



Hardened Shorelines

Formerly indicator #8131

Overall Assessment

Status: Undetermined

Trend: Undetermined

Rationale: An overall assessment is not possible as information allowing a direct comparison to previous hardened shoreline indicator status is only available for the Lake Ontario shoreline.

Lake-by-Lake Assessment

Lake Superior

Status: Undetermined

Trend: Undetermined

Rationale: Available information does not allow a direct comparison to previous hardened shoreline indicator status.

Lake Michigan

Status: Undetermined

Trend: Undetermined

Rationale: Available information does not allow a direct comparison to previous hardened shoreline indicator status.

Lake Huron

Status: Undetermined

Trend: Undetermined

Rationale: Available information does not allow a direct comparison to previous hardened shoreline indicator status.

Lake Erie

Status: Undetermined

Trend: Undetermined

Rationale: Available information does not allow a direct comparison to previous hardened shoreline indicator status.

Lake Ontario

Status: Poor

Trend: Deteriorating

Rationale: Updated (2001-2002) shoreline classification datasets for Lake Ontario indicate that approximately 63.0% of the shoreline has less than 40% hardening which is below the poor threshold of 70%. While the percent of shoreline in the “no protection” category was comparable to the previous SOLEC update (NOAA, 1997), reductions in the “minor protection” category were offset by increases in the “moderate protection” and “major protection” categories suggesting a potential trend towards increased overall shoreline hardening in some areas. There is uncertainty in the trend analysis due to variations in input datasets as discussed further below.

Purpose

- To assess the amount of shoreline altered by the construction of shore protections, such as sheet piling, rip rap and other erosion control shore protection structures.
- To infer the potential harm to aquatic-dependent life, water quality and natural processes from conditions created by shore protections.
- To be used as a pressure indicator under the Resource Use & Physical Stressor category under the SOLEC

indicator framework.

Ecosystem Objective

Impacts from hardened shorelines should not impair the physical, biological or chemical integrity of the Great Lakes as reflected in Annex 2 of the Great Lakes Water Quality Agreement – restoration and protection of beneficial uses.

Ecological Condition

Measure

The amount (kilometres/miles) of shoreline that has been hardened through construction of sheet piling, rip rap and other erosion control shore protection structures. Shoreline reaches are categorized using descriptions from the baseline shoreline classification dataset and include highly protected (70-100%), moderately protected (40-70%), minor protection (15-40%), no protection (< 15%), non-structural protection, and unclassified.

Note: measure does not include artificial coastal structures that extend out into the waters, such as jetties, groynes, breakwalls, piers, etc.

Endpoint

The reference values for basinwide and lakewide scales are as follows.

Good = >80% of the shoreline has minor to no protection (i.e. 0-40% hardened shoreline measure categories).

Fair = 70-80% of the shoreline has minor to no protection (i.e. 0-40% hardened shoreline measure categories).

Poor = < 70% of the shoreline has minor to no protection (i.e. 0-40% hardened shoreline measure categories).

Trend determination will be based on no net increase in the percent of shoreline in the highly protected and moderately protected categories. The defined endpoint is intended to support an assessment of relative change over time and represents an initial suggestion for establishing preferred conditions. However, further discussion and refinement of the endpoint categories is required to reflect improved understanding of shoreline hardening and ecosystem impacts. The Status Justification section below outlines some of the challenges with attempting to define reference conditions for hardened shorelines.

Status Justification

There is limited documentation on specific shoreline hardening objectives, particularly at the basinwide and lakewide scales. The proposed end-point values for a hardened shoreline status assessment provide a descriptive point of reference using the baseline SOLEC estimates of the extent and intensity of shoreline hardening. Various environmental services can be impacted by shoreline hardening including changes or reductions in aquatic habitat, alterations in sediment transport, and changes in nearshore groundwater-lake interactions (see Province of Ontario, 2001). There are a variety of challenges in defining appropriate end-point values regarding shoreline hardening. In particular, a refined end-point assessment should reflect the differing quality and quantity of environmental services being provided (or not provided) by differing shoreline locations (e.g. pollution filtration, fish habitat, etc.) and weight the necessity and amount of the shoreline services required to achieve established ecosystem goals relative to the extent and impact of various shoreline hardening activities. However, the ecological services provided by natural shorelines and the impacts of hardened shorelines are difficult to measure as they often relate to many complex, long-term, and interdependent ecological processes (such as pollution filtration and sediment transport), in addition to more immediate and observable effects such as habitat and habitat loss. There are also variations in the extent to which certain types of shoreline hardening activities actually impact various ecological services based on the age, quality, and design characteristics of the shoreline structures. The current end-point categories only provide a general estimate of the extent and intensity of shoreline hardening and do not reflect an assessment of the relative sensi-

tivity to shoreline hardening on each lake. The selected endpoints account for the fact that some shoreline hardening already exists on the Great Lakes and is likely to be maintained into the future. The trend assessment captures the relative change in the percent of shoreline with >40% hardening.

For the purpose of this report, an overall undetermined reference value has been selected for the basinwide assessment due to the lack of a standardized dataset on many of the lakes that can be directly compared to the baseline conditions established for the SOLEC hardened shoreline indicator. Where updated datasets do exist, they tend to be limited in geographic scope (i.e. they do not cover a full lake basin) or there are issues in matching the existing hardened shoreline indicator categories. The baseline conditions, as represented in the 2009 SOLEC hardened shoreline indicator report, are provided in Table 1 for reference.

Lake Ontario does have a full dataset that can be compared with the baseline conditions identified in previous SOLEC reporting based on NOAA 1997 data. The updated dataset was developed in 2001 and 2002 to support the International Joint Commission's (IJC's) International Lake Ontario – St. Lawrence River Regulation Study. A similar methodology was utilized to classify the full U.S. and Canadian Lake Ontario shoreline based on the type and extent of shoreline hardening (see Stewart, 2002) with the results summarized in the Flood and Erosion Prediction System (FEPS) database (see Baird, 2005). The dataset was used to model water level impacts on shoreline structure life-span and as a result, there are small gaps where direct comparisons to the baseline data set are difficult. In particular, there were some instances where the percent of very low quality shoreline structures was not identified as they were not included in the water level impact modeling. In the case of the SOLEC comparison, these areas were identified within the unclassified category, even though there was likely some shoreline hardening occurring. It should also be noted that the updated Lake Ontario classification dataset utilized a higher resolution shoreline delineation than was used in the baseline conditions identified in previous SOLEC reporting. As a result, the classified shoreline extent is greater for the updated dataset. Finally, the updated dataset estimates the percent hardened shoreline using standard 1 km reaches along the full shoreline whereas the baseline dataset categorized reaches of variable (and generally greater) length.

Table 2 provides the length of shoreline in the baseline and updated (2001-2002) datasets along with the percent of shoreline within the various percent hardening categories for Lake Ontario. The percent of shoreline within the moderately (40 to 70% hardened) and major (>70% hardened) categories increased by 9.8 and 1.7 %, respectively while the percent of the shoreline within the minor (15 to 40% hardened) and no protection categories (<15% hardened) was reduced by 12.8%. The extent of shoreline in the minor and low protection categories is below the poor threshold established in the endpoint discussion and resulted in the poor status classification. The results suggest that there has been an increase in the amount of shoreline hardening since the baseline dataset was established in the late 1980s and a deteriorating trend was identified. However, since the overall length of categorized shoreline increased due to the refined shoreline delineation, there is uncertainty as to whether the identified change represents a true increase or a difference in dataset methodologies. Figure 1 provides maps of both the baseline Lake Ontario shoreline hardening categorization and the updated Lake Ontario data.

Linkages

Hardening shorelines can result in the loss of habitat, further erosion of unprotected properties adjacent to the structure, water quality degradation and the interruption of natural shoreline processes including reduced downdrift sediment transport.

Management Challenges/Opportunities

Shoreline hardening is generally implemented to stabilize shorelines and/or protect existing or planned infrastructure from erosion and flooding. Past high water conditions resulted in increased demand for shoreline hardening

activities, although projects were often undertaken on a case-by-case basis without considering potential ecological consequences or impacts to adjacent property owners. The ecological impacts are not only difficult to quantify as a monetary equivalent, but difficult to perceive without an understanding of sediment transport along the lakeshores. The importance of the ecological process of sediment transport needs to be better understood as an incentive to reduce new shoreline hardening. An educated public is critical to ensuring wise decisions about the stewardship of the Great Lakes basin ecosystem, and better platforms for getting understandable information to the public are needed.

Opportunities exist to identify particular shoreline functions that need to be maintained and where shoreline hardening is deemed necessary, to implement structures that are compatible with the ongoing ecosystem and sediment transport functions. There are also opportunities to modify existing shoreline hardening features to enhance identified ecosystem functions or even to remove certain shoreline hardening features altogether where other methods exist to reduce vulnerabilities (e.g. moving vulnerable infrastructure away from eroding shorelines).

Comments from the author(s)

There is uncertainty in undertaking direct comparison between the original hardened shorelines dataset previously reported for SOLEC and the more recent Lake Ontario dataset. In particular, the categorization is based on shoreline reaches which are defined differently in both datasets. The original dataset uses shoreline reaches of variable length whereas the more recent Lake Ontario data uses fixed 1 km shoreline reaches. It is possible that the large increase in highly hardened shorelines between the two datasets reflects a general reduction in reach length and not an overall increase in shoreline hardening. In addition, the overall shoreline lengths vary between the two datasets due to the base shoreline mapping used in the classifications. The recent Lake Ontario dataset uses a higher resolution shoreline delineation and includes certain features such as embayments that may not have been included in the original medium resolution shoreline delineation from the baseline hardened shoreline dataset. Since the indicator is based on a relative difference in the percent of shoreline within various categories, it is still possible to make some comparisons. However, it should be recognized that direct comparisons between data sets will be highly uncertain without using a common baseline shoreline delineation and comparable reach lengths. Finally, the baseline dataset is not clear on the transition between percent protected categories. For example, a shoreline reach that is 70% hardened could fall within either the 40% to 70% category or the 70% to 100% category. More explicit transitions were used for the categorization of the updated dataset.

There are opportunities for future updates to the hardened shorelines SOLEC indicator. Updated high resolution aerial imagery exists for much of the Great Lakes shoreline and oblique imagery has been recently collected or is planned to be collected for much of the U.S shoreline of the Great Lakes. With the information, it will be possible to use existing reach delineations and update the percent of shoreline hardening. Any efforts to update existing datasets should ensure that classification methodologies are similar to past efforts (e.g. as used for the updated Lake Ontario shoreline classification) and standardized reach delineations are utilized.

Assessing Data Quality

Data Characteristics	Strongly Agree	Agree	Neutral or Unknown	Disagree	Strongly Disagree	Not Applicable
1. Data are documented, validated, or quality-assured by a recognized agency or organization		x				
2. Data are traceable to original sources		x				

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3. The source of the data is a known, reliable and respected generator of data		x				
4. Geographic coverage and scale of data are appropriate to the Great Lakes basin			x			
5. Data obtained from sources within the U.S. are comparable to those from Canada		x				
6. Uncertainty and variability in the data are documented and within acceptable limits for this indicator report			x			
<p>Clarifying Notes:</p> <ol style="list-style-type: none"> 1. There is documentation prepared as part of the IJCs International Lake Ontario – St. Lawrence River Study (see Stewart, 2002). The classification itself was undertaken by private contractors with considerable experience in shoreline classification procedures. However, there is no formal validation methodology for undertaking this type of shoreline classification 2. The data can be traced to original sources 3. The classification itself was undertaken by private contractors with considerable experience in shoreline classification procedures 4. The geographic scale for the updated information only covers Lake Ontario and cannot be used for Great Lakes Basin wide assessments 5. The procedure for identifying hardened shorelines was applied consistently on both the Canadian and U.S. shorelines of Lake Ontario. However, the identification and interpretation of hardened shorelines was influenced by the imagery and input datasets which varied around the shoreline in terms of age and resolution (see Stewart, 2002). The specific age and quality of input imagery used for individual shoreline reaches are not identified. 6. The identification and interpretation of hardened shorelines was influenced by the imagery and input datasets which varied around the shoreline in terms of age and resolution. As mentioned previously, the variation in reach length and detail of shoreline delineation between the baseline dataset and the updated Lake Ontario data result in uncertainty in the overall status and trends analysis regarding hardened shorelines 						

Acknowledgments

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Information Sources

Baird. 2005. *Final Flood and Erosion Prediction System Database (MS Access Database)*. Prepared for the Coastal Zone Technical Working Group of the International Joint Commissions International Lake Ontario – St. Lawrence River Study.

National Oceanic and Atmospheric Administration (NOAA). 1997. *Great Lakes and St. Lawrence River Medium Resolution Vector Shoreline Data*. (GIS dataset)

Province of Ontario. 2001. *Understanding Natural Hazards*. Ministry of Natural Resources. Queen's Printer for Ontario.

Stewart, C.J. 2002. *Task Summary Report: A Revised Geomorphic, Shore Protection, and Nearshore Classification of the Canadian and United States Shoreline of Lake Ontario and the St. Lawrence River*. Prepared for the Coastal Zone Technical Working Group of the International Joint Commissions International Lake Ontario – St. Lawrence

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River Study.

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Source: National Oceanic and Atmospheric Administration (1997)

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Source: Baseline SOLEC data from National Oceanic and Atmospheric Administration (1997) and updated Lake Ontario data from Stewart (2002) and Baird (2005)

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Figure 1. Maps of baseline SOLEC hardened shoreline classification and updated (2001-2002) hardened shoreline classification for Lake Ontario

Source: Baseline SOLEC data from National Oceanic and Atmospheric Administration (1997) and updated Lake Ontario data from Stewart (2002) and Baird (2005)

Last Updated

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Lake/ Connecting Channel	Heavily Protected (%) (>70% protected)	Moderately Protected (%) (40-70% protected)	Minor Protection (%) (15-40% protected)	No Protection (%) (<15% protected)	Non- structural Protection (%)	Unclassified (%)	Total Shoreline (km)
Lake Superior	3.1	1.1	3	89.4	0.03	3.4	5080
St. Marys River	2.9	1.6	7.5	81.3	1.6	5.1	707
Lake Michigan	8.6	2.9	30.3	57.5	0.1	0.5	2713
Lake Huron	1.5	1.0	4.5	91.6	1.1	0.3	6366
St. Clair River	69.3	24.9	2.1	3.6	0.0	0.0	100
Lake St. Clair	11.3	25.8	11.8	50.7	0.2	0.1	629
Detroit River	47.2	22.6	8.0	22.2	0.0	0.0	244
Lake Erie	20.4	11.3	16.9	49.1	1.9	0.4	1608
Niagara River	44.3	8.8	16.7	29.3	0.0	0.9	184
Lake Ontario	10.2	6.3	18.6	57.2	0.0	6.2	1772
St. Lawrence River	12.6	9.3	17.2	54.7	0.0	6.2	2571

Table 1. Baseline SOLEC hardened shoreline classification used for 2012 assessment based on information provided in 2009 SOLEC indicator report

Source: National Oceanic and Atmospheric Administration (1997)

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	Baseline SOLEC Classification	Updated Lake Ontario Classification
Length of Shoreline Categorized (km)	1772.0	2444.3
1. Heavily Protected (%)(>70% protected)	10.2	20.0
2. Moderately Protected (%) (40-70% protected)	6.3	8.0
3. Minor Protection (%) (15-40% protected)	18.6	5.7
4. No Protection (%) (<15% protected)	57.2	57.3
5. Non-structural Protection (%)	0.0	0.1
6. Unclassified (%)	6.2	8.8

Table 2. Comparison of baseline SOLEC hardened shoreline classification and updated (2001-2002) hardened shoreline classification for Lake Ontario

Source: Baseline SOLEC data from National Oceanic and Atmospheric Administration (1997) and updated Lake Ontario data from Stewart (2002) and Baird (2005)

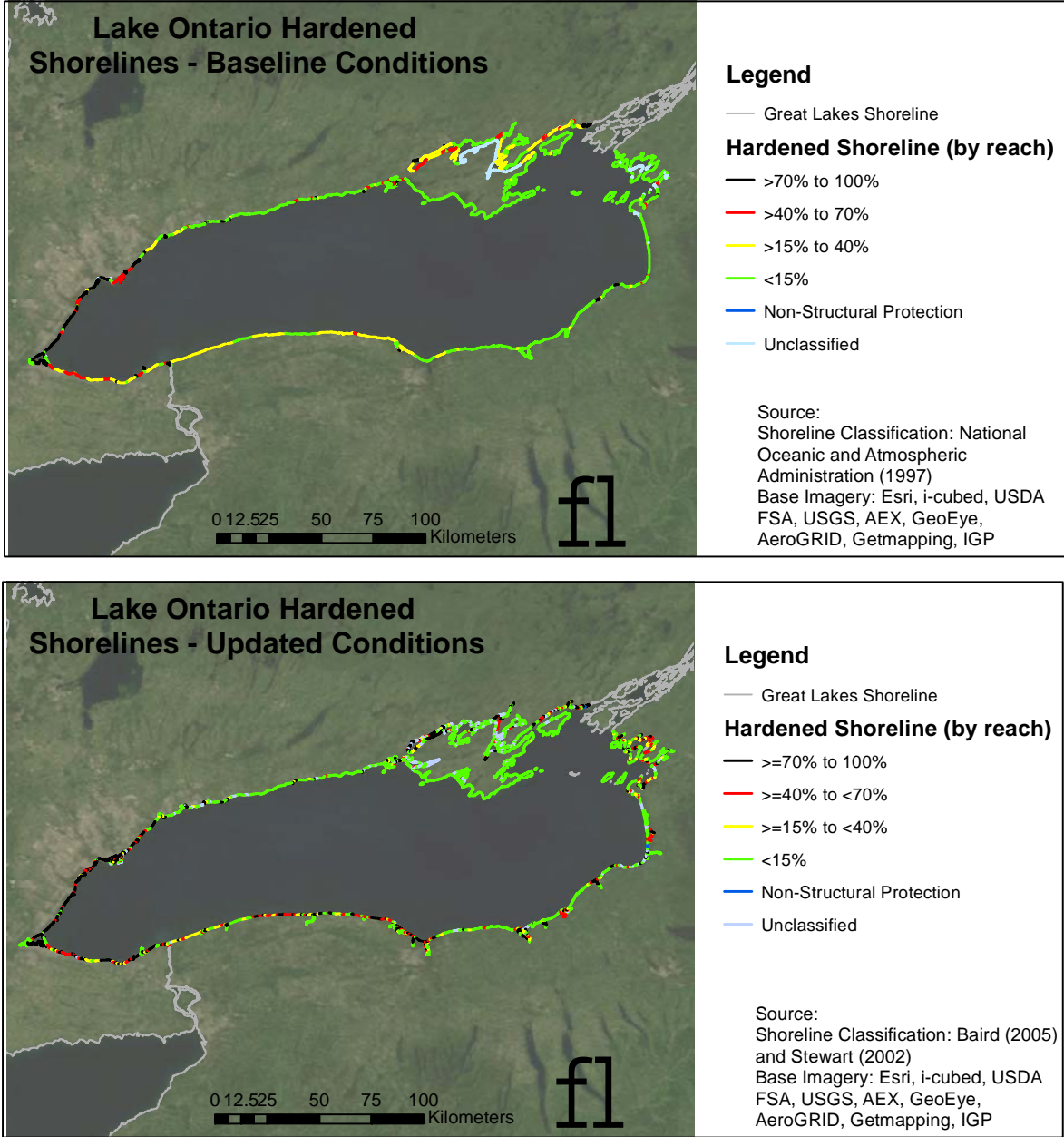


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