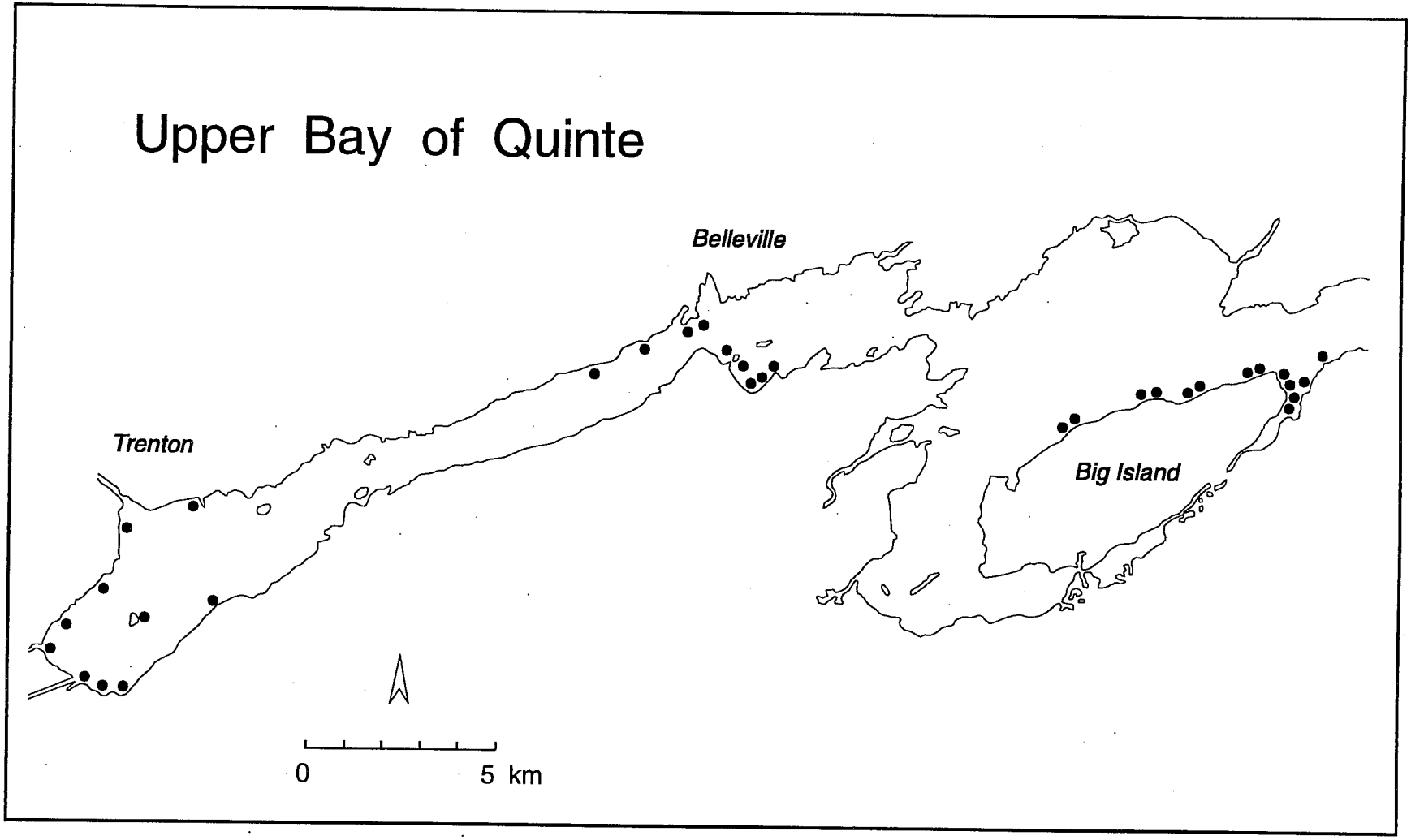


Fig. 2 Figure showing the location of the electrofishing transect in relation to the shoreline and offshore bathymetry. Offshore echosounding transects to determine depth and macrophyte density are also indicated.

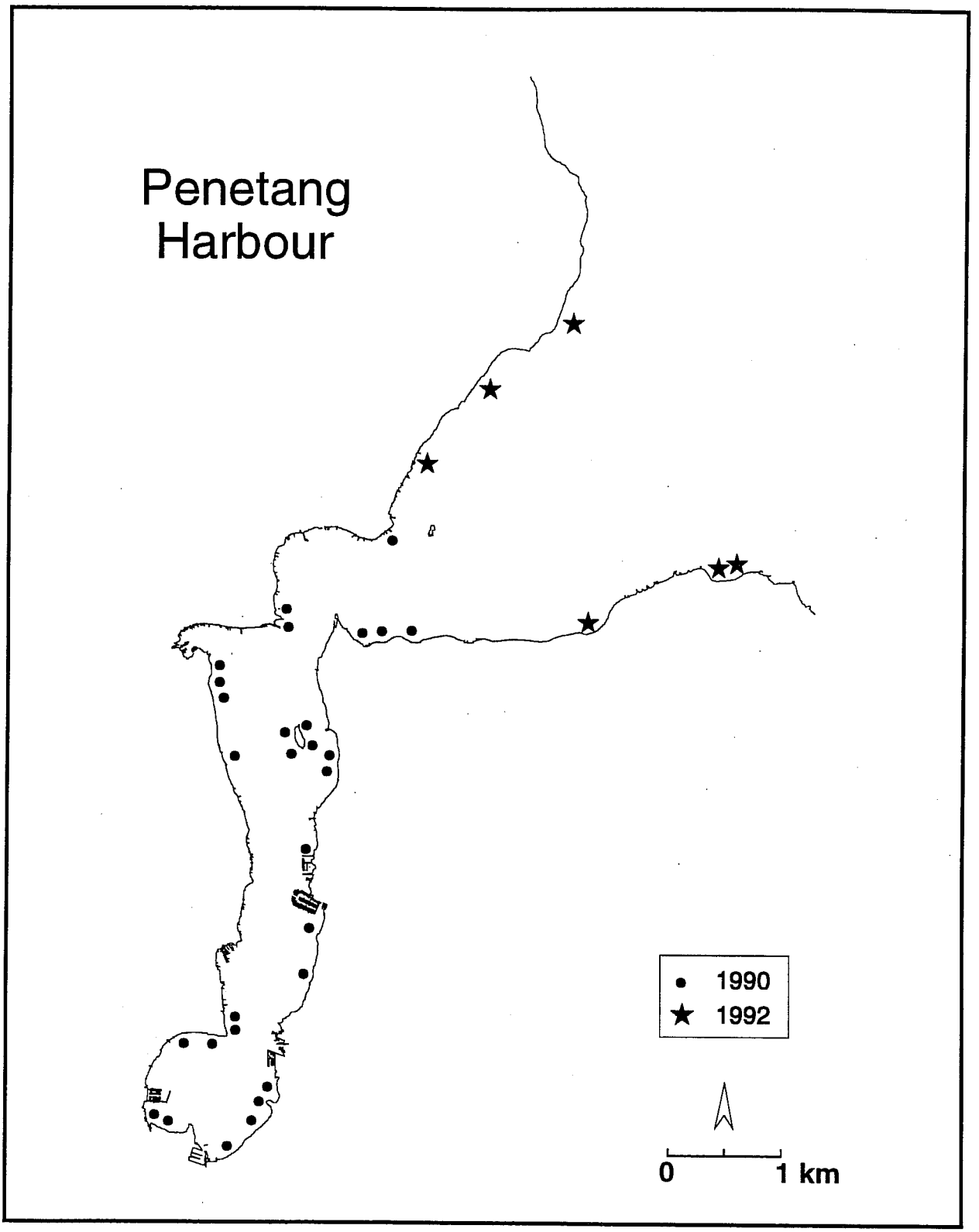
Appendices



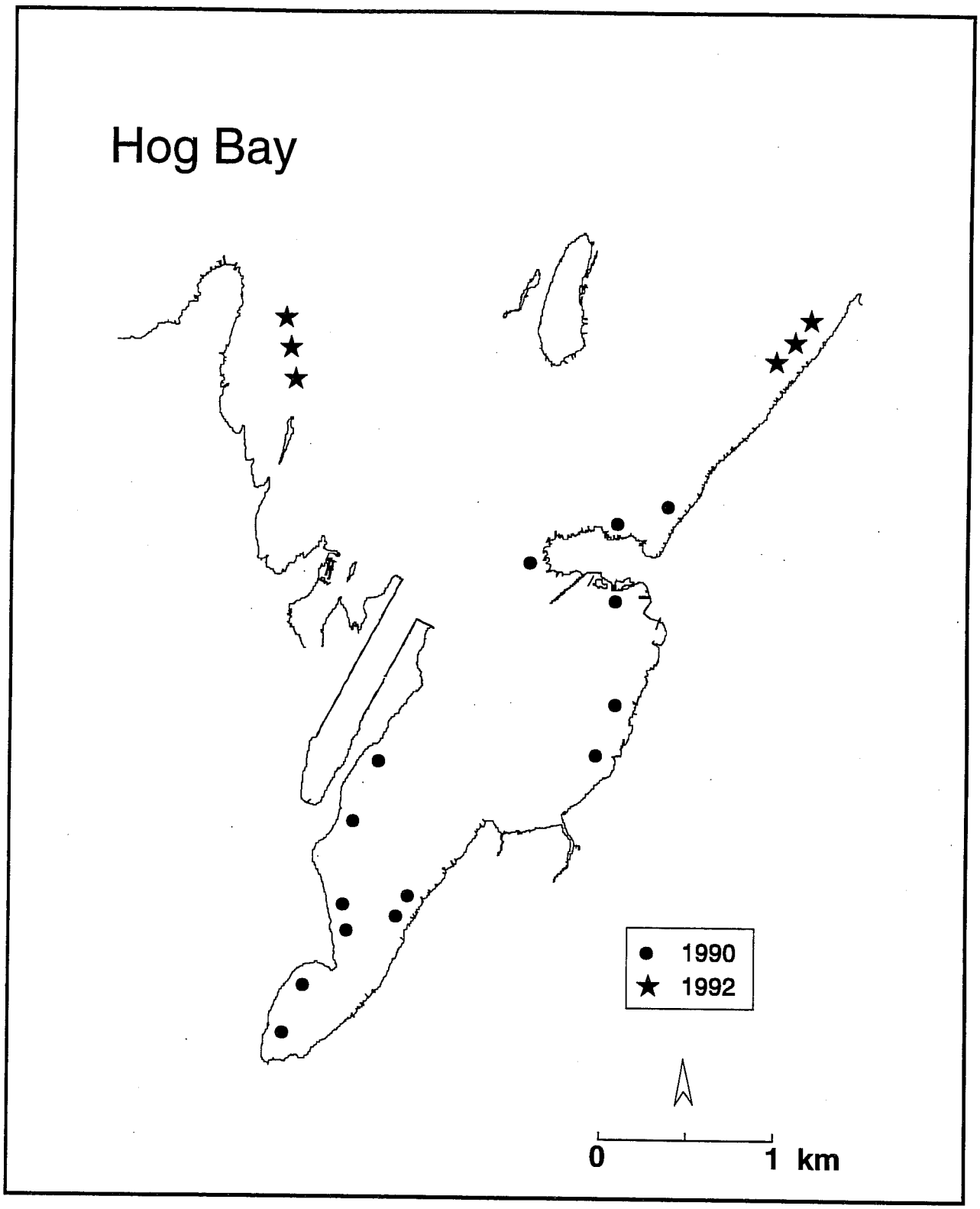
Appendix 1a. Map of Hamilton Harbour, showing the transect locations sampled in 1990.



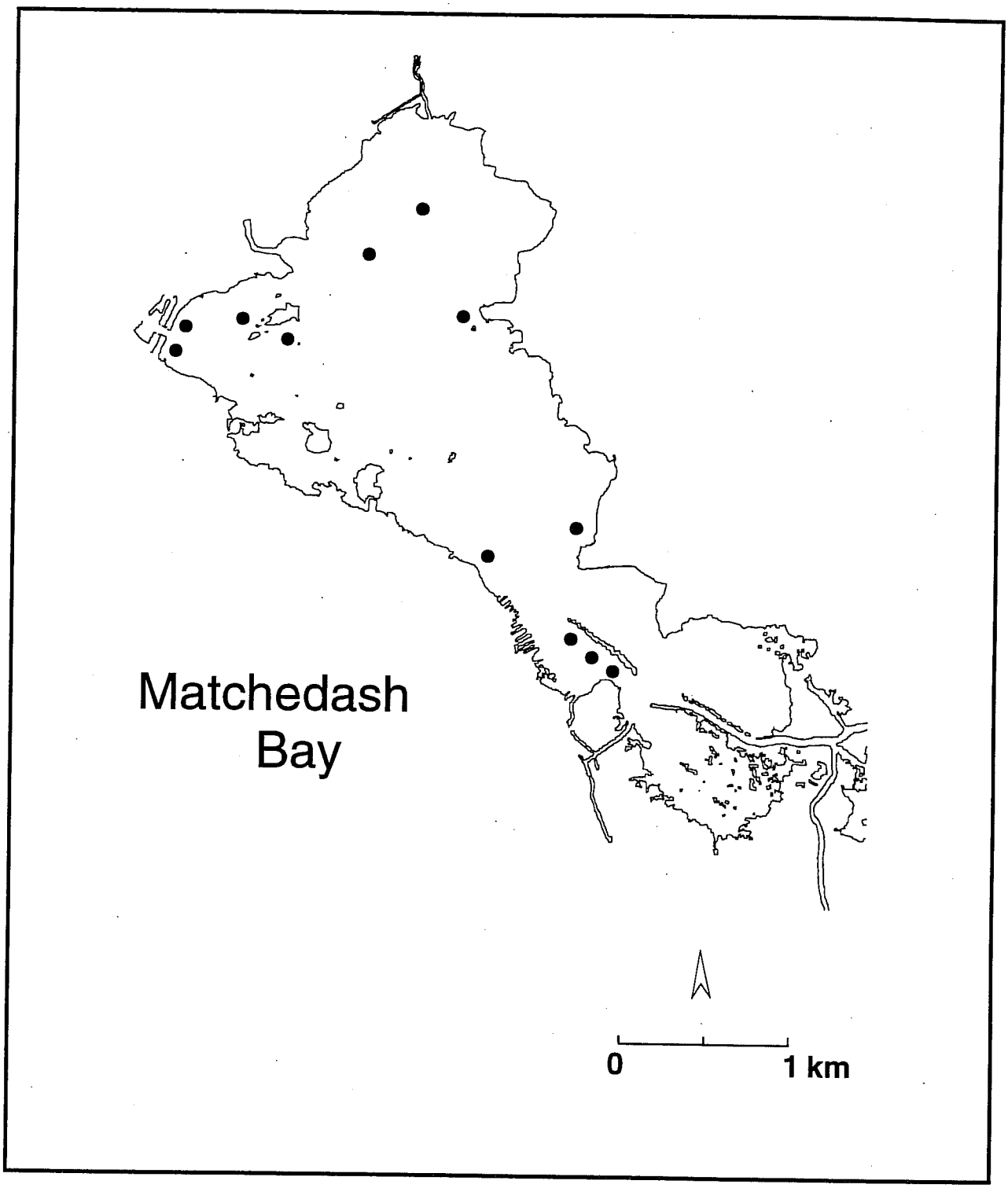
Appendix 1b. Map of the upper Bay of Quinte, showing the transect locations sampled in 1990.



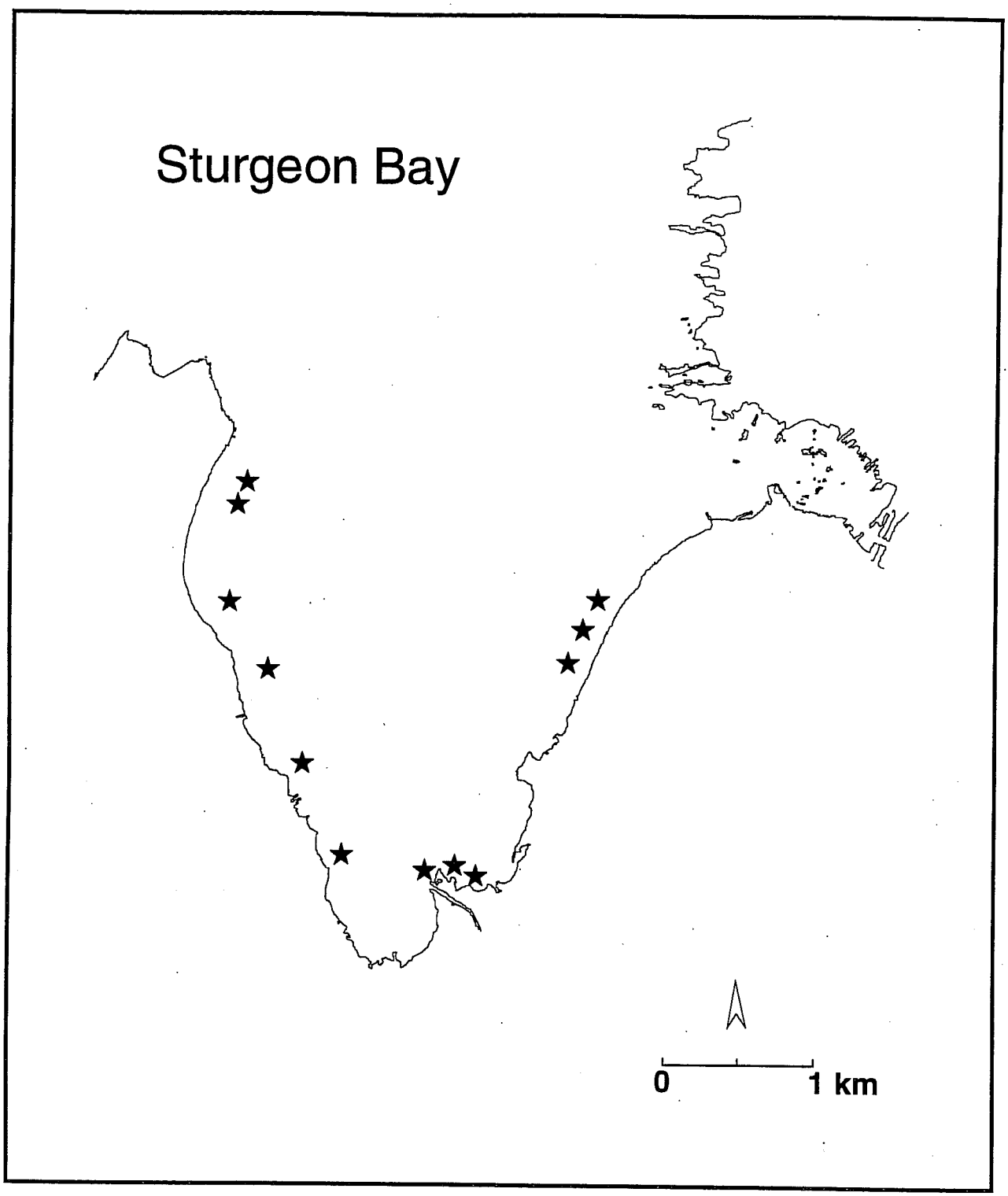
Appendix 1c. Map of Penetang Harbour, showing the transect locations sampled in 1990 and 1992.



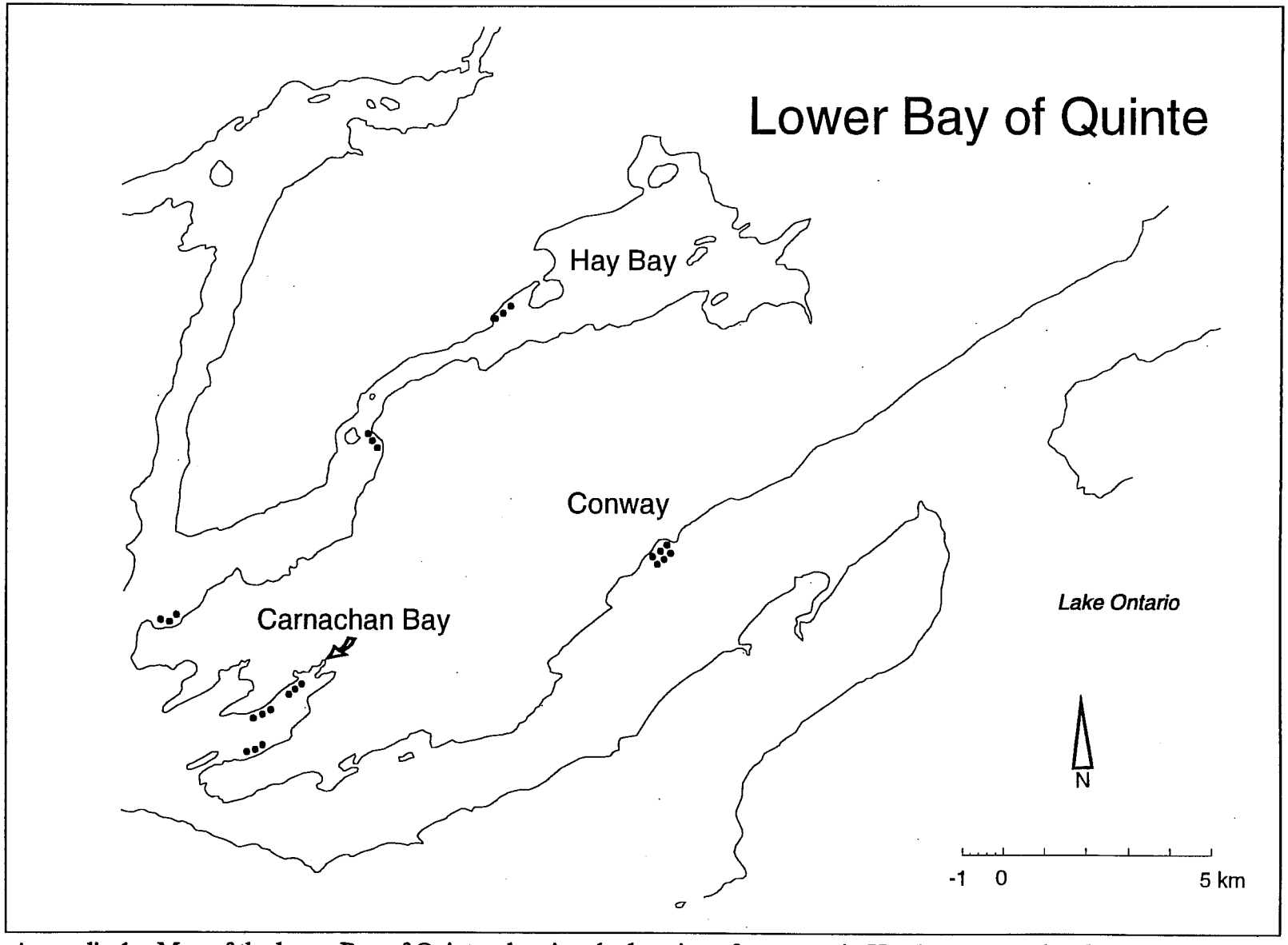
Appendix 1d. Map of Hog Bay, showing the locations sampled in 1990 and 1992.



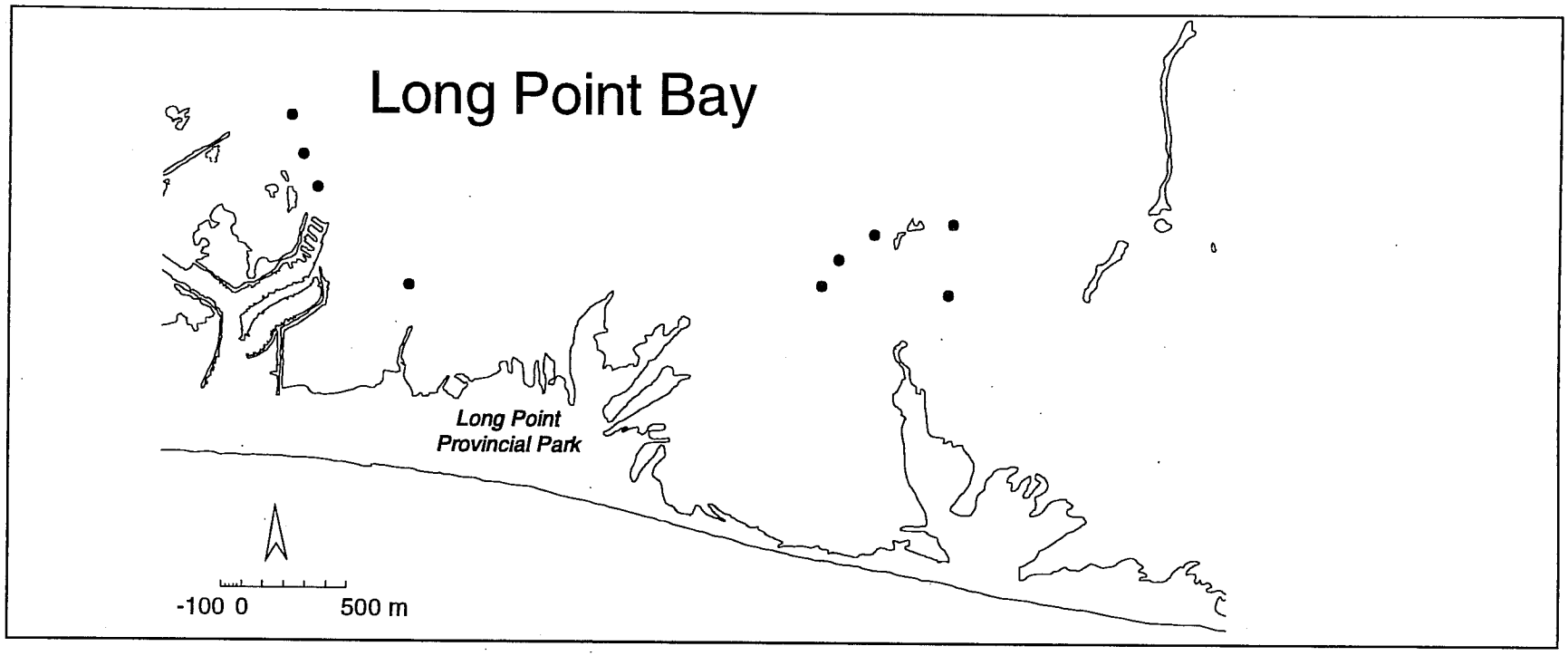
Appendix 1e. Map of Matchedash Bay, showing the transect locations sampled in 1990.



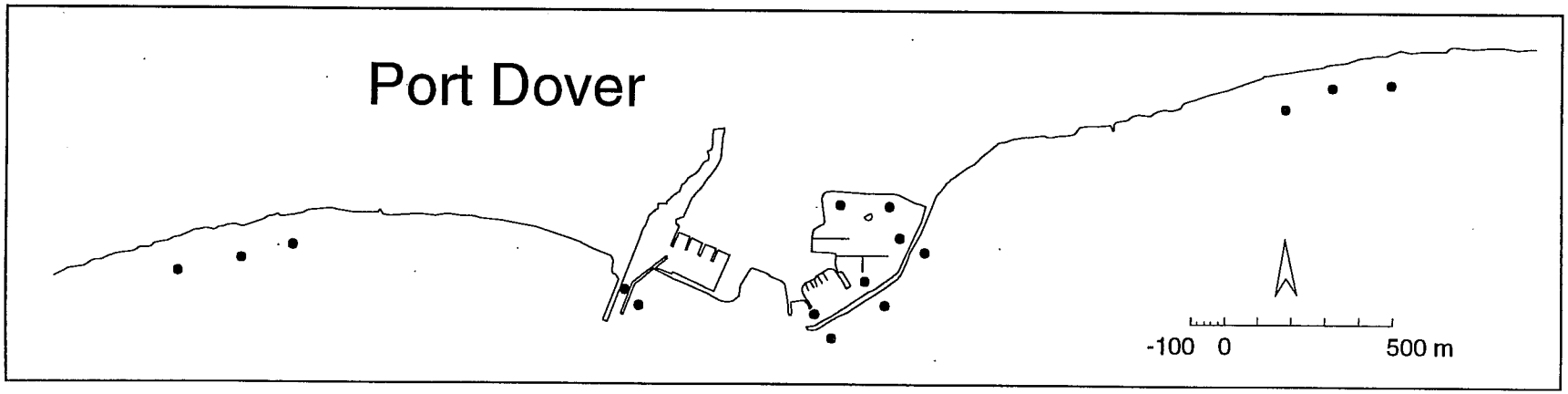
Appendix 1f. Map of Sturgeon Bay, showing the transect locations sampled in 1992.



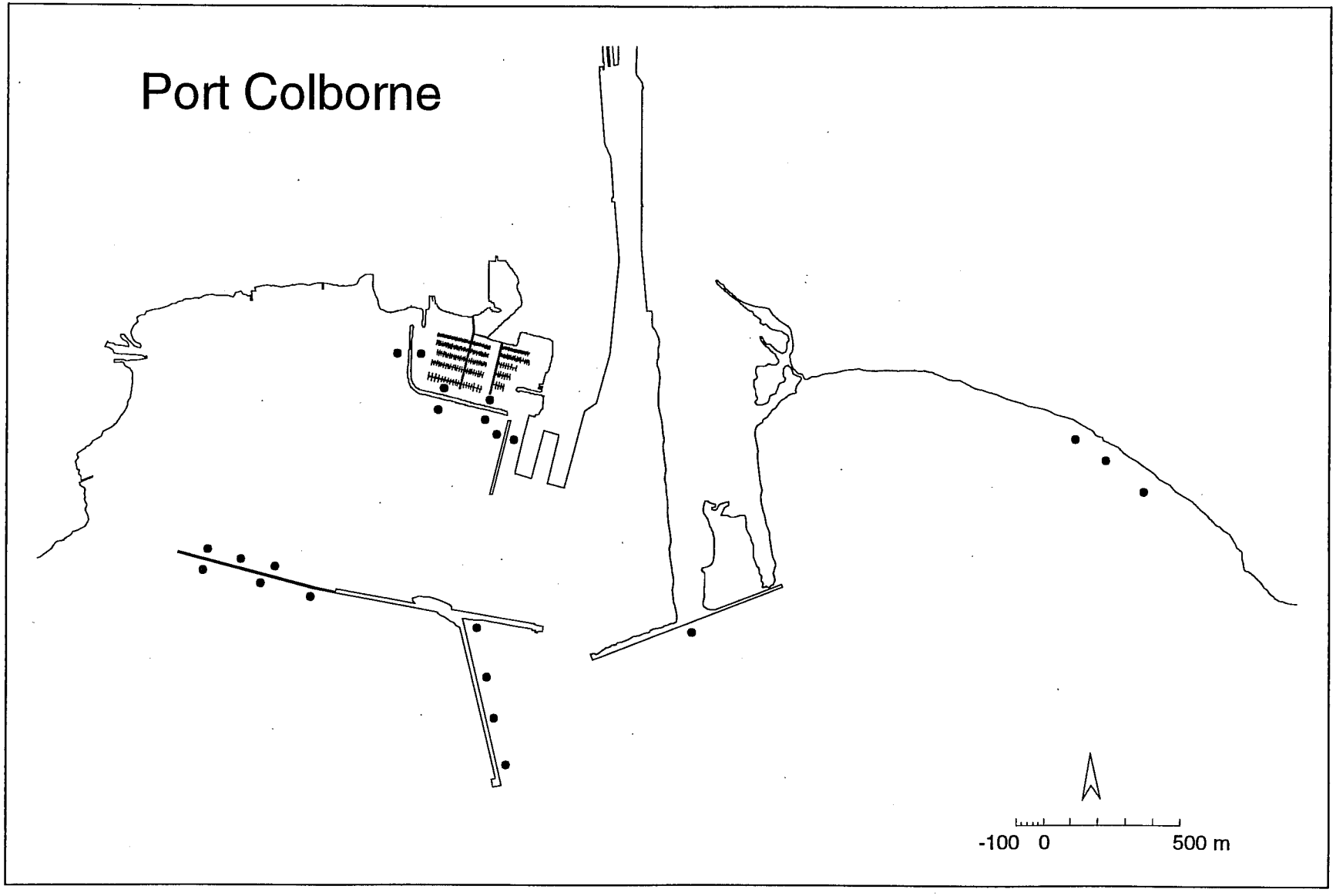
Appendix 1g. Map of the lower Bay of Quinte, showing the location of transects in Hay Bay, Carnachan Bay and at Conway (Adolphus Reach).



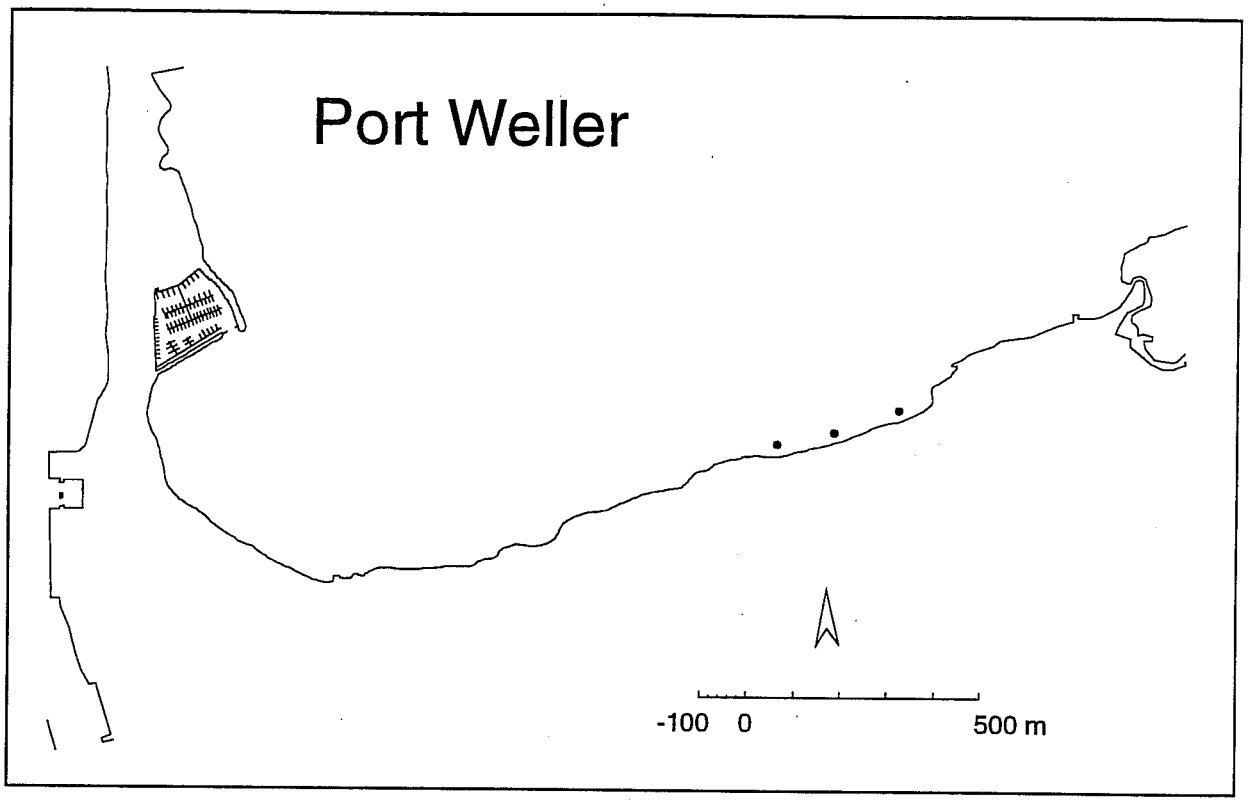
Appendix 1h. Map of Long Point Bay, showing the location of transects sampled in 1994.



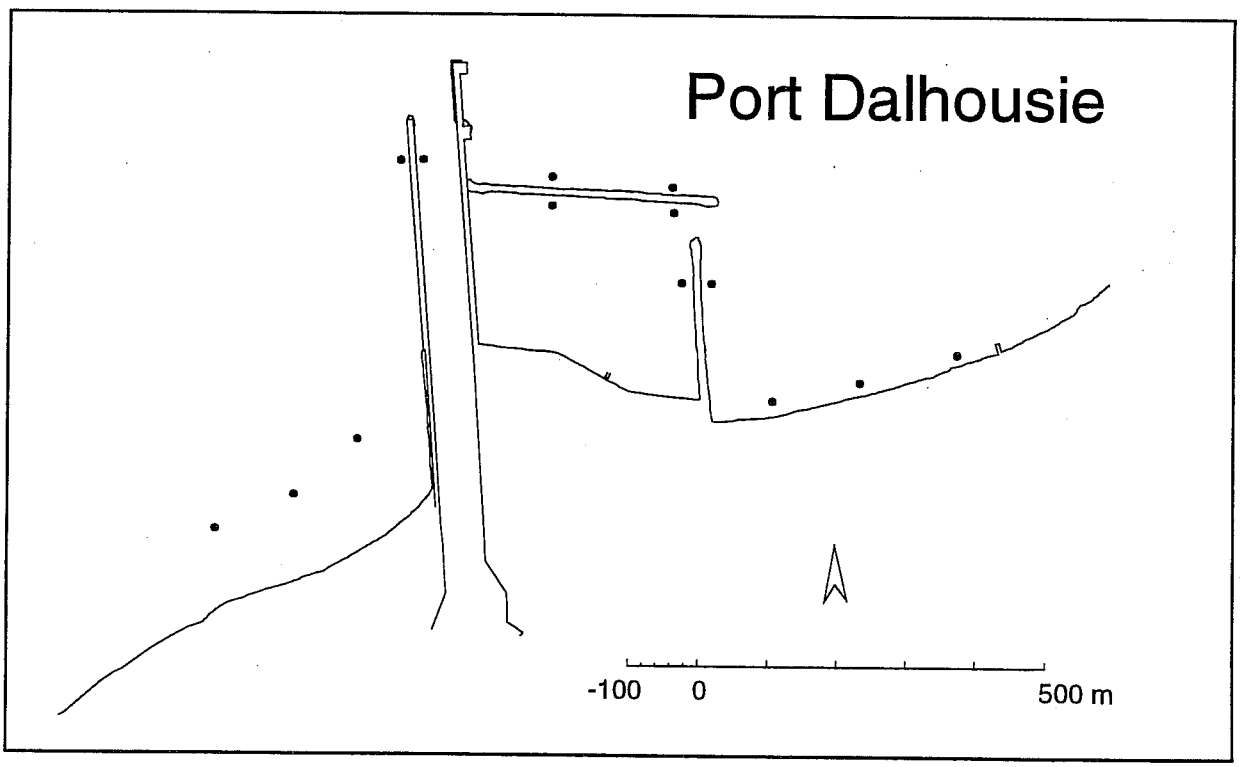
Appendix 1i. Map of Port Dover Harbour, showing the location of transects sampled in 1994.



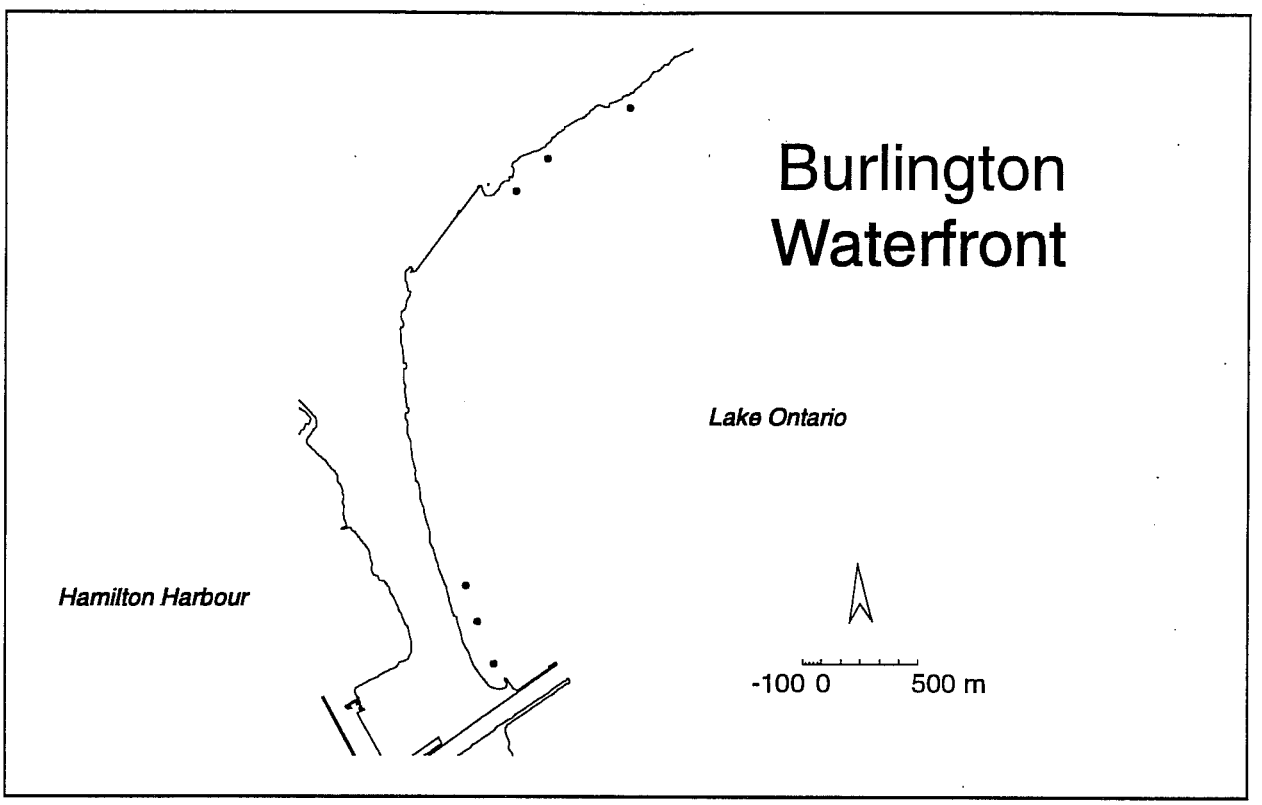
Appendix 1j. Map of Port Colborne, showing the location of transects sampled in 1994.



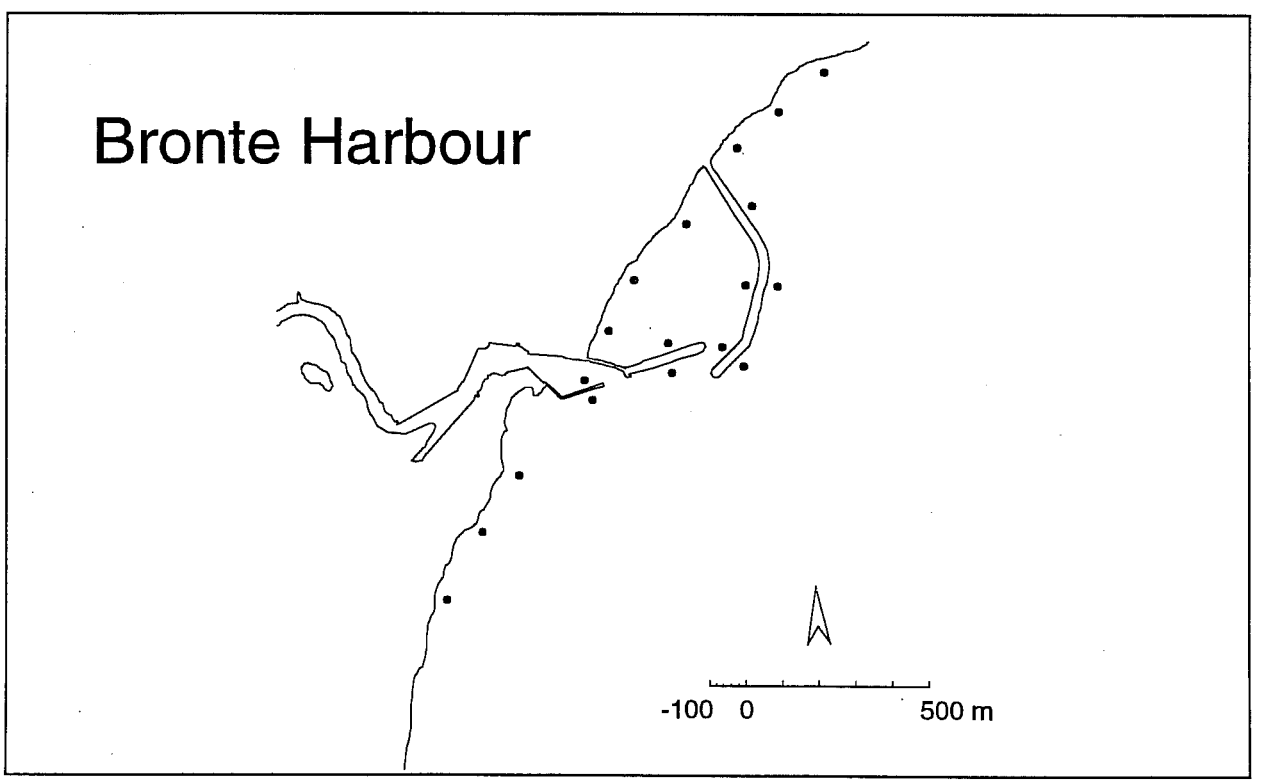
Appendix 1k. Map of Port Weller, showing the location of transects sampled in 1994.



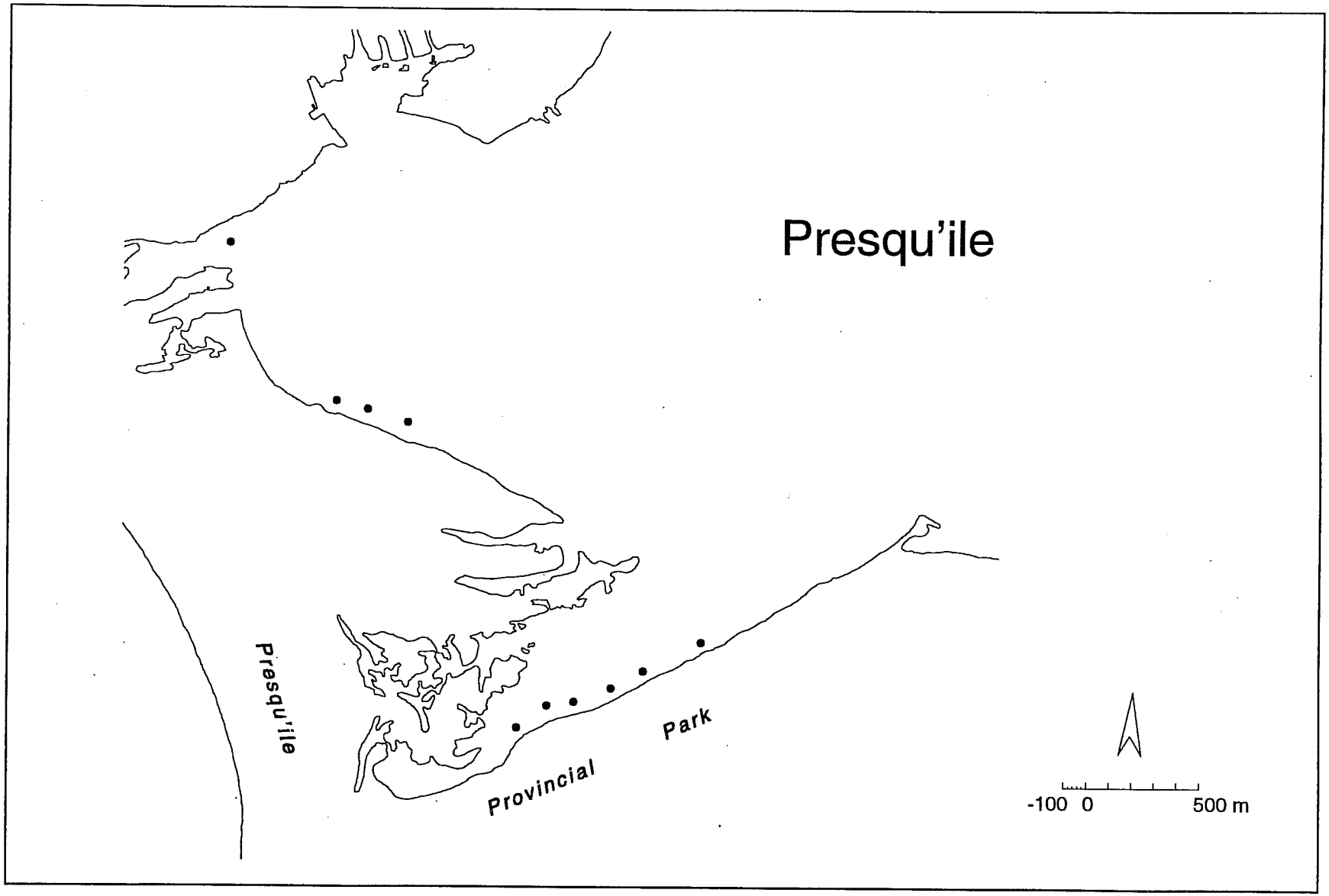
Appendix 1l. Map of Port Dalhousie, showing the location of transects sampled in 1994.



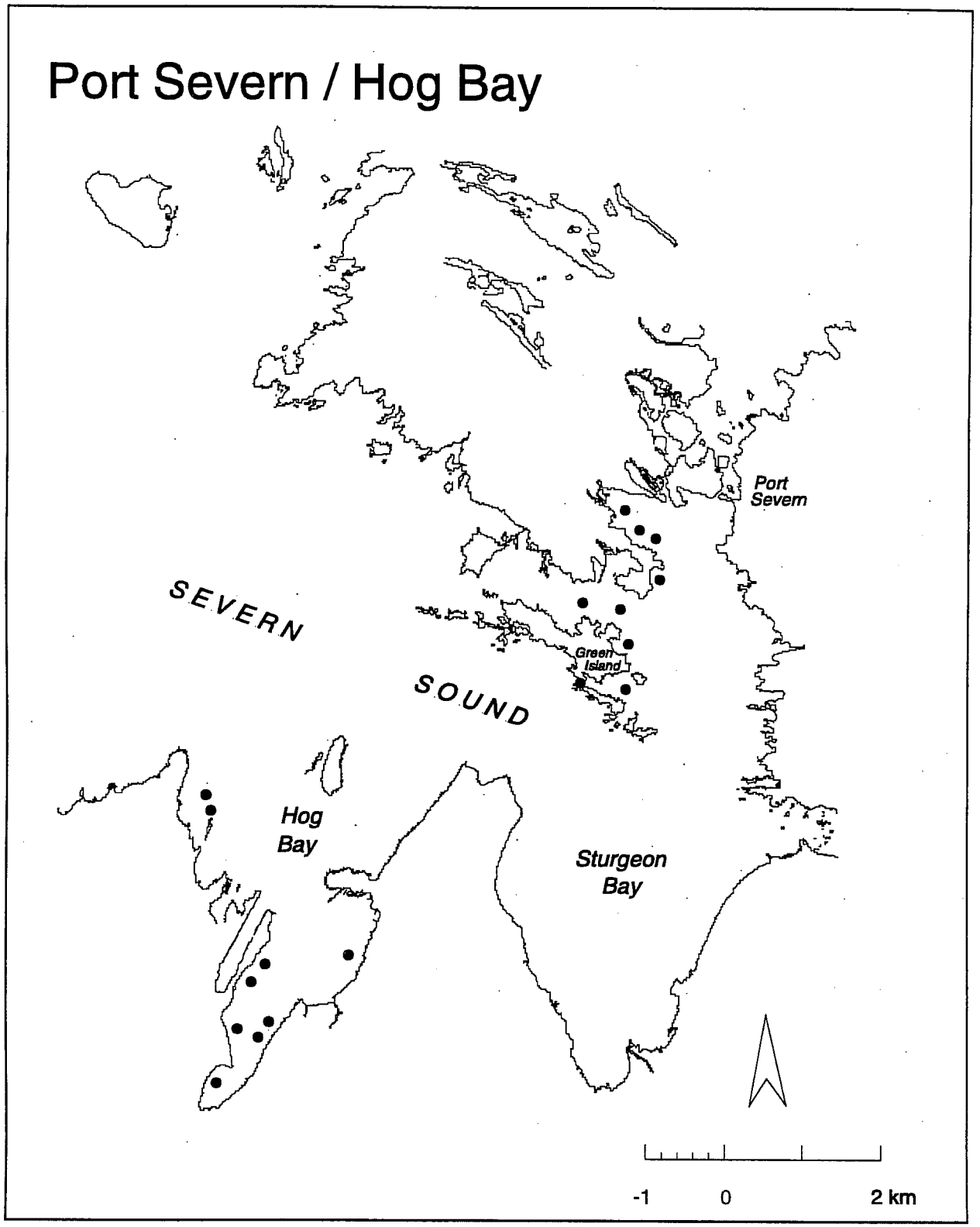
Appendix 1m. Map of Burlington waterfront, showing the location of transects sampled in 1994.



Appendix 1n. Map of Bronte Harbour, showing the location of transects sampled in 1994.



Appendix 1o. Map of the Presqu'ile area, showing the location of transects sampled in 1994.



Appendix 1p. Map of Severn Sound, showing transect locations in Port Severn and Hog Bay, sampled in 1995.

Appendix 2. List and description of data fields for the Electrofishing Field Data Sheet.

Data Element	Description
TRANSECT	transect number
DATE	date of electrofishing survey
TIME (24 hrs)	start (S) and finish (F) times using 24 hr clock
SHOCK (s)	the actual electrofishing time in seconds
WTEMP (°C)	surface water temperature taken at mid transect
SECCHI (cm)	Secchi disk depth in centimetres.
AMPS	average amperage delivered
VOLTS	voltage setting
WIND (0-9)	a rating of wind speed on a scale of 0 to 9, with each increment representing roughly 5 kph. eg. 0 (flat calm), 3 (15 km/h winds), 9 (45 km/h winds)
W.DIR. (N=1,E=2,S=3,W=4)	coding for predominant wind direction within 45 degrees (ie. winds coming from out of the north would be coded with a "1", a wind coming from the SW would be coded as "3,4")
DOx (0.75 m)	replicate x of two dissolved oxygen readings (mg/l) at 0.75 m
Tx	replicate x of two temperature readings (°C) taken at 0.75 m at the same time as the respective dissolved oxygen reading
DO3 (5 m)	dissolved oxygen reading (mg/l) at 5.0 m directly out from middle of transect
T3	temperature reading (°C) taken with dissolved oxygen reading at 5.0 m
COND (μScm^{-1})	surface conductivity reading taken at mid point of transect
SHEET#_OF_	current sheet # and total sheets for particular electrofishing transect
SPP	species name or code number from MNR species code list
FL (mm)	fork length of fish measured in millimetres (total length for fish with a rounded or truncated caudal fin)
W (g)	fish weight in grams
SX	sex of fish (where applicable)
SCALE#	scale sample number (where applicable)
NUMBER	number of fish in batch weight
WEIGHT (g)	weight of batch in grams
NOTES	any additional information or comments about the electrofishing run (ie. pauses in current output, strong winds blowing boat off course, etc.)

Appendix 3. List and description of data fields for the Habitat Field Data Sheet.

Data Element	Description
DATE	date habitat survey was conducted
TRANSECT	transect number
TIME (24hrs)	starting time of habitat survey using a 24 hour clock
WIND (km/h)	average wind velocity in Km/h
WIND DIR. (N=1,E=2,S=3,W=4)	coding for predominant wind direction within 45 degrees (ie. Wind coming from out of the north would be coded with a "1", a wind coming from the SW would be coded as "3,4")
D1 (m)	distance in metres from the water line to the 5 m marker float
D2 (m)	distance in metres from the water line to the 5 m marker float
D3 (m)	distance in metres from the water line to the end of the echosounding run as marked by the hand float
D4 (m)	distance in metres from the water line to the end of the echosounding run as marked by the hand float
SUBSTRATE	classification of sediment type from Ekman sample
ECHOGRAM TIME (s)	elapsed time in seconds for echosounder tracing
PULSE WIDTH (μs)	pulse width setting on echosounder
DISCRIMINATION	discrimination setting on echosounder
SURFACE CLUTTER	surface clutter setting on echosounder
PAPER SPEED	paper speed (0-7) of echosounder
NORTHING	GPS northing co-ordinate (Universal Transverse Mercator) of end marker
EASTING	GPS easting co-ordinate (Universal Transverse Mercator) of end marker
ZONE	Universal Transverse Mercator zone number that site is located in
PERCENT COVER	observation of percent coverage of macrophytes as seen through the garbage can viewer*
DOMINANT VEG.	the dominant plant taxa found along the transect
NOTES	notes of any complications or additional relevant information, which may have affected the survey

* Garbage can viewer is made from a 77 L plastic garbage can with the bottom cut out and a panel of black cloth fastened around the circumference of the top end of the can. The cloth is cut in such a manner that a person can easily drape it over their head and back to shield out any sunlight while bending over and looking into the water through the bottom hole.

Appendix 4. Guidelines for filling out the Physical Habitat Integrity (PHI) data sheets.

VEGETATION

Record wetlands on the shoreline only, not inland wetlands. For macrophytes, we are interested in the area defined by a 300 metre length of shore centred on the line transect and reaching out to the electrofishing transect at the 1.5 metre contour.

1 Wetland proximity: Record presence/absence and if present, proximity to the shore position. Little scraps of bull rushes on the shore do not count as a wetland.

2 Wetland size: Specify one of four categories.

3 W 1st dominant: Note the dominant vegetation form, and choose the appropriate category.

4 W Openness- How much of the interior of the wetland is open water?

5 Macrophyte abundance- Use a concept of areal coverage to make this decision: 80-95% cover is abundant, 20-80% common, 100% is very dense,<20-1% is sparse.

6 M height as % of depth: This gives a measure of volume occupation and should be weighted toward conditions at the 1.5 metre contour

7 M 1st dominant: As for wetland, we want to know if the weed bed is monospecies or diverse.

8 M plant types: Circle the types observed double circle the most common form.

9 Riparian vegetation: Record the degree to which vegetation occurs along the shoreline and overhangs the water.

SHORELINE SUBSTRATE

1 Substrate types: Along the wetted edge note the types by dominance. If sand is 80 percent, mark sand for 1st and 2nd, etc.

2 Structure: the presence of features (logs, trees, boulders, outcrops, etc.) which create horizontal and vertical discontinuities in the littoral zone.

Appendix 4. cont'd

WATER QUALITY

1 Turbidity and colour:

2 Secchi depth: Average of 3 measures along the length of the electrofishing transect in 1.5 metres of water.

TOPOGRAPHY

1 Onshore slope: Does the shore grade upwards gradually or steeply? A beach ridge close to the water implies steep but shallow if far from the water's edge.

2 Offshore slope: judged by the closeness of the 1.5 metre contour and perceptions of rate of increasing depth.

3 Exposure: Condition at the shoreline in terms of openness to the main basin.

4 Fetch: Condition of the area between the shoreline and the transect with respect to prevailing winds and openness to the main basin.

5 Shoreline development: Measures the sinuosity of the shoreline. A straight uninterrupted shore is low or nil while a shore with many indentations, bays, etc. is very high.

TRANSFORMATION

1 Impermeable surfaces: In the onshore area, how much is paved, asphalted, gravelled tracks, covered with buildings, etc.

2 Buildings: Are there many, few, or no buildings close to the shore. This distinguishes between urban and rural areas.

3 Waterfront structure: Is the shoreline man-made or natural, riprap or sheet steel, etc.

4 Proximity to major inputs: STPs, industrial effluents, river mouths, marinas, downtowns, etc.