Sylvania City Council
November 4, 2013

5:00 p.m. Finance Committee
2014 Budget

6:00 p.m. Public Hearing
Flower Hospital, PD-3-2013

7:30 p.m. Council Meeting
Agenda

1. Roll call.

2. Pledge of Allegiance to the United States of America led by Mr. Haynam.

3. Additions to the agenda.

4. Approval of the meeting minutes of October 21, 2013.

5. Report on Public Hearing PD-3-2013 Flower Hospital.

6. Proposed Ordinance 80-2013, Revision the Administrative, Departmental and Divisional Organization of the City & Codified Ordinances creating the new part-time position of "Assistant Prosecutor".

7. Proposed Ordinance 81-2013, Authorizing an agreement with Sylvania Township for transporting prisoners to and from Sylvania Municipal Court from Lucas County jail and appropriating funds.

8. Proposed Ordinance 82-2013, Authorizing Flower Hospital to affix banners to utility poles along Monroe St and Harroun Rd.

9. City Water Rates:
   a. Service Director's report on rate increases from Toledo.
   b. Set Utilities & Environment Committee meeting.

10. OPWC Grant Application-Arbor Way Sanitary Sewer, Cadet Drive Water Main Replacement, Forestgate Street Reconstruction project:
    a. Service Director's report on Grant Application.
    b. Resolution 16-2013, Authorizing to file a grant application with OPWC for project.

11. Proposed Resolution 17-2013, Re-appointing George France to the Board of Trustees of SAJRD for three year term to expire on December 31, 2016.

12. Proposed Resolution 18-2013, Re-appointing Norman R. Ladd to the Zoning Board of Appeals for a three year term expiring December 31, 2016.

13. Proposed Resolution 19-2013, Appointing Greg Feller as City Council's representative to the Housing Councils for Community Reinvestment Area Nos. 1,6, & 8 for a three year term, expiring December 31, 2016.

14. Set 2014 Meeting Schedule.

15. Committee reports.
    a. Finance Committee meeting from 5:00 p.m.

16. Committee referrals.

Information

A. Certificate of Notice – PD-3-2013, Flower Hospital

B. Fact Sheets and Articles regarding Asian Carp.

Minutes of the Meeting of Council
October 21, 2013

The Council of the City of Sylvania, Ohio met in regular session on October 21, 2013 at 7:30 p.m. with Mayor Craig A. Stough in the chair. Roll was called with the following members present: Mike Brown, Katie Cappellini, Doug Haynam, Sandy Husman, Mark Luetke, Mary J. Westphal (6) present. Roll call: Milner absent, excused.

Mrs. Cappellini led the Pledge of Allegiance to the United States of America. Pledge of Alleg.

Mayor Stough stated that Council will now consider agenda item 3.

Requests were made for the following additions to the agenda: Additions to the agenda.

13b. Schedule Finance Committee Meeting.
D. First Energy scheduled outages information.

Mr. Haynam moved, Mrs. Westphal seconded, to approve the agenda as amended; roll call vote being: Brown, Cappellini, Haynam, Husman, Luetke, Westphal,(6) yeas; (0) nays. The motion carried.

Mayor Stough stated that Council will now consider agenda item 4.

Mrs. Westphal presented the October 7 minutes. Mrs. Westphal moved, Mr. Luetke seconded, that since the Mayor, members of Council, and others had been furnished copies of these minutes prior to this meeting, Council dispense with the reading of these minutes at this time, and the journal of the minutes of the regular meeting of October 7, 2013 be approved; roll call vote being: Cappellini, Haynam, Husman, Luetke, Westphal, Brown (6) yeas; (0) nays. The motion carried. Approval of the October 7 minutes.

Mayor Stough stated that Council will now consider agenda item 5.

Mary Fair, 5727 Balfour was not in attendance.

Mayor Stough stated that Council will now consider agenda item 6.

Mrs. Westphal presented and read aloud by title only, proposed Resolution 13-2013, a written copy of same having been previously furnished to each member of Council, "Resolution accepting the amounts and rates as determined by the Budget Commission and authorizing the necessary tax levies and certifying them to the Council Auditor." Mrs. Westphal moved, Mrs. Husman seconded, that Council dispense with Resolution 13-2013, "…accept- the amounts and rates….Budget Commission…"

the Second and Third Readings of said Resolution; roll call vote being: Cappellini, Haynam, Husman, Luetke, Westphal, Brown (6) yeas; (0) nays. The motion carried.

Mrs. Westphal moved, Mr. Luetke seconded, that Resolution 13-2013 be enacted as an emergency measure as declared therein; roll call vote being: Haynam, Husman, Luetke, Westphal, Brown, Cappellini, (6) yeas; (0) nays. The motion carried.

Mayor Stough stated that Council will now consider agenda item 7.

Resolution 14-2013, "....supporting Freshwater Future...Asian Carp..."

Mr. Brown presented and read aloud by title only, proposed Resolution 14-2013, a written copy of same having been previously furnished to each member of Council, "Resolution of the Council of the City of Sylvania supporting the mission of Freshwater Future to keep Asian carp out of the Great Lakes; and declaring an emergency." Mr. Brown moved, Mrs. Westphal seconded, that Council dispense with the Second and Third Readings of said Resolution; roll call vote being: Husman, Luetke, Westphal, Brown, Cappellini, Haynam, (6) yeas; (0) nays. The motion carried.

Mr. Brown moved, Mrs. Westphal seconded, that Resolution 14-2013 be enacted as an emergency measure as declared therein; roll call vote being: Luetke, Westphal, Brown, Cappellini, Husman, (5) yeas; Haynam, (1) nay. The motion carried.

Mr. Luetke requested that council consider a process to refer Resolutions that request the City's support to Committee prior to council vote.

Mayor Stough stated that Council will now consider agenda item 8.

Resolution 15-2013, "... participation in Regional Water Advisory Board"

Mr. Brown presented and read aloud by title only, proposed Resolution 15-2013, a written copy of same having been previously furnished to each member of Council, "Resolution of the Council of the City of Sylvania to formally participate in the inaugural Regional Water Advisory Board; and declaring an emergency." Mr. Brown moved, Mrs. Husman seconded, that Council dispense with the Second and Third Readings of said Resolution; roll call vote being: Westphal, Brown, Cappellini, Haynam, Husman, Luetke, (6) yeas; (0) nays. The motion carried.

Mr. Brown moved, Mrs. Westphal seconded, that Resolution 15-2013 be enacted as an emergency measure as declared therein; roll call vote being: Brown, Cappellini, Haynam, Husman, Luetke, Westphal, (6) yeas; (0) nays. The motion carried.

Mayor Stough stated that Council will now consider agenda item 9.

Mrs. Westphal presented and read aloud by title only, proposed Ordinance 70-2013, a written copy of same having been previously furnished to each member of Council, "Appropriating an amount not to exceed $1,500 for the establishment and implementation of a pilot program to help with the stray/feral cat issue in the City of Sylvania; and declaring an emergency." Mrs. Westphal moved, Mr. Haynam seconded, that Council dispense with the Second and Third Readings of said Resolution; roll call vote being: Cappellini, Haynam, Husman, Luetke, Westphal, Brown, (6) yeas; (0) nays. The motion carried.

Ordinance 70-2013, "...Stray cat...pilot program...$1,500 ...."

Mrs. Westphal moved, Mr. Luetke seconded, that Ordinance 70-2013 be enacted as an emergency measure as declared therein; roll call vote being: Haynam, Husman, Luetke, Westphal, Brown, Cappellini, (6) yeas; (0) nays. The motion carried.

Mayor Stough stated that Council will now consider agenda item 10.

Mayor Stough presented the list of items to be offered for sale. Mrs. Westphal moved, Mrs. Husman seconded, to authorize the sale of items from the Police Division and the Sewer Division on GovDeals.com since they are no longer needed by the City; roll call vote being: Husman, Luetke, Westphal, Brown, Cappellini, Haynam, (6) yeas; (0) nays. The motion carried.

Items for GovDeals.com

Mayor Stough stated that Council will now consider agenda item 11.

Service Director's report on the Monroe Street Reconstruction and Waterline Replacement Project, Change Order No. 1 (Final) was placed on file. Mr. Brown presented and read aloud by title only, proposed Ordinance 79-2013, a written copy of same having been previously furnished to each member of Council, "Authorizing the Mayor and Director of Finance to approve Change Order No. 1 (Final) to this City's agreement with Gleason Construction Company, Inc. for the Monroe Street Reconstruction and Waterline Replacement project which reflects the actual materials used and work performed on this project; decreasing the contract amount by $12,662.78; and declaring an emergency." Mr. Brown moved, Mrs. Westphal seconded, that Council dispense with the Second and Third Readings of said Ordinance; roll call vote being: Luetke, Westphal, Brown, Cappellini, Haynam, Husman, (6) yeas; (0) nays. The motion carried.

Ordinance 79-2013 "Authorizing CO #1...Monroe St Waterline.... decrease by $12,662.78..."

Mr. Brown moved, Mr. Haynam seconded, that Ordinance 79-2013 be enacted as an emergency measure as declared therein; roll call vote being: Westphal, Brown, Cappellini, Haynam, Husman, Luetke, (6) yeas; (0) nays. The motion carried.

Mayor Stough stated that Council will now consider agenda item 12.

After discussion regarding pending agreements with CVS Pharmacy regarding cross access easements and ingress/egress driveway agreements, the setting of the public hearing was tabled pending more information.

Mayor Stough stated that Council will now consider agenda item 13.

Mr. Luetke reported on the Employee & Community Relations meeting from 10/16/13 and 10/21/13.

Mr. Luetke moved, Mr. Haynam seconded to appoint Greg Feller as Council's appointment to the Community Reinvestment Areas Housing Council and to strongly recommend Thomas Reynolds as the Housing Councils' appointed seat; roll call vote being: Cappellini, Haynam, Husman, Luetke, Westphal, Brown, (6) yeas; (0) nays. The motion carried.

CRA Housing Council Appointment.... Greg Feller.

Mr. Luetke moved, Mr. Haynam seconded to order legislation to re-appoint George France as council's appointment to the SAJARD Board; roll call vote being: Haynam, Husman, Luetke, Westphal, Brown, Cappellini, (6) yeas; (0) nays. The motion carried.

Mr. Luetke moved, Mr. Haynam seconded to order legislation to re-appoint Norman Ladd to the Board of Zoning Appeals for an additional term; roll call vote being: Husman, Luetke, Westphal, Brown, Cappellini, Haynam, (6) yeas; (0) nays. The motion carried.

Mayor Stough stated that Council will now consider added agenda item 13b.

Mrs. Westphal will confirm with Committee members to hold a Finance Committee meeting for November 4, 2013 at 5:00p.m. to discuss the 2014 budget.

Mayor Stough stated that all items on the agenda had been considered.

Mrs. Westphal moved, Mr. Haynam seconded, that this meeting adjourn; all present voting yea (6); (0) nays. The motion carried and the meeting adjourned 8:36 p.m.

Adjournment.

Clerk of Council

Mayor

6

ORDINANCE NO. __80__-2013

REVISING THE ADMINISTRATIVE, DEPARTMENTAL AND DIVISIONAL ORGANIZATION OF THE CITY AND THE CODIFIED ORDINANCES THEREOF BY CREATING THE NEW PART-TIME POSITION OF "ASSISTANT PROSECUTOR"; AMENDING SYLVANIA CODIFIED ORDINANCE CHAPTER 131 – DEPARTMENT OF LAW TO ADD THE PART-TIME POSITION OF "ASSISTANT PROSECUTOR"; AMENDING SYLVANIA CODIFIED ORDINANCE SECTION 139.02(e)(3) TO SET THE SALARY OF THE ASSISTANT PROSECUTOR AT $40 PER HOUR NOT TO EXCEED 24 HOURS PER WEEK EFFECTIVE JANUARY 1, 2014; AND DECLARING AN EMERGENCY.

NOW, THEREFORE, BE IT ORDAINED by the Council of the City of Sylvania, Lucas County, Ohio, _______ members elected thereto concurring:

SECTION 1. That Sections 131.01 and 139.03(e)(3) of the Codified Ordinances of Sylvania, 1979, as amended, be and it is, hereby further amended to read as set forth on the attached "Exhibit A" effective January 1, 2014 and thereafter.

SECTION 2. It is hereby found and determined that all formal actions of this Council concerning and relating to the passage of this Ordinance were adopted in an open meeting of this Council, and that all deliberations of this Council and of any of its committees that resulted in such formal action, were in meetings open to the public, in compliance with all legal requirements including Section 121.22 of the Ohio Revised Code.

SECTION 3. That the Clerk of Council is hereby directed to post a copy of this Ordinance in the Office of the Clerk of Council in the Municipal Building pursuant to ARTICLE III, Section 12, of the Charter of this City.

SECTION 4. That this Ordinance is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, health, safety, property and welfare and for the further reason that the changes to the administrative structure of the City should be made at the earliest possible time. Provided this Ordinance receives the affirmative vote of five (5) or more members elected to Council, it shall take effect and be in force immediately upon its passage and approval by the Mayor; otherwise, it shall take effect and be in force thirty (30) days after it is approved by the Mayor or as otherwise provided by this Charter.

Vote dispensing with the second and third readings: Yeas _____ Nays _____

Passed, ____________________________, 2013, as an emergency measure.

____
President of Council

ATTEST:

____
Clerk of Council

APPROVED:

____
Mayor

____
Date

APPROVED AS TO FORM:

____
Director of Law

131.01 DEPARTMENT OF LAW -- DIRECTOR, DIVISION OF PROSECUTION.

* * *

(c) The Department of Law shall have a Division of Prosecution comprised of one full-time prosecutor, one part-time assistant prosecutor, one Secretary II, and one Secretary who will be employed on a part-time basis, who shall serve under the direction of the Prosecutor. The prosecutor and assistant prosecutor in the division of Prosecution shall be primarily responsible for the prosecution of all City of Sylvania and State cases in Sylvania Municipal Court and the cases of all municipalities with whom the City of Sylvania has contracted to provide prosecutorial services, subject to the oversight of the Director of Law. The prosecutor and assistant prosecutor shall be attorneys at law duly admitted to practice law in the State of Ohio. The prosecutor and assistant prosecutor shall be appointed by the Mayor, subject to confirmation by a majority of the members of Council, to serve until removed as provided in Section 5.0(c) of Article IV of the Charter. The Mayor may appoint, on a case by case basis, such Special Prosecutors as may be necessary when the prosecutor and/or assistant prosecutor has a potential conflict of interest or there exists other legal grounds why the prosecutor should not prosecute a particular case. The Prosecutor and Assistant Prosecutor shall be compensated in accordance with the provision made for them in the Position and Compensation Plan. The Prosecutor shall submit reports to the Director of Law at such frequency, in such detail and covering such matters as the Director shall require.

(Ord. ______-2013. Passed _________-2013.)

139.02(e)(3) Compensation for elective and appointive officials. The following elective and appointed officials which are not otherwise provided for in this chapter shall be compensated as follows:

TITLE	**RATE**
	* * *
Assistant Prosecutor	$40 per hour not to exceed 24 hours per week commencing January 1, 2014 and thereafter.
	* * *

(Ord. ______-2013. Passed ________-2013.)

*Those persons in this subsection (e)(3) occupying the positions indicated above by an asterisk after such position shall each have the sum of one thousand dollars ($1,000) paid and deposited by the City to their respective credit in one of the City's approved deferred compensation plans annually commencing with the year 1991.

ORDINANCE NO. 81 -2013

AUTHORIZING THE MAYOR AND DIRECTOR OF FINANCE OF THE CITY OF SYLVANIA, OHIO, TO ENTER INTO AN AGREEMENT WITH SYLVANIA TOWNSHIP FOR TRANSPORTING PRISONERS TO AND FROM SYLVANIA MUNICIPAL COURT FROM THE LUCAS COUNTY JAIL; APPROPRIATING FUNDS THEREFORE; AND DECLARING AN EMERGENCY.

WHEREAS, the Lucas County Sheriff's Office ceased providing prisoner transport to and from Sylvania Municipal Court and the Lucas County Jail; and,

WHEREAS, Ordinance No. 8-2009, passed February 2, 2009, authorized the purchase of equipment necessary for the implementation of video arraignments which has been installed, however, there is still occasion for prisoners to be transported to and from Sylvania Municipal Court and the Lucas County Jail; and,

WHEREAS, Ordinance No. 28-2009, passed March 16, 2009, authorized the Mayor and Director of Finance to enter into an Agreement with Sylvania Township for the purpose of transporting the City of Sylvania's prisoners to and from Sylvania Municipal Court and the Lucas County Jail at an annual cost to the city of $20,800; and,

WHEREAS, Ordinance No. 11-2010, passed February 1, 2010, authorized the Mayor and Director of Finance to enter into an Agreement with Sylvania Township for the purpose of transporting the City of Sylvania's prisoners to and from Sylvania Municipal Court and the Lucas County Jail at an annual cost to the City of $5,325; and,

WHEREAS, the Chief of Police has recommended the City enter into an Agreement with Sylvania Township for prisoner transport at an annual cost to the City of Eight Thousand One Hundred Eighty-Four Dollars ($8,184.00), a copy of which is attached hereto as "Exhibit A."

NOW, THEREFORE BE IT ORDAINED by the Council of the City of Sylvania, Lucas County, Ohio, _____ members elected thereto concurring:

SECTION 1. That the Mayor and Director of Finance be, and they hereby are, authorized to enter into, on behalf of this City, an Agreement in the form and substance of said "Exhibit A" with Sylvania Township.

SECTION 2. That to provide funds for said services hereby authorized, there is hereby appropriated from the **GENERAL FUND** from funds therein not heretofore appropriated to **Account No. 110-7210-51268 – Prisoner Support-Foreign Jail** the total sum of Eight Thousand One Hundred Eight-Four Dollars ($8,184.00).

SECTION 3. It is hereby found and determined that all formal actions of this Council concerning and relating to the passage of this Ordinance were adopted in an open meeting of this Council, and that all deliberations of this Council and of any of its committees that resulted in such formal action, were in meetings open to the public, in compliance with all legal requirements, including Section 121.22 of the Ohio Revised Code.

SECTION 4. That the Clerk of Council is hereby directed to post a copy of this Ordinance in the Office of the Clerk of Council in the Municipal Building pursuant to ARTICLE III, Section 12, of the Charter of this City.

SECTION 5. That this Ordinance is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, health, safety, property and welfare and for the further reason that the Agreement for prisoner transport should be entered into at the earliest possible time. Provided this Ordinance receives the affirmative vote of five (5) or more members elected to Council, it shall take effect and be in force immediately upon its passage and approval by the Mayor; otherwise, it shall take effect and be in force thirty (30) days after it is approved by the Mayor or as otherwise provided by the Charter.

Vote dispensing with the second and third readings: Yeas______ Nays______

Passed, ________________, 2013 as an emergency measure.

____
President of Council

ATTEST:

____
Clerk of Council

APPROVED AS TO FORM:

____
Director of Law

APPROVED:

____
Mayor

____
Date

AGREEMENT

This Agreement is entered into this _____ day of ______________, 2013, by and between the Township of Sylvania, Lucas County, Ohio (hereafter the "Township") and the Municipality of Sylvania, Lucas County, Ohio (hereafter the "Municipality").

WITNESSETH:

WHEREAS, the Municipality desires to utilize the services of the Township to transport persons to and from the Sylvania Municipal Court and the Lucas County jail for purposes of court proceedings, and

WHEREAS, the Township has agreed to assist in the transport of such persons.

NOW, THEREFORE, in consideration of the promises and conditions herein contained, the parties agree as follows:

1. Services. The Township, by, through and under the direction of its Chief of Police, agrees to transport any and all persons in the custody of the Municipality to and from the Sylvania Municipal Court and the Lucas County jail for any and all court proceedings ordered by the Court.

2. Term/Renewal. The Township will perform the above-noted transport services beginning on February 1, 2014 and ending on January 31, 2015. This Agreement shall be automatically renewed for additional one (1) year periods unless terminated pursuant to Section 3 below. Compensation to the Township for renewal periods shall be in accordance with Section 4 below.

3. Either party may terminate this Agreement by providing written notice to the other party at least one (1) month prior to the effective date of termination. In the event of premature termination, the compensation payable pursuant to Section 4 shall be prorated through the effective date of termination.

4. In consideration for the transport services provided to it, the Municipality agrees to pay to the Township the sum of Eight Thousand One Hundred Eighty-Four Dollars ($8,184.00). At least two (2) months prior to the then effective termination date of the Agreement, the Township Chief of Police, subject to approval by the Township Board of Trustees, shall submit to the Municipality's Chief of Police the cost of compensation for the ensuing year of the Agreement. Unless otherwise agreed, it shall become the Compensation for the ensuing year, payable to the Township on or before the then effective date of termination.

5. While performing services under this Agreement, Township employees shall remain exclusively in its employ and the Township shall be considered the employer for all purposes including, but not limited to, rights and benefits pursuant to collective bargaining agreements and issues relating to potential liability. Insofar as it is applicable to the operation of police departments, Chapter 2744 of the Ohio Revised Code applies to members of the Township police department when

they are rendering services outside their own political subdivision pursuant to this Agreement. Police personnel acting under this Agreement outside of their political subdivision are also entitled to all rights and benefits under Ohio Revised Code Sections 4123.01 to 4123.94 the same as if they were performing police services within the Township.

6. This Agreement is subject to the express authorization of the Township Board of Trustees and the Municipality's Council.

Witness the signatures of the authorized officers of each party to this Agreement, each of which has been authorized to enter into this Agreement by either resolution or ordinance of its governing body.

Date: ______________________

CITY OF SYLVANIA	**TOWNSHIP OF SYLVANIA**
By: ______________________ Craig A. Stough, Mayor	By: ______________________
By: ______________________ Toby Schroyer, Director of Finance	Its: ______________________
Approved as to form:	
______________________ James E. Moan, Law Director	______________________ Law Director

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ORDINANCE NO. 82 -2013

AUTHORIZING FLOWER HOSPITAL TO AFFIX BANNERS TO UTILITY POLES ALONG MONROE STREET AND HARROUN ROAD; AUTHORIZING THE DIRECTOR OF PUBLIC SERVICE TO INDICATE SUCH APPROVAL ON BEHALF OF THE CITY OF SYLVANIA; AND DECLARING AN EMERGENCY.

WHEREAS, Ordinance No. 1-2006, passed February 22, 2006, adopted a new Chapter 1166 - Sign Regulations to the Sylvania Codified Ordinances; and,

WHEREAS, Ordinance No. 37-2010, passed April 19, 2010, authorized Flower Hospital to affix banners to utility poles along Monroe Street and Harroun Road for a period of twelve months; and,

WHEREAS, Flower Hospital has submitted a request to affix street banners to utility poles along Monroe Street and Harroun Road.

NOW, THEREFORE BE IT ORDINANCE by the Council of the City of Sylvania, Lucas County, Ohio, _______ members elected thereto concurring:

SECTION 1. That the request of Flower Hospital to affix banners to utility poles along Monroe Street and Harroun Road within the public right-of-way is hereby approved, provided however, that the banners shall be removed within twelve months from the effective date of this Ordinance.

SECTION 2. That the Director of Public Service is authorized to inform Flower Hospital of the City's authorization of the placement of the banners.

SECTION 3. It is hereby found and determined that all formal actions of this Council concerning and relating to the passage of this Ordinance were adopted in an open meeting of this council, and that all deliberations of this Council and of any of its committees that resulted in such formal action, were in meetings open to the public, in compliance with all legal requirements, including Section 121.22 of the Ohio Revised Code.

SECTION 4. That the Clerk of Council is hereby directed to post a copy of this Ordinance in the Office of the Clerk of Council in the Municipal Building pursuant to ARTICLE III, Section 12, of the Charter of this City.

SECTION 5. That this Ordinance is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, health, safety, property and welfare and for the further reason that permission should be granted immediately to provide for the immediate hanging of the banners. Provided this Ordinance receives the affirmative vote of five (5) or more members elected to Council, it shall take effect and be in force immediately upon its passage and approval by the Mayor; otherwise, it shall take effect and be in force thirty (30) days after it is approved by the Mayor or as otherwise provided by the Charter.

Vote dispensing with the second and third readings: Yeas _____ Nays _____

Passed, ____________________________, 2013, as an emergency measure.

____
President of Council

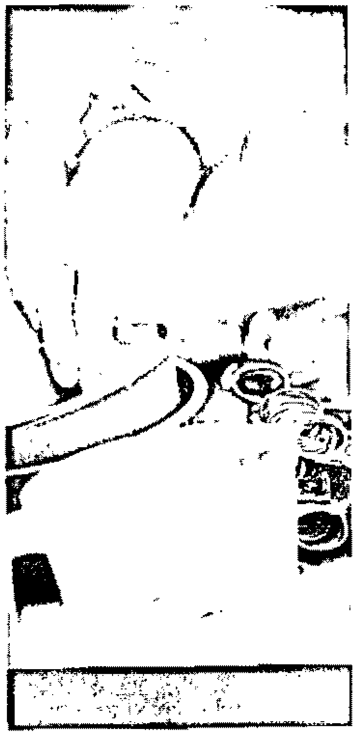
ATTEST: APPROVED AS TO FORM:

____________________________ ____________________________
Clerk of Council Director of Law

APPROVED:

____
Mayor

____
Date



Innovation

PROMEDICA
FLOWER HOSPITAL

Excellence

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Compassion

Teamwork

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9

City Of Sylvania

DEPARTMENT OF PUBLIC SERVICE
KEVIN G. ALLER, PE DIRECTOR

October 29, 2013

To: The Mayor and Members of City Council

Re: City Water Rates

Dear Mayor and Members of Council:

The City of Toledo has announced planned water rate increases through the year 2018. Therefore, our cost to provide water to our citizens will also increase. I would like to request a utilities committee meeting to review our suggested rate adjustments in response to the City of Toledo's upcoming rate increases.

Please call if you have any questions.

Sincerely,

Kevin G. Aller, P.E.
Director of Public Service
KGA/dsw

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www.cityofsylvania.com

10a

City Of Sylvania
DEPARTMENT OF PUBLIC SERVICE
KEVIN G. ALLER, PE DIRECTOR

October 31, 2013

To: Mayor and Members of City Council

Re: **OPWC Grant Application**
Arbor Way Sanitary Sewer
Cadet Drive Water Main Replacement
Forestgate Street Reconstruction

Dear Mayor and Council Members:

The Arbor Way Sanitary Sewer is a project that has been requested by the area property owners. A majority of the project costs will be assessed to those same owners. The estimated cost for this project is $325,000. We will be assessing 56% of the cost, or $225,720, and are requesting permission to apply for Ohio Public Works Commission (OPWC) grant funds in the amount of $99,280.

The Cadet Drive Water Main Replacement Project has been under consideration for some time. This project involves replacing the water main between Acres Road and Dornell Drive which has broken several times in recent years. This disruption affects the entire neighborhood as well as four businesses along Alexis Road. The estimated cost for this project is $216,000. We are requesting permission to apply for OPWC grant funds in the amount of $116,860.

The Forestgate Court project has also been under consideration for some time. This court was originally constructed of concrete and has seen much frost heave and subsequent repairs. The estimated cost for this project is $155,000 and we are requesting permission to apply for OPWC grant funds in the amount of $83,860.

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The projects will be combined into one OPWC application as it is to the City's benefit in order to maximize our grant award. Therefore, a summary of the projects follows:

Total Cost:	$696,000
Less Assessments	(225,720)
Less OPWC	(300,000)
City Cost	**$170,280 ($99,140 water, $71,140 capital)**

We recommend proceeding with these projects as one OPWC application requesting $300,000.

Please call if you have any questions,

Sincerely,

Kevin G. Aller, P.E.
Director of Public Service
KGA/dsw

10 b.

RESOLUTION NO. 16 -2013

A RESOLUTION AUTHORIZING THE MAYOR AND DIRECTOR OF FINANCE TO FILE A GRANT APPLICATION WITH THE OHIO PUBLIC WORKS COMMISSION FOR THE ARBOR WAY SANITARY SEWER PROJECT, THE CADET DRIVE WATER MAIN REPLACEMENT PROJECT AND THE FORESTGATE STREET RECONSTRUCTION PROJECT; AND DECLARING AN EMERGENCY.

WHEREAS, the Director of Public Service, by report dated October 31, 2013, has requested permission to apply for Ohio Public Works Commission ("OPWC") grant funding for three projects; and,

WHEREAS, the Arbor Way Sanitary Sewer Project is a project that has been requested by the property owners who recently sought and were granted annexation into the City to facilitate the completion of this project; and,

WHEREAS, while a majority of the project costs will be assessed to the property owners, the Director of Public Service has requested permission to apply for Ohio Public Works Commission ("OPWC") grant funds in the amount of $99,280 and the estimated cost for the project is $325,000; and,

WHEREAS, the Cadet Drive Water Main Replacement Project has been under consideration for some time and involves replacing the water main between Acres Road and Dornell Drive which has broken several times in recent years; and,

WHEREAS, the Director of Public Service has indicated that the estimated cost for this project is $216,000 and is seeking grant funding in the amount of $116,680; and,

WHEREAS, the Forestgate Street Reconstruction Project has also been under consideration for some time as it was originally constructed of concrete and has seen much frost heave and subsequent repairs; and, WHEREAS, the Director of Public Service has indicated that the estimated cost for this project is $155,000 and is seeking grant funding in the amount of $83,860.

NOW, THEREFORE BE IT RESOLVED by the Council of the City of Sylvania, Lucas County, Ohio, _____ members elected thereto concurring:

SECTION 1. That the Mayor and Director of Finance of the City of Sylvania are hereby authorized to file an application for OPWC grant funding for the Arbor Way Sanitary Sewer Project, the Cadet Drive Water Main Replacement Project and the Forestgate Street Reconstruction Project.

SECTION 2. It is hereby found and determined that for all formal actions of this Council concerning and relating to the passage of this Resolution were adopted in an open meeting of this Council, and that all deliberations of this Council and of any of its committees that resulted in such formal action, were in meetings open to the public, in compliance with all legal requirements, including Section 121.22 of the Ohio Revised Code.

SECTION 3. That the Clerk of Council is hereby directed to post a copy of this Resolution in the office of the Clerk of Council in the Municipal Building pursuant to ARTICLE III, Section 12 of the Charter of this City.

SECTION 4. That this Resolution is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, health, safety, property and welfare and for the further reason that the City should file its application for the grant immediately and and therefore this Resolution should be made effective immediately. Provided this Resolution receives the affirmative vote of five (5) or more members elected to Council, it shall take effect and be in force immediately upon its passage and approval by the Mayor; otherwise, it shall take effect and be in force thirty (30) days after it is approved by the Mayor or as otherwise provided by the Charter.

Vote dispensing with the second and third readings: Yeas____ Nays ____

Passed, ________________________, 2013, as an emergency measure.

____
President of Council

ATTEST:

APPROVED AS TO FORM:

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Clerk of Council

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Director of Law

APPROVED:

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Mayor

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Date

JJ

RESOLUTION NO. 17 - 2013

RE-APPOINTING GEORGE FRANCE TO THE BOARD OF TRUSTEES OF SYLVANIA AREA JOINT RECREATION DISTRICT (SAJRD) FOR A THREE YEAR TERM TO EXPIRE ON DECEMBER 31, 2016; AND DECLARING AN EMERGENCY.

WHEREAS, this Council, by Resolution No. 3-2005, passed January 3, 2005, re-appointed George France to the Board of Trustees of the Sylvania Area Joint Recreation District for a three-year term expiring December 31, 2007; and,

WHEREAS, this Council, by Resolution No. 20-2007, passed December 17, 2007, re-appointed George France to the Board of Trustees of the Sylvania Area Joint Recreation District for a three-year term expiring December 31, 2010; and,

WHEREAS, this Council, by Resolution No. 3-2011, passed January 3, 2011, re-appointed George France to the Board of Trustees of the Sylvania Area Joint Recreation District for a three-year term expiring December 31, 2013; and,

WHEREAS, Mr. France has expressed his desire to be re-appointed to the Board of Trustees of the Sylvania Area Joint Recreation District for an additional three-year term expiring December 31, 2016 and the Community Relations Committee and the Mayor have recommended Mr. France's re-appointment.

NOW, THEREFORE, BE IT RESOLVED by the Council of the City of Sylvania, Lucas County, Ohio, _____ members elected thereto concurring:

SECTION 1. That George France is hereby re-appointed to the Board of Trustees of Sylvania Area Joint Recreation District for a three-year term expiring December 31, 2016.

SECTION 2. That the Clerk of Council be, and she hereby is, directed to certify a copy of this Resolution to Sylvania Area Joint Recreation District.

SECTION 3. It is hereby found and determined that all formal actions of this Council concerning and relating to the passage of this Resolution were adopted in an open meeting of this Council, and that all deliberations of this Council and of any of its committees that resulted in such formal action, were in meetings open to the public, in compliance with all legal requirements, including Section 121.22 of the Ohio Revised Code.

SECTION 4. That the Clerk of Council is hereby directed to post a copy of this Resolution in the Office of the Clerk of Council in the Municipal Building pursuant to ARTICLE III, Section 12, of the Charter of this City.

SECTION 5. That this Resolution is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, health, safety, property and welfare and for the reason that an open position on the Board of Trustees of the Sylvania Area Joint Recreation District required to be filled now so that said Board will be fully constituted at the earliest possible time. Provided this Resolution receives the affirmative vote of five (5) or more members elected to Council, it shall take effect and be in force immediately upon its passage and approval by the Mayor; otherwise, it shall take effect and be in force thirty (30) days after it is approved by the Mayor or as otherwise provided by the Charter.

Vote dispensing with the second and third readings: Yeas_____ Nays_____

Passed, ________________, 2013 as an emergency measure.

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President of Council

ATTEST:

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Clerk of Council

APPROVED:

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Mayor

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Date

APPROVED AS TO FORM:

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Director of Law

12

RESOLUTION NO. 18 - 2013

RE-APPOINTING NORMAN R. LADD TO THE ZONING BOARD OF APPEALS FOR A THREE YEAR TERM EXPIRING DECEMBER 31, 2016; AND DECLARING AN EMERGENCY.

WHEREAS, Resolution No. 12-2010, passed by Sylvania City Council on April 5, 2010, appointed Norman R. Ladd to the Zoning Board of Appeals to fill the unexpired term of Karen Smith, which expired on December 31, 2010; and,

WHEREAS, Resolution No. 4-2011, passed January 3, 2011, re-appointed Norman R. Ladd to the Zoning Board of Appeals for a three-year term expiring December 31, 2013; and,

WHEREAS, the Employee and Community Relations Committee met and thereafter recommended that Norman R. Ladd be re-appointed to the Zoning Board of Appeals for a term ending December 31, 2016.

NOW, THEREFORE, BE IT RESOLVED by the Council of the City of Sylvania, Lucas County, Ohio, _____ members elected thereto concurring:

SECTION 1. That Norman R. Ladd is hereby re-appointed to the Zoning Board of Appeals for a term ending December 31, 2016.

SECTION 2. That the Clerk of Council be, and she hereby is, directed to certify a copy of this Resolution to the Secretary of the Zoning Board of Appeals.

SECTION 3. It is hereby found and determined that all formal actions of this Council concerning and relating to the passage of this Resolution were adopted in an open meeting of this Council, and that all deliberations of this Council and of any of its committees that resulted in such formal action, were in meetings open to the public, in compliance with all legal requirements, including Section 121.22 of the Ohio Revised Code.

SECTION 4. That the Clerk of Council is hereby directed to post a copy of this Resolution in the Office of the Clerk of Council in the Municipal Building pursuant to ARTICLE III, Section 12, of the Charter of this City.

SECTION 5. That this Resolution is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, health, safety, property and welfare and for the reason that the appointment to the Zoning Board of Appeals should be made immediately to provide for all of the seats of the Board to be filled. Provided this Resolution receives the affirmative vote of five (5) or more members elected to Council, it shall take effect and be in force immediately upon its passage and approval by the Mayor; otherwise, it shall take effect and be in force thirty (30) days after it is approved by the Mayor or as otherwise provided by the Charter.

Passed, ________________, 2013, as an emergency measure.

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President of Council

ATTEST:

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Clerk of Council

APPROVED:

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Mayor

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Date

APPROVED AS TO FORM:

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Director of Law

RESOLUTION NO. 19 - 2013

APPOINTING GREG FELLER AS CITY COUNCIL'S REPRESENTATIVE TO THE HOUSING COUNCILS FOR COMMUNITY REINVESTMENT AREA NOS. 1, 6 AND 8 FOR A THREE YEAR TERM EXPIRING DECEMBER 31, 2016; AND DECLARING AN EMERGENCY.

WHEREAS, Resolution No. 9-2013, passed by Sylvania City Council on July 15, 2013, established the procedure for Sylvania City Council's appointments to the Community Reinvestment Area ("CRA") Housing Councils; and,

WHEREAS, at the October 18, 2013 meeting of Sylvania City Council, the Employee and Community Relations Committee reported that it met to consider the candidates interested in serving on the Housing Councils and thereafter recommended that Greg Feller be appointed as City Council's representative to the Housing Councils for CRA Nos. 1, 6 and 8 for a three-year term expiring December 31, 2016.

NOW, THEREFORE, BE IT RESOLVED by the Council of the City of Sylvania, Lucas County, Ohio, _____ members elected thereto concurring:

SECTION 1. That Greg Feller is hereby appointed as City Council's representative to the Housing Councils for CRA Nos. 1, 6 and 8 for a term ending December 31, 2016.

SECTION 2. That the Clerk of Council be, and she hereby is, directed to certify a copy of this Resolution to the Housing Officer for CRA Nos. 1, 6 and 8.

SECTION 3. It is hereby found and determined that all formal actions of this Council concerning and relating to the passage of this Resolution were adopted in an open meeting of this Council, and that all deliberations of this Council and of any of its committees that resulted in such formal action, were in meetings open to the public, in compliance with all legal requirements, including Section 121.22 of the Ohio Revised Code.

SECTION 4. That the Clerk of Council is hereby directed to post a copy of this Resolution in the Office of the Clerk of Council in the Municipal Building pursuant to ARTICLE III, Section 12, of the Charter of this City.

SECTION 5. That this Resolution is hereby declared to be an emergency measure necessary for the immediate preservation of the public peace, health, safety, property and welfare and for the reason that the appointment to the Housing Councils for CRA Nos. 1, 6 and 8 should be made immediately to provide for all of the seats of the Board to be filled. Provided this Resolution receives the affirmative vote of five (5) or more members elected to Council, it shall take effect and be in force immediately upon its passage and approval by the Mayor; otherwise, it shall take effect and be in force thirty (30) days after it is approved by the Mayor or as otherwise provided by the Charter.

Passed, ________________, 2013, as an emergency measure.

____
President of Council

ATTEST:

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Clerk of Council

APPROVED:

____
Mayor

____
Date

APPROVED AS TO FORM:

____
Director of Law

City Of Sylvania

SYLVANIA CITY COUNCIL
SHARON M. BUCHER, CLERK

Date: November 1, 2013

To: Mayor Craig Stough and City Council Members

From: Sharon Bucher, Clerk of Council

Subject: 2014 Meeting Schedule

The following holidays fall on a regular Monday night Council meeting in 2014:

January 20	Martin Luther King, Jr.'s Birthday
February 17	Presidents' Day
September 1	Labor Day

Council should consider on what alternate days these meeting will be held.

Also, pursuant to Article III, Section 9.0 MEETINGS of the Sylvania City Charter, Council may dispense with one of its regular meetings in the months of July and August. Council may wish to consider cancelling one or two of its summer meeting now or later in the calendar year.

6730 MONROE STREET • SYLVANIA, OHIO 43560-1948 • (419) 885-8930 • FAX (567) 455-0718
www.cityofsylvania.com

A

City Of Sylvania

SYLVANIA CITY COUNCIL
SHARON M. BUCHER, CLERK

To: Mayor Craig A. Stough and Members of City Council

From: Sharon Bucher, Clerk of Council

Certificate of Notice
PD-3-2013, Flower Hospital

The undersigned Clerk of Council hereby certifies as follows:

A. Thirty (30) days of time and place of public hearing was published in the *Toledo Blade* on September 30, 2013.

B. Written notice of hearing was mailed by first class mail, twenty (20) or more days prior to the scheduled hearing date to all owners of property within, contiguous to, and directly across the street from the subject parcel or parcels, which owners, so notified, are listed as follows:

Owner	Property Address	Owner Address

See attached listing. (1 page)

Sharon Bucher 9/27/13
Clerk of Council Date

CITY OF SYLVANIA
DEPARTMENT OF PUBLIC SERVICE

City of Sylvania

PLANNED DEVELOPMENT AMENDMENT FOR FLOWER HOSPITAL (HEARTLAND)
PROPERTY OWNER NOTIFICATION LIST

NO.	ADDRESS	OWNER	MAILING ADDRESS	CITY	STATE	ZIP
1	5341 Harroun Road	Terry L. Luhring	5341 Harroun Road	Sylvania	OH	43560
2	5329 Harroun Road	Jo-Anne Gembolis	5329 Harroun Road	Sylvania	OH	43560
3	5319 Harroun Road	Joseph R. & Cindy L. Mehling	5319 Harroun Road	Sylvania	OH	43560
4	5307 Harroun Road	Patricia Ortman	6310 Ravine Drive	Sylvania	OH	43560
5	5239 Harroun Road	Flower Hospital Foundation	5200 Harroun Road	Sylvania	OH	43560
6	5227 Harroun Road	Greater Metropolitan Title, LLC	P.O. Box 8827	Toledo	OH	43623
7	6312 Oakland Court	Federal National Mortgage Association	6312 Oakland Court	Sylvania	OH	43560
8	6311 Oakland Court	Norman A. & Joanna L. Koenigseker	6311 Oakland Court	Sylvania	OH	43560
9	5143 Harroun Road	John S. Rightmyer	5143 Harroun Road	Sylvania	OH	43560
10	5123 Harroun Road	Carol J. Van Tuinen	5123 Harroun Road	Sylvania	OH	43560
11	5111 Harroun Road	Judith A. Koles	5111 Harroun Road	Sylvania	OH	43560
10	5101 Harroun Road	Robert M. Lubell & Stephanie G. Grand-Lubell	5101 Harroun Road	Sylvania	OH	43560
11	5055 Harroun Road	Pamela & Donald Roork	5055 Harroun Road	Sylvania	OH	43560

B

[UNLEASHING THE POWER OF GREEN]

Fact Sheet

The Threat of Asian Carp

Our Great Lakes are in danger from invasive species

Our Great Lakes

Sandra Cobb

People come from far and wide to visit Ohio's Lake Erie shoreline. They come to fish, swim, boat, and admire nature's beauty. They also come to spend money.

Tourism accounted for over $10 billion in sales on Ohio's Lake Erie shore 2009, with $300 million spent just on fishing. This economic infusion was responsible for 114,000 Ohio jobs in 2009—more than Wal-Mart, the Cleveland Clinic, and the Wright-Patterson Air Force Base combined.

The Great Lakes are a national treasure as well as an economic gold mine. They are the world's largest source of fresh water, and home to a $7 billion sport and commercial fishing industry and a $16 billion recreational boating industry. In Ohio alone, the recreational boating industry contributes the equivalent of 26,000 full-time jobs and $3.5 billion in economic activity.

Over the past few decades, the Great Lakes have been ecologically traumatized by 185 invasive species, which have already cost the region over $200 million in damage and control costs.

As just one example, facilities that draw in large amounts of water from Lake Erie have spent $400,000 each year to remove invasive species such as zebra and quagga mussels from their intake pipes.

Lake Erie, the shallowest and warmest of the Great Lakes, is also the most biologically diverse and productive Lake. It is the walleye capital of the world, and produces more fish for human consumption than all of the other Great Lakes combined.

Because it is so biologically productive, Lake Erie has the most to gain from restoration efforts, and the most to lose from potential ecological devastation.

A New Threat

Spawning populations of Asian carp, also known as silver and bighead carp, are just miles from the Great Lakes, threatening to decimate the Great Lakes' ecology.

These voracious fish can weigh up to 40 lbs, about the size of a five-year-old child. Some even grow to 100 lbs, eating huge amounts of plankton each day.

Juvenile game fish such as trout, walleye, and salmon depend on this plankton, and when these carp move in, the native game fish die out.

If Asian carp establish a foothold, recreational and commercial fishing in Lake Erie will be devastated. If these invaders make it past our barriers, the Great Lakes could suffer the same fate as parts of the Missouri river, where more than 90% of all fish are Asian carp.[1]

(continued)

For more information contact:

Ohio Environmental Council
1207 Grandview Ave, Suite 201
Columbus, Ohio 43212

tel (614) 487-7506
fax (614) 487-7510
e-mail OEC@theOEC.org
web www.theOEC.org

A New Threat (con't)

There carp are known to leap up to 10 feet in the air when disturbed by the noise of a boat motor. Imagine boating in an area where 40-pound fish might hit a child in the head, breaking a nose or neck.

If this scenario comes to pass, many of 424,000 Ohioans who have registered boats on Lake Erie can expect physical injury and property damage.

Some experts once thought that Asian carp could not reproduce in the Great Lakes.

But scientists now agree that suitable Asian carp spawning conditions exists in many parts of the watershed.

Lake Erie is considered the most vulnerable of the Great Lakes, as Ohio's Maumee, Black, Vermillion, Huron, and Portage Rivers boast the right combination of factors to become fertile Asian Carp breeding grounds.

What Won't Work

The most direct path for the carp to enter the Great Lakes is through the Chicago Area Waterway System, a series of artificial canals that connect Lake Michigan to the Mississippi River.

The U.S. Army Corps of Engineers has enacted temporary measures to block Asian carp from passing through the canals while it studies a more permanent solution.

These measures depend on three electric barriers along the Illinois River, which work by sending an electric current through the water to immobilize or kill the fish.

There are three main problems with the electric barriers:

- the barriers have proven ineffective on small fish, such as young Asian carp.
- the barrier is less effective when fish swim in the "electric shadow" that is caused when a barge passes through the barrier and reduces the voltage in the area alongside the hull.
- electric barriers require maintenance and constant operation, and they are only effective under normal conditions.

If we rely on the electric barrier for long enough, it will fail. For example, it would not function properly in the event of a widespread power outage or a severe flood.

The Corps briefly experimented with increasing the voltage to try to stop smaller fish, but that experiment has been shelved indefinitely.

And no barrier that requires constant operation and maintenance can provide the kind of permanent, worry-free protection that is needed to ensure the safety of the Great Lakes.

[1] http://www.jsonline.com/news/wisconsin/120417019.html
[2] http://www.lrc.usace.army.mil/pao/Other_Pathways_Preliminary_Risk_Characterization.pdf

Not Just a Chicago Problem

As if the problems in the Chicago area waterway aren't enough, the Army Corps has released a preliminary risk assessment that identified other sites where there is a "high" or "acute" risk of carp crossing into the Great Lakes watershed.[3]

These sites include locations in Minnesota, Indiana, and Ohio. Although temporary band-aid measures have been taken in some of these areas, the Army Corps study on permanent separation, which represents the best hope to come up with a workable long-term solution, is not due for completion until 2015.

Asian carp do not just threaten the Great Lakes. They threaten all of Ohio's waterways and our fishing, boating, and tourism industries. The fish are not yet present in Ohio, but they are established downstream in the Ohio River and could move further north.

There is also a spawning population of silver carp in the Wabash River, which is a mile flood plain away from the Maumee River. Both of these rivers are known to occasionally flood and mix waters, putting the Great Lakes, Lake Erie, and all Ohioans who enjoy recreating on the water at risk.

Recommendation

Photo: Bonnie Carless, 2004 "Life on Lake Erie" Award Winner

The only long-term solution to the threat of Asian carp and other invasive species is complete hydrological separation of the Great Lakes and Mississippi River water basins.

The Stop Asian Carp Act (House Resolution 892/Senate Bill 471) directs the U.S. Army Corps of Engineers to speed up their study on how to achieve hydrological separation of the Great Lakes and Mississippi River basins.

It also calls on President Obama to appoint an individual to oversee the study to make sure it gets done quickly and to change the focus of the study from reducing the risk of species spreading to preventing the exchange of harmful species between the Mississippi basin and the Great Lakes.

Please contact your Congressional members by phone or email.

Congress Switchboard: (202) 224-3121

House Website: www.house.gov

Senate Website: www.senate.gov

Urge them to co-sponsor the Stop Asian Carp Act. In addition, ask them to request that leadership and their colleagues quickly enact this vital legislation.

Ohio Congressional members that are current co-sponsors of this legislation are Senator Brown and Representatives Fudge, Kaptur, LaTourette, and Sutton.

For more information please contact Kristy Meyer, Director of Agricultural & Clean Water Programs, at (614) 487-7506 or Kristy@theOEC.org.

Section 11: Significant Ongoing and Emerging Issues

Photo: U.S. Fish & Wildlife Service

11.1 Introduction

The dynamic nature of Lake Erie means that things change, often unpredictably. Section 2 describes how the issues of concern in the lake have changed over time. Some of the issues were resolved through management actions over a short period of time, while others required long-term and ongoing management plans. Some goals, such as phosphorus concentrations in the lake, were considered achieved until zebra mussels invaded and concentrations began fluctuating again. The invasion of a host of new non-native species has created much alteration in the biological community. The ecosystem management objectives for Lake Erie attempt to set goals for management actions in the areas of land use, nutrient management, contaminants, resource use and non-native invasive species. It may be necessary to continually revisit these goals as new unexpected situations arise. This section provides some insight into programs and problems that are currently important in the lake, as well as those that may be emerging as important future issues. The adaptive management approach of the LaMP process accepts the fact that change is inevitable. The challenge to the LaMP is to keep abreast of lake conditions, identify and encourage research in areas needed to make the appropriate management decisions, and modify management goals and actions when needed.

11.2 2003 Update on Non-Native Invasive Species in Lake Erie *(Prepared by Lynda D. Corkum & Igor A. Grigorovich, University of Windsor)*

A detailed overview on the history of non-native invasive species in Lake Erie was presented in Section 11 of the Lake Erie LaMP 2000 document. An update of ongoing and emerging issues (including non-native invasive species) was presented in Section 10 of the 2002 Lake Erie LaMP report. This is the second update on the status of non-native invasive species (NIS) in Lake Erie. The material presented represents new information on NIS (and anticipated invasions) as well as historical information that was not presented in the previous reports.

Of the approximately 170 NIS in the Laurentian Great Lakes drainage basin (A. Ricciardi, McGill University, personal communication), there are about 132 NIS in the Lake Erie watershed, including: algae (20 species), submerged plants (8 species), marsh plants (39 species), trees/shrubs (5 species), disease pathogens (3 species), molluscs (12 species), oligochaetes (9 species), crustaceans (9 species), other invertebrates (4 species), and fishes (23 species) (Leach 2001). The number of NIS is a conservative estimate because small organisms, or those that are difficult to classify, are typically less well studied.

The increase in NIS during the 20th century is attributed to the shift from solid to water ballast in cargo ships and to the opening of the St. Lawrence Seaway in 1959 (Mills et al. 1993). Ballast water discharge from ships has been the primary vector for NIS entering the Great Lakes (Mills et al. 1993). Despite voluntary (1989-1992) or mandatory (1993 onward, United States Coast Guard, 1993) compliance with the ballast water exchange program, the rate of NIS introductions from 1989 to 1999 has tripled compared to the previous three decades (Grigorovich et al. 2003a). Unfortunately, vessels with cargo designated with "no ballast on board" (NOBOB) status are not subject to regulations even though these vessels carry residual ballast water and associated organisms (Bailey et al. 2003). Between 1981 and 2000, about 72% of NOBOB vessels made their first stop at Lake Erie ports where they unloaded cargo and took on Great Lakes water to compensate for the loss in cargo weight (Grigorovich et al. 2003a). The mixing of water with residual sediment could result in increased invasions. The Lake Huron-Lake Erie corridor has been identified as one of the four invasion "hotspots" along with the Lake Erie-Lake Ontario corridor, the Lake Superior-Huron corridor and the western end of Lake Superior (Grigorovich et al. 2003a). The hotspots represent less than 5.6% of the total Great Lakes water surface area, but account for more than half of the NIS documented since 1959 (Grigorovich et al. 2003a).

Lake Erie ranks second to Lake Ontario (31 sites) of all Great Lakes for first records of NIS. There have been 22 sites in the open waters of Lake Erie where non-native invasive aquatic animals and protists were first reported (Table 11.1). Explanations for the large number of NIS reported in the lower Great Lakes may be due to the intensive sampling in the region, similar physical/chemical characteristics between donor and recipient regions, lake productivity, and facilitation of invasion by previously established invaders. Given the many species introductions into Lake Erie by human activities, natural barriers to dispersion and gene flow among the Great Lakes have been essentially eliminated (de LaFontaine and Costan 2002).

There have been reports of new invaders in Lake Erie. Protozoans (Rhizopoda), *Psammonobiotus communis* (two sites east of Wheatley to Rondeau on the north shore of Lake Erie) and *P. dziwnowii* (eastern Lake Erie), were reported in a 2002 survey of Lake Erie (Nicholls and MacIsaac 2004). It is likely that these euryhaline species entered the Great Lakes through ballast water. *Psammonobiotus communis* is pandemic, whereas *P. dziwnowii* was found only on the Polish coast of the Baltic Sea before it was reported in Great Lakes waters. A new species, *Corythionella golemanskyi*, also has been described. These three species have been described from several Great Lake locations where they occur in beach sand. It is likely that these species became established long ago, but investigators simply had not looked for them (Nicholls and MacIsaac 2004).

Lake Erie proper has 34 non-native invasive fish species and new species are likely to enter the lake from the Mississippi drainage basin and from adjacent lakes. The common carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*) were likely the first introduced fishes into the Great Lakes. Carp were intentionally introduced into the Great Lakes in 1879 as a food fish (Emery 1985). By the 1890s, carp were "very abundant in the Maumee River at Toledo, Ohio and in the west end of Lake Erie" (Kirsch 1895). Carp are a nuisance because they degrade habitat for native fish and waterfowl and feed on eggs of other fish (Fuller et al. 1999). Goldfish, often cultured for bait and used in the aquarium trade, may have been the first foreign fish to be introduced to North America (Courtenay et al. 1984). Back-crossing and hybridization between goldfish and carp is common. In Lake Erie, hybrids may be more abundant than either parental species (Trautman 1981). Western Lake Erie has some of the largest populations of goldfish in the continental United States (Fuller et al. 1999), particularly in the shallower waters of the basin with dense vegetation and in the low-gradient tributaries of the lake (Trautman 1981).

Table 11.1: Non-native Metazoans and Protists First Established in Lake Erie Since the 1800s (Grigorovich et al. 2003b). Taxonomic groups are listed from most ancient to most advanced; species are listed in alphabetical order within each taxonomic group. The Protista were reported in hosts of other animals.

Number	Taxonomic Group	Species Name	Year of 1st Discovery	Location
1	Protista	*Acineta nitocrae*	1997	Lake Erie
2	Protista	*Glugea hertwigi*	1960	Lake Erie
3	Protista	*Myxosoma cerebralis*	1968	Ohio drainage, Lake Erie
4	Cnidaria	*Cordylophora caspia*	1956	Lake Erie
5	Cnidaria	*Craspedacusta sowerbyi*	1933	Lake Erie
6	Bryozoa	*Lophopodella carteri*	1934	Lake Erie
7	Mollusca	*Cipangopaludina japonica*	1940	Lake Erie
8	Mollusca	*Corbicula fluminea*	1980	Lake Erie
9	Mollusca	*Dreissena bugensis*	1989	Port Colborne, Lake Erie
10	Mollusca	*Pisidium moitessierianum*	1895	Lake Erie
11	Annelida	*Barbidrilus paucisetus*	2001	Lake Erie
12	Annelida	*Potamothrix vejdovskyi*	1965	Lake Erie
13	Annelida	*Pristina acuminata*	1977	Lake Erie
14	Annelida	*Pristina longisoma*	2001	Lake Erie
15	Annelida	*Psammoryctides barbatus*	2001	Lake Erie
16	Crustacea	*Daphnia galeata*	1980s	Lake Erie
17	Crustacea	*Daphnia lumholtzi*	1999	Lake Erie
18	Crustacea	*Echinogammarus ischnus*	1994	Lake Erie
19	Crustacea	*Eurytemora affinis*	1991	Lake Erie
20	Pisces	*Lepomis humilis*	1929	Lake Erie
21	Pisces	*Oncorhynchus kisutch*	1933	Lake Erie
22	Pisces	*Phenacobius mirabilis*	1950	Ohio drainage, Lake Erie

There have been a few instances of accidental occurrences of other species of Asian carp in Lake Erie. In 2000, there were unusual sightings of the Chinese bighead carp, *Hypophthalmichthys nobilis*. On October 16, 2000, the third specimen ever of Chinese bighead carp was caught in a trap net on the west side of Point Pelee in the western basin of Lake Erie (T. Johnson, Ontario Ministry of Natural Resources, Wheatley, personal communication). The fish is native to eastern China and introduced into the United States in 1973. The 2000 sighting was probably the result of a fish escape from aquaculture ponds (T. Johnson, personal communication). In October 30, 2003, a grass carp (*Ctenopharyngodon idella*) was caught at the mouth of the Don River, Lake Ontario (Beth MacKay, OMNR, personal communication). It is believed that this record was an isolated occurrence and that there are no established populations of grass carp in the Great Lakes. Earlier (1985), a grass carp was reported from Lake Erie.

Southern U.S. fish farmers introduced several species of Asian carp to control vegetation (grass carp), algal blooms (bighead and silver carp) and snails (black carp) in aquaculture facilities. The grass carp, bighead carp, silver carp (*Hypophathlmichthys molitrix*) and the black carp (*Mylopharyngodon piceus*) have been released and/or have escaped into the wild. All of these species are large fish with adults ranging from 20 to 40 kg. Both bighead carp and silver carp are moving upstream in the Mississippi and Illinois Rivers towards the Great Lakes basin (Taylor et al. 2003). These species of Asian carp will likely spread into the Great Lakes if mechanisms are not established to stop their upstream spread. Bighead and silver carp are a threat to Great Lakes fish because they filter and consume plankton. The competition threat from these species exists for all fish because each fish species consumes plankton early in development. There is also anticipated competition between the Asian carp and adults of commercially important lake whitefish, *Coregonus clupeaformis*, and bloaters, *Coregonus hoyi*, that rely on plankton.

An electric barrier (energized in April 2002) on the Des Plaines River, Illinois, was designed to impede the exchange of organisms between the Great Lakes and Mississippi basins. In addition to the electric barrier, other guidance systems (Sound Projection Array, SPA) are being tested to deter the species of Asian carp from upstream movement. The SPA uses an air bubble curtain that creates a wall of sound that deters fish away from designated regions. This technique combined with a graduated electric field barrier was effective in laboratory studies in repelling 83% of fish that attempted to cross the barrier (Taylor et al. 2003). Field studies on the effectiveness of the electric barrier in preventing fish passage are on-going.

Kolar and Lodge (2002) used a quantitative model to predict potential invasive fishes and their impact in the Laurentian Great Lakes. If introduced, five Ponto-Caspian fishes will likely become established in the Great Lakes and are expected to spread quickly (Table 11.2). Intentional introductions result from aquaculture, sport fishing, pet trade and bait fishes. Three species (Eurasian minnow, European perch and monkey goby) are currently in the water garden or aquarium trade in Europe.

Table 11.2: Ponto-Caspian Fishes and Pet, Sport, Aquaculture and Bait Species Predicted to Become Established in the Great Lakes if Introduced (Kolar and Lodge 2002). Family names are listed from most ancient to most derived groups.

Family	Scientific name	Common name	Unintentional Introductions	Intentional Introductions
Clupeidae	*Clupeonella cultriventris*	Tyulka	X	
Cyprinidae	*Phoxinus phoxinus*	Eurasian minnow	X	
Cyprinidontidae	*Aphanius boyeri*	Black Sea silverside	X	
Percidae	*Perca fluviatilis*	European perch		X
Gobiidae	*Neogobius fluviatilis*	Monkey goby		X

The non-native invasive round goby fish has continued to expand its range in the Great Lakes basin. The fish entered western Lake Erie in 1993 and, since 1999, has occupied all three basins of the lake. There were an estimated 14.5 billion round gobies in western Lake Erie in 2001 (Johnson et al. 2003). Videography was the most effective tool (in comparison with trawls or traps) used to determine the density of this bottom-dwelling species (Johnson et al. 2003). Lee (2003) determined that the round goby population in western Lake Erie consumes more than 2.6×10^4 tonnes of benthic prey each year, 17% of which is represented by invasive dreissenids. Clearly, zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena bugensis*) have facilitated the establishment of the round goby.

Efforts in Great Lakes jurisdictions are being made (and more are needed) to control the entry of non-native invasive species introduced through ballast water, canals and recreational boating (Vásárhelyi and Thomas 2003). However, there are relatively few practices in place to control established invasive species without affecting non-target species or resulting in collateral environmental damage. Because attempts to eliminate a NIS throughout an ecosystem are not possible, control programs are typically species and site specific. "Introductions, like extinctions, are forever" (Marsden 1993).

One recent example to develop an effective control measure focuses on reducing the reproductive success of the round goby. Laboratory findings support the hypothesis that mature female round gobies actively respond by moving to sex attractants released by conspecific males (Corkum et al. 2003). It is expected that the application of this research will lead to the development of a control strategy using natural pheromones to disrupt reproductive behaviours of the invasive round goby. Because juvenile and adult round gobies feed on eggs of several native fishes (lake trout, Chotkowski and Marsden 1999; lake sturgeon, Nichols et al. 2003; and smallmouth bass, Steinhart et al. 2004), there is great value in reducing the reproductive success of this invasive predator. The ultimate goal is to develop a pheromone trap that targets round gobies (and no other species) to be deployed at known spawning locations of native fishes where round gobies co-occur and are known to prey on eggs of native fishes (Corkum et al. 2003).

Although the focus of NIS in Lake Erie is on aquatic invasive species, a metallic wood-boring beetle (Family, Buprestidae), known as the emerald ash borer (*Agrilus planipennis*), has damaged millions of ash trees in the western Lake Erie drainage basin (Michigan, Department of Agriculture Fact Sheet). The exotic beetle, native to Asia, was first discovered in southeast Michigan in 2002. It has now spread to northwest and central Ohio. Many infested trees in these areas have been cut down and burned. The beetle also has been reported in Windsor, Ontario, and is expanding throughout Essex County into southwestern Ontario. A quarantine is established to help prevent the movement of ash trees and ash products outside the infested regions. Evidence of infestation is the characteristic D-shaped beetle exit holes on the branches and trunks on ash trees. Although little is known about the control or management of this pest, research projects are currently underway.

Once NIS colonize a waterbody, become established, disperse and ultimately affect either native species or habitat, the management options to control the species become more limited at each step in the process (Kolar and Lodge 2002). In November 2001, Environment Canada and the Ontario Ministry of Natural Resources organized a national workshop on invasive alien species to identify issues in the management of invasive species. Since then, the federal, provincial and territorial Ministers for Wildlife, Forests, and Fisheries and Aquaculture approved a "blueprint" for a National Plan and requested the establishment of four working groups including: 1) invasive aquatic species; 2) terrestrial animals; 3) terrestrial plants; and, 4) leadership and co-ordination. A discussion document was prepared, providing a hierarchical approach to respond to invasive alien species that prioritizes: 1) the prevention of new invasions; 2) the early detection of new invaders; 3) rapid response to new invaders; and, 4) the management of established and spreading invaders (containment, eradication, and control) (Anonymous 2003) (Beth MacKay, OMNR, personal communication).

Public awareness efforts are essential in reporting, preventing and slowing the spread of established non-native invading species. The Great Lakes Sea Grant Network in the United States and the Ontario Federation of Anglers and Hunters in collaboration with the Ontario Ministry of Natural Resources have established effective Invasive Species Awareness programs (Dextrase 2002). There is a Great Lakes Panel on Aquatic Nuisance Species to develop and co-ordinate invasive species in the Great Lakes basin. For information, contact the Great Lakes Commission web site (www.glc.org), Sea Grant State Offices or the Ontario Federation of Anglers and Hunters Invasive Species Hotline at 1-800-563-7711. It is the collaborative and co-operative efforts among the public, government agencies, non-government agencies, academic institutions and industry that will result in effective management of non-native invasive species (Dextrase 2002).

Photo: Eric Engbretson, U.S. Fish & Wildlife Service

11.3 Nutrients and the Food Web: a Summary of the Lake Erie Trophic Status Study *(Presented at the Lake Erie Millennium Network Third Biennial Conference 2003, prepared by Jan Ciborowski, University of Windsor)*

Photo: Upper Thames River Conservation Authority

Long-term records relating to Lake Erie's nutrient status suggest a process of reduced nutrient status. U.S. EPA's water quality data show a downward trend of eutrophy (the Carlson Trophic State Index) for the period 1983-2000. Furthermore, concentrations of total phosphorus in the water, averaged over the whole year have been falling by about 0.2 mg/m³/yr. However, the amounts of nutrients present in the water in early spring have continued to rise, extending to eight years a trend that was first seen in 1995. Much of the among-year variation in the amount of phosphorus entering the lake over the last few years is due to the intensity and timing of storms, which cause flooding and erosion, rather than to municipal inputs. Data from the last several years indicate that more phosphorus is leaving Lake Erie in the waters of the Niagara River than is entering the Lake from the major tributaries.

The period of water turbidity associated with spring is persisting longer than formerly. The planktonic algal cells are smaller than they were in the 1980s, and there seem to be more algae during the spring than in the late 1990s. However, zooplankton are not more abundant than previously. Over the period 1991-2000, the biological demand for oxygen in the bottom waters of Lake Erie's central basin has not changed, when averaged over the whole year. Biological oxygen demand of the sediments seems to increase over the course of the summer.

In summertime, light is penetrating deeper into the water - algae are now growing (and producing oxygen) in the deep layers of the central basin and on the western and central basin lake bottoms. Extensive layers of the filamentous alga, *Cladophora* are common along rocky shorelines around the Lake. There is also more bacterial activity deep in the water, but there are very few planktonic algae in the shallow water near shore, where zebra mussels are most abundant. There is only limited evidence that the scarcity of planktonic algae is due to nutrient limitation, either in the spring, or later in summer. Microbes in the water are more likely to be limited by the availability of carbon than by either phosphorus or nitrogen. Studies to determine if the scarcity of trace metals such as iron, copper or zinc may be limiting algal production have been inconclusive. The picoplankton are most responsive to experimental additions of these metals.

Populations of dreissenid (zebra and quagga) mussels and *Hexagenia* mayflies are steady or declining. The development of thick mats of algae along shorelines, especially in the eastern and central basins, reduces the living space available for dreissenid mussels. Zebra mussels have all but disappeared from eastern and central basins, being supplanted by quagga mussels. Overall mussel densities seem to be lower than in recent previous years, possibly because there are so many gobies now in the lake. The diversity and abundance of invertebrate animals, especially mayflies and net-spinning caddisflies in the wave-washed zone of the shoreline, have dropped markedly since the last time they were surveyed in the 1970s.

The goby population in Lake Erie is large, but the numbers are quite a bit lower than they were two years ago. Most of the gobies occur in rocky and sandy areas closer to shore in all three basins. Gobies will likely become an acceptable source of food for walleye. Gobies are now common in the diets of almost all of the Lake Erie sports fish.

Evidence seems to suggest that we are seeing new pathways of internal cycling of nutrients, likely caused by the activities of dreissenids, which may be altering the size structure and dynamics of particles in Lake Erie. However, the consequences of physieal (weather-related) influences cannot be ruled out as an accompanying explanation for the apparent increasing frequency and extent of central basin anoxia events. The persistent periods of spring turbidity may be due to the effects of heavy fall and winter storms, which contribute more sediment for a given amount of precipitation than summer storms. Also, cold water is more viscous than warm water, causing particles to settle more slowly. Spring water temperatures in 2002 and 2003 have been among the coldest on record, perhaps partly accounting for the greater concentrations of spring turbidity and possibly associated nutrients.

11.4 Double-Crested Cormorants in the Great Lakes
(Prepared by Mike Bur, USGS)

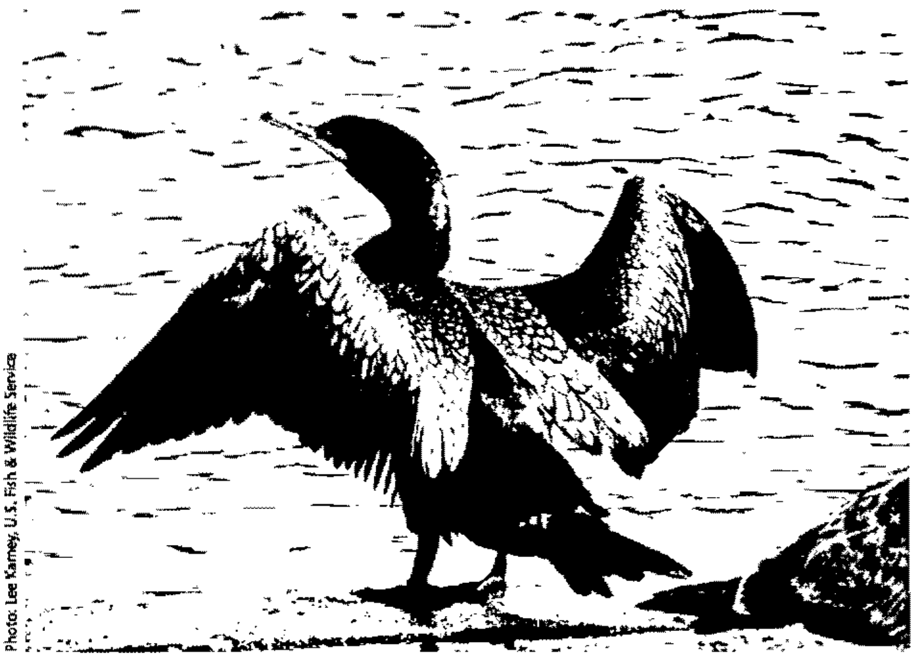


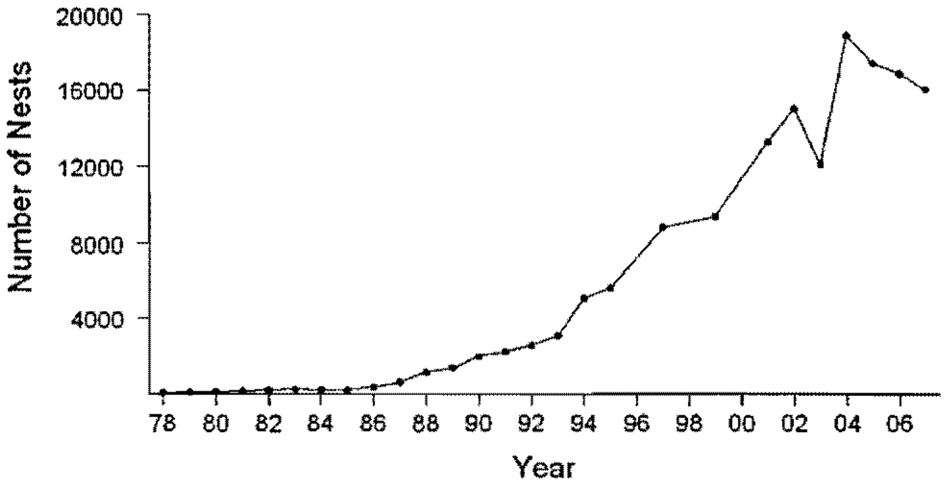
Photo: Lee Karney, U.S. Fish & Wildlife Service

Double-crested cormorants are colonial waterbirds that breed in large colonies, often mixed with other species, and nest on the ground or in trees. They have an extensive range in North America, occurring throughout the interior as well as on both coasts. For the contiguous United States as a whole, the breeding population increased at an average rate of 6.1% per year from 1966 to 1994, and now stands at approximately 370,000 breeding pairs. The total number of breeding and non-breeding birds is estimated at nearly two million birds. Resident populations in the south-central United States disappeared or declined throughout the middle of the 20th century. The interior and California populations declined from 1950 to 1970 (Hatch 1995). However, by the late 1980s most populations were increasing (Jackson and Jackson 1995; Carter et al. 1995; Krohn et al. 1995).

The first report of cormorant nesting on the Great Lakes occurred between 1913 and 1920, and by 1950 the breeding population was at 900 pairs (Weseloh et al. 1995). Human persecution and environmental contaminants led to the virtual extinction of cormorants on the Great Lakes by the early 1970s. From 1970 to 1991, the Great Lakes cormorant population increased from 89 nests to more than 38,000 nests. The population has increased at an annual rate of 23% from 1990 to 1994 (Tyson et al. 1999). Major factors leading to an increase in the Great Lakes population were reduced contaminants and persecution plus an abundance of prey fish (Weseloh et al. 1995; Blokpoel and Tessier 1996). By 2006 there were nearly 119,000 nesting pairs in the Great Lakes. On Lake Erie there has been a dramatic increase in the number of nests. In 1978, there were 58 nests; the nest count peaked at 19,000 in 2004 and, in 2007, the nest count was down to 16,050 (Figure 11.1).

With the burgeoning cormorant population there has been an increase in conflicts with commercial and sport fisheries in the Great Lakes. The common opinion of many fishers is that cormorants have a negative impact on the fish communities. After increasing concerns arose, diet and related studies were conducted to identify impacts of cormorant feeding on the Great Lakes fisheries. The effect of cormorants on fish populations in open waters is less clear than at aquaculture facilities. Studies conducted worldwide have repeatedly shown that while cormorants can, and often do, take fish species that are valued in commercial and sport fisheries, those species usually comprise a very small proportion of the birds' diet. One

Figure 11.1: Total number of double-crested cormorant nests on Lake Erie



study found that in Lake Erie the number of these fish (i.e., yellow perch, smallmouth bass, and walleye) consumed by cormorants was less than 5% of the total consumed (Bur et al. 1999). Other studies suggest that cormorants have the ability to deplete fish populations in localized areas (Burnett 2001; Lantry et al. 1999; Rudstam et al. 2004).

In Canada, double-crested cormorants are managed under the authority of the provincial agencies. The Ontario Ministry of Natural Resources is currently conducting a research program to assess the effects of cormorants on fish stocks, and is working with U.S. state and federal agencies to manage cormorants where necessary and appropriate.

A major concern is the adverse impacts cormorants have on vegetation in nesting colonies and roosting areas. These birds often inadvertently kill trees and vegetation with their feces. Some of these areas include stands of uncommon or rare species, such as the Kentucky coffee tree (*Gymnocladus dioicus*) remaining on most of the Lake Erie islands. Vegetation alteration may affect the ecological balance of an area and, to a lesser extent, possibly lower property, recreational, and aesthetic values. Cormorants can affect other colonial waterbirds at mixed and breeding colonies directly by physical displacement, and indirectly by altering the vegetation (Trapp et al. 1999). Lake Erie's West Sister Island has the largest colonial waterbird colony in the Great Lakes.

Since 1972, depredation permits allowing the taking of double-crested cormorants have been authorized on a case-by-case basis, usually when negative impacts on aquaculture operations and habitat have been demonstrated. Most permits were for birds causing depredation problems at aquaculture operations. The U.S. Department of Agriculture's Wildlife Services Division is responsible for documenting economic losses.

The persistence of conflicts associated with double-crested cormorants, widespread public and agency dissatisfaction with the status quo, and the desire to develop a more consistent and effective management strategy for double-crested cormorants has steered the U.S. Fish & Wildlife Service to the decision to prepare a national cormorant management plan for the contiguous United States. The purpose of the management plan for double-crested cormorants is threefold: to reduce resource conflicts associated with double-crested cormorants in the contiguous United States; to enhance the flexibility of natural resource agencies in dealing with double-crested cormorant-related resource conflicts; and to ensure the conservation of healthy, viable double-crested cormorant populations.

Under an Environmental Assessment, the public resource depredation order authorizes States, Tribes, and U.S. Department of Agriculture's Wildlife Services to manage and control double-crested cormorants to protect public resources (fish, wildlife, plants, and habitats). The order allows control techniques to include egg oiling, egg and nest destruction, cervical dislocation, shooting, and CO_2 asphyxiation. The order applies to 24 states including the Lake Erie states: Michigan, Ohio, Pennsylvania and New York. Agencies acting under the order must have landowner permission, may not adversely affect other migratory bird species or threatened and endangered species, and must satisfy annual reporting and evaluation requirements. The USFWS will ensure the long-term conservation of cormorant populations through annual assessment of agency reports and regular population monitoring.

In recent years, natural resource agencies have conducted population reduction procedures (e.g., egg oiling and shooting) to reduce the populations of cormorants on the Great Lakes. Major justifications were to protect rare native vegetation and reduce impacts on colonial bird nesting habitats. Ohio implemented a double-crested cormorant damage management program in 2005. In the past two years Ohio DNR, U.S. Department of Agriculture's Wildlife Services, and U.S. Fish & Wildlife Service initiated population control measures on several islands in western Lake Erie. In 2006, the population of adult cormorants was reduced by 5,868, and 3,579 cormorants were removed in 2007.

Conservation measures will also protect fish, other birds, vegetation, federally listed threatened and endangered species, water quality, human health, economic impacts, fish hatcheries, property losses, and aesthetic values.

11.5 Status of the Fish Community *(Prepared by Jeff Tyson, Ohio Department of Natural Resources and Rich Drouin, Ontario Ministry of Natural Resources)*

Lake Erie's fisheries differ strongly from the other Great Lakes because the Lake Erie fisheries rely predominantly upon natural reproduction of native species within the lake and its tributaries. Rehabilitation of these environments is critical to restoration of biological integrity of the Lake Erie ecosystem. The Lake Erie Committee of the Great Lakes Fishery Commission has established Fish Community Goals and Objectives and Environmental Objectives to define rehabilitation, and to recognize that the Lakewide Management Plan is vital to recovery of ecosystem integrity. A healthy fish community will be a measure of restoration of that integrity.

Walleye is a critically important species to the ecology and fisheries of Lake Erie. As a top predator with broad distribution, this species is expected to bring more stability to the fish community. Information from tagging and genetics studies shows that the population is composed of several distinct stocks. There are three major spawning sites in western Lake Erie: the Maumee River, Sandusky River, and the island shoals. There are also three major spawning areas in eastern Lake Erie: the New York shoreline, Grand River (ON) and nearby shoals. The success of Lake Erie's walleye in reproduction depends on environmental conditions at these sites (e.g., total suspended solids in the Maumee and Grand Rivers) and other river and lake habitats that support the early life history of this species.

The walleye population built up in the 1980s with the help of two very strong year classes, but began a long-term decline in the 1990s. The Lake Erie Committee of the Great Lakes Fishery Commission recognized the need to protect the reproductive potential of the population under the "Coordinated Percid Management Strategy." Harvest levels were reduced from 2001 to 2003 by Ontario, Michigan, New York, Ohio and Pennsylvania. Conservative harvest levels were established earlier in eastern Lake Erie (East Basin Rehabilitation Plan 2000-04) in Ontario's jurisdiction.

Subsequent to implementation of the Coordinated Percid Management Strategy, the Lake Erie Committee has developed a Walleye Management Plan with an exploitation strategy that is tied to population abundance. At lower population levels, exploitation rates are reduced significantly, while at higher abundances exploitation rates are higher. The intent of this exploitation strategy is to reduce fishing mortality at low abundances to enhance the recovery of the population to sustainable levels. A strong year class of walleye in 2003 provided the potential to bring the population back up to desirable levels; however, recruitment of subsequent year classes has been well below long-term averages. In accordance with the Walleye Management Plan it will be necessary to have the new exploitation strategy in place for several years to determine whether the strategy adequately addresses overall walleye abundance and fish community stability.

The yellow perch population in Lake Erie also declined in the 1990s, but its recovery began with the strong 1996-year class in the western and central basins. A strong year class in 1998 has supported recovery in eastern Lake Erie. Recovery in all three basins has continued with strong year classes in 2001 and 2003. The Lake Erie Committee is also in the process of developing a Fisheries Management Plan and exploitation strategy for yellow perch that is similar to the Walleye Management Plan.

Photo: Mike Weimer, U.S. Fish & Wildlife Service

Lake trout is an important top predator for the cold-water fish community in eastern Lake Erie. The species is being re-established by stocking. Survival of stocked fish was depressed in the 1990s, but has improved in recent years. Recently, little natural reproduction has been documented for lake trout. Other stocking strategies, as well as different strains, are being explored by the Lake Erie Committee.

Like walleye, lake whitefish had a strong year-class in 2003. Lake herring have been rare in Lake Erie since the early 1960s. While they are still considered to be rare, there are signs that a slow increase in the lake herring population is occurring.

The current state of Lake Erie's fisheries and strategies for coordinated management will be published by the Great Lakes Fishery Commission in a "State of the Lake" report due out in 2008.

11.6 Cyanobacteria *(Prepared by Thomas Bridgeman, University of Toledo and Julie Letterhos, Ohio EPA)*

Blooms of cyanobacteria (blue-green algae) are again becoming noticeable at certain places and times. Some species produce chemicals that are potent toxins to humans and wildlife. Others create a nuisance for aesthetics, recreational use and cause taste and odor problems in drinking water.

In the 1960s and 1970s, cyanobacteria blooms were commonplace in Lake Erie. Shorelines were often rimmed in the color aqua, and offshore waters were thick with algae in the warm calm months of August and September. As Lake Erie began to respond to the efforts of phosphorus reduction, and phosphorus levels dropped toward the limits promoted by research under the Great Lakes Water Quality Agreement, cyanobacteria blooms decreased and then disappeared altogether.

Quite suddenly and unexpectedly, cyanobacteria blooms recurred in the western basin in 1995. This time the blooms were dominated by *Microcystis aeruginosa*, a non-nitrogen-fixing species that produces the hepatotoxin microcystin. Past blooms were dominated by nitrogen-fixing species such as *Anabaena* and *Aphanizomenon*. It was suspected that the blooms were associated with ecological changes in the system brought about by dreissenids and potentially with a changing P/N ratio in the lake.

Blooms of *Microcystis* did not occur in 1996 or 1997, but returned in 1998, and have occurred to varying extent every year since 2001. *Microcystis* blooms in 2003 were particularly heavy, not just in the western basin, but also in the central basin (Figure 11.2). The percent biomass of cyanobacteria is also increasing in the eastern basin. Year to year variation in bloom intensity may be influenced by annual variation in weather patterns but, overall, the recurrence of open-water algal blooms, along with the expanded areas of anoxia and hypoxia in the central basin, is suggesting a change in eutrophy in parts of the lake. In addition to potential hepatotoxins produced by *Microcystis* species, other toxic compounds have been identified in Lake Erie waters associated with other species of cyanobacteria. Cyanobacterial taste, odor and biomass issues have also occurred.

In 2006 and 2007, large blooms of the benthic, mat-forming cyanobacteria species *Lyngbya wollei* occurred along the shoreline of Maumee Bay. Although *L. wollei* is not necessarily new to Lake Erie, such massive blooms were previously unknown in the lake, suggesting a further change in the ecosystem. Mats have washed up on the shore and created a substrate upon which vegetation has taken hold (Figure 11.2a). Massive amounts

Figure 11.2: *Microcystis* bloom in the Western Basin, August 18, 2003 (LANDSAT 7 Image)

Figure 11.2a: *Lyngbya wollei* mats along the Maumee Bay shoreline (Sandy Bihn, Western Basin Waterkeeper)

of *Lyngbya* create a strong odor and impact the use of beaches and nearshore areas where they accumulate.

The University of Toledo, NOAA's Great Lakes Environmental Research Laboratory, the Ohio Department of Natural Resources and other academic researchers are continuing to track the occurrence of *Microcystis*, *Lyngbya* and other cyanobacteria as well as the status of other components of the plankton community in various Lake Erie locations. There is a continuing need to do more research to better understand the biology of cyanobacteria and the causes of their blooms. Several such investigations are currently underway. Samples collected in various open-water areas revealed a correlation between locations where blue-green algal pigments were most abundant and places where dreissenid mussels were abundant. There is a need to track the distribution and incidence of such blooms to improve our understanding of their risk to human and animal health. Increasing tributary loads of dissolved, bioavailable phosphorus may also be contributing to the increased algal growth.

Although human poisoning by ingestion of cyanobacterial toxins is very unlikely in Lake Erie waters, direct contact with water containing noticeable amounts of cyanobacteria should be avoided. Prolonged contact with mats that have washed up along the shore should also be avoided because of the potential of these species to cause skin irritation or harbour other bacteria.

11.7 *Cladophora* (Prepared by Scott Higgins, University of Waterloo and Todd Howell, Ontario Ministry of the Environment)

Cladophora glomerata is a filamentous green alga that grows attached to rocky lake bottoms and man-made structures in relatively well illuminated and alkaline waters. It was first identified in western Lake Erie in 1848. While *Cladophora* has a ubiquitous distribution throughout the Laurentian Great Lakes and associated tributaries, historical 'nuisance' growths were most often associated with excessive phosphorus loading. Where *Cladophora* growths are extensive the blooms are followed by a major sloughing, or dieback, event where filaments detach from the lake bottom and become free floating. Floating *Cladophora* mats tangle fishing nets, reducing their efficiency and increasing downtime for net-cleaning, and are a potential hazard for swimmers. The mats also clog intake screens of municipal and industrial water intakes (IJC 2003; Kraft 1993; Michard 2005) increasing maintenance costs and sometimes resulting in costly short-term shut-downs. Shoreline accumulations of decaying *Cladophora* release obnoxious odors, reducing shoreline property values, the aesthetic value of beaches and associated tourism. Recent research by Byappanahalli et al. (2003) has documented high concentrations and survival rates (>6 months at 5°C) of *E. coli* within shoreline accumulations of *Cladophora*. This research indicates that *Cladophora* mats are a potential source of *E. coli* to recreational waters, potentially confusing the use of *E. coli* as an indicator organism for pathogens derived from fecal material.

Cladophora filaments require hard surfaces such as rocky lake bottoms or man-made structures such as piers or breakwalls for attachment. Significant areas of shallow bedrock are restricted to the eastern basin, portions of the central basin's southern shoreline, and islands of the western basin. Man-made structures, however, are common to all basins.

The most recent systematic *Cladophora* surveys (1995-2002) by Howell (1998) and Higgins et al. (2005b) have been restricted to the eastern basin. Across the northern shoreline of the east basin dense *Cladophora* mats were found over 96% of available rocky lake bottom (Figure 11.3) and were not spatially limited to nutrient point sources such as the mouths of tributaries or sewage treatment outfalls. The standing biomass of *Cladophora* along this reach of shoreline was estimated to be 11,000 tonnes (dry weight). Shoreline accumulations of *Cladophora* (Figure 11.4) were common during July and August, causing noxious odors and prompting numerous complaints from local homeowners. Heavy shoreline accumulations of *Cladophora* were also noted along the southern shorelines of eastern Lake Erie in Dunkirk, NY (Obert 2003).

Figure 11.3: Underwater photograph of Lake Erie lake bottom overlain with *Cladophora*. Photo taken at Grant Point, 2 m depth, July 2003.

Figure 11.4: Shoreline fouling by *Cladophora* in eastern Lake Erie. Photo taken approximately 2 km south of Peacock Point, August 2001.

In the central basin, persistent shoreline fouling by *Cladophora* has been noted in Rondeau Bay, Ontario (Shepley 1996), Cleveland, OH (Kraft 1993), and Pennsylvania shorelines (GLRR 2001). Data for other areas are not available. In the western basin, *Cladophora* is currently found growing on bedrock areas surrounding offshore islands, and on man-made structures at the basin perimeter. However, to date no complaints from area residents have occurred regarding *Cladophora* fouling of shorelines in the western basin.

The depth distribution of *Cladophora* is related to light availability, and the maximum depth of colonization in eastern Lake Erie was approximately 15 metres. The biomass of *Cladophora* at shallow depths (<5 m) was found to be similar to levels during the 1960s and 1970s (median value 176 g DM m^{-2}). Depth integrated biomass likely increased due to increases in water clarity caused by zebra and quagga mussels. A *Cladophora* growth model (Canale and Auer 1982), originally developed on Lake Huron, was revised and validated in eastern Lake Erie (Higgins et al. 2005a). The model predicted that *Cladophora* growth was highly sensitive to soluble phosphorus concentrations during the spring and that reductions in ambient phosphorus concentrations would significantly reduce bloom occurrences. The modeling results were supported by direct evidence, indicating that phosphorus concentrations within *Cladophora* tissues rapidly declined to critical levels by early summer. A preliminary phosphorus addition study using slow release nutrient agar also suggested *Cladophora* growth and biomass accrual were strongly P-limited (Figure 11.5, 11.6) (S. Higgins, University of Waterloo).

Previous studies by Lowe and Pillsbury (1995) documented increases in benthic algal growth, including *Cladophora*, over zebra mussel beds in Saginaw Bay of Lake Huron. Unfortunately, benthic algal surveys were not conducted over the colonization period in Lake Erie. Efforts are currently ongoing to use the *Cladophora* growth model to estimate the influence of zebra and quagga mussels on *Cladophora* resurgence in the east basin (S.

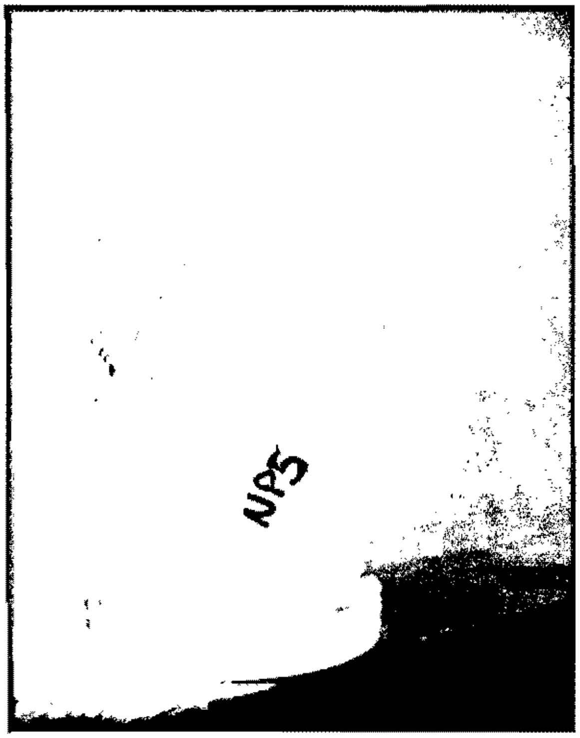


Figure 11.5: *In situ Cladophora* growth chamber with non-nutrient enriched agar.

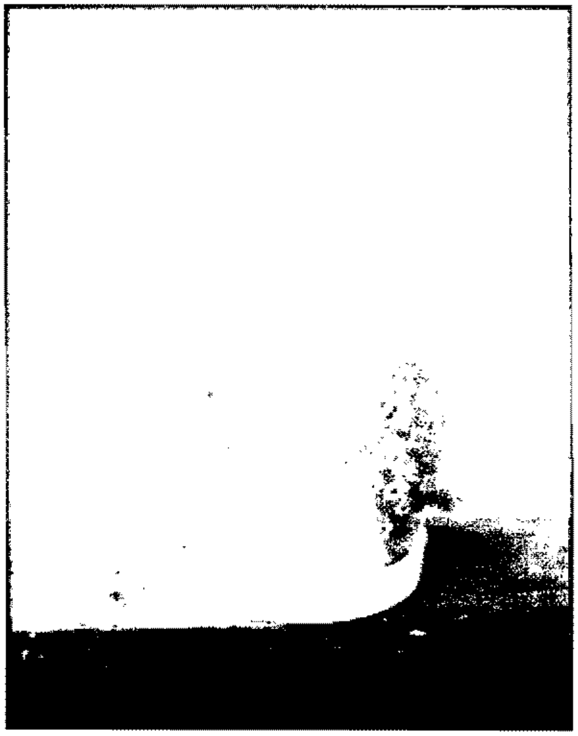


Figure 11.6: *In situ Cladophora* growth chamber with phosphorus enriched agar.

Higgins, University of Waterloo) and to investigate the influence of tributaries on growth potential in eastern Lake Erie (S. Higgins, University of Waterloo; and Ontario Ministry of the Environment).

11.8 Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in the Environment

(Prepared by Jacqueline Fisher, U.S. EPA for the Great Lakes Human Health Network)

Over the past few decades, an increasing concern has developed about the potential and inadvertent contamination of water resources from the production, use, and disposal of the numerous chemicals used to improve industrial, agricultural, and medical processes. Analgesics, anti-inflammatory drugs, birth control chemicals, Prozac-like drugs, and cholesterol-lowering drugs have all been found in the effluent from water treatment plants discharging into the Detroit River, although at low concentrations (Lake Erie Millennium Network 2003). Even some commonly used household chemicals have raised concerns. Increased knowledge of the toxicological behavior of these chemicals raises the need to determine any potentially adverse effects on human health and the environment. For many of these contaminants, public health experts do not fully understand the toxicological significance, particularly the effects of long-term exposure at low levels. Further study needs to be done to determine the transport of these chemicals at trace levels through the environment and to determine any resulting adverse human health effects.

The U.S. Geological Survey conducted the first nationwide reconnaissance of the occurrence of pharmaceuticals, hormones, and other organic wastewater contaminants (OWCs) in water resources in 1999 and 2000. Concentrations of 95 OWCs in water samples from a network of 139 streams across 30 states were measured using five newly developed analytical methods. The selection of sampling sites was biased toward streams susceptible to contamination (i.e. downstream of intense urbanization and livestock production). OWCs were prevalent during this study, being found in 80% of the streams sampled. The compounds detected represent a wide range of residential, industrial, and agricultural origins and uses with 82 of the 95 OWCs being found during this study. The most frequently detected compounds were coprostanol (fecal steroid), cholesterol (plant and animal steroid), *N,N*-diethyltoluamide (DEET insect repellant), caffeine (stimulant), triclosan (antimicrobial disinfectant), tri(2-chloroethyl)phosphate (fire retardant), and 4-nonylphenol (nonionic detergent metabolite). Measured concentrations for this study were generally low and rarely exceeded drinking water guidelines, drinking water health advisories, or aquatic life criteria. Many compounds, however, do not have such guidelines established.

The detection of multiple OWCs was common for this study, with a median of seven and as many as 38 OWCs being found in any given water sample. Little is known about the potential interactive effects (such as synergistic or antagonistic toxicity) that may occur from complex mixtures of OWCs in the environment. In addition, results of this study demonstrate the importance of obtaining data on metabolites to fully understand not only the fate and transport of OWCs in the hydrologic system but also their ultimate overall effect on human health and the environment. (http://toxics.usgs.gov/regional/emc_sourcewater.html)

11.9 Fish and Wildlife Deaths Due to Botulism Type E
(Prepared by Jeff Robinson, Canadian Wildlife Service)

Since 1999 there have been annual large scale die-off events of fish, fish-eating birds and mudpuppies (a native aquatic amphibian) observed in Lakes Erie, Huron and, in 2003, Lake Ontario. These events have occurred annually in Lake Erie and it is here where the largest toll of fish and wildlife has occurred. The type E botulism bacterium is believed to be the cause of the die-off events.

Type E botulism is caused by *Clostridium botulinum,* a bacterium that is native to North America. The bacterium is quite widespread in the soils and sediments around the Great Lakes. Movement of the bacterium through the food chain resulted in mortality events of fish-eating birds in the Great Lakes basin during the 1960s. Humans were affected by food poisoning from poorly handled fish or wildlife and improperly prepared canned products. In the past, it has rarely been known to kill large numbers of fish or birds. Previous events primarily affected loons and grebes on Lakes Huron and Michigan.

On Lake Erie, shoreline landowners have observed remarkable natural fish die-offs as a result of strong storm fronts moving over the lake in the late summer or early fall. The lake has been warming through the summer and sets up a layer of warm surface water and a much colder layer in the deeper water generally well offshore. As these storm events or strong cold fronts pass, there are often sustained strong winds from the north that push the warmer surface waters to the south shore and bring the much colder water from deeper parts of the lake into the nearshore zone on the north shore. This results in a drop of the ambient water temperature so quickly and so drastically that resident fish, unable to escape the sudden temperature change, tend to be disabled or die. These events are quite regular as weather patterns, shoreline configuration and nearshore morphology do not change much over time. These dead fish afford an easy meal for inexperienced juvenile gulls and bald eagles learning to forage on their own. Occurring at a critical time of dispersal of young birds, this phenomenon has likely gone on for centuries.

What has been rarely observed in the past is apparent botulism type E poisoning of hundreds, if not thousands of fish-eating birds as well as dead fish and mudpuppies washing ashore in unprecedented numbers during the late summer and early fall period. Fall and early winter events have been less of a perceived problem as the number of recreational users on the beaches at that time of year is much lower.

Outbreaks

The earliest known or suspected incidents of type E botulism poisoning on Lake Erie have occurred during June, involving mudpuppies and gulls. These June incidents generally involved a few gulls found dead or dying along beaches or several hundred dead mudpuppies washed ashore or floating in the eastern basin of Lake Erie.

Summer die-off events tend to affect resident fish and wildlife whereas late summer events (August and September) start to affect populations of wildlife migrating through the Great Lakes. The fish affected tend to be bottom dwelling, warm water species such as: the round goby, stonecat, sheepshead, smallmouth bass, rock bass and sturgeon. The birds affected in the die-offs include: ring-billed gull, herring gull, double crested cormorant, greater black-backed gull, Caspian tern, common tern and a few shorebird species. Most of the birds involved breed near the areas where they are found dead. However, end of August outbreak events have found cormorants, breeding as far away as Lake Huron and eastern Lake Ontario, dead on Lake Erie.

The Canadian Wildlife Service reported that the fish die-off of freshwater drum and round goby at Wheatley, Ontario on August 16, 2001 did not result in any unusual bird mortalities. However, after a similar die-off of fish near Port Dover, Ontario also on August 16, there were 38 dead birds, one mudpuppy, three shorebirds and a report of a sick great blue heron. On October 29, 2001, the Canadian Wildlife Service reported die-offs of the common loon, ring-billed gulls, red-breasted mergansers, gadwalls, and long-tailed ducks (old squaw) along the northeast shore of Lake Erie between Port Dover and Dunnville in Ontario. In addition, there were dead fish along the beach including round goby, carp, and catfish as well as a mudpuppy. Specimens were sent to the Canadian Cooperative Wildlife Health Centre at the University of Guelph for assessment.

Similar mortalities of fish and birds occurred along the New York shoreline of Lake Erie during the same period. Among fish found dead along the New York shoreline in September 2001, 81% were freshwater drum (Figure 11.7) with the remainder consisting of nine other species. Bird collections in fall 2000 revealed an estimated 5,000 to 6,000 birds died that year, with red-breasted merganser the most common species (Figure 11.8). Estimates of dead common loons in New York were over 500 birds in 2000, and over 1000 birds in 2001. In addition, seven dead lake sturgeon (a threatened species in New York) were found in 2000, while 27 individuals were collected in 2001.

During the months of November and December bird deaths generally occur after the passage of strong cold fronts that appear to be related to mixing of lake waters, movement of migrant birds into Lake Erie and movement of fish from the nearshore to deeper water off shore. Thousands of waterfowl and loons have been observed over the past four years dead due to apparent botulism type E poisoning.

Migration of Die-off Events

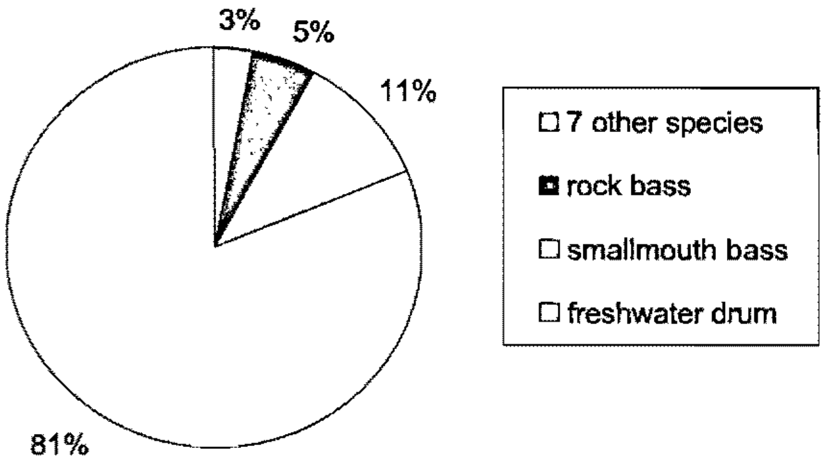
In 1999, botulism type E mortality was first observed in October along beaches at Pinery Provincial Park, Ontario on Lake Huron and beaches west of Rondeau Bay, Ontario in the central basin of Lake Erie. The Lake Huron event involved primarily common loons while the Lake Erie event was primarily red-breasted mergansers.

In 2000, there were no reports from Lake Huron. The major mortality was observed along stretches of shoreline in the central basin of Lake Erie, primarily the area east of Rondeau Bay and near Presque Isle Bay, Pennsylvania. Starting in 2000, fish die-offs in late summer saw the first bird die-offs of gulls. Fall events involved gulls, cormorants, common loons and grebes.

In 2001, the mortality events moved further east into the eastern basin of Lake Erie with some reports from the north shore of the western basin but not in any numbers. In the late fall of 2001 large numbers of red-breasted mergansers were killed along with an estimated several thousand common loons during November and December.

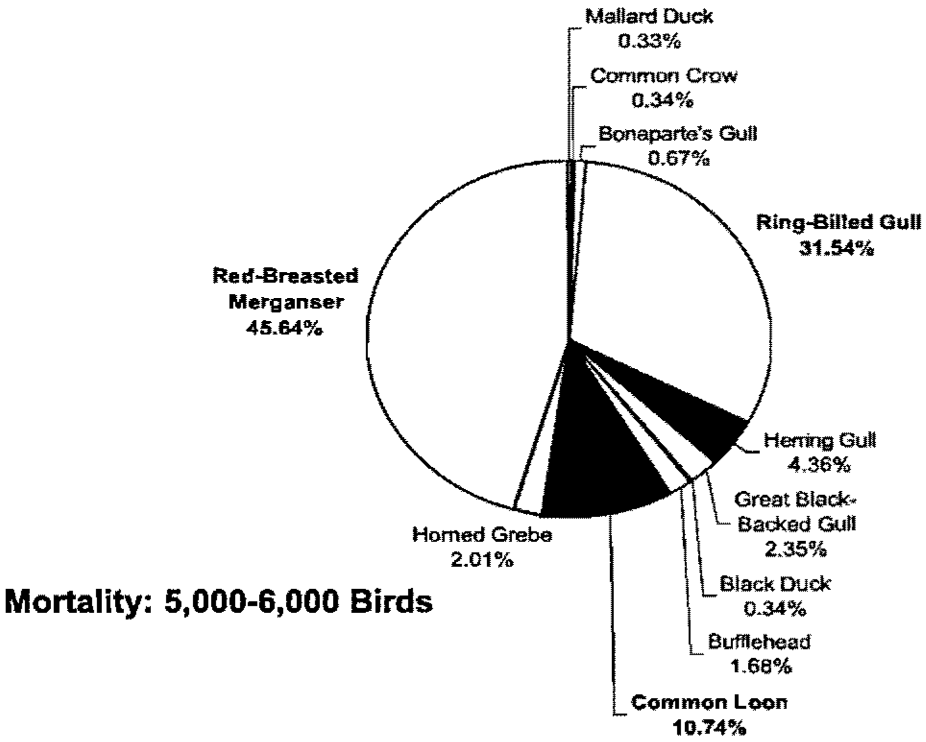
In 2002, there was virtually no observed mortality in the western or central basins, but large mortalities observed at several locations in the eastern basin. Large numbers of gulls at a colony near Buffalo, New York died during July. A major event occurred over the Labour Day weekend at Long Point involving gulls, cormorants and shorebirds as well as thousands of fish (mostly sheepshead as well as a sturgeon). In the November to December period, several thousand common loons and grebes were again encountered dead in the eastern basin and thousands of long-tailed ducks washed ashore dead from apparent botulism type E poisoning. During this period there were also reports of dead common loons washing

Figure 11.7: Frequency of dead fish species observed along NY Lake Erie beaches, September 2001



Information from NYSDEC

Figure 11.8: Percent mortality on NY Lake Erie shoreline by species observed, fall 2000



ashore on Lake Huron from Goderich to Kincardine in Ontario. During the botulism type E events in the eastern basin, several adult sturgeon were found washed ashore, mostly in New York, which is a real management concern for this small population in Lake Erie. The same can be said of the mouth of the Niagara River on Lake Ontario as the last two years have seen reports of dead sturgeon and birds there due to apparent botulism type E poisoning as well.

In 2003, there were not any remarkable events in the summer and early fall on Lake Erie. Common loons and grebes were found dead on beaches of the eastern basin, but at much lower numbers than in previous years. As well, birds apparently suffering from botulism type E were recovered further north in Lake Huron (between Kincardine and Port Elgin, Ontario) and in eastern Lake Ontario. Government employees and private citizens continue to monitor the beaches on Lakes Huron, Erie and Ontario to report fish and bird die off events that may be related to botulism type E or other causes.

What Do We Know to Date

Most initial work concentrated on counting the numbers of fish and birds being affected by the botulism outbreaks. This only served to identify the possible locations of the die-offs in the lake and did little to help understand the mechanism for the toxin getting into the food chain or the environmental conditions on the bottom of the lakes that led to production of toxin at levels that start to affect the food chain.

The current thinking on what is causing these outbreaks is that ecological changes in the Great Lakes due to recent non-native species invasions have changed the way the food chain operates, with much more energy in the system staying on or near the bottom of the lake. When zebra and quagga mussel populations expanded into the Great Lakes there were no observable occurrences of unusual mortalities in wildlife or fish that tend to consume them as food (e.g. scaup ducks, freshwater drum or sheepshead). Over the last eight years, there has been the more recent invasion of the round goby into the Great Lakes and this has seen a tremendous change in fish productivity in Lake Erie where the bulk of the fish biomass is now dominated by these bottom dwelling fish. Formerly, the fish community was much more balanced, and it is thought that very rarely would the benthic community, where the botulism toxin is thought to be produced, be able to mobilize the toxin into the upper levels of the food web. Consequently, much of the current research effort is working to determine if this theory is indeed valid.

Alicia Perez-Fuentetaja and Theodore Lee at the State University of New York in Fredonia are currently studying bottom ecology near Dunkirk, New York to better understand possible triggers for toxin production. Preliminary results suggest that ambient water temperature may be important. They also measured redox potential at the bottom and found that the lowest value generally preceded summer outbreaks by several days in 2002. Results are not complete for 2003 when no major summer events were observed. U.S. EPA/Great Lakes National Program Office and the U.S. Fish and Wildlife Restoration Act funded this project.

At Cornell University, Paul Bowser and Rod Getchell have been examining the prevalence of the botulism bacteria in healthy, moribund, and dead fish in areas of confirmed botulism outbreaks and in unaffected areas in Lake Erie and Lake Ontario. Answers will be sought to the questions: is the bacterium more likely to be present in healthy, moribund or dead fish; is one species of fish more likely to carry the bacterium; does the toxin form in fish prior to and after death and, are fish carrying the bacterium associated with waterfowl death events? The researchers are working with the New York State DEC to collect fish, primarily carp and round gobies, from both lakes for examination. Tests will assess the cause of death as well as other pathogens present in the fish. The New York Sea Grant Program funds this project.

Photo: Mike Werner, U.S. Fish & Wildlife Service

In Ontario, Richard Moccia at the University of Guelph has been working with Health Canada to study the behavior of various native and non-native fish species to known doses of botulinin toxin. Fish studied or proposed to be studied are: round goby, walleye, yellow perch and possibly lake sturgeon and mudpuppies. This study is designed to enable a better understanding of the role, if any, that key fish species play in the bird deaths occurring within the Great Lakes. This study attempts to refute, or support, the current working hypothesis that fish and mudpuppies represent a potential "living transport vector" of botulism neurotoxin in the lake, and that they may be a primary source of lethal doses of the type E toxin to affected bird populations. Furthermore, this work will also contribute to a better understanding of the ecology of botulism neurotoxin production in the Great Lakes, and help to assess the potential for human health consequences resulting from the infection, or intoxication, of freshwater fish and birds with *Clostridium botulinum* (Types E botulism). Environment Canada, Ontario MNR, Health Canada and the University of Guelph support this work. As well, wildlife pathologists with New York DEC in Albany and the Canadian Co-operative Wildlife Health Centre at the University of Guelph continue to examine dead birds and fish submitted during these outbreaks to determine cause of death and retrieve specimens for further assessment.

A much more complete description of monitoring and research on botulism in the Great Lakes is available at the following link hosted by New York, Pennsylvania and Ohio Sea Grant at: www.nyseagrant.org/. This link lists proceedings from annual workshops held in 2001, 2002 and 2003 on botulism in the Great Lakes.

11.10 The 2005 Fall Turnover Incident *(Prepared by Jim Grazio, Pennsylvania Dept. of Environmental Protection)*

Because phosphorus is a key macronutrient governing eutrophication in the Great Lakes, Annex 3 of the Great Lakes Water Quality Agreement set forth specific goals with respect to its control. For Lake Erie, these specific goals were "substantial reduction in the present [1978] levels of algal biomass to a level below that of a nuisance condition in Lake Erie" and "restoration of year-round aerobic conditions in the bottom waters of the central basin of Lake Erie." As a result of binational efforts to reduce phosphorus loading from municipal sewage discharges, household detergents, agriculture, and other major sources, phosphorus loading to Lake Erie decreased by over 50% since 1965 and phosphorus concentrations reached record lows in 1995. It seemed to all observers that the cultural eutrophication of Lake Erie had been halted and that the target loads and specific management goals for phosphorus had been attained. In the last decade, however, phosphorus concentrations in Lake Erie have begun to increase once again and signs of cultural eutrophication are again apparent. Nuisance growths of *Cladophora*, *Microcystis* and other undesirable algae are again being reported and seasonal dissolved oxygen depletion in the central basin may be intensifying.

Both the central and eastern basins of Lake Erie thermally stratify into a warmer upper layer (epilimnion) and cooler lower layer (hypolimnion) in the summertime. The epilimnion of the lake maintains its life-giving dissolved oxygen through the photosynthesis of aquatic plants and algae and by mixing with oxygen from the air. The dark hypolimnion is isolated from the oxygen rich epilimnion, and oxygen levels naturally decrease throughout the summer growing season as the result of aquatic organism respiration and the biochemical oxygen demand of decomposing plant matter. With an average depth of 25 meters (82 ft.), oxygen is never completely depleted in the eastern basin. In the central basin, however, with an average depth of 18 meters (60 ft.), the size of the hypolimnion is much smaller and the water may become devoid of oxygen by the end of the summer growing season. As the limiting macronutrient for aquatic plant growth, increases in the amount of bioavailable phosphorus fertilize the growth of algae, thereby accelerating the rate of eutrophication in the lake.

Monitoring of dissolved oxygen levels in the central basin by the US E.P.A.'s Great Lakes National Program Office has suggested that the rate of dissolved oxygen depletion in the central basin hypolimnion may be increasing and that the depletion may be occurring earlier in the summer. For example, average dissolved oxygen concentrations of less than 1.0 mg/L were recorded by the end of August in the central basin during 2001, 2002, and 2003—a hypoxic condition documented only twice in the monitoring period of record from 1985 through 2004. Still, the data are quite variable from year-to-year and definitive trends and causes have yet to be established. Nonetheless, dramatic additional evidence that central basin hypoxia is intensifying occurred on September 29, 2005 when a large "burp" of anaerobic gases was released from the central basin during the annual fall overturn.

Hydrogen sulfide odors were detected by residents along the southern shore from roughly Cleveland, Ohio to Buffalo, New York, causing mild panic among some lakeshore residents and prompting hundreds of phone calls to regulatory and law enforcement agencies. Odors were typically described as "rotten eggs", "sewer gas", or "sulfur", generating widespread speculation of causes ranging from sewage treatment facility upsets to natural gas leaks to distant chemical plant explosions. Emergency response teams were called in to investigate the source of the odors in one Pennsylvania community. Fortunately, an experimental, real-time monitoring buoy deployed in the central basin by the National Oceanic and Atmospheric Administration's International Field Year on Lake Erie (IFYLE) effort allowed scientists to correlate the sulfurous odors to the abrupt mixing of the upper and lower layers of the central basin of Lake Erie.

The "big burp" of 2005 was a not-so-subtle reminder of the importance of systematically monitoring water quality parameters and conditions related to the onset of hypoxia in the central basin. More generally, it was a reminder of the importance of ongoing monitoring and research to truly understand and manage the ever-changing Lake Erie ecosystem. It is also important to note that without the nutrient controls imposed on point and nonpoint sources, unpleasant conditions related to the lake turnover would be a lot more common.

11.11 Climate Change, Water Quality and Habitat

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has concluded that the warming of the climate system is unequivocal, as evidenced by actual observations of global increases in air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (IPCC 2007). Over the years, considerable research has been done to document the evidence of global warming, why it is occurring, how climate patterns may change, and what impacts these changes may have on existing ecosystems human use.

The member agencies of the Lake Erie LaMP Management Committee are particularly concerned about how global warming may impact Lake Erie water quality, habitat and the diversity of biological communities in or dependent upon the lake. Climate change and its impact on the Great Lakes Region have been assessed and summarized (IJC 2003; Kling et al. 2003; MacIver 2007). Projected changes in the Great Lakes Basin climate include: further increases in air temperatures; a decrease in the daily temperature range; an increase in the intensity and frequency of extreme events (heat waves, drought, intense precipitation); more winter precipitation falling as rain and less as snow with a subsequent increase in winter runoff; earlier spring freshet with potentially less flow; increased evapotranspiration with warmer temperatures; and less ice cover (IJC 2003). While it is natural for Lake Erie's water level to fluctuate seasonally, annually and over decades, most impact assessments of climate change on the hydrology of the Great Lakes Basin project lower net basin supplies and increased frequency and duration of low water levels (Mortsch et al. 2000, 2006; Quinn and Lofgren 2000; Lofgren et al. 2002; Croley 2003).


Photo: Upper Thames River Conservation Authority

Mortsch et al. (2006) examined the potential impacts of projected climate change on Great Lakes coastal wetlands, including Long Point, Turkey Point, Rondeau Bay and Dunnville wetland complexes in Lake Erie. Using models developed for this purpose, the study assessed how low water levels would affect wetland vegetation communities and wetland-dependent birds and fishes. Modeling results project major shifts are likely in all taxonomic groups beginning with vegetation changes. Lower water levels favor the expansion of drier vegetation types, particularly along the upper margins of the wetland, and a reduction in open water and submerged vegetation in embayments. The wetland bird and fish communities have the ability to respond to potential changes in vegetation community redistributions, although it is not equitable. Over-water nesting bird species and fish species that required flooded vegetation for reproduction and nursery habitat were most vulnerable. Hydrogeomorpholgy plays a critical role in wetland and habitat responses and there were site-specific differences in responses.

Climate change is an additional stressor compounding the ecosystem management challenges already posed by increasing population, land use change, chemical contamination, eutrophieation and invasive species. A portfolio of adaptation measures will be required to respond to climate change in the Lake Erie Basin. Adaptation measures are aimed at reducing risks or impacts and taking advantage of new opportunities presented by climate change. The objective becomes how to mainstream climate change adaptation or incorporate climate change information into decision making in the Basin, in light of other important technological, social, economic and ecological trends. LaMP managers will require access to information on regional climate change scenarios and projected impacts on the natural environment, as well as the tools to assess options for incorporating climate change information into lake management strategies that address both human and ecosystem needs.

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First evidence of grass carp recruitment in the Great Lakes Basin

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ABSTRACT

We use aging techniques, ploidy analysis, and otolith microchemistry to assess whether four grass carp *Ctenopharyngodon idella* captured from the Sandusky River, Ohio were the result of natural reproduction within the Lake Erie Basin. All four fish were of age 1+. Multiple lines of evidence indicate that these fish were not aquaculture-reared and that they were most likely the result of successful reproduction in the Sandusky River. First, at least two of the fish were diploid; diploid grass carp cannot legally be released in the Great Lakes Basin. Second, strontium:calcium (Sr:Ca) ratios were elevated in all four grass carp from the Sandusky River, with elevated Sr:Ca ratios throughout the otolith transect, compared to grass carp from Missouri and Arkansas ponds. This reflects the high Sr:Ca ratio of the Sandusky River, and indicates that these fish lived in a high-strontium environment throughout their entire lives. Third, Sandusky River fish were higher in Sr:Ca ratio variability than fish from ponds, reflecting the high but spatially and temporally variable strontium concentrations of southwestern Lake Erie tributaries, and not the stable environment of pond aquaculture. Fourth, Sr:Ca ratios in the grass carp from the Sandusky River were lower in their 2011 growth increment (a high water year) than the 2012 growth increment (a low water year), reflecting the observed inverse relationship between discharge and strontium concentration in these rivers. We conclude that these four grass carp captured from the Sandusky River are most likely the result of natural reproduction within the Lake Erie Basin.

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Introduction

Grass carp *Ctenopharyngodon idella* is a large, herbivorous fish first imported to North America in 1963 for vegetation control (Mitchell and Kelly, 2006). It is one of the four "Asian carps" addressed in the Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States (Conover et al., 2007). By the early 1970s grass carp had escaped from impoundments where they were stocked and entered the rivers of the central United States (Kelly et al., 2011). Despite some doubt as to whether conditions existed for grass carp reproduction and recruitment outside their native range (Henderson, 1979; Tsuchiya, 1978), Stanley (1976) predicted that grass carp would establish populations and that spawning would first occur by 1978 or 1979. Conner et al. (1980) later detected grass carp larvae in samples collected from the Mississippi River in 1975. Grass carp have since established throughout much of the Mississippi River Basin and also in a Texas Gulf Coast watershed (Baerwaldt et al., 2013). Several grass carp have been captured in Lake Erie and at least three US Lake Erie tributaries (Baerwaldt et al., 2013). Although models and risk assessments (Cudmore and Mandrak, 2011; Kocovsky et al., 2012; Murphy and Jackson, 2013) have predicted that Asian carps with drifting eggs could recruit in the Great Lakes Basin, there has been no previous evidence of reproduction or recruitment of grass carp or any other Asian carp.

Triploid grass carp have been artificially produced since 1983 (Malone, 1984) and are thought to be facultatively sterile (Allen et al., 1986). Stocking of triploid grass carp has been approved in many states, including the Lake Erie states of Ohio, Pennsylvania, and New York (Rasmussen, 2011) because they effectively control unwanted macrophytes and are thought to be unlikely to become self-sustaining (Zajicek et al., 2011). No state or Canadian province in the Great Lakes Basin allows the stocking of fertile diploid grass carp, but illegal importation of presumably fertile diploid grass carp into the basin has been documented (Michigan Department of Natural Resources, 2012). Grass carp have been occasionally collected from the Lake Erie Basin since at least 1980 (prior to the production of triploid grass carp; USGS, 2012) but there has been little previous effort to establish the

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ploidy of captured grass carp or evaluate whether captured grass carp are the progeny of recruitment within the basin or escaped stocked fish.

In 2012, a commercial seine fisher captured four grass carp from a site in the Sandusky River, Ohio. Their uniform and small size range (450–550 mm total length; TL) suggested that they may have been from the same cohort, raising the question whether these fish may have been naturally reproduced at or near their point of capture, or came from another single point source, such as an accidental or intentional stocking.

The Sandusky River has unusually high strontium concentrations, ranging from approximately 0.5 mg/L in very high discharge periods to over 6 mg/L in periods of low discharge (Trombley, 2009). Skougstadt and Horr (1960), in a survey of the United States that did not include the Sandusky River, found "high" (>1.5 mg/L) concentrations of strontium in surface water only in a southwestern region located mostly in Texas and New Mexico. Mean strontium concentrations of the Sandusky River fall well into the "high" category, whereas the Great Lakes watershed, the Midwest, and the Midsouth were classified as "low" (<0.5 mg/L) in strontium. Among sampled locations within those areas no locations ranked as high, and only the Maumee River, a Lake Erie tributary neighboring the Sandusky River, ranked in the moderate strontium category (0.5 to 1.5 mg/L). Strontium is incorporated into fish otoliths similarly to calcium, thus the record of changes in strontium:calcium (Sr:Ca) ratio retained in the otoliths of fishes (Ludsin et al., 2006) provides a unique opportunity to assess the origin of these grass carp. Otoliths from fish that have spent their lives in the Sandusky River will likely reflect the variable but high Sr:Ca ratio of the river while fish from pond aquaculture will likely reflect the stable Sr:Ca ratio of ponds. Furthermore, most cultured grass carp are produced in the Midwest and Midsouth, regions of low Sr:Ca ratios. Wild fish transferred by bait bucket from the Ohio River Basin or from most of the Mississippi River Basin should reflect the lower Sr:Ca ratios of those areas.

Here we report on efforts to estimate ages, determine ploidy, and examine otolith microchemistry of these fish to determine whether they might have been naturally reproduced in tributaries to Lake Erie. We compare otolith microchemistry between these four wild-caught grass carp and pond-raised grass carp, and discuss the likelihood that the four grass carp captured from the Sandusky River were stocked fish originating in aquaculture facilities. We also discuss the likelihood of potential alternative origins of these fish, including bait bucket transfer from the Mississippi River Basin, and the live food fish trade.

Methods

Sample collection and preparation

In October 2012, four grass carp, ranging between 1.155 kg and 1.827 kg, and ranging from 451 to 514 mm total length, were captured from the Sandusky River (N 41.426988 W 83.056006; Fig. 1) by a commercial fisher. The fish were placed on ice and delivered to the Ohio Department of Natural Resources in Sandusky, Ohio. There, eyes were removed, placed in 0.9% NaCl solution, stored at 4 °C, and then shipped overnight to the U.S. Geological Survey (USGS) National Wetlands Research Center in Lafayette, LA for ploidy analysis 8 days later. Carcasses were then frozen and delivered to the USGS Lake Erie Biological Station, where the anterior portion of the fish from the snout to just posterior of the pelvic fins was excised and shipped overnight to the USGS Columbia Environmental Research Center (CERC) in Columbia, Missouri. At CERC, several structures were collected for age estimation and otoliths were collected for elemental analysis.

Fish age analysis

Ages of all four Sandusky River grass carp were estimated using scales, postcleithra (Johal et al., 2000), ossified pectoral fin rays (Nuevo et al., 2004) and vertebral sections (unpublished data), all of which have been used previously to estimate ages for the closely related bighead carp *Hypophthalmichthys nobilis* and silver carp *Hypophthalmichthys molitrix* (together, the bigheaded carps). Aging structures other than scales were mounted in Specifix 40 media (Struers Inc., Cleveland OH), and 0.5 mm thickness sections were taken through the focus using a low speed diamond saw and mounted on slides. Structures were imaged using transmitted light and fish ages were independently estimated from

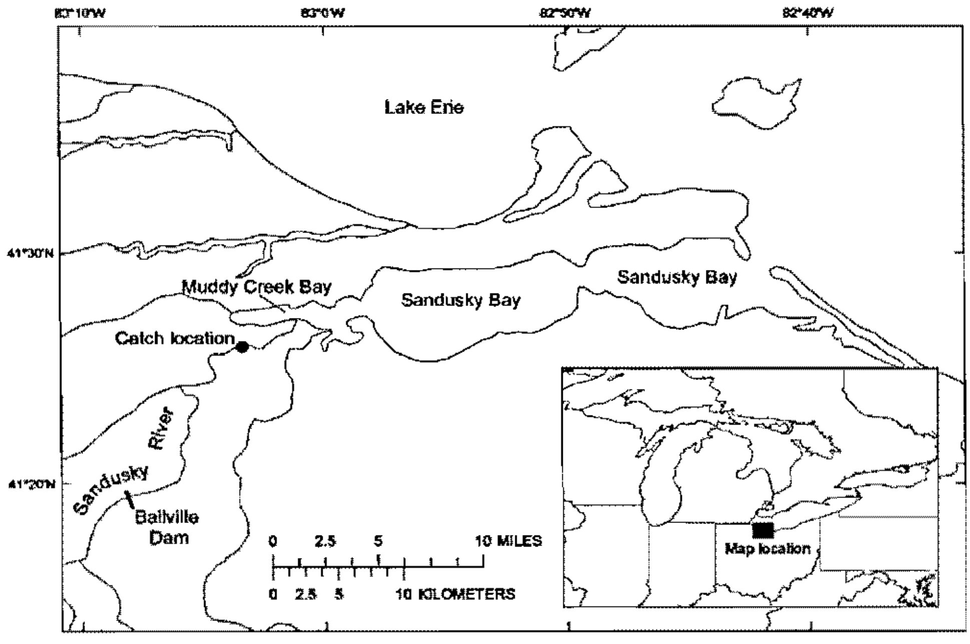

Fig. 1. Capture location of four grass carp collected from the Sandusky River in 2012.

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the images by three experienced biologists. Annuli were also observed on the otoliths sectioned for microchemistry but the otolith annuli were indistinct and annulus location on the otoliths was aided by comparison with other aging structures. Length of fish at first annulus formation was back-calculated using scales and the Fraser–Lee method (Devries and Frie, 1996) using an intercept value of 30 mm developed for triploid grass carp by Morrow et al. (1997).

Ploidy analysis

Ploidy of the grass carp captured from the Sandusky River was determined by flow cytometric analysis of cells from the eyeball vitreous humor (Jenkins and Thomas, 2007; Thomas et al., 2011). Flow cytometry was performed with a FACSCalibur® (Becton Dickinson Immunocytometry Systems [BDIS], San Jose, CA), using CellQuest software (BDIS) for data analysis. Blood from Nile tilapia (*Oreochromis niloticus*) having a genome size of 2.40 pg was used as the internal control.

Otolith microchemistry

Lapilli and asterisci otoliths were extracted from the Sandusky River fish, but only lapilli otoliths were used for microchemistry analysis because the lapilli had a homogenous aragonite crystalline structure, whereas the asterisci had a vaterite structure as determined by micro-Raman analysis (Renishaw inVia, Renishaw, Inc., Gloucestershire, UK; Gauldie et al., 1997). Aragonite, having a higher affinity for the trace element of interest (strontium) than vaterite (Gauldie, 1996; Macdonald et al., 2012), was thus superior for this work. To establish a relationship between otolith elemental incorporation and water chemistry for this species, four grass carp were obtained from an aquaculture facility in Arkansas, and five fish were obtained from CERC research ponds in Missouri. Both the Arkansas ponds and the Missouri ponds are filled with water from on-site wells. The Missouri fish were captured as young-of-the-year from an isolated floodplain wetland of the Missouri River, in October 2011, and transferred to the research ponds. The Missouri fish were stocked in research ponds to control macrophytes, but may have also consumed salmon starter (Skretting USA, Tooele, UT) given as a supplemental food to bigheaded carps in the same ponds. Arkansas fish were stocked as fry into a pond previously prepared for grass carp by allowing macrophytes to grow, and received no supplemental feeding. Otoliths were mounted in Specifix 40 media and sectioned to a thickness of 1.0 mm in the transverse plane, using a low speed diamond blade saw. Otolith sections were prepared for spectroscopic and microchemical analyses following standard methods (Hayden et al., 2011; Secor et al., 1991). Otoliths were polished to a thickness of approximately 100 µm using progressively finer polishing media including 3 M silicon carbide sandpaper, 3 M lapping paper, and aluminum oxide powder (20 µm, 10 µm, 6 µm, and 0.3 µm) to expose the primordial core. Polished sections were mounted on petrographic slides using a thin layer of West System epoxy resin (#105 resin and #206 slow hardener). The slides were then cleaned by triple rinsing in ultrapure water (18.2 MΩ cm @25 °C; EMD Millipore, Merck KGaA, Darmstadt, Germany) and sonicated for 10 min. All samples were stored in acid washed Petri dishes while awaiting analyses. Pond grass carp otoliths were similarly prepared with the exception of being mounted in West System (Bay City, MI) epoxy resin.

Micro-chemical analyses of otoliths were performed at the Great Lakes Institute for Environmental Research (GLIER), University of Windsor (Windsor, Ontario). Laser ablation inductively coupled plasma mass spectrometry was performed by utilizing a Quantronix® Integra C femtosecond laser that operated at a 100 Hz pulse rate producing a 24.8–25.9 mJ/pulse at the 2.5 mm pinhole resulting in an approximately 25 µm laser crater. The laser was linked to a Thermo-Elemental X7 quadrupole ICP-MS operating in low resolution peak-jumping mode (isotope dwell time: 10 ms, carrier gas: Ar; Shaheen et al., 2008). A gas blank was analyzed for 60 s before each sample to obtain a background reading. Instrument drift was controlled by analyzing a National Institute of Standards and Technology 610 (NIST 610) glass standard before and after each slide of otoliths. The laser ablation traverse traveled from one edge, through the primordium, to the opposite edge. Laser speed during the traverse was approximately 5.0 µm/s. Isotopes assayed included ^{25}Mg, ^{43}Ca, ^{44}Ca, ^{55}Mn, ^{86}Sr, ^{88}Sr, ^{120}Sn, ^{137}Ba, and ^{138}Ba. Each isotope was measured approximately every 0.57 µm along the traverse. The stoichiometric concentration of calcium in aragonite (400,432 µg $Ca \cdot g^{-1}$ $CaCO_3$) was used as an internal standard to compensate for differences in the amount of material collected. Data manipulation and reduction were performed off-line using a Microsoft Excel macro developed at GLIER based on algorithms developed by Longerich et al. (1996), Yang (2003) and Shaheen et al. (2008).

Water chemistry

Water samples were taken from the Sandusky River during spring 2011 ($n = 6$). Water samples were taken from Missouri ($n = 3$) and Arkansas hatchery ponds ($n = 2$) synoptically with the pond fish samples. These were placed in acid-washed high density polyethylene jars, refrigerated, and transported to the Bowling Green State University (Bowling Green, OH) where they were filtered using 0.45 µm pore size cellulose-acetate filters and acidified to 2.0% (v/v). Trace elemental chemical analyses of water samples were performed with a Thermo Elemental iCap 6500 Inductively Coupled Plasma–Optical Emissions Spectrometer (Thermo Electron Corporation, New Mills, UK) interfaced with an ASX 520 autosampler (CETAC Technologies, Omaha, NE) following standard methods (Eaton et al., 2005). To control instrument drift, standards of known concentrations were analyzed before and after each set of samples.

Comparison of otolith microchemistry to water chemistry and river discharge

To better understand the variability observed in Sr:Ca ratios in grass carp otoliths from the Sandusky River, we conducted two ancillary analyses involving discharge from the Sandusky River to assist interpretation of otolith microchemistry results. We plotted log Sr concentration versus discharge data from the USGS stream gage on the Sandusky River at Fremont, Ohio (USGS 04198000) from the period 10/11/1982 to 6/2/1994.

Log-transformed Sr:Ca ratios over the otolith transect were compared between the pond fish ($n = 9$) and the Sandusky River fish ($n = 4$) using ANOVA (SAS Institute, Inc., 2008). Variability of Sr:Ca ratios within the otoliths between the two sets of fish was compared by ANOVA of the coefficients of variation (CV) for each fish. A paired *t*-test was used to compare Sr:Ca ratios in otolith material deposited before and after the annulus of Sandusky River grass carp, using the region between the focus and the anterior margin of the otolith, because the annulus was more distinct in the anterior than the posterior section.

River discharge and spawning events

We also used USGS discharge measurements from the Fremont gage and from the USGS gage on the Maumee River at Waterville, Ohio (USGS 04193500) from May through September 2011 to identify peaks in discharge hydrographs that may serve as potential spawning events. That year was selected for this purpose based on the results of the aging results for these fish. Identification of these peaks followed published thresholds for mass spawning of grass carp (Kocovsky et al., 2012) and favorable hydrodynamics for successful transport of Asian carp eggs to the hatching phase based on detailed field assessments (Murphy and Jackson, 2013). The discharge required for successful transport of Asian carp eggs is river dependent and is a function of flow velocity and turbulence in the water column (Murphy and

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Jackson, 2013). The Maumee River was included in this analysis because it was identified as a potential Asian carp spawning location by Kocovsky et al. (2012) and Murphy and Jackson (2013). Discharge data from these same stream gages from May through September 2012 were also included for reference because 2011 was a high water year and 2012 was a low water year (drought). In this analysis, the approximate date of the spawning season initiation was defined as June 23 based on the maturation date for grass carp estimated by Kocovsky et al. (2012) for western Lake Erie. The approximate end of the spawning season in 2012 was defined as September 15 based on water temperatures observed to fall below 18 °C (normal lower limit for Asian carp spawning; Kolar et al., 2007) in the Sandusky River at Fremont, Ohio. We recognize that water temperature may not represent temperatures in 2011 at the same location, but a lack of water temperature data for 2011 on the Sandusky River requires this assumption. The dates defined as the potential start and end of spawning season for this analysis are based on the best available data, but should be used with caution because they will vary somewhat from year to year depending on water temperature.

Results

All three biologists agreed that all four Sandusky River grass carp were age 1+, indicating that the fish were spawned in 2011. Back-calculation of length at age resulted in estimated lengths at the first annulus of 158 mm to 186 mm, small for grass carp at that age at similar latitude (Hickling, 1967).

Ploidy analysis of the four grass carp captured in October 2012 revealed that two were clearly diploid (Fig. 2). Two replicate samples of fish number 1 had estimated genome sizes of 2.13 pg and 2.07 pg, and fish number 2 had an estimated genome size of 2.15 pg. These values clearly indicate diploidy; triploid grass carp have a genome size of approximately 3 pg. No ploidy results for the other two fish were available because of equipment failure (Table 1).

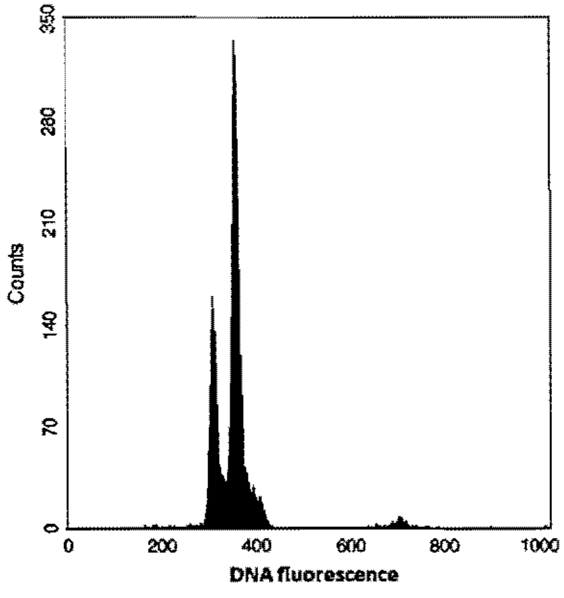

Fig. 2. Flow cytometric histogram display of fluorochrome-stained DNA from a grass carp captured in the Sandusky River, Ohio, on October 9, 2012. The peak on the right (approximately 340 counts) is DNA from nuclei of freshly bled Nile tilapia (*Oreochromis niloticus*), serving as an internal control (2.40 pg). The peak on the left is nuclei from ocular fluid of grass carp 1, 8-days post-mortem (2.07 pg), indicating a diploid result. Triploidy would have been indicated by a peak to the right of the tilapia nuclei, with a DNA mass at approximately 3.0 pg.

Table 1
Total length, back-calculated length at annulus 1, and ploidy of grass carp collected from the Sandusky River, Ohio, in July 2012. Ploidy results were not available for fish 3 and 4 because of equipment failure.

Fish number	Total length	Back-calculated total length at annulus 1	Ploidy
1	514	186	Diploid
2	458	158	Diploid
3	461	171	Not determined
4	451	158	Not determined

Otoliths of grass carp captured from the Sandusky River had a mean Sr:Ca ratio of 8.27 mmol:mol (Fig. 3a). Grass carp from Missouri (1.77 mmol:mol) and Arkansas (1.78 mmol:mol) ponds had much lower Sr:Ca ratios. Otolith Sr:Ca ratios reflected Sr:Ca ratios in water samples (Fig. 3b) from all three sources. Sr:Ca ratios for the four Sandusky River fish were significantly higher (ANOVA, $F = 357.5$, $df = 1,11$, $P < 0.0001$) throughout the otolith than those for the Missouri and Arkansas pond fish. Although nearly all Sr:Ca ratio measurements on the grass carp captured from the Sandusky River were higher than all measurements from the pond fish, the variability in measurements across the otolith within individual fish (mean of 3970 measurements for Sandusky River fish and 2910 measurements for pond fish) was also significantly higher (ANOVA, $F = 9.74$, $df = 1,11$ $P = 0.01$) in the Sandusky River fish (mean $CV = 0.276$, $n = 4$) than the pond fish (mean $CV = 0.188$, $n = 9$). Comparison of otolith Sr:Ca ratios before

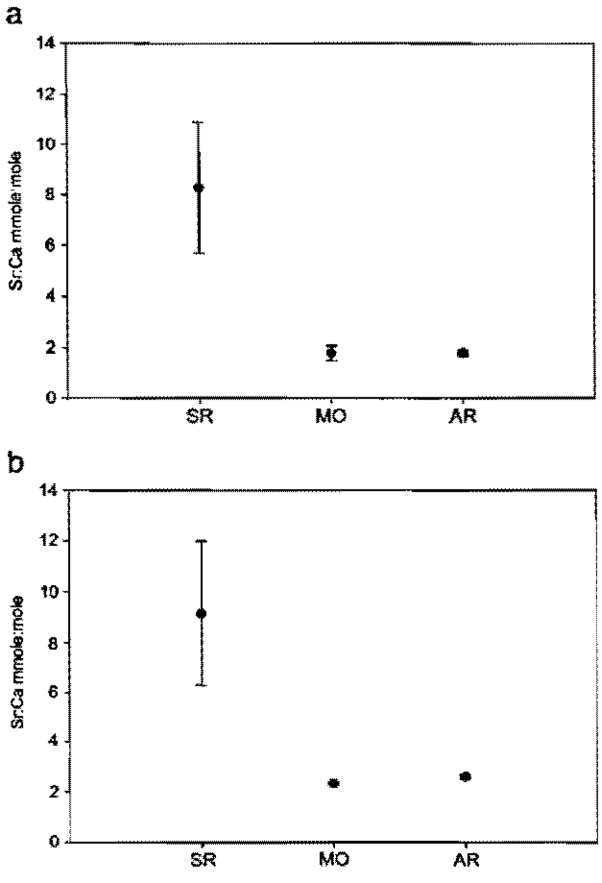

Fig. 3. (a) Mean Sr:Ca (mmol:mol) ratio from traverse transects of otoliths from grass carp captured from the Sandusky River (SR; n = 4) compared to measurements from pond fish from Missouri (MO; n = 5) and Arkansas (AR; n = 4, with 95% confidence intervals). (b) Mean Sr:Ca (mmol:mol) ratio of water samples from the Sandusky River (n = 4) compared to the Missouri (n = 3) and Arkansas (n = 2) pond water samples.

and after the annulus in grass carp collected from the Sandusky River (i.e., comparing signatures from 2011 to 2012) was significantly lower before the annulus (mean = 7.5 mmol:mol) than after the annulus (11.0 mmol:mol; *t*-test, t = 18.1 df = 3, $P < 0.0001$). These ratios reflect the pattern of variability in Sr:Ca ratio in the Sandusky River, which decreased with increasing discharge in the Sandusky River (Fig. 4).

There were four high-flow events on the Sandusky River in 2011 (Fig. 5) that met or exceeded the minimum flow required to transport Asian carp eggs (Murphy and Jackson, 2013) that also followed the achievement of minimum thermal thresholds reported by Kocovsky et al. (2012). The most notable of these was at the end of July, when discharge increased from near baseflow conditions to one of the highest discharges of the calendar year. Other potential spawning events occurred in early August and early September 2011. The Maumee River experienced two events in 2011 that met thermal and hydrodynamic requirements for spawning, one in late June and one in mid-September. Several smaller events in July and August also met, but did not exceed, the discharge threshold for egg suspension and transport. While 2011 discharge data show that both the Sandusky and Maumee rivers had discharge peaks that could act as potential spawning events based on thermal and hydrodynamic requirements, the events on the Sandusky River were more pronounced relative to the egg suspension and transport discharge threshold.

Discussion

Otolith microchemistry has not been previously used to discern the origin of grass carp, but otolith microchemistry of the closely related bigheaded carps has been used successfully in this manner (Zeigler and Whitledge, 2010, 2011). Otolith microchemistry of many other fish species has been well validated in several studies of Lake Erie and its tributaries to assess fish origin and movement (Hayden et al., 2011; Ludsin et al., 2006; Pangle et al., 2010). The high Sr:Ca ratio of the Sandusky River fish compared to that of the Missouri and Arkansas fish is consistent with the unusually high strontium concentrations (Skougstadt and Horr, 1960) of the Sandusky River watershed. Otolith Sr:Ca ratios of the four Sandusky River grass carp were higher than those of the Arkansas and Missouri pond fish at all points across the otolith, from the focus to the margin, a clear indication that the Sandusky River fish lived in a high Sr:Ca ratio environment (or environments) for their entire lives.

Strontium to calcium ratios in the Sandusky River, while generally high, are variable spatially within the watersheds and also vary over time, especially being influenced by changes in hydrograph (Fig. 4). The source of Sr in Sandusky River water is groundwater from celestite (SrSO4)-bearing upper Silurian-age dolostone bedrocks of the Salina Group (Carlson, 1987); as discharge increases with surface runoff, the contribution of groundwater inputs is diminished and diluted, resulting in lower Sr:Ca ratios at higher discharge. Furthermore, wild grass carp have the capability to choose a variety of diets which may also influence body Sr:Ca ratios (Ophel and Judd, 1969; Ophel and Fraser, 1970). Fish inhabiting the Sandusky River would thus be expected to have a higher Sr:Ca variability than pond fish, which are confined to more constant water quality from well water. The observed high Sr:Ca variability in the Sandusky River grass carp otoliths is thus consistent with fish that have spent their entire lives in the Sandusky River watershed.

The Sandusky River experienced a high water year in 2011, but was in drought in 2012 (Fig. 5). The significantly lower Sr:Ca ratio in otolith material laid down before the first annulus of the four Sandusky River grass carp reflects the inverse relation between discharge and Sr:Ca ratio that would be expected in fishes of this age that have spent their lives in the Sandusky River (Fig. 4).

If these grass carp had been raised in an aquaculture setting and then stocked in Ohio at the typical size at which grass carp are purchased for stocking for vegetation control (150–250 mm, to avoid predation), their otolith microchemistry would reflect that history. The expected pattern would be low and static Sr:Ca ratio near the primordium, changing to high and variable Sr:Ca ratio in portions of the otolith deposited after the fish were stocked. We did not observe that pattern, and the observed otolith microchemistry is consistent with that of fish that have spent their entire life within a high strontium environment. It is possible but unlikely that an aquaculture pond would have an Sr:Ca ratio as high as the Sandusky River; in that eventuality those high ratios would be reflected in the otoliths of the fish, but the high Sr:Ca ratio variability in the Sandusky River would not have been so reflected.

Multiple lines of evidence thus point away from the conclusion that these fish are escapees from stocking:

1) Stocking of diploid grass carp is illegal in all Great Lakes states and in Ontario, the only province bordering the Great Lakes.
2) Sr:Ca ratios are highly elevated in all four grass carp from the Sandusky River, with elevated Sr:Ca ratios throughout the otolith transect, in comparison to grass carp from Missouri and Arkansas pond environments.
3) Sandusky River fish were higher in Sr:Ca ratio variability than fish from ponds, with high variability throughout the otolith transect.
4) Sr:Ca ratios in the grass carp from the Sandusky River were lower in their 2011 growth increment, as would be expected for a high water year, than they were in 2012, a low water year.

There are pathways other than escapement or stocking of pond-reared fish that might result in the introduction of grass carp into the Great Lakes. Grass carp are well established and abundant in portions of the Mississippi River Basin, and these fish could be transported intentionally or unintentionally and released into the Great Lakes Basin (for example, a bait bucket introduction). However, the only known reproducing population of grass carp (Hargrave and Gido, 2004) within the region classified as high strontium concentration by Skougstadt and Horr (1960) is in the Red River watershed bordering Oklahoma and Texas. We cannot completely rule out the possibility that these four fish were spawned and grew in a different high strontium river environment elsewhere in North America, and were later transplanted to the Sandusky River. However, the likelihood that four fish from such unusual water chemistry were transplanted from that area to another area of quite similar water chemistry seems extremely low.

Another possibility would be escape or release of grass carp from the live food trade. Grass carp have been sold in the live food trade, but are normally sold at sizes much larger than the four grass carp captured from the Sandusky River (Chapman, personal observation). Live food fish markets exist in the province of Ontario (Herborg et al., 2007), but

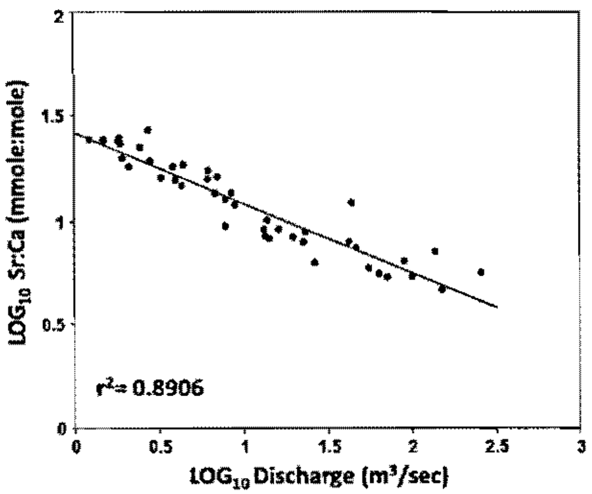

Fig. 4. Relationship between Sr:Ca ratios and discharge in Sandusky River, Fremont, OH. Discharge data as cubic feet per second (cfs) are from USGS gaging station 01498000 from 10/11/1982 to 6/2/1994 (http://waterdata.usgs.gov/oh/nwis/uv?site_no=04198000).

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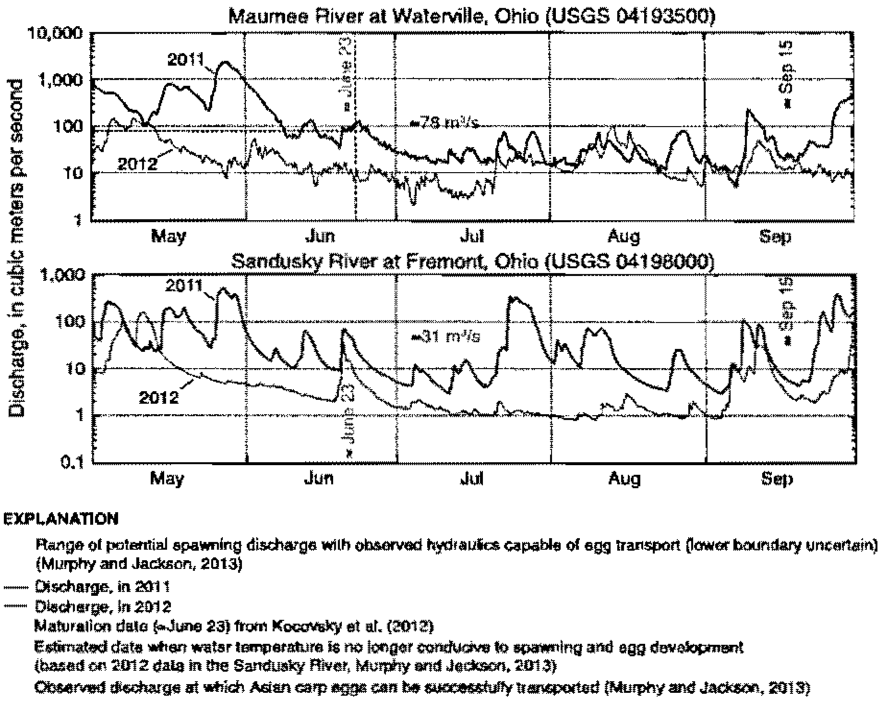

Fig. 5. Hydrographs of Sandusky (Fremont, OH; USGS gage 04198000) and Maumee (Waterville, Ohio, USGS gage 04193500) rivers, in 2011 and 2012, in relation to predicted spawning season and discharges capable of successful transport of the drifting eggs of Asian carps.

possession of live grass carp in Ontario has been illegal for longer than the life span of the Sandusky River fish. Grass carp in the live food trade might be wild-caught or from aquaculture, but in either case it would be extremely unlikely that four escapees of the live food fish trade, of this size, and with the observed otolith strontium signature, would be captured together.

The nearby Maumee River has moderately elevated strontium concentrations, but only about half those of the Sandusky River. Hayden et al. (2011) successfully used this concentration difference to distinguish between fish spawned between the Sandusky and Maumee rivers. It is possible that grass carp could be spawned in the Maumee River and carried as young fish by the prevailing currents through Lake Erie (Léon et al., 2005) toward the Sandusky River. This movement would be detectable in the otolith history unless the grass carp left the Maumee River, passed through Lake Erie, and entered the Sandusky River within a few days after they were spawned. There was no such signature in the otoliths of grass carp captured from the Sandusky River. Additionally, despite the generally higher discharge of the Maumee River, conditions in the Sandusky River in 2011 were far superior for egg suspension and transport than those in the Maumee River (Fig. 5). Thus, it is possible but unlikely that the four grass carp captured in the Sandusky River were the progeny of a Maumee River spawn.

Growth rate in the grass carp captured from the Sandusky River could be consistent with either wild or hatchery fish. Asian carps are fishes of large year classes, typically with low recruitment in many years and high recruitment in a few years (Krykhtin, 1975), typically with highest recruitment in high water years such as 2011. However, it should be noted that the relatively low back-calculated growth in 2011 compared to 2012 is consistent with the 2011 temperature and hydrograph in the Sandusky River. Although rheophilic-spawning Asian carps sometimes do spawn without a hydrograph peak (Kolar et al., 2007; Coulter et al., 2013), mass spawning events of grass carp have long been known to occur primarily on the rising limb of substantial peaks in the hydrograph (Yi et al., 1988). Using temperatures at which grass carp may spawn and required degree-days for first spawning (as described in Kocovsky et al., 2012) and the Sandusky River hydrograph, the first likely mass spawning event would have occurred on July 27, which was the largest hydrograph peak of the spawning season (Fig. 5). July 27 is late in the year for grass carp spawning but within the observed spawning period for grass carp at similar latitude (Krykhtin and Gorbach, 1981). A July 27 spawning date would have produced the observed smaller-than-normal first year's growth.

The implications that grass carp have spawned and recruited in the Great Lakes Basin are profound. The primary effect that grass carp have on a system is removal of submerged aquatic macrophytes. Although few undesirable effects of grass carp have been noted in the Mississippi River Basin where grass carp are established and abundant, those systems are depauperate of submerged macrophytes because of turbidity and highly fluctuating hydrograph. When grass carp are stocked with sufficient density in lentic systems with macrophytes, they can cause nearly complete removal of those plants (Sills, 1970). If populations of grass carp increase in Lake Erie, they may threaten vegetated nearshore areas and wetlands, which are important spawning and recruitment areas for native fishes. Removal of vegetation by grass carp has also been shown to be detrimental to waterfowl (McKnight and Hepp, 1995). Lake Erie coastal wetlands have declined due to anthropogenic effects (Herdendorf, 1992) and further loss of vegetated wetlands would likely result in further loss of the ecosystem benefits that accrue from wetlands, including their high biological productivity, shore erosion protection, water management, nutrient-cycle control, accumulation of sediment, and supply of detritus (Herdendorf, 1987) and mitigation of nonpoint source pollution (Mitsch 1992).

In addition, the bigheaded carps have spawning and early life history requirements very similar to those of grass carp (Yi et al., 1988). The bigheaded carps have reached extremely high densities in the Mississippi River Basin and there is great concern that they will invade the Great Lakes (Conover et al., 2007). Successful recruitment of grass carp is an indication that bigheaded carps may also be able to spawn and recruit.

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Successful recruitment of four grass carp is not necessarily indicative of a self-sustaining population of grass carp, or that conditions are adequate for establishment of a self-sustaining or increasing population of grass carp or bigheaded carps. However, existing risk assessments (Cudmore and Mandrak, 2011; DeVaney et al., 2009; Kolar et al., 2007) suggest that establishment is possible.

Assuming that these four grass carp were spawned in the Sandusky River, there are important implications regarding the recruitment requirements of Asian carps. The flowing length of the Sandusky River between Ballville Dam and Muddy Creek Bay (approximately 26 km) is much shorter than the 100 km previously proposed as a minimum length for recruitment (Kolar et al., 2007). However, recent field measurements and modeling of the temperature, velocity, and turbulence of the Sandusky River with Ballville Dam in place, indicate that a high flow event of a magnitude similar to that observed in early August 2011 could provide adequate conditions for drift and hatching of Asian carp eggs in as little as 15 km (Garcia et al., 2013; Murphy and Jackson, 2013) at the mean summer water temperature of the Sandusky River. It should be noted that while the discharges capable of suspension and transport of Asian carp eggs observed by Murphy and Jackson (2013) are characteristic of smaller events that approach the lower limit for successful egg transport (see Murphy and Jackson, 2013), these discharge thresholds are not absolute and some lower discharge flows may be capable of transporting water-hardened Asian carp eggs. Successful spawning and recruitment of grass carp in the Sandusky River would add credence to these new and much less restrictive limits on Asian carp spawning river requirements.

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Commentary

Dividing the waters: The case for hydrologic separation of the North American Great Lakes and Mississippi River Basins

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ABSTRACT

Legislation has been introduced this year in the U.S. Congress, but not yet enacted, that would direct the U.S. Army Corps of Engineers to complete a study of the options that would prevent the spread of aquatic nuisance species between the Great Lakes and Mississippi River Basins. Hydrologic separation is the only option which closes the aquatic connection between the two basins and does not require continuous operation and maintenance of various technologies that have some risk of failure. The one-time, capital cost to separate the two basins is widely acknowledged to be high, and the outstanding question is whether the costs are justified given the significant risk of future ecological damages and long-term economic losses. Interests opposing separation have mounted a public campaign that the news media have picked up to deny that hydrologic separation should be considered or that a problem even exists. The campaign rests on four assertions: (1) existing electric barriers in the Chicago canals are effective; (2) it is too late–the carps are already in the Great Lakes or soon will be; (3) Asian carps will not thrive in the Great Lakes due to inadequate food and spawning habitat; and (4) Asian carps are unlikely to cause serious harm. Our review of these assertions and the ecological and socio-economic threats to both basins supports our recommendation that the pending legislation be passed and that it include analysis of hydrologic separation of the two basins.

Introduction

Responding to a public health risk more than 100 years ago, engineers reversed the Chicago River and built the Chicago Sanitary and Ship Canal to carry sewage away from Lake Michigan, the city's source of drinking water (Hill, 2000). The canal breached the low natural divide between two of North America's iconic watersheds, the Great Lakes and the Mississippi River, thereby opening a shipping route for recreational boats and commercial barges, but also providing an invasion route for harmful aquatic species; two of which are currently of major concern, bighead (*Hypophthalmichthys nobilis*) and silver (*H. molitrix*) carp. The imminent threat of these invasive Asian carp swimming through the canal system and colonizing the Great Lakes has elicited legislation from the U. S. Congress (Water Resources Development Act, 2007) authorizing the U.S. Army Corps of Engineers (USACE) to conduct "a feasibility study of the range of options and technologies available to prevent the spread of aquatic nuisance species between the Great Lakes and Mississippi River Basins through the Chicago Sanitary and Ship Canal and other aquatic pathways." However, more than three years passed before the USACE issued the study's first Draft Project Management Plan, and the completion date for the study has slipped to 2015 (USACE, 2010c). Additional legislation which has been introduced, but not yet enacted (U.S. House, 2011; U.S. Senate, 2011), would direct the USACE to complete its separation study within 18 months. Political support for this legislation threatens to be undermined by a media campaign based on the following four assertions:

1. Existing electric barriers (constructed in the Chicago Sanitary and Ship Canal to prevent migration of harmful aquatic species) have proven effective in blocking Asian carp; Asian carp recently captured on the Lake Michigan side of the barrier arrived by other means (Frede, 2010).
2. Asian carp have already found their way into the Great Lakes, or soon will, through various means such as the dumping of bait buckets by anglers or intentional transfers — therefore it is too late to prevent the invasion (Frede, 2010; McCloud, 2010; Stanek, 2010).
3. Asian carp will not thrive in the Great Lakes due to a lack of adequate food and spawning habitat (Flesher, 2010; Golowenski, 2010).
4. Asian carp are not likely to cause serious damage to the Great Lakes ecosystem (Smith and Vandermeer, 2010).

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Our critical review of these assertions and the ecological and socio-economic threats to both basins supports our recommendations that the pending legislation needs to be passed and that it should include serious consideration of re-separation of the basins.

Are existing barriers effective?

The existing electric barriers in the Chicago Sanitary and Ship Canal are designed to repel, not kill fish. The voltages required to kill fish would also be dangerous to humans who might fall into the water. Electric barriers are subject to shut down due to power interruptions, accumulation of debris, and periodic maintenance (USACE, 2010b). The electric field near steel-hulled barges can be reduced, possibly inducing fish to remain close to the hulls to avoid shock as they transit the electric field (Dettmers et al., 2005). During flood events, temporary water connections can allow fish to bypass the existing electrical barriers (USACE, 2010a,b). On the upstream (lakeward) side of the electrical barriers, only narrow strips of land separate the Sanitary and Ship Canal from the Des Plaines River and the old Illinois and Michigan Canal, which are connected to the Illinois River, a tributary of the Mississippi River. In September 2008, floodwaters connected the Sanitary and Ship Canal with the Des Plaines River (USACE, 2010a). To reduce the risk of fish by-passing the electric barriers, the Corps of Engineers recommended construction of 34,600 ft (10,546 m) of concrete barricades and 33,400 ft (10,180 m) of Chain Link Fence with ¼-inch (6.35 mm) openings to separate the Des Plaines River floodplain from the Sanitary and Ship Canal at an estimated cost of $13,174,000. To date, a portion of the barricade and fence system has been completed in the area most likely to flood and two culverts that connect the old, unused Illinois and Michigan Canal to the Sanitary and Ship Canal have been blocked (USACE, 2010a).The frequency and size of flood events that may provide direct access for adults, eggs, or larvae of Asian carp to Lake Michigan around the electrical barrier are still under analysis (USACE, 2010a). Most experts agree that permanent solutions to block Asian carp and other harmful aquatic species from invading the Great Lakes must look beyond electrical barrier systems.

In addition to by-passes and other potential failures to prevent upstream movements, one of the greatest deficiencies of electrical barriers or other permeable devices that allow the free flow of water and boats are their inability to block *downstream* movements. Electric fields cannot prevent downstream migration and drifting of invertebrates, fish eggs and larvae, and potentially harmful plants, parasites and disease organisms. Pulsed DC electric fields generally are not strong enough to kill drifting organisms and propagules (Jerde et al., 2010a). Risks of harmful species transfers downstream from the lakes to the Mississippi River Basin must be taken as seriously as the threats to the Great Lakes. Recent assessments indicate that there are more than 156 nonnative aquatic species restricted to either the Great Lakes or Mississippi River Basin (Jerde et al., 2010a). Of these, 10 species present in the Great Lakes could damage the Mississippi River Basin and 17 species present in the Mississippi River Basin could damage the Great Lakes (Jerde et al., 2010a).

Are Asian carps already in the Great Lakes?

Traditional electrofishing and netting methods have been used in attempts to detect the presence of Asian carp beyond the electric barriers. Far more sensitive methods are needed for accurate monitoring, especially near the leading edge of the invasion front, where the population will be initially low (Jerde et al., 2010a).

One such method, detection of bighead and silver carp DNA in water samples (environmental DNA, eDNA), was employed in parallel with conventional techniques, but the efforts were not integrated into a scientifically-based framework designed to validate this new methodology (Jerde et al., 2010b; Jerde et al., 2011). Due to its novelty in this application, the eDNA methodology has been viewed by some as an unproven, experimental method of detecting the presence of Asian carp. However, the eDNA methodology has been used, documented, and accepted in other applications in aquatic environments (Ficetola et al., 2008).

An EPA audit report concluded: "When eDNA results are positive, the public can have a high degree of confidence that Asian carp DNA is present" (Blume et al., 2010). The eDNA results do not indicate how many fish were present, only that at least one live carp was in the vicinity or upstream of the sample location within a few days of the time the sample was taken (Jerde et al., 2010b). While it is possible that eDNA could be present in the absence of a live fish, it is highly unlikely that the overall temporal and spatial patterns of Asian carp eDNA detected over two years above the electrical barrier can be attributed to any source other than live Asian carp. Jerde et al. (2010b) report 32 positive detections of eDNA from bighead carp and 26 detections of silver carp eDNA upstream of the electric barriers, including one silver carp eDNA detection in Calumet Harbor on Lake Michigan. Silver carp eDNA was also detected in the Chicago River in downtown Chicago and in the river's North Shore Channel, both less than 1 km from Lake Michigan (Fig. 1).

To date, there is no evidence of reproducing populations of Asian carps in the canals upstream of the electric barriers or in Lake Michigan. To reproduce, males and females must mature, produce eggs and sperm, and find each other in sufficient numbers that many eggs are fertilized. Then the eggs, larvae and young fish must survive and grow to maturity. There are many obstacles to successful reproduction and recruitment that often cause invasions to fail many times before they succeed (Drake and Lodge, 2006). However, given enough time, even low probability events will ultimately occur.

Intentional releases also pose risks that need to be addressed, primarily through education and regulations that are carefully targeted and strictly enforced. To minimize the risks of overland transfers, public education programs have been undertaken and legal prohibitions on the sale, transport and possession of live Asian carp have been enacted at the city, state and federal levels (Finster, 2007).

In summary, it is likely that only very small numbers of Asian carps have accessed the Chicago waterways upstream of the electric barriers, but to date probably have not successfully reproduced.

Will Asian carps thrive in the Great Lakes?

Food sources and potential spawning areas in the Great Lakes and tributary rivers are available to support bighead and silver carp, despite assertions to the contrary that were based on misrepresentation of one bioenergetics paper (Cooke and Hill, 2010) and inadequate knowledge of the physical complexity of the Great Lakes. That paper carefully acknowledged the existence of other food sources omitted from the bioenergetics model due to lack of data on the various forms of organic carbon floating on the surface, suspended in the water column, or resting on the bottom. The paper also acknowledged the existence of locally favorable plankton conditions in productive embayments around the Great Lakes (e.g., Green Bay, Saginaw Bay, Lake St. Clair, Western Basin Lake Erie, etc.) and major tributary rivers. Silver carp have recently been reported to consume *Cladophora*, a genus of filamentous alga comprising several species that are found in abundance around the margins of the Great Lakes (personal communication, Leon Carl, USGS Midwest Area Regional Executive, to the 28 April 2011 meeting of the Asian Carp Regional Coordinating Council). Food availability was one of many factors considered in a Canadian government risk assessment that concluded it is reasonably certain that bighead and silver carp will reproduce and spread in the Great Lakes if they are provided access (Mandrak and Cudmore, 2004).

The Great Lakes and tributary rivers are neither too cold nor too stagnant to support Asian carp spawning. In Asia, bighead carp thrive

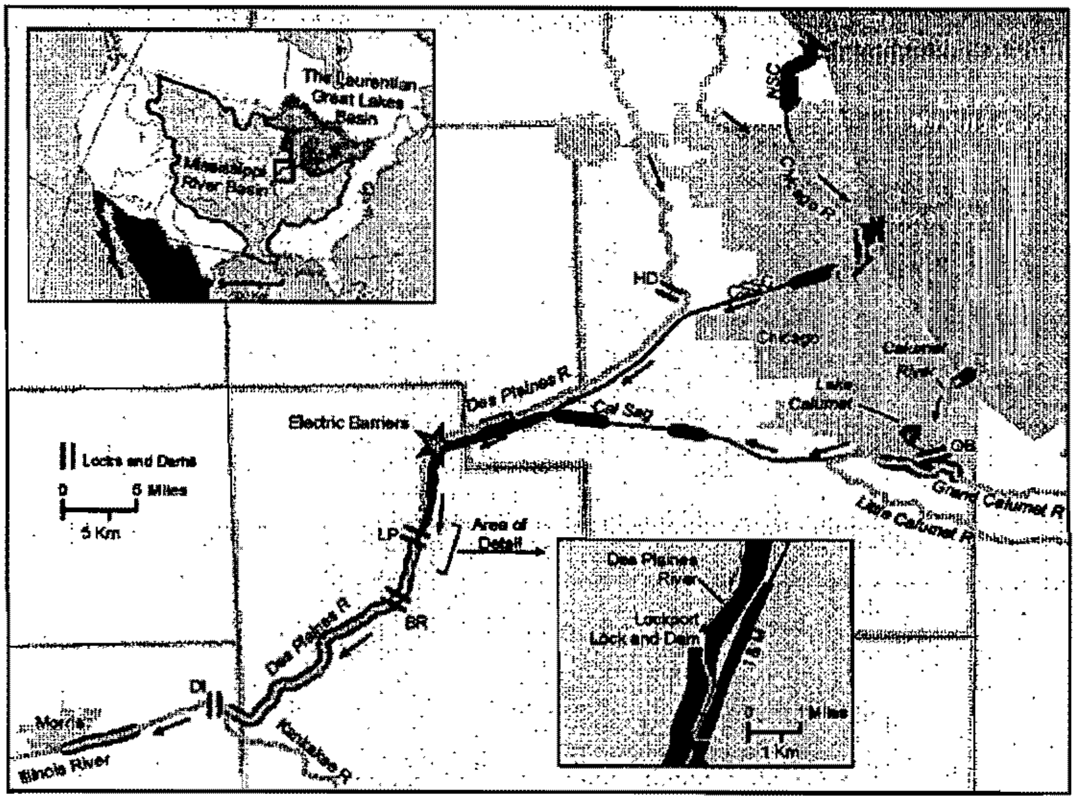

Fig. 1. Asian carp DNA detections (red) in the Chicago waterways upstream and downstream of the electric fish barriers in 2009 and 2010. Jerde et al. (2011) report 32 positive detections of eDNA from bighead carp and 26 detections of silver carp eDNA upstream of the electric barriers, including one silver carp eDNA detection in Calumet Harbor on Lake Michigan. Silver carp eDNA was also detected in the Chicago River in downtown Chicago and in the river's North Shore Channel, both less than 1 km from Lake Michigan. The waterways in Chicago connect downstream to the Des Plaines River which joins the Illinois River, a major tributary of the Mississippi River. There are locks and dams at Dresden Island (DI), Brandon Roads (BR), Lockport (LP), O'Brien (OB), Chicago River, Wilmette Pumping Station, and a low, notched dam, Hoffman Dam (HD), on the Des Plaines River. In Asia, bighead carp range north to 47° latitude, silver carp to 54° north. Map by S.R. Mysorekar, The Nature Conservancy, with DNA data from Jerde et al. (2010 and 2011).

in rivers as far north as 47° latitude, which equates in North America to the latitude of Lake Superior, or about 100 miles north of Lake Huron and almost 300 miles north of Lake Ontario. The native range of silver carp extends to 54° north, which cuts across the southern basin of Hudson Bay (Kolar et al., 2010). Twenty-two tributaries on the United States side of four Great Lakes are at least 100 km long and may have sufficient current velocity to keep Asian carp eggs in suspension long enough to hatch (Kolar et al., 2010). Water velocities and other factors in the tributaries are currently being assessed by the same group of researchers. Reports also exist of bighead and silver carp spawning in stagnant backwater environs, and fry being found in 50–55 °F (10–12 °C) water (personal communication, Mark Pegg, Illinois Natural History Survey, cited in Mandrak and Cudmore (2004)). Therefore, successful Asian carp reproduction may be possible in many smaller, shorter tributaries to the Great Lakes where oxygenated sand and gravel substrates occur.

Will Asian carps harm the Great Lakes?

Those who believe that too much is being made of an Asian carp invasion of the Great Lakes downplay the risk, claiming Asian carp will simply join the many species that are now accommodated by the Great Lakes ecosystem. For half a century fisheries biologists have struggled to minimize the damage wrought by a series of biological invasions [e.g., the sea lamprey, *Petromyzon marinus*; alewife, *Alosa pseudoharengus*; zebra and quagga mussels, *Dreissena polymorpha* and *D. rostriformis bugensis*; and most recently, fish diseases (e.g., viral hemorrhagic septicemia, *Ichthyophonus hoferi*)] (Fahnenstiel et al., 2010; Mills and Leach, 1993). These invaders have seriously damaged recreational and commercial fisheries, increased costs for natural resource management, severely impacted businesses dependent on recreation, clogged water intake systems, and fundamentally altered the food webs in most of the Great Lakes. Ship-borne invasive species (e.g., zebra mussels) alone are estimated to have cost raw water users, sport and commercial fisheries, and wildlife watchers on the U.S. portion of the Great Lakes over $200 million annually through 2006 (Lodge and Finnoff, 2008).

There are only two examples of successful management of harmful invasive aquatic species in the Great Lakes, and both have had significant economic and ecological costs. Sea lamprey abundance in the Great Lakes is controlled by barriers, traps, periodic applications of a toxicant in their spawning areas, and release of sterile males, at a cost of $22.8 million in 2008 and a projected cost of $29.7 million in 2010 (Great Lakes Fishery Commission, 2008). The barriers and toxicants have some negative effects on non-target species, but the effects are considered acceptable by fishery managers in return for protecting highly valued fishes. Populations of alewife have been substantially reduced in the upper Great Lakes, first through predation by intentionally introduced salmon and now by competition from unintentionally introduced mussels that have reduced zooplankton populations. Unfortunately, zooplankton is essential not only to alewives but also to early life stages of highly-valued commercial and sport fishes (Fahnenstiel et al., 2010; Shuter and Mason, 2001).

introduction of Asian carps, which are efficient plankton feeders throughout their life spans, would further deplete the base of the already-stressed food webs in the Great Lakes. After Asian carp populations exploded in the Illinois River, the condition factor of two native planktivores, the bigmouth buffalo (*Ictiobus cyprinellus*) and gizzard shad (*Dorosoma cepedianum*), declined, presumably as a result of competition for food (Irons et al., 2007). There is no species-specific approach yet available to control the Asian carps, and previous experience with lampreys demonstrates that control measures are likely to be costly and have some unavoidable side effects. It is better to prevent invasions than attempt to manage a harmful species after invasion.

Potential harm to biodiversity in the Mississippi River Basin

Recent media reports have focused on the threat to the Great Lakes posed by the Asian carps, and little attention has been paid to species in the Great Lakes that are potential invaders of the Mississippi Basin, including the 10 species mentioned by Jerde et al. (2010a). The 10 include two fishes, five plants, and three crustaceans. The fish-hook waterflea (*Cercopagis pengoi*), is a planktonic crustacean that preys on other zooplankton, thereby competing with larval and small fishes, while avoiding predation itself because of its long tail spine. The Eurasian ruffe (*Gymnocephalus cernuus*) is a 4–6-inch (10–15 cm), spiny fish that is likely to compete with native fishes for food. In terms of sheer number of endemic species, there is actually more to lose in the Mississippi than in the Great Lakes.

The Mississippi River Basin has the highest diversity of freshwater fishes (260 species) known for any region at comparable latitudes (Fremling et al., 1989; Smith, 1981). The diversity is especially high in tributaries of the Tennessee, particularly among shiners and minnows (Family Cyprinidae) and darters (Family Percidae). European gobies and other small invasive fishes that are already in the Great Lakes can move downstream and then upstream into very small tributaries. For instance, the round goby (*Apollonia melanostomus*) already moved through the Chicago canals into the upper Illinois River. Since gobies seek the same habitats and food sources as many darters, they are very likely to compete with the native species.

North America is the world center of biodiversity for freshwater mussels with 297 recorded species, most of which occur in the Mississippi River and its tributaries (Pennak, 1989). Unfortunately, 72% of the North American mussels are currently listed as endangered, threatened, or of special concern (Master, 1990; Williams et al., 1992). The introduction and spread of invasive mollusks (such as the zebra and quagga mussels, which probably entered the Mississippi through the Chicago waterways) have contributed to the decline of native mussels (Master, 1990). The local extirpations of native mussels in the western basin of Lake Erie and in Lake St. Clair bodes ill for the native mussels that are endemic to the Mississippi Basin (Nalepa et al., 1996; Ricciardi et al., 1998).

Conclusions and recommendations

The electric barriers have not been fully effective on Asian carp and will not work on organisms or propagules that drift downstream; eDNA evidence suggests silver and bighead carp are in the Chicago waterways well upstream of the electric barriers (Jerde et al., 2010b). Based on our current understanding of Asian carp dietary and habitat requirements it is unlikely they would be limited by food or habitat in the entire Great Lakes basin. The addition of two more species of plankton feeders to the Great Lakes would adversely affect an already stressed food base. There are more invasive species besides the Asian carps that could cause species extinctions, declines of valuable fisheries, and other economic losses if they pass between the Great Lakes and Mississippi basins via the Chicago connection. It is imperative to stop the exchange of invasive species as quickly as possible.

In response to the delays in the authorized study by the USACE, state elected and appointed officials on the Great Lakes Commission and mayors of Great Lakes cities have secured funding from foundations to begin evaluating the engineering feasibility and estimated cost of alternatives for separating the two basins, with final recommendations to be presented in January 2012 (Great Lakes Commission, 2011). These evaluations do not obviate the need for a feasibility study by the USACE that includes separation, because the USACE is the only agency with the Congressional authority to implement whichever alternative is finally selected.

Hydrologic separation is the only option which closes the aquatic connection between the two basins and does not require continuous operation and maintenance of various technologies that have some risk of failure. The one-time, capital cost to separate the two basins is widely acknowledged to be high, and the outstanding question is whether the costs are justified given the significant risk of future ecological damages and long-term economic losses to the region. The pending legislation needs to be passed, so the public and their elected officials can evaluate the costs and relative risks based upon the best scientific information and engineering technology available.

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