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An Evaluation of Biotic Indices and Habitat Suitability Scores for Classifying Littoral Habitats

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Canadian Manuscript Report of Fisheries and Aquatic Sciences

An Evaluation of Biotic Indices and Habitat Suitability Scores for Classifying Littoral Habitats

March 1995

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ABSTRACT

Degradation of nearshore habitats through human activity in the Great Lakes basin is prompting fish nd wildlife habitat managers to integrate nearshore habitat management plans with more traditional approaches to urban and regional planning. To support the development of a nearshore habitat management plan for the Bay of Quinte, a pilot study was undertaken using ground level and remote sensing inventories of the nearshore habitat of Potter's Point in the Bay of Quinte. The study area was mapped and scored into habitat types based upon substrate and submerged aquatic vegetation.

Each habitat type was assigned two Index of Biotic Integrity (IBI) scores based upon seine netting and electrofishing results. A third habitat scoring system was derived from a spawning habitat survey and assigned to each habitat type. Habitat scores were scaled to reflect area weightings and the resulting scores were mapped onto three habitat maps of the Potter's Point nearshore area. The spawning, seining and electrofishing habitat maps were then combined to produce a habitat map depicting overall IBI scores for the Potter's Point study area.

The habitat evaluation process described in this paper provides a workable and relatively unbiased method of classifying nearshore habitat. Strengths of the process include its reliance on physical habitat data which is relatively easy to sample and more constant over time than biological data. After the relationship between habitat variables and IBI scores has been validated by other studies, the process may be used to guide shoreline development. Future work must concentrate on the analysis and development of models which combine the IBI scores from spawning, seining and electrofishing habitat maps into an objective and defensible overall habitat map.

RÉSUMÉ

La dégradation des habitats côtiers provoquée par les activités humaines dans le bassin des Grands Lacs pousse les gestionnaires du poisson et de la faune à intégrer les plans de gestion des habitats côtiers aux démarches plus classiques de la planification urbaine et régionale. Une étude pilote a été réalisée à l'appui d'un plan de gestion de l'habitat côtier dans la baie de Quinte. L'étude a porté sur l'utilisation d'inventaires de l'habitat côtier de la pointe Potter, dans la baie de Quinte, réalisés à partir du sol ou par télédétection. La zone étudiée a été cartographiée et divisée en types d'habitats auxquels une cote a été assignée en fonction du substrat et de la végétation aquatique immergée.

Deux indices d'intégrité biotique (IIB), fonction des résultats d'une pêche à la senne ou d'une pêche électrique, ont été assignés à chaque type d'habitat. Un troisième système d'attribution d'une cote, à chaque type d'habitat, a été élaboré à partir d'un relevé des habitats de frai. Les cotes ont été pondérées en fonction des superficies et les valeurs résultantes reportées sur trois cartes des habitats de la pointe Potter. Les cartes des cotes attribuées pour le frai et les résultats des pêhes à la senne ou à l'électricité ont été fusionnées en une carte des IIB généraux dans toutes la zone étudiée.

Le processus d'évaluation de l'habitat décrit constitue une méthode de classement des habitats côtiers qui est pratique et très peu biaisée. L'intérêt de cette approche réside dans l'utilisation de données sur l'habitat physique dont l'obtention est relativement facile et qui sont moins variables dans le temps que les données biologiques. La démarche présentée pourra être appliquée à la mise en valeur des rives, une fois que le rapport entre les variables de l'habitat et les cotes IIB aura été validé par d'autres études. Les prochains travaux devront être axés sur l'analyze et la mise au point de modèles permettant de réunir les cotes IIB des cartes sur le frai et la pêche à la senne ou à l'électricité en une seule carte générale de l'habitat qui soit objective et justifiable.

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1.0 INTRODUCTION

Both Beamish et al. (1986) and Pearse (1988) have reported that the main cause of the continuing decline of freshwater fisheries in Canada is habitat destruction and degradation. At the watershed scale, much progress has been made at integrating habitat management with traditional land use planning. Increasing pressure to develop or modify nearshore habitats in the Great Lakes basin is prompting fisheries and other habitat managers to integrate nearshore habitat management plans into more traditional urban and regional planning programs. However, efforts to develop nearshore habitat management plans have been hampered by consistent proof of habitat/fish population linkages, lack of habitat assessment and classification procedures, and poor or nonexistent georeferenced fish and habitat inventories.

The goal of this project was to use available fisheries data to calculate Index of Biotic Integrity (IBI, Karr, 1991) scores for each habitat type on the nearshore area of Potter's Point in the Bay of Quinte. The resulting nearshore habitat maps will provide input to traditional land use plans, facilitating shoreline management scenarios and habitat restoration compensation and mitigation actions.

Habitats in the nearshore zone of the Great Lakes provide reproductive, nursery and/or feeding habitat for most of the native fish species. Some species spend their entire lives in the shallow coastal waters or wetland areas while others use them for a portion of their life cycle. These productive nearshore habitats are under constant pressure from developers, municipalities, industry and individual landowners. Development can result in habitat loss through dredging and filling, shoreline alterations, contaminated runoff from urbanized areas, and alteration of habitats during the preparation of sites for construction. It is generally accepted that cumulative incremental loss of nearshore habitat reduces fish production. However, these losses are difficult to quantify due to the range of factors influencing fish production and the normal variability of fish populations.

The Fisheries Act is the primary piece of legislation through which the Policy for the Management of Fish Habitat in Ontario is implemented. The Policy is intended to ensure that habitat alterations result in a net gain in the productive capacity of fish habitat. What constitutes a gain or loss is not always clear, and only recently have quantitative methods been suggested to measure changes in productive capacity (Minns, 1995). As a result, present management decisions are made on a case by case basis often with incomplete information on the role that a specific habitat plays within the larger ecosystem. Fish and wildlife habitat managers are required to justify regulations on shoreline development, often in judicial proceedings. Without a rigorous and consistent approach to evaluating habitats, shoreline regulation will become increasingly difficult to defend.

The nearshore habitat classification approach described in this report is not intended to be definitive. Its primary intent is to guide the habitat restoration and management plan for the Bay of Quinte Remedial Action Plan (RAP). However, it is our hope that this report will stimulate discussion and eventually lead to a more objective, robust and defensible method of nearshore habitat classification.

2.0 STUDY AREA

The Bay of Quinte is located on the north eastern end of Lake Ontario (Figure 1: inset). Major tributaries flowing into the Bay include the Trent, Moira, Salmon and Napanee Rivers. The Bay has been identified as an Area of Concern (AOC) under the Canada-United States Great Lakes Water Quality Agreement (GLWQA) due to the impairment of 10 of 14 beneficial use categories. These impairments generally relate to eutrophication, bacteriological contamination, loss of fish and wildlife habitat, and toxic contamination.

The area selected for our study, commonly referred to as Potter's Point, is located on the south shore of the Upper Bay opposite the City of Trenton (Figure 1). The site was selected because digitized shoreline habitat data were available for the area, it contained a wide variety of habitats common to the whole of the Bay of Quinte, and the mapping results could be used to help guide the many shoreline developments presently being considered for the area.

3.0 METHODS AND RESULTS

3.1 Overview

The habitat mapping process began with a detailed nearshore habitat survey of the Bay of Quinte shoreline, describing substrate composition and vegetation type/density. The survey maps were interpreted into discrete polygons describing substrate composition and vegetation density, then digitized into a GIS database. Seining and electrofishing data from sites with a range of vegetation densities were then used to calculate two sets of IBI scores based on vegetation density. A third and final habitat scoring system based on substrate composition was calculated from a Lake Ontario spawning habitat survey (Christie, 1982).

The spawning, seining and electrofishing based habitat scores were weighted to reflect the importance of habitat areas which were locally abundant in the Potter's Point area but regionally rare in the larger Trenton to Belleville nearshore zone (or vice versa). These area weighted habitat scores were then normalized to compare results from the different assessment methods. Finally, the habitat scores were mapped for the three assessment methods and a combined habitat map was prepared to depict the highest habitat score for each habitat polygon in the Potter's Point area. Figure 2 depicts the steps of the habitat scoring and mapping process we undertook.

3.2 Habitat Inventory

Habitat data collected by the Ontario Ministry of Natural Resources for the entire Bay of Quinte nearshore were mapped onto 1:2000 scale base maps published under the Canada Ontario Flood Damage Reduction Program (FDRP). Aquatic and terrestrial vegetation type, vegetation density and near shore substrate were recorded on these base maps. Plant species were also identified for aquatic vegetation and general terrestrial cover types identified (conifer, deciduous, lawn, pasture, etc.). Data were collected from small boats surveying along the 2 meter depth contour.

For this study, only submerged aquatic vegetation density and substrate type were digitized into polygons in a Geographic Information System. In addition to providing an efficient storage and retrieval system, the GIS can execute complex spatial queries and explore relationships that would not be feasible using paper map products, or traditional database and spreadsheet programs. The system was used to generate summaries of the habitat features and facilitate the application of classification models. A more detailed description of the methods of mapping and database development is provided by Sawyers and Smith (1991), and database descriptions are provided in MacLeod and Ferguson (1992).

3.3 Habitat Score Weightings

Minns et al. (1993) introduced the concept that the importance of physical features in the aquatic environment will vary inversely with their relative abundance in the region of interest, based upon the concept of uniqueness or 1 - % occurrence. In order to account for local variations in habitat availability, all habitat index values were multiplied by an area weight. The weighting factor was determined from the total areas and the percentage of the total within each habitat class based on the habitat inventory data. The area weight is defined as 1-fractional % of the total area.

To provide a regional approach to the calculation of area weighting factors, the section of the Bay of Quinte west of Belleville (referred to as the Belleville - Trenton area) was used as the standard regional habitat sample. This region includes the Potter's Point however, the habitat of the Belleville - Trenton regional area contains a smaller proportion of submerged vegetation, and a larger proportion of sandy and rocky substrate (Figure 3). Using the area weightings, index values for regionally abundant habitats such as "absent vegetation" were adjusted downward, and the relative importance of index values assigned to regionally scarce habitats such as "gravel" and "very dense vegetation" increased. For example, if the index score for a patch of habitat was 0.750 and the habitat covered 90% of the regional area of interest, then the weighted index score was adjusted downwards to (0 .750* (1.0 - 0.90)) = 0.075.

Areas weighted habitat suitability scores were calculated for the seining, electrofishing and spawning habitat classes. The vegetation and substrate scores for the three habitat maps were then normalized so that they could be compared to produce a final combined habitat map. The highest ranked habitat feature in each map was assigned a value of 100.0 and other habitat types were scaled relative to the highest score.

3.4 Spawning Habitat Suitability Scores and Habitat Map

Christie (1982) described five substrate types (rock, gravel, sand, mud, submerged vegetation) used for spawning by 69 fish species which inhabit Lake Ontario. An index of spawning habitat suitability was generated from these data by counting the number of species which spawned on each habitat type. Where more than one substrate type was used by a particular species, a weighted score (1/w) was calculated, where w equals the number of substrates noted for that species. For example, if three substrates were used by a single species, the sum of each substrate score was incremented by 1/3. The sum of species using each substrate was calculated and the 5 substrates were ranked accordingly. The final spawning habitat suitability score for each substrate in Potter's Point was area weighted to adjust for the regional abundance of each habitat type, and normalized for comparison to the seining and electrofishing scores (Figure 1).

The results indicated that gravel was the most preferred spawning habitat, while the least preferred was mud (Table 1). Although more fish species spawn on rocky substrates than on sand, the area weighted spawning suitability index was higher for sand than for rock because sand was a regionally uncommon substrate type. The final spawning suitability indices were normalized and mapped onto Potter's Point (Figure 4).

Submerged vegetation was the predominant substrate type at Potter's Point (45 %) and was assigned a final score of 40.1. Submerged vegetation was generally found in the sheltered bays and inlets while rocky substrate was found on open shoreline. The high scoring gravel substrate represented only 4% of the Potter's Point shoreline.

3.5 Electrofishing Index of Biotic Integrity and Habitat Map

Minns et al. (1994) calculated A total of 34 and 59 electrofishing samples were collected during 1989 and 1990 respectively from nearshore transects in the Bay of Quinte. For additional detail on the sampling methods and catch statistics readers should refer to Randall et. al. (1993). Fish were captured along 100 m transects parallel to the shoreline at the 1.5m depth contour and held in live wells until the transect was complete. All fish were identified, counted and up to 20 individuals per species were measured and weighed. Physical data recorded at each transect included wind speed and direction, water temperature, and turbidity (secchi disc reading). The percent cover of submerged vegetation was recorded by divers at several sites along each electrofishing transect. Plant Biomass was estimated from stem densities at 33 transects.

IBI scores were calculated from the electrofishing data for the Bay of Quinte, Hamilton Harbour, and Severn Sound using metrics representing positive or negative attributes of the fish community in another study (Minns et. al., 1994). Metrics were defined as measures of species richness, trophic structure, or abundance and condition. Twelve metrics were selected for inclusion in the IBI and species memberships were assigned to each metric (Minns et al., 1994). Both numbers and biomass of fish species were used jointly to measure the status of the assemblage because of the wide variation of fish sizes among the species encountered in the samples. Using a regression model (Minns et al., 1994), electrofishing IBI values (IBI-EF) were calculated for six classes of percent vegetation cover, from absent to very dense. Each map polygon with a reported vegetation cover was assigned a corresponding IBI-EF value. For additional detail on the calculation of the IBIs used in this project, refer to Minns et. al (1994). For a more general discussion of IBIs and their application, readers should refer to Karr (1991).

The initial IBI-EF scores were area weighted and scaled for comparison to the other indexes (Table 2), then mapped onto the Potter's Point area (Figure 5). The majority of the Potter's Point nearshore (44.1%) had no vegetation cover, and was assigned a relatively low IBI-EF score of 13.1. The "very dense" habitat type covered 8.5 % of the Potter's Point nearshore habitat and received the maximum IBI-EF score of 100. In contrast to the spawning survey result, high IBI-EF scores were assigned to areas where there was high vegetation cover. Areas with dense vegetation cover tended to occur in sheltered inlets, while areas with no vegetation cover occurred along the more open shoreline.

3.6 Seine Netting Index of Biotic Integrity and Habitat Map

Seine netting surveys were conducted at sites representing a range of habitat types in the Bay of Quinte. A total of 298 samples were collected during 1991, 1992 and 1993. Fish species were identified and categorized as Young of Year (YOY) or older. Site descriptions were recorded and habitats characterized on the basis of substrate and vegetation type. Detailed habitat data were collected during the habitat inventory and so less time was spent recording habitat information during the seine netting. Collection methods are described in greater detail by Sawyers and Smith (1991). Seining sites were recorded on the field inventory maps and physical features extracted from the mapped information. Summaries were generated for a range of habitat combinations.

The seine netting IBIs (IBI-SN) were calculated following the methods used by Minns et al. (1994). Nine of the twelve possible metrics used by Minns et al. (1994) were selected because fish from the seine netting surveys were not measured or weighed and very few non-native or intolerant fish species were captured during seining. Metrics of species richness included species counts for native species, cyprinids, centrarchids, and percids. Abundance metrics included the number of native fish and young of year fish (of native species). Trophic structure metrics included the proportions of the catch which were piscivores, generalists, and specialists (Minns et al. 1994). IBI-SN scores were developed to correspond to vegetation cover at catch sites, then area weighted and scaled to compare to the other indices (Table 3).

Following the trend of the IBI-EF scores, the IBI-SN scores increased in value through the "absent" to the "very dense" vegetation classes, ranging from 15.9 to 100. The IBI-SN scores were slightly higher than the IBI-EF scores for each vegetation density class. IBI-SN scores were assigned to the same vegetation density polygons as the IBI-EF scores to create a seine netting based IBI classification map (Figure 6).

Fish captured by seining were smaller (< 50g) (Andy Smith, pers. comm., 1994) than those captured with the electrofishing gear (561g) (Minns et al. 1994). Yellow perch, pumpkinseed and walleye were the most frequently caught fish among the total of 32 species captured by electroshocking. Seine net catches were dominated by yellow perch, log perch, and bluntnose minnows. A total of 29 species were caught by seine netting.

3.7 Overall Habitat Suitability Map

The area weighted and normalized habitat scores from the spawning, electrofishing and seining exercises were used to create a combined habitat map which reflected the highest score for each polygon of habitat at Potter's Point. A database containing polygon scores from the 3 input maps was used to select the maximum score for each habitat polygon. The maximum score for each polygon became the score of the combined habitat classification map (Figure 7).

Sixty-five percent of the habitat polygons had overall scores between 20 and 40 while thirty-five percent of the polygons had scores between 70 and 100. The highest habitat scores in the combined map reflect areas of gravel substrate from the spawning survey scores, or areas of very dense vegetation from the seining and electrofishing results. The lower scores correspond to areas without gravel substrate and with less submerged vegetation. The overall score of 72%

of the polygons was determined by the spawning habitat index, while 38% of the scores were determined by the seine netting IBI. The electrofishing IBI did not contribute to the overall suitability score.

4.0 DISCUSSION

4.1 Strengths of the Nearshore Habitat Classification System

The consistency of the physical habitat data used for the nearshore habitat classification system is excellent compared to biological information. Fish populations can vary widely through locations, seasons, or weather conditions. In comparison, vegetation and water quality measurements show moderate variability while physical features like substrate and depth are relatively constant. Thus a habitat classification system results in data which is easier to collect, easier to measure, and more objective and repeatable than a biologically based classification system.

Although the OMNR collected very detailed habitat inventory data, the information was condensed into very broad classifications for this exercise. The electrofishing and seining data were based on six classes of percent cover of submerged vegetation and the spawning suitability maps were based on 5 substrate types. The level of effort required to collect this type of information is significantly less than that required to compile the 1:2000 scale information collected in the Bay of Quinte, and would be a significant advantage for future studies. Given the spatial and temporal variability of the fish data, discriminating habitats at high levels of resolution may be impossible. To this end, we recommend that fish surveys be conducted in advance of extensive detailed habitat mapping. Analysis of fish data will identify what level of detail will be required in habitat surveys.

The weighting technique incorporated into this methodology forces habitat evaluation to occur on a regional rather than a local scale. This increases the protection of habitats which may be locally abundant, but regionally rare. The converse is also true. In the Potter's Point study, area weightings strongly influenced the overall scores. In the case of vegetation density, a high proportion (78%) of the Belleville to Trenton regional area corresponded to the (vegetation) "absent" class, so the IBI scores for "absent" habitats at Potter's Point were weighted downward significantly. However, if the Potter's Point area was examined in isolation, "absent" areas represent a much smaller percentage (44.1%) of the littoral zone and the downward adjustment would have been much less.

The selection of a suitable regional area as a reference for habitat weighting factors is a difficult but necessary task. The regional area of interest may reflect known fish habitat, jurisdictional areas, or larger areas of shoreline where data is readily available. In the Potter's Point case, the Belleville to Trenton area was chosen because it was relatively distinct and homogeneous area within the Bay of Quinte.

The differences in average weights of fish caught by electrofishing versus seine netting are likely due to the different size selectivities, sampling depths, and timing of the two techniques. The seining results were sufficiently different from the electrofishing results to require an IBI based upon nine metrics instead of the usual twelve. However, the final IBI scores from these two different methods resulted in very similar habitat rankings. When combined with the spawning habitat index into the overall habitat score these differences in fishing techniques provide a robustness to the evaluation technique. A combination of a wide variety of sampling techniques should result in habitat evaluations which will be more representative of the nearshore ecosystem.

The greatest strength of this habitat evaluation is that it provides an unbiased and defensible method of quantifying habitat. Habitat evaluations will have an impact on land values and on land use decisions. Biologists have attempted to protect habitat from development in the past without defensible and objective evaluation techniques. In some cases, this has resulted in interpretations of the value of habitats which have not always been consistent between jurisdictions or between biologists in the same jurisdiction. We feel that a more defensible and objective method for protection of habitat could be developed by the use of a methodology similar to the one described in this paper.

4.2 Limitations

Combining the fisheries and habitat data into useful and valid map products highlighted many problems. Habitat and fisheries data are not typically collected with a single application in mind, and data from separate surveys may not be comparable, or the variables or interest may not have been collected. Detailed shoreline surveys like the one completed for Quinte require a tremendous amount of time and human resources to complete. The cost to convert mapped information into a digital product can also be prohibitively high. However, techniques are being developed to shorten the time required to generate habitat maps by using combinations of remote sensing, image analysis, field ground truthing, and geographic information systems (Macleod et. al., 1992). In addition, desktop computing capabilities continue to increase exponentially, and data such as satellite scenes once considered unmanageable can now be managed using relatively inexpensive software.

There are several limitations to the reliability of the fisheries and habitat data, and additional work required to prepare suitable habitat maps. In all of the three data sets, the habitat data needed to be reclassified to include or exclude areas, or create new areas based on combinations of substrate and vegetation characteristics. This underlines the need for more studies like those of Randall et al. (1993) and Minns et al. (1993) explicitly designed to quantify the linkages between fish and habitat.

No attempt was made to assess the relative importance of the 3 habitat classification maps generated by this exercise. It is assumed that all three scores reflect important and discrete ecological functions and until a procedure is adopted to determine the relative value of each, they were treated equally. The three techniques depict the value of critical habitat at three stages of fish development. Rather than summing or averaging the scores, the final habitat classification map simply reflects the highest score from any individual map. A more rigorous model would assess and quantify the relative importance of habitat for various life stages of each species of interest. Efforts to address this task are emerging (Minns et al, in review). Minns et al. (in review) have linked population dynamics to habitat supply for pike in Hamilton Harbour.

4.3 Future Steps

Widespread calibration data are needed for the development of IBIs and similar indices. Once IBI scores and weights have been fine tuned for a particular study area, the rankings of habitat types should be tested. If the rankings are accurate, IBI scores should be reproducible with either electrofishing and/or seining data from new sites containing the "preferred" habitat features. Although the digital map data were not used to select sample sites for this exercise, classified maps should be used to select sites and confirm the scoring system.

After initial habitat classifications are established, relationships to other habitat features can be explored. Fetch, nearshore and backshore slope, water quality and circulation patterns may also influence the distribution and abundance of fish in the Bay of Quinte. These variables are being considered in other efforts to link fish and habitat (Randall et al., in review). There are many combinations of habitat variables or fish index scores that could be used to produce a habitat classification system. The habitat maps and fish index score used here are just a few examples of the types of products that can be generated. The focus here was on the process, rather than the end product.

There are a range of classification techniques that can be applied as shown in this exercise. Future classifications should consider the relative sensitivity of nearshore habitat features to impacts. Sensitivities can vary spatially as well as temporally and certain activities that would be very harmful during spawning for example, may be neutral at other times of the year.

The IBI scores provide a relatively unbiased means of ranking both fisheries data and habitat data by association. The metrics selected to score a particular data set should consider peculiarities of the fish community across sites. Carp and alewife were excluded from total catch and biomass metrics from the Quinte electrofishing data for this reason. Procedures for combining individual rankings can be more rigorous than the methods used here, but it would require a larger circle of participants. Planning methods are available for assessing the relative importance of environmental components such as Kozlowski's (1986) 'Ultimate Environmental Threshold" (UET) method or Saaty's (1982) Analytical Hierarchy Process.

In the context of a management plan, classifications must be tied to specific actions. Careful consideration needs to be given to how the classified maps are presented. Highly restrictive classifications can impact land use patterns and affect property values or commercial operations.

The resulting maps generated by the classification process should reflect the management objectives for the system. In this example, fish community index scores were used and overall spawning suitability assessed. Depending on the fisheries management goals adopted for the system, the scoring system can be adjusted to reflect a higher value for sport fish, for example. These adjustments can be made at the IBI metric level, or the selection of species to be included in the spawning suitability assessment. The intended application should also influence the scoring and weighting system. The type of scores used and the resulting maps would be entirely different if the objective was to develop a land use strategy for the riparian zone, than if we wanted to identify areas that could be enhanced to provide additional pike spawning habitat. Each map however, could be produced using the same raw material, and simply adjusting the input variables, scores and weights. A flexible and reusable assessment scheme can be developed with the use of GIS as opposed to traditional paper map data.

The classifications described here are far from perfect, or near completion. However, the process as described is workable. Adjustments to the individual scores and weighting scenarios are quickly translated into new classifications and the results in terms of spatial patterns are obvious. The resulting maps become inputs into further analysis, and can be used to guide shoreline developments.

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Table 1. Spawning Habitat Classes and Scores

Spawning Habitat Classes	Spawning Suitability Index	Area (% of Belleville - Trenton total)	Area Weighted Spawning Suitability Index	Scaled Spawning Suitability Index
rock	11.9	34.6	7.8	33.0
gravel	25.2	6.6	23.5	100.0
sand	10.2	11.7	9.0	38.2
mud	7.4	12.5	6.4	27.4
weed	14.4	34.7	9.4	40.1
Totals	69.0	100.0		

Table 2. Electrofishing IBI Habitat Classes and Scores

Submerged Vegetation Classes	Electrofishing IBI	Area (% of Belleville - Trenton total)	Area Weighted Electrofishing IBI	Scaled Electrofishing IBI
absent	34.4	77.4	7.8	13.1
very sparse	41.7	1.4	41.1	69.2
sparse	45.3	2.4	44.2	74.4
moderate	49.6	7.7	45.8	77.1
dense	54.1	7.8	49.9	84.0
very dense	61.4	3.3	59.4	100.0
		100.0		

Table 3. Seining IBI Habitat Classes and Scores

Submerged Vegetation Classes	Seine Netting IBI	Area (% of Belleville - Trenton total)	Area Weighted Seine Netting IBI	Scaled Seine Netting IBI
absent	29.3	77.4	6.6	15.9
very sparse	30.8	1.4	30.4	72.8
sparse	33.3	2.4	32.5	77.7
moderate	36.3	7.7	33.5	80.2
dense	39.6	7.8	36.5	87.4
very dense	43.2	3.3	41.8	100.0
		100.0		

Figure 1. **Location of Potter's Point Study Area; Bay of Quinte, Lake Ontario**

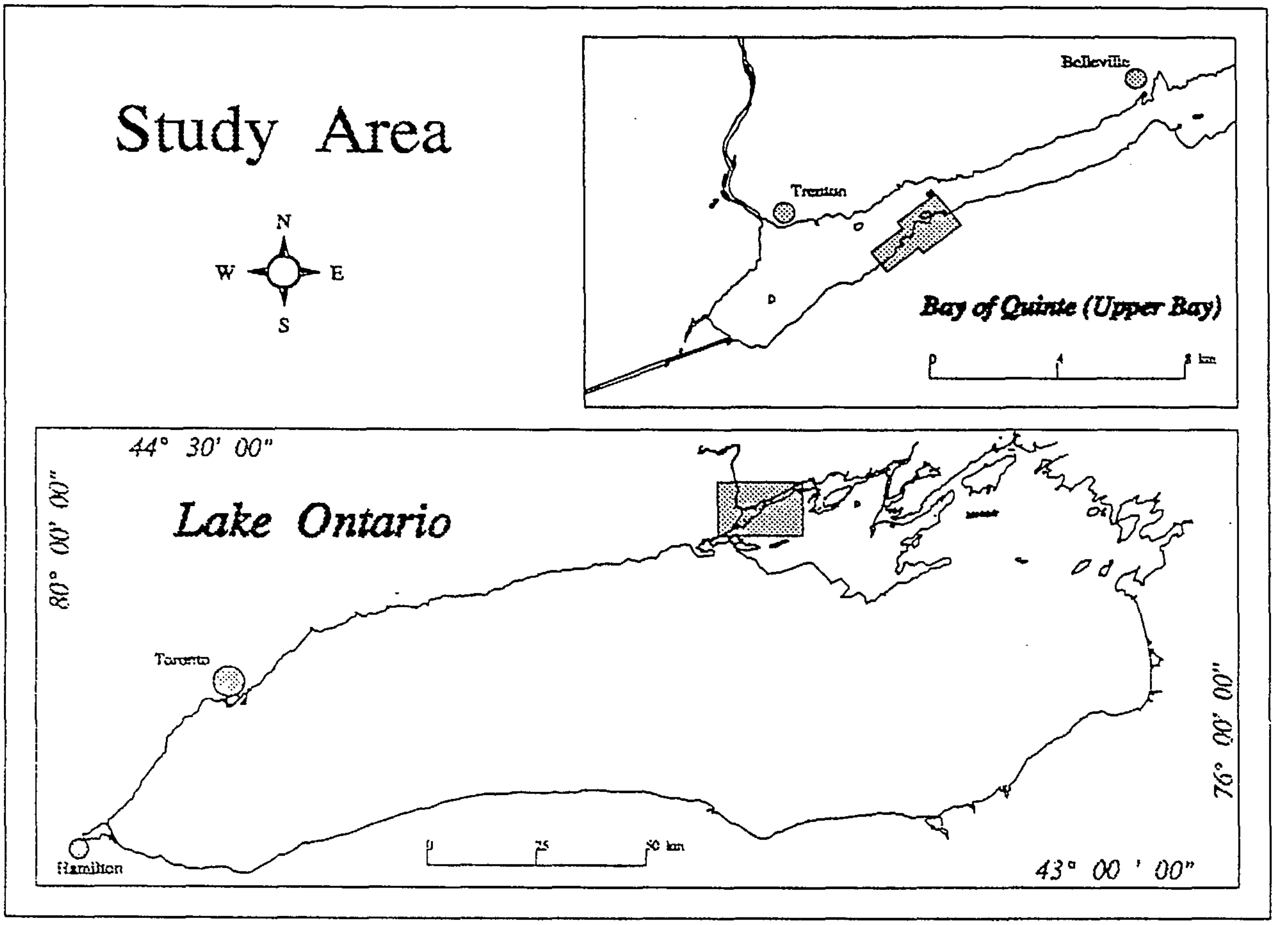


Figure 2. Overview of habitat ranking process.

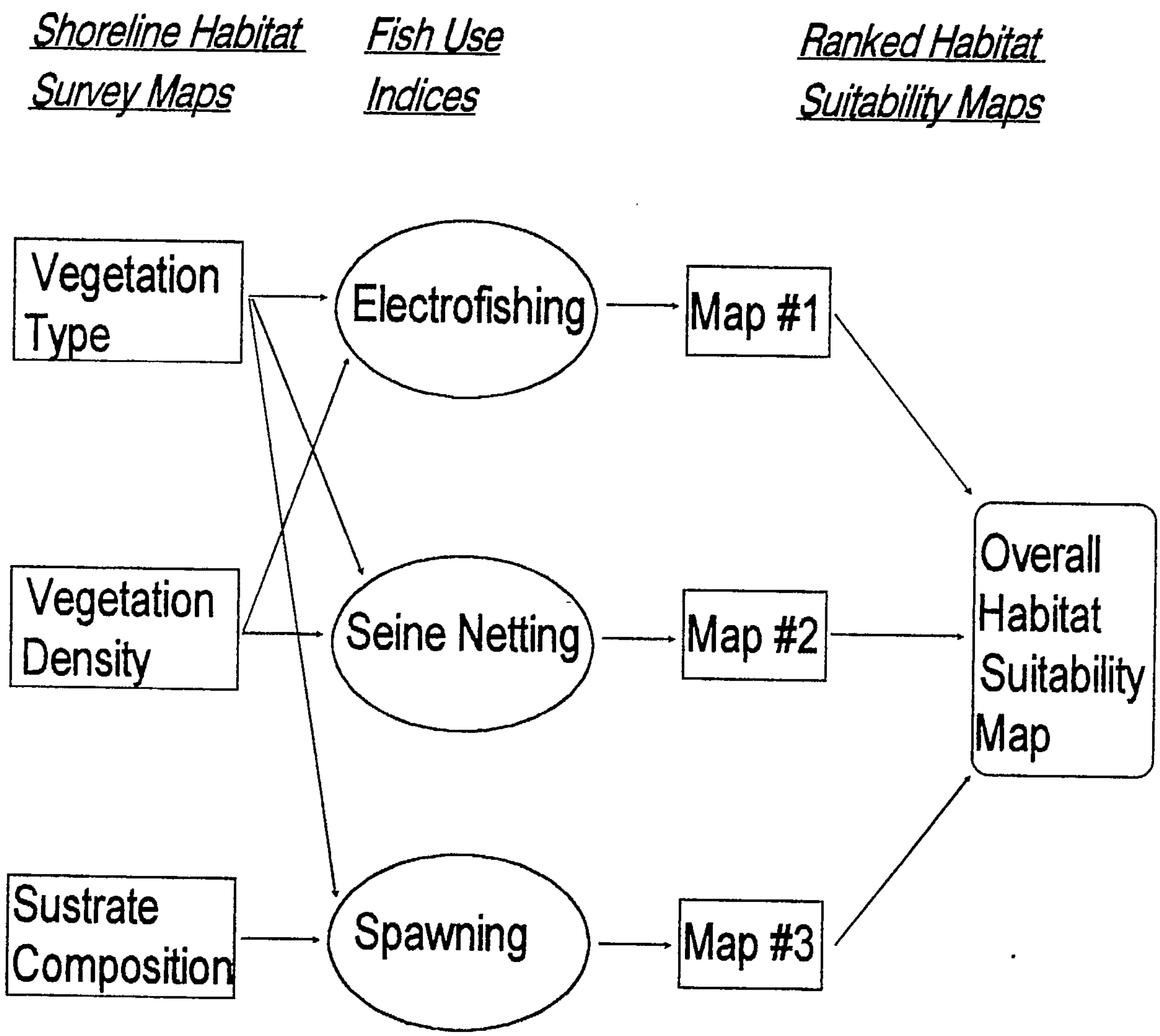
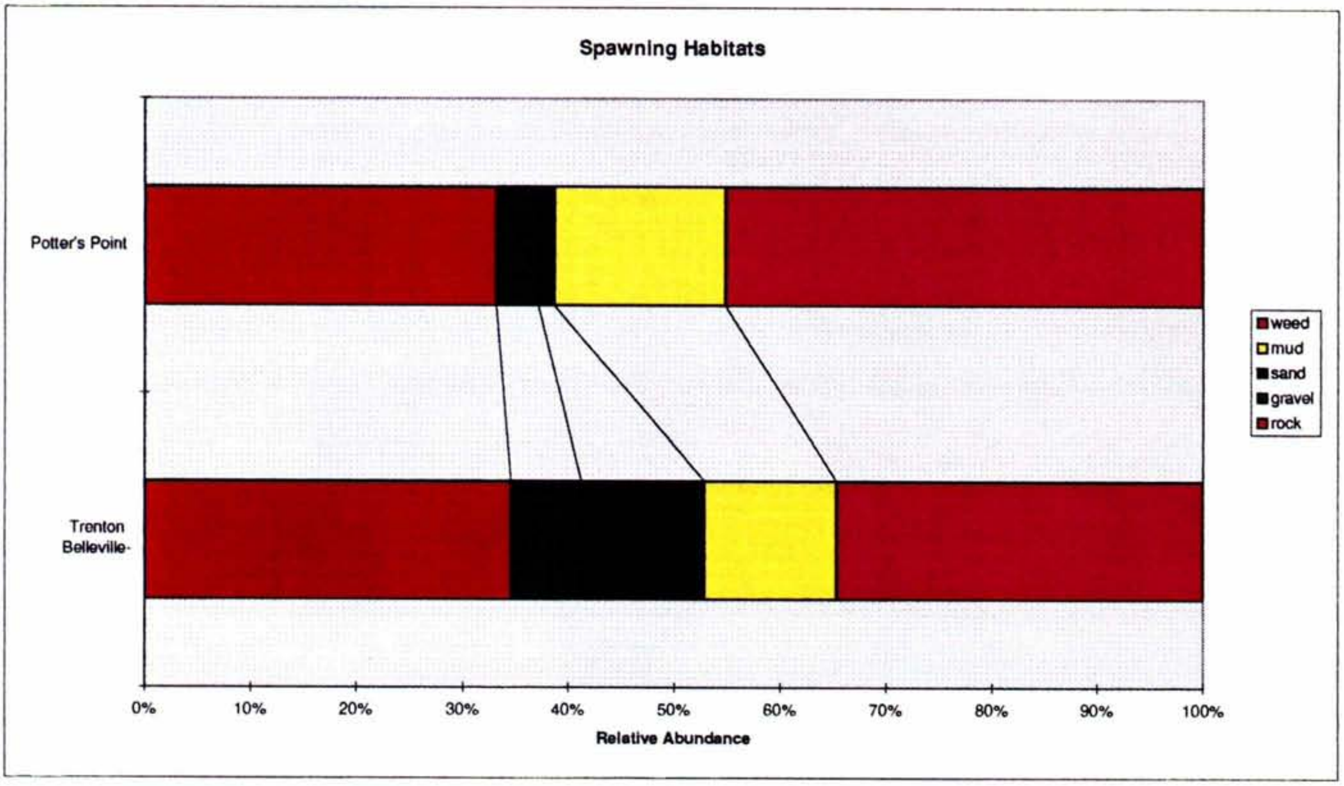


Figure 3. Relative abundance of spawning and submergent vegetation habitats at Potter's Point and Belleville-Trenton areas.



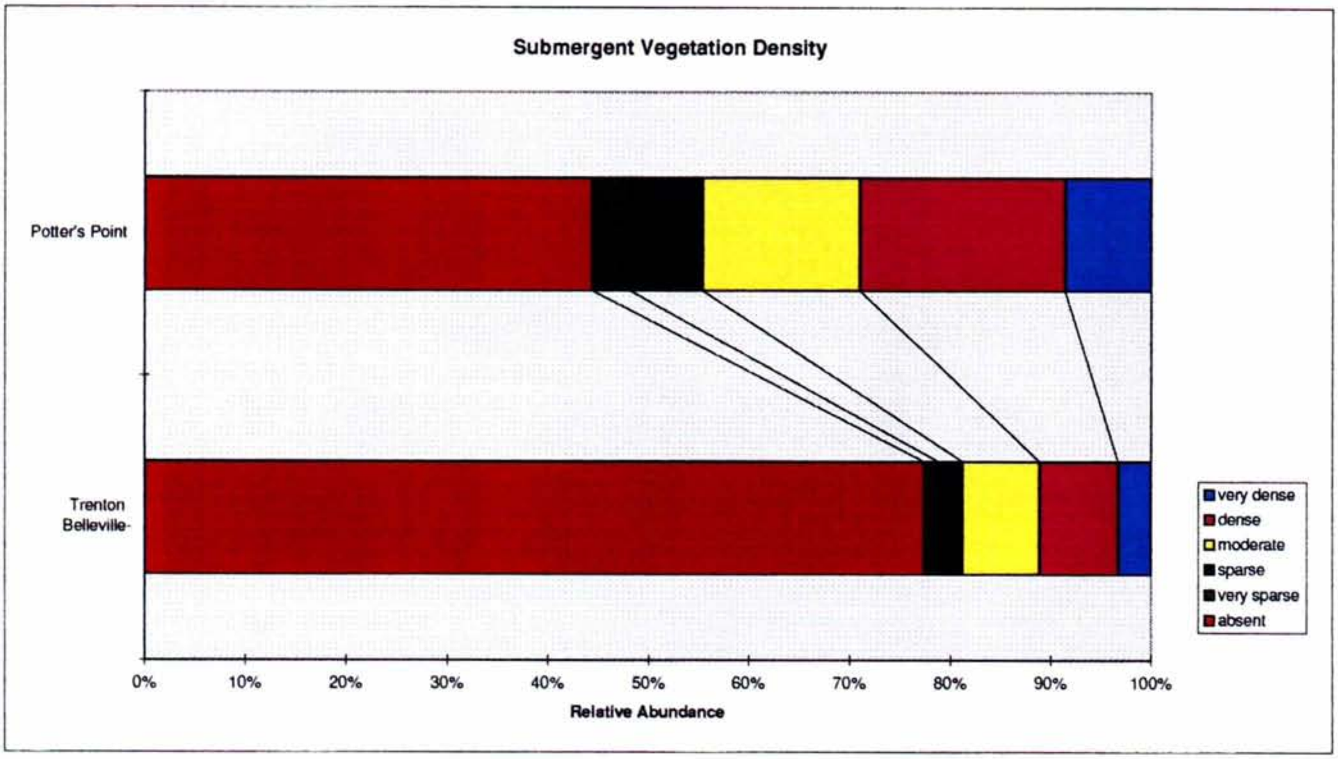


Figure #4

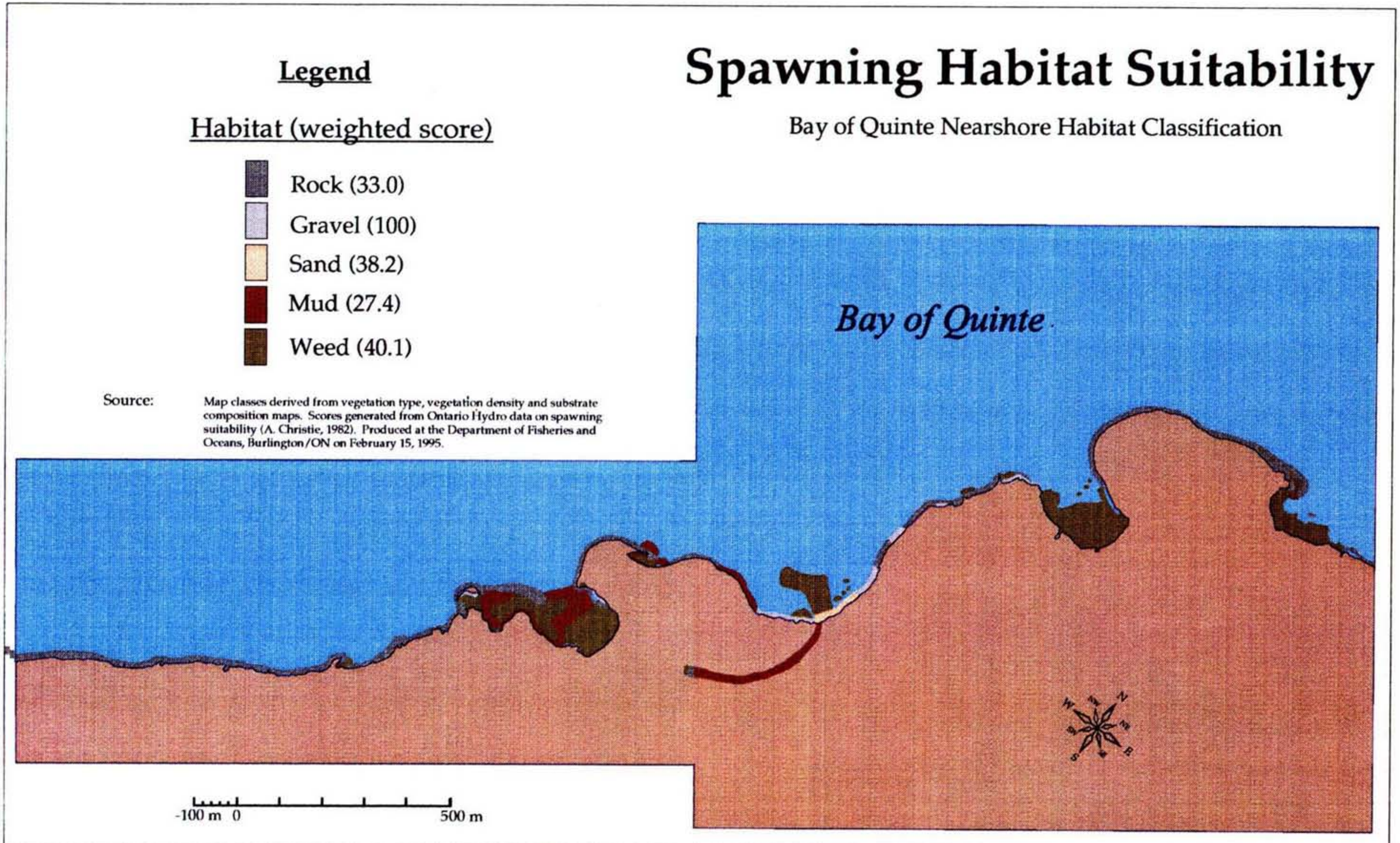

Spawning Habitat Suitability
Bay of Quinte Nearshore Habitat Classification
Legend
Habitat (weighted score)
Rock (33.0)
Gravel (100)
Sand (38.2)
Mud (27.4)
Weed (40.1)
Source:
Map classes derived from vegetation type, vegetation density and substrate composition maps. Scores generated from Ontario Hydro data on spawning suitability (A. Christie, 1982). Produced at the Department of Fisheries and Oceans, Burlington/ON on February 15, 1995.
Bay of Quinte
-100 m 0
500 m

Figure #5

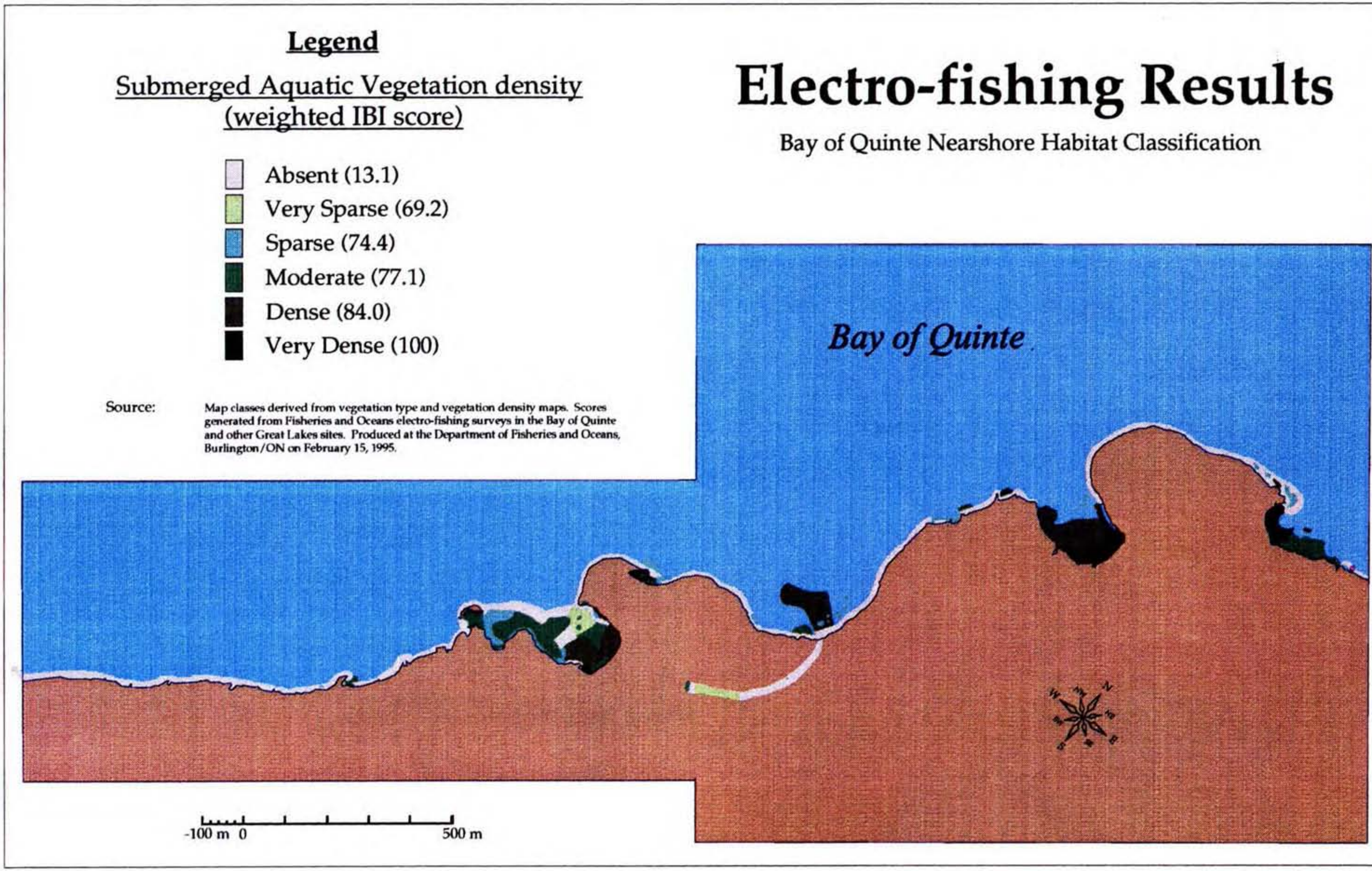

Legend
Submerged Aquatic Vegetation density
(weighted IBI score)
Absent (13.1)
Very Sparse (69.2)
Sparse (74.4)
Moderate (77.1)
Dense (84.0)
Very Dense (100)
Source:
Map classes derived from vegetation type and vegetation density maps. Scores generated from Fisheries and Oceans electro-fishing surveys in the Bay of Quinte and other Great Lakes sites. Produced at the Department of Fisheries and Oceans, Burlington/ON on February 15, 1995.
Electro-fishing Results
Bay of Quinte Nearshore Habitat Classification
Bay of Quinte
-100 m
0
500 m

Figure #6

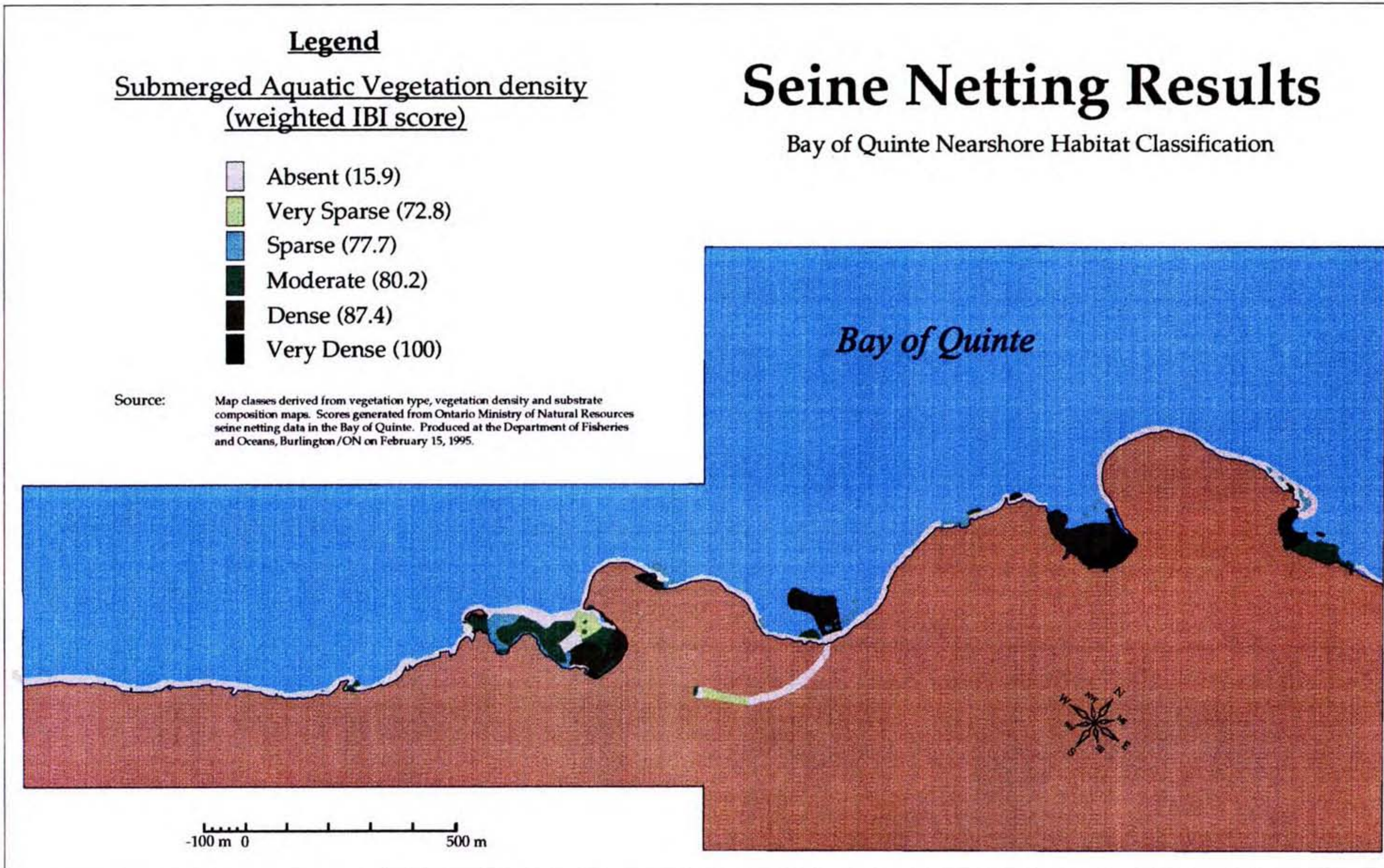

Legend
Submerged Aquatic Vegetation density
(weighted IBI score)
Absent (15.9)
Very Sparse (72.8)
Sparse (77.7)
Moderate (80.2)
Dense (87.4)
Very Dense (100)
Source:
Map classes derived from vegetation type, vegetation density and substrate composition maps. Scores generated from Ontario Ministry of Natural Resources seine netting data in the Bay of Quinte. Produced at the Department of Fisheries and Oceans, Burlington /ON on February 15, 1995.
Seine Netting Results
Bay of Quinte Nearshore Habitat Classification
Bay of Quinte
-100 m 0
500 m

Figure #7

Combined Habitat Scores

Bay of Quinte Nearshore Habitat Classification

Legend

Unclassified	Minimum = 27.4
1 - 25	Maximum = 100
25 - 50	Average = 69.18
50 - 75	
75 +	

Source: Map classes derived from seine netting, electrofishing and spawning suitability maps. Scores represent the highest individual score from the three input maps, for each unique area. Produced at the Department of Fisheries and Oceans, Burlington/ON on February 15, 1995.