GREAT LAKES FISHERY COMMISSION

2002 Project Completion Report[1]

Binational GIS database of coastal wetlands for Lake Ontario and the St. Lawrence: a demonstration project

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Completion Report

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ABSTRACT

In this project, I assembled a seamless binational GIS database that contains all available shapefiles of coastal wetlands of Lake Ontario in ArcMap (ESRI). Information for the Canadian wetlands were obtained from two main sources: the Digital version of the Environmental Sensitivity Atlases published by Environment Canada, along with wetland polygons from the Ontario Ministry of Natural Resources, and geographic location of wetland centroids provided by the Natural Heritage Information Centre. Data for the U.S. wetlands were obtained by combining information from the National Wetland Inventory of the U.S.Fish and Wildlife Service, and centroids reported in Herdendorf and Hartley (1980). All data correspond to aerial surveys taken during the early to mid-1980s. Forty-four regional maps were produced that shows the location and size of wetlands; these maps cover the entire shoreline of Lake Ontario and the St. Lawrence River above Cornwall, Ontario. Individual maps were also produced for 276 wetlands that show the cover of vegetation and in the case of U.S. wetlands, the type of vegetation. All maps can be viewed at the WIRE Net (Wetland Inventory for Research and Education) website (http://www.wirenet.info). GIS was used to quantify the total wetland area for each country, and for each of the modified eco-reach segments identified in SOLEC 98 (Chow-Fraser and Albert 1999). In addition, data from Goodyear et al. (1982) were imported into the WIRE Net database, and a spatial-pattern analysis of fish distribution in coastal wetlands of Lake Ontario was conducted (Wei and Chow-Fraser 2002).

Background

The Great Lakes Fishery Commission considers the over-development of biologically sensitive shorelines of the Great Lakes (coastal wetlands and drowned river mouths in particular) to be a serious threat to the conservation of Great Lakes fishes. Degradation and depletion of such wetlands has had a strong negative impact on the fish community because near-shore regions and rivers provide important habitat for fish and other aquatic biota that form their food base. Environmental management agencies must be able to measure losses and gain in these habitats at regular intervals because such an inventory is necessary to guide land-use planning to ensure the ecological integrity and health of the Great Lakes fishery.

A necessary first step to building such an inventory is the development of a binational GIS database that contains all coastal wetlands for each of the Great Lakes. This was first pointed out in the 1996 SOLEC and was re-emphasized in the 1998 SOLEC. Virtually all who work in management or restoration, or conduct research on coastal wetlands would benefit from development of such a database, and yet despite this widely accepted view, the scientific community is no further ahead at the end of 2001 as we were in 1996. One reason for this is that the relevant geo-referenced data exist in various formats in archives of several agencies (e.g. National Wetlands Inventory (NWI; U.S.), State Wetland Inventories (Michigan, Ohio, Pennsylvania, New York), Evaluated Wetlands (Ontario), Ontario Coastal Wetlands Atlas, WIRE Net (Chow-Fraser, McMaster University), and it has been extremely difficult to simultaneously focus the efforts of different agencies towards this single project. There are also some vocal opponents who believe that existing data are too dated to be useful, and that effort should be directed at building a database with new/current data. Others simply feel that the task is too big and would involve cooperation of too many agencies with sometimes incompatible funding structures and program objectives.

Project Objectives and Deliverables:

A. Development of a seamless and complete GIS database that contains a theme of all classified coastal wetlands of Lake Ontario and the St. Lawrence River corresponding to the early-to-mid 1980s
B. Development of a similar layer that uses digitized information from the most recent aerial photos (1999 and later)
C. A report that will use GIS analysis to compare differences between layers A and B to determine losses and gains in wetland coverage over the two decades

Methodology and approach

A) Development of GIS database of coastal wetlands of Lake Ontario

GIS data for this project came from various sources and had to be imported into the WIRE Net database, and made compatible with each other. The U.S. data could be freely downloaded from the National Wetlands Inventory website (see below), but had to be manipulated before they could be incorporated into the database. By comparison, the

Canadian data did not require very much manipulation but they were not freely available, but had to be provided by the Ontario Ministry of Natural Resources through a restricted Memorandum of Understanding (MOU) with McMaster University. It took two months to work out mutually acceptable terms for the MOU between our Research Services and OMNR, and consequently, the project start date was delayed until March 8, 2002. In addition to this delay, there followed a 2-month work stoppage by OMNR support staff from March to May. Fortunately, we were able to work on the U.S. data during the OMNR strike, and completed sub-project A by mid-summer. Below, I describe how the different data sources have been incorporated into WIRE Net database.

Canadian coastal wetlands of L. Ontario

Canadian wetlands were obtained from two main sources:

- Digital version of the Environmental Sensitivity Atlases (ESA) published by Environment Canada (see list in Literature Cited), and wetland polygons provided by the OMNR

- Wetland centroids provided by the Natural Heritage Information Centre (NHIC)

NHIC information consisted of the geographic location of the wetland centroids but not the wetland polygon whereas ESA wetland polygons accounted for most of the Canadian wetlands. This database has information on OMNR's evaluated wetlands.

U.S. coastal wetlands of L. Ontario

U.S. wetlands were obtained by combining information from National Wetland Inventory (NWI) of the U.S.Fish and Wildlife Service, and data from Herdendorf and Hartley (1980) as follows:

- Digitized NWI landcover maps were downloaded from the NWI website (http://wetlands.fws.gov/downloads.htm) for relevant areas along the U.S. shoreline of Lake Ontario and imported into Arcview. We then used their landcover classification codes (see Smith 1991) to interpret the boundaries of wetland complexes.

- Wetland centroids reported in Herdendorf and Hartley (1980) were entered into GIS, and were superimposed on NWI wetland complexes. Based on proximity of the centroids to wetland complexes and the size of wetlands reported in Herdendorf and Hartley (1980), we were able to identify almost all of the U.S. complexes. (See Appendix I for a detailed description of how we interpreted the wetland boundaries and named the wetlands.)

B) Creation of updated GIS layer

Upon completion of sub-project A, I had intended to locate recently taken orthorectified aerial photos of select wetlands and incorporate these into the WIRE Net database. Unfortunately, the OMNR work stoppage prevented me from making arrangements with the appropriate people who could have provided me with at least some of the photos. I had noted in the original proposal that from firsthand experience, what is promised and what we actually get can vary drastically, and I warned then that the plan may have to be revised accordingly. Since we did not have any data for sub-project B, I instructed the personnel on this project to spend the allotted time on producing maps and resources for the WIRE Net website (http://www.wirenet.info; see Deliverable Products below).

C) Quantification of losses and gains in wetland coverage

Since we could not finish sub-project B, we could not quantify losses and gains in wetland coverage. However, we used GIS to quantify the total wetland area for each country, and for modified eco-reach segments identified in Chow-Fraser and Albert (1999). In addition, we imported the Goodyear et al. (1982) data into WIRE Net, and conducted a spatial-pattern analysis of fish distribution in wetlands of Lake Ontario (Wei and Chow-Fraser 2002).

Deliverable Products

Because data for the Canadian wetlands were obtained through a restricted data-sharing agreement with OMNR (NRVIS data), the entire WIRE Net GIS database must remain at McMaster University for use by investigators and students. Anyone who wishes to use this database should contact the author to make individual arrangements. As explained earlier, because of unforeseen problems in completing sub-project B, I decided to allocate resources to produce maps of individual wetlands, and posted them on the WIRE Net website: (http://www.wirenet.info/lake_ontario_coastal_wetlands.htm) so that at the very least, investigators can readily see the location of wetlands and use the vegetation maps for most of the U.S. wetlands. A copy of the overview map of Lake Ontario produced for the website is shown in Figure 1. This map provides links to 44 regional maps (see Appendix 2 on accompanying CD), which are then linked to 276 maps of individual wetland and/or complexes (see Appendix 3 on accompanying CD).

Since development of this database was prompted by the need to conduct analyses at the scale of the entire lake basin, it is probably not suitable for site-specific research; however, for anyone requiring information to plan sampling programs, or to determine regional distribution of wetlands, this database is invaluable. Besides being comprehensive and binational, the Lake Ontario pilot database contains data that date back to the early to mid-1980s, making it an ideal database against which to compare current or future coverages to track changes through time for the entire Lake.

One of the goals of this pilot project (sub-project C) was to quantify losses and gains in coastal wetlands by comparing data collected approximately two decades apart (i.e. data from 1980s from sub-project A and data from 2000 from sub-project B). However, because I was not successful in getting access to data to complete sub-project B, I am presenting here only a cursory analysis of data from sub-project A. As mentioned earlier, the complete set of GIS maps for all the Lake Ontario wetlands are available in appendices which can be found in the accompanying CD or from the WIRE Net website (http://www.wirenet.info). A summary of the geographic coordinates and wetland areas corresponding to these wetlands are presented in Table 1. (It is important to point out that area calculated for the Canadian wetlands do not include open water in coastal marshes, and is not directly comparable to U.S. statistics.) In this table, I also include the associated eco-reach for each wetland based on updated delineations presented in Chow-Fraser and Albert (1999) and modified for use in SOLEC 2000 (Figure 2a).

Especially when one considers that total area for Canadian wetlands are underestimated (because they do not include open-water areas), there is a great disparity in how wetlands are distributed among the eco-reaches (Figure 2b). OS3a (which occurs entirely within Canada) is associated with the most wetland area. This eco-reach includes the very productive wetlands of the Bay of Quinte, which have been shown to be excellent fish habitat (Chow-Fraser and Albert 1999; Wei and Chow-Fraser 2002). From this analysis, it is also clear that there are more hectares of Canadian than U.S. wetlands along the shores of Lake Ontario.

I have also provisionally classified these Lake Ontario wetlands according to the scheme shown in Table 2. Protected embayments are very abundant in the Canadian eco-reaches (OS2, OS3a, OS4a&b and OS4c) (Figure 3). When expressed as hectares, protected embayments are even more important in the eco-reaches along the St. Lawrence and Bay of Quinte (Figure 4). It is important to know the relative distribution of these wetlands by type so they can be properly sampled. These cursory analyses are given as examples of what can be obtained when querying the database.

Recommendation for Future Work

The relevant GIS data layers for Lake Ontario have been saved into an ESRI ArcMap project at McMaster University so that a seamless binational database of coastal wetlands can be queried on site. However, non-restrictive data-sharing agreements should be negotiated with OMNR so that these data can be made available to any researchers and environmental agencies off site. Other useful data layers, such as roads, rivers and land use, etc. can and should be incorporated in the future, and these should also have non-restrictive data-sharing agreements. More importantly, funds should be allocated to make this project served on the internet with ESRI Internet Map Server software (or equivalent software from Intergraph) so that the database can be used by anyone. It goes without saying that another attempt should be made to incorporate more current digital data for a subset of both the U.S. and Canadian wetlands. For U.S. wetlands, at least, I have noted NWI updates on their websites, and it is more than reasonable to expect a loss-gain analysis to be completed for a subset of the U.S. wetlands in 2003. As for the Canadian wetlands, I have located digital orthorectified air photos from the Region of Hamilton-Wentworth (not from OMNR) that were taken in 1999,

and these could be used to compare losses and gains for approximately 4 coastal wetlands in the region, including Cootes Paradise Marsh. Finally, the Lake Ontario database should be used to assess the appropriateness of using satellite images to map coastal wetlands to produce future inventories.

Literature Cited

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Table 1. Summary of geographic coordinates and wetland area for coastal wetlands of Lake Ontario. NOTE: Areas corresponding to Canadian wetlands do not include any open water.

Wetland Name	Country	Latitude	Longitude	Eco-reach	Area (m^2)
Willard Road Wetland	US	-74.994	44.92408	OS1	1867231.51
St. Regis Area Wetland	US	-74.6485	44.99101	OS1	156605.26
Raquette River Area Wetland	US	-74.8418	44.97285	OS1	882951.67
St. Regis (Thick Marsh)	US	-74.5266	45.02985	OS1	32120348
St. Lawrence Station West	US	-74.8575	44.97932	OS1	249505.77
Robinson Creek Area Wetland	US	-74.8418	44.97285	OS1	570130.34
Robinson Bay Wetland	US	-74.8292	44.98364	OS1	33902.56
Croil Islands Wetland Complex	US	-74.9913	44.96667	OS1	201488.85
Wilson Hill Wetland	US	-75.0762	44.91129	OS1	1897429.87
Coles Creek Wetland	US	-75.0924	44.89994	OS1	799897.35
Clark Point Wetland	US	-75.1816	44.87138	OS1	56891.76
River Road Wetland	US	-75.2537	44.83966	OS1	619918.49
Whitehouse Bay Marsh	US	-75.2797	44.83093	OS1	120555.57
Brown Church Bay Wetland	US	-75.2949	44.82488	OS1	141848.39
Township Beach Wetland	US	-75.3649	44.77333	OS1	45958.32
Galop Island Wetland	US	-75.3582	44.78102	OS1	37781.02
Red Mills Area Wetland	US	-75.3827	44.75135	OS1	45135.36
Tibbits Creek Marsh	US	-75.4331	44.72361	OS1	13169.69
Ogdensburg East Area	US	-75.4642	44.70962	OS1	70117.07
Morristown Bay Wetland	US	-75.6473	44.58044	OS1	6551.19
Sheephead Marsh Wetland	US	-75.775	44.46606	OS2	156708.08
Willy Island Marsh Ea	US	-75.7753	44.47545	OS2	29001.77
Chippewa Creek Marsh	US	-75.7273	44.47399	OS2	5484076.82
Oak Island Marsh	US	-75.7862	44.4307	OS2	347316.22
Schermerhorn Landing	US	-75.7782	44.42287	OS2	108823.87
Duck Cove Wetland	US	-75.7958	44.40113	OS2	30724.73
Crooked Creek Wetland	US	-75.8158	44.37738	OS2	2740851.98
Scribby Road Area Wetland	US	-75.8373	44.39163	OS2	11274.07
Greens Creek Area Wetland	US	-75.8967	44.34783	OS2	57309.17
Goose Bay Cranberry Marsh	US	-75.8581	44.3564	OS2	5999654.44
Otter Creek Marsh	US	-75.922	44.32286	OS2	57341.49
Point Vivian Marsh	US	-75.9468	44.31183	OS2	240502.22
Swan Bay Marsh	US	-75.9709	44.30045	OS2	80909.04
Moore Landing Marsh	US	-75.9831	44.29479	OS2	61499.75
Grass Point Area Wetland	US	-75.9878	44.29053	OS2	66126.39
Deer Island Wetland	US	-75.9083	44.36271	OS2	5108.36
Westminister Marsh	US	-75.9485	44.33932	OS2	248067.53
Fairyland Island Area	US	-75.9261	44.35357	OS2	74192.16
Waterloo Wetland	US	-75.9556	44.3404	OS2	14869.1

Densmore Area Wetland	US	-75.9711	44.32265	OS2	648019.3
Barnett Area Wetland	US	-75.9569	44.30669	OS2	14888.69
Otter Point Marsh	US	-76.0034	44.31409	OS2	44130.75
Eel Bay Wetland	US	-76.0259	44.32011	OS2	50348.7
Flatiron Marsh	US	-76.0437	44.3222	OS2	198618.65
Rift Marsh	US	-75.9953	44.3406	OS2	97940.49
South Bay Marsh Complex	US	-76.0279	44.29336	OS2	66629.72
Wellesley Island Wetlands	US	-75.9705	44.32665	OS2	367968.84
Lake of the Isles Wetland	US	-76.0134	44.31904	OS2	451095.84
Waterson Point Area Wetland	US	-76.0061	44.33732	OS2	43114.36
Murray Isle Wetland	US	-76.0455	44.29187	OS2	12370.43
Blind Bay Marsh by Mullet Cr	US	-76.0165	44.26155	OS2	148631.72
Blind Bay Marsh	US	-75.7813	44.46952	OS2	101270.04
Aquatic Beds Near Round Island	US	-76.0637	44.24519	OS2	67332.8
Round Island Area Wetland	US	-76.0637	44.24519	OS2	38611.29
Carrier Bay Wetland	US	-76.072	44.23991	OS2	10927.9
Clayton Wetland	US	-76.0797	44.23938	OS2	10712.56
French Creek Wetland	US	-76.1302	44.20184	OS2	2876704.24
Plumtree Marsh	US	-76.0752	44.29711	OS2	134862.95
Delaney Marsh	US	-76.088	44.28126	OS2	641077.3
Aunt Janes Bay Wetland	US	-76.1094	44.26708	OS2	35212.15
Boscobel Area Wetland	US	-76.1159	44.25502	OS2	8271.02
McCreae Marsh	US	-76.1285	44.27781	OS2	586218.8
Thurso Bay Wetland	US	-76.1418	44.28213	OS2	3819.32
Potter Island Area Wetland	US	-76.149	44.28124	OS2	1640.47
Buck Bay Wetland	US	-76.1442	44.24881	OS2	98236.68
North Buck Bay Area Wetland	US	-76.1508	44.25629	OS2	60427.37
Buck Bay Islands Wetlands	US	-76.1461	44.25371	OS2	15754.4
Flynn Bay Wetland	US	-76.1322	44.25546	OS2	189941.67
Millen Bay Wetland	US	-76.2455	44.16827	OS3b	28040.67
Hell Street Area Wetland	US	-76.2504	44.1668	OS3b	7615.48
Grass Bay Wetland	US	-76.2738	44.15689	OS3b	20785.64
Wilson Bay Marsh	US	-76.3384	44.09338	OS3b	805245.16
Mud Bay Marsh	US	-76.3039	44.08237	OS3b	1012096.69
Basin Harbor Wetland	US	-76.3467	44.04211	OS3b	145428.2
Grenadier Island Wetland	US	-76.3674	44.05036	OS3b	26360.17
Fox Island Wetland	US	-76.3302	44.03685	OS3b	320750.19
Fox Creek Marsh	US	-76.2932	44.05867	OS3b	87703.43
Little Fox Creek Marsh	US	-76.2885	44.04963	OS3b	249289.94
Reeds Bay Wetland	US	-76.1989	43.97134	OS3b	13141.17
Unidentified by Cliness Point	US	-76.2209	44.00049	OS3b	81580.35
Black River Delta Marsh	US	-76.0298	44.0019	OS3b	980328.97
Point Peninsula North	US	-76.2746	44.00589	OS3b	99132.45
Sherwin Creek Wetland	US	-76.1667	43.97319	OS3b	211901.75
Cliness Point Wetland	US	-76.2177	44.02479	OS3b	3550.46

Isthmus East Wetland	US	-76.2578	44.01759	OS3b	47122.09
Boultons Beaches	US	-76.1305	43.92781	OS3b	153294.12
Unidentified by Sherwin Creek	US	-76.174	43.96248	OS3b	15415.57
North Shore Wetland	US	-76.2789	44.0312	OS3b	55340.81
Long Carry Marsh	US	-76.2735	44.04938	OS3b	94042.71
Carrying Place Road Wetland	US	-76.2414	44.06503	OS3b	83839.5
Three Mile Bay Area Wetland	US	-76.2148	44.07067	OS3b	190483.37
Chaumont River Mouth	US	-76.1501	44.0478	OS3b	553230.56
Chaumont River Wetland	US	-76.1049	44.10282	OS3b	929728.3
Sawmill Bay Wetland	US	-76.135	44.05969	OS3b	85450.45
Guffin Bay Marsh	US	-76.1229	44.0352	OS3b	707834.86
Marsh Point Wetland	US	-76.1875	43.99688	OS3b	9504.65
Perch River Wetland	US	-76.0854	43.99604	OS3b	1334657.72
Muskalonge Bay Wetland	US	-76.0634	43.97636	OS3b	2843556.4
Campbell Marsh	US	-76.1147	43.90831	OS3b	363536.03
Wescott Beach State P	US	-76.1249	43.89807	OS3b	23765.29
Wescott Beach	US	-76.1267	43.90369	OS3b	28864.76
South Galloo Island Wetland	US	-76.4261	43.89286	OS3b	54046.09
South Galloo Island Wetland	US	-76.4213	43.89536	OS3b	222895.38
Calf Island Wetland	US	-76.3956	43.88151	OS3b	5689.55
Association Island Wetland	US	-76.2089	43.90349	OS3b	17439.02
Stony Point Island Wetland	US	-76.303	43.91741	OS3b	34499.32
Henderson Harbour Wetland	US	-76.2083	43.84741	OS7	25109.05
Ray Bay Marsh	US	-76.2597	43.8385	OS7	93720.19
Stony Creek Wetland (By Ray Bay)	US	-76.234	43.81893	OS7	663004.55
Black Pond-Little Stony Creek	US	-76.2239	43.79889	OS7	1439908.17
Southwick Beach Marsh	US	-76.2097	43.76213	OS7	1512127.44
Southwick Beaches	US	-76.2174	43.76576	OS7	513751.54
Little Sandy Beaches	US	-76.1967	43.65718	OS7	442241.93
Mud Creek Wetland	US	-76.149	43.66735	OS7	451831.69
Sandy Creek Marsh Complex	US	-76.1872	43.72076	OS7	9950299.41
Cranberry Pond Marsh	US	-76.1919	43.68716	OS7	683023.68
Blind Creek Wetland	US	-76.1517	43.64802	OS7	811499.94
Little Sandy Creek Marsh	US	-76.1642	43.63549	OS7	690492.98
South Pond Wetland	US	-76.1812	43.60198	OS7	3320592.65
Deer Creek Marsh	US	-76.1835	43.59336	OS7	1912708.82
Salmon River Marsh	US	-76.1821	43.56612	OS7	1742138.1
Grindstone Creek Marsh	US	-76.2043	43.545	OS7	669109.43
Ramona Beach Marsh	US	-76.2212	43.53049	OS7	470358.93
Skinner Creek Mouth Wetland	US	-76.1548	43.6924	OS7	1482828.14
Sage Creek Wetland	US	-76.2436	43.52235	OS7	137968.53
Little Salmon River Marsh	US	-76.2507	43.51594	OS7	209086.5
Butterfly Swamp	US	-76.2858	43.51119	OS6	1693703
Mexico Point Area Wetland	US	-76.2599	43.51784	OS7	188692.25
Rice Creek Marsh	US	-76.5659	43.43872	OS6	121537.99

Nine Mile Creek Wetland	US	-76.632	43.4033	OS6	72894.74
Eightmile Creek Wetland	US	-76.6222	43.40982	OS6	43706.63
Juniper Pond Wetland	US	-76.6698	43.36179	OS6	143805.44
Sterling Creek Wetland	US	-76.6764	43.34345	OS6	3758439.15
Little Sodus Bay Wetland	US	-76.7165	43.31416	OS6	500437.11
Blind Sodus Bay Wetland	US	-76.7237	43.32345	OS6	1129415.45
Black Creek Wetland	US	-76.746	43.30663	OS6	1910778.83
Red Creek Wetland	US	-76.7693	43.29333	OS6	2588173.67
Desborough Park Area Wetland	US	-76.8145	43.28986	OS6	627711
Port Bay Wetland	US	-76.8259	43.27579	OS6	3726965.81
Beaver Creek Wetland	US	-76.8491	43.27802	OS6	1017553.67
East Bay Wetland	US	-76.9121	43.27053	OS6	3426077.5
Root Swamp	US	-76.9313	43.27075	OS6	510432.51
Sodus Bay Wetland	US	-76.9597	43.23058	OS6	3895622.73
Maxwell Bay Wetland	US	-77.0256	43.26585	OS6	92803.44
Mink Creek Wetland	US	-77.1387	43.28316	OS6	19316.67
Holland Cove Wetland	US	-77.1451	43.28707	OS6	14230.73
Irondequoit Bay Wetland	US	-77.5297	43.20663	OS5b	4852081.66
Unidentified #2	US	-75.1581	44.88103	OS5b	66811.41
Eastman Lake Area Wetland	US	-77.6175	43.2287	OS5b	1143094.94
Round Pond Wetland	US	-77.6579	43.26522	OS5b	1006289.61
Buck Pond	US	-77.6736	43.277	OS5b	3006325.99
Northrup Creek (Long Pond)	US	-77.695	43.28751	OS5b	2267733.7
Braddock Bay-Cranberry Marsh	US	-77.7024	43.29579	OS5b	1774384.67
Braddock Bay Wetland	US	-77.7411	43.31109	OS5b	8731749.39
Payne Beach Area Wetland	US	-77.7289	43.32466	OS5b	611546.06
Bogus Point Wetland	US	-77.7592	43.33422	OS5b	198911.27
Davidson Beach Wetland	US	-77.7694	43.33703	OS5b	110539.15
East Creek Wetland	US	-77.7955	43.33622	OS5b	123335.23
Brush Creek Wetland	US	-77.8205	43.33269	OS5b	776133.74
Cowsucker Creek/Shore Acres	US	-77.8333	43.34078	OS5b	518504.16
Unidentified #1	US	-76.2844	44.01154	OS3b	116068.79
Benedicts Beach Area Wetland	US	-77.8623	43.34567	OS5b	126461.21
Sandy Creek (West) Wetland	US	-77.895	43.3454	OS5b	336605.72
Beach by Sandy Harbour	US	-77.9577	43.3636	OS5a	212145.57
Sandy Harbor Wetland	US	-77.9307	43.35436	OS5b	467414.1
Bald Eagle Creek Wetland	US	-77.9577	43.3636	OS5a	247069.31
Eighteen Mile Creek Wetland	US	-78.7127	43.27392	OS5a	718005.74
Tuscarora Wetland	US	-78.8374	43.26737	OS5a	369130.51
Twelve Mile Creek	US	-78.8598	43.25434	OS5a	285976.15
Bainsville Bay (Pointe Mouillee) Marsh	Canada	-74.3929	45.17186	OS1	768114.91
Westley's Creek Marsh	Canada	-74.4311	45.15891	OS1	52543.43
South Lancaster Wetland	Canada	-74.5042	45.12247	OS1	5502.9
IR 59 - Squaw Island wetland	Canada	-74.5025	45.08832	OS1	15918.58
Charlottenburg Marsh Complex	Canada	-74.6276	45.07672	OS1	22191690.7

Cameron's Island	Canada	-74.5112	45.06689	OS1	508019.16
Colquhoun Island Wetlands	Canada	-74.6481	45.02564	OS1	215700.3
Wetland South of Pilon Island	Canada	-74.6616	45.01705	OS1	2218.47
Pilon Island Wetland	Canada	-74.6672	45.02629	OS1	400838.52
Hoople Creek Marsh	Canada	-74.9674	45.0096	OS1	123750.83
Hoople Bay Marsh	Canada	-74.9461	45.0244	OS1	939598.45
Upper Canada Migratory Bird Sanctuary and Marsh	Canada	-75.0283	44.97222	OS1	3321860.24
Riverside Marsh	Canada	-75.141	44.92292	OS1	283049.29
Hoasic Creek Marsh	Canada	-75.1715	44.96645	OS1	8592490.68
C.F.B.P. Wetland	Canada	-75.0692	44.95746	OS1	3014.28
Doran Creek Marsh Complex	Canada	-75.29	44.85698	OS1	2164716.52
McLaughlins Creek Marsh Complex	Canada	-75.4218	44.77894	OS1	136086.26
Edwardsburgh Marsh	Canada	-75.4371	44.78031	OS1	4464660.9
Johnstown Marsh Complex	Canada	-75.4521	44.75001	OS1	850240.81
Bradley's Creek Wetland	Canada	-75.539	44.70055	OS1	88522.67
South Augusta Wetland Complex	Canada	-75.6464	44.65026	OS1	3553535.33
Grant's Creek Wetland	Canada	-75.7198	44.56423	OS1	267340.08
Mollys Gut Wetland Complex	Canada	-75.7353	44.5505	OS1	112538.97
Jones Creek Marsh	Canada	-75.8243	44.50226	OS2	2054396.84
Poverty Island Wetlands	Canada	-75.8764	44.40222	OS2	22334.28
Browns Bay Wetland Complex	Canada	-75.8519	44.46029	OS2	317429.85
Grenadier Island Wetland Complex	Canada	-75.9071	44.40946	OS2	2825949.61
Larue Mills Creek Wetland Complex	Canada	-75.9309	44.41173	OS2	4075385.3
Hill Island West Marsh	Canada	-75.9727	44.34625	OS2	235263.24
Hill Island East Marsh	Canada	-75.9487	44.36213	OS2	214013.29
Mulcaster Island Wetlands	Canada	-76.0511	44.34262	OS2	63141.75
Collier Island Wetland	Canada	-76.065	44.34748	OS2	201678.58
Landon Bay Marshes	Canada	-76.0569	44.3606	OS2	447780.72
Ivy Lea Wetland Complex	Canada	-76.0357	44.36235	OS2	1019518.28
Halstead Creek Marsh	Canada	-76.0708	44.35935	OS2	218717.66
Halstead Bay Marsh	Canada	-76.0998	44.34251	OS2	334478.33
Gray's Creek Marsh	Canada	-76.1107	44.34604	OS2	478203.34
Legges Creek Marsh	Canada	-76.1201	44.34502	OS2	672878.02
Gordon Island Wetland	Canada	-76.1038	44.33086	OS2	84068.94
Hay Island Marsh	Canada	-76.1507	44.30978	OS2	164230.03
Stave Island Marsh	Canada	-76.072	44.33602	OS2	89388.35
Bostwick Island Wetland Complex	Canada	-76.1778	44.29862	OS2	321120.68
Willowbank Marsh	Canada	-76.2117	44.32424	OS3a	1058376.58
Firman's Creek Marsh	Canada	-76.2365	44.31092	OS3a	137330.38
Seburns Creek Wetland	Canada	-76.2267	44.29846	OS3a	272357.8
Johnson Bay Marshes	Canada	-76.2736	44.27966	OS3a	1101876.26
Grass Creek Wetland	Canada	-76.304	44.29512	OS3a	237264.75
Pitts Ferry Wetland	Canada	-76.3269	44.27984	OS3a	34014.83
Lawless Wetland	Canada	-76.3396	44.27752	OS3a	298390.69
Cassidys Bay Wetland	Canada	-76.3365	44.2609	OS3a	31868.46

Madoma Marsh	Canada	-76.3676	44.26589	OS3a	191308.64
Oak Point Wetland	Canada	-76.3377	44.23292	OS3a	415513.02
Wolfe Island Wetland Complex	Canada	-76.2936	44.21644	OS3a	1560743.52
Button Bay Wetland	Canada	-76.3734	44.13807	OS3a	328359.07
Bayfield Bay Marsh	Canada	-76.3689	44.19156	OS3a	2893901.29
McDonell Bay Wetland	Canada	-76.3931	44.22624	OS3a	927363.61
Barrett Bay Wetlands (Wolfe Is.)	Canada	-76.4208	44.19984	OS3a	377189.66
Sand Bay Marsh (Wolfe Is.)	Canada	-76.5002	44.16004	OS3a	736132.75
Reeds Bay Wetland (Wolfe Is.)	Canada	-76.4563	44.14457	OS3a	258246.27
Big Sandy Bay Wetland (Wolfe Island)	Canada	-76.4387	44.10816	OS3a	263541.95
Cataraqui River Marsh	Canada	-76.4712	44.26769	OS3a	2768557.05
Little Cataraqui Marsh	Canada	-76.5453	44.23518	OS3a	950889.56
Parrott's Bay Marsh	Canada	-76.6912	44.22186	OS3a	214960.9
Amherst Island Complex/Long Point Bay Wetlands	Canada	-76.7102	44.12449	OS3a	5866100.63
Bath Point Wetland	Canada	-76.777	44.18601	OS3a	192639.15
Cressy Swamp	Canada	-76.8851	44.08218	OS3a	1991272.76
Lake on the Mountain Swamp	Canada	-77.0747	44.01816	OS3a	2923889.52
South Bay Marsh	Canada	-77.0445	43.91709	OS3a	748458.95
Big Sand Bay Wetland (near Picton)	Canada	-76.9156	43.92165	OS3a	2017518.65
Soup Harbour Wetland	Canada	-77.1745	43.86708	OS3a	803710.32
Salmon Point Wetland	Canada	-77.2139	43.86008	OS3a	1427830.94
East Lake Marsh	Canada	-77.163	43.94639	OS3a	2440499.12
West Lake Wetlands	Canada	-77.283	43.95908	OS3a	8093079.14
Carnachan Bay Wetland Complex	Canada	-77.063	44.07762	OS3a	1451654.62
Hay Bay Marsh	Canada	-76.9191	44.17778	OS3a	10589743.7
Pike Creek Swamp	Canada	-76.9543	44.20024	OS3a	1357741.38
Lower Napanee River Wetland	Canada	-77.0175	44.1922	OS3a	1883228.53
Big Island Marsh	Canada	-77.223	44.11025	OS3a	5728208.97
Blessington Creek Marsh	Canada	-77.323	44.16965	OS3a	1438095.53
Sawguin Creek Wetland	Canada	-77.3907	44.11115	OS3a	17518517
Belleville Treatment Plant Marsh	Canada	-77.3914	44.15245	OS3a	162916.23
Bayside Wetlands	Canada	-77.4965	44.11931	OS3a	78637.67
Pine Point Wetland	Canada	-77.504	44.0955	OS3a	321336.49
Carrying Place Marsh	Canada	-77.566	44.05891	OS3a	214288.6
Wellers Bay/Barcovan Beach Wetland	Canada	-77.6065	44.01509	OS4c	433255.86
Wellers Bay Wetlands Complex	Canada	-77.5797	44.02626	OS3a	2244789.36
Consecon Lake Marsh	Canada	-77.5024	44.00255	OS3a	192912.73
Pleasant Bay Wetlands	Canada	-77.4709	43.95279	OS3a	1095094.85
Huyck's Bay	Canada	-77.4616	43.94641	OS3a	3032202.83
Dead Creek Marsh	Canada	-77.6349	44.03734	OS4c	3467222.13
Presqu'ile Bay Marsh Complex	Canada	-77.6929	44.03043	OS4c	6197582.72
Colborne Creek Wetland	Canada	-77.8962	43.98335	OS4b	442408.98

Wicklow Bay Wetland	Canada	-77.9781	43.97725	OS4b	475972.73
Grafton Swamp	Canada	-78.0242	43.97603	OS4b	5962182.63
Carr Marsh	Canada	-78.22	43.95278	OS4b	421923.45
Peter Rock Marsh	Canada	-78.2506	43.95351	OS4b	14339.78
Port Britain	Canada	-78.3716	43.93189	OS4b	394287.53
Crysler Point Wetland	Canada	-78.4034	43.91844	OS4b	377879.43
Lower Wilmot Creek Wetland	Canada	-78.5997	43.89864	OS4b	185061.34
Pawson Marsh-Darlington	Canada	-78.6702	43.89256	OS4b	357541
Westside Creek Wetland	Canada	-78.6806	43.8864	OS4b	513550.82
Raby Head Wetland #1	Canada	-78.6976	43.87677	OS4b	47485.01
Raby Head Wetland #2	Canada	-78.6926	43.8787	OS4b	85202.64
Second Marsh	Canada	-78.819	43.87528	OS4b	930953.67
Pumphouse Marsh	Canada	-78.8387	43.8589	OS4b	52016.93
Lower Corbett Creek	Canada	-78.8888	43.85646	OS4b	273302.37
Lynde Marsh	Canada	-78.9593	43.85226	OS4b	332827.39
Cranberry Marsh	Canada	-78.9681	43.84282	OS4b	103604.74
Carruther's Creek Marsh	Canada	-78.9869	43.8303	OS4b	260637.31
Duffins Creek Marsh	Canada	-79.0392	43.82607	OS4b	71129.51
Frenchman's Bay-Hydro Marsh	Canada	-79.0761	43.81658	OS4b	425876.93
Frenchman's Bay Marsh	Canada	-79.0915	43.82334	OS4b	458171.45
Petticoat Creek Wetland	Canada	-79.1168	43.80739	OS4b	962255.54
Rouge River Marsh	Canada	-79.1264	43.79654	OS4b	500671.21
Highland Creek Wetland Complex	Canada	-79.1523	43.76915	OS4b	100260.34
East Ward's Island Wetland	Canada	-79.3532	43.63122	OS4a	81050.57
Mugg's Island Wetland	Canada	-79.3856	43.62424	OS4a	158499.38
Forestry Island Wetland	Canada	-79.3819	43.61816	OS4a	62638.77
Humber River Marshes	Canada	-79.4933	43.64641	OS4a	368238.55
Lakefront Promenade Pk Wetland	Canada	-79.5644	43.56519	OS4a	76329.38
Rattray Marsh	Canada	-79.6098	43.51659	OS4a	459999.89
Joshua Creek Valley	Canada	-79.6299	43.48179	OS4a	355161.49
Bronte Creek Wetland	Canada	-79.738	43.40355	OS4a	1689566.47
Cootes Paradise	Canada	-79.925	43.27013	OS4a	629592.97
Jordan Station Marsh	Canada	-79.37	43.16051	OS4a	449754.42
Fifteen Mile Creek Wetland	Canada	-79.3215	43.16927	OS4a	1689271.67
Martindale Marsh	Canada	-79.2643	43.19899	OS4a	818650.78
Eight Mile Creek Estuary	Canada	-79.1844	43.22898	OS4a	178530.55
Four Mile Creek Estuary	Canada	-79.0896	43.25105	OS4a	659343.03

Table 2. Classification scheme for naturally occurring Great Lakes coastal wetlands based on dominant hydrologic source and connectivity to lake (proposed by Denny Albert and Doug Wilcox for adoption by Coastal Wetlands Consortium, 2001)

Lacustrine strongly affected by lake level fluctuations, currents, seiches, ice scour	Open	***Open Shoreline (1)***
		Open Embayment (2)
	Protected	***Protected Embayment (3)***
		Sandspit Embayment (4)
Riverine water quality and sediment accumulation controlled by drainages; water level controlled by coastal processes	Drowned River-mouth	***Open drowned river-mouth (5)***
		Barred drowned river-mouth (6)
	Connecting Channel	***Connecting Channel (7)***
	Delta	***Delta (8)***
Barrier-Protected separated from lake by coastal processes and protected from wave action; groundwater, surface water more important when not connected to lake	Barrier-beach lagoon	***Barrier-beach lagoon (9)***
	Swale Complexes	***Sandspit swales (10)***
		Ridge & swale complexes (11)

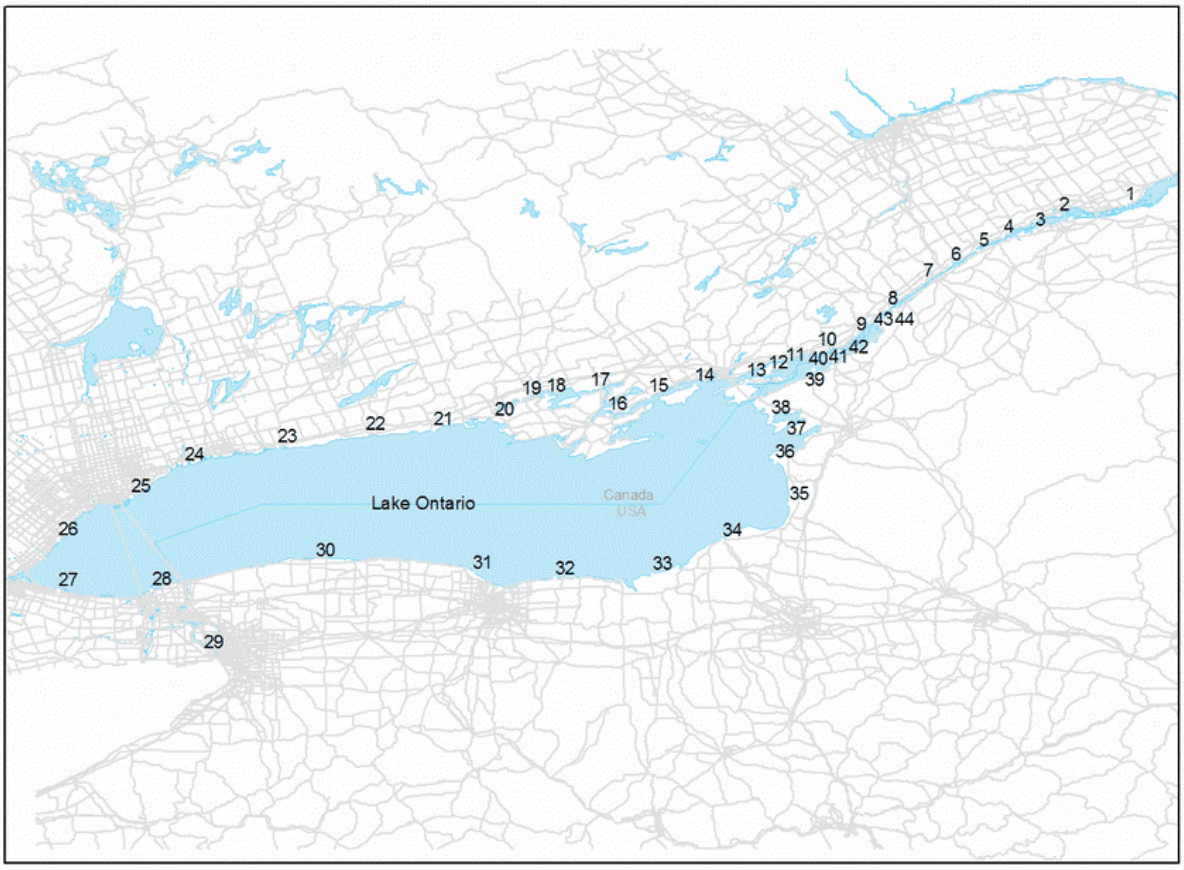
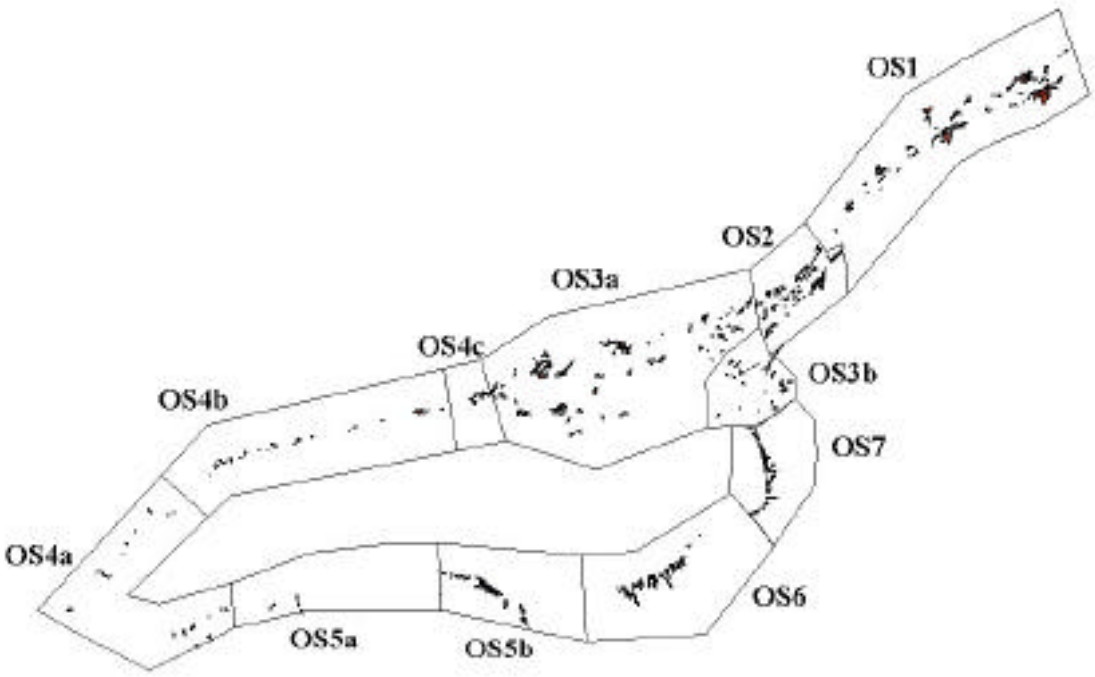


Figure 1. Overview map of Lake Ontario, showing links to 44 regional maps of coastal wetlands.

a)



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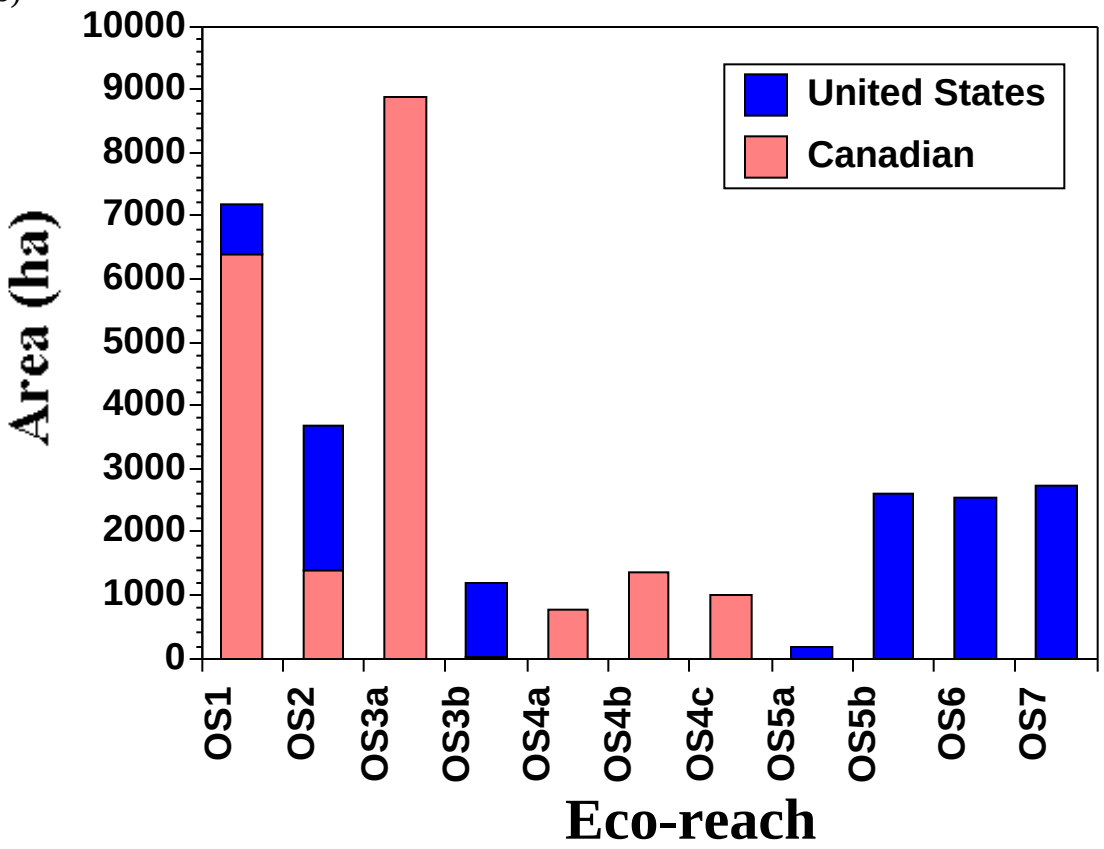

Figure **2a)** Boundaries of eco-reach for Lake Ontario (after Chow-Fraser and Albert 1999).
b) Summary of wetland areas sorted by ecoreach

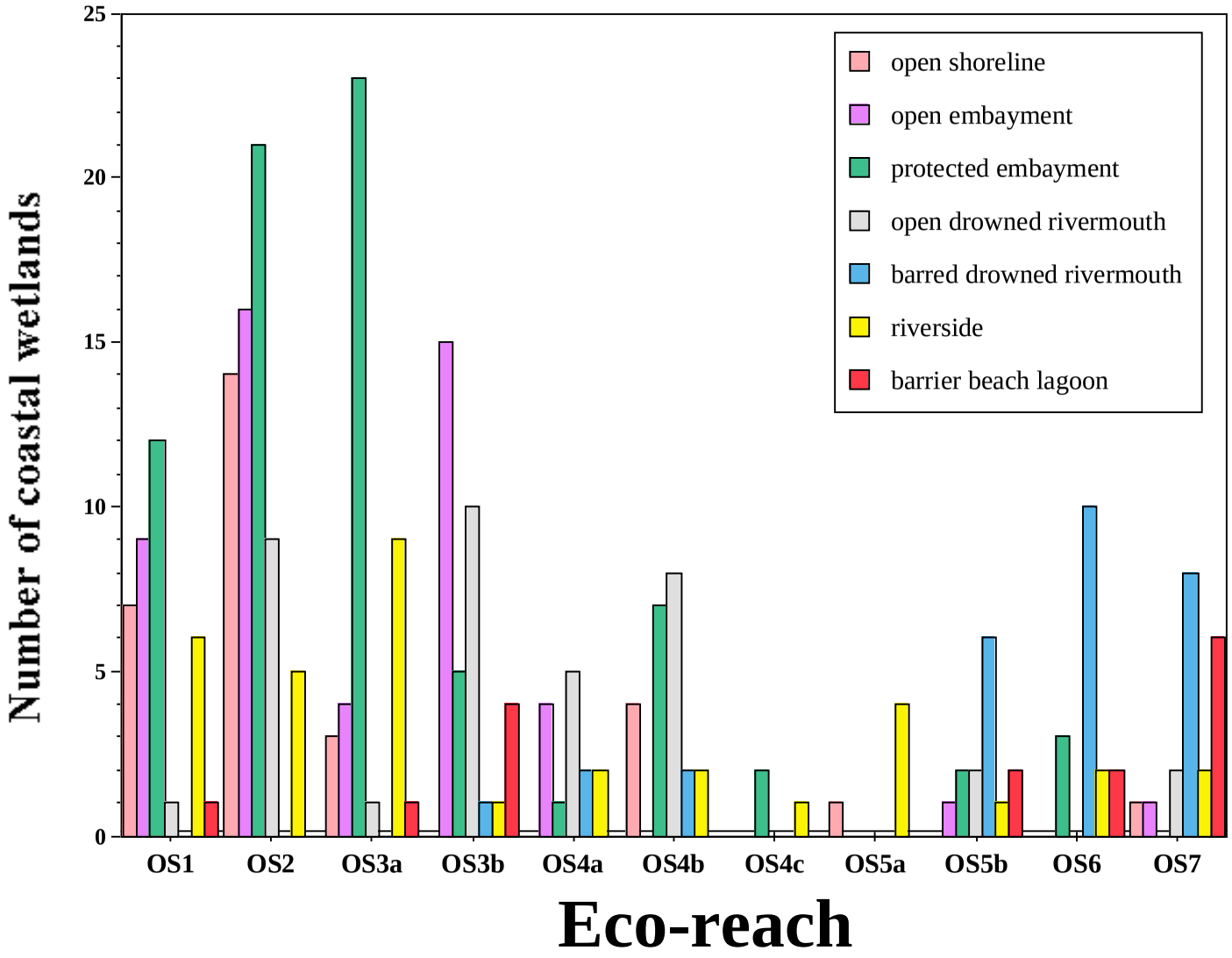

Figure 3. Number of coastal wetlands sorted by wetland type within each eco-reach.

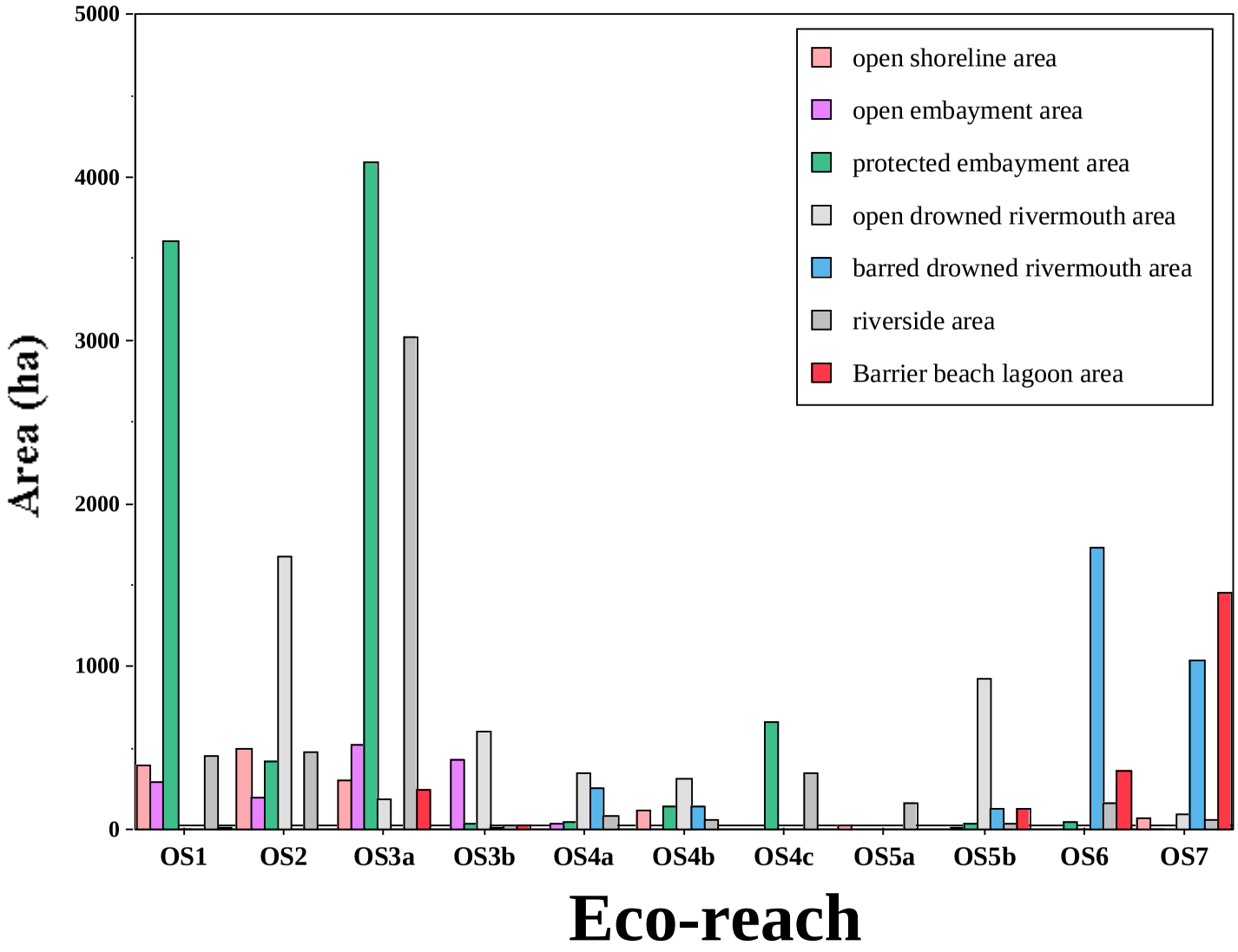

Figure 4. Area of coastal wetlands sorted by wetland type within each eco-reach.

List of Appendices

Appendix 1: Detailed description of interpretation of NWI landcover data.

Appendix 2: Regional maps corresponding to 44 links in Figure 1. (provided on CD-ROM)

Appendix 3: Individuals maps of 276 coastal wetlands of Lake Ontario. (provided on CD-ROM)

Appendix I

Detailed description of interpretation of NWI landcover data

This is the procedure we used to extract relevant landcover data from NWI shapefiles which were subsequently used to delineate the boundaries of coastal wetlands and/or wetland complexes:

First, we had to extract the most useful and relevant information in the shapefiles. The NWI wetland classification scheme is hierarchical(Smith 1991) and is applicable to all wetlands in the U.S. At the highest level is the "*System*" (Marine, Estuarine, Riverine, Lacustrine and Palustrine). For this project, we were able to exclude all palustrine and marine systems since all coastal wetlands are Estuarine, Riverine or Lacustrine. The next level, which is called "*Sub-system*", includes categories such as subtidal, intertidal, tidal, lower perennial, upper perennial, intermittent, unknown, limnetic and littoral, information that we could ignore for all intents and purposes. The third level was very important to this project because sub-systems were divided into "*Classes*" that were based on the type of substrate and vegetation in the landcover:

- **Rock bottom** (permanently flooded bedrock or large chunks of bedrock)
- **Unconsolidated bottom** (permanently flooded sand, gravel, mud or cobble substrate)
- **Unconsolidated shore** (periodically exposed sand, mud or gravel substrate)
- **Aquatic bed** (Floating or floating-leaved submerged aquatic vegetation (e.g. duckweed, pondweed and algae))
- **Reef** (substrate composed of livign organisms, e.g. mussels, oysters)
- **Rocky shore** (periodically exposed bedrock or large chunks of bedrock)
- **Open water** (Open water, no visible vegetation)
- **Streambed** (periodically flooded channel composed of gravel, sand or bedrock)
- **Emergent wetland** (herbaceous (non-woody) vegetation (e.g. grasses, sedges, rushes and flowering herbs)
- **Scrub/shrub wetland** (woody vegetation <20 ft tall (includes dwarf trees in bogs, shrubs and saplings)
- **Forested Wetland** (woody vegetation 20 feet or taller (trees))
- **Moss/lichen wetland** (dominant vegetative cover of mosses, lichens or both

There were other modifiers that described for instance, the salinity of the different marine sub-systems, but these were not relevant to the project. The only modifier that could have been applicable was "diked/impounded" had we been assembling a database for Lake Erie rather than Lake Ontario; hence, we did not include any modifiers.

We therefore created a new classification scheme that grouped all landcover units into the following units:

Figure 1. Key to landcover classes used in WIRE Net for U.S. wetlands.

We then excluded all landcover units that were NOT Estuarine, Riverine or Lacustrine. This produced a contiguous layer of landcover units along the shoreline of Lake Ontario and the St. Lawrence River. The next step was to join landcover units that belonged to the same wetland complex and name them. This was one of the most labour-intensive steps. To delineate wetlands, we first entered the geographic coordinates of wetland centroids from Herdendorf and Hartley (1980) into the GIS database (Arcview 3.2) and projected them onto the contiguous landcover layer. Maps were produced for each centroid (over 300), along with associated landcover units within reasonable proximity. From these maps, decisions were made regarding the boundaries of wetland complexes, based on information of wetland size and description from Herdendorf and Hartley (1980), and hydrologic information (names of creeks or rivers that flowed into wetlands). Then, finally, the landcover shapefiles were imported into ArcMap and polygons for each wetland complex were merged in GIS to create shapefiles for each wetland complex. Almost all of the names were inferred from the location of the centroids in Herdendorf and Hartley (1980); in three instances, landcover units suggested existence of a wetland even though there were no corresponding centroid, and these have been denoted as “Unidentified #1” to “Unidentified #3”.