GREAT LAKES FISHERY COMMISSION

2003 Project Completion Report[1]

Development of a lakewide electronic database for lower trophic level monitoring in Lake Erie

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Completion Report

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Prepared Jan 27, 2003 by:

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Abstract

The Great Lakes Fishery Commission (GLFC) Coordination Activities Program supported the development of a database for managing information and reporting on the state of the lower trophic levels in Lake Erie. The database was developed in MS Access, utilising modules created in Visual Basic to analyse and export data to MS Excel. The database provides a user friendly environment accessible to all Lake Erie agencies to provide timely updates on the state of the Lake. Information is reported annually in the Lake Erie Forage Task Group report.

Introduction

In September of 1998, the Lake Erie Forage Task Group (FTG) convened an expert workshop to seek direction on how to link ecosystem changes with fisheries production. On the basis of the expert recommendations, the FTG identified 9 key variables that could be used to document long-term ecosystem change (Table 1). The Forage Task Group designed a survey that would take advantage of the lakewide distribution of provincial, state and federal resource offices to recognize the complex spatial structure of Lake Erie. The survey design also took advantage of existing field operations and utilised apparatus currently possessed by most agencies. In a time of shrinking agency budgets, this program provided a cost effective means to undertake an comprehensive survey of lower trophic levels in Lake Erie.

While any information generated by this survey would enhance our understanding of the state of the Lake, the greatest benefit of the program was the long-term

Table 1.- Nine key limnological variables collected by Lake Erie agencies as part of the lakewide coordinated lower trophic level program. (* only the epilimnion is sampled when the water column is stratified).

Variable	Method	Parameters generated
Temperature	vertical profile	epi- / hypolimnetic temperature, thermocline depth
Oxygen	vertical profile	epi- / hypolimnetic concentration; percent saturation
Secchi	depth	
Light	PAR	euphotic depth
Total Phosphosous	composite epilimnetic* or whole water column	total phosphorous concentration
Chlorophyll a	composite epilimnetic* or whole water column	uncorrected chlorophyll a concentration
Phytoplankton	composite epilimnetic* or whole water column	currently archived (not analysed)
Zooplankton	composite epilimnetic* or whole water column	density, size, biomass and composition of zooplankton
Benthos	triplicate petite Ponar, spring and fall	density, biomass and composition of benthos in soft sediment

commitment made by all agencies. In total, 7 agencies sample 20 stations once every two weeks from May 1 through September 30 of each year for all or most of the 9 critical variables identified. The FTG quickly recognised they needed an efficient means for managing the large volume of data collected. Further, the FTG wanted to maintain the Lake Erie Committee's commitment to the GLFC of timely reporting of results, and therefore needed an efficient way to analyse and summarise the database at appropriate spatial and temporal scales. A relational database developed in MS Access was proposed, and it's development was supported by the GLFC through it's Coordination Activities Program.

Database Objectives

The objectives of the database are several. First we needed an efficient system for storing and retrieving large amounts of data. We wanted a relatively simple environment that could be readily accessed and maintained by agency personnel with a minimum of training. MS Access was identified as the environment. Second, the database should provide a rapid means for processing the information – generating descriptive parameters such as thermocline depth and annual biomass of zooplankton by station and basin. Performing all intermediate calculations within the database environment minimises the potential for erroneous calculations, and greatly shortens processing time. Visual Basic (VB) was identified as the preferred means of accomplishing these tasks, as macros developed within MS Access are much more limited in their utility:

- VB makes databases easier to maintain as code events are built into a form or reports; whereas macros are separate objects which can get lost when forms are removed, moved or copied;
- VB creates functions with complex calculations that can be reused by various forms and reports;
- VB can move through records in a table one by one, whereas macros treat a table as one unit;

- VB links applications to system level actions such as sending data to MS Excel.

Finally, we needed a standardised output format that would enable rapid reporting of results. Templates created in MS Excel, enable data to be exported rapidly to an environment familiar to most scientists and managers. Results can be exported in three formats: tabular data by station ("raw" data), tabular data by basin (average of station data), and graphical data showing useful ecological indices. These three formats can assist managers and scientists in understanding short-term temporal dynamics, long-term trends (comparing time-weighted annual means) and possible consequence for the ecosystem (indices). Collectively all three objectives are accomplished within the Lake Erie Lakewide Lower Trophic Level Database.

Database Environment and Structure

The database was developed in Microsoft Access 2000 (ver 9.0.2720) in an XP operating environment. Modules for analyses and reporting were created in Microsoft Visual Basic ver 6.3, while ActiveX Data Objects (ver 2.1) was selected as the VB language of choice given Microsoft's assurances of widespread compatibility and longevity. All output was stored in Microsoft Excel ver 9.0.2720 compatible spreadsheets.

In the original project design, 10 pairs of stations were identified and each pair was assigned to an agency. Each station has a unique numeric code which will be adhered to for the duration of the project (see Figure 1). Each time an agency visits the

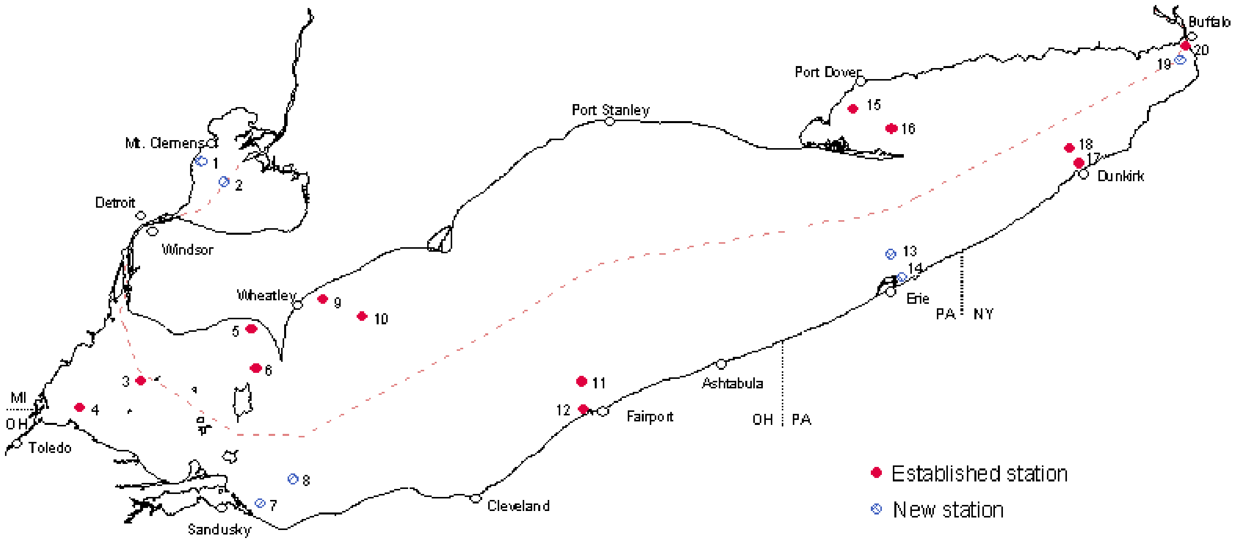

Figure 1.- Map showing location and assigned station code number.

station, a unique serial sample identifier (SamID) is assigned. While each pair of stations was assigned a serial block of 1000 SamIDs, the primary key for all relationships in the database is composed of both the SamID and the date (in case the same SamID is used on two separate dates). SamID and date are therefore repeated fields in all tables within the database which allow relationships to be formed that link sample data between tables.

The database consists of 7 primary tables (Table 2), and 5 information tables. Data recorded on the field data sheets appears in tblStation. Temperature and oxygen profile data appear in tblProfile, while light profiles (PAR) appears in tblLight. Nutrient results (total phoshporous and chlorophyll a concentrations) appear in tblNutrient. Zooplankton and benthic results appear in their respective tables, while an archive of phytoplankton samples (not currently analysed) is maintained in tblPhyto. Information describing the agencies and their vessels is recorded the tblAgencyInfo and tblVesselInfo, respectively. Lists of zooplankton and benthic taxon codes (names and numeric identifiers, including agency synonyms) appear in tblZoopTaxon and tblBenthicTaxon. TblZoopBiomass contains length-weight coefficients for converting zooplankton size and density into biomass.

Table 2.- Description of contents of primary tables contained within the Lake Erie lower trophic level database.

Table	Description	Variables
tblStation	site description on sampling date	date, samID, station ID, latitude, longitude, agency, vessel name, crew, time, site depth, Secchi, wind speed and direction, wave height, cloud cover, zooplankton depth, zoop haul time, zoop flow meter (start and end), depths for composite water sample (maximum 5), volume filtered for chlorophyll, comment
tblProfile	temperature and oxygen profile data	date, samID, station ID, depth, temperature, oxygen, saturation, comment
tblLight	light profile data	date, samID, depth, surface PAR, PAR at depth
tblNutrients	results describing total phosphorous and chlorophyll a concentrations	date, samID, station ID, total phosphorous concentration, chlorophyll a concentration (2 records), comment
tblZoopData	zooplankton data	date, samID, station ID, species code, count, density, biomass
tblBenthos	benthic invertebrate data	date, samID, station ID, replicate sample number, substrate type, taxon code, count, comment
tblPhyto	archive of phytoplankton samples	date, samID, station ID, archive (yes/no), comment

One of the single greatest benefits of the database is the standardisation of units for reporting of information. With 9 different agency offices collecting and reporting on the lower trophic levels of Lake Erie, much opportunity exists for variation in choice of units to represent parameters. Standard field and laboratory protocols have been developed for use by all agencies, and field and laboratory data sheets have been compared to minimise the opportunity for inconsistent reporting. All protocols and data sheets are archived within the database as pdf documents employing MS Access' ability to store various media. Data input masks constrain the user to pre-determined formats, while validation rules prompt the user to re-check potentially errant values before they can be accepted into the database. Where practical, pick-lists were used to minimise the number of variations of input data (i.e. station name, vessel name, dominant substrate type, etc.). Further, certain fields were automatically filled based on other input (e.g. station latitude, longitude, and depth are assigned after station name identified), although the user could choose to overwrite the information (i.e. modified lat/long to avoid pleasure boat fishing at preferred site). Units for all variables, and "normal expected range" are given in Table 3.

Table 3.- Data format and units used in the Lake Erie lakewide lower trophic level database. (* range limits for these variables are specific to a station).

Variable	Units	Expected Range
Date	dd-mmm-yy (e.g. 05-May-02)	
Time	hhmm (24 hour clock)	0700-1900
Latitude / longitude	Decimal degrees	Automatically assigned *
Station depth, Secchi depth, sample depth	m	0 to 40 *

Wind direction	character bearing	N, NNE, NE, ENE, E, etc.
Wind velocity	knots	0 to 30
Wave height	m	0 to 3
Cloud cover	tenths	0, 0.1, 0.2, etc.
Zooplankton sample depth (depth to surface)	m	0 to 40 *
Zooplankton sample time	seconds	0 to 30
Zooplankton flow meter	revolutions	
Composite water sample depths	m	0 to 30 *
Volume of water filtered for chlorophyll sample	ml	100-2000
Total phosphorous and chlorophyll concentration	mg/L	0.0000 to 1.0000
Zooplankton density	#/L	0 to 100
Zooplankton biomass	g/L	derived from length-weight regressions
Benthic invertebrate density	#/m2	0 to 1000

<u>Database Output</u>

Automated reports can be generated summarising key limnological variables. The user can generate customised reports using the query and report functions of MS Access; however, we felt the automated reports would ensure consistency in analysis and reporting. In order to make the query function user-friendly, a form was created that allows the user to select from available data to create the query string. Automated reports are available in spatial (station or basin level reporting) and temporal (annual by date, or interannual comparing annual averages) formats. Separate reports can be generated for physical-chemical (Table 4), zooplankton (Table 5), and benthic variables. Select variables (i.e. date, station depth, Secchi depth) are simply reported observations made directly in the field, while other parameters are derived (i.e. thermocline depth, euphotic depth).

Time weighted means (TWM) are used to provide annual average values for each of the variables. While all agencies try to adhere to a uniform sample regime (once every two weeks, between approximately May 1 and Sept 30 of each year), logistic problems (weather, mechanical breakdowns, etc.) sometimes prevent one or more of the sample dates to be attained. The time weighted mean, weighting adjacent observations by the time interval between, provides a more statistically defensible result when comparing between stations or years. However, a TWM is calculated only when at least one sample was taken every 30 days between May 1 and September 30. In years where many sample dates are missed at a station, a decision rule was developed to exclude the parameters for that station in further analyses. In a similar way, a basin average was calculated only when at least 4 of the 6 stations within a basin were sampled in a given year (stations 1-2 = Lake St. Clair; stations 3-8 = western basin; stations 9-14 = central basin; stations 15-20 = eastern basin).

Table 4.- Sample physical-chemical output generated for a single station in a single year.

Annual Limnology Summary - Lake Erie

Agency OMNR - Wheatley

Station XX

Depth 22.3

Date	Sample depth (m)	Thermocline depth (m)	Mean epi temperature (C)	Mean epi DO (mg/L)	Mean hypo DO (mg/L)	Secchi depth (m)	Euphotic depth (m)	Light extinction coeff (m-1)	Total phosphorous (mg/L)	chl a uncorr (mg/L)
04-May-00	22.8		11.60	10.20		3.00			0.0127	0.0064
15-May-00	22.8		15.70	9.10		5.00			0.0109	0.0025
31-May-00	22.9		17.00	9.40		4.00	12.20	0.38	0.0077	0.0025
13-Jun-00	22.3		21.40	8.80		3.50	14.90	0.31	0.0127	0.0021
26-Jun-00	22.3		23.60	9.60		4.50	15.70	0.29	0.0094	0.0045
10-Jul-00	22.3	15.0	23.20	8.60	7.40	4.50	22.30	0.17	0.0059	0.0029
25-Jul-00	22.4	16.0	22.83	9.15	6.85	4.50	15.10	0.30	0.0083	0.0052
21-Aug-00	22.3	17.0	22.00	8.71	3.20	4.30			0.0071	0.0023
08-Sep-00	22.4	20.0	22.29	9.07	2.31	6.00	17.50	0.26	0.0103	0.0024
18-Sep-00	22.8	21.0	19.71	8.45	2.46	5.00	10.60	0.43	0.0141	0.0023
03-Oct-00	22.5		17.02	8.52		3.20	11.60	0.40	0.0175	0.0050
23-Oct-00	23.0		14.03	9.80		4.00	11.50	0.40	0.0203	0.0052
annual time weighted mean		17.37	19.92	9.02	4.51	4.34	14.60	0.33	0.0109	0.0035

Table 5.- Sample zooplankton output of time weighted annual means generated for all stations in the western basin of Lake Erie 1999-2002.

Annual Zooplankton summary – Lake Erie

Agency	OMNR – Wheatley
Basin	West
Stations included	3, 4, 5, 6, 7, 8

	Zooplankton Density (#/L)					Zooplankton Biomass (ug/L)				
Year	Cladocera	Calanoid	Cyclopoid	Nauplii	Veliger	Cladocera	Calanoid	Cyclopoid	Nauplii	Veliger
1999	20.24	1.15	6.78	11.74	3.64	24.88	2.07	12.34	0.80	2.38
2000	26.48	0.71	5.87	6.36	4.16	32.92	1.39	10.98	0.41	2.59
2001	19.91	1.30	9.44	16.64	5.05	26.25	2.23	17.77	1.07	3.54
2002	28.17	1.23	3.40	14.28	2.98	34.25	2.11	5.77	0.94	1.92
mean	23.70	1.10	6.37	12.25	3.96	29.58	1.95	11.72	0.80	2.61

In addition to reporting on observation, several useful ecological indices are currently being incorporated into the database (Table 6), and their results will be graphically displayed (e.g. Figure 2). While this component of the database potentially has the greatest value to the manager, it also is the one most subject to criticism (debate over applicability of indices, oversimplification, etc.). As such, we see this as an area for future development – we will continue to monitor the results of the subset of indices currently employed, and evaluate their utility / applicability in understanding the current state of Lake Erie and the response of certain variables to ecological change. In

Table 6.- List of ecological indices currently available in the Lake Erie lower trophic level database.

Index	Description	Reference
Trophic classification	Total phosphorous concentration	Vollenweider 1968
Grazing pressure	Ratio of TP to chlorophyll a	Mazumder 1994
Zooplankton community composition	Ratio of density of calanoida to [cladocera + cyclopoida]	Johannsson et al. 1999a
Zooplanktivory	Mean zooplankton length in 0.63μm net	Mills et al. 1987; Johannsson et al. 1999b

representing these indices, we opted to provide only a visual graphic showing levels of the variable in a predefined environmental space that has been categorised to facilitate interpretation (i.e. total phosphorous concentration plotted amidst three broad trophic classifications of eutrophic, mesotrophic and oligotrophic).

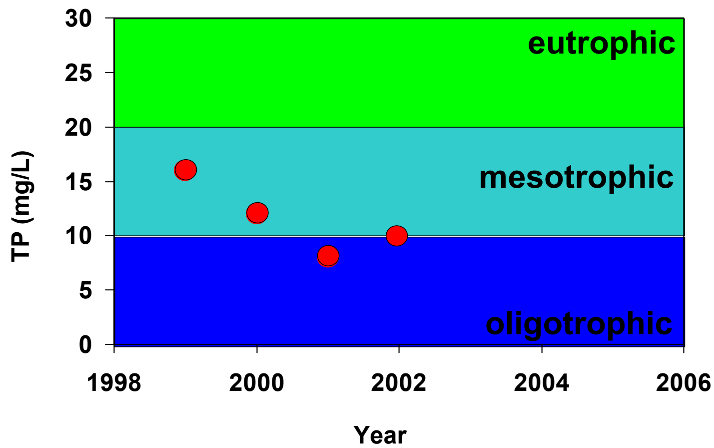

Figure 2.- Hypothetical output for trophic classification index using total phosphorous.

Training and Database Management

In conjunction with the semi-annual Lake Erie Forage Task Group meeting, a 2-day training and database management workshop was held in Amherst, New York (Dec 17-18, 2002). Through our workshop and training, the FTG members were introduced to the general structure of the database (tables, queries and reports), naming conventions and how the database interacts with Visual Basic and MS Excel. At least one representative from each agency was in attendance at the training, and all people felt they knew enough about the basic structure of the database to update and maintain their assigned stations.

From the onset of the Lake Erie lower trophic level project in 1999, the U.S. Fish and Wildlife Service (USFWS) accepted the role of database manager. Our project will take advantage of the Master / Replicate feature of MS Access – the USFWS copy of the database will be the master, and all agencies will maintain their own replicate. Each agency will be responsible for entering and validating their own data. Once per year, at the fall Forage Task Group meeting, all copies of the database will be synchronised, incorporating all changes (appended data, corrections) from the agency copies into the master. Once all agency copies have been synchronised with the master, updated replicates will be returned to each agency. Each agency will then have a complete copy of the lakewide database to take back to their facility.

The current version of the database contains tables and reporting formats suitable to our current objectives. Updates and changes to the database will be evaluated on a case-by-case basis. Because of the complex nature of the database, and our current in-house (within the task group) lack of expertise with programming in Visual Basic, few major modifications to the database will be undertaken without consulting with the developer. The “master” feature of the database will ensure that no accidental corruption of the database occurs (only the master can modify structure of existing tables and queries). However, all agency users can create new tables and queries within the database, to satisfy their own personal objectives. If through consensus, these changes warrant a database wide update, the developer will be consulted.

Next Steps

During the winter of 2002/03 the Forage Task Group will work to populate the database with all available information through the end of the 2002 field season. Each agency will also validate all information (from 1999 through 2002) prior to the winter Forage Task Group meeting (late February 2003). The section of the Forage Task Group report dealing with the lower trophic level project will be generated using the automated reporting features of the database. Problems encountered during any of the data entry, validation and reporting exercises will be documented and reported to the developer who has agreed to work with the Forage Task Group during the implementation of the database.

Over the next year, the Forage Task Group will begin to consult with other researchers working on Lake Erie and other large systems, soliciting input and interpretation on our choice of indicators. The database developer has expressed interest in continuing to work with the task group in modifying and / or incorporating additional indices if additional funds become available. Ecological indices are an area of research interest to the developer and we feel with his assistance, the incorporation of these metrics will provide a very valuable tool for managers and scientists alike trying to understand the degree of ecological change in Lake Erie.

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