Dreissena polymorpha
INFORMATION REVIEW
ZEBRA MUSSEL INFORMATION CLEARINGHOUSE
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"QUAGGA MUSSEL" UPDATE

Investigators: J. Ellen Marsden, Edward Mills, Adrian Spidle, & Bernie May, Lake Michigan Biological Station, Illinois Natural History Survey, Zion, IL and Department of Natural Resources, Cornell University, Ithaca, NY.

At the November, 1991 International Zebra Mussel Research Conference in Rochester, NY, we (JEM and BM) reported finding a second species of zebra mussel, which we temporarily named the "quagga mussel", in Lake Ontario. Since then, the "quagga mussel" has been sighted at a number of new locations. Unfortunately, due to the interest generated about the potential impacts of this zebra mussel species, several conjectures have been misinterpreted as facts. The purpose of this article is to set the record straight on what is currently known about the "quagga mussel" and its present range, preliminary to the reporting of any new findings at the Third International Zebra Mussel Research Conference in Toronto in February, 1993.

The "quagga mussel" was first detected during a study to examine the genetic structure of zebra mussel populations around the Great Lakes (May and Marsden 1992). Initially, a single mussel with a significantly different genotype was noted in a random sample of supposed zebra mussels collected from the Erie Canal at Palmyra, New York. A subsequent examination of the shell revealed that this mussel was also morphologically different from all of the other zebra mussels previously observed. The shell of the mussel lacked the sharp angle, or carina, between the dorsal and ventral surfaces which is a characteristic of the zebra mussel. Subsequent examination of 100 mussels collected near Rochester revealed 49 individuals which matched the genetic pattern seen in the first individual. The extent of the genetic differences between these individuals and zebra mussels confirmed that they were a distinct species, and not simply a variety of *Dreissena polymorpha.* The new species was dubbed "quagga mussel" after the "quagga", an extinct African relative of the zebra.

The "quagga mussel" is undoubtedly one of several dreissenid mussels found in Europe. Unfortunately, as Dan Marelli reported in a previous issue of this newsletter, the taxonomy of the Dreissenidae is in disarray. Shells from "quagga mussels" were sent to several taxonomists and mussel experts in the U.S. and Europe, but to date no-one has identified the species. Our only information about the "quagga's" range in Europe is the identification of a population in the former Soviet Union which is genetically identical to the "quagga" (authors, unpublished data). Why is the identity of the "quagga mussel" important? One of the reasons why researchers and utilities were able to rapidly forecast the scope of the zebra mussel problem, and take steps to minimize damage, was because they knew the identity of the mussel and thus had access to information about the mussels from European literature. Information about the species identity of the "quagga mussel" will enable collection of information about its ecological requirements and behavior from its native range. Only with this information will researchers be able to predict possible impacts of the "quagga mussel" in North America. For example, one often-cited relative of *D. polymorpha* has a much higher salinity tolerance than *D. polymorpha.* Other species may have different tolerances for cold or heat, which could allow them to expand to areas restricted to *D. polymorpha.* To date, however, the only confirmed ecological data on the "quagga mussel" is related to their depth distribution and size. In parts of Lake Ontario, "quagga mussels" comprise a higher proportion of the dreissenid community in deeper waters and the maximum shell length of "quagga mussels" is greater than that of *D. polymorpha* (Table 1, p. 10). At Lake Ontario sites where depths exceed 50m, "quagga mussels" represent from 30% to nearly 90% of the mussel population (Ed Mills, unpublished data).

Will the "quagga mussel" create additional problems to those caused by *D. polymorpha?* This question is difficult to answer without additional information about the species. Broad-spectrum controls such as chlorine and heat are likely to kill the "quagga" as effectively as *D. polymorpha,* even if their tolerances are slightly different. However, narrow-spectrum controls such as taxon-specific pathogens and physiological agents may not work on both species. Differences in diet, preferred habitat, distribution, and behavior between the mussels may influence their effect on native species. An understanding of such differences will be an important consideration for researchers describing the ecology of the zebra mussel. In many respects, the worst problem with the "quagga" at the moment is the lack of information, which makes it impossible to anticipate how the species may differ from *D. polymorpha.*

As information about the presence of the "quagga mussel" spreads, increasing numbers of "quagga" sightings have been reported. In some cases, researchers have examined old samples and discovered "quagga mussels" which they had previously assumed to be an "odd form" of zebra mussel. Information about the range of the "quagga mussel" will assist researchers in determining where and when the mussel was introduced. The following table documents the known range of "quagga mussels" to date, as determined from samples whose identity was confirmed morphologically by the authors. Individuals with additional information about the range of "quagga mussels" are requested to contact the authors.

May, B. and J.E. Marsden. 1992. **Genetic identification and implications of a second invasive species of dreissenid mussel in the Great Lakes.** *Can. J. Fish. Aquat. Sci.* 49:1501-1506.

(Dr. J. Ellen Marsden, Lake Michigan Biological Station, Zion, IL)

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Submissions for inclusion in the **Review** are encouraged. Please direct correspondence to:

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PUBLIC INFORMATION

Counter-productive Public Information: the "Noah Fallacy" and Mussel Myths

Investigators: Dr. Ladd E. Johnson and Dr. James T. Carlton, Maritime Studies Program, Mystic, CT

While the education of the public with regard to the invasion of North American waters by the zebra mussel and its close relatives has generally been commendable, there are a number of cases of speculation, folklore, and hyperbole that work against the general goals of public education. What exactly are these goals? Aside from the idealistic notion of "knowledge for knowledge's sake" and the pragmatic motive of encouraging public support for funding, we believe public education serves three primary purposes: (1) to increase the general appreciation of the harm that can result from the importation of exotic species, (2) to aid in the early detection of range expansion, and (3) to prevent or reduce the spread of mussels to uninhabited waters. Public awareness of almost any kind can only help in the first two cases, but in the latter case, we believe that we must be very cautious in our approaches towards public education.

In a world where the dire consequences of AIDS have had a remarkable small effect on human behavior, it is not surprising that extreme viewpoints and warnings have been invoked to attempt to induce dispersal preventative behavior (DPB) in the general population. However, alarmist warnings and ultra-conservative recommendations for DPB are, in our estimation, counter-productive. They make the spread of zebra mussels seem so inevitable and the necessary preventative measures appear so difficult as to make the average citizen feel as though such actions are both draconian and ineffective. The public's perception would not be so important if it were not the fact that, for the most part, such behaviors are voluntary. With few exceptions, there are no legal pressures operating that will force people to take steps that will reduce the likelihood that their activities will spread zebra mussels. Indeed, attempts to induce DPB in the public has had to take the form of "advisories" and "recommendations." Compliance thus relies on the good will and voluntary cooperation of the public. Unfortunately, when such a bleak picture is painted for them, the likely response is "Why even try?"

So, who has painted this bleak picture? Although both government agencies and the press have had influential roles as the proximate suppliers of information, we must recognize the role played by the scientific community as the ultimate source of information. Problems lie not only in our conservative, cautious answers to questions of appropriate "decontamination" methods, but, more seriously, in our unsubstantiated ideas about the process of species invasions. Both of these errors are best illustrated by examples. Here are our favorite "mussel myths" with regard to zebra mussel dispersal.

1. **The Noah Fallacy**

The myth: A population can be established by introducing a single pair of mussels into an isolated watershed. Considerations of genetic bottleneck notwithstanding, the likelihood of even a small group of mussels being able to overcome the obstacles of external fertilization and larval mortality seems low. What number is the "critical mass"? It probably depends on the population's size, sex ratio, and spatial distribution, the physiological stress experienced during dispersal, and a host of other considerations. The short answer is that we simply do not know, and until we have a better idea, we should be more forthcoming about our ignorance instead of relying on the theoretically possi-

Date Sighted	Reported by	Lake	Location	Depth	Sizes (mm)	Proportion of quaggas
July 3, 1990	Ted Schaner, OMNR	Ontario	Niagara on the Lake, Ont	NA	9-13	NA
July 1991	authors	Erie Canal	near Palmyra, NY	<3m	23	0.02
July 1992	authors	Erie Canal	near Brockport, NY	<3m	NA	0.02
Nov, 1991	authors	Ontario	Rochester, NY	to 25m	8-28	0.47
	authors	Onondaga	Onondaga outlet nr. Syracuse, NY	NA	NA	<0.01
	authors	Ontario	Cape Vincent, NY	5-12m	16-36	0.37
Nov. 1991	authors	Ontario	Stony Island, eastern basin, NY	5-7m	NA	0.52
April 6,1992	Ron Dermott, CCIW	Ontario	Niagara plume nr. Wilson, NY	19m	14-33	NA
April 7,1992	Cameron Lange Acres International	Erie	Perry, OH	service water	16-20	low
April 1992	E. Mills; Joe Ackerman, Univ. of Toronto	Erie	settling plates, Nanticoke Generating Station, Ont.	NA	NA	1.0
June 10,1992	E. Mills	Ontario	30 Mile Point, NY	15m	10-26	0.14
				25m	5-30	0.30
				35m	5-27	0.34
				45m	5-24	0.44
				55m	5-24	0.31
				75m	5-22	0.88
June 1,1992	E. Mills	Ontario	Olcott, NY	8m	8-20	0.02
				15m	--	0.00
				25m	5-14	0.50
				35m	5-24	0.13
				45m	5-25	0.21
				55m	5-22	0.50
				65m	7-25	0.40
				75m	6	0.33
June 30,1992	E. Mills	Niagara R	near Erie Canal	<1m	10-18	0.18
July 1992	Ken Pickering, USFWS	Erie	2 mi S of Buffalo, NY	4-5m	14-26	low
July, 1992	Louise Barton, Cleveland Electric Co.	Erie	Perry Nuclear Plant, OH	intake	<10	<0.1
Aug. 24,92	Louise Barton	Erie	Ashtabula, OH	intake	30	~1.0
Aug. 1992	Bill Culligan, NYDEC	Erie	near Dunkirk, NY	30m	12-30	low

Table 1. Quagga mussel sightings in North America as of Sept., 1992. NA = data not available.

ble, but realistically remote, idea that populations are started when boy meets girl.

The public perception: "How can I possibly be sure I have killed or removed every last mussel off of my gear!?!"

2. **"It only takes one mistake."**

The myth: This is a tautology depending on how one defines "mistake". However, the general idea is that one introduction of mussels into a body of water is sufficient for an outbreak. For many of the reasons mentioned above, we have little idea of how many times mussels might need to be introduced before a self-sufficient population is established. Perhaps densities build up over repeated introductions until a "critical mass" is reached. Or maybe repeated introductions are like buying lottery tickets occasionally conditions come together for a "winner" and the more times you do it, the more likely you are to win.

The public perception: By taking the conservative position (i.e., one mistake is sufficient), we discourage cooperation from the public because they will think "if it only takes one mistake, why should we bother when we know someone else will make a mistake."

3. **"Mussels can live for weeks our of water."**

The myth: Although the statement may be true for adult mussels held under ideal conditions (low temperature, high humidity, and still air) in the laboratory, it is unlikely that mussels survive out of water for more than several days under most natural conditions.

The public perception: The public does not generally appreciate this kind of subtlety, and thus is likely to perceive the mussel as even more invincible. Moreover, it often leads to official advisories to leave one's boat out of water for 10 or more days before moving the boat to uninfested waters — unlikely behavior from those anxious to get the most out of the boating season especially because this period can span two weekends.

4. **"Ducks will bring them in anyway."**

The myth: This is a classic for the dispersal of aquatic organisms. While it may be generally true for some types of organisms, and there are records of small bivalves on birds, we have no evidence as yet for the role of birds in the dispersal of zebra mussels. The more relevant concern is how fast animal-mediated processes are relative to human-mediated dispersal vectors.

The public perception: Again, "why bother if something else is going to spread them there anyway".

5. **"The invasion is inevitable."**

The myth: Here again the problems of semantics and time scales lead to perception errors. Many disastrous things are inevitable (e.g., ice ages, the "death" of the sun) but generate little concern. With regard to zebra mussels, the spread to unconnected inland waters has been much slower than first predicted. Moreover, the invasion of European waters still continues 150 years after it began. Both these observations should inspire us in our efforts to prevent the spread of the zebra mussel across the continent. Even if the invasion is only delayed, we will have "bought time" for further research advances in control and local eradication as well as spared water users some years of the problems associated with zebra mussels.

The public perception: Once again, "why try if it is going to happen anyway?"

Given the generally voluntary nature of DPB, we believe the best course of action is to (1) tone down the "scare tactics" that can ultimately lead to discouragement and (2) adjust recommended DPB to encourage greater rates of compliance. Behaviors that are guaranteed to be 100% effective (i.e., kill every mussel) are not worth much if only 10% of the population is complying. From our experience with monitoring transient boating activities, we would recommend the following:

Inspect and remove any visible aquatic vegetation ("weeds") from boat and trailer. This is a simple yet important DPB as mussels are commonly found on aquatic plants.

Flush engine cooling system, bilge areas, and live wells with **tap water.** Hot water is usually unavailable, and chlorine/salt solutions can damage clothing, equipment, and the environment.

Discard all bait that has contacted infested waters before leaving the site.

Leave boat out of the water for at least 48 hr. unless visibly fouled by algae in which case leave out until exterior is completely dry or wash down hull at a car wash.

While none of these steps are guaranteed to remove or kill all the mussels picked up by a boater, they should vastly reduce the number of mussels being transported away from infested sites and thus greatly reduce the probability of further spread.

While a myth can be defined as "an ill-founded belief held uncritically especially by an interested group", we hope that, in the present context, we have taken a more neutral approach in considering myths to be commonly held beliefs that require scientific substantiation. Thus we hope that we have not only encouraged researchers and policy makers to be more careful and thoughtful in making recommendations but perhaps also directed attention to subjects that require more research. Likewise we hope that workers in other zebra mussel sub-disciplines will explicitly recognize similar gaps in other areas of our knowledge and avoid trying to bridge them with myths that lead to misinterpretations and perception errors. It behooves us all in these first years of the colonization of North America by the zebra mussel to minimize misinformation of any form, lest it jeopardize our credibility.

(Dr. Ladd E. Johnson and Dr. James T. Carlton, Maritime Studies Program)

Public Knowledge and Opinion about the Zebra Mussel in a Great Lakes Community

Investigator: Danielle DeLuca, American Studies, Tufts University

Five years after the discovery of the zebra mussel, *Dreissena polymorpha,* in North America, and extensive media coverage in the Great Lakes since then, it becomes of interest to ask what the public knows about the zebra mussel and what public opinion is on its impact and on the allocation of research monies to study the new invader.

To answer this question, a community was chosen (Grosse Pointe [hereafter GP], Michigan, on Lake St. Clair) where the Lakes form an integral part of the community's economic and social life. In December 1991, questionnaires were distributed to members of the GP community as follows: (1) 104,200 questionnaires were inserted into mailings of the Great Lakes Yacht Club's monthly newsletter, *The Telltale,* and a weekly community newspaper, *The GP News; (2)* 300 questionnaires and drop boxes were available at three branches of the GP Public Library and a fishing tackle store, Lakeside Tackle; (3) 1,020 questionnaires were distributed at local schools, The GP Academy [grades 4-8], GP North High School, and Brownell Middle School.

The questionnaire assessed the depth of the community's knowledge about the way the zebra mussel has affected their lives and livelihood, people's use of the lake, and their sources of information about the mussel. Of the 105,520 questionnaires distributed, 1.19% (1,254) were returned. Source (1) provided 70 questionnaires, source (2) provided 178 questionnaires, and source (3) provided 1006 questionnaires. The responses were thus school-aged cohort loaded, but this did not cause a disparity in responses. By comparing the school-aged group's responses to question 1 to the entire respondent pool's answers (65.1% of school-aged respondents answered that they had heard of the zebra mussel compared to 70.5% of the entire respondent pool), it was concluded that the responses were not vastly different. A further study of responses by age group will be presented later. The questions and responses are as follows:

1. Have you ever heard of the zebra mussel? and **2. Have you ever seen a zebra mussel? -** A vast majority of those surveyed—70.5% (884 respondents)—replied that "yes," they had heard of the zebra mussel prior to the survey [fig. 1] (those who responded "no" were requested to skip the questions that would require knowledge of the zebra mussel). Of those who responded "yes," 56.2% said that they had seen a zebra mussel [fig.2]. Those who had seen a zebra mussel had so through television, pictures in newspapers and magazines, or first-hand on boat bottoms or beaches (see question 6 for detailed study).

3. Has the zebra mussel impacted you economically in any way? - Only 11.170 responded that they had experienced increased expenditures as a result of the mussel [fig.3]. Costs incurred due to zebra mussel fouling were the most frequently reported. Cleaning boat hulls (11), repairing boat engines (4), and replacing boat engines (1) were specifically cited by those intimately involved in the boating community. Other costs due to fouling were to sprinkler systems (2) and pumps for a pond (1). Buying and applying antifouling paint (1), purchasing protective footwear (2), and paying doctor bills as a result of cut feet (1) were also reported. Indirectly, 34 respondents cited increased industry and water works costs, and 4 reported an increase in taxes as a result of the mussel. The purported tax increases are more likely based upon assumption than any actual increase. Claiming loss of revenues to fisheries (4) and wasted money spent on recreational fishing (4) were noted, and 1

respondent reported a drop in property value. Many who responded "no" added "not yet" to their reply.

4. Do you expect the zebra mussel to affect the natural inhabitants (birds, fish, clams, etc.) of the lake? - Almost two-thirds - 61.6% - of those who responded yes to question 1 replied that they believe the zebra mussel will affect the natural inhabitants of the lake [fig.4]. Negatively affecting the ecosystem (65) and competing for resources (52) were the reasons cited most frequently. Other reasons included hurting fish and fishing (13), changing water quality (8), killing native clams (4), and depleting the water's oxygen supply (2).

5. Do you support the allocation of tax monies for zebra mussel research? - Almost two-thirds of those who responded 63.4% - said that "yes," they support the allocation of tax monies for zebra mussel research [fig.5]. People believe there is more to be learned about the zebra mussel (59) and that tax monies should be spent to eradicate the mussel (46). Other reasons for support were for controlling the zebra mussel (27), saving the ecosystem (15), preventing higher costs in the future (15), and saving recreational industries (7). Those who responded as to why they did not support the allocation of tax monies for zebra mussel research said that they believed there were more important issues on which to spend money (23), that they were taxed enough already (10), or that they are not personally affected by the zebra mussel (5). Other responses were that nature should be left to run its course (4), that Europe has already researched the mussel (1), or that private industry should be responsible for spending money on research (1).

6. I learned about the zebra mussel through: (Respondents were instructed to check all that apply, thus totals may add to more than 100%). - Of those who responded that they had heard of the zebra mussel, 57.4% (507 responses) said that they had learned about the mussel through newspapers or magazines. Television and radio were the educational sources of 50.8% (449) of the respondents. The next popular means of information was by word of mouth—37.6% (332), followed by school or community discussion—31.7% (280), and first-hand knowledge 21.5% (190). Only 9.95% (88) learned about the zebra mussel from scientific journals.

7. I use the lake as a resource for: (Respondents were instructed to check all that apply, thus totals may add to more than 110%). For those who replied that they had heard of the zebra mussel, 63.0% (557 responses) replied that beaches were their most common use of the lake. Recreational boating was cited by 58.8% (520) of the respondents. Recreational fishing was noted by 51.0% (451), vacationing by 50.3% (445), residence by 17.3% (153), and swimming by 4.19% (37). Other respondents—2.49% (22)—included birdwatching, jetskiing, art inspiration, and recreational walking in their list of uses.

For those who answered that, "no," they had not heard of the zebra mussel, beaches were the most common reported use of the lake by 69.7% (258 responses). Recreational boating was noted by 63.2% (234), vacationing by 59.7% (221), recreational fishing by 37.6% (139), residence by 16.8% (62), other uses by 6.76% (25), and swimming by 5.40% (20). 1.62% (6) of the respondents claimed they did not use the lake as a resource.

Comparisons by Age Group: - Comparing the percentages of those who had seen the zebra mussel by age, the groups with the highest response were aged 26-55. The under 14-18 age groups have the lowest percentages of "no" answers (for having heard of the mussel). This could be due to the fact that these respondents have learned about the zebra mussel in school. Responses of not having seen the zebra mussel were highest among the 56-66+ and 19-25 age brackets [fig.6]. The middle

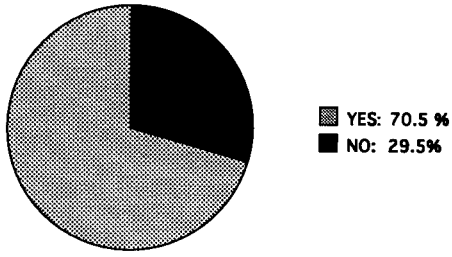

Figure 1: Have you ever heard of the zebra mussel before?

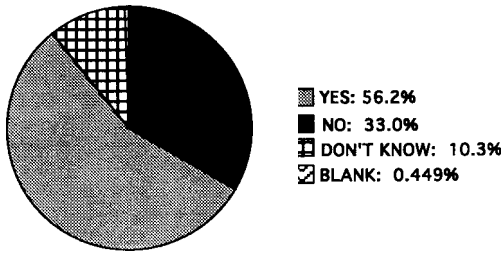

Figure 2: Have you ever seen a zebra mussel?

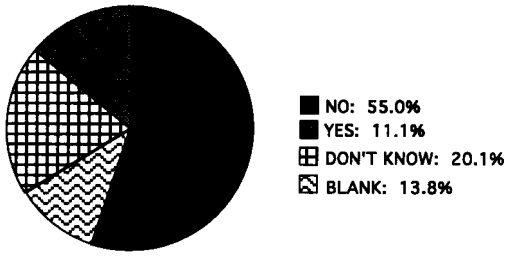

Figure 3: Has the zebra mussel impacted you economically in any way?

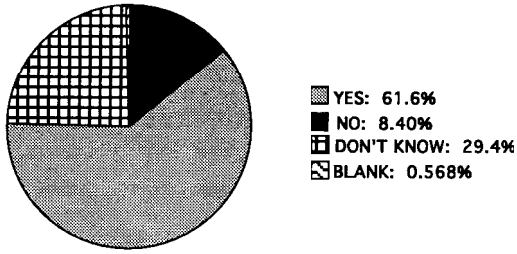

Figure 4: Do you expect the zebra mussels to affect the natural inhabitants of the lake?

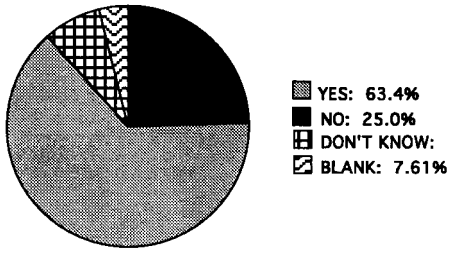

Figure 5: Do you support the allocation of tax monies for zebra mussel research?

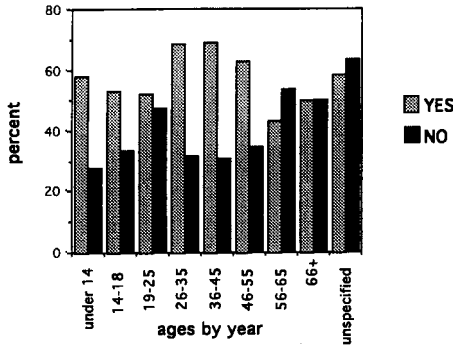

Figure 6: Have you ever seen a zebra mussel — responses in percentages by age

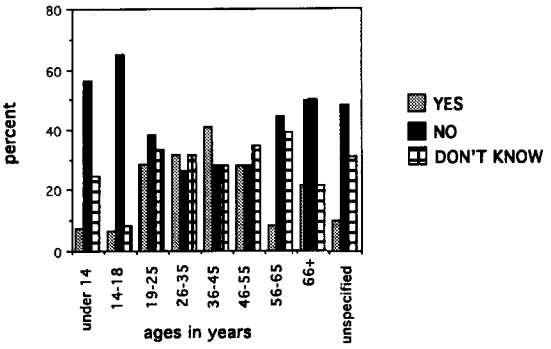

Figure 7: Has the zebra mussel impacted you economically in any way — responses in percentages by age

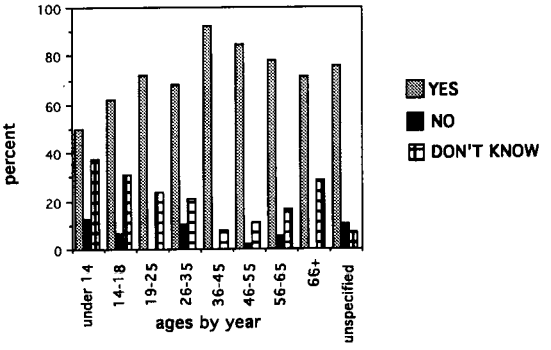

Figure 9: Do you expect the zebra mussel to affect the natural inhabitants of the lake — responses in percentages by age

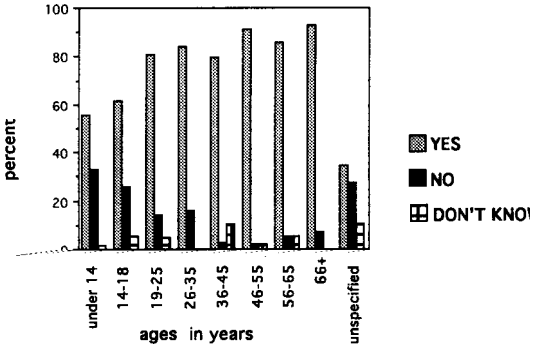

Figure 10: Do you support the allocation of tax monies for zebra mussel research — responses in percentages by age

age groups are more likely to encounter the zebra mussel in their lives due to their levels of recreational activity and monetary spending. Hence, these groups are more likely to be aware of phenomena that could have a negative (or positive) effect on their livelihood. Similarly, these age groups responded with a higher percentage of "yes" answer; to the question about economic impact [fig.7].

All groups are in positive agreement relative to the impact of the zebra mussel on the natural inhabitants of the lake [fig.9]. The middle age group has the highest percentages of "yes" responses, perhaps because this age group is most aware of the events in their community. Comparing the responses to support of allocation of tax monies for zebra mussel research, opposition is, interestingly enough, with the younger groups (under 14-18) [fig. 10]. This suggests that basic support of zebra mussel issues may increase with age, perhaps due to a greater understanding of the depth of impact of this remarkable invasion. It would be worthwhile to repeat this survey at regular two- to three-year intervals to document how one Great Lakes community's knowledge, perception, and opinion evolves as the zebra mussel becomes an integral part of its life.

Acknowledgments

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(Danielle DeLuca, American Studies, Tufts University)

CURRENT RESEARCH

Editor's note: The following six projects have been selected for funding by the US EPA/duluth.

Field experimental analysis of factors regulating the potential distribution, abundance, and community impact of zebra mussels in large rivers.

Investigator: James H. Thorp, University of Louisville

OBJECTIVE: Conduct field, outdoor mesocosm, and laboratory experiments that will help predict the distribution and abundance of zebra mussels as well as their impact on large river ecosystems.

APPROACH: (1) Conduct field experiments to determine the success of zebra mussels in a large river as measured by rates of secondary production and space exploitation on woody debris in the presence or absence of fish predators, and examine the impact of zebra mussels on native species colonizing this substrate, (2) compare results of laboratory experiments on the effects of turbidity with data from field mesocosm studies where animals are maintained in flow-through artificial channels receiving untreated water from the Ohio River, (3) place adult and larval zebra mussels in floating, in situ mesocosms, or "potamocorrals", and measure their response to and effect on native potamoplankton and larval fish during 7-10 day research voyages down the Ohio River.

A bioenergetics model for the zebra mussel.

Investigators: Richard E. Sparks and Daniel W. Schneider, Illinois Natural History Survey, University of Illinois

OBJECTIVE: Refine a previously developed bioenergetics model for zebra mussels in lakes to apply to river systems.

APPROACH: Experimentally examine the effects of flow and suspended sediments on zebra mussel energetic. Refine model using the results of these experiments. Test model against

growth data measured in the field, using physical-chemical data from the Illinois and Mississippi rivers. Use the range of physical-chemical data under which the model was calibrated, with the aid of a Geographic Information System, to identify where zebra mussels are likely to reach nuisance populations, both in terms of population levels, and in terms of potential effects on food webs.

Introduction and spread of zebra mussels: Factors influencing distribution in the Upper Mississippi River.

Investigators: Andrew C. Miller and John W. Barko, U.S. Army Corp of Engineers Waterways Experiment Station

OBJECTIVE: (1) Evaluate the effects of spread and colonization of zebra mussels on density, biomass, and trophic structure of selected macroinvertebrate assemblages in the upper Mississippi River (UMR), (2) investigate physical and chemical characteristics of water and sediment that affect density, distribution and demography of zebra mussels, and assess changes in these conditions as abundances of zebra mussels increase.

APPROACH: (1) Determine the effects of colonization of zebra mussels on native freshwater mussels, (2) investigate the relationship between sedimentation/resuspension rates and zebra mussel densities, (3) investigate the relationship between selected water quality parameters and density and population structure of zebra mussels.

Utility of the physical habitat template as a predictor of lotic ecosystem invadability by alien aquatic species.

Investigators: N. LeRoy Poff and Karen L. Prestegaard, University of Maryland

OBJECTIVE: Describe physical habitat stability in lotic ecosystems at multiple spatial scales in different landscape settings, relate this to functional measures of benthic invertebrate community structure in these different settings, and generalize the results into a framework for characterizing stream invadability by alien aquatic species.

APPROACH: Describe habitat structure and stability at selected sites in two contrasting hydroclimatological regions in physical terms that take into account dynamic fluvial processes as studied by geomorphologists. Quantify functional attributes of species and assemblages that are likely to be sensitive to differences in habitat stability to verify the importance of habitat templates.

The potential influence of the zebra mussel on the biodiversity, population structure, and physiology of native mussels.

Investigator: Daniel J. Hornbach, Macalester College

OBJECTIVE: Examine the potential effect of zebra mussels on the biodiversity, population structure, and physiology of native mussels in the St. Croix River, Minnesota/Wisconsin.

APPROACH: (1) Conduct field studies to determine the existing population density and community structure of native unionid mussels, prior to invasion by zebra mussels, (2) conduct laboratory studies to examine the influence of zebra mussel colonization on the physiology of individual unionids.

Invasion, impact, and interactions of zebra mussels and rusty crayfish in the St. Joseph River basin, Indiana-Michigan, and in streams of northern Wisconsin-Michigan.

Investigators: Gary A. Lamberti and David M. Lodge, University of Notre Dame

OBJECTIVE: Describe and understand the spread of zebra mussels and rusty crayfish in the St. Joseph River watershed, Indiana-Michigan, and in streams of northern Wisconsin-Michigan.

APPROACH: (1) Document the distribution of adult zebra mussels and rusty crayfish using an extensive, annual basin-wide survey of tributaries and main-stem of the St. Joseph River and rivers in northern Wisconsin-Michigan, (2) at selected sites from among the extensive survey sites make intensive measurements of the abundance of zebra mussels and crayfish, other native invertebrates, periphyton, macrophyte, and fish to build on baseline studies of native organisms conducted previously by the P. Is. and others, (3) conduct field and laboratory feeding experiments to explore the potential of crayfish to reduce mussel populations or prevent their colonization.

IN THE FIELD

A Pro-Active Approach for Controlling Zebra Mussels in the New York City Water System

This article is meant to provide municipalities and others, who are just developing an awareness that they will need to plan for controlling zebra mussels in their water supply systems, with an overview of the pro-active strategy used by New York City to accomplish this. This article reports on steps taken through the planning phase of the project, which was completed in September 1992.

The New York City Department of Environmental Protection (NYCDEP) supplies drinking water to approximately nine million people, or roughly one-half the population of New York State. In March of 1991, NYCDEP first began to research the impact zebra mussels could have on drinking water suppliers. First, an extensive review of the literature (both European and American) was done to learn as much as possible about zebra mussels.

In May of 1991, the NYCDEP hired a consulting firm (Acres International) to begin monitoring the City's reservoirs for veligers and the settlement of juveniles. It became clear that early detection of these mollusks would be critical for conserving resources and minimizing the impact on the City's water supply system.

While the literature review was being done, contacts were made with scientists researching limiting factors for the zebra mussel, as well as with those researching control strategies. In addition, contacts were made with managers of water supplies who were challenged with controlling an already existing zebra mussel problem.

As information became known at NYCDEP about the impact zebra mussels could have on a water supply, the decision was made to be pro-active and develop a plan for controlling zebra mussels before they were found in the City's water supply system. It should be noted that, to date, zebra mussels have not been identified with the New York City water supply system. They have, however, been identified at the Chelsea Pumping Station which has been used by NYCDEP during severe droughts to draw water from the Hudson River to supplement the City's drinking water supply.

Given the size and complexity of NYC's water supply system, and the speed at which the zebra mussels were moving through New York State, it was decided that Phase 1 of this project would be contracted out to a consultant who would conduct a complete evaluation of the City's water supply system's infestation potential, as well as develop an action plan for controlling zebra mussels. Recommendations would include feasible control options, placement of controls, alternative options for control, and a back-up emergency plan in the event that zebra mussels should appear where they were not expected, or appear in the

Continued on p. 10

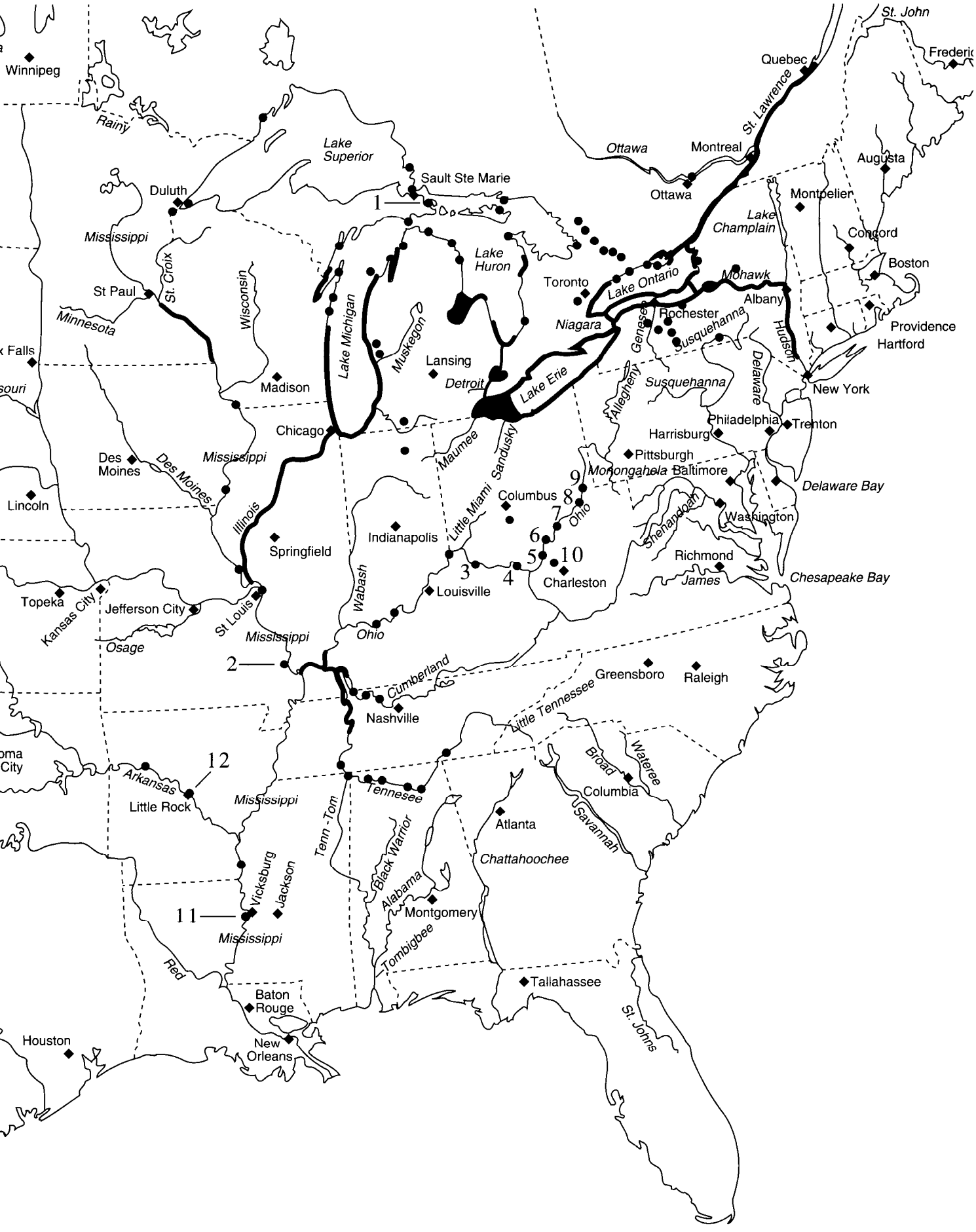
SIGHTINGS

North American Range of the Zebra Mussel

as of 3 January 1993

Compiled by New York Sea Grant with information from: Empire State Electric Energy Research Corp., Fisheries and Oceans Canada, Great Lakes Sea Grant Network, Illinois Natural History Survey, Ontario Hydro, Ontario Ministry of Natural Resources, Tennessee Valley Authority, US Army Corps of Engineers, US Fish & Wildlife Service, and Utilities and others throughout North America.

1. Sugar Island
2. Cape Girardeau, MO, River Mile 46
3. Meldahl Lock and Dam, Ohio River Mile 436.2
4. Greenup Lock and Dam, Ohio River Mile 341.1
5. Gallipolis Lock and Dam, Ohio River Mile 279.3
6. Racine Lock and Dam, Ohio River Mile 237.5
7. Belleville Lock and Dam, Ohio River Mile 203.9
8. Willow Island Lock and Dam, Ohio River Mile 161.8
9. Hannibal Lock and Dam, Ohio River Mile 126.5
10. Winfield Lock and Dam, Kanawha River Mile 31.1
11. Vicksburg, MS, Mississippi River Mile 436
12. Little Rock, AR, Arkansas River


Winnipeg
Rainy
Lake Superior
Duluth
Sault Ste Marie
1
Mississippi
St. Croix
Wisconsin
Minnesota
St Paul
Lake Michigan
Muskegon
Lansing
Lake Huron
Detroit
Lake Erie
Madison
Chicago
Des Moines
Des Moines
Mississippi
Illinois
Springfield
Lincoln
Maumee
Sandusky
Little Miami
Columbus
Indianapolis
Wabash
Ohio
Louisville
Topeka
Kansas City
Jefferson City
St Louis
Osage
Mississippi
2
Cumberland
Nashville
Arkansas
Little Rock
12
Mississippi
Tennessee
Tenn - Tom
Black Warrior
Alabama
Montgomery
Tombigbee
Vicksburg
Jackson
11
Mississippi
Red
Baton Rouge
New Orleans
Houston
Tallahassee
St. Johns
Atlanta
Chattahoochee
Savannah
Broad
Wateree
Columbia
Greensboro
Raleigh
Little Tennessee
Charleston
3
4
5
6
7
8
9
10
Ohio
Monongahela
Pittsburgh
Harrisburg
Allegheny
Susquehanna
Baltimore
Shenandoah
Washington
Richmond
James
Chesapeake Bay
Delaware Bay
Philadelphia
Trenton
New York
Delaware
Hudson
Albany
Mohawk
Rochester
Genesee
Niagara
Susquehanna
Toronto
Lake Ontario
Ottawa
Montreal
Quebec
St. Lawrence
Lake Champlain
Montpelier
Augusta
Concord
Boston
Providence
Hartford
St. John

system before the City was prepared for them. Thus, the City would have both a short-and long-term plan for controlling zebra mussels for every component of the water supply system. With the plan in hand, the City would be prepared to move into action immediately, if zebra mussels were detected.

However, the City's normal contracting process can take up to two years before a consultant can begin working on a project. The NYCDEP realized that the City could be faced with a serious water supply problem, unless Phase 1 could be completed rapidly. A meeting was arranged with NYCDEP's oversight agencies: the City Law Department and the Comptroller's office. NYCDEP presented the problem and requested that they permit this agency to move in an emergency mode to complete Phase 1 of this project. They agreed and an emergency was declared by NYCDEP'S Commissioner Appleton on January 28, 1992, to allow for rapid planning.

In the process of choosing a consultant for Phase 1 of this project, a national survey was conducted of engineering firms that had experience in controlling zebra mussel populations. The five firms that best met NYC's requirements for this project were invited to submit proposals for Phase 1 of the zebra mussel project. A meeting was held on January 30, 1992, with these five firms, and their proposals were submitted 11 days later, on February 10. A NYCDEP Evaluation Committee reviewed these proposals in 4 days, and submitted a recommendation to the Bureau Director on February 14. Malcolm Pirnie was the consultant chosen for this contract; the subcontractor for performing the infestation potential study of the reservoirs was Acres International. The kick-off meeting between NYCDEP and our consultants was held on February 24.

In approximately six months, a plan of action was developed for the control of zebra mussels for each of the 19 reservoirs, 7 aqueducts and tunnels in the NYC water supply system, as well as a contingency plan for each component of this system. This plan primarily recommends the use of chlorination and mechanical removal, depending on the site, for the control of the mussels. A ranking of structures based on their vulnerability to zebra mussel infestation and importance in this water supply system was completed. Design and construction will be done for the most vulnerable and important structures, first. Many of the reservoirs are unlikely to develop a zebra mussel problem due to low calcium concentrations in the water. However, if they do appear where they are not expected, we now do have a plan for controlling them.

PROJECT	DATE OF INSPECTION	METHOD OF COLLECTION	AREA OF STRUCTURI WHERE FOUND	NUMBER OF INDIVIDUALS COLLECTED
MARMET	AUG 20	PICKING	DE-WATERED, UPPER END SILL & VICINITY	ESTIMATE 1000 PRESENT
WINFIELD	AUG 21	SCRAPING	UPPER END SILL	41
GALLIPOLIS	AUG 24	SCRAPING	UPPER END SILL	2
MELDAHL	AUG 25	PICKING	EMERGENCY GATE, 1½ FOOT EXPOSURE	6
GREENUP	AUG 26	PICKING	EMERGENCY GATE, EXPOSED TO FIRST PLATFORM	5
RACINE	AUG 26	PICKING	EMERGENCY GATE, EXPOSED TO FIRST PLATFORM	35
WILLOW ISLAND	AUG 27	PICKING	EMERGENCY GATE, EXPOSED TO FIRST PLATFORM	14
BELLEVILLE	AUG 27	SCRAPING		NONE FOUND*
LONDON	AUG 28	SCRAPING	UPPER END SILL	1
	SEPT 9	PICKING	DE-WATERED, UPPER END SILL	4

*** BELLEVILLE DOES NOT HAVE UNDERWATER STORAGE OF EMERGENCY GATES.**

Table 1 (see article p. 11). Project-specific information concerning presence and collection of zebra mussels at Huntington district locks and dams (1992).

In addition, the NYCDEP has worked to prevent the spread of zebra mussels into the City's reservoir system by: (1) Educating fishermen and boaters who use these reservoirs on the threat zebra mussels pose and actions they can take to prevent their spread. Thousands of letters, and brochures were distributed to them. Signs have been posted at all boat launching sites around every reservoir, describing the zebra mussel problem and how the spread of these mussels can be prevented. (2) Restricting boat access to the reservoirs. (3) Setting up a free steam cleaning service for boats that may have been exposed to zebra mussels.

Separate contracts will be established for Phase 2, a detailed design for the control system based on the plan developed in Phase 1 of this project; and for Phase 3, construction management.

(Sharon Neuman, New York City Department of Environmental Protection)

First Bimonthly Status Report Huntington District Activities Regarding Zebra Mussel Infestation

Investigator: William L. Cremeans, Jr., US Army Corps of Engineers, Huntington District

Recent Sightings - Zebra mussels were first discovered on 20 August 1992 at Marmet Locks and Dam on the Kanawha River during de-watering for maintenance. Artificial substrate samplers were inspected prior to this discovery and again immediately following the knowledge of their presence. The samplers, located in the upper pool and protected from navigation by restricted traffic zones, failed to detect presence. Inspections of all other river projects over the following days revealed the same lack of success in using artificial substrates, at least for low population densities.

Table 1 (p. 10) lists collection information by project. In short, zebra mussels have been found at every river project with the exception of Belleville Locks and Dam within the Huntington District. I believe the mussels are present at Belleville, but due to project differences, readily available immersed structures are not present at Belleville as they are at other high-lift structures on the Ohio River.

Observations and Concerns - The older and smaller river projects Winfield, Marmet and London on the Kanawha River and Gallipolis on the Ohio River have in common a concrete sill on the upstream end of the lock chambers. At these projects, two of which were de-watered and examined (Marmet and London), zebra mussel colonization appears to be greatest on and near these sills. Additionally, all specimens collected were from below the low-pool elevation, except for two which were in a stream of water from leaking gates. Isolating the condition(s) conducive to zebra mussel settlement, or those more favorable to

	5/25	6/1	6/8	6/15	6/22	6/29	7/6	7/13	7/20	7/27	8/3	8/10	8/17	8/24
DELAWARE LAKE				0		0	0							
ALUM CREEK LAKE							0		0	0	0		0	0
PAINT CREEK LAKE				R, 0	R, 0	0	0	0			0		0	0
ATWOOD LAKE							0		0					
LEESVILLE LAKE					0		0			0	R	R	R	
TAPPAN LAKE									0			0		
PIEDMONT LAKE					0				0		0		0	
SENECAVILLE LAKE			0											
SUMMERSVILLE LAKE						0		0				0		
BEECH FORK LAKE					0									
GRAYSON LAKE		0		0		0		0						0
PAINTSVILLE LAKE														
FISHTRAP LAKE														
MARMET LOCKS & DAM				0						R, 0		0	0, C	
LONDON LOCKS & DAM						0		0		0		0		
GALLIPOLIS LOCKS & DAM												C		
BELLEVILLE LOCKS & DAM		0						0						
GREENUP LOCKS & DAM	0		0	0	0	0	0		0		0	0	0	0, C
CPT A. MELDAHL L&D		0	0	0				0			0	0		0, C
RACINE LOCKS & DAM	0	0	0	0	0	0						0		0, C
WILLOW ISLAND L&D		0			0		R, 0	0				0		0, C
WINFIELD LOCKS & DAM													C	

"0" DENOTES SMOOTH SAMPLER SURFACE (NO REASON TO SUSPECT PRESENCE OF ZEBRA MUSSELS)
"R" DENOTES ROUGH SAMPLER SURFACE (REASON TO SUSPECT PRESENCE OF ZEBRA MUSSELS, SAMPLER AWAITING EXAMINATION)
"C" DENOTES CONFIRMED FIND IN LOCK CHAMBER, BUT NOT ON ARTIFICIAL SUBSTRATE SAMPLERS

Table 2. Results of inspections of artificial substrate samplers and lock chambers (1992).

survival of the bivalves, may advance our knowledge with respect to quantification and control of the organisms.

Lock chambers examined during de-watering did not contain representatives from all age classes of mussels. The size of mussels collected ranged from 1.2 centimeters to just over 2.5 centimeters. This suggests that all specimens collected thus far have originated from boat traffic as a result of adult mussels being dropped, or removed by boat or barge hulls scraping against lock chamber walls. Smaller individuals from various age classes should have been present if the mussels had attached themselves as veligers and developed to adults within the chambers. If this hypothesis is true, locks and dams, as well as other stopping points for traffic along the rivers may serve as brood chambers and thereby facilitate population growth. A power plant eight miles downstream of Meldahl Locks and Dam, as one example supporting this hypothesis, reported finding veligers one month before we discovered the adults in our chambers.

Status of Monitoring Program and Devices - A series of three PVC plate samplers with embedded glass microscope slides has been sent to all river projects and selected reservoir projects. Sampler plates have been suspended from buoys at depths ranging from three to six feet. Project personnel were urged to install and inspect the samplers at intervals of no more than two weeks. If surface roughness was detected, they were to notify Water Quality personnel to inspect the plates.

Table 2 (p. 11) shows target projects and the frequency of inspection. Overall cooperation between OR and ED staff has been good and yet no zebra mussels have been found on the sampler plates. The lock chambers themselves appear, at this time, to be the best zebra mussel sampling device.

Dr. Barry Payne of CEWES-ER-A, in a conference call, indicated that sampler plates may not be effective in approximating densities until a larger population is present within the vicinity of the monitors. In light of this, OR personnel at river projects have been relieved of the time-consumptive task of checking the samplers until a review of strategies is conducted. Willow Island Locks and Dam are scheduled to be de-watered in November. It is hoped that an inspection of this project will provide additional insights into both the distribution patterns and the population densities of the mussels.

CORBICULA, TOO

Corbicula fluminea

Investigator: L. Ray Tuttle, Jr., New York State Electric & Gas Corporation, Binghamton, NY.

On October 5, 1992, while inspecting for zebra mussel colonization at the New York State Electric & Gas Corporation's Greenidge Station located on Seneca Lake in Dresden, NY, samples of freshwater bivalves were provided for identification. The organisms were identified by Kurt Jirka of Ichthyological Associates and confirmed by Dave Strayer of the New York Botanical Garden, Institute of Ecosystem Studies as the Asiatic Clam, *Corbicula fluminea.* This sighting is of interest in that it is the northern edge of the range for *Corbicula.* Densities of several hundred organisms per square foot were found in the dewatered intake pipe and specimens were also found in heat exchangers within the station. Further investigations as to the extent and location of colonization will be done.

ANNOTATIONS

Birger, T.L. & Malyarevskaya, A.Ya. 1975.
Biochemical changes in *Dreissena* after regulation of the flow of the Dnieper.
Hydrobiological Journal, 11(3):63-66. *($0.40)* **DPBI006**

Differences in biochemistry between reservoir and river dwelling *Dreissena* were measured over time, and a decrease in the variability of the parameters occurred as the reservoirs became stabilized. *(bib;tab)*

Cherry, D. S., Roy, R. L., Lechleitner, R.A., Dunhardt, P. A., Peters, G. T., & Cairns, J., Jr. 1986.
***Corbicula* fouling and control measures at the Celco Plant, Virginia.**
American Malacological Bulletin, Special Edition No. 2:69-81. *($1.30)* **CBIC001**

Discusses the infestation of the Celco Plant by *Corbicula fluminea* and control measures. Both the plant and the river pumphouse station were affected. In addition to in-plant continuous chlorination, clam-laden sediment was removed from the pumphouse, and the water holding towers and dead pipe spaces were periodically flushed. The authors found no discernible impact of chlorination on the invertebrate populations sampled in the New River. *(bib;fig;tab)*

Demoss, D., Bernhard, H.F., Flood, T.J., & Ortmayer, M.J. 1991.
Initial results of 1991 veliger settlement monitoring program with implications for timed chlorination treatment.
In Proceedings, *Electric Utility Zebra Mussel Control Technology Conference,* Itasca (Chicago), IL, 22-23 October 1991. 14p. **DPIC043**

Reviews the establishment of 1991 monitoring program in southern Lake Michigan and western Lake Erie in order to evaluate the effects of various lake water conditions on veliger settlement. Design of the sampling program and plexiglass samplers, as well as initial results of sampling are presented. Tentative results indicate possible preferential settlement periods correlate with sustained water temperatures in excess of 70°F. *(fig)*

Goss, L. B., Jackson, J. M., Flora, H. B., Isom, B. G., Gooch, C., Murray, S. A., Burton, C. G., & Bain, W.S. 1977.
Control studies on *Corbicula* for steam-electric generating plants.
Proceedings, *First International Corbicula Symposium, Texas Christian University,* pp. 139-151. *($0.70)* **CBIC002**

Describes the biofouling problem experienced by the Tennessee Valley Authority and the control methods being examined. They include mechanical straining, controlled release surfaces, chemical biocides, and heat treatment. Detailed results of the laboratory and field studies of these methods are provided. *(bib;tab)*

Hamburger, K., Dan, P. C., & Jonasson, P.M. 1990.
The role of *Dreissena polymorpha* Pallas (Mollusca) in the energy budget of Lake Esrom, Denmark.
Verhandlungen der International Vereinigung fur Theoretische und Angewandte Limnologie, 24:621-625. *($0.50)* **DPEC065**

Within the littoral/sublittoral zone below 3.5 m., *Dreissena polymorpha* constitutes 98% of the biomass, and it assimilates 9% of the annual net phytoplankton production.

Hunter, R.D. & Bailey, J.F. 1992
***Dreissena polymorpha* (zebra mussel): Colonization of soft substrata and some effects on unionid bivalves.**
The Nautilus, 106(2):60-67. *($0.80)* **DPSP050**

SCUBA examination of three sites in southern Lake St. Clair (Ontario), where the bottom is mostly soft and unionids are the only hard surfaces, indicated an increase in *Dreissena polymorpha* abundance and biomass from west to east. Unionid density showed a reverse trend. *Dreissena* extended laterally from the original "seed" surface of unionids, which face elimination. *(bib;fig;tab)*

Ingram, W.M. 1956.
Snail and clam infestations of drinking-water supplies.
Journal American Water Works Association, 48(3):258-268. *($1.20)* **MFGN005**

Examines snail and clam problems in raw water sources, water treatment plants, and distribution systems. Reviews the literature, then considers: pipe-dwelling snails and clams, points of entry into the supply, elimination of the molluscs. *(bib;fig)*

Isom, B. G., Bowman, C.F., Johnson, J.T., & Rodgers, E.B. 1986.
Controlling *Corbicula* (Asiatic clams) in complex power plant and industrial water systems.
American Malacological Bulletin, Special Edition No. 2:95-98. *($1.40)* **CBIC005**

Discusses an effective plan developed and implemented within the Tennessee Valley Authority for the control of *Corbicula.* The plan included knowledge of the clam's life history including the size of the benthic veligers and spawning times, straining, chemical injection, and general "housekeeping". *(bib;fig)*

Johnson, K. I., Henager, C. H., Page, T. L., & Hayes, P.F. 1986.
Engineering factors influencing *Corbicula* fouling in nuclear service water systems.
American Malacological Bulletin, Special Edition No. 2:47-52. *($0.60)* **CBIC006**

The biological characteristics of *Corbicula* and the engineering characteristics of service water systems were analyzed to find engineering factors common to service water systems that are conducive to fouling by *Corbiczda.* The limits of engineering parameters which support *Corbicula* growth are given. Safety implications are discussed and recommendations for minimizing the potential for fouling are provided. *(bib;fig)*

Kraak, M.H.S. 1992.
Ecotoxicity of metals to the freshwater mussel *Dreissena polymorpha.*
Amsterdam: Michael H.S. Kraak & Section Aquatic Ecotoxicology, 121 pp. *($12.10)* **DPTX009**

This is a collection of papers, published in or submitted to various journals, on the following topics: biomonitoring of heavy metals in the Rhine and the Meuse by *Dreissena polymorpha;* the effect of the parasite *Phyllodistomum macrocotyle* (Trematoda) on heavy metal concentrations in *D. polymorpha;* filtration rate as a parameter for determining the effects of heavy metals on the zebra mussel; evaluation of the ecotoxicity of mixtures of metals to the zebra mussel, using the toxic unit concept; chronic ecotoxicity of mixtures of Cu, Zn and Cd to the zebra mussel. There are concluding remarks and a summary. *(bib;fig;tab)*

Kraak, M. H. S., Scholten, M. C.T., Peeters, W. H.M., & de Kock, W.C. 1991.
Biomonitoring of heavy metals in the Western European Rivers Rhine and Meuse using the freshwater mussel *Dreissena polymorpha.*
Environmental Pollution, 74(2): 101-114. *($0.80)* **DPTX010**

Active and passive biomonitoring programs were used in the Rhine and the Meuse to detect copper, zinc, cadmium and lead. In the active programs, *D. polymorpha* were transported from a site free of the metals to the site to be monitored. In the passive program, the mussels inhabiting the site to be monitored were used. The use of active biomonitoring avoids possible problems arising from population differentiation due to chronic exposure of the indigenous population. In the Rhine, the cadmium concentration in exposed mussels has decreased from 1976 to 1988, while it has increased in the Meuse. Mussels from Lake Heerhugowaard, Lake Markermeer, Lake Maarsseveen, and the River Dieze showed seasonal variations in their heavy metal concentrations, perhaps due to their annual growth and reproductive cycle, as well as the bioavailability of the metals. This must be taken into account in collecting specimens. *(bib;fig)*

Lemma, A., Wolde-Yohannes, L., Fraleigh, P. C., Klerks, P. L., & Lee, H.L. 1991.
Ended is lethal to zebra mussels and inhibits their attachment.
Journal of Shellfish Research, 10(2):361-365. *($0.50)* **DPIC024**

In laboratory conditions, using both static and recirculating-flow systems, Ended was found to inhibit attachment of zebra mussels at concentrations lower than 20mg/L. and to kill them at higher concentrations. Ended is derived from the African soap berry *Phytolacca dodecandra.* *(bib;fig;tab)*

Lewandowski, K. 1983.
Formation of annuli on shells of young *Dreissena polymorpha* (Pall.).
Polskie Archiwum Hydrobiologii, 30(4):343-351. *($0.90)* **DPBI017**

Variations in annuli counts in young mussels of the same age living in the same conditions suggest limits to their use as age indicators. Causes of variation suggested. English with Polish summary. *(bub;fig;tab)*

Lewandowski, K. 1983.
Occurrence and filtration capacity of young plant-dwelling *Dreissena polymorpha* (Pall.) in Majcz Wielki Lake.
Polski Archiwum Hydrobiologii, 30(3):255-262. *($0.80)* **DPBI018**

Compares filtering capacities of young plant-dwelling zebra mussels with those of other filtrators. Dense vegetation populations were larger than those of the littoral bottom, and the filtration capacity exceeded that of older adults. English with Polish summary. *(bib;fig;tab)*

Lewandowski, K & Stanczykowska, A. 1986.
Molluscs in Lake Zarnowieckie.
Polish Ecological Studies, 12(3/4):315-330. *($0.80)* **MOGN073**

Study of mollusks of the littoral zone in Lake Zamowieckie (Poland) between 1974 and 1981, including ten species of snails, six large bivalves, numerous sphaeriids, and the dominant *Dreissena polymorpha.* Factors investigated for *D. polymorpha* included: depths of attachment, substrates, average population, lifespan, reproductive activity, water temperature, seasonal presence, and density of larval forms. English with Polish summary. *(bib;fig;tab)*

Lyakhov, S.M. & Mikheev, V.P. 1964.
The population and distribution of *Dreissena* in the Kuibyshev Reservoir seven years after its construction.
In Shtegman, B.K. (ed), *Biology and Control of Dreissena: A Collection of Papers* (pp.1-14). Moskow: Institute of the Biology of Inland Waters. (Washington, DC: Federal Clearinghouse for Scientific and Technical Information, TT 67-51396.) *($1.40)* **DPSP011**

Survey conducted July 16-23, 1962. Accumulations of zebra mussels (up to 10,246 individuals/m^2) in the major underwater habitats (forests, thickets, meadows, sandy beaches, and stony outcrops) were compared. Distributions on various substrates and on particular parts of trees were also compared. *(bib;fig;tab)*

Mackie, G.L. & Kilgour, B.W. 1992.
Effects of salinity on growth and survival of zebra mussels *(Dreissena polymorpha)*.
Research Report EP 91-17. *Empire State Electric Energy Research Corporation* (ESEERCO). *(available from ESEERCO)* **DPIC026**

The purpose of this study was to describe the salinity tolerance of zebra mussels to different salts (Instant Ocean, sodium chloride, potassium chloride); to describe the growth of the organisms in different salinities; and to explore the possible interactions between temperature and salinity on survival and growth. Veliger larvae were excluded from the study. The mussels were collected from Lake St. Clair and maintained in the laboratory. There are a table of contents and a list of tables and illustrations. *(bib;fig;tab)*

MacPhee, D.D. 1986
A mechanical strainer design for *Corbicula* fouling prevention in the service water system at Arkansas Nuclear One, Unit 2.
American Malacological Bulletin, Special Edition No. 2:59-61. *($0.30)* **CBIC008**

Difficulties in obtaining nuclear grade strainers for the service water supply lines of this nuclear power plant forced Arkansas Power and Light Company to have "clam traps" designed and built for them. These new strainers provided for periodic flushing and cleaning, as well as passive removal of clams and debris. The design and operation of these strainers are discussed.

Magni, R.J., Jr. 1992.
Zebra mussel impacts - Ohio's regulatory perspective.
In Proceedings, *Electric Utility Zebra Mussel Control Technology Conference,* Itasca (Chicago), IL, 22-23 October 1991. 6p. **DPPP005**

Describes Ohio EPA's approach to controlling the zebra mussel with biocides and molluscicides in industrial facilities. The (unnamed) chemical additives approved by Ohio EPA have been cost-effective and environmentally sound. Monitoring of their effectiveness is continuing, as well as investigation of new products.

Mowery, D., McClellan, E., Lyons, L. A., Austin, D. M., & Karlovich, D.N. 1990.
Asiatic clam control experience at Peach Bottom Atomic Power Station.
Technical Paper 320. *Betz Industrial. 6p. (available from Betz Industrial)* **CBIC010**

Discusses the use of a nonoxidizing biocide, Betz Clam-Trol CT-1, as a 100% effective molluscicide due to the fact that it is not sensed by the clams, which fail to "clam up" in its presence. The authors discuss the spawning characteristics of the clam, with respect to time and temperature, and the program and application procedures used at Peach Bottom Atomic Power Station on the Susquehanna River in Pennsylvania. *(bib;fig)*

Reeders, H.H. 1990.
Mussel-power in fresh water: A natural filter to counter water pollution.
Land & Water International, 67:16-17. *($0.20)* **GENR033**

Suggested use of *D. polymorpha's* filter-feeding as a means of concentrating pollution at the inlet to Volkerak-Zoommeer, the Netherlands. Nets colonized by mussels would be suspended in the inlet and the rate of sedimentation of pollutants would increase. Maintenance, efficiency, and the ethics of the use of the mussels are discussed briefly. *(photo)*

Schloesser, D.W. & Kovalak, W.P. 1991
Infestation of Unionids by *Dreissena polymorpha* in a power plant canal in Lake Erie.
Journal of Shellfish Research, 10(2):355-359. *($0.50)* **DPEC031**

Infestations of three unionids *(Leptodea fragilis, Anodonta grandis,* and *Proptera alata)* by *D. polymorpha* were observed. The age structure of the infesting population was recorded in February and August, and the numbers and mean weights of mussels/unionid were measured. Possible effects of such infestations are suggested. *(bib;fig;tab)*

Schwartz, D., Kasper, J.R., and Pisani, W. 1991.
Strategies to control zebra mussel fouling at Kewaunee Nuclear Power Plant.
In Proceedings, *Electric Utility Zebra Mussel Control Technology Conference,* Itasca (Chicago), IL, 22-23 October 1991. 16p. **DP1C053**

Strategies to control zebra mussels have been planned and implemented by the Wisconsin Public Service Corporation. The monitoring program consists of sidestream macrofouling monitors, substrate monitoring, underwater diving inspection, visual equipment and piping examination, plankton net sampling, and piping radiography. Planned control methods include installation of separate chlorobromination systems for the circulating water and service water systems and intermittent injection of a non-oxidizing biocide for the fire protection system. *(bib;fig)*

Sonalysts, Inc. & Aquatic Sciences, Inc. 1992.
Evaluation of ultrasound for zebra mussel mitigation.
Research Report EP91-17. *Empire State Electric Energy Research Corporation* (ESEERCO). *(available from ESEERCO)* **DPIC027**

The study was designed to determine the effect of underwater acoustic energy on the zebra mussel. The work was conducted in both the field and the laboratory. A range of 39-41 kilohertz fragments veligers "within a few seconds" in flowing water and kills attached adults within 19 to 24 hours. Table of contents, list of illustrations, list of tables. *(bib;fig;tab)*

Sonalysts, Inc. & Aquatic Sciences, Inc. 1992.
Zebra mussel deterrence using acoustic energy.
Research Report EP 90-38. *Empire State Electric Energy Research Corporation* (ESEERCO). *(available from ESEERCO)* **DPIC028**

Describes an experimental survey in both the field and the laboratory of the effectiveness of underwater acoustic energy between 155 hertz and one megaherz as a method of deterring *Dreissena polymorpha.* Veligers were fragmented in less than 60 seconds, juvenile shells up to 1.1 cm. were fractured in less than 7 minutes, and adult viability on natural substrates was reduced within 18 hours. The possibilities for use in treating water intake streams and surfaces are discussed. Table of contents, list of illustrations, list of tables. *(bib;fig;tab)*

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ANNOUNCEMENT

Conference Announcement

Third International Zebra Mussel Conference '93 will be held 23-26 February 93 at the Westin Harbour Castle, Toronto, Ontario, Canada. This will be the only major Zebra Mussel Conference to be held in North America in 1993. It combines the previous conferences sponsored by the Great Lakes Sea Grant Network, the Electric Power Research Institute, and various Canadian agencies. This four-day conference will highlight current research into the biology and impact of the zebra mussel as well as the latest research on control options and systems developed to cope with the mussels. Registration after December 15, 1992:$374.50 Canadian, $330 U.S.

Conference topics will include: U.S. and Canadian zebra mussel public policies, economic impacts, biology of the zebra mussels, mussel population dynamics, ecological impacts, monitoring, other exotic species, mitigation case studies, chemical control options, biofouling and corrosion, biological control options for zebra mussels and other exotics, and physical control options. Abstracts and papers presented will be collated for distribution. Selected full-length papers will be published by the Electric Power Research Institute (EPRI).

There will also be a vendors exhibit from the afternoon of the 23rd through early evening on the 24th.

The Conference is being sponsored by: Ontario Ministry of Natural Resources, Ontario Ministry of Environment, Ontario Hydro, Department of Fisheries and Oceans (Canada), Great Lakes Sea Grant Network, Electric Power Research Institute (EPRI).

For information, contact:
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Service Water Reliability Improvement Seminar, July 14-16, 1993, Philadelphia, PA. Sponsored by EPRI and the EPRI NDE Center. Technical sessions will cover the following areas: Inspection, Cleaning, Materials, Water Treatment, and Performance Monitoring. A vendor exhibit is also planned. Contact Bruce Lube at (704) 547-6080 for more information.

New Russian Translation In Progress

The Clearinghouse is pleased to announce the near-completion of two special bibliographic projects. The. first is the translation into English of the here-to-fore untranslated Russian language bibliography of zebra mussel research (1964-1977) as compiled by N. A. Limanova and published in Moscow in 1978. The second is an English compilation of contemporary (1978-1992) zebra mussel research papers originally published in Cyrillic. Both projects are being prepared for the Clearinghouse by Dr. Michael Ludyanskiy, formerly of the Ukrainian Academy of Science. When completed, both bibliographies will be available from the Clearinghouse. Every attempt will be made to secure copies of all papers listed in each bibliography (these will not, however, be in English).

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