BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
WATER QUALITY STANDARDS AND	)	R08-9
EFFLUENT LIMITATIONS FOR THE	)	(Rulemaking - Water)
CHICAGO AREA WATERWAY SYSTEM	)	
AND THE LOWER DES PLAINES RIVER:	)	Subdocket C
PROPOSED AMENDMENTS TO 35 Ill.	)	
Adm. Code Parts 301, 302, 303 and 304	)	

NOTICE OF FILING

To: ALL COUNSEL OF RECORD
(Service List Attached)

PLEASE TAKE NOTICE that on the 2nd day of February, 2011, I electronically filed with the Office of the Clerk of the Illinois Pollution Control Board, the **Pre-Filed Testimony of Scudder D. Mackey in Support of a New Aquatic Life Use Designation Proposal.**

Dated: February 2, 2011.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

By: */s/ Fredric P. Andes*
One of Its Attorneys

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PROOF OF SERVICE

The undersigned attorney certifies, under penalties of perjury pursuant to 735 ILCS 5/1-109, that I caused a copy of the foregoing, **Notice of Filing** and **Pre-Filed Testimony of Scudder D. Mackey in Support of a New Aquatic Life Use Designation Proposal**, to be served via First Class Mail, postage prepaid, from One North Wacker Drive, Chicago, Illinois, on the 3rd day of February, 2011, upon the attorneys of record on the attached Service List.

/s/ David T. Ballard
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TESTIMONY OF SCUDDER D. MACKEY IN SUPPORT

OF A NEW AQUATIC LIFE USE DESIGNATION PROPOSAL

Introduction

My name is Scudder D. Mackey and I am an Environmental Consultant specializing in aquatic habitat mapping and characterization in both riverine and lake systems. I am the owner of Habitat Solutions NA, which is an independent environmental consulting firm. I currently hold dual appointments as a Visiting Research Professor in the Departments of Biological Sciences and Geological Sciences at the University of Windsor, Ontario, Canada. I hold a Bachelor of Science Degree in the Geological Sciences from Hobart College and a Master of Science in Geology from the University of Wisconsin – Madison. I received a Doctor of Philosophy Degree in Geology (fluvial sedimentology) from the State University of New York at Binghamton.

My areas of technical specialization are in aquatic habitat characterization and mapping; developing biophysical linkages to habitat; surface and watershed hydrology; nearshore, coastal, and riverine processes; and application of geospatial data and analyses (GIS) to Great Lakes aquatic ecosystems. I served as Supervisor for the Lake Erie Geology Group for the Ohio Department of Natural Resources and worked for the Great Lakes Governors as Project Implementation Manager with the Great Lakes Protection Fund (GLPF). I currently serve as co-

Chair and member of the Lake Erie Habitat Task Group for the Great Lakes Fisheries Commission and the AIS Barrier Advisory Panel for the USACE Chicago Waterway electric field dispersal barrier project. I also serve on the Asian Carp Regional Coordinating Committee Monitoring/Rapid Response subcommittee. I am currently the Project Manager for the Ecosystems Technical Working Group for the International Joint Commission International Upper Great Lakes Study that is evaluating potential ecological impacts of changes to Lake Superior water-level regulation on the Upper Great Lakes. Review of my curriculum vitae (Attachment 1) will reveal that my work has been focused on developing linkages between physical processes, physical habitat, and the organisms that use those habitats.

Overview

In my earlier pre-filed testimony (Exhibit #179), it was clearly demonstrated that existing habitat classification schemes and Aquatic Life Use designation categories developed for natural systems do not apply to artificial man-made and highly urbanized systems such as the Chicago Area Waterway System (CAWS). A review of the CAWS UAA Report (CDM 2007) and IEPA's Statement of Reasons revealed that the data and methodology used by IEPA was inaccurate, flawed, and did not adequately consider all of the key elements necessary to assess the condition of aquatic habitats. I concluded in my pre-filed testimony that most of the CAWS was clearly habitat limited and that it was unlikely that the standards proposed in IPCB rulemaking R08-09 by IEPA would significantly improve fish community structure and diversity in the CAWS. In fact, many of the major deficiencies in IEPA's approach were listed in Table 1 of my pre-filed testimony (Exhibit #179).

Moreover, based on a review of the CAWS UAA Report (CDM 2007), IEPA's proposed rule R08-9, and supporting documentation, it became clear that there were major gaps in the

CAWS environmental datasets, especially with respect to physical habitat, spatial and temporal sampling, and the need for new indices designed specifically to assess and summarize habitat and biological conditions in low-gradient, non-wadeable, highly altered, urban streams and rivers. In part to address these deficiencies, the Metropolitan Water Reclamation District of Greater Chicago (the District) initiated a comprehensive Habitat Evaluation and Improvement Study of the CAWS.

My testimony has three components: 1) I will briefly summarize the conclusions of the CAWS Habitat Evaluation and Improvement Study; 2) I will address the habitat significance of new information acquired during the asian carp eradication/sampling events within the CAWS by the Illinois Department of Natural Resources; and 3) I will briefly describe the relative habitat potential of the CAWS based on a new habitat index in support of three distinct Aquatic Life Use categories proposed by the District for the CAWS.

1) Results of the Habitat Evaluation and Improvement Study

The District contracted LimnoTech, Inc (LimnoTech) to assess habitat conditions in the CAWS and to provide the technical information necessary to fully evaluate the importance of physical habitat to aquatic communities within the CAWS. As part of this assessment, LimnoTech developed a habitat index designed specifically for the CAWS that is well-supported by scientific data and has undergone a rigorous peer-review. This index was then used to assist in the development of appropriate Aquatic Life Use designations for each waterway. The results from the Chicago Area Waterway System Habitat Evaluation and Improvement Study are presented in two reports, entitled, "Habitat Evaluation Report" (Filed on January 6, 2010 PC 284) and "Habitat Improvement Report" (Filed on January 6, 2010 PC 284). Details of these

reports will be summarized by Dr. Scott Bell in separate pre-filed testimony (Filed February 2, 2011). Significant findings of these reports include:

All of the CAWS segments are fundamentally limited by the irreversible functional limitations of the CAWS – The CAWS is an artificial man-made system with minimal natural attributes, and the designation of Aquatic Life Uses must consider those irreversible functional limitations. Even though the shoreline habitat improvements recommended in the Habitat Improvement Report would benefit many of the fish species already found in the CAWS, it would not benefit populations of intolerant or moderately intolerant obligate riffle dwellers that require fast moving water and coarse substrates commonly found in natural channels. Sustainable populations of less tolerant species that require higher energy conditions and coarse substrates will always be limited by existing functional uses and physical characteristics associated with a man-made artificially constructed waterway such as the CAWS. These channelized waters are similar to impoundments and by design, will not exhibit many of the physical habitat characteristics associated with natural streams or rivers.

Physical Habitat is a major limiting stressor in the CAWS - The Habitat Evaluation Report outlines the process of index development and explains the habitat attributes in the CAWS that are expected to most influence fish communities. Page 104 of the Habitat Evaluation Report describes the methods used to reduce the initial set of 241 habitat variables to the final 16 habitat variables that were compared with a "combined fish metric" which serves as a CAWS-specific index of biological integrity for fish. Using multiple regression analysis techniques, the six habitat variables that were statistically most predictive of fish data were as

follows: maximum depth of channel, off-channel bays, percent of vertical wall banks in reach, percent of riprap banks in reach, manmade structures in reach, and percent macrophyte cover in reach. These six variables account for 48 percent of the variability in fish data in the CAWS. The report also states that "Of the half of fish data variability that is not explained by these physical habitat variables, 70% of that half can be explained by variation in fish sampling results from year to year." (Page 123, Habitat Evaluation Report). The remaining 15% of the variability in fish data may be explained by other factors, such as navigation or conveyance of wastewater. In fact, navigation was deemed to have a potential affect on aquatic life uses in the CAWS, but current datasets were inadequate to evaluate those impacts quantitatively (pages 91-93 of the report).

DO was significantly less important to aquatic life than physical habitat limitations - LimnoTech used multiple regressions to statistically compare various DO metrics to CAWS fish metrics and concluded that water quality, including DO, was significantly less important to aquatic life than physical habitat limitations in the CAWS. The most significant correlation between a DO metric (the percent of time that DO was less than 5 mg/L at each station between June through September) and the CAWS fish metrics indicated "*that only 3 percent of CAWS fish data that is not explained by the six physical habitat variables in the regression equation (1.5 % of total variability in fish data) may be explained by DO conditions at each sampling station.*" (Page 121, Habitat Evaluation Report). These results clearly demonstrate that current DO levels are not a significant limiting factor of Aquatic Life Uses in the CAWS, and that further increases in DO would yield only marginal improvements to aquatic life in the CAWS due to severe physical habitat limitations.

These conclusions are consistent with testimony presented earlier where physical habitat limitations were described to be the primary limiting factor in the CAWS. For instance, on pages 15-16 of my August 4, 2008 pre-filed testimony, it states:," *In my opinion, the substantial investments needed for infrastructure to provide incremental increases in DO and/or reductions in temperature will not yield a proportionate biological response with respect to attaining sustainable fish communities and/or other beneficial uses. The lack of diverse bank-edge and instream habitats within the CAWS may be a much more significant limitation on the development of sustainable fish communities than current levels of DO or temperature. Without suitable habitat pattern and diversity, sustainable populations of these species can not be established irrespective of how much improvement there is in water quality.*"

The dominant species represent a relatively complete fish community in that they occupy most of the trophic levels in the food web - LimnoTech reported on page 94 of the Habitat Evaluation Report: "*The constructed and heavily modified conditions within the CAWS, combined with the management of the system for its intended uses of wastewater conveyance and navigation, have limited the structural and functional conditions for aquatic habitat. These limited habitat features have resulted in a biotic community (as measured by fish) that is tolerant of the modified conditions and appears to be thriving. These conditions also impose a significant limitation on the potential of the CAWS to support fish communities different than what presently exist there.*"

The CAWS fish species assemblage were composed primarily (96%) of fish in three families, including the herring family (Clupiedae – 40% of all fish collected), the carp and minnow family (Cyprinidae – 37%), and the sunfish family (Centrarchidae -19%). The most

abundant sunfish were largemouth bass, pumpkinseed, and bluegill, which are popular game fish species. This assemblage consists of generally warm-water pool-oriented species that are considered to be tolerant or moderately tolerant to pollution. The dominant species represent a relatively complete fish community in that they occupy most of the trophic levels in the food web. Moreover, the existing fish community is thriving and has achieved a sustainable balance within the CAWS.

2) Habitat Implications of results from rotenone applications in the vicinity of the Aquatic Invasive Species Dispersal Barrier.

The Illinois Department of Natural Resources (IDNR) submitted additional public comments on Proposed Designated Uses and Standards for the CAWS and Lower Des Plaines River (PC 505). In the these comments, the IDNR describes the sampling results from two separate applications of rotenone as part of ongoing asian carp control and monitoring operations under the direction of the asian carp Regional Coordinating Committee (RCC). These data were not collected as part of a scientific study but rather were collected opportunistically as a result of actions taken to: 1) remove fish from a 5.5 mile reach of the Chicago Sanitary and Ship Canal (CSSC) in preparation for maintenance work at the Aquatic Invasive Species Dispersal barrier (dispersal barrier), and 2) verify eDNA sampling results in the Cal Sag Channel and Little Calumet River near the T. J. O'Brien lock and dam.

IDNR uses these data to highlight apparent high species abundance and diversity within the CAWS, and suggests that water quality and habitat availability within the CSSC are suitable to support a "*diverse, healthy, reproducing population of fish comprised of a high percentage of moderately tolerant species in adult and early life stages*." (PC 505, page 4). IDNR argues in

favor of the proposed water quality standards, even though according to their interpretation of the sampling data, there already is a "*diverse, healthy, reproducing population of fish*" in existence within the CSSC under existing water quality standards. Moreover, IDNR suggests that because young-of-the-year fish may be present, that the system is not habitat limited and that existing habitat within the CSSC is adequate to support a "*diverse, healthy, reproducing population of fish*".

In fact, the IDNR analysis of the rotenone sampling data is inaccurate, flawed, and the conclusions made with respect to habitat quality and availability are speculative and are not supported by the data. There have been no improvements made to the physical characteristics of the CAWS since sidescan sonar and additional physical habitat data were collected from the CSSC in the summer of 2008, and those surveys clearly demonstrated a lack of available habitat with suitable spawning and nursery characteristics used by many species of fish (Mackey pre-filed testimony, Exhibit #179). Moreover, the testimony of Greg Seegert (EA Engineering, IPCB testimony dated November 9, 2010 pages 230 to 261) clearly describes many of the deficiencies in the IDNR analysis and interpretation of the rotenone sampling data. Important issues to consider when evaluating the validity of the IDNR recommendations in PC 505 include:

1) Sampling and assessment of fish communities is typically done using standardized methods and techniques so that valid spatial and temporal comparisons can be made. The District uses standardized electrofishing protocols that are directly comparable not only with historical datasets, but data collected by other agencies and/or contractors as well. Fish community assessments and indices such as the IEPA's Index of Biotic Integrity are developed and calibrated using these standardized datasets.

The analysis and conclusions presented by IDNR in PC 505 are inaccurate, flawed, and speculative because the underlying data are not standardized and can not be directly compared with data or indices derived from other sampling methods or protocols. For example, the RCC rotenone action was designed to kill all fish within a 5.5 mile reach of the CSSC downstream from the dispersal barrier. The event lasted for three days and impacted a large volume of water (minimum 200 million cubic feet). Electrofishing samples a relatively small volume of water (estimated 1 to 2 million cubic feet) over a short period of time (hours). The fish data collected as a result of the RCC rotenone action are clearly not standardized or directly comparable with fish data or indices derived from other more traditional sampling methods or protocols. The recommendation made by IDNR to alter Aquatic Life Use designations and habitat assessments based solely on the rotenone fish sample data is flawed and is not scientifically defensible.

2) The rotenone sampling results recorded only 34 species from the CSSC during the December rotenone action (PC505, Table 1) – less than have been found in the CAWS in District fish surveys. In fact, most of the species reported by IDNR have been collected previously during earlier District monitoring surveys.

3) IDNR states that the presence of young-of-the-year fish, especially high abundances of young-of-the-year channel catfish in the CSSC sample "*indicates that the existing water quality and habitat is sufficient to support larval stages of this species, and spawning is commonly occurring.*" (PC 505, page 3). Channel catfish have not been categorized either as being a tolerant or intolerant species by IEPA, but the presence of young-of-the-year catfish indicate that current water quality conditions are suitable for young-of-the-year of this species. With respect to habitat, channel catfish typically spawn in protected low flow areas and are considered to be "cavity spawners". Typical nest sites include protected hollows, depressions,

logs, undercut banks, bedrock shelves or cavities. Sidescan sonar surveys in the CSSC and visual observation of the channel walls confirm that there are localized areas where cavities/depressions exist within the channel walls of the CSSC. These features are present where blocks of dolomite have spawled out of the channel walls onto the channel floor. These localized areas would be considered to be potential spawning/nesting sites for channel catfish. However, this type of habitat is limited, somewhat unique, and is not used as spawning habitat by most species of fish. So as stated in Dr. Mackey's earlier pre-filed testimony (Exhibit #178), the CSSC does not exhibit many of the habitat characteristics or features commonly found in natural rivers or streams and is therefore habitat limited.

4) The area of the CSSC that was sampled during the RCC rotenone action in December 2009 extends from the dispersal barrier at RM 296.8 downstream past the Lockport Lock and dam and the confluence with the Des Plaines River to RM 288.8. Examination of the USACE navigation charts above the Lockport Lock and Dam, specifically between RM 292.0 and RM 293.5 and RM 295.2 to RM 296.2 (USACE Map No. 113 – 116) reveals portions of the CSSC that are considerably wider and shallower than the CSSC reaches upstream of the dispersal barrier. These reaches include several fleeting areas, haul out and repair basins, loading docks, shallow embayments, and areas where the width of the CSSC is two to three times wider than the main channel. All of these sites are protected low flow shallow-water areas and represent the best potential channel catfish spawning and nesting habitats that exist within the CSSC. Moreover, located downstream from the Lockport Lock and Dam is the confluence with the Lower Des Plaines River, which is a natural river with habitat characteristics that may be more suitable for use as spawning and nesting habitat for channel catfish. In fact, many of the fish sampled during the RCC rotenone action in December could have been from spawning and

nesting sites within the Lower Des Plaines River, especially those fish collected below the Lockport Lock and Dam.

5) When the electric field dispersal barriers are active, movement upstream or downstream by adult or juvenile channel catfish (or other species of fish) is restricted. The RCC rotenone action on December 3 – 6, 2009 sampled fish located (or trapped) on the downstream side of the dispersal barrier and therefore may not be representative of fish populations above the barrier (especially young-of-the-year fish). Unlike the CSSC reaches downstream from the dispersal barrier, there are no natural rivers or streams feeding young-of-the-year fish into the CSS and there are no fleeting areas or shallow embayments in close proximity to the dispersal barrier within the upstream reaches of the CSSC.

3) Evaluation of Relative Habitat Potential in CAWS

The CAWS Habitat Evaluation report determined habitat index scores for all of the CAWS reaches between the Wilmette pump station, Chicago River Controlling Works and O'Brien Lock and Dam, and the Lockport lock and dam. The results of this evaluation are presented in Table 7-7 on page 139 of the CAWS Habitat Evaluation Report. Based in part on the habitat index scores, the District has proposed three Aquatic Life Use Categories:

- **<u>CAWS ALU Category 1</u> – Modified Warm Water Aquatic Life Waters - Represents the highest quality environmental conditions and habitat quality in the CAWS**

- **<u>CAWS ALU Category 2</u> – Limited Warm Water Aquatic Life Waters - Represents a more limited set of environmental conditions and habitats in the CAWS.**

- **<u>CAWS ALU Category 3</u> – Severely Limited Aquatic Life Waters - Represents the most limited set of environmental conditions and poorest habitat quality in the CAWS.**

The environmental characteristics associated with these categories will be described in more detail in the pre-filed testimony of Jennifer Wasik (Filed on February 2, 2011). Application of the Habitat Index and subsequent assignment of the proposed CAWS ALU Categories reveals that the Upper and Lower North Shore Channel, Upper North Branch of the Chicago River, and the Little Calumet River are CAWS ALU Category 1 waterbodies exhibiting the highest quality habitat and environmental conditions within the CAWS. The Lower North Branch and Main Branch of the Chicago River, Sanitary and Ship Canal, and the Cal Sag Channel are CAWS ALU Category 2 waterbodies with moderate habitat quality and limited environmental conditions. Due to stagnant water, low DO levels, and highly variable wet-weather flow events, Bubbly Creek is classified as a CAWS ALU Category 3 waterbody, which represents the most limited set of environmental conditions and poorest habitat quality in the CAWS. These Categories, when applied to the CAWS, compare favorably with field observations and general environmental conditions observed in each of the waterway segments.

In summary, the results of the CAWS Habitat Evaluation and Improvement Study clearly demonstrate that the artificial and highly urbanized Chicago Area Waterway System (CAWS) is clearly habitat limited and that further improvements in water quality will not significantly improve fish community structure and diversity. In fact, the results of the Habitat Evaluation Study confirmed and validated the conclusions reached in earlier pre-filed testimony submitted by Dr. Mackey to the Illinois Pollution Control Board (Exhibit #179).

Conclusions

After reviewing the CAWS UAA Report (CDM 2007), IEPA's proposed rule R08-9, and supporting documentation, it was clear that there were major gaps in the CAWS environmental datasets, especially with respect to physical habitat, spatial and temporal sampling, and the need for new indices designed specifically to assess and summarize habitat and biological conditions in low-gradient, non-wadeable, highly altered, urban streams and rivers. Completion of Chicago Area Waterway System Habitat Evaluation and Improvement Studies addresses many of the deficiencies identified in my earlier testimony including limited habitat data and a lack of an appropriate science-based methodology to designate Aquatic Life Uses. The results of these studies clearly demonstrate that the artificial and highly urbanized CAWS is habitat limited and that further improvements in water quality will not significantly improve fish community structure and diversity.

This testimony describes the scientific basis for a new, tiered Aquatic Life Use Classification system developed specifically for low-gradient, non wadeable, highly altered, artificial systems as epitomized by the CAWS. The classification system was developed by the District and is based primarily on a habitat index that is well-supported by scientific data and statistical methodology as described in the Chicago Area Waterway System Habitat Evaluation Study.

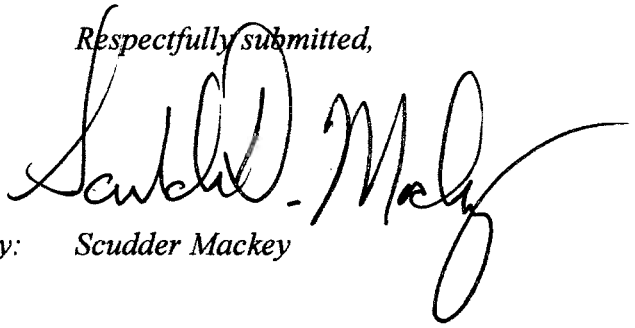
The IDNR analysis of the rotenone sampling data is inaccurate, flawed, and the conclusions made with respect to habitat quality and availability are speculative and are not supported by the data. The testimony presented here clearly shows that fish data collected as a result of the RCC rotenone action are not standardized or directly comparable with fish data or

indices derived from other more traditional sampling methods or protocols. The recommendation made by IDNR to alter Aquatic Life Use designations and habitat assessments based solely on the rotenone fish sample data is flawed and is not scientifically defensible.

Based in part on the habitat index scores, the District has proposed three Aquatic Life Use Categories: These Categories, when applied to the CAWS, compare favorably with field observations and general environmental conditions observed in each of the waterway segments. It is important to note that further habitat improvements are possible, but all of these waterway segments are fundamentally limited by the irreversible functional limitations of the CAWS. The CAWS is an artificial man-made system with minimal natural attributes, and the designation of Aquatic Life Uses must consider those irreversible functional limitations. The CAWS Habitat Index and the proposed CAWS ALU Categories developed by the District represent a major step forward in the development of robust methods to designate Aquatic Life Uses in highly urbanized, artificial waterway systems.

I would like to thank the Illinois Pollution Control Board for the opportunity to present this testimony.

Respectfully submitted,



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Testimony Attachments, Tables, and Figures

1. Curriculum Vitae: Scudder D. Mackey, Ph.D.

Literature Cited

CDM. (2007). Chicago Area Waterway System Use Attainability Analysis. 8-01-07 edits version. http://www.ipcb.state.il.us/documents/dsweb/Get/Document-59252/ Accessed Jan. 2008.

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Habitat Solutions NA

Habitat Solutions NA

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- Demonstrated management abilities and leadership skills
- Excellent concept generation and synthesis skills – innovative solutions to complex problems
- Experience dealing with multiple stakeholders and partners during project planning and design
- Strong facilitation and communication skills

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- Conservation Geology
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Dr. Mackey is Principal and Owner of Habitat Solutions NA, an environmental consulting firm based in Chicago, Illinois. Habitat Solutions NA is an environmental consulting firm specializing in aquatic habitat assessment, protection, and restoration; riverine and coastal physical processes and habitat dynamics; and Great Lakes water resource issues. Dr. Mackey holds a Doctorate in Geology (fluvial sedimentology) with areas of technical specialization in aquatic habitat characterization and mapping; development of biophysical linkages to habitat; surface and watershed hydrology; nearshore, coastal, and riverine processes; and application of geospatial data and analyses (GIS) to Great Lakes aquatic ecosystems.

Dr. Mackey has considerable experience working with multiple stakeholders and has been directly involved with policy development and numerous protection and restoration initiatives focused on a broad range of environmental issues, including: Great Lakes water resources and diversions (Annex 2001), aquatic invasive species (ballast water introductions and Asian Carp), natural flow regime restoration (dam removals and watershed flow-path analyses), and the mapping and characterization of fish and aquatic habitats in large riverine and nearshore systems of the Great Lakes using geophysical (sidescan sonar) and remote sensing technologies. He has collaborated with many key environmental groups and resource management agencies in both the U.S. and Canada and has an excellent rapport with agency, academic, and NGO organizations within the Great Lakes basin. Dr. Mackey has strong facilitation and communications skills and has considerable experience developing innovative solutions to complex environmental problems within the Great Lakes basin.

Dr. Mackey served as Supervisor for the Lake Erie Geology Group for the Ohio Department of Natural Resources and worked for the Great Lakes Governors as Project Implementation Manager with the Great Lakes Protection Fund (GLPF). Dr. Mackey developed, reviewed, and participated in numerous aquatic habitat protection and restoration projects in both coastal and riverine settings. He currently holds a dual appointment as an Adjunct and Visiting Research Professor in the Departments of Biological Sciences and Earth Sciences at the University of Windsor, Canada.

RELEVANT AGENCY EXPERIENCE

Dr. Mackey served as the Supervisor of the ODNR Lake Erie Geology Group from 1992 through 2003. This field office provided technical support and services to lakefront property owners, local communities, and local, State, and Federal agencies. The primary focus of this office was to develop a better understanding of coastal erosion and sediment transport processes along the Ohio Lake Erie coastline, and how to manage those processes in a sustainable way that benefits the people of the State of Ohio. The Lake Erie Geology Group worked closely with the U.S. Army Corps of Engineers on numerous coastal issues and assisted with the technical evaluation of projects proposed for Ohio Lake Erie waters. This office reviewed applications for new shore protection projects as part of a multi-agency review process, with a strong focus on sand resource conservation and management.

From 1992 though 1996, Dr. Mackey was a co-PI with the USGS National Coastal Center as part of major study to document and understand the underlying framework and processes influencing coastal erosion along the Ohio Lake Erie coastline. Dr. Mackey also initiated a comprehensive inventory of shore protection structures and a comprehensive assessment of the distribution of lakebed materials in coastal margin and nearshore zones in Ohio waters. Working with coastal stakeholders, the Lake Erie Geology Group developed and implemented the protocols to systematically map and quantify Coastal Erosion Areas as part of the Ohio Coastal Management Program.

Dr. Mackey also initiated habitat-related projects in cooperation with both State and Federal agencies, with a specific emphasis on developing linkages between physical habitat structure, the processes that create and maintain those habitats, and the biological organisms that rely on those habitats. Examples include the Metzger Marsh wetland restoration project, assessments of Walleye spawning habitat over the Western Basin Reefs and mapping of potential small-mouth bass habitat around the fringes of the Lake Erie Islands using sidescan sonar, and numerous dam removal and stream habitat assessment and protection projects in tributaries flowing into Lake Erie.

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RELEVANT PROJECT EXPERIENCE

International Joint Commission - IJC International Upper Great Lakes Study (ongoing) Dr. Mackey has been retained as the Project Manager for the IUGLS Ecosystems Technical Workgroup tasked to evaluate ecological impacts resulting from potential changes in Lake Superior water-level regulation. Specifically, this study is designed to evaluate the effects of changing water-level regimes on coastal ecosystem functions and resources (wetlands and fisheries) in Lakes Superior, Michigan-Huron, the connecting channels and Lake Erie. In collaboration with the Ecosystem Technical Workgroup co-Chairs, Dr. Mackey is responsible for overall project oversight, management, and technical evaluation of potential ecosystem impacts to the Upper Great Lakes. The results of this work will be incorporated with information from other technical workgroups (Hydropower, Shipping, Recreational Boating, Coastal, and Hydroclimate) to formulate a revised Lake Superior water regulation plan.

USFWS - Restoration Act Sponsored Research Lake Trout Spawning Habitat Assessment in Lake Michigan (ongoing) In cooperation with the Illinois Natural History Survey and the Illinois Department of Natural Resources, Dr. Mackey is a co-PI on a project designed to identify and characterize potential lake trout fish spawning habitat over two known lake trout spawning reefs in Lake Michigan waters. Sidescan sonar data acquired over Waukegan Reef and Julians Reef will be integrated with high-resolution bathymetric data to provide a detailed map of potential spawning habits over these reef complexes. Both of these reefs are documented Lake Trout spawning areas and these habitat data will be used to guide additional sampling and monitoring efforts over these reefs.

TRCA – Toronto Region Conservation Authority – Restoration and Naturalization of Lower Don River, Toronto, Ontario (ongoing) in cooperation with Staff from Applied Ecological Services and the Toronto Regional Conservation Authority, Dr. Mackey is mapping channel morphology and potential fish habitat structure in three urban rivers in the Greater Toronto area. Two of these rivers are being used as reference sites to establish habitat-fish community relationships from areas that have not been severely degraded. It is anticipated that this information and data will be used to guide a comprehensive restoration and naturalization effort in the Lower Don River.

The Ohio State University – Aquatic Habitat Mapping and Assessment – Sandusky Bay and Sandusky River, northern Ohio (completed) In May 2008, Dr. Mackey working in collaboration with a Graduate Student from the OSU Aquatic Ecology Laboratory and Fisheries Biologists from the ODNR mapped the distribution of aquatic and fish habitats in the Sandusky River and Sandusky Bay using sidescan sonar. This work was supported by the ODNR – Division of Wildlife. This study is part of an ongoing effort to establish baseline data in anticipation of the removal of Ballville Dam on the Sandusky River in Fremont, Ohio.

USFWS - Restoration Act Sponsored Research Lake Trout Spawning Habitat Assessment in Lake Erie (completed) In cooperation with the Ohio Division of Wildlife, New York State Department of Environmental Conservation, U.S. Geological Survey, Ontario Ministry of Natural Resources, and Environment Canada, Dr. Mackey is a co-PI on a project designed to identify and characterize potential lake trout fish spawning habitat in the eastern basin of Lake Erie. Sidescan sonar data has been acquired over historical spawning sites including Brocton Shoal and the Pennsylvania/Long Point ridge. The OMNR, USFWS, NYDEC, ODNR, and USGS are working to rehabilitate native lake trout populations in Lake Erie through habitat protection and rehabilitation efforts combined with an intensive stocking effort to begin in the fall of 2008. These habitat data will be used to locate potential stocking sites in both Canadian and U.S. Lake Erie waters within the eastern basin of Lake Erie.

OMNR – Lake Erie Fisheries Management Unit - Lake Erie nearshore Mapping and Lake Trout Rehabilitation (ongoing) In July 2007, Dr. Mackey working in collaboration with Fisheries Biologists from the Ontario Ministry of Natural Resources (OMNR), initiated a COA-funded project to collect sidescan sonar data from nearshore areas of the Canadian Lake Erie coastline to identify and characterize potential lake trout fish spawning habitat in the eastern basin of Lake Erie. The OMNR, USFWS, NYDEC, ODNR, and USGS are working to rehabilitate native lake trout populations in Lake Erie through habitat protection and rehabilitation efforts combined with an intensive stocking effort to begin in the fall of 2008. These habitat data will be used to locate potential stocking sites in both Canadian and U.S. Lake Erie waters.

ODNR - Division of Wildlife – Reconnaissance Sidescan Sonar Data Acquisition – Mentor/Fairport area (completed) In May 2008, Dr. Mackey working in collaboration with Fisheries Biologists from the ODNR – Division of Wildlife, collected more than 50 line miles of sidescan sonar data from nearshore and offshore waters in Lake Erie as part of a regional fish habitat characterization project. These data will be integrated with older data collected by the ODNR – Division of Wildlife to develop linkages between fish communities and nearshore habitat distributions. These data are being used to identify and guide potential fish habitat restoration and protection projects within Maumee Bay.

GLFC – GLFT – Ecological Separation Study for the Chicago Waterway System (completed)
Dr. Mackey was a co-PI funded by the Great Lakes Fisheries Commission and the Great Lakes Fisheries Trust to explore the feasibility of ecologically separating the Great Lakes and Mississippi Basins via the Chicago Waterway System. This study was designed to create the framework for a more comprehensive feasibility study to assess permanent long-term strategies to prevent the exchange of aquatic invasive species (e.g. Asian Carp) between the Great Lakes and Mississippi basins.

U.S. EPA – Lake Michigan Nearshore and Coastal Margin Habitat Assessment Project (completed)
In cooperation with Michigan State University, Dr. Mackey was a co-PI on a project to characterize nearshore habitat zones and develop biophysical linkages between nearshore habitats and the aquatic organisms that use them. Dr. Mackey used sidescan sonar and underwater video to identify and map nearshore and coastal margin habitats off the Lake Michigan coastlines of Wisconsin and northern Illinois. He continues to work with aquatic ecologists and fishery biologists from Michigan State University to characterize the biophysical linkages and heterogeneity of nearshore substrates. Ultimately, the results of this work will be used to assess the potential impact of changing water levels (climate change) and shoreline modifications (armoring) on nearshore habitat distribution and structure. The Wisconsin DNR and Regional Planning Commissions will use this information to guide development of new rules for shoreline development to protect and restore fish and aquatic habitats in Lake Michigan nearshore waters.

U.S. EPA – Lake Erie Binational Map Project (completed)
In cooperation with the University of Minnesota, the University of Windsor, Great Lakes Commission, and the U.S. Geological Survey, Dr. Mackey was a co-PI on a project to develop a unified habitat classification system and map for the entire Lake Erie basin. This project developed tools to assist the Lake Erie Lakewide Management Plan (LaMP) to develop a bi-national inventory of the status and trends in the quantity and quality of fish and wildlife habitats in the Lake Erie basin. The integrated habitat map will be used to track improvements in habitat quantity and quality resulting from preservation, conservation, and restoration efforts and to guard against further loss or degradation from land-use alterations. The project team is developed a strategy to revise and expand the classification scheme to the rest of the Lake Erie Basin and also developed a binational habitat map data exchange website which includes links to geospatial metadata and habitat coverages in the basin. The Lake Erie habitat classification and mapping project serves as a model for the development of a comprehensive basinwide habitat classification system and inventory for the entire Great Lakes basin.

ODNR - Division of Wildlife – Reconnaissance Sidescan Sonar Data Acquisition - Maumee Bay (completed)
In early May 2007, Dr. Mackey working in collaboration with Fisheries Biologists from the ODNR – Division of Wildlife, collected more than 75 line miles (121 line km) of sidescan sonar data from shallow-water areas of Maumee as part of a regional fish habitat characterization project. These data will be integrated with older data collected by the ODNR – Division of Geological Survey that characterizes nearshore substrate distributions along the entire 262-mile Lake Erie shoreline and more recent data collected by Environment Canada in deeper-water areas of the Western Basin. These data are being used to identify and guide potential fish habitat restoration and protection projects within Maumee Bay.

SEWRPC – Racine County Shore Structure Inventory and Assessment Project (completed)
In cooperation with the Southeast Wisconsin Regional Planning Commission and the Wisconsin DNR, Dr. Mackey developed and implemented a set of field protocols to identify, characterize, map, and inventory shore protection structures along the Racine County Lake Michigan shoreline. This pilot project included extensive field work and data collection using portable GPS equipment and development of a geospatial database and GIS to assess the current state of shoreline armoring along the Wisconsin Lake Michigan shoreline. As part of this project, the condition and integrity of structures were assessed along with the potential of these structures to modify nearshore coastal processes and habitats. In part based on this work and a similar inventory of shore protection structures along the

Wisconsin Lake Michigan shoreline, Dr. Mackey recently developed a new shoreline alteration index (SAI) that assesses not only the physical impacts of shore protection in the nearshore zone, but potential biological impacts as well. Ultimately, the results of this work will be combined with results from the U.S. EPA project (described above) to assess the impact of shoreline armoring on coastal processes and nearshore habitat distribution and structure.

USFWS - Restoration Act Sponsored Research (completed)

In cooperation with the University of Windsor and The Ohio State University, Dr. Mackey was a co-PI on a recently completed project designed to create a framework and develop a process to systematically identify, coordinate, and implement aquatic and fish habitat restoration opportunities in the Lake Huron to Lake Erie Corridor (Huron-Erie Corridor, HEC) within a context of water-level change resulting from potential long-term effects of global climate change. This project summarized existing datasets and initiatives and developed a comprehensive strategy to identify and implement sustainable aquatic and fish habitat restoration opportunities within the Corridor. Components of this restoration strategy are currently being implemented by the U.S. Geological Survey, U.S. Fish & Wildlife Service, Michigan DNR, Environment Canada, and the Great Lakes Commission.

International Joint Commission – Great Lakes Water Quality Agreement (completed)

In 2005, the Water Quality Board of the International Joint Commission retained Dr. Mackey to explore more fully the role of physical integrity as part of a comprehensive ongoing review of the Great Lakes Water Quality Agreement. Currently the GLWQA is a "water chemistry" agreement that does not adequately define or incorporate the critical elements of physical or biological integrity. Dr. Mackey's work succinctly defined physical integrity and provides specific examples of the importance of physical integrity to both the environmental and economic health of the Great Lakes basin. This work provides the conceptual underpinnings for a suite of developing projects focused on the protection and restoration of fish and aquatic habitats within connecting channels and waters (St. Clair and Detroit Rivers) and Lake St. Clair. Moreover, this work may form the basis for delisting criteria for Benthic Habitat and Fish and Wildlife populations within the St. Clair and Detroit River AOCs. Incorporating physical integrity into the GLWQA will provide new policy guidance and broaden the scope of the Agreement to include heretofore unrecognized protection and restoration opportunities within the Great Lakes basin.

SERVICE

Dr. Mackey currently serves as a co-Chair and member of **Lake Erie Habitat Task Group for the Great Lakes Fisheries Commission** and the **AIS Barrier Advisory Panel** and the **Asian Carp Regional Coordinating Committee Monitoring and Rapid Response Group** for the USACE Chicago Waterway aquatic nuisance species dispersal barrier project.

HONORS/AWARDS

Letters of Commendation – Ohio Senate, U.S. House of Representatives, Spring 2001: For services to the People of the State of Ohio and the Natural Resources of Lake Erie.

Speaker, Plenary Session - International Association for Great Lakes Research, 1999: *Cumulative Impacts: Physical and Biological Linkages to Habitat*. 42nd Conference on Great Lakes Research, Cleveland, Ohio, May 24-28.

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