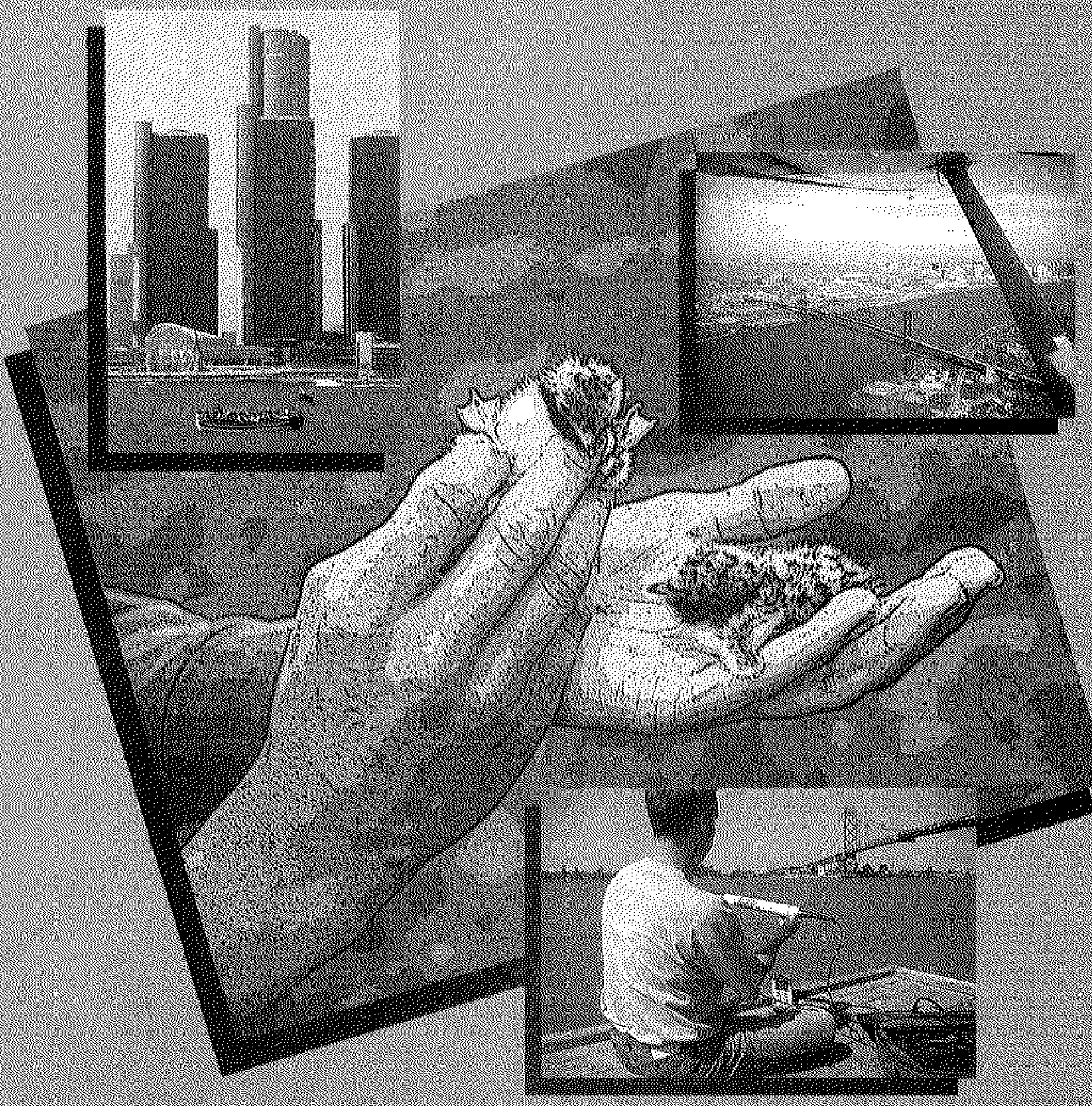
STATE of the STRAIT

STATUS and TRENDS of the DETROIT RIVER ECOSYSTEM



Conference Proceedings

2001

State of the Strait:

Status and Trends of the Detroit River Ecosystem

Proceedings

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University of Windsor

Hosts

GREAT LAKES INSTITUTE
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Cover Photos: Black and white image of common tern held by Robert Bull on Mud Island, 1972 (James Bull, Detroit Audubon Society); upper right: aerial view of Detroit River showing Ambassador Bridge through aeroplane struts (Todd Leadley, GLIER, University of Windsor); upper left: Detroit 300 celebration on the Detroit River with Renaissance Center towers in background (Dave Brenner, Michigan Sea Grant); lower right: scientist using hydrolab showing Ambassador Bridge in background (Todd Leadley, GLIER, University of Windsor)

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Executive Summary

The *State of the Strait* Conference was held at the University of Windsor on March 27, 2001 as one of the year-long events celebrating the 300th anniversary of European settlement in the Detroit-Windsor area. It brought together Canadian and U.S. researchers, natural resource managers, policy makers, students and concerned citizens to review the status and trends of the Detroit River ecosystem. Invited speakers and panelists shared information on historical uses of the river, as well as long-term environmental changes and current ecological conditions. Members of the the audience heard about the exciting potential for rehabilitation of the river's ecosystem that both complements and encourages economic sustainability. For example, U.S. Congressman John D. Dingell unveiled landmark conservation legislation introduced in Congress that same day. If passed, the Detroit River International Wildlife Refuge Establishment Act will create a refuge along the Detroit River and allow the U.S. Secretary of the Interior to cooperatively manage wildlife habitat for conservation and recreation. The proposed refuge would result in the first international refuge in North America, conserve unique and valuable resources and add perspective to the balance among economic, social and environmental uses of the river. This legislation will also demonstrate how governments and local officials in the United States and Canada can work as a team with businesses, conservationists and citizens to create something special that will improve the quality of life for all people in the region.

Major findings of the *State of the Strait* Conference Steering Committee follow:

- We need to follow through and actively support the binational designation of the Detroit River as an international wildlife refuge and simultaneously take action to conserve and rehabilitate key habitats consistent with habitat priorities established by the U.S. Geological Survey and the Essex Region Conservation Authority;
- Management agencies must ensure that a systematic and binationally-coordinated Detroit River monitoring program is in place and that it targets specific management issues and goals (particular emphasis should be placed on indicator species and restoration criteria for beneficial uses);
- Universities, government agencies and businesses should offer the Detroit River as a case study for preparation of a quantitative ecosystem indicator report to be developed in the next two years (consistent with State of the Lakes Ecosystem Conference reporting promoted by Environment Canada and the U.S. Environmental Protection Agency);
- Communities and businesses must continue to support waterfront redevelopment and greenway projects that attract more people to the Detroit River, help people gain a greater appreciation for this historical, cultural, ecological and economic asset, and help build broad-based support for further rehabilitation and conservation efforts, consistent with the principles of new urbanism and sustainable development;
- Management agencies, businesses, and universities must continue to cooperate on ecosystem-based management of the Detroit River, including seeking and supporting the ways and means of restoring fisheries and other aquatic resources by promoting sustainable fisheries practices, preventing the introduction of invasive species, identifying and eliminating sources of water and sediment pollution, and rehabilitating fishery habitat wherever waterfront redevelopment, shoreline protection, and navigational aids are being planned and implemented; and
- All universities, management organizations and government agencies should buy into and support a binational Detroit River data archive and clearinghouse to support coordinated management efforts as has been developed by the Great Lakes Institute for Environmental Research at the University of Windsor, i.e. the **D**etroit **R**iver **D**ata **R**etrieval, **E**xchange, **A**rchival, and **M**anagement **S**ystem.

Acknowledgments

The *State of the Strait* Steering Committee wishes to thank everyone who helped make the conference a success. We are especially appreciative of our cosponsors: Environment Canada, the United States Environmental Protection Agency, the Ontario Ministry of the Environment, the Michigan Department of Environmental Quality, the Canadian Consulate (Detroit), Michigan Sea Grant — MSU Extension, the University of Windsor, the University of Michigan — Dearborn, the City of Windsor, the Detroit Water and Sewerage Department, Windsor Port Authority, Essex Region Conservation Authority, Wayne County Department of the Environment, Detroit Edison — a DTE Energy Company and BASF. The Steering Committee also wishes to thank University of Windsor President, Dr. Ross Paul, His Worship Mayor Michael Hurst, Mr. Peter Stroh, Chair of the Executive Committee of the Greater Detroit American Heritage River Initiative and Congressman John Dingell for their gracious welcoming remarks, and Mr. Heath Meriwether for his visionary keynote address. Our moderators, John Hartig, Orin Gelderloos and Mark Breederland did an admirable job of keeping the day running on time. Finally, the Steering Committee wishes to acknowledge the hard work of our volunteers — Mark Whelley, Harold Beth, J.C. Barrette, Sarah Bandoni, Julianna Borbely, Elizabeth Filatre, Wasi Pramono and Denis Roy. Thanks for all your cheerful help!

Introduction

The Detroit River is a 32-mile strait or connecting channel, linking the upper Great Lakes to the lower Great Lakes. Native Americans were first attracted to the Detroit River as a source of sustenance, transportation and communication. The potential for trade and commerce brought European explorers up the St. Lawrence River system to our region. Although a number of French explorers travelled along the Detroit River during the late 1600s, it was not until 1701 that Antoine de la Mothe Cadillac established a settlement on a bluff that provided an unobstructed view of both the upstream and downstream portions of the river. From that modest beginning arose the urban centres we see today. The Detroit River was central to the growth and development of the Greater Detroit-Windsor Region; it enabled and supported the fur trade, ship building, the automobile, and the steel and chemical industries, among others.

The 2001 tricentennial provides a unique opportunity for us to recognize the historic achievements of the people of Detroit and Windsor, achievements that will provide the foundation for our future. Detroit 300 is a binational, year-long celebration of our history, culture, ethnic diversity, natural resources, commerce and trade. It is a time to celebrate and reflect on:

- the past — the unique and powerful history of the Detroit-Windsor area and its peoples, industries, arts and culture;
- the present — the progress and current state of our region, including a new, positive image of Detroit for local, national and international audiences; and
- the future — the opportunity to leave a permanent legacy for future generations.

Informed by the spirit of the Detroit 300 celebration, the *State of the Strait* conference was convened on March 27, 2001 at the University of Windsor across the river from where Cadillac established his settlement. A binational steering committee composed of representatives from universities, businesses and government agencies on both sides of the border organized the conference. It was hosted by the Greater Detroit American Heritage River Initiative and the Great Lakes Institute for Environmental Research (GLIER) at the University of Windsor. Co-sponsors included Environment Canada, the U.S. Environmental Protection Agency, the Ontario Ministry of Environment, the Michigan Department of Environmental Quality, the Canadian Consulate-Detroit, Michigan Sea Grant-MSU Extension, the University of Windsor, the University of Michigan-Dearborn, the City of Windsor, the Detroit Water and Sewerage Department, the Windsor Port Authority, the Essex Region Conservation Authority, the Wayne County Department of Environment, Detroit Edison a DTE Energy Company and the BASF Corporation. See Appendix One for the conference agenda. Appendix Two is a list of conference attendees.

The *State of the Strait* conference was held in conjunction with *Lake Erie in the Millennium* in an effort to establish stronger science and management linkages between the Detroit River and Lake Erie. As part of *Lake Erie in the Millennium*, the International Joint Commission sponsored a session titled *Frameworks for Modelling Ecological Change in the Detroit River-Lake Erie Corridor*.

Keynote Address

Heath Meriwether
Publisher, Detroit Free Press

Mr. Heath Meriwether is publisher of the Detroit Free Press, a board member of Detroit 300 and an active member of the Greater Detroit American Heritage River Initiative's Business-Industry Group. He is inspired by the collective community vision of revitalizing the Detroit waterfront and is dedicated, along with a variety of other leaders, to working toward a brighter future for those of us living along this 51 kilometre (32 mile) urban river. Highlights of his address are presented below.

Journalists joke that all it takes to make a trend is three related developments on the same topic. Using that standard, what's happening on the Detroit River isn't just a trend, it's a phenomenon — with at least ten major initiatives and hundreds of millions of dollars dedicated to preserving and enhancing our most visible and important natural resource.

More importantly, it means that the 32-mile stretch of water that we've turned our back on for most of the last century is finally being perceived as the spectacular front porch it should become in our future.

The river was in the news last week on two fronts: Detroit Mayor Dennis Archer announced recently that a planned riverfront casino-hotel district won't happen because of land acquisition costs. Instead, only one of Detroit's casinos, the MGM Grand, will move there, but the city will pursue land around it for parks and open green space. That was a welcome development. Today, almost 300 civic leaders, elected officials, biologists, engineers and environmentalists have gathered at the University of Windsor to consider the "State of the Strait." A key conclusion is that things are looking up, especially considering the neglect and pollution this waterway endured in the previous century.

For me, the conference signals what a once-in-a-lifetime opportunity we have in southeast Michigan to restore the waterway that lies at the centre of our history, and will be the focus of attention this summer when Detroit celebrates its 300th birthday. There could be no more lasting birthday present to ourselves as a community than to create a cleaner, richer future for the river that carried Antoine de la Mothe Cadillac and his canoes here on July 24, 1701.

The momentum and signs of progress are all around us. Consider what's already going on — workers are labouring feverishly to finish the $6.2-million promenade along the river from General Motors' international headquarters at the Renaissance Center to Joe Louis Arena. Millions of people will come to the water and the new promenade in July for the city's huge birthday celebration, including celebrity homecoming concerts, the parade of tall ships and the reenactment of Cadillac's landing near what is now Hart Plaza.

Next to the promenade, GM is literally turning its headquarters' front door to the water, with a massive $500-million redevelopment. The five-story, glass-enclosed public space, called the WinterGarden, with magnificent vistas of the river, will be ready later this year. But while GM's project is the headliner, the Greater Detroit American Heritage River Initiative and the Metropolitan Affairs Coalition have recently highlighted 13 other greenway projects, ranging from a $340,000 bike path on the Woodruff Corridor in Downriver's Brownstown Township east to a $2.3-million improvement at Detroit's Maheras/Gentry Park with walkways and a fish habitat. When completed, these projects will provide connections to open space, protection for our natural resources and panoramic views of the river.

The American Heritage River designation, championed by businessman Peter Stroh and pushed by U.S. Representative John Dingell, (D-Dearborn) has allowed Detroit River navigator John Hartig and the Metropolitan Affairs Coalition to provide essential coordination for communities and businesses along the river. John Hartig and Peter Stroh also have been invaluable in encouraging riverfront businesses to get involved. National Steel, for example, recently donated Mud Island, in the Detroit River, to the U.S. Fish and Wildlife Service.

The GreenWays Initiative of the Community Foundation for Southeastern Michigan has become a national model for how a community can come together to support greenways that connect communities. More than $14 million has been raised from private organizations, $10 million of which is from the Kresge Foundation, toward a goal of $25 million. That money, in turn, will be used to leverage another $50 million in public dollars. It promises to help not only bolster riverfront greenways but link communities throughout southeast Michigan.

The Rouge River Gateway Project, a collaborative effort of several governments, nonprofit organizations and businesses, promises not just to clean up the once hopelessly polluted Rouge River, but to redevelop the land around it for recreation and preservation.

The National Automotive Heritage Trail, while not focussed solely on the river, will also help enhance efforts along the Rouge and at the mouth of the Detroit River.

The Belle Isle masterplan, just released by Detroit, provides a $180-million blueprint to restore this extraordinary 982-acre park to its rightful place as the crown jewel of the Detroit River. While it faces major political challenges in its proposed fees for users, it's the most comprehensive plan yet to address the crisis of neglect on Belle Isle. Historic Fort Wayne, which has been closed to the public for ten years, will be open for Detroit's 300th birthday celebration, and there are behind-the-scenes discussions aimed at getting it reopened, fulfilling one of the goals of the Wayne County parks millage of 1996.

What all these projects tell me is that it's time to seize the moment. With all the attention focussed on the river this year, we need to make sure this isn't just a one-time effort, but a continuing catalyst for making the river a place to gather, to renew community and to make this a great place to live, work and play.

Our future depends on it!

Special Address

John D. Dingell
U.S. Congress, 16th District

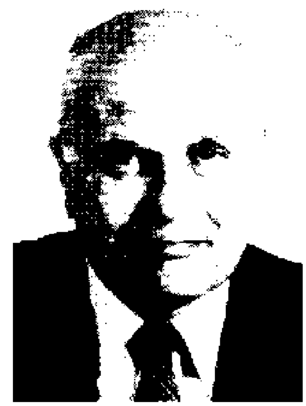
U.S. Congressman John D. Dingell, who represents the 16th District of Michigan in the U.S. House of Representatives, has served more consecutive terms than any other Congressman. He is the Ranking Member on the Commerce Committee. Congressman Dingell has long been a champion of preserving our natural resources and enhancing our quality of life. In 1960 he was responsible for creating the Wyandotte National Wildlife Refuge in the Detroit River and has been instrumental in writing every major law to improve air quality standards, including the Clean Air Act of 1990. Further, he has been spearheading efforts to fund the Rouge River cleanup and the Greater Detroit American Heritage River Initiative, and currently serves on the Migratory Bird Conservation Commission.

At the *State of the Strait* conference, Congressman John Dingell announced he was introducing legislation that same day to create an international wildlife refuge for the lower Detroit River. He noted that the Detroit River has long been an under-appreciated and under-utilized resource. Its modern history has been as an industrial river serving an industrial town. Although approximately 95 percent of the original coastal wetlands have been lost to development, the river is home to 29 species of waterfowl and 65 kinds of fish.

The Detroit River is an important waterfowl migration corridor at the intersection of the Atlantic and Mississippi flyways. An estimated three million ducks, geese, swans and coots migrate annually through this region. The Canada-United States North American Waterfowl Management Plan has identified the Detroit River as part of one of 34 Waterfowl Habitat Areas of Major Concern in the United States and Canada, i.e. lower Great Lakes-St. Lawrence basin. In addition, marshes along the lower Detroit River and northwest Ohio have been declared part of a Regional Shorebird Reserve by the Western Hemispheric Shorebird Reserve Network.

In 1998 the Canada-U.S. State of the Lakes Ecosystem conference identified the Detroit River-Lake St. Clair ecosystem as one of 20 Biodiversity Investment Areas in the Great Lakes basin ecosystem because it supports an exceptional diversity of plants, fish and birds, and the requisite habitats to support them. The diversity of biota and habitats in the lower Detroit River benefits the more than five million people who live near it. Millions of dollars in economic benefits accrue from hunting, fishing, birding, photography and other recreational uses.

This new legislation would set aside the lower 29 kilometres (18 miles) of the Detroit River for wildlife conservation and recreation. A similar effort is underway in Canada that would result in the first international wildlife refuge in North America. The legislation introduced in the United States would specifically prohibit any taking of private property for the refuge. Private landowners will be asked to participate voluntarily. Property owners will have the option of managing their lands in support of the wildlife refuge, selling their property to the reserve, placing their land in the reserve while retaining ownership, or keeping the property and developing it as they had planned. Again, recreational use will be encouraged and the refuge will not interfere with navigational use. Congressman Dingell noted that this cooperative effort to establish and manage an international wildlife refuge for the lower Detroit River was an important step toward conserving our natural resource assets and sustaining the quality of life that attracts so many people to the Detroit River corridor.



John D. Dingell, Representative, 16th District, U.S. Congress (photo courtesy

Message from Deputy Prime Minister Herb Gray

The Honourable Herb Gray is a native Windsorite and a graduate of McGill University and the Osgoode Hall Law School. He was initially elected to Parliament in 1962 and has been re-elected in all subsequent federal elections. His riding takes in a large part of the City of Windsor. Mr. Gray has served in several governments, variously as Minister of Parliamentary Affairs, Economic and Industrial Development, Finance, Consumer Protection and Competition, International Trade and Foreign Investment. In 1993 he was appointed Leader of the Government in the House of Commons and Solicitor General of Canada. In 1997 he was appointed Deputy Prime Minister of Canada.

Deputy Prime Minister and Windsor MP, Herb Gray (Photo courtesy Dave Brenner, Michigan Sea Grant)

Unfortunately, pressing Parliamentary duties in the House of Commons prevented Mr. Gray from attending the *State of the Strait* conference, but he did send a message that was delivered by a steering committee member. Mr. Gray noted that he was pleased to see the university-led consortium of partners from both sides of the Detroit River coming together to share knowledge and insights about environmental quality, status and trends.

He noted that the Government of Canada has supported efforts to preserve and enhance the river's natural environment and recognized that reviewing the "state of the strait" is an essential part of these efforts. The Government of Canada remains committed to working with its U.S. neighbours, through local universities and coalitions such as the Detroit River Canadian Cleanup Committee, not only to enhance our understanding of the river, but also to promote our capacity to address its challenges. Mr. Gray acknowledged that the Detroit River provides an important focus -- economic, social and environmental -- for the communities that border its banks and emphasized that he looks forward to reviewing the findings of the *State of the Strait* conference.

Detroit River: Yesterday, Today and Tomorrow

Jennifer Read
Great Lakes Institute for Environmental Research
University of Windsor
Windsor, Ontario

The Detroit River today is fundamentally different from the river that Cadillac sailed up three hundred years ago and yet it is the same river. It lies at the heart of the Laurentian Great Lakes, completing the last leg of the connecting channel between lower Lake Huron and western Lake Erie. The river is 51 kilometres (32 miles) long, rushes by at approximately 5,208 cubic metres/second (186,000 cubic feet/second) and falls about one metre (three feet) over its length. All of these attributes it had 300 years ago, and yet Cadillac would not recognize the Detroit River today. And the First Nations people who greeted him would be angered and confused by the state of the strait. Where are the whitefish and sturgeon? Where are the wetlands, inlets and small streams? Where are the deer and bison, the otter and mink? Where are the trees and grasses and prairies? What are these great, steel boats? What is all that noise? And what is that smell?

The same river, yet different: this paradox highlights two concepts I want to explore today — continuity and change. I want you to think about the river in a new way for a moment. It is not just the sum of its physical attributes, not merely a river through space. Today I want you to think about it as a river through time. And in so doing, I want you to consider that the river has always been the determining factor in the economic and social development of the watershed. That's the river as continuity, the thread connecting us to the past. But, I also want to talk to you about change and how our understanding of and attitude toward the river have evolved over the past 100 years or so. In these two concepts are some things to keep in mind as we move forward with our current and future efforts to restore the strait.

Location, Location, Location: The Detroit River as Cohesive Thread

The Detroit River has always been the key influence on the people who live along its banks. The First Nations people who lived in the watershed settled here because of advantages offered by the river. It provided them immediate access to an efficient regional transportation network composed of the rivers, connecting channels and the Great Lakes themselves. This was an especially important consideration as the Wyandot, Weshnabek and Adawe peoples were all accomplished traders. In addition to transportation needs, the rich soil and plentiful fish, bird and animal populations of the watershed provided them with everything they needed to live or the means to trade for it (Malinowski and Sheets 1998; Reddy 1993).

For the French, the Detroit River provided an opportunity to maintain sole access to the furs of the upper lakes and the north-west. The location of Fort Ponchartrain on the Detroit River had two advantages. On the macro level, the river was mid-way along a chain of real and imagined outposts between the St. Lawrence and Mississippi rivers, whose purpose was to keep English trade rivals out of the region. On a micro level, the fort was located on a large prairie, obviating the need to clear a building site and providing the French with an expansive view of the river.

The French emphasis on furs and the fur trade kept the watershed, and the entire upper Great Lakes, relatively free of European settlers while they controlled the region. At the time of the British Conquest of New France, in 1759, there were fewer than 1,400 people living in the vicinity of Fort Ponchartrain. By the end of the 19th Century, a little over 100 years later, there were well over 350,000 people living in the watershed, over 300,000 alone in greater Detroit. Not only that, where the watershed had been a single British colonial possession in 1759, by 1900 it was divided between two new North American nations — Canada and the United States (Farmer 1890; Schoolcraft 1820; Atlas of Essex Co. 1880).

The Detroit River's location and attributes were the primary factors responsible for this incredible growth. One of the most attractive aspects of settling along the river was easy access to regional markets at Detroit, Sandwich and Amherstburg, as well as proximity to the newly emergent transportation network in the Great Lakes basin.

The opening of the Erie Canal in 1825 and the Welland Canal four years later, brought an influx of settlers to the Great Lakes. Drawn by the lure of inexpensive or free land, tens of thousands of people a year poured into the region. The need to move all these people into the region and get the resources they extracted to markets on the east coast and Europe, created a boom in commercial transportation. First wind, then steam, powered the passenger and cargo vessels on the Great Lakes. Over the course of the 19th and 20th Centuries, improvements to navigation, innovative ship design and low freight costs greatly enhanced the region's economy. Today the 8,000 plus ships that annually traverse the river help make the Detroit River one of the busiest commercial waterways in the world (Ashworth 1986; Baellert pers. communication 2000).

The river provided impetus for industrial growth as well. Early industrial development occurred along the riverfront where enterprising capitalists from both countries took advantage of transportation opportunities and an abundant supply of clean, raw water. Beginning in the 1850s, and accelerating after the turn of the century, foundries, chemical and pharmaceutical companies, and distilleries began to operate on both sides of the river. Enterprises such as the Michigan Car Company, the Russell Wheel Foundry, Park Davis and Company, and Hiram Walker fueled the early industrial development of the region (Farmer 1890). Henry Ford sealed Detroit and Windsor's industrial destiny when he opened his automobile plant in 1914. The river provided cheap transportation for both raw materials and finished goods; it was the source of raw water used in manufacturing processes and it provided an inexpensive means for effluent disposal.

As Europeans evolved into North Americans, they too transformed the Detroit River watershed. Throughout the first 200 years of the evolutionary process just outlined, the river provided the common, focal thread. It was arguably the most influential factor in decisions relating to settlement and riparian use, whether those decisions were related to the fur trade, access to the watershed's bountiful natural resources and rich farmland, or the opportunity to exploit the water supply, cheap labour and efficient transportation.

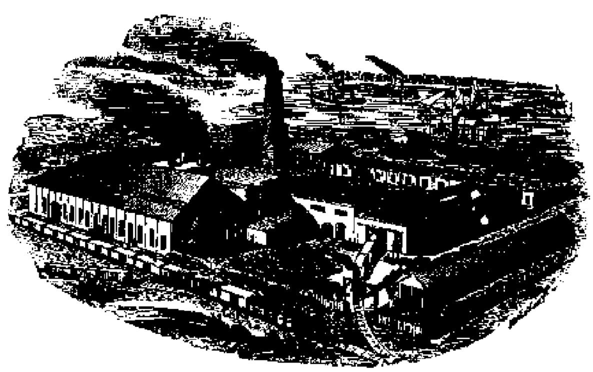
From Sink to Mirror: Our Changing Relationship with the Detroit River

While the Detroit River provided the primary thread of continuity throughout the first 200 years of settlement, we have had a dynamic relationship with the river itself. The most obvious manifestation of this evolution is the way in which our understanding of and attitude toward the river has changed, especially over the last 100 years. Initially, people believed that the river, and everything in the watershed, should be shaped to serve human ends. We now recognize that it is our own uses of the watershed that must be managed if we are ever to restore and protect its natural integrity. One excellent example of this intellectual evolution is the way in which our understanding of the river's assimilative capacity has changed and continues to evolve.

The first hint of what would become a large-scale use of the river's assimilative capacity occurred in 1824 when the Detroit City Council assumed the power to construct sanitary sewers. By 1890 there were 376 km (235 miles) of trunk and connector sewers emptying raw human waste directly into the Detroit River. Although today we consider the release of substantial amounts of raw sewage as a significant danger, it drew few comments at the time. After all, before the turn of the 20th Century, it was commonly believed that running water purified itself.

The waterborne disease statistics, however, tell another story. By the turn of the 20th Century typhoid fever menaced communities along the river. It was only after public health officials installed plants to chlorinate municipal water supplies that disease rates declined. The release of raw sewage, however, did not decline. A 1918 report by the International Joint Commission indicated that all the connecting channels, including the Detroit River, were heavily polluted. They were "unsightly, malodorous, and absolutely unfit for domestic purposes" and posed considerable danger to the public (IJC 1918). By 1918, the Detroit River received the untreated sewage from almost 900,000 people. At Amherstburg the colon bacillus, *B. Coli.*[1] count reached over 1,000 organisms per cubic centimeter when anything over 20 was considered polluted (IJC 1918).

A follow-up study in 1948 found bacteria levels three to four times higher than in 1918 even though 86 percent of sewage now received primary treatment. Clearly this treatment was not enough to address the problem. And investigators found an even more disturbing change. By 1946 the volume of industrial pollution had surpassed the amount of domestic sewage being released into the connecting channels. After World War II, the average daily discharge of industrial effluent was more than two billion U.S. gallons, compared with 270 million gallons of mostly treated municipal sewage. The study found the lower Detroit River to be one of the most degraded areas anywhere in the Great Lakes basin (IJC 1951).



Russel Wheel and Foundary Co. (1880) (Image: Farmer 1890)

The IJC recommended improved treatment of municipal and industrial effluent. It also recommended adopting general and specific water quality objectives describing overall water quality and establishing concentration limits for specific pollutants (IJC 1951). Although this report indicated that the Detroit River could no longer assimilate unlimited amounts of municipal and industrial effluent, water resource agencies responsible for the river continued to rely on its assimilative capacity as the primary means for managing pollution.

By the middle of the 1960s, the consequence of relying on the Detroit River's assimilative capacity could no longer be ignored. During the summer of 1964, 2,072 square km (800 square miles) of Lake Erie was covered in an algal bloom attributed to elevated levels of phosphorus inputs from sewage and agricultural runoff. Fish and duck kills and oil spills had become increasingly common along the river. The obvious environmental insults here, elsewhere in the Great Lakes basin and across the world, helped to fuel the newly emerging environmental movement. This new conceptual understanding of the world viewed human beings as a part of nature, not something apart from it, and reflected concern about human impacts on the natural world as they related to physical and spiritual well-being.

Over the past 30 years, environmental concepts have been gradually assimilated into mainstream society and are increasingly influential. Most recently, natural resource managers have pushed these ideas further and are beginning to take an ecosystem approach to watershed management, i.e. looking at the interconnectedness of all elements of the watershed — physical, chemical and biological, including human. Such a conceptualization requires us to stop viewing nature as something that we can manage or control and instead compels us to manage our own uses of it. With an ecosystem approach to management comes a recognition that some uses of the river, such as effluent assimilation, will have to be limited or eliminated altogether if we are ever to restore its environmental integrity.

We came to the river. We used the river, abused it and turned our back on it. But now we're coming back to the river, now we recognize that the river, in essence, reflects us. And we're beginning to understand that what we do to the river, ultimately we do to ourselves. Our relationship with the river is truly dynamic.

Conclusion

What does this mean for resource managers today and in the future? The river is our link to the past, our continuity, and we certainly need to be aware of the challenge presented by historic uses and abuses. Moreover, we must also be aware that the river has always been the key influence on our economic and social life, even when we turned our backs on it. Rather than risk this happening again, good policies and programs must keep the river at the fore.

Also, in our evolving understanding of the river, I recognize a need for caution. It was not malice that drove those resource managers who assumed the river had an infinite assimilative capacity. Although today we know that approach was wrong, we must never assume that our own knowledge is complete. We must be flexible, cautious and always ready to act on new knowledge. As our understanding of the river will always be dynamic, we have to develop policies and programs that are equally dynamic. And we will continue to need opportunities, such as we have today, opportunities to share our knowledge and our understanding about the state of the strait.

[1] Commonly *E. coli* today.

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Changes in River Biota Over Time

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Native Americans lived along the Detroit River long before the first European settlement was established 300 years ago. Both Native Americans and Europeans were no doubt attracted to the Detroit River for waterborne transportation and an abundant supply of fish and wildlife. Even before the turn of the last century, fish and wildlife were succumbing to over-exploitation, loss and degradation of habitat, and pollution. The river was largely ignored as a natural resource while urban expansion, manufacturing and shipping developed at a feverish pace. Today, there is renewed interest in the Detroit River as pollution abatement and harvest limits result in the recovery of fish and wildlife populations. This paper will highlight some of the dramatic changes in Detroit River biota, with emphasis on fish, bottom-dwelling animals (benthos) and wild celery.

Changes in Biota Along the Detroit River Corridor

Fish

Sixty-seven fish species are known to occur in the Detroit River: native fishes such as walleye and largemouth bass comprise 54 species, and 13 exotic species were either purposefully introduced, e.g. common carp, or accidentally introduced, e.g. alewife, white perch, round goby and tube-nose goby. The high diversity of Detroit River fishes is partially attributable to the variety of habitats — deep channels, shallow-water nearshore, and the land-water edge, including river shorelines, island shorelines and coastal wetlands. In addition to the 34 resident species, the high diversity is enhanced by 28 species that use the river as a migratory pathway between Lakes Erie, St. Clair and Huron, and stop in the river for spawning, feeding and nursery grounds (Manny *et al.* 1988).

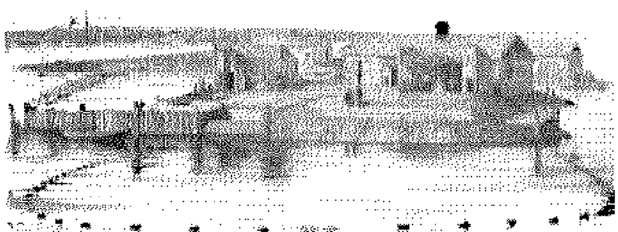
Little information exists on the composition of the permanent resident fish community during the earliest years of European settlement. As in Lakes St. Clair and Erie, the Detroit River probably supported extensive beds of rooted aquatic plants in nearshore areas that, in turn, provided habitat for abundant populations of bluegill, pumpkinseed sunfish and muskellunge. As habitat was destroyed and degraded, and pollution caused a decline in rooted plants and an increase in algae, these nearshore fish communities undoubtedly were severely altered. Today, trap net surveys reveal that these nearshore habitats are still degraded as indicated by the preponderance of rough fish such as common carp, quillback sucker, bowfin, freshwater drum and white sucker. Nonetheless, it is encouraging that these habitats are also supporting populations of panfish such as pumpkinseed sunfish, bluegill, black crappie, rock bass and yellow perch, and gamefish such as channel catfish, large-mouth bass and northern pike (Francis, pers. communication 2001). At least 35 fish species have been caught in the Detroit River near Humbug Marsh by trap net and electrofishing methods, indicating that this area of the river is providing spawning, nursery, cover and feeding habitat for more than half the fish species known in the Detroit River (Francis pers. communication 2001; Manny 1998).

In contrast to the scanty records of permanent resident fishes, the accounts of migrant fishes in the Detroit River are well documented, largely because the migrations were and continue to be so spectacular. Historically, lake whitefish made huge fall spawning runs out of Lake Erie to and through the Detroit River. At the time of the first comprehensive surveys of the Great Lakes fishery in 1871, these fisheries were already in decline (Milner 1874) and had disappeared by the early 1900s (Bogue 2000) (Figure 1). Today, lake whitefish are making a modest recovery in Lake Erie, and it is exciting to think that spawning migrations of lake whitefish may one day return to the Detroit River. Similarly, lake sturgeon, historically abundant in the Detroit River during spring spawning runs, appear to be making a modest recovery today (Caswell pers. communication 2001).

The big fish migration story today in the Detroit River, however, is the fabulous recovery of the walleye, which undergo their spring spawning migration out of Lake Erie into the Detroit River. The Lake Erie walleye declined in the 1950s and 1960s and made a tremendous recovery in the 1980s, supporting a multi-million dollar sport fishery. The sport fishery and related services have pumped over $1 million each spring into the local economy.

Benthos

Bottom-dwelling organisms (benthos) are an important food source for many fish species as well as being useful indicators of water and sediment quality. Over 300 species of benthic organisms have been recorded in the Detroit River with a predominance of oligochaetes (worms), chironomids (midge larvae), mollusks (snails and clams), ephemeropterans (mayfly nymphs), trichopterans (caddisfly larvae) and amphipods (scuds) (Manny *et al.* 1988). The speed of the current at specific locations in the river significantly influences the bottom habitat and, consequently, the distribution of different kinds of benthos. Hard-bottom substrates such as hard clay, gravel and submerged bedrock outcrops are located where the currents are strong. The exotic zebra mussel became established in the river in the mid-1980s and is now found on virtually all hard-bottom substrates. Net-spinning caddisflies were nearly absent from the river between 1930 and 1963; low numbers were observed between 1968 and 1977; and they have been steadily increasing in density and diversity since 1980. As these caddisflies are moderately pollution-tolerant, their increase in recent decades is an indicator of ecosystem recovery in the Detroit River. Soft-bottom, muddy and sandy substrates are located in the slower-flowing areas of the Detroit River. In general, the presence of mayflies indicates good water/bottom sediment conditions and a predominance of worms and midges, degraded water/bottom sediments. Periodic surveys of benthic communities show increases in mayflies in most areas along with a concomitant decrease in worms and midges since the 1960s, indicating significant improvements in water quality, especially along most of the Ontario shoreline and north of the Rouge River along the Michigan shoreline. However substantial areas remain, such as the Trenton Channel, where the benthic communities still indicate degraded water/sediment quality conditions (Cibrowski 2001).



1a

Figure 1a: Grassy Island, pictured in figures 1a through 1c, is a microcosm of environmental changes and potential for restoration in the Detroit River strait. It was once a marshy island that was productive for fish and wildlife, as depicted in this line drawing of a lake whitefish fishery (Milner 1874).

Wild Celery

Although we generally know little about changes over time in Detroit River weed beds, wild celery (*Vallisneria*) is an exception. This species provides important cover for many kinds of fishes and its starchy tubers are preferred food for many diving ducks such as canvasbacks, redheads and scaup during spring and fall migrations and overwintering on the Detroit River. Studies indicate that tubers were still relatively abundant in 1950-51, were much reduced in 1984-85, and made a substantial recovery by 1996 (Schloesser and Manny 1990; Manny and Schloesser 1999). Rafts of diving ducks are once again observed in the Detroit River, taking advantage of improved water and sediment quality and the recovery of wild celery.

Possibilities for Further Remediation

Changes in fishes, benthos and wild celery over time indicate that the Detroit River is a recovering ecosystem. Successful pollution abatement is resulting in habitat improvements and recovery in the riverine biological communities. Harvest limits and other aspects of fishery management are contributing to this recovery. Continuation of this positive trend will require the cleanup of the remaining pollution problems and assurance that future economic developments are compatible with, and even enhance, environmental quality for river biota.

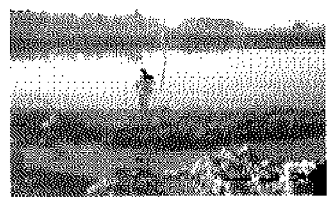


Figure 1b: Grassy Island was converted to a diked confined disposal facility (CDF) for disposal of dredged spoils from the lower Rouge and Detroit and rivers in 1959. (Photo courtesy US Fish and Wildlife Service)

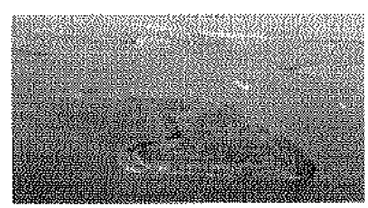


Figure 1c: Today, Grassy Island, part of the Wyandotte National Wildlife Refuge, has potential for restoration of diverse habitats for attracting and sustaining resident and migratory fish and wildlife. (Photo courtesy Doug Spencer, US Fish and Wildlife Service)

Monitoring and Implementation

The following recommendations will promote the recovery of the Detroit River ecosystem:

- Support for water quality protection and improvement programs on the Detroit River and upstream on the St. Clair River and Lake St. Clair for the betterment of Detroit River biota;

- Support the reduction of toxic contaminant sources and remove contaminated sediment 'hot spots' to improve soft-bottom habitats for river biota;
- Support hard-bottom substrate protection and soft engineering practices (Caulk et al. 2000) to improve structural habitat for fishes and other biota;
- Support fishery management practices to enhance the long-term sustainability of Detroit River fish populations. Because of the importance of migratory fishes in the Detroit River ecosystem, such support should include the entire St. Clair-Detroit-Lake Erie corridor.

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Detroit River Habitat: Past and Present

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Introduction

Habitat for fish and wildlife was once abundant in the Detroit River. An 1815 map shows contiguous, coastal wetlands up to 1.6 km (1 mile) wide along both sides of the Detroit River for nearly its entire 51-km (32-mile) length (*Figure 2*). Since then, uses of the riverfront for industry, housing and navigation have reduced these coastal wetlands to less than 3 percent of their original extent (USGS 1999). In the 1980s, dwindling populations of fish and wildlife inhabiting the river raised concerns about the loss of habitat for fish and wildlife (Manny *et al.* 1988) that culminated in the 1992 Binational Remedial Action Plan (RAP) for the Detroit River (MDNR and OMEE 1992). Loss of fish and wildlife habitat is now listed as one of numerous impaired beneficial water uses that must be restored before the Detroit River can be delisted as an international Area of Concern. Existing knowledge of habitat for fish and wildlife remaining in the Detroit River was inadequate to begin the process of habitat remediation. In response to the highest priority recommendation regarding loss of habitat in the 1996 Detroit River Remedial Action Plan Report (MDEQ 1996), a U.S. Environmental Protection Agency (U.S. EPA)-funded inventory was conducted of remaining candidate sites for habitat protection and restoration in Michigan waters of the Detroit River (USGS 2001).

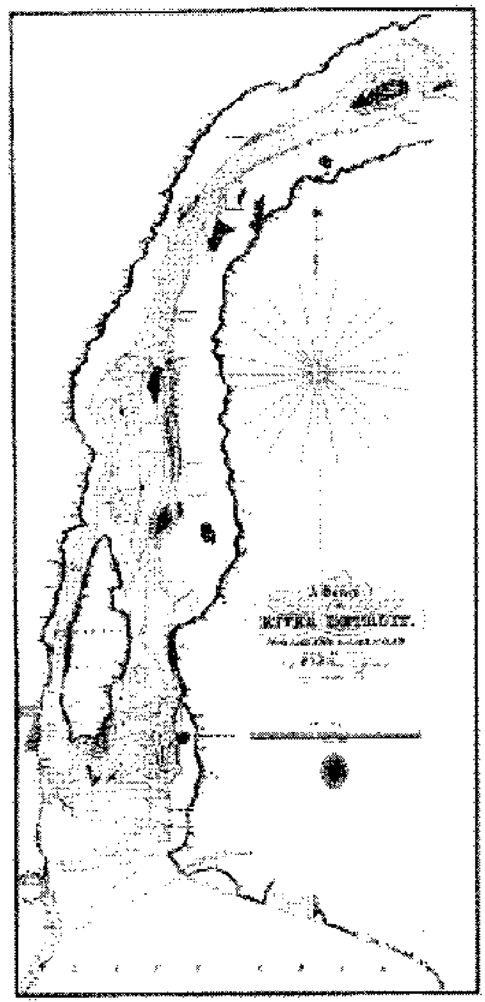

Figure 2: An 1815 map of the Detroit River showing coastal wetlands up to 1.6 kilometres (.99 miles) wide along both shores of the river for most of its length, prior to shoreline development. [*A Survey of the River Detroit. From Lake Erie to Lake St. Clair* by Capt. W. F. W. Owen and assistants, in 1815. Published at the Hydrographical Office of the British Admiralty in London, England, 1828. Source of 1815 map: Association of Canadian Map Libraries and Archives (ACMLA), comp. ACMLA Facsimile Map Series, Serge A. Sauer Map Library, Department of Geography, Univ. of Western Ontario, London, ON, Canada, N6A 5C2.]

Changes in Habitat Along the Detroit River Corridor

The habitat inventory sought to: (1) describe the physical characteristics of remaining habitat for fish and wildlife in the Detroit River; (2) classify all candidate sites as either habitat productive for fish and wildlife to be protected from impairment, or unproductive, impaired habitats to be restored and enhanced; (3) determine the number, location and size of remnant, productive and impaired fish and wildlife habitats; (4) summarize available public information about each site, including ownership, planned land use, level of expected development, land use on adjacent parcels, shoreline treatment, and fish and wildlife resources found there; and (5) evaluate the potential of each site for habitat protection and restoration.

To find candidate sites for habitat protection and restoration, biologists examined 1996 low-altitude, aerial photography provided by the U.S. Army Corps of Engineers and located undeveloped areas along the Michigan riverfront.

A candidate site was operationally defined as a parcel of vacant, riparian land visible on these aerial photographs. Each site was visited by boat on public waters or from public rights of way to: obtain geographic coordinates with a Global Positioning System, complete a field data form, and photograph current uses of lands adjoining the site and river shoreline treatment. All these data were entered into a Geographic Information System (GIS) that linked each site to: a spreadsheet containing 32 fields of information, sources of information, the photographic record and a research completion report. Private property rights were carefully respected in all aspects of the study. Candidate sites were investigated further by examining existing public records about land ownership, assessed value, soil types, and water connectivity, and fish and wildlife resources. The research completion report for the habitat inventory project will rank all candidate sites in the productive and impaired categories in priority for protection or restoration, using existing criteria in a Canadian report (OMNR 1993). Application of those criteria ensures consistent, compatible evaluation of all candidate sites on both sides of the river. The completed report will evaluate the most promising sites, using an existing scoring system of cost/benefit, design simplicity, partnerships, land ownership etc. to determine the measures required to protect productive sites and the existing remediation techniques required to restore and enhance the biological productivity and biodiversity of impaired sites. All aspects of the study will be closely tied to objectives and goals in the Detroit River Remedial Action Plan.

This inventory identified 104 candidate sites for habitat protection and restoration, totaling 1390 hectares (3,436 acres). Thirty-nine of the sites, comprising 647 hectares (1,599 acres; 46 percent by area), are in private ownership and 65 sites, comprising 743 hectares (1,837 acres; 54 percent by area), are in public ownership. Public sites were comprised mostly of parks (24) and plots of land conserved through the Grosse Ile Open Space Program (nine). Thirteen islands were identified in the Detroit River as candidate sites; six of them are owned by federal, state or city governments. Ten of the public sites contain aquatic habitat (seven on Belle Isle and two on Grosse Ile). Four of the public sites and 10 of the private sites were classified as brownfields. Private sites were owned largely by business, industry and utility companies (26 sites); the remainder (13 sites) were owned by private citizens or conservation groups. Seven private sites were either islands or land located on an island. Four private sites contained aquatic habitat. In total, the inventory found 1,094 hectares (2,703.7 acres) of terrestrial habitat and 296 (732.4 acres) of aquatic habitat that may have potential for restoration and protection. The inventory included a total of 52 sites on the Michigan mainland totaling 17.97 kilometres (11.24 miles) of shoreline; 6.89 kilometres (4.31 miles; 38 percent) were armored with a concrete wall, 3.36 kilometres (2.1 miles; 19 percent) were armored with concrete riprap, 2.84 kilometres (1.78 miles; 16 percent) were armored with a steel wall, and the remaining 4.88 kilometres (3.05 miles; 27 percent) were unarmored, earthen shoreline.

Possibilities for Further Remediation, Monitoring and Implementation

Information derived from this habitat inventory provides a starting point for determining the kinds and amounts of habitat required to sustain the kinds and numbers of desirable plants and animals deemed desirable for the river, i.e. a Natural Resource Vision for the Detroit River (cf. Manny 2001). The inventory could be used to balance sustainable uses of the river in terms of habitat conservation, economic development and social pursuits as numerous riverfront remediation initiatives protect and enhance natural resources, stimulate the economy of Detroit and downriver communities, and increase public access. Inventory results could lend much needed perspective to habitat remediation efforts implemented in the Detroit River on Belle Isle, the Wyandotte National Wildlife Refuge, the Rouge River, riverfront parks owned by the cities of Trenton and Detroit, islands in the lower Detroit River, and in Canadian waters of the river. Results of this project could help define shoreline habitat enhancements planned by the Greater Detroit American Heritage River Initiative, the City of Trenton, and the City of Detroit Parks and Recreation Department.

Habitat protection and restoration is integral to the City of Trenton's Riverfront Parks project, U.S. EPA's Western Lake Erie Biodiversity Investment Area, the Focus Area identified by the U.S. Fish and Wildlife Service in the St. Clair and Detroit rivers, remediation of Grassy Island in the Wyandotte National Wildlife Refuge (Manny 1998), a U.S. EPA-funded Evaluation of Lake Sturgeon Habitat in the Detroit River (Manny and Kennedy 2001), conservation of fish and wildlife habitat on islands in the Conservation Crescent near the mouth of the Detroit River (Jones 1997), and the creation of an international wildlife refuge in the lower Detroit River (Dingell 2001).

Organizations committed to habitat protection and remediation such as the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the Grosse Isle Nature and Land Conservancy, and the Friends of the Detroit River, and all jurisdictions along the Michigan waterfront need detailed habitat information to make informed land-use decisions. Information gathered by the habitat inventory project will aid and direct community-based efforts included in the 1998 binational conference, *Rehabilitating and Conserving Detroit River Habitats* (Tulen et *al.* 1998) and the development of a habitat management plan for the Detroit River by regional fish and wildlife management authorities.

In the future, our first priority for protection and restoration of habitat could be agreement on the number of each species of fish, wildlife and plants we wish to sustain in the Detroit

River in perpetuity. State and provincial management biologists could seek agreement on a Natural Resource Vision for the river. This vision could list the number and kinds of each natural resource, e.g. fish, wildlife and plants to be provided for public use and enjoyment. The list could be enlarged to include other plants and animals identified by other natural resource organizations. Our second priority could be for natural resource professionals to seek agreement on how much of each kind of native habitat once present in the Detroit River is needed to sustain in perpetuity each desired fish, wildlife and plant species listed in the Natural Resources Vision. Our third priority could be to determine how much of each kind of habitat needed by these desired plants and animals currently exists in the river.

The protection and restoration of habitat could begin with the small amount of remaining undeveloped shoreline. Protection of privately owned, high value, productive habitat sites could be encouraged concurrent with redevelopment of "brownfields," using a market-driven transfer of development rights program, authorized by state and local governmental authorities and incentives provided by the International Wildlife Refuge Establishment Act (Dingell 2001). As earthen shorelines are more conducive to fish production than armored shorelines (Schmetterling *et al.* 2001), it may also be possible to create some habitat for fish and wildlife on armored shorelines and "brownfields" as they are redeveloped, using soft engineering techniques on the shoreline (Caulk *et al.* 2000). To measure our progress, the four parties to the RAP process could set realistic, achievable benchmarks for the protection and restoration of those kinds and amounts of habitats which everyone agrees will permit loss of habitat to be delisted as a water use impairment. Ideally, the benchmarks would be monitored quantitatively in terms of the number of hectares (acres) of protected, productive and uncontaminated habitat and the number of kilometres (miles) of vegetated, earthen and soft-engineered shoreline, to be protected in perpetuity. For five years following the achievement of habitat targets, the protected, restored and created habitats could be monitored annually to verify that each remains protected, productive (fish and wildlife) and uncontaminated. Then, each of us would be able to determine if adequate progress had been made toward protecting and restoring the desired kinds and amounts of fish and wildlife habitat needed to delist loss of fish and wildlife as a beneficial water use impairment in the Detroit River. Each of us could be a part of the achievement!

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Biodiversity Along the Detroit River Corridor: Changes and Prospects

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It is 1701. Antoine de la Mothe Cadillac describes the strait area (with an unfortunate racist appellation), giving us a glimpse of what it must have been like for thousands of years during which only Native American peoples lived here:

The Detroit is actually but a channel or river of medium breadth and twenty-five leagues in length . . . Its borders are so many prairies [marshes no doubt] and freshness of the beautiful waters keep the banks always green. Under these broad walks one sees assembled by hundreds the timid deer and faun, also the squirrel bounding in his eagerness to collect the apples and plums with which the earth is covered. Here the cautious turkey calls and conducts her numerous brood to gather the grapes and here also their mates come to fill their gluttonous crops. Golden pheasants, the quail, the partridge, woodcock, and numerous doves swarm in the woods and over the country which is dotted and broken with thickets and high forests of full grown trees, forming a charming perspective . . . The hand of the pitiless reaper has never mown the luxuriant grass upon which fatten woolly buffaloes of magnificent size and proportion.

There are ten species of forest trees, among them are the walnut, white oak, red oak, the ash, the pine, white-wood, and cottonwood; straight as arrows, without knots, and of prodigious size. Here the courageous eagle looks fixedly at the sun, with sufficient at his feet to satisfy his boldly armed claws. The fish are nourished and bathed by living water of crystal clearness, and their great abundance renders them none the less delicious. Swans are so numerous that one would take for lilies the reeds in which they are crowded together. The gabbling goose, the duck, the widgeon and the bustard are so abundant that to give an idea of their numbers I must the use the expression of a savage whom I asked before arriving if there was much game. "So much" he said, "that they draw up in lines to let the boats pass through." (Farmer 1890, p. 11)

Wetlands

The richness of the flora and fauna in this area in 1701 was stunning. Manny's (in prep.) pre-settlement map of the Detroit River corridor vividly shows that the wet "prairies" (marshes) described by Cadillac lined the entire shore on both sides of the river. Coastal marshes and thick adjacent woodlands provided hiding places for American soldiers waiting in ambush during the War of 1812 (Smith 1997). Ninety-seven percent of those wetlands no longer exist and in their place is an almost continuous steel seawall which provides none of the shallow water habitats that had been so rich in native biota. No coastal wetlands exist on the Michigan side of the Detroit River until just below Trenton at the Detroit Edison property. Just a little further south is the 465 acre Humbug Complex, including the 100 acre marsh, perhaps the richest repository of biodiversity left on the Detroit River (Tulen et *al.* 1998). Marshes at the mouth of the Canard River are Humbug's more extensive counterpart of biological richness on the Canadian side.

Stretching for a mile or more inland from the coastal marshes, lowland areas were interspersed with extensive marshes and open water expanses. At what is now Grand Circus Park, Farmer (1890) remarks that "up to 1844 [this area was covered with] ponds and marshes enlivened only by the music of the bullfrog and used as a place of deposit of every kind of refuse." One would have to have very good ears to hear the distant call of a bullfrog from this, the front yard of Tiger baseball's new home at Comerica Park. Slocum's Island in the Trenton area was surrounded by marsh until 1919 when Giles Slocum made dredging the marsh and naming the resulting park for his daughter Elizabeth conditions for his gift of the island to Wayne County. Wetlands were not areas to save but areas which needed to be reclaimed and transformed for "useful" purposes.

Aquatic Environment

Although early accounts did not fully describe the aquatic flora and fauna, the history of superlative fishing in the area attests that it must have been diverse and robust. Twenty taxa of submergent macrophytes are known to occur in the Detroit River, in beds comprised of 2-11 species (Manny et *al.* 1988). Vegetation, in order of common occurrence, includes wild celery, musk grass, species of narrow leafed *Potamogeton*, the exotic Eurasian watermilfoil and water stargrass.

The rapid biodiversity fluctuation is illustrated by zebra and quagga mussels. Prior to the arrival of these exotic invaders in the mid-1980s, native species comprised 97 percent of samples taken. After the invasion, they accounted for only 10 percent (Schloesser et *al.* 1998). At least ten native mussels (eight uncommon and two common) were extirpated from the Detroit River in just 12 years. Zebra mussels also appear to have affected duck populations such as the lesser and greater scaup, which feed on these efficient accumulators of toxic substances. Scaup populations first increased dramatically, then plummeted, as they began to feed on the new arrivals (Craves 1991, Allen *et al.* 1991).

Beach Environments

It's 1961. A seven year old boy [the author] walks along an earthen dike which juts a half mile into the river from its origin near Belle Isle's water intake. He watches his footsteps as if life hung in the balance with every one. It did. He is here with Cranbrook naturalist Walter Nickell and his father to band common terns. About 1,000 nests, each with spotted eggs and young, blend well with the sand and stones, hence his caution. Hundreds of screaming terns, circle overhead incensed at the intrusion, bomb the men and jab at their heads with their pointed beaks. The same crew banded terns on Bob-Lo Island and later on Mud Island into the early 1970s. This work reveals that some of these birds spent their winters in Chile.

The picture was quite different in late spring 1964. Power mowers had run over hundreds of tern nests, chopping eggs and chicks alike into little pieces. Of 360 nests, only 51 escaped the carnage. Today, the Belle Isle dike is lined with tall shrubs; its top is covered with short mown grass, providing nesting sites for Canada geese. And the terns, which are no longer "common," rarely nest on the Detroit River. The common tern is considered a threatened species in Michigan and has been proposed for listing as endangered (Scharf 1991). While the power mowers were dramatic, loss of beach habitat is the primary factor in the terns' downfall.

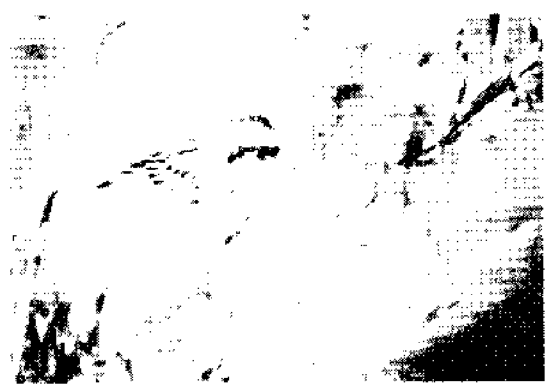
Terrestrial Environments

Prairies, once so extensive that they supported large herds of bison, are represented today by only the occasional remnant grass or flower species on Belle Isle, a few other spots and in Ontario's restored Objibway Prairie. Wild turkey were so abundant that an island in the Detroit River was named for them. With the disappearance of the prairies, the distinctive flora, bison, wild turkeys and a plethora of other grassland species vanished as well.

Cadillac mentioned ten tree species "straight as arrows, without knots and of prodigious size." Other early accounts add several other species. The presence of bear, moose, lynx and wolves indicate that a forest of significant proportions must have bordered the prairie swaths. Sugar, Hickory and Bois Blanc (Bob-Lo) islands were named for their dominant trees: sugar maple, shagbark hickory and either paper birch or aspen in the case of Bois Blanc. Today much of the original forest is gone. Pockets exist here and there, notably on Peche Island, Belle Isle, Mud Island, Grosse Ile, the University of Michigan-Dearborn Natural Area, the Humbug Complex and parks surrounding the Detroit area. Peche Island boasts carolinean species in a remnant southern forest with the characteristic Kentucky coffee tree and hackberry. Some of the trees lining city streets are native wetland or riparian species that tolerate the harsh conditions there as well as they do wet areas: silver maple, red maple, cottonwood, willow, sycamore. Many others are exotics which, when planted near forests, escape and compete with native trees. Suburban sprawl eats up more and more treed landscape, making further losses to biodiversity a virtual certainty.

Birds: A Case In Point
Importance of the Detroit River to Migratory Birds

Southeastern Michigan is located at the convergence of the Mississippi and Atlantic flyways, two of the four major bird migration routes in North America. The Detroit River, with its approximately north-south orientation, is an important corridor along this flyway. Raptors, waterfowl and landbirds all pass through the Detroit River corridor en route to summer nesting and winter feeding grounds.



Migrating species, such as the rare Kirtland's warbler, need migration stopover habitat on the Detroit River (Photo courtesy Jim Bull, Jim Bull photographer)

Fifteen species of raptors, including bald eagles, golden eagles, turkey vultures, red-tailed hawks and broad-winged hawks are regularly counted during annual migration. Gross numbers average between 200,000 and 300,000 birds, one of the largest concentrations in the eastern United States (Tessen 2000). The Detroit River is a traditional staging area for migratory waterfowl, both during migration and over winter. Wild celery attracts thousands of ducks, especially canvasbacks, redheads and scaup (Wooley 1998). In the 1940s and 1950s canvasback counts ranged from 200,000-400,000 (Schloesser and Manny 1990). As the wild celery declined 72 percent between 1950 and 1985, likely due to pollution, so did the canvasbacks (Schloesser and Manny 1990). For migrating landbirds, the availability of appropriate stopover habitat is critical to successful migration (Moore *et al.* 1995). Nearly half of Michigan's migrant species use the Rouge River Bird Observatory as a stopover site, to rest and refuel; most stay more than one day and most gain weight (Craves and Gelderloos 1996). This illustrates how crucial stopover sites are in urban areas, especially in regions along major flyways. Still, migrant birds are not as abundant today as they were at the turn of the 20th century.

Importance of the Detroit River to Breeding Birds

Historically, many wetland-dependent bird species nested in the marshes that once lined the Detroit River. Mallard, wood duck, American black duck, northern pintail and redhead nested on the lower Detroit River as late as 1968. By 1983 there were no records of nesting pintails or redheads on either side of the river and no nesting of blue-winged teals or black ducks on the American side (Manny 1998; Brewer *et al.* 1991). Black-crowned night herons, abundant in migration, may also nest in some marshes as they do on the western end of Lake Erie. Both osprey and bald eagles feed throughout the summer at Humbug Marsh and bald eagles nest and feed at Canard River Marsh. Although bald eagles have long nested on the Canadian side, in spring 2001 a nest was discovered on the U.S. side for the first time in many years (Hartig 2001).

For landbirds, even in an area as urbanized as the Detroit River, high biodiversity is possible. Evidence of nesting for over 80 bird species was noted at the Rouge River Bird Observatory, although an index based on size indicates it should have only 50 species (Craves 1996; Craves and Gelderloos 1996). This finding demonstrates the importance of natural areas for breeding bird diversity in the Detroit River region. Unfortunately, since 1915, about 70 percent of the bird species identified as regularly nesting in Wayne County, Michigan have declined or are no longer present as breeding species (Craves, in prep.).

Prospects

While there have been serious reductions in both diversity and abundance of flora and fauna with loss and degradation of habitat, the Detroit River is still an amazingly rich area. The *State of the Lakes Ecosystem* conference identified the Detroit River-Lake St. Clair ecosystem as one of 20 Biodiversity Investment Areas in the Great Lakes basin, based on its exceptionally high ecological value (Reid *et al.* 1999).

It may come as a surprise that canoeists on the Detroit River can watch osprey and bald eagles diving for fish, black-crowned night herons dotting the dense green shrubs on all sides, blue-winged teal so numerous that they are impossible to count, great blue herons and common egrets in large numbers in trees lining an inlet. All of this occurs at Humbug Marsh. Development of some 300 homes here may destroy this last vestige of the river's natural heritage.

Existing natural areas must be saved if remaining biodiversity is to be preserved and improved. This has to be the top priority. Humbug and Canard marshes, along with Grassy Island, are the most critical and threatened areas. Beyond preservation, there is also much room for habitat restoration. Continuing efforts to curb and correct past pollution are critical. Exotic species that are already here must be controlled and new exotic introductions prevented. Stronger regulation of ballast water discharge will help. Habitat which has been lost can be restored to some extent. Coastal marshes could be restored on Belle Isle and in several other areas. Through the American Heritage River program, areas have been identified where soft shoreline and more natural flooding regimes can be re-established; the initiative is being successfully promoted. While bison will never come back, small prairies could be created in some of the large areas of open space on Detroit's east side. Common tern colonies might be re-established on Belle Isle and Bob-Lo Island and, with some management changes, terns nesting may increase on Fighting Island as well. We will never have the extensive forest required to support moose and bear, but there is room to rehabilitate existing forest and re-establish native woodlands in riverfront parks and in open areas further from the river.

The integration of biodiversity preservation and enhancement into effective regional planning is crucial. Involving people in efforts to preserve and enhance biodiversity, and launching education programs to reach school children, young adults and the general public will go a long way toward creating the political will necessary for preserving and enhancing biodiversity. According to Primack (1995) "some people feel discouraged by the avalanche of species extinctions occurring in the world today, but it is also possible to feel challenged by the need to do something to stop the destruction." Now it is up to us to feel that challenge and to meet it! It can be done.

About to be banded: common tern chicks held by Robert Bull on Mud Island, 1972 (Photo courtesy Jim Bull, Jim Bull photographer)

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Contaminants in Water and Sediments

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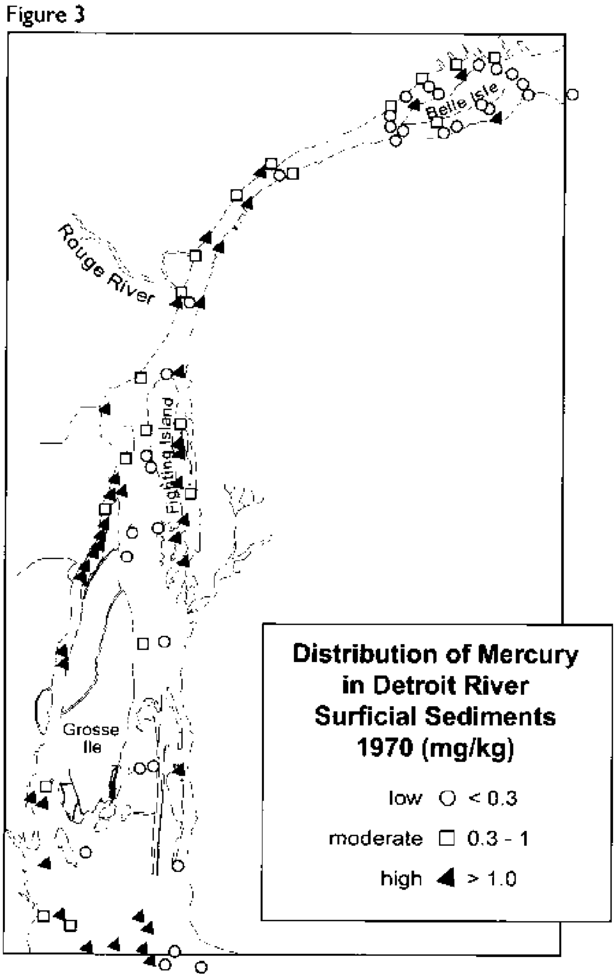
The Detroit River has experienced over a century of heavy contaminant discharges from industry and municipalities (MDNR and OMOE 1991). The sources of contaminants vary and include: nonpoint sources (stormwater runoff and air deposition), combined sewer overflows, point sources (both municipal and industrial), tributaries, sediments and upstream inputs (MDEQ 1996). The high water volume flow issuing from upstream waterbodies (Lake Huron, the St. Clair River and Lake St. Clair) is closely connected to the quality of the Detroit River ecosystem (UGLCCS 1988; MDEQ 1996). The primary contaminants of concern have been cadmium, copper, lead, mercury, zinc and PCBs, although several other contaminants have also been identified in water and sediments that exhibit reason for concern (UGLCCS 1988). A considerable number of beneficial use impairments in the Detroit River center on contaminants in water and sediments, particularly as they relate to ecological and human health (MDEQ 1996).

Figure 3



Demonstrable improvements in water and sediment quality have occurred during the past three decades (MDEQ 1996). The long term trends of lead, copper and zinc concentrations in the water column exhibit distinct decreases from 1981 through the present (MDEQ 1996). Similarly, over the same time period, instances when ambient water quality objectives have been exceeded have decreased from between 5-10% to 2% or less. Although the sharpest declines were observed through the mid-1980s, fairly uniform concentrations have been observed since that time. Water quality trend data for mercury and PCBs are not continuous or readily available. The limited extant data, however, indicate apparent decreases in mercury and PCBs in the water column concentrations over time (Kaiser *et al.* 1985; UGLCCS 1988; USEPA 1988a, 1988b; Froese *et al.* 1997; Rossmann pers. communication 2001). Data limitations indicate the need for a synthesis of historic monitoring data and a coordinated monitoring program based on the contaminants.

The importance of and distinct linkage among discharges, water quality and sediment quality is recognized as sediments act as a repository for discharged contaminants. Sediment surveys that can be compared on a river-wide basis were conducted in 1970, 1980 and 1991 (Hamdy and Post 1985; Farara and Burt 1993). These surveys indicated that concentrations of mercury and other heavy metals distinctly declined between 1970 and 1980. Between 1980 and 1991, however, little change in concentrations was exhibited. In some cases, increases were observed or the findings were mixed, depending on the contaminant and location. PCB concentrations in sediments exhibited a slight decrease throughout the system between 1980 and 1991. In general, sediments in the U.S. sector of the river were considerably more contaminated than on the Canadian side. In 1991 approximately 50 percent of all stations exceeded sediment quality guidelines for severe effects and 97 percent of all sediments exceeded at least one sediment quality objective (Farara and Burt 1993).

As already noted, the Detroit River recovered from the extremely high levels of pollutants in sediment and water. There is little doubt that the environmental quality of the river improved considerably from the early 1950s when pollutants were released into the river with few or no abatement programs, to the middle 1980s when pollution control programs had been implemented. We will now examine whether these improvements have continued over the past 15 years.

In 1999 an extensive survey of the sediments of the Detroit River was conducted by the Great Lakes Institute for Environmental Research at the University of Windsor, with the financial support of the Sustainability Fund managed by Environment Canada. Unlike the surveys already discussed, which assessed environmental quality only in areas suspected of being polluted, the 1999 survey addressed the overall environmental quality of the river. This river-wide study provided many insights about how the Detroit River functions as an ecological system. The examples of PCBs, PAHs and mercury demonstrate not just the "state of the strait," but illustrate how this knowledge can be used for future remediation efforts.

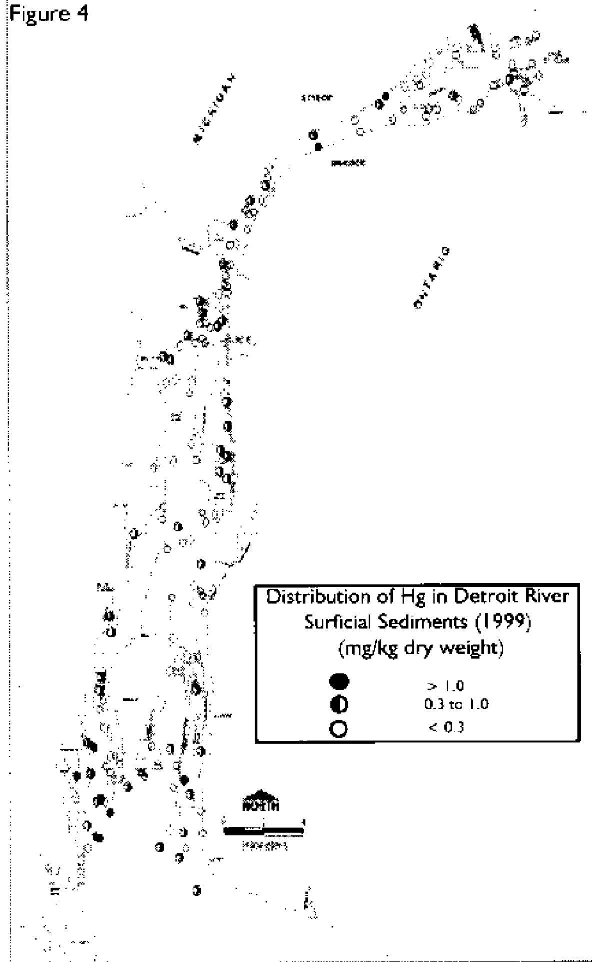
The 1999 study revealed important facts about current mercury distribution in the Detroit River. The historic pockets of high concentration no longer exist, instead mercury is now distributed quite evenly throughout the river. Thirty-three percent of the stations sampled exceeded the Low Effect Levels (LEL) established by the Ontario Ministry of the Environment (MOE). In addition, approximately ½ of one percent exceeded the Severe High Effect Levels (SEL) concentration (Figure 4).

For PCBs, the situation is similar. Unlike mercury, however, where the major sources were upstream in the St. Clair River, inputs along the shoreline of the Detroit River have dominated PCB loadings. The 1999 study revealed that PCBs are widely distributed throughout the sediments of the river. Twenty-four percent of the stations had levels exceeding the MOE LEL guidelines and approximately ½ of one percent of stations exceeded the MOE SEL guidelines.

Both PCBs and mercury are persistent chemicals; they bioaccumulate to increasingly higher concentrations in the food web and are recognized to be very toxic. That we no longer see areas of extremely high concentrations does not mean that the PCB problem has been resolved. Many of the delisting criteria established for the Detroit River and Lake Erie will need to address effective management of further inputs and minimization of the effects of *in situ* pollutants.

The final example of chemicals in sediment is polynuclear aromatic hydrocarbons (PAHs). This is a complex group of chemicals, many of which can be metabolized to produce very potent carcinogens. In the late 1800s Percival Potts was the first person to associate cancer rates in humans with exposure to environmental chemicals, in particular PAHs. PAHs are present in the sediment and water of the Detroit River at rather elevated levels, as much as 8,220 mg/kg, based on organic carbon content. PAHs in Detroit River sediment are associated with high genotoxic stress and with the development of tumors in fish such as the brown bullhead. Unlike PCBs and mercury, where there have been definite attempts to control loadings, PAHs are leaching from coal yards along the shoreline, deposited in oils placed in sewer systems and by atmospheric loads contributed by diesel trucks and other processes associated with incomplete carbon burning.

Figure 4



It is difficult to discuss changes in the level of hazard presented by chemicals in the waters of the Detroit River. Water is a very difficult and expensive phase of the environment to monitor and it is challenging to obtain accurate data on spatial and temporal distributions of chemicals. A novel approach, biomonitoring, has been accepted and used by the

City of Windsor over the past five years. In this case, the biomonitor is a clam (or mussel for the scientifically inclined), that has been calibrated so that one can simply place a clam in the river for three weeks and then estimate the average water concentrations of chemicals in water during that time. With the City of Windsor data set it is possible to obtain extensive information on chemicals such as PCBs in water. Near Goyer's Marina, PCB concentrations are shown to be very constant over time. Only a slight indication of declining PCB concentrations in water exists there. Comparing these water concentrations with those measured during the Upper Great Lakes Connecting Channels Study in the mid-1980s, we can see that conditions in this area have not changed dramatically.

Sediment and water quality data are essential for making informed decisions on remediation programs in the Detroit River. It should be apparent to everyone that more must be done. We must be able to determine the relative importance of chemical exposures from water and sediment to know which remedial options will produce the most benefit. Although the historic monitoring programs have yielded limited information on whether conditions are getting better or worse in the Detroit River, they have provided the data required to design future monitoring programs. We know monitoring programs must be integrated and that we require a modelling construct that directly relates monitoring data to management policies.

In conclusion, we would like to address the three specific questions posed by the organizers of this conference.

How have things changed? PCBs and mercury in sediments have decreased between 1970 and 2001. Water data are not, however, sufficient to make many strong statements about improvements to water quality over this time period. Some things have not changed: PCBs, mercury, dioxin, lead, cadmium and copper are still concerns as they were in the early days of monitoring. Sufficient information exists to support continued investigation of the toxic stress associated with PAHs and arsenic.

Is there potential for remediation? Over 90 percent of the water entering the Detroit River is pristine water from Lake Huron, yet 20 hours or so later, measurable changes in water concentrations have occurred. The relative importance of chemical loading as opposed to chemical desorption from the sediment needs to be determined. Current studies suggest many of the chemicals in the sediment are not biologically available, and so pose little threat to the riverine ecosystem. With such high rates of water renewal, the Detroit River is an excellent candidate for remediation.

What are the monitoring requirements? Loadings data must be confirmed, and this activity must include appropriate sampling strategies and quality assurance protocols. River monitoring data must be collected in a systematic, coordinated manner, with the Huron-Erie corridor being considered as a monitoring unit. A modelling construct must be developed for the corridor to integrate monitoring data and directly use them to develop and/or modify management policies for the Detroit River.

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Long-term Trends in Contaminant Levels in Herring Gull Eggs and Breeding Waterbird Populations in the Detroit River, 1977-2000

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For more than a quarter of a century, the Canadian Wildlife Service-Ontario Region has maintained two Great Lakes monitoring programs for colonial waterbirds. One program monitors contaminant levels in herring gull eggs (Mineau *et al.* 1984; Pekarik and Weseloh 1998; Hebert *et al.* 1999) and the second, jointly with the U.S. Fish and Wildlife Service, monitors breeding populations of colonial waterbirds (Blokpoel and Tessier 1996; Scharf and Shugart 1998). These programs have been instrumental in identifying and tracking temporal and spatial trends of toxic chemicals in top aquatic avian predators in the Great Lakes food web and the potential population level effects of those contaminants. This paper will summarize the findings of these programs in the Detroit River, from their inception to the present day, and will comment on specific remediation issues.

Methods

The methods and protocol for the Herring Gull Egg Monitoring Program have been described previously (Mineau *et al.* 1984; Ewins *et al.* 1992; DiMaio *et al.* 1998). Briefly, ten-13 fresh herring gull eggs were collected, one per completed clutch from Fighting Island (LaSalle, ON) in late April-early May, 1978-2000 (except for 1980). They were sent to the lab, refrigerated and analyzed by gas chromatography within eight weeks of collection (Won *et al.* 2000). Prior to 1986, the eggs were prepared and analyzed individually. Although they are still prepared individually, since 1986 a subsample from each egg has been taken to form a single site pool, which is then analyzed. Compounds presented in this summary are PCB 1:1 (estimated 1:1 ratio of Aroclors 1254:1260 based on levels of PCB 138), DDE, mirex, dieldrin, hexachlorobenzene (HCB), heptaclor epoxide (HE) and 2,3,7,8-TCDD. For all compounds except 2,3,7,8-TCDD, concentrations are given in ug/g (wet weight); for 2,3,7,8-TCDD, concentrations are given in pg/g (wet weight). Temporal trends and changes within the time series were determined by change-point (piecewise) linear regression (Draper and Smith 1981; Pekarik and Weseloh 1998). Although eggs were analyzed for 21 organochlorine compounds, up to 65 PCB congeners and up to 41 dioxin and furan congeners, this paper discusses only seven key compounds. Data for all compounds can be found in Bishop *et al.* 1994, Pettit *et al.* 1997 and Pekarik *et al.* 1998.

For population surveys, the study area included the entire Detroit River from Lake St. Clair to Lake Erie. The species included: double-crested cormorant (*Phalacrocorax auritus*), ring-billed gull (*Larus delawarensis*), herring gull (*L. argentatus*), great black-backed gull (*L. marinus*), common tern (*Sterna hirundo*) and caspian tern (*S. caspia*). The survey methods consisted of counting nests individually (detailed descriptions of methods can be found in Blokpoel and Tessier 1996; Scharf and Shugart 1998). Briefly, on small colonies, nests were counted individually, on large colonies, plastic tapes and/or ropes were laid out on the ground to divide the nesting area, and nests were counted by section. All nests were counted during mid- to late-incubation to eliminate disturbance to newly hatched chicks.

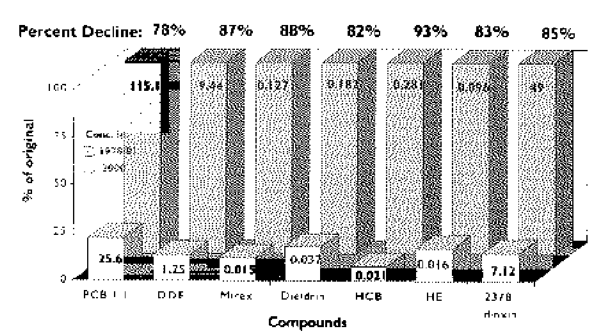
Results and Discussion

Egg Contaminant Levels

One of the questions addressed in this presentation is whether contaminant levels in the biota changed over time along the Detroit River corridor. This question can be partially addressed by looking at trends over the last 20 years.

All seven compounds discussed here have declined significantly between when they were first measured in gull eggs from Fighting Island, in most cases since 1978, and 2000.

Figure 5. Contaminant concentrations (ug/g, wet wt.), and percent declines from the first year of analysis, 1978 (dioxin = 1981, reported in pg/g, wet wt.) and 2000 at Fighting Island, Detroit River



The extent of their decline ranged from 78 to 93 % (Figure 5). The pattern of the decline, however, has varied quite dramatically among compounds. DDE and HE have declined at a constant rate throughout the duration of the study. Mirex and dieldrin displayed no significant trend from 1978 through the mid-1980s, but have shown a significant declining trend since then. PCBs declined significantly from1978 through 1996, but there has been no significant trend, upward or downward, since then. Concentrations of 2,3,7,8-TCDD decreased by 50 % from 1995 to 1996, nonetheless regression analyses indicated no significant temporal trend before or after that decrease. HCB levels declined significantly between 1978 and 1997. Since then, however, they have increased and levels in 2000 were comparable to those in 1996.

A second question addressed here is our estimation of the potential for further improvements in contaminants in biota. Although millions of dollars have been spent on remediation and cleanup activities along the Detroit River, in many ways the river is still a point source of pollution and contaminants, especially for Lake Erie. It would seem obvious that more work could be done to reduce contaminant input from the air and effluent input into the water and sediments.

As for the final question about developing a monitoring program and the institutional capacity to implement it, we seem already to be well on our way. In terms of the linear geography of this Area of Concern, the herring gull and fish monitoring programs already provide good data on those components of the Detroit River ecosystem. Other trophic levels or portions of the ecosystem could be monitored: snapping turtles would be very good indicators of the bottom of the water column; various components of wetlands could be monitored as well as migrant and overwintering waterfowl. Several other features could provide us with a more complete picture than what we now have. Certainly the capacity exists to undertake any of these suggestions, we just need the financial commitment to initiate and maintain sampling programs.

The topic of sediment remediation must be considered carefully, especially in a waterbody such as the Detroit River. In a natural situation that somewhat duplicated a large scale sediment remediation scenario, Ludwig *et al.* (1993) documented the impacts of a 100-year flood which scoured the sediments from the Saginaw River and deposited them in Saginaw Bay. He showed that for caspian terns nesting nearby, hatching success was reduced from a range of 65-82 percent to 0-28 percent. The rate of deformities in young terns was 163 times higher than during the 1962-67 period and fledging success was reduced by 62-88 percent; in some years there was total reproductive failure. Likewise, dioxin equivalents were greatly elevated and approached the LD_{95} value. Sediment remediation need not cause as extensive disturbance as in this flood, but it is a warning of potential impacts.

Breeding Populations of Colonial Waterbirds

In 1997-99 the Detroit River was home to approximately 92,000 breeding gulls and terns, almost exclusively ring-billed gulls (99.5 percent), much smaller numbers of herring gulls (0.4 percent) and less than 0.1 percent common terns; all birds nested on Fighting Island (C. Pekarik et *al.* unpub.data; Cuthbert et *al.* 2001). In the last 23 years, the number of ring-billed gull nests has increased more than 600-fold and herring gull nests 4.6-fold while the number of common tern nests has declined by 98 percent. No cormorants, black-backed gulls or caspian terns were found nesting in the Detroit River, nor are we aware of any historical nesting records there. Great egrets (*Casmerodius alba*) and great blue herons (*Ardea herodias*) used to nest on Stoney Island but they were last recorded there during surveys in 1977 (Scharf and Shugart 1998).

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Sources and Loadings of Contaminants to the Detroit River

David Dolan
University of Wisconsin — Green Bay
Green Bay, Wisconsin

Introduction

The Detroit River Area of Concern has a long history of pollution problems dating back to the turn of the 20th Century. As governments became aware of the adverse impacts of water pollution, the concepts of loading and assimilative capacity were used with some success to design treatment facilities to reduce gross pollution entering the river. Mathematical modelling of algal production in Lake Erie allowed the establishment of a target load for total phosphorus that, in turn, provided a goal for treating sewage entering the Detroit River and the lake. In the mid-1980s, attention turned to reducing persistent toxic substances that were the cause of fish advisories, bird and animal deformities and other impairments of beneficial uses. The Remedial Action Plan (RAP) for the Detroit River (1991) identified six chemicals of concern: cadmium, copper, lead, mercury, PCBs and zinc. Remedial activities were to focus on reducing the loadings of these chemicals. Success in the implementation of the RAP could then be judged by evidence of substantial reductions in loadings.

Figure 6a: Loading Estimates for Total PCBs

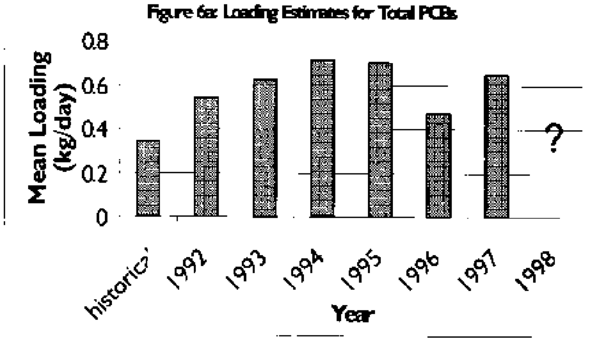
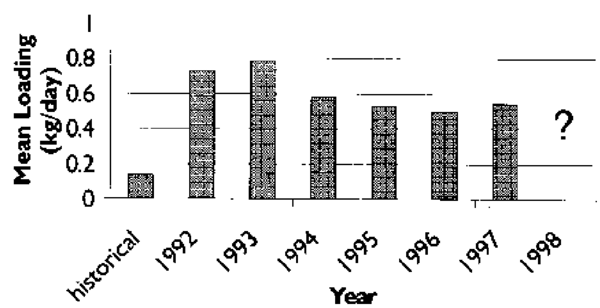


Figure 6b: Loading Estimates for Mercury



Current State of Knowledge

In 2000 the Four Parties (U.S. Environmental Protection Agency, Environment Canada, Michigan Department of Environmental Quality, and Ontario Ministry of the Environment) wished to update the information on loadings of the six chemicals of concern. Available point source data were collected from U.S. and Canadian municipal and industrial dischargers and used to estimate these loadings in the same manner as previous studies (El-Shaarawi and Dolan 1989; Dolan and El-Shaarawi 1989). Although much of the data were incomplete, load estimates made for 1994-1997 showed that decreases in point source loading had occurred for cadmium, copper and zinc compared with historic loads. Increases have been experienced, however, for lead, mercury and PCBs (See for example, Figures 6a and 6b).

During data collection it was observed that the data being reported were becoming less and less useful for load estimation. Monitoring for chemicals of concern was no longer required for many dischargers. Dischargers still reporting these chemicals did so less frequently and with higher analytical detection limits. Although the load estimation methods which had been used allowed for some censored data (non-detects), data from later years, e.g. 1998 were such that no estimate was possible.

In a system such as the Detroit River, nonpoint source loadings are best detected by differences; by their nature, these sources are diffuse and not amenable to regular monitoring. Therefore, they are best estimated by the difference between total loading to the area and the sum of known point sources (Dolan and El-Shaarawi 1989). The last time total loads of various pollutants were determined in the Detroit River was during the Upper Great Lakes Connecting Channels Study (UGLCCS) in 1986. Various estimates of point source total loading have been made as part of Remedial Action Plan (RAP) efforts. The most recent effort, already discussed, was for 1997. So, the current state of knowledge is based on point source data that are five years out of date and total system loads that are fifteen years out of date. No separate effort has been undertaken to monitor the air pathway, although methods do exist to make estimates.

Improving Loading Estimates for Sources and Pathways

In terms of point sources, the most important measure for point source data would be chemical analytical methods that can reliably detect parameters of concern in municipal and industrial effluents. In terms of total system loads, upstream/downstream loading in the Detroit River needs to be designed and implemented in a manner similar to that identified in the UGLCCS (1988) study of 1986. When such a study is implemented, additional sampling should be conducted to augment the data: tributaries, combined and storm sewers, and atmospheric fluxes should all be monitored to allow complete interpretation of the data obtained.

Contaminant-specific loading targets should be set based on the upstream loading of the parameter of concern. This procedure would provide a target of no net increase in loading for the Detroit River system. Since all parameters of concern (cadmium, copper, lead, mercury, PCBs and zinc) are currently persistent toxic substances, this approach is consistent with the Great Lakes Water Quality Agreement principle of zero discharge.

Monitoring and Implementation

A standing, binational committee such as the Niagara River Monitoring Committee, extant for 15 years, is needed to oversee the monitoring of the Detroit River. The work of the extant committee would be a good starting point for formation of a Detroit River committee. Such a committee's work plan should include: sampling design, chemical methods, data quality and data interpretation. If self-monitoring data for point sources is to be included in the prospective set of data to be considered, the committee must have the authority to require analytical methods with adequate detection limits.

Conclusion

Information on sources and loadings of contaminants to the Detroit River is incomplete and out of date. The situation is rapidly worsening. The current system of collecting point source data that are intended to monitor compliance and to estimate loadings of persistent toxic substances is not working. Further, these data by themselves, even if they were accurate and timely, do not address total system loads, the atmospheric pathway and nonpoint sources in general. A new approach is needed if loadings of chemicals of concern are to be successfully tracked in the Detroit River.

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Panel Session I: Waterfront Redevelopment, New Urbanism and Neighbourhoods

F. J. Blanchard
General Motors
Worldwide Realestate
Detroit, Michigan

K. Anderson
Hamilton, Anderson and Associates
Detroit, Michigan

F. Langmaid
Windsor Parks and Recreation Department
Windsor, Ontario

Session Moderator:
Mark Breederland
Michigan Sea Grant Extension
Port Huron, Michigan

The *State of the Strait* conference addressed waterfront redevelopment, "new urbanism" and neighbourhoods. New urbanism seeks to redefine the nature of metropolitan areas by reintroducing traditional notions of neighbourhood design and fitting those ideas into a variety of urban and suburban settings. Some new urbanism principles include:

- walkable neighborhoods oriented to a five-minute walk;
- primary orientation to public transit systems;
- preservation of open space and greenways; and
- greater integration of different types of land uses at the neighborhood level.

Consistent with the thinking of sustainable development, the conference steering committee endeavoured to showcase creative and effective ways of integrating environmental, economic and societal objectives in projects along the Detroit River.

Presentations from panelists included an overview of General Motors Corporation's (GM) ongoing $500 million renovation and associated waterfront development at the Renaissance Center in Detroit, the City of Windsor's waterfront masterplan, and a discussion of the new coordinated plan for Detroit's 962 acre island park called Belle Isle.

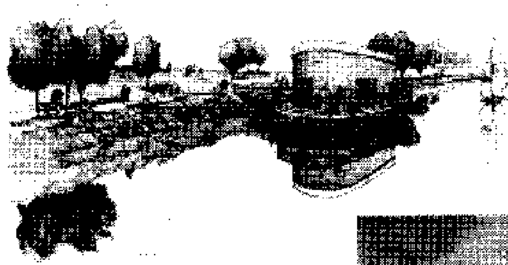
Artist's rendition of GM Wintergarden (above) and River East (right). (Image: General Motors, Worldwide Realestate.)

General Motors Leadership in Waterfront Renewal

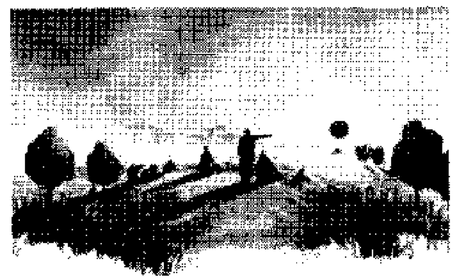
John Blanchard highlighted GM's commitment to help create a vibrant and sustainable community. In direct response to this commitment, GM purchased one of Detroit's landmark building complexes, the Renaissance Center, in 1996 and shortly thereafter began to reinvent it as their Global World Headquarters. A major part of this effort is a plan to create a riverfront promenade and a five story, glass enclosed public hall along the riverfront. This hall, called the Wintergarden, will open in late 2001. It will contain retail space and a variety of restaurants, and will provide magnificent views of the Detroit River and the Windsor skyline.

Further, General Motors is building over 3,000 feet of riverfront promenade, stretching east from the Renaissance Center. Preliminary plans include terracing the river's edge, constructing a promenade with trees and benches, and demonstrating a small stretch of soft engineered shoreline along the eastern extremity of GM's property. This riverfront promenade at the Renaissance Center will also link to the newly opened Detroit Civic Center Riverfront Promenade, realizing a one-and-a-quarter mile riverfront promenade that will attract people to the waterfront and help reacquaint them with the Detroit River.

A 25-acre mixed-use, new urbanism project called River East will be developed east of the Renaissance Center property and is expected to be completed by 2009. Some initial sketches of the proposed mixed-use development shown during this session included ground floor retail development with housing above. GM's investment along the Detroit riverfront has been referred to as "ground zero" for much of the ongoing urban waterfront redevelopment of the river's edge in Detroit.



Artist's rendition of Windsor, Ontario waterfront. (Image: Department of Parks and Recreation, Windsor.)



City of Windsor

Faye Langmaid noted that the City of Windsor has a longstanding commitment to its riverfront and recently completed a masterplan. Her presentation covered the history of the Windsor waterfront, the masterplan and environmental assessment process, design elements, the implementation strategy and some recent actions. Back in 1947, the *Metropolitan Park System Waterfront Development Programme* recommended a well-balanced unified development of waterfront recreational facilities for all citizens and the "creation of a shoreline parkway." A number of activities occurred in the 1990s, including a buyback of the Ramada Inn lease in 1999, which was the only building on the north side of Riverside Drive along the Detroit River shoreline. The "Riverwalk 99" celebration in October 1999 involved an estimated 20,000 people in celebrating the opening of another three miles of riverfront greenway in Windsor. This new extension of the Windsor greenway helps promote the river and create an exciting venue to work, play and socialize downtown.

A design charette was held in late 1999 and a final draft of the Central Riverfront Implementation Plan was tabled with City Council on May 23, 2000. The guiding principles set out in the masterplan will be amalgamated into the Official Plan for the City of Windsor. Elements which ensure that the central riverfront will be perceived as one cohesive area with a series of special and distinct elements within it. These elements include five park pavilions called "beacons," a circulation system, signage, landscaping and heritage narratives.

The estimated implementation cost of the masterplan is $60 million (Canadian) over 25 years, breaking down to an average $2.4 million in capital costs per year. In addition to municipal sources — community, corporate and private sponsorships in association with provincial and federal programs will represent a significant source of funding for many central riverfront components.

Belle Isle Park

Kent Anderson discussed the City of Detroit's Belle Isle Park and masterplan that his firm coordinated. Belle Isle is a 962-acre island park, which suffers from overuse and maintenance challenges. The history of Belle Isle is rich and extensive research was performed as part of the development of the new masterplan that calls for approximately $200 million (U.S.) in capital outlay.

Fundamental parts of the masterplan include a formal zone (Scott Fountain and surrounding area), an active zone (which would include a reclustering of the cultural campus) and a natural zone on the east end of the island. A new road skeleton framework would be created on the island to enhance and preserve island amenities (if the masterplan is funded), and would redirect traffic and create a small amount of new parking .

Consistent funding for maintenance and operations of the park is a continuing challenge and various options were presented to the Detroit Recreation Department for consideration. It is hoped that Belle Isle's masterplan can be implemented and the island can be polished to appear as a "jewel"in the Detroit River.

The presentations generated much discussion and interest. It was agreed that successful waterfront redevelopment projects will integrate economic, societal and environmental objectives and achieve sustainability. It was also stated that the Detroit River will become even more important in the future in achieving our societal and economic goals. Conference participants noted that greenway projects are key linkages and unique destinations that provide open space, protect natural and cultural resources, improve the quality of life throughout our region and serve as a unique legacy to future generations. These greenways are also important because they attract people to the shoreline and give them first-hand experience of the river. Such first-hand experience is essential in building support for further nonpoint source control efforts, brownfield redevelopment, contaminated sediment remediation, pollution prevention, and habitat rehabilitation and conservation. These greenways also provide for alternative modes of transportation that further new urbanism and sustainable communities.

Panel Session II:
Four Agency Framework Relating to Detroit River Management

Simon Llewellyn
Environment Canada
Downsview, Ontario

David Hamilton
Michigan Department of Environmental Quality
East Lansing, Michigan

Session Moderator
John Marsden
Environment Canada
Downsview, Ontario

Jo Lynn Traub
U.S. Environmental Protection Agency
Chicago, Illinois

Jim Richardson
Ontario Ministry of the Environment
London, Ontario

The conference included a panel discussion involving the four agencies charged with primary responsibility for Detroit River management.

The objectives of this panel discussion were to inform the public and stakeholders of the binational cooperation papers issued by the four agencies; describe ongoing monitoring programs, priorities and successes; and present a vision for the future of the Detroit River. To accomplish these objectives, the presentation was divided into four sections:

- Four Agency Framework of Roles and Responsibilities for Implementing Binational Remedial Action Plans (RAPs),
- Key Four Agency Detroit River Monitoring Programs,
- Detroit River Priorities and Success Stories, and
- Visions for the Future.

"The Four Agency Framework of Roles and Responsibilities for Implementing Binational RAPs" directly addresses the binational Areas of Concern (AOCs), including the Detroit, St. Clair and St. Marys Rivers. Position papers have been prepared that address administration, delisting, public involvement and reporting for these binational AOCs. The four agencies also agreed to a Lake St. Clair (LSC) initiative to address LSC issues in the context of the Huron-Erie corridor, while recognizing limited resources and not creating new management structures.

The Four Agency Framework is not an umbrella to address all corridor issues, nor a replacement for what all stakeholders need to do, and it is not a commitment of new resources. The Agreement is a four agency coordination mechanism, focussed on delisting binational AOCs. The *Four Agency Compendium of Papers* can be found at: www.on.ec.gc.ca/glimr/raps/connecting/detroit/detroit_compend12.pdf

Monitoring is essential for measuring progress and trends during RAP implementation, for measuring restoration of impaired beneficial uses in AOCs, and for confirming delisting of AOCs. It is also necessary to provide data for models, work plans and source tracking activities.

All four agencies have ongoing monitoring programs in the Detroit River that among them assess water quality, habitat, sediments, swimming, fish and other conditions. The Four Agency Binational Monitoring Initiative is intended to coordinate and facilitate monitoring. A monitoring committee has been created by the four agencies to:

- report biennially on the status of programs,
- encourage collaboration and coordination,
- identify and address monitoring gaps, and
- develop web access to information.

There have been a number of successes pertaining to Detroit River priorities, which include:

- control of combined sewer overflows (CSOs),
- control of sanitary sewer overflows (SSOs),
- point/nonpoint source pollution controls,
- remediation of contaminated sediments,
- habitat rehabilitation, and
- pollution prevention.

CSO controls underway in the U.S. include the construction of detention basins and pilot screening/disinfection facilities. Current Canadian activities include assessment of retention basin technology and CSO treatability, expansion and upgrading of the Lou Romano Water Reclamation Plant (Windsor) and ongoing sewer separation/rehabilitation.

Some current nonpoint source pollution remediation activities are tree planting, the installation of buffer strips, soil erosion protection, septic system upgrades, no-till demonstration projects, construction of a sediment retention basin and sponsored training in soft engineering techniques. Habitat rehabilitation activities include protection of approximately 530 hectares (1309 acres) of wetland/upland habitat along the river since 1990, implementation of a biodiversity conservation strategy in the Canard/Turkey and Little River watersheds and preparation of a best practices manual for soft-engineering. Over 100 candidate sites for preservation or rehabilitation along the U.S. side of the Detroit River have been identified and mapped. A binational biodiversity atlas is also being prepared. Other priority projects include:

- $1 million (U.S.) has been appropriated from Clean Michigan Initiative to remove and dispose of contaminated sediments from the Black Lagoon area of the River;
- five other sites in Detroit River/Trenton Channel are targeted for sediment remediation;
- the Detroit Water and Sewerage Department, in cooperation with the National Wildlife Federation, has implemented a PCB and mercury minimization program; and
- the Essex Region Conservation Authority has implemented an ongoing soil erosion and nonpoint source control program for rural landowners on the Canadian side of the river.

Over the years there have been several visions and goals developed for the Detroit River by various groups for specific initiatives such as the RAP process, Great Lakes Initiative and State water quality standards. The four agencies propose building on the goals and visions set forth in previous activities, rather than duplicating work already done. The 1996 Detroit River RAP report, for example, presented water use goals for the river that envisioned restoring the integrity of the Detroit River ecosystem so that it will provide a safe, clean and self-sustaining natural environment where self-sustaining, diverse biological communities are restored and maintained and the presence of contaminants does not limit the use or appreciation of fish, wildlife or the waters.

Any actions proposed or implemented should be designed to help restore beneficial use impairments to the Detroit River or help meet state, provincial and Great Lakes Water Quality Agreement objectives. In the longer term, such activities should also help virtually eliminate the input of persistent toxic substances. In moving forward, the RAP must develop new initiatives and stronger enforcement mechanisms, be integrated with Lakewide Management Plans (LaMPs), and implement local actions to enhance basin-wide efforts. The vision for the future must include ensuring environmental equity and environmental justice. Any vision for the Detroit River must also include the efforts of local organizations from such diverse areas as business, industry, conservation and environmental groups, municipal governments, community groups, the U.S. and Canadian RAP committees and academia. Future four agency efforts will focus on utilizing the Lake Erie LaMP to track progress in the Detroit River, collaborating on monitoring, reporting, outreach and delisting efforts, and specifically focussing on modelling, sediment remediation, habitat restoration and source control.

An audience member questioned the effectiveness of retention basins in helping CSOs meet water quality standards and wondered why Michigan continued to build them if they are ineffective. The panelists representing the four agencies replied that water column tests of water coming out of CSO retention basins do show much lower levels of contamination than the CSO water coming into the basin. They therefore concluded that the basins are effective and that they are a reasonable alternative to consider as a means of controlling contamination to the Detroit River due to CSOs. Another person asked whether earlier monitoring plans or programs such as the Great Lakes International Surveillance Plan were being used by the Four Agency Monitoring Committee in developing a binational monitoring plan for the Detroit River. The panelists representing the four agencies replied that the members of the monitoring committee are aware of previous efforts in developing coordinated monitoring programs and will be building on this established foundation.

DREAMS: Detroit River Data Retrieval, Exchange, Archival and Management System

M. Tomczak, A. MacPherson and G.D. Haffner
Great Lakes Institute for Environmental Research
University of Windsor
Windsor, Ontario

Introduction

Many of the issues addressed today relate to either quantifying past and present beneficial use impairments to the Detroit River or using the results of the recent scientific assessment and modelling studies to decide on the most effective remedial actions to eliminate impairments that still exist. One of the major obstacles to such desirable research-management coupling arises from the sheer volume and diversity of data that these studies produce, data which are also often difficult and time-consuming to access, integrate and interpret.

Researchers at the Great Lakes Institute for Environmental Research (GLIER) designed the **D**ata **R**etrieval, **E**xchange, **A**rchival and **M**anagement **S**ystem (DREAMS) to provide both centralized storage and *timely* and convenient access to the results of the studies that support such prospective management decisions for the Detroit River Area of Concern. This conference provided a unique opportunity to introduce DREAMS to a wider audience.

System Description

In a nutshell, the system consists of an Internet-accessible database with a basic online geographic analysis capability (GIS), and has the following objectives:

- build a systematic inventory of available and planned field monitoring datasets, along with the basic technical details on their sampling design, coverage, format, quality controls and availability (commonly known as metadata);
- provide the platform and opportunity for both Canadian and U.S. agencies retaining the data relevant to managing the river, to contribute their collections to DREAMS and benefit from streamlined access to the contributions of others; and
- simplify the exchange of technical information among the groups working on the Detroit River system, thereby preventing duplication of efforts.

DREAMS can be accessed online at: *http://www.uwindsor.ca/dreams*

The best introduction to DREAMS is to demonstrate some examples of practical application. The system, which is already operational online, provides practical access to 1999-2001 datasets and is ready to accept more entries from working technical groups of the Four Party Agreement signatories.

The DREAMS home screen begins with several menu items on the left (Figure 7). In addition to the typical items such as the mission statement, user manual, links and contacts and a bulletin board, there are three basic *functional* elements of DREAMS:

- the online publications component (used to communicate designs and completed studies),
- the database of metafiles (data descriptions) and the actual results of recent and historical studies, and
- the interactive 1999-2001 sediment quality GIS-friendly database.

The **On-line Publications** section consists of several files, most in PDF or HTML formats, that represent study designs and completed datasets as well as their analyses and interpretation. The majority of the over 30 documents currently posted is a result of studies conducted by GLIER between 1999 and 2001. The highlights of this application are the timeliness in communicating results and the availability of specific study designs for review *before* a study commences,

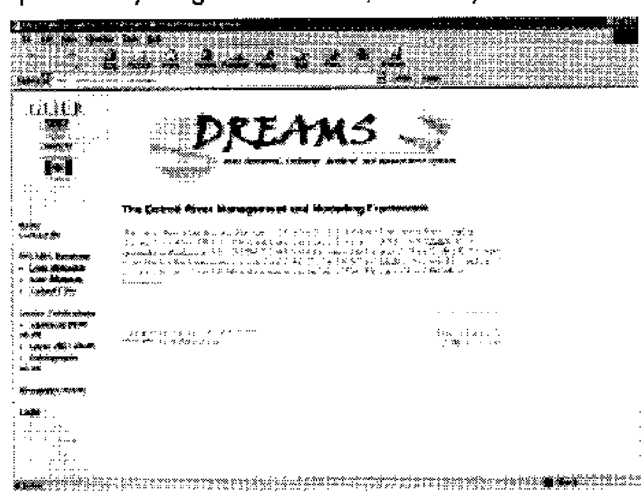


Figure 7: DREAMS Homepage (Image: A. MacPherson)

allowing it to be reviewed, changed and improved to suit monitoring, modelling and management needs. Most of the results of the 1999-2000 sediment quality assessment studies conducted by GLIER, for example, were available within a few months following field sampling events.
The user's interface of the **Metadata and Data** component consists of database-backed data entry forms, customized by type of the monitoring program such as physical, chemical and biological datasets. Once entered, the data are immediately available for review by other authorized users with a *summary* list that can be searched and extended to the full dataset. The emphasis here is on universal access, self-service and instant availability of both metadata, specific technical details of the monitoring program, and the dissemination of results of completed studies.

The third section is the GIS-enhanced results of the 1999-2001 extensive sediment quality assessment (See "Contaminants in Water and Sediments" for data summary). This part of the system consists of over 200 sampling locations where sediments were sampled and analyzed for close to 150 physical, chemical and biological parameters, resulting in a matrix of some 30,000 measurements of sediment quality in the Detroit River to be used in prospective management decisions. The user can search this database using any standard Internet browser by either selecting the desired range of parameters or by using the set of GIS maps to extract the results of interest with a click of a mouse.

Again, users are provided with easy and timely access to very recent datasets and to GIS functionality using only a standard Internet browser.

Conclusions

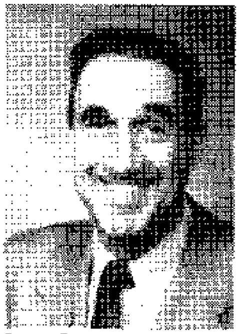
- DREAMS is operational now and relatively inexpensive to maintain;
- DREAMS provides fast and convenient access to data through an Internet interface;
- DREAMS is designed for binational use, e.g. by the Four Parties;
- DREAMS is coordinated with the needs of modellers in mind; and
- DREAMS can support an extended Huron-Erie corridor construct, when required.

Acknowledgments

The DREAMS project is a component of the Detroit River Management and Modelling Framework developed by GLIER for the Detroit River Canadian Cleanup Committee. Environment Canada's Great Lakes Sustainability Fund is the major supporter of this initiative. DREAMS is hosted on University of Windsor servers.

We would like to thank all the collaborators and supporters of the project for their contributions. We also invite you to use DREAMS at *www.uwindsor.ca/dreams* and to send us your comments and suggestions at *dreams@uwindsor.ca*

Conclusions and Recommendations



State Representative George Mans (Photo courtesy Office of Representative Mans)

Michigan State Representative George Mans (23rd House District) offered brief closing remarks. He thanked those who were working on rehabilitating the Detroit River and noted that we must continue these cross-border, collaborative efforts to review progress and challenges and identify critical next steps for ecosystem-based management. State Representative Mans acknowledged his frustration with being denied use of the river while growing up, but admitted to being heartened by the progress he now sees. People no longer feel helpless about the deterioration of the watershed, instead they are demanding remediation.

My passion for quality of life issues is certainly no secret. A life-long resident of the Downriver Area, I feel fortunate to live where we are blessed with the natural resources and wildlife habitats that provide opportunity for highly active recreational activities or quiet meditation beside beautiful rivers and parks. Investment today, in protecting our resources and expanding our green spaces, will enhance the quality of life in our area for generations to come. — George Mans, State Representative, 23rd House District

Major findings of the *State of the Strait* Conference Steering Committee follow:

- We need to follow through and actively support the binational designation of the Detroit River as an international wildlife refuge and simultaneously take action to conserve and rehabilitate key habitats consistent with habitat priorities established by the U.S. Geological Survey and the Essex Region Conservation Authority;

- Management agencies must ensure that a systematic and binationally-coordinated Detroit River monitoring program is in place and that it targets specific management issues and goals (particular emphasis should be placed on indicator species and restoration criteria for beneficial uses);

- Universities, government agencies and businesses should offer the Detroit River as a case study for preparation of a quantitative ecosystem indicator report to be developed in the next two years (consistent with State of the Lakes Ecosystem Conference reporting promoted by Environment Canada and the U.S. Environmental Protection Agency);

- Communities and businesses must continue to support waterfront redevelopment and greenway projects that attract more people to the Detroit River, help people gain a greater appreciation for this historical, cultural, ecological and economic asset, and help build broad-based support for further rehabilitation and conservation efforts, consistent with the principles of new urbanism and sustainable development;

- Management agencies, businesses, and universities must continue to cooperate on ecosystem-based management of the Detroit River, including seeking and supporting the ways and means of restoring fisheries and other aquatic resources by promoting sustainable fisheries practices, preventing the introduction of invasive species, identifying and eliminating sources of water and sediment pollution, and rehabilitating fishery habitat wherever waterfront redevelopment, shoreline protection, and navigational aids are being planned and implemented; and

- All universities, management organizations and government agencies should buy into and support a binational Detroit River data archive and clearinghouse to support coordinated management efforts as has been developed by the Great Lakes Institute for Environmental Research at the University of Windsor, i.e. the **D**etroit **R**iver **D**ata **R**etrieval, **E**xchange, **A**rchival, and **M**anagement **S**ystem.

Appendix One: Conference Agenda

STATE of the STRAIT

Status and Trends of the Detroit River Ecosystem

Tuesday, March 27, 2001
Ambassador Room
CAW Centre
University of Windsor

Greater Detroit American Heritage River

GREAT LAKES INSTITUTE
FOR ENVIRONMENTAL RESEARCH

State of the Strait Steering Committee

John Hartig	John Gannon
Jennifer Read	Doug Haffner
Pat Murray	Cathy Botek
Roberta Urbani	Jan Ciborowski
Orin Gelderloos	Mark Breederland
John Marsden	Rose Ellison
Gary Johnson	Rick Hobrla

Roy Schrameck

We would like to thank our generous co-sponsors:

Environment Canada
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Michigan Department of Environmental Quality
Canadian Consulate (Detroit)
Michigan Sea Grant -- MSU Extension
University of Windsor
University of Michigan -- Dearborn
City of Windsor
City of Detroit Water and Sewerage Department
Windsor Port Authority
Essex Region Conservation Authority
Wayne County Department of the Environment
Detroit Edison - a DTE Energy Company
BASF

and the volunteers who made today possible.

Lake Erie in the Millennium

March 28-29, 2001

Frameworks for Modelling Ecological Change in the Detroit River - Lake Erie Corridor

March 29, 2001

Welcoming Remarks (8:30)

Dr. Ross Paul, *President, University of Windsor;*

Hon. Mike Hurst, *Mayor of Windsor* (Invited);

Mr. Peter Stroh, *Chair, Executive Committee, Greater Detroit American Heritage River Initiative*

Hon. Herb Gray, *Deputy Prime Minister of Canada* (Invited)

Hon. John Dingell, *Rep. 16th Congressional District*

Keynote Address

Mr. Heath Meriwether, *publisher Detroit Free Press*

Detroit River Uses: Yesterday, Today and Tomorrow

Dr. Jennifer Read, *GLIER, University of Windsor*

Changes in the River Biota over Time

Dr. John E. Gannon, *U.S. Geological Survey*

Break/Posters/Displays

Habitat: Past and Present

Dr. Bruce Manny, *U.S. Geological Survey*

Biodiversity

Dr. James Bull, *Detroit Audubon Society*

Lunch/Posters/Displays

Contaminants in Water and Sediments (1:00)

Dr. Russell Kreis, Jr., *U.S. Environmental Protection Agency*

Dr. Douglas Haffner, *GLIER, University of Windsor*

Contaminants in Biota

Dr. Chip Weseloh, *Canadian Wildlife Service*

Sources and Loadings of Contaminants

Dr. David Dolan, *University of Wisconsin-Green Bay*

Waterfront Redevelopment and New Urbanism and Neighborhoods (2:00)

Ms. Faye Langmaid, *City of Windsor*; Mr. John Blanchard, *General Motors Global Headquarters*; Mr. Kent Anderson, *Hamilton-Anderson Associates*

Break/Posters/Displays

Panel: Four Agency Framework and Detroit River Management (3:20)

Mr. Jim Richardson, *Ontario Ministry of the Environment;*

Mr. David Hamilton, *Michigan Department of Environmental Quality;*

Ms. Jody Traub, *U.S. EPA;*

Mr. Simon Llewellyn, *Environment Canada*

Detroit River Data Retrieval Exchange, Archival and Management System

Mr. Maciej Tomczak, *GLIER, University of Windsor*

Summation

Dr. John Hartig, *River Navigator, Great Detroit American Heritage River Initiative, Adjunct Professor Wayne State University*

In recognition of the Detroit River and the speakers who contributed to *State of the Strait: Status and Trends of the Detroit River Ecosystem*, trees will be planted on the campuses of the University of Windsor, the University of Michigan - Dearborn and Michigan State University.

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Ralph Benoit
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Mary Bohling
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Huron River Watershed Council
and Sierra Club

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Jim Dulzo
Metro Times

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CAW, Ford Windsor Casting Plant

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As *The Griffin* sailed up the Detroit River and through Lake St. Clair in 1679, Father Hennepin wrote the following:

"This straight is finer than that of Niagara, being 30 leagues long, and everywhere one league broad, except in the middle which is wider, forming the Lake we have named St. Clair. The navigation is easy on both sides, the coast being low and even. It runs directly from north to south. The country between these two lakes is very well situated and the soil very fertile. The banks of the straight are vast meadows, and the prospect is terminated with some hills covered with vineyards, trees bearing good fruit, groves and forests so well disposed that one would think nature alone could not have made, without the help of art so charming a prospect. The country is stocked with stags, wild goats, and bears which are good for food, and not fierce as in other countries." (Hatcher, H. 1945. *Lake Erie*. Bobbs-Merrill Co., New York, N.Y.)

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