Lake Michigan Biodiversity Recovery Support Document

LAKE MICHIGAN FEDERATION

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The Lake Michigan Federation works to restore fish and wildlife habitat, conserve land and water, and eliminate pollution in the watershed of the largest lake within the United States. We achieve this through education, research, law, science, economics, and strategic partnerships.

- Lake Michigan Federation Mission 2001

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Foreword

Dr. Victor Shelford portentously wrote in his 1913 book, *Animal Communities in Temperate America*, one of the first studies in the world to examine animal ecology:

> Of the admirers . . . of nature I fancy that many, perhaps the majority, think of it as a series of lawn-like pastures, well-trimmed hedges, such as [those] in some of the older countries like England . . . The close observer of nature, even in such man-made conditions as in Bedfordshire or in the Chicago parks, sees all the struggle [of] the birds and mammals [in their] primeval conditions.

The area covered by the modern day Milwaukee-Chicago-Northwest Indiana corridor was a laboratory for the first modern ecologists—Shelford, Cowles, and others—for good reason. It was the junction where widely differing ecosystems, dunes, wetlands, prairies, and forests, come together. Today, this same junction contains 200,000 acres of protected natural lands, housing plant and animal communities that are more rare and threatened than those in the tropical rain forests.

These are the ecosystems that many of us think of here because we as people live on land. We have feet not fins. The ecosystem that makes up an entire border to today's Chicago Wilderness biodiversity reserve, however, is made up of water—Lake Michigan. In many respects Lake Michigan is the "last frontier." Because we don't live on the lake, its open waters have not been impacted by the same development that puts *terra firma* at risk.

The lake and its companion Great Lakes constitute nearly 20 percent of the Earth's fresh surface water supply. Lake Michigan once housed the largest self-sustaining lake trout population in the world. Its waters and winds are responsible for creating the largest concentration of freshwater sand dunes on the globe, home to species that can be found nowhere else.

Because of its ecological significance, and because people value the recreation and aesthetics that it provides, there is fierce competition between humans and wildlife for that narrow band of land and water called "the lakefront."

For these reasons and others, the lake may well be as threatened as any of the terrestrial ecosystems we step foot on. For these reasons, we need to pool our knowledge and together develop a proactive plan for restoring lakefront biodiversity. This report is the first cast in that direction.

Cameron Davis
Executive Director

Executive Summary

The nearshore Lake Michigan zone is among the most biologically productive in the region. Nearly 30 percent of the globally significant species and communities within the Great Lakes basin are associated with coastal shore systems (TNC, 1994).

At the same time, the lakefront is under enormous pressure to produce a strong quality of life for the region. Chicago alone, for example, receives some 60 million visits per year to its lakefront.

If biodiversity is to thrive in Lake Michigan, and in return continue to provide us with a strong quality of life, it will only thrive as the result of proactive planning and implementation. Just as about 100 organizations and agencies produced the Chicago Wilderness *Biodiversity Recovery Plan* in 1999 for inland waters and terrestrial habitats, we need a biodiversity blueprint for Lake Michigan's shoreline and tributaries.

The purpose of this report is to gather relevant information for such a plan. It does this in three ways: first it gathers what we know about the geology and ecology of the lakeshore before settlement took place and today.

Second, it identifies what we still need to know to restore biodiversity. In other words, this report identifies the challenges to and opportunities for bringing habitat back to the lakefront.

Third, for those who do not want to wait until the planning is completed before working to re-build habitat, this report identifies site-specific places that could benefit from habitat recovery.

The process for pulling together this information involved reaching out to representatives of dozens of groups, mostly in the study area, but throughout the Upper Midwest. The groups included members of academia, civic organizations, angling groups, agencies, and other stakeholders, all of whom were invited to participate in the Urban Aquatic Habitat Summit held on November 3, 2000, at IIT Chicago-Kent College of Law. The agenda for the Summit tracked the three points above. The Summit was interactive, with question and answer sessions and breakout segments. The process for gathering the information in this report also involved direct research by Lake Michigan Federation staff and consultation with Summit participants and report reviewers. A list of participants and reviewers is in the Acknowledgements section.

The geographical area covered by this report includes Illinois Beach State Park in Zion, Indiana Dunes National Lakeshore, and points between. The two public parks represent one approach for habitat health in the study area: protecting native biodiversity that exists.

The points between represent the other approach: looking for ways in which to bring native biodiversity back to health. Most of the shoreline connecting the two parks is artificial or substantially impacted by human activity. The goal of the Urban Aquatic Habitat Recovery Initiative—officially launched by the Lake Michigan Federation with the Summit—is to re-build habitat for native species along the lakefront and "connect the dots" between these two

parks. In so doing, the hope is to make the study area the showcase nationally for bringing back native aquatic communities in an urban center.

The study area is unique in that it is highly developed yet supports unique plant and animal life. Indiana's 45-mile Lake Michigan shoreline houses the world's 5th largest oil refinery, 25 percent of the nation's steel production, and the Port of Indiana as the busiest port in the Great Lakes. At the same time Indiana Dunes National Lakeshore ranks third of the country's national parks in plant diversity.

Illinois' 63-mile shoreline sees millions of visitors every year. One lakefront festival, the Taste of Chicago in Grant Park, attracts almost four million visitors over the course of a week. People are attracted to the area's beaches, sporting events, cultural activities, and business opportunities. Illinois Beach State Park is the 11th most visited public park in the country. Millions of neo-tropical migrant songbirds pass along the Illinois lakefront every year, coming from as far away as South America and the Arctic.

The effort needed to strike the balance between human and nature's uses is profound. Toward that end, some of the significant findings in this report are:

- The Illinois - Indiana Lake Michigan shoreline is vastly different from its presettlement state. Most coastal wetlands and nearshore aquatic habitats have been eliminated or degraded. The effect of natural forces on sand transport and shoreline development has been greatly reduced or eliminated entirely in some areas.

- Fish populations have changed dramatically since settlement. Original keystone predator species have been replaced with stocked species. Native species are subject to extreme stresses as a result of exotic species invasions.

- Lake Michigan's fisheries represent a strong potential economic, recreational, and environmental benefit for the Illinois - Indiana area. Significant work is required to develop healthy, sustainable populations of fish species in degraded habitats, including mitigating human impacts and preventing further exotic species invasion. Federal policy tools may prove most helpful in achieving these ends.

- Former and working industrial sites in the Chicago area are beginning to serve as habitats for viable fish and bird populations, suggesting that conditions are favorable for urban habitat recovery.

- It is essential to preserve rare habitats that cannot feasibly be replaced, such as the dune and swale systems of northwestern Indiana. Stresses to these habitats should be minimized as much as possible.

- The Chicago shoreline serves as habitat for a variety of fish species. As the city redevelops its shoreline over the next several years, it has a unique opportunity to emphasize aquatic habitat construction as part of the lakefront park planning process.

- Multiple options for continued large- and small-scale habitat restoration and creation exist in the Chicago area. Primary needs include funding and research from government and academic bodies

I. Setting

The study area for this report is flanked by Indiana Dunes National Lakeshore and Illinois Beach State Park. It includes three counties in Indiana: Lake, LaPorte and Porter. It includes the following cities: Munster, East Chicago, Gary, Hammond, Highland, Griffith, Merrillville, Crown Point, Chesterton, Valparaiso and Michigan City. There are two Illinois counties included: Cook and Lake. The following cities are included: Chicago, Evanston, Wilmette, Winnetka, Kenilworth, Glencoe, Highland Park, Lake Forest, Lake Bluff, North Chicago, Waukegan and Zion.

The terrestrial study area is confined to the Lake Michigan Basin, the land area that drains into Lake Michigan. The basin is very narrow in Illinois and heavily urbanized throughout. For that reason, not all of the Chicago Wilderness counties are included in the study.

Illinois rivers connected to the lake include the Calumet River, Waukegan River and Dead River. The North Shore Channel is also considered part of the study area. Though the Channel usually moves away from the lake, it is in the basin and does discharge into Lake Michigan on occasion. Indiana tributaries include Trail Creek, the Grand Calumet River, and Burns Ditch.

The open water portion of the study area is confined to the nearshore waters of Lake Michigan, defined as the shoreline out to 20-foot water depth. This boundary is usually less than two miles from the shoreline.

Presettlement Geologic Conditions

The Illinois-Indiana coast was formed by two distinct geologic processes. Glacial action formed the Lake Michigan basin, shaped much of the surrounding landscape and deposited a thick layer of glacial sediment across the region. This sediment is primarily compact clay with small quantities (10-15 percent) of sand and gravel. Coastal processes such as waves, currents and fluctuating lake levels contributed to the erosion and transport of the glacial sediments to redistribute them along beaches and the shallow lake bottom. Glacial ice receded from southern Lake Michigan about 14,000 years ago. Since that time coastal processes have shaped and modified this coast (Chrzastowski, 2000).

The Chicago Wilderness coast stretches along two broad arcs, first from the Illinois-Wisconsin state line to Wilmette, and then from Wilmette to the Indiana-Michigan state line. This coast consists of three distinct physiographic settings:

Zion beach ridge plain

Between the Illinois-Wisconsin state line and North Chicago, the Illinois coast is a broad plain no more than about 10-15 feet above mean lake level and consisting of multiple sand ridges and intervening swales. It consists of sand and gravelly sand that has migrated onto the Illinois coast from the Wisconsin coast over the past few thousand years.

Illinois bluff coast

Between North Chicago and Evanston the coast lies along the foot of bluffs that rise as much as ninety feet above mean lake level. Here the coast intercepts one of the moraines that formed on the margin of the receding glacial ice. Erosion along this bluff coast was once a major source of sand and gravel for the beaches and shallow nearshore.

Chicago/Calumet lake plain

From Evanston to the Illinois-Indiana state line, and continuing to the Indiana-Michigan state line is a broad, low-lying plain. This plain is an above-water continuation of the lake bottom. Since glacial ice receded from southern Lake Michigan, this plain was submerged at different times and to different degrees when lake levels were a few feet to as much as sixty feet higher than today. Most of the city of Chicago occupies this plain, as well as Indiana's coastal cities. Coastal processes have left sand deposits across this plain, forming extensive ridges and swales in the vicinity of the Illinois-Indiana state line and contributing to the sand present in the Indiana dunes.

Since glacial times the two most important processes along the coast have been changes in lake levels and littoral transport. Wide fluctuations in lake levels of more than one hundred feet occurred in early post-glacial history. But over the past one or two thousand years, lake level fluctuations have been within a range less than ten feet. Lake level change shifts the shoreline position and shifts the zone of active erosion, transport and deposition of sediment (Chrzastowski, 2000).

Littoral transport is the movement of sediment by wave action. It is essential to shoreline stability since it replenishes sand and gravel supplies to beaches and dunes. All but a few isolated locations of the Illinois coast have a net southward direction of littoral transport. This is due to waves approaching from the north and northeast having the longest fetch and greatest energy for transport. The immense quantities of sediment moving past Chicago each year would fill a football field nine stories high if accrued.

Prior to human alteration of the natural setting, the Indiana coast between Gary and Michigan City was the terminal zone for this littoral sediment moving south along the Illinois shore as well as littoral sediment moving south along the Michigan shore. The fine-grained sand that reached this terminal zone was moved inland by wind and contributed to the formation of the Indiana dunes (Chrzastowski, 2000).

Maps of the depths and sediment distribution across the lake bottom provide a general description of the setting, but detailed work cataloging specifics of the lake bottom landscape remains to be done. The bottom is generally a smooth expanse of thin sand and gravel over glacial clay, or areas of exposed clay. Bedrock knobs of glacially smoothed dolomite protrude above the lake bottom in several locations scattered across Illinois. The lake bottom also contains areas of irregular mounds, ridges and pinnacles of glacial clay such as those off the shores of Lake Forest and Highland Park, Illinois. These are likely related to glacial deposition during the ice retreat. Gullies, swales and ravines are cut into the clay lake bottom at several locations along both the Illinois and Indiana shore. These likely were eroded by stream and river action sometime between 10,000 and 5,000 years ago when lower lake levels exposed this lake bottom (Chrzastowski, 2000).

Current Geologic Conditions

When the first European settlers came to the Illinois and Indiana shores, they found a coast that was essentially a continuous sandy beach along this entire reach. There were no interruptions other than the crossing of a few shallow stream mouths, such as the Chicago and Calumet Rivers and Trail Creek at Michigan City. The lack of any quiet water harbors necessitated the use of rivers as harbors, and engineering was undertaken to deepen and protect the river mouths. The U.S. Army Engineers (USACE) began such river mouth engineering at the mouth of the Chicago River in 1833. Work soon followed at the mouth of Trail Creek in Indiana. The timber and stone jetties that were built at the river mouths resulted in entrapment of sand on the north side of the entrance to the Chicago River and the east side of the entrance to Trail Creek. The deprivation of sand from the opposite side of the entrance resulted in down-drift shore erosion. This set the stage for continuous necessity of erosion control along the Illinois and Indiana shore. The sandy beach landscape along the Illinois and Indiana coast has been replaced by artificial recreational beaches occurring along distinct segments between sites of commercial and residential development (Chrzastowski, 2000).

The original rather featureless curvilinear shore has been altered by introduction of headlands, peninsulas, lagoons, harbors and bays. Growing maritime commerce led to the construction of large-scale breakwater systems, dredged channels and lakefill areas at Indiana, Calumet, Chicago, and Waukegan Harbors. The most ambitious efforts in the coastline sculpturing have occurred along the Chicago lakeshore, as well as at Whiting, East Chicago, and Gary, Indiana. Construction of shore defenses to halt erosion along the highly valued lakeshore of the Illinois bluff coast gradually eliminated this source of sand and gravel supply to the beaches and nearshore. The once-uninterrupted littoral transport pathway has today been segmented into a series of littoral transport cells. These cells are bound by the breakwaters, groins, lakefills and dredged channels that have been built along the Illinois and Indiana coast. Lakefilling has substantially altered the interface between land and lake bottom from a gradually sloping lake bottom up to the shoreline to one of lakefill with a near vertical edge into water depths as great as eighteen feet. In locations where lakefill has been built into water more than fifteen feet deep, the littoral transport process has essentially been eliminated (Chrzastowski, 2000). An example is Navy Pier in Chicago, a structure which effectively starves the entire south Chicago shoreline of natural sand deposition (Jimenez, 2000).

Despite the high degree of human impact to this coast, natural and near-natural shore settings have been preserved at Illinois Beach State Park, located on the Zion beach-ridge plain, and the Indiana Dunes State Park and National Lakeshore, located on the eastern part of the Chicago/Calumet lake plain. However, even these locations are impacted by regional human interventions and coastal sand management is becoming ever more essential to the preservation of these parks (Chrzastowski, 2000).

Presettlement Ecological Conditions

Illinois Beach State Park is a reflection of how Chicago's Lake Michigan shoreline used to look. Low-lying beaches and wetlands formed the terrain that present-day Chicago is built upon. Northeastern Illinois' presettlement landscape consisted of dune complexes, savanna

and oak woodlands and some inland wetlands. The predominant dunes were capped with stunted cedars, juniper berries and pine, oak and willow trees (Kinzie, 1856). Along the shore there was a succession of low sand hills, partly covered with a scrubby growth of cedars, junipers and pines (Gale, 1902). Appendix 2 lists common dune plants and animals found in the area. Inland wetland and prairie areas were home to wolves, bears, deer, buffalo, waterfowl and passenger pigeons (City of Chicago, 1976). Fringing marshes were present from Highland Park to Glencoe, while the remaining Illinois shoreline was entirely sand (Shelford, 1913). Landward, there were groves of small black oaks. Further west reaching the north branch of the Chicago River were elms. Further up the stream a fine belt of hickory, maple, beech and a variety of oaks spread gradually east to meet immense forests stretching to the north (Gale, 1902).

The bluffs of the North Shore were a biologically significant entity with ravines serving as the setting for forests of various species of maples and oaks (Greenberg, 2000). Offshore ravines in the clay lake bottom off of Highland Park and along the Indiana shore provided fish habitat (and still do today). Ten thousand to five thousand years ago, the lake levels were much lower than today. Land stretched more than 260 feet into what is today the lake. Rivers drained into ravines that cut into this land. When lake levels rose, the riverbeds were drowned in place. Ravines in the lake bottom and old tree stumps remain and are used as habitat by fish, as are bedrock knobs protruding out of the lake bottom (Chrzastowski, 2000). Lake trout used these areas for spawning, and lake sturgeon used the clay banks off of Mount Baldy, Indiana for habitat. Heterogeneity in the lake bottom attracts fish by providing shelter (Greenberg, 2000).

Indiana's shoreline consisted entirely of moving sand dune complexes ranging from a ¼ mile to several miles wide. The last glaciation formed the dunes along the Indiana shoreline, which are 2,500 to 10,000 years old. This ecosystem was shaped by wind, the predominant geologic force in the area. There were occasional interruptions where clay bluffs met the shore. The shoreline was smooth with no embayments or promontories. Scrub oaks grew on the ridges with swamp flora thriving in the depressions, or swales, which contained standing water (Cressey, 1928).

The presettlement lake held sustainable populations of many fish species that are uncommon today. Lake trout and northern pike were the dominant top predators in the open water and large lake sturgeon were exceedingly common. Seven species of ciscoes thrived in the open water areas. Whitefish, yellow perch and other smaller species were exceedingly abundant.

Current Ecological Conditions

Some vestiges of presettlement terrestrial habitats remain. Illinois Beach State Park dunes support foredune pioneer plants (beach pea, sea rocket, common bugseed, sand reed, seaside spurge, marram grass). Interdunal areas support creeping juniper and bearberry. Cottonwood trees and dune grasses can send roots down ten feet deep to tap underground water deposits. These roots serve to stabilize the fragile dunes against wind energy. Up to sixty plants and animals listed as threatened or endangered currently reside in the State Park.

Indiana Dunes National Lakeshore ranks third in species diversity of all national parks. Vegetation along the first ridge of the backdunes at the Lakeshore includes jack pine, white pine, juniper and an understory of plants, including poison ivy. The second line of backdunes supports an oak community. Further inland exists a forest of beech and maple trees.

Conversely, the beaches found in Chicago contain little natural vegetative cover. They are artificial and must be continually replenished with sand and protected from erosion by revetments (Tetra Tech, 2000). One small exception to this standard has begun to surface. Two natural sand dunes, one 6-8 feet high and one about 2 feet high, have developed at Montrose Beach on the north side of the city. Rare vegetation has taken root, with lakeshore rush, sea rocket (threatened), and marram grass (endangered) all thriving on the dunes. The dunes have developed over the last several years due to lack of Chicago Park District activity and other human disturbances (Long, 2000).

Currently 8-13 percent of the nearshore area in Illinois' northern Lake County is wetland. The Calumet region has 1-7 percent wetland coverage (Chicago Wilderness, 1997). Small remnant and large interdunal wetlands remain in areas south of Chicago and around the southern end of Lake Michigan (Tetra Tech, 2000). Fringing wetlands, which can decrease erosion caused by changes in littoral drift (IDOT, 1980), account for only 1 percent of the shoreline in the study area. Urbanization and protection of Wisconsin's shoreline has decreased littoral drift of sand, resulting in a net erosion of the Illinois shoreline (Research Planning, Inc., 1994).

Presettlement northwest Indiana was continuous wetland. As of 1979, less than 5 percent of the original wetland cover remained. This exists primarily as narrow strips of intact habitat. The current landscape is a patchwork of wildlife habitats, residential areas and industry.

The human disturbances on aquatic biota in the area were first recorded in 1874 in an account on water pollution. Smelting works, sawdust and sewage released into the Lake Michigan were harming fish. However, damage to fish populations was not limited to the effects of pollution. The introduction of the sea lamprey inflicted irreparable harm on the lake's native fish species and the commercial fishing industry. Another exotic species, the alewife, has proliferated in Lake Michigan and currently comprises 85 percent of the biomass in the lake (Greenberg, 2000). It feeds on plankton and fish eggs, competing with native ciscoes for food and devouring lake trout fry. Lake trout catches fell from 6 million pounds per year to less than 100 pounds per year due to destruction of their young and parasitic lamprey activity.

The Caspian Sea's zebra mussel, introduced like most other exotic species from international shipping ballast water discharges, feeds voraciously on zooplankton and phytoplankton. This has resulted in risks to native fish species that traditionally used this food source, and has also resulted in risks to plankton populations. Another source of plankton stress has been noted in reports that 60 percent of the plankton found in certain sections of Lake Michigan have debilitating cysts on their bodies (Boutin, 2000). While the cause of the cysts is still unknown, what is known is that these plankton help form the base of the Lake Michigan food chain and their health is in jeopardy.

Commercial fishing began in 1830 with whitefish providing the most abundant catch. Nearshore species have seen a precipitous drop in numbers as a result of overfishing, habitat destruction and poor water quality. The lake sturgeon was particularly hard hit because females do not reproduce until the age of 25 years and males until the age of 10. Young sturgeon were often removed from the ecosystem before they could reproduce. Open water species, such as the ciscoes, have also suffered. The larger of the seven species of ciscoes were prized as game fish and succumbed to overfishing. The medium sized ciscoes were preyed upon by the sea lamprey. Small ciscoes, also called bloaters, are now a dominant species (Greenberg, 2000).

Several Lake Michigan fish species, such as the blackfin cisco and shortnose cisco, have been declared extinct. The longnose dace and trout perch were once much more common than today. Keystone predators, such as the lake trout, lake whitefish, muskellunge and northern pike, have been either eliminated or had their numbers drastically reduced. Their presence has been supplemented by stocking of Pacific salmon and other trout species. The numbers of native fish in the Lake Michigan watershed, including the nearshore have declined by 22 percent since European settlement. The only native fish to have maintained or increased their populations are the lake herring and the bloater (Simon, Stewart, 1999).

Recent studies have begun to illustrate the status of fish populations in the many waterways and lacustrine, palustrine and riverine wetlands (see glossary for definitions) in the study area. The U.S. Fish and Wildlife Service (USFWS) and the U.S. Geological Survey (USGS) recently sampled 225 public and private sites in the watersheds of the Grand Calumet River, Trail Creek, Lake Michigan and Little Calumet River. Public lands in this region include the Indiana Dunes National Lakeshore, Deep River County Park, Clarke and Pine Nature Reserve and the Indiana Dunes State Park. Surveys used the concept of "least impacted" streams as a reference because "pristine" surface water bodies do not exist in Northwest Indiana. Catches from some of these streams are thought to have historically produced a maximum of 12-14 fish species. Catches in the Northwest Indiana sites produced a maximum of only ten fish species. The study suggested lower than expected numbers of darters, madtoms, sculpins, minnows and other environmentally intolerant species (Simon, 1999, 2000).

Variation in dominant fish species in these mostly degraded waterways can be used as an indicator of overall system health. Dominance of an ecosystem by a fish that is highly tolerant to variable conditions is indicative of poor water quality, while dominance by more sensitive species suggests an ecosystem that is closer to a non-impacted state. The majority of northwest Indiana's headwater streams have been ditched or degraded. The sensitive species red belly dace and sculpin have vanished from these areas. The population of sticklebacks has also dropped while the highly tolerant central mud minnow's numbers have increased. Carnivorous fish dominate the Indiana Dunes National Lakeshore waters due to stocking programs. A large proportion of pioneer species (species that colonize disturbed habitats) were also found on the public lands, which signals that rapid fluctuations in water conditions are occurring. Public lands also have a low number of darters and broadcast spawners. Diseases in fish, e.g., incidences of tumors or lesions, are low in the public streams, but high in private land aquatic habitats (Simon, 1999, 2000).

Exotic species composed the largest portion of the samples (more than 50 percent) in the Grand Calumet River area and Lake Michigan collections. The Little Calumet River and Trail Creek samples had 12-14 percent exotics (Simon, 1999, 2000). Recent Lake Michigan trawls performed by the USGS show that bloaters, the only species of the ciscoes that has not been impacted by overfishing or sea lamprey parasitism, dominate the prey base, making up 30 percent of the biomass collected. The exotic alewife made up 27 percent and sculpins 28 percent. Zebra mussels now comprise a substantial portion of the trawl biomass at most sites (USGS, 1999). The goby, which was first found in the Grand Calumet area, can now be found as far north as South Haven, Michigan (Simon, 1999, 2000).

Natural communities remain in the waters of the Millers Woods Ponds, Grand Calumet River and the Grand Calumet lagoons. However, the water quality in the Grand Calumet area is severely degraded, and some areas do not support any native fish populations (Simon, 1999, 2000). Restoration of the Grand Calumet River has resulted in the return of the Chinook salmon. An unsubstantiated report has surfaced about the presence of lake sturgeon in Wolf Lake as an adult sturgeon was caught there in 1999. Sturgeon used to travel through Wolf Lake to reach Lake George to spawn. Lake George is presently degraded, but it appears that restoration could encourage sturgeon to return.

It was recommended at the Summit that headwater streams be restored, the banks of northwest Indiana waterways be revegetated, and public lands be restored to a state more hospitable to sensitive species. Headwaters can be restored with a variety of engineering strategies, including riffle creation and stream channeling to adjust energy flows. As a first step, the USFWS will be creating riffles in area streams through a project funded by the Natural Resources Damages Assessment program.

Conclusions

- The presettlement Illinois-Indiana shoreline consisted of a series of sand bluffs and dune complexes. Several varieties of woodland communities, marshes, and prairies were present behind the dunes. Multiple rivers drained into the lake and lake trout, pike, sturgeon, ciscoes and perch were common.

- Littoral transport of sand and lake level fluctuations were crucial to the development of the presettlement shoreline and wildlife habitat. Littoral transport has been drastically reduced as a result of river mouths in the Chicago area being converted into harbors, causing significant shoreline erosion.

- Extensive fill introduced into Lake Michigan has produced an artificial shoreline along the entire Chicago lakefront.

- Natural nearshore terrestrial communities are rare in Illinois and Indiana and exist primarily on state or federal land. Wetland coverage is less than 10%, and remaining wetlands are highly fragmented.

- Lake Michigan fisheries are strategically managed for game species, and exotic species invasions have resulted in drastic changes the lake's food web. Native predator populations have plummeted and several fish species have become extinct.

- Some natural communities still exist in the waterways that supply Lake Michigan. These areas should be targeted for restoration.

II. Challenges and Opportunities

Enhancement of the Lake Michigan shoreline in a highly urbanized area will not be an easy task. It is our responsibility to demonstrate that recovering urban aquatic habitat is not only possible, but preferable to other uses. Public perception of the lake as a resource for all people and all uses dictates that we enhance habitat while alleviating the impact of human activity on the lake ecosystem. There are a wide variety of regulatory tools and funding available for shoreline improvements, and coalitions of community groups can provide the expanded knowledge base needed to utilize these tools.

Economic Incentives

The Chicago Wilderness Biodiversity Recovery Plan seeks to increase biological integrity of the Chicago area. However, management decisions are frequently based on economics as well as ecological factors. Lake Michigan Federation research is beginning to show that biodiversity protection makes economic sense. A study performed by Federation Great Lakes Environmental Economics Fellow Anna Cooper suggests that the value of the Chicago area lakefront is between $3 and $5 billion. Our challenge is to continue to develop sound policies that fully account for the true value of biodiversity.

An estimated 60 million visitors use the Chicago lakefront each year for various purposes, making significant contributions to the economy of the city. Even more people visit the lake in the regions north of the city and in Indiana. Of course, these visits depend, in large part, on the maintenance of a healthy and attractive lakefront. The quality of life in the Chicago area is intrinsically tied to the value of our lakefront resources.

Despite the understanding that the lake binds people to the Chicago area, it has been difficult to place an actual dollar value on the integrity of southern Lake Michigan. One method that has been employed to do so is the contingent valuation method. This is a process by which individuals are asked how much they would pay to keep an ecosystem intact for future generations. It does not ask how much they value products from the ecosystem (fish, water) but simply how much they value the presence of the healthy system. A contingent valuation study performed on the Southern Lake Michigan Coastal Zone (the Zone) evaluated citizens' willingness to pay for preservation of fish and bird species. Using existing data sets, the non-use value of the Zone was estimated to be between $3 and $5 billion (Cooper, 2000). This "natural capital" measurement demonstrates how much of an asset Chicago-area Lake Michigan biodiversity is to local citizens.

Great Lakes sport fishing brings in an estimated $4 billion per year and currently 43 percent of all Great Lakes fishing is done in Lake Michigan (Tetra Tech, 2000). In 2000 Chicago hosted the 30th Annual BASS Masters Classic. This is the country's largest professional fishing event. The selection of Chicago as the host city is testimonial to the importance of sport fishing to the local economy. Competitors fished the waters of Lake Michigan, Chicago's harbors, Lake Calumet and the Chicago and Calumet Rivers for largemouth and smallmouth bass. Weigh-ins are open to the public and have attracted as many as 35,000 spectators at past events (Cabell, Charlos, Geib, 2000). The 2000 event drew 80,000 spectators, 5,000 of whom were tourists, suggesting a significant amount of spending from attendees, competitors and organizers. This demonstrates that sustainable fisheries can be economically beneficial.

The economic benefits of the Lake Michigan fisheries have been tempered by the problem of habitat loss, exotic species invasions, and water pollution. Strict fish consumption advisories apply to all Lake Michigan waters in the Chicago area. The consumption advisories' effects are apparent when considering that commercial fish production from Lake Michigan has an estimated value of only $11 million annually from a 14.6 million pound catch.

Policy Tools

A number of policy tools exist on the federal, state and local level that support Lake Michigan coastal habitat recovery. This section outlines some prominent examples.

Endangered Species Act

The federal Endangered Species Act (ESA) is intended to help restore healthy populations of imperiled fish, wildlife, plants, and insects. A recent effort by the US Fish and Wildlife Service (USFWS) - the agency charged with implementing the ESA - illustrates its usefulness around Lake Michigan. The piping plover (*Charadrius melodus*) is a small, pale-colored shorebird. It nests on sandy beaches with sparse vegetation and small stones. Nesting in the Great Lakes begins in mid-May, and plovers remain at the breeding grounds for three to four months. Because the nests are camouflaged with cobble ground cover, they are difficult to see and can be crushed by beach-goers. Historically, the Great Lakes breeding population contained 492 to 682 pairs in Illinois, Indiana, Michigan, Ohio, Pennsylvania, New York, Wisconsin and Ontario. Today only thirty-two breeding pairs nest in the Great Lakes, thirty-one of which are found in northern Michigan (Barry, 2000).

In 1985 the piping plover was listed as an endangered species in the Great Lakes watershed by the USFWS. At that time critical plover habitat was not formally designated for protection. However, a recent court order has directed the agency to designate critical habitat for both the nesting and wintering grounds of the Great Lakes population. Critical habitats proposed within this report's study area are Illinois Beach State Park to Waukegan Beach and Indiana Dunes National Lakeshore/Indiana Dunes State Park, Ogden Dunes, and Dune Acres. Any agency undergoing a federally permitted or funded activity in these locations must consult with USFWS regarding piping plover habitat needs. These protections could potentially safeguard over 20 miles of shoreline habitat in the Chicago area. Unfortunately, language in the ESA requires that if the adverse economic impacts of a critical habitat designation outweigh the

benefits of protection to the species, designation can be prevented (McCloskey, 2000). Log on to http://plover.fws.gov/ for updates on the designations and to review the economic analysis.

Conservation and Reinvestment Act of 2000

The Conservation and Reinvestment Act (CARA) of 2000 was intended to "establish a fund to meet the outdoor conservation and recreation needs of the American people." Under one version of the bill, revenues from the depletion of oil and gas reserves on the Outer Continental Shelf would provide approximately $56 million to Illinois and $32 million to Indiana for coastal protection, wildlife conservation, urban park and recreation programs, historic preservation funds, farmland protection and endangered or threatened species recovery. CARA passed the House of Representatives in May of 2000. In the Senate, it was referred to the Committee on Energy and Natural Resources with different versions gaining the support of over 65 senators as well as President Clinton. Unfortunately, it did not pass the 106th Congress, but it will be brought up in the 107th session. CARA lobbying did result in the appropriation of $100 million in new wildlife conservation grants nationwide in FY 2001 (Teaming, 2000).

Public Trust Doctrine

Another powerful tool in the effort to protect the Lake Michigan environment is the Public Trust Doctrine. In the U.S., the Doctrine originated when Congress authorized the establishment of Illinois and other Upper Midwestern states through the Northwest Ordinance, which granted states primary authority to manage waters and submerged lands in trust for their citizens.

Lake Michigan has been at the root of more than 100 years of court law upholding this trust relationship. In 1892, the U.S. Supreme Court declared in Illinois Central R.R. v. State of Illinois, that submerged lands beneath Lake Michigan are held in trust by the State for the benefit of the public and cannot be given to private interests.

More recently, in Lake Michigan Federation v. U.S. Army Corps of Engineers, a federal district court ruled that the public benefit that must come from a state transfer of lakebottom land must be clear and direct. Dozens of other courts around the country have scrutinized attempts to give away, lease, or even degrade public trust resources, such as water, submerged lands, recreational opportunities, fish, and wildlife. Given federal and state courts' strong stance on the Doctrine, it is quickly emerging as a strong tool for protecting lakefront habitat.

Coastal Zone Management Program

The federal regulation of navigable waters is well established. Management of the adjacent shoreline is left up to the states, resulting in fragmentation of control within the coastal zone. Congress passed the Coastal Zone Management Act in 1972 in response to the ineffective management of coastal resources by state and local governments. It is intended to encourage coastal states to adopt comprehensive management programs that regulate publicly and privately held lands. States that participate in the program with approved plans can obtain

federal financial assistance (Kuechenberg, 1990). Congress made $57 million available in fiscal year 1999 for coastal planning and protection (NOAA, 2000).

Currently, 33 states and territories participate in the program. The program manages 99.9 percent of the United States' oceanic and Great Lakes coastline miles, and only 108 miles have been left out of the program. Sixty-three of those miles lie in Illinois, which does not participate (NOAA, 2000) and has no current plans to do so. Illinois conducted a survey of its biological communities in 1976 as initial research for participation in the program (INHS, 1976). Little action was taken beyond that survey.

The other 45 miles are in Indiana, which is in the process of developing its program. Indiana received federal funds for several studies from the 1970s until 1981. In 1979 the Indiana Department of Natural Resources and the Natural Land Institute completed an inventory of natural areas. Indiana dropped out of the program in 1981 because it was unable to develop an organizational structure to implement the proposed program (Kuechenberg, 1990). Indiana rejoined the program in the fall of 1993 and its management plan is still under development. The state may require additional authorities for improving fish habitat, countering erosion and reducing pollution in order to receive federal approval (NOAA, 2000).

The remaining Lake Michigan states (Wisconsin and Michigan) manage their shoreline according to the Coastal Zone Management Program. Wisconsin's program is run by a 14-member, Governor-appointed Council representing state agencies, the state legislature, local governments, Indian tribes, the University of Wisconsin system and the public. An annual grant program is administered to award federal funds to local entities. Since 1985, the Wisconsin Coastal Management Program has awarded over $9 million in grants for coastal improvements (State of Wisconsin, 2000).

Michigan was among the first states to gain approval of its coastal program, which began in 1978. Michigan's Department of Environmental Quality (MDEQ) receives approximately $2.4 million yearly in federal funds, which are matched 1:1 by state and local funding. One-third of the grant is passed to Michigan's approximately three hundred shoreline communities, all of which are eligible to participate in the program. The remaining funds are used by MDEQ's Land and Water Management Division to support administration of several state programs including sand dune, wetland, and river protection, erosion control and shoreline management (MDEQ, 2000).

Municipal Ordinances

Local governments have a great deal of authority—often far greater power than federal and state government—to control local land use decisions that can affect biodiversity and habitat. One example of local zoning that is often held up as a model for preserving the lakefront is Chicago's "Lakefront Protection Ordinance." Located at Chapter 16-4 of the city's codes, the ordinance creates zones in which certain land uses are acceptable. There is a long and distinguished history of individuals and community organizations using the ordinance to promote open, public space along the shoreline. Other facets of the ordinance can be used to guide biodiversity and habitat protection efforts, such as its goals to, among other things:

(a) Promote and protect the health, safety, comfort, convenience and general welfare of the people, and to conserve our natural resources;

(b) Maintain and improve the purity and quality of the waters of Lake Michigan; and

(c) Insure that construction in the lake or modification of the existing shoreline shall not be permitted if such construction or modification would cause environmental or ecological damage to the lake or would diminish water quality; and to insure that the life patterns of fish, migratory birds and other fauna are recognized and supported.

Other local government ordinances exist to help protect watersheds from development and reduce erosion.

Media

In the fall of 1998 the Chicago Tribune ran the six-part series *Reinventing the Lakefront*. Its author, architecture critic Blair Kamin, won the Pulitzer Prize for criticism. The articles pointed out the lack of coordination and planning along Chicago's lakefront parks, the inequalities between the parks along the northern and southern lakefront and the overuse of popular parks while other lakefront areas lie vacant. His work sparked the interest of Chicago Mayor Richard M. Daley, who in turn prompted the Chicago Park District to plan for the reinvention of Chicago's Burnham Park, Jackson Park and the South Shore Cultural Center on the lakefront. These reinvention plans, created with input from the public, continue to be developed and include the modest creation of wildlife habitat. The *Lakefront* series reflects the immense popularity of the shoreline. It is also a reminder that efforts to rebuild habitat need to be continually communicated to the public and decision makers through the media.

Coalition Building

Effective habitat management for the regional and global benefit of native species must be part of a collaborative effort. Regional planning must incorporate citizens' concerns. One example of such a partnership is Chicago Wilderness. Another is the Lake Michigan Community Council (LMCC), coordinated by the Lake Michigan Federation. The LMCC is a coalition of more than 100 grassroots organizations dedicated to Lake Michigan watershed protection on a community-by-community basis. The LMCC shares information and coordinates efforts on a variety of environmental topics involving public health and the Lake Michigan ecosystem. Both types of collaboration can be extremely beneficial to habitat protection and restoration. Grassroots efforts can focus on specific community needs, while an organizing body can convey information about the successes of model efforts and ensure that migrating species and those with large ranges are being comprehensively managed.

Just as geographic diversity is essential to effective habitat management, partnerships among various interests are necessary. Collaborations among the private sector, government agencies, academia and the non-profit community will ensure that the needs of both the public and

wildlife are met. Likewise, collaborations among sportsmen, environmentalists, public interest advocates, recreationalists, scientists, planners, legislators and economists need to be created.

Competitive Uses

The Illinois and Indiana shoreline is a congested environment. Users with competing interests are constantly vying for a piece of the lakefront to call their own. Industry, homeowners, beach-goers, anglers, tourists and wildlife all have an impact of the shoreline ecosystem. Habitat protection would be much easier to achieve if the region were remote. But the high human population density of the region makes the presence of wildlife even more unique. It is essential to work through the challenge of determining how opposing needs can be met using the limited funding and workforce available. This section provides illustrations of potential competitive uses.

People versus Wildlife

Planning for the myriad uses of the Illinois-Indiana lakefront requires a skillful balancing act. Over 60 millions visitors flock to the Chicago lakefront every year to enjoy its sandy beaches and waterfront trails in close proximity to cultural activities, shopping, dining and entertainment. Indiana's shoreline supports the 5th largest oil refinery in the world, 25 percent of the nation's steel production and the busiest port in the Great Lakes (Port of Indiana) (NOAA, 2000). Tourists, students and academics marvel at nearby Indiana Dunes National Lakeshore, which ranks third in biodiversity amongst the nation's national parks (Tetra Tech, 2000) and is considered the birthplace of modern ecological study.

When considering how to accommodate these uses, planners must be aware that human activities in these areas often occur in close proximity to sensitive ecological processes. The dune systems in Illinois and Indiana are slowly created by movement of sand by wind and waves. Fragile dune vegetation systems are crucial to prevention of rapid erosion. If vegetation is not present, wind can cause a blowout in the dune structure, resulting in a saucer shaped depression that enlarges as wind forces scour out sand exposed by the destruction of vegetation. Ease of access to dune ecosystems should be of great concern in the Chicago area, as serious blowouts are almost always a result of human disturbances. The Chicago harbor system presents another juxtaposition of human activities and wildlife habitat. Harbors are often ecologically significant habitats, providing shelter and feeding grounds for fish and wildlife. Yet Chicago's harbor system, for example, is managed almost solely for recreational boat use.

One of the most crucial services the Lake Michigan shoreline provides to wildlife is that of a migratory bird pathway. Chicago's Field Museum ornithologists have estimated that at least 5 million songbirds migrate along the Chicago lakefront flyway each year. Popular local migratory stopovers include Montrose Point, Jackson Park, and the Lincoln Park Bird Sanctuary. The Bird Conservation Network has emphasized the idea that birds can adapt to using the Chicago shoreline as migratory habitat if natural areas are restored. Human activity centers for athletics, concerts, and beachgoing can be placed in a manner that maximizes

shoreline availability for birds and reduces impact to their habitats (Schilling and Williamson, 2000).

Water Quality Degradation

Another challenge to bringing native biodiversity back to the lakefront is water pollution. One example of a Lake Michigan fishery stressor is toxic pollution. Illinois and Indiana both issue fish consumption advisories based on fish tissue contamination with PCBs, chlordane and mercury. They are updated periodically and can be found posted online at: http://www.idph.state.il.us/public/press99/fish_advs_99.htm (Illinois) and http://www.state.in.us/isdh/dataandstats/fish/fish_adv_index.htm (Indiana). None of Illinois' sixty-three coastal miles are meeting their designated use due to fish consumption advisories. Indiana's general fish consumption advisory covers 241 square miles, including the southernmost waters of Lake Michigan. Several waterways, such as the Grand Calumet River and Indiana Harbor Ship Canal, have 100% "do not eat" advisories posted for their fish stocks (Tetra Tech, 2000).

Bacterial and other pathogenic pollution of the shoreline presents another vexing issue. In recent years, the southern Lake Michigan shoreline has experienced beach health problems indicated by high levels of *Escheria coli* (*E. coli*) bacteria. These bacteria serve as an indicator of the possible presence of more troubling pathogens. These pathogens pose significant risks to human health.

According to Lake Michigan Federation research, the number of days Lake Michigan beaches in Illinois have closed since 1994 has been increasing. In 1994, Illinois' shoreline experienced 10 closings. In 2000, it experienced 119 closings. Though natural sources of contamination leading to beach closings are still largely unknown or uncontrollable (as with sea gull or other wildlife waste), human causes are readily apparent.

For example, in 1999, Chicago's 63rd Street Beach, a shallow, enclosed beach with relatively little circulation, closed 23 times. The city determined that the cause of the closings was a collapsed sewer line about one mile inland from the lake. The sewer line had been built around 1900. It has since been repaired, but it illustrates the need for municipalities to survey the condition of their sewage infrastructure and proactively plan for their maintenance.

The largest known human cause of beach closings along the Illinois lakefront is the North Shore Channel. Running along McCormick Boulevard from Chicago and ending at Wilmette Harbor, the Channel contains untreated wastewater and runoff from adjacent municipalities. When the Wilmette Locks, which contain the Channel, opened in 1999, it was responsible for 30 percent of Cook County beach closings. When it opened in 1997, it was responsible for 74 percent of Cook County beach closings.

Though Indiana beach closings have generally decreased over the years, they still remain unacceptably high. In April 2000, the city of Valparaiso released more than 20 million gallons of untreated wastewater that ran ultimately to Lake Michigan. Though no beaches closed

because the release happened before the start of the official beach season, the impact of the discharge could even be seen from aerial photographs.

While the human health risks from exposure to bacterial contamination at beaches are becoming increasingly clear, the effect of such contamination on aquatic life is less clear. Research on pathogenic contamination impacts on aquatic life must be pursued.

Exotic Species versus Native Species

As urban habitat renewal progresses, attention must be paid to the effects that exotic species have had on the Lake Michigan ecosystem. As discussed earlier, fish populations have changed dramatically since settlement of the lakefront as a result of non-native invasion and fish stocking. The wetland habitats upon which some native aquatic species are dependent have also been severely degraded. There is a concern that restoration may simply provide more habitat for exotics without increasing thriving populations of native species. It is also unclear if passive protection of ecosystems such as those found in Indiana Dunes National Park is actually maintaining healthy native populations.

An artificial reef was constructed in November of 1999 off of Jackson Harbor in Illinois in an attempt to enhance smallmouth bass fishing. Pure granite slabs of varying sizes were dumped into the water to form a 256 meter long, 15.5 meter wide, 2.1 meter tall structure covered by 7.5 meters of water. The Illinois Natural History Survey (INHS) was conducting a study on nearshore fish at the time and was asked to include the reef as a sampling site. In order to determine which types of species were colonizing the reef, fish, zooplankton and benthic invertebrate samples were taken from around the reef and from a reference site (as a measure of species makeup prior to reef installation). Adult fish were collected with gill nets and analyzed for abundance and diversity. The ages and stomach contents of smallmouth bass collected were noted. Visual surveys along transects and surface water collections of larval fish were also conducted. Zooplankton net tows, sediment cores, and rock baskets were used to gather plankton and benthic invertebrates (Charlebois, 2000).

Sampling indicated that exotic species dominate the reef. Rusty crayfish and round gobies were determined to be abundant by visual observations but could not be easily sampled because their preferred habitat is between large rocks. Fish are attracted to the reef, but it is not known if fish abundance is actually enhanced. Fish may opt to use the reef for nursery grounds more so than the protected harbors. This may actually cause a decline in fish numbers, as eggs deposited there may be more susceptible to storm events. The reef may also act as an attractor for anglers and predators that could decrease the populations of any native fish congregated at the reef (Charlebois, 2000).

Three of the eleven artificial Great Lakes reefs are in Lake Michigan. No basin wide policy on reef construction exists. There are no definitive conclusions on the ecological impacts of artificial reefs (Tetra Tech, 2000). An *International Position Statement and Evaluation Guidelines for Artificial Reefs in the Great Lakes* adopted by the binational Great Lakes Fishery Commission has been developed to ensure that fishery management, not waste disposal, is the driving force behind artificial reef construction (Gannon, 1990).

Degraded wetland habitats are susceptible to invasions by exotic species. A prime example of a common invader is the ubiquitous purple loosestrife. Seeds were brought to the United States from Europe in ballast water and by settlers for ornamental use. Purple loosestrife currently exists in all Canadian provinces and all states except Florida. Loosestrife lowers the biodiversity of ecosystems by outcompeting native plants. Fauna diversity is consequently reduced by the loss of native plant cover (Charlebois, 2000).

Some progress has been made in the fight against loosetrife invasion. In 1992 the United States Department of Agriculture approved the use of 5 insects for the biological control of purple loosestrife. The *Galerucella* beetle was first released in Illinois in 1994 and by 1995 the INHS began rearing stocks of the beetles. In 1998, 450,000 beetles were released in Illinois. The adult beetle lays its eggs on purple loosestrife plants. After hatching, the larvae feed on the plants' growing stems and leaves. The beetles were released at the Weingart Road Sedge Meadow Nature Preserve in McHenry County, Illinois in 1994. By 1998 the numbers of loosestrife plants were visibly reduced, and by 2000 they were virtually gone. The beetles were also released in Savannah, Illinois in 1994. By 1999 the loosestrife was virtually gone. In 1994 native plants were rare at the site, but by 1999 16 different types of native plants were recorded. Unfortunately the loosestrife was seen flowering again in 2000, albeit in September instead of the usual flowering month of July. It seems that *Galerucella* introductions can allow native plants to return and can aid habitat restoration. However, the long-term efficacy of this biological control agent is unknown (Charlebois, 2000).

The Old Woman Creek, a freshwater estuary in East Huron, Ohio, provides a case study of the effectiveness of long-term passive preservation of a supposedly healthy ecosystem. In 1980 the creek and its surrounding habitats were designated a National Oceanic and Atmospheric Association (NOAA) Estuarine Research Reserve. It contains a variety of habitats, including marshes, a swamp forest, a stream channel and an island. It is a major way station for migratory birds and supports high plant diversity (Charlebois, 2000), indicative of a healthy ecosystem. Despite its purported health and protected status, this system is also impacted by exotic species. Carp are present, increasing water turbidity and reducing the abundance of native aquatic vegetation. Eurasian water milfoil, phragmites and purple loosestrife are emergent in the wetland areas and are outcompeting native flora.

Exotics can threaten protected habitats as well as degraded areas, making human control of exotics an absolutely critical component of habitat protection. Technologies do allow managers to combat some species, such as the purple loosestrife in wetlands and the sea lamprey in its spawning grounds. Open water species such as the alewife are more difficult to control. There is no effective eradication program for them (Charlebois, 2000). The best control is to prevent future introduction of additional exotic species.

Conclusions

- Lake Michigan's fisheries provide a strong economic benefit to the region. However, industrial contamination of game fish has reduced the use of fish for human consumption.

- Several regulatory pathways exist for protection and creation of habitat along the shoreline. These include the Endangered Species Act, the Conservation and Reinvestment Act, the Coastal Zone Management Program, the Public Trust Doctrine, and local ordinances.

- The media can be an effective means of motivating citizen and political interest in lakefront planning.

- Coalitions between private and public groups and across state lines are essential to redevelopment successes in the Chicago area.

- Contamination of southern Lake Michigan by toxics and pathogens has a marked impact on human uses of the Chicago area lakefront. More research is necessary on the effects of pathogenic pollution on aquatic life.

- Much of the Chicago area shoreline serves as wildlife habitat in addition to providing outlets for human use. Human impact on dune systems, harbors, and areas that serve as migratory bird pathways should be minimized to enhance habitat quality.

- Exotic species have had a deleterious effect on the quality and sustainability of the Lake Michigan ecosystem. Due to the difficulty of eradicating an established species, primary concern must be given to prevention of additional exotic species invasions.

III. Case Studies

Lessons learned from past and ongoing habitat preservation and restoration work serve as a valuable tool for guiding future efforts. The following three case studies are presented to provide a basis on which new projects can be developed and evaluated.

Calumet Area Wetlands

The Calumet Area Wetlands on the south side of Chicago supported extensive dune and swale systems prior to settlement. The area was rapidly converted to industrial use around 1900. The industrial presence created tremendous employment opportunities for the people of the Calumet region, but this boom gave way to a severe economic downturn in the latter half of the 20^{th} century. Active and abandoned industrial site and structures remain in the area. A shift from an industrial mindset is occurring in the area and recreation is becoming an important component of the economy (Anderson, 2000).

The U.S. Environmental Protection Agency's (USEPA) Great Lakes National Program Office (GLNPO) funded the Openlands Project to map out the existing and potential prairie and wetlands areas in the Calumet area in a series of posters aimed at guiding future policies. This was conducted through the cooperation of the governments at the city and state level, which have shown an incredible commitment to the project (Anderson, 2000). The posters identified

cluster sites and macro-sites demonstrating concentrations of habitat and economic redevelopment opportunities.

The Calumet region has unfortunately inherited the traditional legacy of contamination brought on by poor management of industrial waste. A half million acre-feet of slag (a steel processing byproduct) and fill remain in space that once contained wetlands. This slag is extremely basic, causing any water that flows through it to have pH levels of 10-11. Extensive engineering is needed to divert this water away from potential habitat areas or to neutralize the pH to biologically compatible levels (Anderson, 2000).

Despite pollution issues, wildlife in the Calumet region is surprisingly abundant. The Metropolitan Water Reclamation District's sewage dryout beds by the Bishop Ford Expressway have become a virtual birder's paradise. Though they are transected by rail lines that disrupt their hydrology and contaminated by leachate from the slag mentioned above, birding is phenomenal in the wetlands. The black-crowned night-heron is found in the area, as are soras, rails and the occasional pair of swans. The heron is an Illinois endangered species (Illinois Endangered Species Protection Board, 2000) that nests in the Calumet region, and the City of Chicago's Department of Environment, the Field Museum and Chicago Wilderness are currently collaborating on a preservation project for the bird (Anderson, 2000).

Another highly polluted area, the Lake Calumet Cluster Site, has been targeted as having strong restoration potential. The area is a privately owned grouping of six waste disposal sites that has been identified by USEPA as the most heavily polluted area of the Calumet region. Its contiguous nature and history as a wetland make it an ideal site for a low-traffic prairie restoration project.

The waterways in the region also present an opportunity for movement towards sustainable use by both humans and fish. One such waterway, Indian Creek, connects the Calumet River to Wolf Lake. It is currently lined with purple loosestrife, but *Galerucella* beetles were released for biological control of the loosestrife in 1997. Sturgeon have been seen in the creek en route to Wolf Lake. The Ford Motor Company is currently in the planning phase for an industrial park which will showcase Indian Creek as a key habitat feature. The U.S. Forest Service is creating a water trails program on several of the Calumet area rivers that are not heavily used by barge traffic and would be suitable for canoeing and kayaking.

Just north of the Calumet Area Wetlands lies 573 acres of land that served as the site of Chicago's South Works Steel Mill (USX) until 1992. The site has been vacant since that time. The City of Chicago, in cooperation with USX and local citizen groups, has outlined a plan for a mixed-use industrial, residential and commercial development on the site. This plan also calls for the development of a 300-foot wide park along the 1.5 miles of Lake Michigan shoreline on the property. This area will primarily serve as bird and wildlife habitat as well as providing biking and hiking trails. Pioneer plant species and wildflowers are already taking root in the slag-covered landscape, suggesting a strong potential for conversion to viable habitat.

Unified restoration of the Calumet Area Wetlands is a daunting task that will require strong coalitions between government and private landowners. Most of the wetland preservation opportunities are on private property, limiting their long-term conservation potential. The City of Chicago is trying to convert many of these lands to public holdings. Thousands of acres owned by colleges, the Illinois Department of Transportation, and the City of Burnham are interspersed throughout the Calumet area, making development of continuous restored habitat difficult. The expansive Wolf Lake site is bisected by the Illinois-Indiana state line. Any restoration initiative involving this area will require interstate cooperation. Fortunately, a bistate grassroots coalition, Friends of Wolf Lake, currently is developing a comprehensive plan for the area while the Calumet Ecological Park Association is lobbying for a Natural Heritage Corridor (Anderson, 2000).

Management of Northwest Indiana's Dune and Swale Systems

Another case study that illustrates habitat restoration and preservation potential in an industrial area is The Nature Conservancy's (TNC) South Lake Michigan Rim Project. TNC ecologists work here to protect dune and swale systems through acquisition and management of property. Three ecotones intersect in Lake County, Indiana. Tallgrass prairies in the west and eastern deciduous forests in the south are interspersed with boreal forest relics. The dune and swale systems present in this intersection are unique geologically and biologically. Beach ridges (dunes) up to six feet in height running parallel to the Lake Michigan shoreline were created as lake levels receded following glaciations. Rich biological communities exist in the low-lying wetland areas between the ridges (swales). The entire system is unique in that it consists of a series of lowlands immediately adjacent to uplands (O'Leary, 2000).

In the 1930s, a 40,000-acre dune and swale community stretched from the Illinois state line to eastern Gary. This formerly continuous habitat is now fragmented by homes and an airport. TNC has worked to conserve this highly impacted area by looking at three organizational levels: species, community and landscape. At the species level, land can be managed for flora, such as the orchid, that attract individuals who support preservation. However, the orchid cannot flourish if surrounding plant communities are not preserved. Globally rare communities, such as black oak and dry sand savannahs, can only be preserved if management is conducted at the landscape level (O'Leary, 2000).

Fragmentation poses a serious threat to dune and swale protection in Northwest Indiana. Small fragments of habitat are subject to greater stress levels and more rapid degradation than continuous large expanses. Sizeable stretches of habitat, valuable from an ecological perspective, are few and far between in heavily populated areas. The layout of a dune and swale ecosystem presents unique challenges to preservation of habitat fragments. Dunes run parallel to the Lake Michigan shoreline, and a narrow parcel of land may contain a solitary long swale. This provides an expanse of contiguous habitat, but if such a fragment becomes desiccated, the only wetland in the system may be lost. Conversely, a parcel of land perpendicular to the shoreline will have multiple swales but small pieces of each. The resulting small wetland habitats can be easily damaged. Wetland species that cannot easily migrate to a new habitat could thus be locally extirpated. Fragmentation also allows greater

contact of protected areas with roadsides that encourage human disturbances and usher in exotic invaders (O'Leary, 2000).

Small fragments can be connected with corridors to supply wildlife with means to travel between communities. This can alleviate some of the stress a large population can present to a small habitat. However, corridors do not always have the desired effect. Some species cannot migrate through corridors either because they are stationary and cannot disperse seeds/young over great distances, or cannot survive in the riverine environment common to many corridors. Even seemingly related species may display differential ability to exploit corridors. Blanding's turtles can easily travel through corridors, but spotted turtles cannot. Species occupying small habitats that cannot relocate on a regular basis are highly susceptible to the perturbations common to fragmented systems. Corridors also provide avenues for exotic species to spread from one fragment to another.

Each conservation project in the NW Indiana region provides an opportunity to conserve a fragment of one of the many varieties of dune and swale communities. The differences between communities must be articulated in order ensure preservation of all essential species. Comparison of various preserve communities (Ivanhoe, Gibson Woods, Clark and Pine, Clark Junction) demonstrated marked divergences in soil composition and species diversity. Ivanhoe and Gibson Woods have greater species richness and older, more acidic soils. The Clark and Pine Preserve and Clark Junction are closer to Lake Michigan and thus have much younger soil profiles. These two preserves are the most similar of TNC's preserves. Even so, they have only 65 percent of species in common. Preservation of a single area simply will not protect all dune and swale species. Construction of efficient corridor systems depends on comprehension of the differences between communities within each preserve (O'Leary, 2000).

TNC has found that preservation of intact dune-swale systems is much more important and useful than attempting to create new dunes. Revitalization of an impacted dune is a more effective means of preservation than attempting to create new presettlement-type habitat. Dune systems that have been impacted but not completely degraded can be rejuvenated by the removal of stressors and exotic species. It is extremely difficult to create a similar viable ecosystem through landscape manipulation and seeding. A dune and swale landscape can be created by constructing ridges and valleys with a bulldozer. However, achieving the successful interaction of vegetation, wildlife, hydrology, soil chemistry and climate within a sustainable community presents a significant challenge (O'Leary, 2000).

Stakeholders in this area must determine what scale is important for protecting biological integrity and whether their priorities can be integrated with activities occurring on a larger scale. Many properties containing ecologically significant systems are privately owned. Partnerships with state officials and comprehensive understanding of local land-use regulations are vital to successful preservation projects. Management agreements should be sought between property owners and restoration groups. Groups must also determine whether their goals are achievable only through preservation, or if a combination of restoration and conservation strategies would suffice.

Armored Shorelines and Incidental Habitat

The heart of the city provides a study of how wildlife coexists with extensive shoreline construction. The Chicago shoreline is predominantly artificial and lakefill along the coast averages 1500 feet in width. Since the existence of a stable shoreline in the Chicago area is unnatural, the land requires armored structures to protect it from erosion and storm damage. Chicago's existing shoreline armaments were built between 1910 and 1931. Four different types of structures were employed: offshore breakwaters, revetments, piers, and beaches anchored by groins. They were designed to last fifty years, but most are now over seventy-five years old.

Lake levels in the late 1980s were unusually high and caused a series of environmental incidents around the Great Lakes. Houses collapsed into the water due to significant bluff erosion, and shoreline roadways and cities flooded. The South Water Purification Plant in Chicago, which provides drinking water for 2.5 million people, was flooded during a 1988 storm despite being protected by an onshore revetment and an offshore breakwater. Wooden revetment supports had rotted away since being exposed to open air due to fluctuating lake levels (Jimenez, 2000).

The City of Chicago renewed its efforts at this time to obtain federal funding to protect its shoreline). In 1993 the United States Army Corps of Engineers (USACE) recommended to Congress that eight miles of Chicago's shoreline be reconstructed to protect the city from further land loss and flooding. This eight miles included four miles on the north side of the city from Montrose to Oak Street, a stretch on the south side of the city from McCormick Place to 57th Street, the eastern edge of Northerly Island and the breakwater that protects the South Water Purification Plant (Jimenez, 2000).

USACE conducted an environmental impact assessment on Chicago's proposed shoreline construction to evaluate the project's potential impacts on the quality of aquatic, terrestrial, archeological, historical and social resources. It was concluded that habitat would be disturbed during construction, but the net benefits of the project would provide for similar and even improved aquatic habitat. Fish would likely be driven away during construction, but would quickly return. Placing new stone would disrupt benthic organisms and change the substrate from sandy to rocky, but new surfaces would be colonized by algae and invertebrates (USACE, 1993). The term "incidental habitat" has been coined to describe such artificial structures, such as break walls, marinas, jetties, channels, navigations cells, confined disposal facilities and dredge spoil islands, that unintentionally provide habitat for and access to wildlife. These structures allow anglers to access deeper waters and serve as a shelter for Lake Michigan fish.

Several options exist for breakwater construction. The Chicago District of the USACE conducted fish sampling at southern Lake Michigan harbors from 1992 to 1998 (Appendix 3). They found a variety of fish species associated with rubble mound structures (Moy, 1994). Rubble mound structures are composed of layers of armor stone, core stone and the underlying bedding or mattress stone. The bedding, composed of the smallest stones in the three layers, extends out from the toe of the structure and can be manipulated to provide fish habitat. Another type of breakwater, called walled structure, is composed of a sheet pile or timber crib

filled with rock, rubble or other materials. The toe stone at the foot of the walls, which is in place to prevent erosion and undercutting by waves, can be modified to provide habitat if lake conditions allow (Moy, 1994). But the majority of the surface area of these structures is a featureless surface that provides no potential for fish shelter or habitat.

The USACE's Shoreline Protection Project, including repairs to existing structures and the addition of new layers of stone, officially began in 1997 at the South Water Purification Plant. The breakwater there had been serving as habitat and spawning grounds for fish. Aquatic life was disturbed during construction, and plankton and eggs were crushed during stone installation. The area was quickly recolonized, and the creation of larger structures and the addition of irregularly shaped stones at the breakwater and onshore provided even more fish spawning and feeding grounds (Jimenez, 2000).

The bulk of Chicago's public lakefront is protected by the smooth walled structures mentioned above, creating a severe dropoff in depth at the shoreline. This dropoff effectively eliminates the shallow water areas essential to fish spawning habitat. This design will be reconstructed and topped with stepstones as part of the Shoreline Protection Project, and are expected to last one hundred years. The depth of the water at the edges of the new structures will be 6-14 feet. The varying depth will hopefully attract a broader spectrum of fish life. City planners are also working with the State of Illinois on a project to seed vegetation into the toe stones of the new revetments (Jimenez, 2000). It is also highly cost effective to incorporate habitat modifications into routine maintenance projects. Wooden breakwater supports and stone revetments do decay over time. These aging structures can be modernized using structures modified to provide as much incidental habitat as possible (Moy, 1994).

The Shoreline Protection Project also contains an outline for a beach protection program. Chicago's coastline includes thirty-two public beaches. The beaches at Fullerton, Montrose, 12th Street, and 31st Street are all in need of repair. The groins and piers that hold sand in place are aging, and sand continually erodes away. Due to heavy public use of these beaches, unique issues have arisen that are not relevant to other aquatic construction projects. Beach construction has created bays and quiet water areas where fish can seek shelter. They also have protected the lake bottom where natural vegetation has established a foothold. However, the relatively calm water in these enclosed areas circulates more slowly than surrounding waters, allowing bacteria levels to increase to the point where they endanger public health. USACE has to employ structures that allow water to circulate away from the beachfront without compromising the stability of the lake bottom. Merely including holes in the edifice is not preferred since high water levels could force sand through the holes and require dredging. Rehabbed beach structures, such as Casino Pier near 63rd Street Beach, are instead being designed with gates. When water levels are low and bacteria counts could reach unsafe levels, the gates are opened to allow stagnant water to be flushed out. When water levels are higher, the gates can be closed to protect the area from wave action and sand transport. Irregularly shaped stones that create holes for fish shelter have also been added to Casino Pier (Jimenez, 2000).

It is encouraging to note that Chicago's lakefront construction can be manipulated to enhance fish habitat. However, even modified straight wall revetments cannot provide nearly as much

habitat as natural shoreline and dune systems. An evaluation of the potential for rebuilding sustainable wildlife habitat while protecting such a highly developed shoreline is sorely needed. It has been demonstrated at Montrose Beach that, given the right conditions, stable shoreline communities can develop over time. Historically, aquatic construction designs have been aimed primarily at ensuring adequate shoreline protection. Habitat creation and natural area preservation has been a secondary concern following safety, erosion control and navigational needs. Coordination between engineers and aquatic biologists is essential throughout the design phase to assure that potentially habitat-enhancing features are integrated into shoreline protection projects. It is recognized that certain areas of the lakefront experience significant human activity. A balance needs to be achieved between these uses and the opportunity to enhance Chicago's historic natural character.

Conclusions

- The Calumet area wetlands provide extensive habitat recovery opportunities. Citizen groups have identified several large current and former industrial sites that are already serving as habitat for rare species. Cooperation among all levels of government and several local community organizations has provided the potential for development of a long-term plan to integrate wildlife habitat into an urban industrial zone.

- Viable habitat exists mostly in small fragments in northwest Indiana. Dune and swale fragments support a wide diversity of species, but are subject to high stress due to their size. Corridor construction can serve to mitigate some of this stress by allowing wildlife to exploit more than one habitat. It is essential to preserve existing habitats, as dune and swale ecosystems are difficult to create using restoration techniques.

- Most aquatic habitat in the city of Chicago exist as incidental habitat on breakwaters and shoreline revetments. These structures are deteriorating and are currently under repair by the USACE. While some of the new construction can be managed to serve as habitat, natural shoreline habitats employing shallow water and natural vegetation can support more stable and diverse fish populations.

IV. Site Specific Recovery Opportunities

Summit attendees congregated according to their primary geographic area of interest: northern Illinois, Chicago, or Indiana. They were asked to identify specific restoration opportunities within each area.

Northern Illinois

- The South Unit of Illinois Beach State Park is eroding. A sand recycling program in which sand from the south is moved north and allowed to move southward by way of lake currents has been proposed as an alternative to habitat-destroying revetment construction. The project will cost $1 million, but only $500,000 is available. Additional funds are needed to control erosion in a habitat friendly manner. The continuance of a preservation ethic is required in the State Park.

- The City of Waukegan has extensive habitat restoration potential, as much of its degraded lakefront is open and free from structures. Its harbor area can be used a shelter for fish once contaminated sediment cleanup is complete. The Waukegan River can be rehabilitated to provide fish spawning grounds, nursery habitat, and connections to inland wetlands. Funding is again the driving factor. Inclusion by Illinois in the Coastal Zone Management Program could supply funds for this and the above project.
- The bedrock reefs and ravines off of Highland Park may be supplying fish habitat. They need to be studied and mapped, as does the rest of the Lake Michigan bottom, to demonstrate their habitat value. This work is essential to habitat protection from future threats, such as the proposed natural gas pipeline from the Illinois-Indiana border to Milwaukee.

Chicago

- Northerly Island presents a protected embayment, shallow water, non-beach habitat opportunity on the west side of the peninsula. It is essential that this area be delineated as a habitat preserve instead of a heavy traffic park. Planning and stewardship involving community groups, government agencies at the state and federal level and the Chicago Park District is vital.
- Harbors provide valuable fish nursery habitat. These areas could be seeded with aquatic plants to enhance the habitat opportunities. Species lists for flora and fauna that use Chicago harbors as habitats are needed. The Jackson Park Lagoon offers a restoration and education opportunity while the west end of the Calumet Harbor was identified as having shallow water habitat potential. Restoration of the Calumet River may also provide a much-needed fish corridor to inland waters and wetlands.
- Sand dunes and rare plant species are appearing at Montrose Beach. It is essential that managers and beach goers recognize and respect the temporal nature of the dunes and their associated vegetation and animal life. The area was fenced off but is currently unprotected as the Chicago Park District determines a course of action.
- Three golf courses exist near area harbors. Management of these areas must take the health of the lake into account by minimizing the use of fertilizers and pesticides and by turning “rough” areas into native tall grass bird habitats.
- Parkland is currently being used as a storage site for revetment reconstruction equipment. When this equipment is removed, the area should be replanted/seeded with native vegetation.
- Use the Port of Chicago as a study site for recently introduced aquatic exotics.
- A dune and swale system could be constructed on the Morgan Shoals, which are outcroppings off of Chicago’s shore from 47th to 51st Street. It is not known how much area is needed to create a viable system, and it is unlikely that a successful community could be built without continuous management.

Indiana

- The Grand Calumet lagoons and the headwaters of the Little Calumet River and Salt Creek need to be restored. Water flow has been reversed from its original state in some areas. The Natural Resources Damage Assessment program can provide support for

this. Corridors along these waterways need to be included in the Illinois Beach State Park. However, opposition from property owners is expected.

- The Hammond Migratory Bird Trap is underway to provide songbird habitat. Planners are looking into incorporating native plants into the area. Continuing support is needed for this effort.
- The wetlands around the Clark and Pine Preserve are in danger of being filled according to the City of Gary's redevelopment plans. The wetlands will probably be listed as valuable habitats in the plans. A USEPA report of an advanced identification of wetlands in Northwest Indiana is almost complete.

A lake bottom survey was identified as crucial to future restoration efforts in each break out group's assessment.

V. Findings and Recommendations

The southern end of the Lake Michigan shoreline today bears little resemblance to its natural state. The presettlement character of both terrestrial and aquatic habitats has been highly compromised by lakefill along the shoreline, invasion of exotic species, residential and commercial development, and management practices that favor human uses of Lake Michigan resources. Most wetland and shallow nearshore habitats that are essential to fish feeding and spawning have been eliminated or degraded, resulting in a reduction of healthy native fish populations.

Any attempts to develop wildlife habitat along the shoreline faces significant challenges. The economic value of the Lake Michigan fishery has been compromised by industrial contamination. Several exotic species have established a firm foothold on the Lake Michigan ecosystem, forever changing how native species interact with their habitats. Several areas that have restoration potential are divided into sections along political or property lines, necessitating that any feasible solution involve a multitude of stakeholders. Many species are forced to use habitats that also serve as human activity centers. Any detrimental impacts humans have on these areas influences how wildlife are able to use the habitat.

Despite the tremendous impact human activities have had on lakeshore habitats, there is strong potential for future recovery. The Calumet area wetlands on the south side of Chicago are slowly reawakening as wildlife habitat. Several conservation groups across Illinois and Indiana are assisting government agencies in developing a long-term plan to continue rehabilitation of the area. In addition, many small wetland fragments still exist in the dune landscape of northwestern Indiana. The Nature Conservancy is working to connect these fragments into a contiguous habitat for native species.

Even the shoreline of the city of Chicago provides opportunities for habitat development. As Chicago implements its lakefront park planning process and federally supported Shoreline Protection Project, it is essential to incorporate natural habitat features that stabilize the shoreline while building as much habitat as possible into artificial structures.

It is absolutely imperative that what little remains of the natural south Lake Michigan shoreline is preserved intact. This means fostering an understanding of the value of the habitats in Illinois Beach State Park and the state and federal dune parks in Indiana. These habitats should serve as a basis upon which to expand wildlife habitat throughout the Chicago lakefront.

Best efforts should be made to educate government officials of the possibilities for habitat renewal around the lakefront. As our understanding of what constitutes "habitat" undergoes modification, the examples of the Calumet area and the northwest Indiana lakeshore should remind us that wildlife will employ a variety of landscapes as habitat despite their degradation by human activities. We now have the opportunity to integrate human use with wildlife habitat in such a way that they complement each other instead of competing.

VI. Appendices

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Appendix 2: Presettlement Dune Plants and Animals

Association (in order from lake)	Common Plants
beach	sea rocket, bugseed, beach pea, cinquefoil, wormwood, sand thistle, cocklebur
fore-dune	sand reed grass, marram grass, rye grass, winged pigweed, green milkweed, seaside spurge, mullein, sand cherry, furry willow
cottonwood	cottonwood, sand cherry, smooth and glandular willows, bittersweet, horsetail
pine	jack pines, white pines, arbor vitae, red cedar, common juniper, prostrate juniper, bearberry, shinleaf, checkerberry, prince's pine, starflower, flase lily-of-the-valley, bluebells, puccoon, horsemint, hairy phlox, st john's wort, star grass, Solomon's seal, bellwort, wild rose, staghorn sumac, dwarf sumac, aromatic sumac, red-osier dogwood, bittersweet, woodbine, poison ivy, grape
black oak	black and chestnut oaks, sassafras, shadbush, pincherry, chokecherry, hop tree, dwarf blackberry, huckleberry, blueberry, bush honeysuckle, spiderwort, bastard toadflax, anemone, columbine, rock cress, lupine, hoary pea, bush clover, wild geranium, milkweed, flowering spurge, bird's foot, arrow-leaved violets, prickly pear cactus, butterfly weed, green milkweed, wild bergamot, lousewort, blazing star, goldenrods, sunflowers, yellow daisy
mixed oak	black, chestnut, white and red oaks, slippery and red elms, basswoods, beach, hop hornbeam, yellow lady's-slipper, hepatica, May apple, Canada violet, long-spurred violet, rattlesnake root

Association (in order from lake)	Common Animals
beach	crows, herring gulls, flies, predatory ground beetles, sandpiper, piping plover, knots, godwits, curlews, willets, white ants, termites, sand-colored spider
fore-dune	beetles, gnats, flies, dragon flies
cottonwood	tree swallow, locusts
pine	bronze tiger beetle, white ants, locusts, black ant, pitch moth, downy and hairy woodpeckers, golden-crowned and ruby-crowned kinglets, black-throated green warbler, pine warbler (during migration), chickadee, ruffed grouse, red squirrel,
black oak	ruffed grouse, ant lion, six lined lizard, blue racer, hog nose (puffer adder), locusts, grass hoppers, katydids,
mixed oak	earthworms, woodchuck, snails, millipedes, centipedes, bees, wasps, butterflies, crickets, tree toad, red-tailed and red-shouldered hawks, red-headed woodpecker, wood pewee, crow, blue jay, bluebird, least fly catcher, wood thrush, black and white creeping warbler, yellow warbler, gray and fox squirrels

(Downing, 1922)

Appendix 3: Fish found at South Lake Michigan Harbors

Common Name	Latin Name	Common Name	Latin Name
Alewife	*Alosa pseudoharengus*	Brown bullhead	*Ameiurus nebulosus*
Gizzard shad	*Dorsoma cepedianum*	Channel catfish	*Ictalurus punctatus*
Coho	*Onchorynchus kisutch*	Troutperch	*Percopsis omiscomaycus*
Rainbow trout	*Onchorynchus mykiss*	Burbot	*Lota lota*
Chinook	*Onchorynchus tshawytscha*	3-spine stickelback	*Gasterosteus aculeatus*
Lake trout	*Salvelinus namaycush*	9-spine stickelback	*Pungitius pungitius*
Brown trout	*Salvelinus trutta*	White perch	*Morone americana*
Rainbow smelt	*Osmerus mordax*	White bass x Striped bass hybrid	*Morone chrysops x M. saxatilis*
Northern pike	*Esox lucius*	Rockbass	*Ambloplites rupestris*
Goldfish	*Carassius auratus*	Green sunfish	*Lepomis cyanellus*
Common carp	*Cyprinus carpio*	Pumpkinseed	*Lepomis gibbosus*
Golden shiner	*Notemigonus crysoleucas*	Warmouth	*Lepomis gulosus*
Spottail shiner	*Notropis blennius*	Bluegill	*Lepomis macrochirus*
Emerald shiner	*Notropis atherinoides*	Redear sunfish	*Lepomis microlophus*
Bluntnose minnow	*Pimephales notatus*	Smallmouth bass	*Micropterus dolomeui*
Fathead minnow	*Pimephales promelas*	Largemouth bass	*Micropterus salmoides*
Longnose dace	*Rhinichthys cataractae*	Black crappie	*Pomoxis nigromaculatus*
Longnose sucker	*Catostomus catostomus*	Yellow perch	*Perca flavescens*
White sucker	*Catostomus commersoni*	Walleye	*Stizostedion vitreum*
Lake chubsucker	*Erimyzon sucetta*	Drum	*Aplodinotus grunniens*
Silver redhorse	*Moxostoma anisurum*	Mottled sculpin	*Cottus bairdi*
Golden redhorse	*Moxostoma erythrurum*	Round goby	*Neogobius melansotomus*
Shorthead redhorse	*Moxostoma macrolepidotum*		

Performed by the Army Corp of Engineers from 1992 to 1998.
(Moy, 1994)

Appendix 4: Web Resources

Agency	Address	Comments
Aquatic Plant Management Society	www.apms.org	exotic plant fact sheets
Army Corps of Engineers	www.wes.army.mil	Waterways Experiment Station, links to various publications
Calumet Environmental Resource Center	www.csu.edu/cerc	links to organizations, description of library services
Center for Aquatic and Invasive Plants	aquat1.ifas.ufl.edu	pictures of plants and birds
Illinois Natural History Survey	www.inhs.uiuc.edu/cwe/rra/rra.html	Inventory of Resource Rich Areas in Illinois
Lady Bird Johnson Native Plants	www.wildflower.org	search by state or plant name for native plants, includes habitat information
Michigan Department of Environmental Quality	www.deq.state.mi.us/lwm/grt percent5Flakes/czm/czm.html	Michigan Coastal Management Program
Michigan Sea Grant Program	www.engin.umich.edu/seagrant/wetlands/michigan.html	Lake Michigan wetlands
State of Wisconsin Department of Administration	www.doa.state.wi.us/dhir/boir/coastal	Coastal Management Program
National Oceanic and Atmospheric Administration	www.ocrm.nos.noaa.gov/czm www.ocrm.nos.noaa.gov/czm/czmindiana.html	Coastal Zone Management Program Indiana Coastal Resources Program
US Congress	http://thomas.loc.gov/home/c106query.html	Conservation and Reinvestment Act (search from this page)
US Department of Agriculture	plants.usda.gov/plants	native plants database, search by state, look for threatened and endangered plants
USEPA Office of Water SOLEC	 www.epa.gov/owow/wetlands/restore www.epa.gov/grtlakes/solec/96/coastal/index.htm	 River Corridor and Wetland Restoration Program state of Lake Michigan wetlands

USFWS	http://www.nwi.fws.gov http://www.fws.gov/cep/coastweb.html http://news.fws.gov/NewsRelease/SearchDisplay.cfm?ID=267 http://plover.fws.gov	National Wetlands Inventory Coastal Habitat Conservation Programs Piping Plover Critical Habitat Designation
USGS Great Lakes Science Center Northern Prairie Wildlife Research Center	http://www.glsc.nbs.gov/information/atlas/index.htm www.glsc.nbs.gov www.npwrc.usgs.gov	Atlas of the Spawning and Nursery Areas of Great Lakes Fish restoration, fish and ecosystem surveys biological resources
U of W-Madison Center for Restoration Ecology	www.ies.wisc.edu/cre	describes restoration projects and challenges

Appendix 5: Funding Sources

Name	Funder	Description	For More Information
Great Lakes Aquatic Habitat Network and Fund	Tip of the Mitt Watershed Council	small organizations for advocacy and education in Great Lakes states/provinces	http://www.glhabitat.org
The Coastal Program	US Fish and Wildlife Service	coastal states, including Great Lakes, conserve fish and habitats, balance with ecologically sound levels of public use, economic benefits, and enjoyment of natural resources, $15 million available next year. Funds from excised taxes on small engine fuels through the Coastal Wetlands Planning, Protection, and Restoration Act. Only state governments eligible.	http://www.fws.gov/cep/cepcode.html
North American Wetlands Conservation Act Grants	US Fish and Wildlife Service	wetlands and associated uplands habitat protection, restoration, or enhancement. Funds from excise taxes on small engine fuels, $10 million available for coastal wetlands, $5 million for inland wetlands	http://northamerican.fws.gov/NAWCA/granpro.html
Migratory Bird Conservancy	National Fish and Wildlife Foundation	program goal: raise $500,000/yr from businesses and birders, funds will be invested in habitat projects that benefit birds	http://www.nfwf.org/mbcpage.htm
Challenge Grants	National Fish and Wildlife Foundation	conservation projects to federal, state, local gvrnts., educational institutions, and nonprofit organizations, targets protection and restoration on private lands and sustainable community development	http://www.nfwf.org/guidelines.htm
Ecological (Habitat) Protection and Restoration	USEPA GLNPO	assist partners by funding activities which demonstrate new and innovative practices & tools for protecting and restoring aquatic, terrestrial, and wetland habitats. Goals for Lake Michigan basin include: demo of brownfield to habitat restoration, protection and restoration of sand dunes with native vegetation, and protection of critical habitats (wetlands) from destruction	http://www.epa.gov/glnpo/fund/2000guid/appendix2.html#Ecological http://www.epa.gov/glnpo/fund/glf.html
Wildlife Habitat Incentive Program (WHIP)	Natural Resources Conservation Service, USDA	Cost-share payments to owner, landlord, operator, tenant of eligible lands for improvement of aquatic habitats with obstruction removal, fish passages, stream bank stabilization, invasive plant control	http://aspe.os.dhhs.gov/cfda/p10914.htm http://epa.gov/glnpo/fund/Tables/nrcs.html

Wetland Reserve Program (WRP)	Natural Resources Conservation Srvc, USDA	provide technical and financial support to help landowners with their wetland restoration efforts	http://epa.gov/glnpo/fund/Tables/nrcs.html
State Wetland Protection Grants	USEPA	assist state and tribal governments to develop new or refine existing wetlands protection programs	http://www.epa.gov/grtlakes/seahome/resources/funding-details2000.htm#Wetlands
Northeastern Illinois Wetlands Conservation Account	The Conservation Fund in cooperation with the Chicago Metro Office of the USFWS, USACE, US Justice Dpt.	restoration, preservation, creation of wetlands in six IL ne counties, matching grants to local groups, emphasize development of urban wetlands, restoration, conservation of degraded area, funded by penalties imposed when Section 404 violations occur, restorations are to offset infractions, government agencies, private landowners, and non-profit conservation organizations	http://www.conservationfund.org/conservation/features/wetlands.html http://www.conservationfund.org/conservation/features/niwca.html http://homepage.interaccess.com/~niwca
River Corridor and Wetland Restoration: Five-Star Restoration Program	USEPA Office of Water	citizen & youth groups, corporations, students, landowners, gvmt agencies, restore stream banks and wetlands, challenge grants, technical support, peer information exchange, on-the-ground restoration component, long term ecological, educational, or social benefits to communities	http://www.epa.gov/owow/wetlands/restore/5star/5strblk.html
Beneficial Use of Dredged Material Funding	US Army Corps of Engineers	state and local governments and non - profit groups, protect, restore, enhance aquatic habitat using dredged material from federal projects	http://www.epa.gov/glnpo/fund/Tables/usace.html
Aquatic Ecosystem Restoration Funding	US Army Corps of Engineers	state and local governments and non-profit groups, plan, design, construct aquatic ecosystem restoration, protection projects	http://www.epa.gov/glnpo/fund/Tables/usace.html
Restoration of Environmental Quality Funding	US Army Corps of Engineers	state and local governments, non-profit groups, modify Corps structures to restore env. quality	http://www.epa.gov/glnpo/fund/Tables/usace.html
Flood Mitigation & Riverine Restoration Funding	US Army Corps of Engineers	state and local governments, develop flood protection projects that restore natural functions of floodplains and enhance habitat	http://www.epa.gov/glnpo/fund/Tables/usace.html
Natural Resources Damage Assessment		supplemental environmental projects	

Appendix 6: Glossary

lacustrine--aquatic sites with sparse vegetation associated with a lake or pond.

littoral transport--movement of sand and sediment by lake currents.

palustrine--wetlands with a dense stand of cattails, trees, or other persistent vegetation.

riverine--aquatic sites with sparse vegetation associated with a stream or river.

Appendix 7: Participating Organizations

Aquatic Research Institute
Biology Department, Loyola University
Bird Conservation Network ^
Cass Conservation District
Charles Stewart Mott Foundation
Chicago Audubon Research Committee
Chicago-Kent School of Law, Program in Environmental and Energy Law
Chicago Park District ^
Chicago Sportfishing Association
Chicago Wilderness Magazine
City of Chicago Committee on Energy, Environment, and Public Utilities
City of Chicago Committee on Parks & Recreation
City of Chicago Department of Planning and Development ^
City of Chicago Department of the Environment * ^
Ducks Unlimited
Forest Preserve District of Cook County ^
Forest Preserve District of DuPage County *
Fort Dearborn Audubon ^
Friends of the Chicago River
Friends of the Marine Community ^
Friends of the Parks ^
Gaylord & Dorothy Donnelley Foundation
Grant Park Advisory Council
Great Lakes Boating Magazine ^
Great Lakes Environmental Research Laboratory
Great Lakes Fishery Commission
Illinois Department of Natural Resources, Lake Michigan Fisheries Program
Illinois-Indiana Sea Grant # * ^
Illinois Natural History Survey # *
Illinois State Geological Survey * ^
Indiana Department of Natural Resources
Indiana Dunes Environmental Learning Center ^
Jackson Park Advisory Council ^
John G. Shedd Aquarium # ^
Lake View Citizens' Council ^
Loyola University, Department of Biology
National Park Service ^
Northeast Illinois Planning Commission ^
Northwestern University, Civil Engineering Department ^
Northwest Indiana Regional Planning Commission
Openlands Project *
Purdue University Calumet, Department of Biological Sciences
Save the Dunes Council ^
Smith Group JJR ^

Southwest Michigan Land Conservancy
The Field Museum
The Nature Conservancy Great Lakes Program # ^
The Nature Conservancy, Southern Lake Michigan Rim Project *
The Nature Museum, Chicago Academy of Sciences ^
Trout Unlimited
University of Illinois at Chicago, Great Cities Initiative ^
University of Notre Dame, Department of Biological Sciences
US Environmental Protection Agency, Great Lakes National Program Office ^
US Environmental Protection Agency, Water Office ^
US Fish and Wildlife Service * ^
US Geological Survey, Great Lakes Science Center

official collaborator * presenter ^ steering committee member

LAKE MICHIGAN FEDERATION

Citizen Action to Protect a Great Lake

www.lakemichigan.org