# Status and Extent of Aquatic Protected Areas in the Great Lakes

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## Introduction

The Laurentian Great Lakes are immensely important to the environmental, economic, and social well-being of both Canada and the United States (US). They form the largest surface freshwater system in the world. At over 30,000 km long, their mainland and island coastline is comparable in length to that of the contiguous US marine coastline (Government of Canada and USEPA 1995; Gronewold et al. 2013). With thousands of native species, including many endemics, the lakes are rich in biodiversity (Pearsall 2013). However, over the last century the Great Lakes have experienced profound human-caused changes, including those associated with land use changes, contaminants, invasive species, climate change, over-fishing, and habitat loss (e.g., Bunnell et al. 2014; Smith et al. 2015). It is a challenging context in terms of conservation, especially within protected areas established to safeguard species and their habitat.

According to the International Union for Conservation of Nature (IUCN), a *protected area* is "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008). Depending on the management goals, protected areas can span the spectrum of IUCN categories from highly protected no-take reserves to multiple-use areas (Table 1). The potential values and benefits of protected areas are well established, including conserving biodiversity; protecting ecosystem structures and functions; being a focal point and context for public engagement, education, and good governance; supporting nature-based recreation and tourism; acting as a control or reference site for scientific research; providing a positive spill-over effect for fisheries; and helping to mitigate and adapt to climate change (e.g., Lemieux et al. 2010; Burt et al. 2014).

Given their size and importance, the Great Lakes are often included in the designs of marine protected area systems of both nations (Government of Canada 2011; NMPAC 2015).

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| Designation | Brief Definition | Great Lakes Examples |
|---|---|---|
| IUCN Ia: Strict nature reserve | Protects biodiversity and possibly geological/geomorphical features, where human visitation, use, and impacts are strictly controlled and limited. | Nature reserves, migratory bird sanctuaries (e.g., Nature Conservancy of Canada Baptist Harbour Reserve, Mississagi Delta Provincial Nature Reserve). |
| IUCN Ib: Wilderness area | Usually large unmodified or slightly modified area managed to preserve its natural condition. | National wilderness areas, wilderness-class provincial parks (e.g., Isle Royale National Park). |
| IUCN II: National park | Protects large-scale ecological processes and species, and provides a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational, and visitor opportunities. | National parks, conservation reserves, provincial parks, state parks (e.g., French River Provincial Park, Point Pelee National Park). |
| IUCN III: Natural monument or feature | Protects a specific natural monument (e.g., landform, seamount, cave, ancient grove). Generally a small area, highly valued by visitors. | Provincial parks (e.g., Inverhuron, Agate Island Wilderness Area, Michipicoten Provincial Park). |
| IUCN IV: Habitat/species management area | Protects and manages a particular species or habitat. | National wildlife refuges, national wildlife areas, state nature preserves (e.g., Detroit River International Wildlife Refuge, Nayanquing Point Wildlife Area). |
| IUCN V: Protected landscape/ seascape | The interaction of people and nature produces an area of distinct character with significant, ecological, biological, cultural and scenic value. Safeguarding this interaction is vital to protection and sustaining the area. | US forest reserves, national lakeshores, conservation areas, state parks (e.g., Sleeping Bear Dunes National Lakeshore, Thunder Bay National Marine Sanctuary, Apostle Islands National Lakeshore). |
| IUCN VI: Protected area with sustainable use of natural resources | Conserves ecosystems and habitats together with associated cultural values and traditional natural resource management systems. Use of resources compatible with nature conservation. | National marine conservation areas, state forest areas (e.g., Fathom Five National Marine Park, Superior National Forest). |
| Other: Fish refuge | Area closed to the harvest of all or some species of fish (e.g., walleye or lake trout), usually by fishery regulation, lacking the permanence of an act. May serve as an effective area-based conservation measure. | Fish sanctuaries (e.g., Six Fathom Bank–Yankee Reef, Drummond Island, Parry Sound), fisheries research areas. |
| Other: *De facto* protected area | Designated for other purposes, such as to manage vessel traffic, they accomplish goals similar to traditional protected areas. | Security zones, regulated navigation areas, danger zones (e.g., Erie Ordnance Depot, Lake Huron South Channel, Volk Field). |
| Other: Cultural heritage sites | Manages and protects submerged cultural resources. An area of enhanced appreciation and understanding that may or may not influence natural heritage conservation. | State bottomland preserves (e.g., Alger Great Lakes State Bottomland Preserve, Manitou Passage Great Lakes State Bottomland Preserve). |

**Table 1.** Protected area designations. IUCN categories summarized from Dudley (2008) and de facto areas as recognized by NOAA (2010).

For instance, Canada's national marine conservation area system and the US's national marine sanctuary system both include freshwater protected areas within the Great Lakes (Mercier and Mondor 1995; NOAA 2009). Efforts to plan, establish, and more effectively manage freshwater protected areas are broadly supported by the World Summit on Sustainable Development (United Nations 2002), the 2014 World Parks Congress (IUCN 2014), and other high-level international meetings (e.g., Saunders et al. 2002; Fitzsimons and Robertson 2005; Abell et al. 2007; Nel et al. 2009; Strayer and Dudgeon 2010). The Convention on Biological Diversity's (CBD's) Aichi Target 11 specifically commits Canada to the conservation of at least 17% of its terrestrial lands and inland waters by 2020 "through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures" (SCBD 2010). (Of note, the US is one of just two countries—the other is the Vatican State—that have not ratified or otherwise accepted the treaty; SCBD 2017.)

Although a Great Lakes-wide protected area strategy does not exist, there are examples of binational mechanisms that could support such a strategy. For instance, the Great Lakes Water Quality Agreement (GLWQA), as renewed in 2012, facilitates cooperative actions to restore and protect the Great Lakes, and includes a species- and habitat-specific annex (Governments of the United States and Canada 2012). The Great Lakes Fishery Commission coordinates fishery research and cooperative fisheries management, and has examined the use of protected areas as a fisheries management tool (Hedges et al. 2011). Sub-nationally, all eight states bordering the Great Lakes, the province of Ontario, and regional and local governments have variously established protected areas. Dedicated nongovernmental organizations (NGOs) and private interests have also actively acquired lands for conservation and advocated for better protection.

At a quick glance there appears to be hundreds of protected areas managed by a multitude of authorities, often working independently of each other. To advance conservation efforts and network thinking, we developed a database of coastal and in-lake protected areas for the Great Lakes.

## Methods

The geospatial database for coastal and in-lake protected areas was built on a 1:24,000 scale Great Lakes GIS map layer (USGS 2014b). This high-resolution layer included the mainland and island coasts for each lake, excluding the St. Marys, Niagara, and St. Lawrence rivers. Available protected area databases (NOAA 2010; GLAHF 2014; USGS 2014a; CCEA 2015; IUCN and UNEP–WCMC 2015) were accessed, cross-referenced, and compiled into a single geodatabase layer. Government agencies responsible for parks and protected areas, and NGO conservation organizations, were also queried for additional geospatial data or information. The imported data were assessed for errors in spatial and attribute quality, and scale inconsistencies and, where necessary, geometries were corrected to ensure that boundaries were accurate, properly intersected, or coincided with the shoreline layer. In cases where digital data were absent (e.g., boundaries described in literature through coordinate references), feature polygons were digitized for individual protected areas. The attribute table for the geodatabase included the site name, management authority, designation type, IUCN category, and geometry (e.g., length or area) for each feature. If an IUCN category was not already assigned to a protected area in the imported data or by the agency source, it was designated as "not reported." A feature was designated "no protected area" if it did not meet the IUCN definition (Dudley 2008). Also included were areas not designated as protected areas, but which may provide partial protection or serve as "other effective area-based conservation measures" (refer to SCBD 2010), including fish refuges, cultural heritage sites, and de facto sites (see Table 1). Although inland areas will affect the health and ecological integrity of the lakes, the scale of focus for this analysis was coastal lands and the Great Lakes proper.

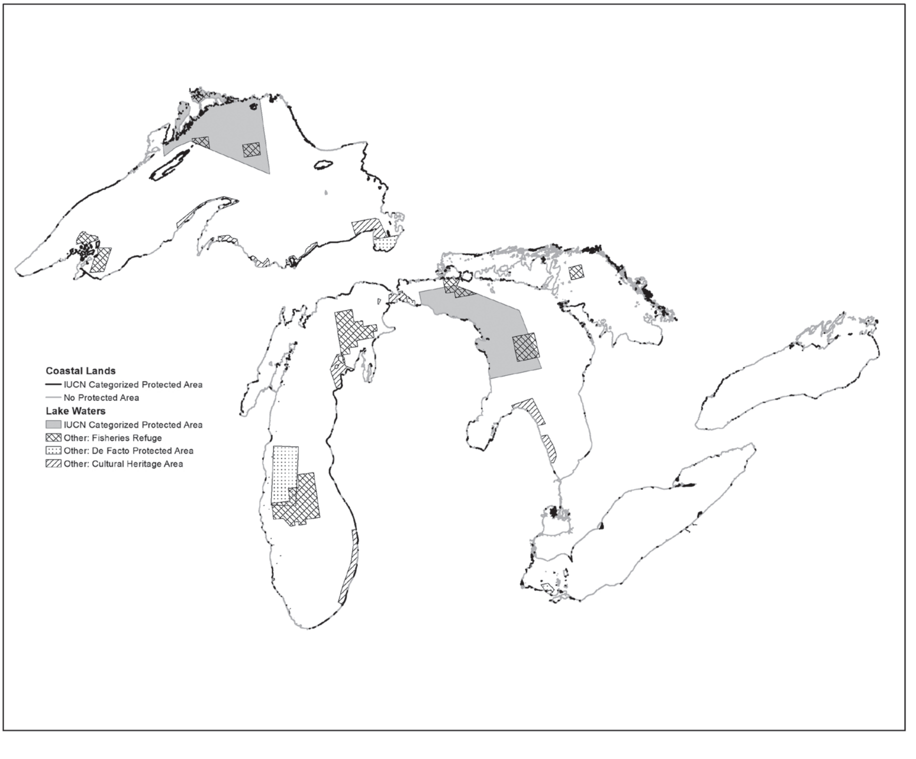
The extent of coastal protection was measured as the length of shoreland protected at the water's edge; the extent of in-lake protection, as the area within a protected area. The extent of protected and no-protected coast was calculated using the ESRI ArcGIS Desktop 10.3 "intersect" command using the 1:24,000 shoreline feature-class and comprehensive protected areas feature-class as inputs. The output polyline feature-class was segmented to represent lengths of shoreline coincident with areas protected and not protected. The length of each protected and no-protected coast segment was calculated using the "calculate geometry" function within ESRI ArcGIS and output with meters as the units using the North America Lambert Conformal Conic projection.

## Results

Of the databases that were accessed, none provided complete and comprehensive representation of protected areas. Refinement of feature geometries (e.g., snapping and clipping) was often required to accommodate the higher-resolution scale of this project. There were very few examples of contiguous land–lake protected areas. The shoreline, as defined by the ordinary high-water mark or water's edge, generally served as the boundary for terrestrial protected areas along the coast.

***Great Lakes coastal protected areas.*** Over 370 protected areas representing IUCN categories I–VI were found to protect 27% of the length of the Great Lakes coast (Figure 1; Table 2). The largest category was "IUCN II National Park," with 68 areas cumulatively representing 11% of the coast; the longest individual area was French River Provincial Park (979 km of Lake Huron). The most commonly assigned category was "IUCN V Protected Landscape" with 156 areas representing 4% of the coast length. Of the 558 km of coast protected within 110 "IUCN Ia Strict Nature Reserves," the majority of areas (n=74; 313 km) were established by NGOs (e.g., The Nature Conservancy, Nature Conservancy of Canada). The "IUCN Not Reported" category was assigned to 232 areas, representing 1.4% of the coast. Of the coastline consisting of "No Protected Area" (i.e., distance between protected areas), 62 coastal segments were >50 km in length, including one segment in Lake Ontario

**Figure 1.** Great Lakes coastal and in-lake protected areas.



| Designation | # | Lake Superior US | Lake Superior Can | Lake Huron US | Lake Huron Can | Lake Michigan | Lake St. Clair US | Lake St. Clair Can | Lake Erie US | Lake Erie Can | Lake Ontario US | Lake Ontario Can | Great Lakes Total | Great Lakes % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IUCN Ia | 110 | 24 | 126 | 20 | 213 | 21 | | | 14 | 116 | | 25 | 558 | 1.9 |
| IUCN Ib | 7 | 637 | | 15 | 57 | 6 | | | 2 | | | | 717 | 2.4 |
| IUCN II | 68 | 13 | 996 | | 1,972 | | | | | 144 | | 66 | 3,191 | 10.7 |
| IUCN III | 3 | | 8 | | 4 | | | | | | | | 12 | 0.04 |
| IUCN IV | 47 | 37 | | 105 | | 282 | 269 | 7 | 125 | 2 | | | 827 | 2.8 |
| IUCN V | 156 | 620 | 10 | 107 | 18 | 344 | 17 | | 92 | 2 | 35 | 9 | 1,255 | 4.2 |
| IUCN VI | 14 | 142 | 444 | 58 | | 54 | | | | 450 | | | 1,147 | 3.8 |
| Not Reported | 232 | 43 | 22 | 10 | 65 | 13 | 70 | | 69 | 0.4 | 51 | 72 | 416 | 1.4 |
| No Protected Area | — | 1,076 | 1,863 | 1,542 | 10,269 | 1,936 | 680 | 863 | 876 | 994 | 518 | 1,222 | 21,838 | 72.9 |
| Total Area | — | 2,592 | 3,469 | 1,857 | 12,598 | 2,656 | 1,036 | 870 | 1,178 | 1,708 | 604 | 1,394 | 29,961 | 100 |

**Table 2.** Coast length of Great Lakes protected areas. Terrestrially based coastal protected areas as measured in km along the shoreline at 1:24,000 scale. The column marked "#" represents the sum of individual sites (e.g., Hiawatha National Forest is reported as one site, although it has 56 different coastal sections).

exceeding 400 km, and five segments in Lake Huron and two segments in Lake Superior that exceeded 150 km in length.

***In-lake protected areas.*** Five protected areas representing three IUCN categories protected 8.7% of the Great Lakes proper (Figure 1; Table 3). Similar to the coast, the in-lake waters of the upper Great Lakes (Lake Superior, Lake Michigan, and Lake Huron) contained greater coverage of protected areas than the lower Great Lakes (Lake Erie and Lake Ontario), with Lake Ontario having no in-lake IUCN category of protected area. The largest category represented was "IUCN V Protected Seascape" at 4.4% of the Great Lakes assigned to two areas, with Thunder Bay National Marine Sanctuary (TBNMS) in Lake Huron being the largest (11,060 $km^2$). The "IUCN VI Protected with Sustainable Use" category was second largest, protecting 4.3% of the Great Lakes in two areas, with Lake Superior National Marine Conservation Area being the largest (10,840 $km^2$). A total of 121 protected areas not assigned an IUCN class were identified, covering 8.3% of the lakes proper. These areas included: 12 fish refuges, mostly lake trout (*Salvelinus namaycush*) or walleye (*Sander vitreus*) spawning sanctuary areas, that accounted for 4% of the Great Lakes area, two of which are partially located within TBNMS; 47 cultural heritage areas, including shipwreck sites and bottomland preserves that accounted for 2% of the Great Lakes area; and *de facto* areas (see Table 1 for examples) that accounted for 2.3% of the Great Lakes area.

## Discussion

***IUCN classification.*** With over 100 management authorities and 40 general designations (e.g., state park, migratory bird sanctuary, conservation easement, national marine sanctuary) within the Great Lakes, assessing the status and extent of protection would have been difficult without the consistency and standardization provided by the IUCN protected area classification system (Dudley 2008). It is an important mechanism to assist in communication and cooperation among the various protected area agencies and interests (e.g., Gray et al. 2009). For this project, we utilized the assigned IUCN category found within the accessed data. However, we noted areas that have not been classified and may in fact be protected areas

| Designation | # | Lake Superior US | Lake Superior Can | Lake Huron US | Lake Huron Can | Lake Michigan | Lake St. Clair US | Lake St. Clair Can | Lake Erie US | Lake Erie Can | Lake Ontario US | Lake Ontario Can | Great Lakes Total | Great Lakes % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IUCN IV | 1 | | | | | | | | 2 | | | | 2 | 0.0 |
| IUCN V | 2 | 11 | | 11,060 | | | | | | | | | 11,072 | 4.4 |
| IUCN VI | 2 | | 10,840 | | 114 | | | | | | | | 10,953 | 4.3 |
| Other: Fish Refuge | 12 | 1,099 | | 2,089 | 313 | 5,508 | | | 0.5 | | | | 10,174 | 4.0 |
| Other: De Facto | 62 | 1,085 | | 1,179 | | 3,273 | | | 206 | | 3 | | 5,747 | 2.3 |
| Other: Cultural | 47 | 2,292 | | 1,160 | | 1,701 | | | | | | | 5,154 | 2.0 |
| No Protected Area | — | 49,761 | 18,186 | 8,798 | 36,611 | 50,287 | 555 | 832 | 13,581 | 13,517 | 9,404 | 10,317 | 211,850 | 84 |
| Total Area | — | 54,248 | 29,026 | 24,286 | 37,038 | 60,769 | 555 | 832 | 13,790 | 13,517 | 9,407 | 10,317 | 254,952 | 100 |

**Table 3.** Area of in-lake Great Lakes protected areas. The column marked "#" represents the sum of individual sites; all other values represent area in sq km.

(e.g., many of Ontario's conservation areas, NGO-run nature preserves), plus protected areas with multiple zones that were only assigned a single category, and partially protected areas (e.g., fish refuges, municipal lands) that are important for conservation, but do not fit the IUCN assessment framework. Given these specialized contexts, there is merit in developing guidance for the application of IUCN categories (similar to inland water protected areas, as discussed in Dudley 2008) and "other effective area-based conservation measures" for the Great Lakes.

Such guidance could also assist in evaluating the performance and management effectiveness of a protected area to meet its IUCN designation and demonstrate how it will "achieve the long-term conservation of nature." An assessment exercise could help to integrate and align fisheries and protected area management efforts to restore, protect and, where permitted, ensure sustainable use (e.g., to facilitate recovery of deepwater fishes; Zimmerman et al. 2009).

***Do Great Lakes protected areas work?*** Although poorly studied and far fewer in existence, freshwater aquatic protected areas have demonstrated conservation benefits similar to those of their marine counterparts in terms of species and habitat protection (e.g., Hedges et al. 2010). Key to such effectiveness, as evident from marine protected areas in other regions of the world, is the need to include areas of full protection—"no-take" zones (Edgar et al. 2014). The effectiveness of individual lake trout refuges (Swanson and Swedberg 1980; Bronte et al. 1995, 2007; Edsall et al. 1995; Hansen et al. 1995; Holey et al. 1995; Schram et al. 1995; Madenjian and DeSorcie 1999; Reid et al. 2001; Desorcie and Bowen 2003; Madenjian et al. 2004; Reid et al. 2004; Pollock et al. 2007; Madenjian et al. 2008) and a smallmouth bass (*Micropterus dolomieui*) refuge (Sztramko 1985) in the Great Lakes has been examined. All of the evaluations concluded that the refuges were having a positive effect on the target population or species, regardless of the metric used in the assessment (e.g. number of spawning adults, body size, local abundance) (Hedges et al. 2011). However, most aquatic protected areas in the Great Lakes do not have full protection areas for fishes, and fisheries are generally managed independently of the protected area authority. As has been mentioned, better integration of fisheries management areas and protected areas for a common conservation goal is clearly needed.

As identified by Hedges et al. (2011), in the Great Lakes there is considerable variation in protected area size, type of protection afforded, and level of enforcement, among other factors. These authors concluded that the existing matrix of protected areas provides ample opportunities to examine the relative effectiveness of different protection measures, but such analyses are scarce. To evaluate effectiveness, surveys are required that quantify current distributions of species, habitats, and ecosystem threats. Research gaps and associated research priorities related to the design, establishment, effectiveness, and current protection needs are found in Table 4.

***Network thinking.*** A *protected area network* is "a collection of individual protected areas that operates cooperatively and synergistically, at various spatial scales, and with a range of protection levels, in order to fulfill ecological aims more effectively and comprehensively than individual sites could alone" (IUCN–WCPA 2008). As demonstrated in the design features of successful networks, there needs to be the incorporation of representation, replication, and connectivity of ecosystem structures and functions; good governance; and an ability to mitigate human impacts (IUCN–WCPA 2008; Gleason et al. 2013; Burt et al. 2014). To be functional, networks are organized around different tasks, including those focused on: (1) establishment and planning; (2) management and monitoring; and (3) communication and awareness. Although there is no single, coordinated Great Lakes-wide protected area strategy or network, there are inspired examples from specific regions and initiatives, such as the coordinating role of the US Marine Protected Areas Center (http://marineprotectedareas.noaa.gov), the collaborative partnership of the Upper Midwest and Great Lakes Landscape Conservation Cooperative (https://greatlakeslcc.org/), the regional efforts of the Georgian Bay Biosphere Reserve (http://www.gbbr.ca), and the binational cooperation demonstrated by the Detroit River International Wildlife Refuge (https://www.fws.gov/refuge/detroit_river).

**Table 4.** Research gaps and opportunities, revised from Hedges et al. (2011).

**1. Design factors:**

a. How effective is habitat protection alone?
b. Which species require networks? How are such networks designed?
c. How effective are the different government, NGO, and private strategies at protecting coastal ecosystems?
d. What are the size, shape, representation, and replication considerations of a protected area?

**2. Realistic outcomes:**

a. Do Great Lakes protected areas increase the desired resilience of a social–ecological system?
b. Are protected ecosystems more resistant to invasive species?
c. Do no-take areas have cascading effects throughout the aquatic food web and region?
d. Are management plans adaptive and responsive to climate change and system novelty?

**3. Current needs:**

a. Do a gap analysis of species, habitats, and threat distribution to identify under-protected areas.
b. Conduct pre- and post- establishment comparative studies to examine factors affecting the effectiveness of a protected area.
c. To answer the question "Is the IUCN protected area classification being properly applied?", complete an assessment of effectiveness of the various types.
d. Determine whether there are societal impediments to the creation of Great Lakes protected areas and networks. If so, how can the impediments be overcome?

In the Great Lakes, some species show strong site fidelity as adults (e.g. *Micropterus* spp.), but many of the species targeted by commercial and recreational fisheries are more mobile (e.g., walleye and lake trout). Johnson et al. (2015) highlighted the lakewide home range of large predatory fish species and how differently we should consider refuge and corridor concepts. Protecting critical life stages and viable populations and enabling post-disturbance colonization (e.g., recovery of coastal wetlands from low-lake-level events) through protected area networks are evident in many areas of the world. For instance, the state of California increased its marine protected areas from 2.7% of state waters and 0.2% in "no-take" zones in 1999 to 16% and 9.4%, respectively, by 2013, with associated social and ecological gains. The state protected representative key habitats (and replicates thereof) spaced to maintain ecological connectivity (e.g., at intervals of 50–100 km), with a 5–20 km alongshore span extending from intertidal to deeper waters (~5km). This redesigned network reflected effective integration of science, governance, and interests of communities and other stakeholders. The average alongshore span of coastal protected areas in the Great Lakes is 9 km, with a 24-km separation between them. As much as this current situation in the Great Lakes is a promising beginning, more desirable in terms of protected area development would be: an increase in total area protected, particularly under full protection; a land–lake linkage (shore to deep waters); a framework based on representivity and replication (e.g., Brock 2015); and an integrated planning process involving federal, state/provincial, Indigenous, regional, and local partners.

***Considerations.*** At the international level, it is important to note that the Aichi targets for protected areas includes inland waters. An optimal manner in which to meet this target is to protect 17% of each representative ecosystem within that nation's jurisdiction. For the Great Lakes, Canada has established 12.1% within protected areas (in two of the four Canadian Great Lakes); this amount increases to 12.4% if fish refuges are included. The US has established 6.8% within protected areas; 18.9% if fish refuges, cultural sites, and *de facto* areas are included. The Aichi target includes provisions for "other effective area-based conservation measures." MacKinnon et al. (2015) helped define and operationalize these measures to ensure that candidate areas are included for having achieved evidence-based conservation gains. The fish refuges included in the database for this exercise appear to meet the definition, and it would be beneficial to bring them into the broader conversation on, and planning for, protected areas.

The GLWQA and associated activities, including lakewide action and management plans (LAMPs), biodiversity conservation strategies, coordinated science and monitoring initiatives, nutrient and contaminant management, climate change response, nearshore frameworks, and actions under the species and habitat annex (Governments of the United States and Canada 2012; Pearsall et al. 2013) provide a binational framework to restore and protect the Great Lakes. Although a protected area system or network plan is not explicitly identified as part of the GLWQA, protected areas do serve as the cornerstone for many of the agreement's place-based conservation efforts. Perhaps a Great Lakes-wide protected area collaborative will emerge, but in the interim we feel that the GLWQA, and its LAMP processes in particular, may be a good forum in which protected area managers can engage on conservation matters and explore future network prospects with other organizations and governments.

### Conclusion

Given the large number and diversity of protected areas in the region, Canada and the United States are well on their way to meeting their international and national obligations for protecting the Great Lakes. To maximize their effectiveness, new protected areas need to be strategically planned to expand and complete networks across various scales in the Great Lakes. Such planning should be informed by research on the design, establishment, effectiveness, and protection needs in the Great Lakes. Although a single, coordinated Great Lakes-wide protected areas strategy is lacking, there are existing conservation initiatives, including the GLWQA, the Great Lakes Fishery Commission, and the Upper Midwest and Great Lakes Landscape Conservation Cooperative, that effectively demonstrate the collaborative spirit and tools needed to advance such an effort.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