

**Interim Report on the
Findings & Recommendations**

Of The

**Candlewood Lake Authority
Zebra Mussel Task Force**

For

**The Prevention of Introduction and Control of
Zebra Mussels (*Dreissena polymorpha*)
At Lakes Candlewood, Lillinonah and Zoar**

October 31, 2011

Executive Summary

Zebra mussels (*Dreissena polymorpha*) have detrimentally, and sometime irreversibly, impacted the ecology, recreational values, and other resource values of many lakes across the country. Following their discovery in Laurel Lake, Laurel Brook, and the Housatonic River in western Massachusetts in 2009, small numbers of zebra mussels were found and removed downstream in Lakes Lillinonah and Zoar in October of 2010. In response to these findings and the threat to Lakes Candlewood, Lillinonah and Zoar, the Candlewood Lake Authority assembled a Zebra Mussel Task Force which included individuals and agencies with applicable expertise and/or represented lake community residents and users.

The Task Force met monthly from December to April and again in August of 2011. They reviewed much of the related scientific and gray literature, established communications with zebra mussel prevention and control programs nationwide, and gathered other information specific to the local threat. Based on the best scientific information available, the Task Force concluded that zebra mussels posed a threat to area water resources and in response, developed a set of recommendations for immediate implementation.

The recommendations collectively represented a strategy to prevent introduction of zebra mussels to Candlewood Lake and to contain and prevent further spread of the aquatic nuisance mollusk from Lakes Lillinonah and Zoar. Specific recommendations included:

- Determine if zebra mussels are in Candlewood Lake and have continued to spread in Lakes Lillinonah and Zoar;
- Develop and implement an early detection / monitoring program on Lakes Candlewood, Lillinonah and Zoar;
- Develop and/or support education / outreach materials and programs to raise awareness of the risks and prescribed preventative measures among lake user groups;
- Support and/or facilitate boat ramp monitoring and user certification programs;
- Support regulatory measures to discourage the further spread of zebra mussels;
- Continue to investigate boat decontamination measures;
- Investigate / track the federal approval processes of products to eradicate zebra mussel colonies (e.g. Zequenox and BioBullets);
- Develop and maintain a comprehensive database on current zebra mussel research, prevention and control methods; and
- Develop the financial means to fund these and future efforts.

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Introduction

In October of 2010, the Connecticut Department of Energy and Environmental Protection (CT DEEP) reported that zebra mussels had been found in Lakes Lillinonah and Zoar based on the findings of the Biodrawversity LLC consulting group. This exotic, nuisance freshwater mollusk is spreading across the country and can cause extensive ecological, recreational, and commercial damage to certain inland water resources.

The findings were the result of a littoral zone¹ survey conducted by Biodrawversity LLC on behalf of FirstLight Power Resources in fulfillment of FirstLight's 2004 Federal Energy Regulatory Commission (FERC) license. Prior to this, the only known infestations of zebra mussels in Connecticut were at East and West Twin Lakes in Salisbury, CT, which were discovered in 1998 and 2001, respectively.

Given the proximity of Lakes Lillinonah and Zoar to Candlewood Lake, and the distinct possibility that the Housatonic River could be the source of the infestation, the Candlewood Lake Authority (CLA) initiated a fact-finding and information sharing process. The CLA organized and co-sponsored a public seminar on zebra mussels held on November 15, 2010 as part of Western Connecticut

State University's *Science at Night* Seminar Program.

Speakers at the seminar included Nancy Balcom from CT Sea Grant, Peter Arrestad from the Inland Fisheries Division of CT DEEP, and Ethan Nedeau of Biodrawversity (for presentations see candlewoodlakeauthority.org). Ms. Balcom would later become an advisor and Mr. Arrestad a member of the Zebra Mussel Task Force. Mr. Nedeau is owner and principal aquatic biologist of Biodrawversity LLC, the consulting firm that performed the Zebra Mussels Phase I Diagnostic Feasibility Study for the Commonwealth of Massachusetts (Biodrawversity 2009); performed the littoral zone survey at Lakes Lillinonah and Zoar on behalf of FirstLight Power Resources; and will be working on a zebra mussel survey of inland waters in Connecticut for the CT DEEP.

Following the seminar, the CLA began assembling a Zebra Mussel Task Force (hereinafter Task Force) to assist in the development of a plan to address the threat of infestation of Candlewood Lake and other waterbodies.

Although the discovery of zebra mussels is not good news for Western Connecticut, it reflects the shrinking world in which we live, where non-native species can migrate far and wide and out-compete native species. In that regard, the CT DEEP lists 19 aquatic nuisance plant species that have or could become an additional problem in our local waters. (Note: that this is plant species only.) Should additional invasions occur, this Task Force may be called to re-assemble to address the next threat.

¹ The littoral zone of a lake is generally described as the near shore area where sunlight penetrates all the way down to the sediment providing for the growth of aquatic plants.

Table 1. Names and affiliation of those agreeing to serve on the CLA Invasive Species Subcommittee's Zebra Mussel Task Force

Name	Affiliation
Phyllis Schaer	CLA Invasive Species Subcommittee Chairman; CLA Delegate and Executive Committee member from Sherman, CT; lakefront resident in Holiday Point Association (HPA) in Sherman; current board member and past VP of HPA
Peter Aarrestad	Director of the CT DEEP Inland Fisheries Division
Linda Berger	Resident of the Atchison Cove Tax District (ACTD) on Candlewood Lake; past president of Tax District and current Chair of the Watershed Committee of the ACTD; Vice Chairman of the Sherman Inland Wetlands & Watercourse Commission
Greg Bollard	Member of the <i>Friends of the Lake</i> (FOTL) on Lake Lillinonah; Chairs FOTL Water Quality Division, ZMTF liaison for Lake Lillinonah Authority
Bart Conant	Staff at Echo Bay Marina representing commercial interests on the lake; long-time resident and user of local lakes
Ray Crawford	Lakefront resident on Candlewood in New Milford, CT; involved in watermilfoil and historical research on Candlewood; Master Diver averaging 100 dives in Candlewood per year and has dove in other waters where ZMs exist
Bill Foreman	CT DEEP Inland Fisheries Division; responsible for fishing tournament scheduling and permitting
Gwendolyn Flynn	CT DEEP Boating Division; coordinates statewide invasive volunteer program
Mark Howarth	CLA Director of Public Outreach and Development
Bernie Lintzner	Lake Zoar Authority Board member and lakefront resident from Oxford
Eleanor Mariani	Director of the CT DEEP Boating Division, which oversees use of State ramps
Larry Marsicano	CLA Executive Director
Marven Moss	Lake Zoar Authority from Monroe, CT
Greg Pettricone	Lake Lillinonah Authority from Brookfield, CT
Mark Propper	Lakefront resident on Candlewood Lake in Danbury for 35 years; member of Candlewood Lake Users & Boaters Association – a local grassroots organization concerned about Candlewood Lake
Meghan Ruta	Water Protection Manager for the Housatonic Valley Association
David Santos	Conservation Director of the CT BASS Federation Nation; provides environmental education to angling community
Gary Smolen	FirstLight Power Resources Senior Engineer responsible for environmental aspects of the Housatonic Hydropower facilities
Dr. Mitch Wagener	Faculty at WCSU Biology and Environmental Sci. Department; has worked with aquatic invertebrates for over 30 years; Candlewood milfoil weevil research
Sharon Ward	Lake Lillinonah Authority from New Milford, CT
Nancy Balcom*	CT SeaGrant

* Ms. Balcom served the Task Force in an advisory capacity

Task Force Process

The Task Force was formed under the auspices of the CLA's Invasive Species Subcommittee. The members were selected on the basis of either applicable expertise or to provide equitable representation of the various stakeholders / user groups associated with Candlewood Lake. A decision was made to also invite representatives from neighboring Housatonic River agencies and associations. Members who accepted the CLA's invitation to participate and their affiliations are listed in Table 1.

The Task Force acknowledges that there are other communities in Connecticut within the Housatonic River watershed that are at risk of introduction of zebra mussels. While the work of this group does not directly focus outside of the Candlewood-Lillinonah-Zoar area, it is hoped that these efforts prove beneficial to all communities that are threatened by this aquatic nuisance species.

The Task Force met on December 15, 2010, January 19, 2011, February 9, 2011, March 2, 2011, April 27, 2011, and August 17, 2011 and will continue

to meet as necessary. Detailed information regarding the content of the Task Force meetings may be found at CLA's website at candlewoodlakeauthority.org.

Task Force Goals

At the first meeting the Task Force established the following goals:

- Develop a coordinated and collaborative community effort
- Develop and agree upon a set of recommended actions for short and long-term implementation to prevent an infestation of zebra mussels in Candlewood Lake.
- Develop and agree upon a set of recommendations for short and long-term implementation to control the populations that may be established at Lakes Lillinonah and Zoar to prevent additional infestation elsewhere.
- Focus recommendation on
 - 1) Education and outreach,
 - 2) Prevention and containment,
 - 3) Early detection and monitoring,
 - 4) Legislation, and
 - 5) Funding
- Begin implementation of actions before the 2011 boating season

Zebra Mussel Background

Biology & Ecology

The zebra mussel (*Dreissena polymorpha*) is a freshwater bivalve mollusk native to Eastern Europe and western Asia. Adults are small in size, ranging up to over 1.6 inches (40 mm) in length, with most individuals one inch (25 mm) in length or less. The D-shaped shell is yellowish to brown (Fig. 1) and normally contains both dark and light-colored stripes. Unlike most freshwater mussels, zebra mussels grow in clusters or colonies containing numerous individuals. Ram and McMahon (1996) reported densities of up to 700,000 individuals in a square meter.



Figure 1. Adult zebra mussels in a Petri dish along side a dime for scale. (Photo by CA Department of Fish and Game)

Zebra mussel habitat is freshwater lakes, ponds and rivers. There they grow attached to hard substrates (e.g. rocks, logs, docks, boats and intake structures), unlike other freshwater mollusk species that live unattached to a substrate in the sediment.

Zebra mussels reach sexual maturity in one to two years. Spawning occurs when water temperatures approach the mid 50 °F range (approximately 12.8 °C) (Mackie & Schloesser 1996; Ram et. al. 1996; Benson & Raikow 2011). Females may produce over 30,000 eggs per reproductive cycle or more than one million eggs per spawning season (Cohen & Weinstein 2001).

Cohen and Weinstein (2001) provide a thorough review of the life cycle of the zebra mussel, which includes:

- Spawning starts in the spring when water temperatures rise above the mid 50 °F (approximately 12.8 °C) range, although most spawning occurs above approximately 63-64 °F (17-18 °C). Spawning is often prolonged, continuing in pulses through the late summer or early fall.
- Fertilization occurs in the water with embryos developing into swimming larvae, called trochophores in 6 to 96 hours after fertilization (see Fig. 2).
- After an initial nonfeeding phase, the larvae develop intestines and a feeding and swimming organ known as the velum, and begin a feeding phase in two to nine days after fertilization. Once the velum appears the larvae are called veligers and their developmental process proceeds through several substages (see Fig. 2).
- After a week to a month or more of growth the veligers settle to the bottom. Settling larvae attach by byssal threads to hard substrates such as

rock, shells, or submersed plants, though they sometimes attach directly to sand grains. It is in this stage where most of the veliger mortality (99%) occurs (Benson and Rai-kow, 2011). Upon settlement they are known as postveliger or planti-grade mussels, which metamorphose into juveniles by losing the velum and forming, enlarging and reorienting the body structures that are characteristic of adult mussels.

- Zebra mussels reach sexual maturity and shell lengths of 0.2 to 0.87 inches (5 to 22 mm) in one to two years; they live for 2-9 years and reach maximum shell lengths of over 1.6 inches (40 mm).

Spread across North America

Zebra mussels have been spreading across North America since the late 1980s. Zebra mussels were reported in North America at Lake St Clair (located on the Michigan / Canada boarder near Detroit) in 1988 and believed to have been introduced there several years earlier (Mackie & Schloesser 1998). By 1991, zebra mussels were observed in all five Great Lakes, the Finger Lakes region of New York, and in the Mississippi River basin (MA DCR & MA DFG 2009). Whittier et al. (2008) describes continued expansion of zebra mussels from 1995 to 2006 within the Great Lakes and additional inland locations in the Upper Midwest and New York State, and a slower extension down the Arkansas and Missouri Rivers, but no significant

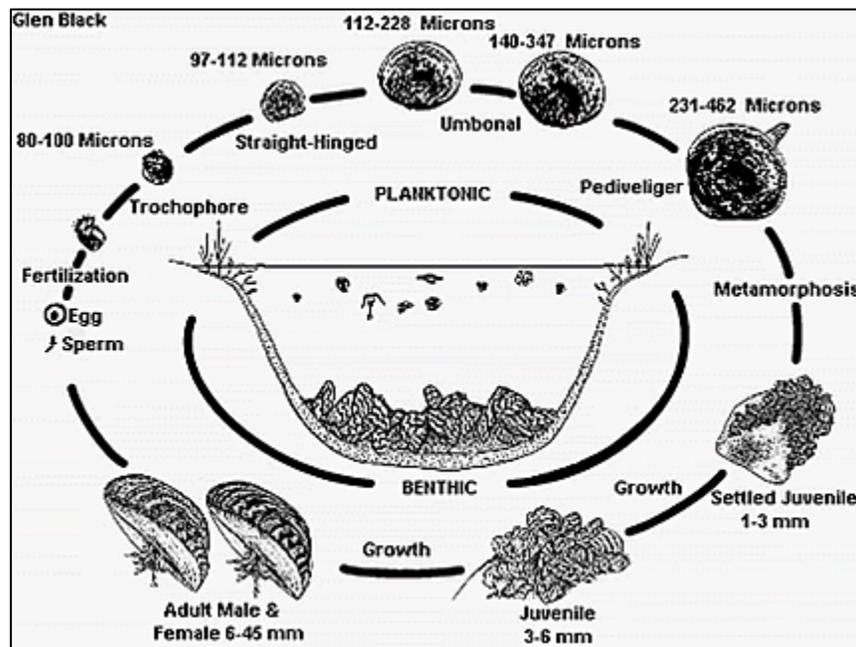


Figure 2. Line drawing of the life cycle of zebra mussels taken from the US Fish & Wildlife Image Library at www.fws.gov/Midwest/mussel/image_library_line_drawings.html.

invasion of New England, the mid-Atlantic Piedmont and Coastal Plains, the southeast, or areas west of the 100th meridian.

The United States Geological Survey (USGS) maintains a website with thorough and up-to-date data on the distribution of zebra mussels, including annual maps showing the distribution of zebra mussels since 1988, and other background information. The website is <http://nas.er.usgs.gov/taxgroup/mollusks/zebramusel/>. The map below (Fig. 3) from their website shows the distribution of zebra and quagga mussels as of February 2011.

Spread across Southern New England

In 1998, adult zebra mussels were reported in East Twin Lake (Washing Lake) in Salisbury, CT. By 2001 adult zebra mussels were found in West Twin Lake (Washinee Lake) which is connected to East Twin by a small outlet (CT DEEP 2010a). No other observations of zebra mussels had been reported in Connecticut since that time until the recent findings in Lakes Lillinonah and Zoar almost twelve years later.

In 2009, zebra mussels were found in the upper Housatonic River basin in Laurel Lake in western Massachusetts (MA

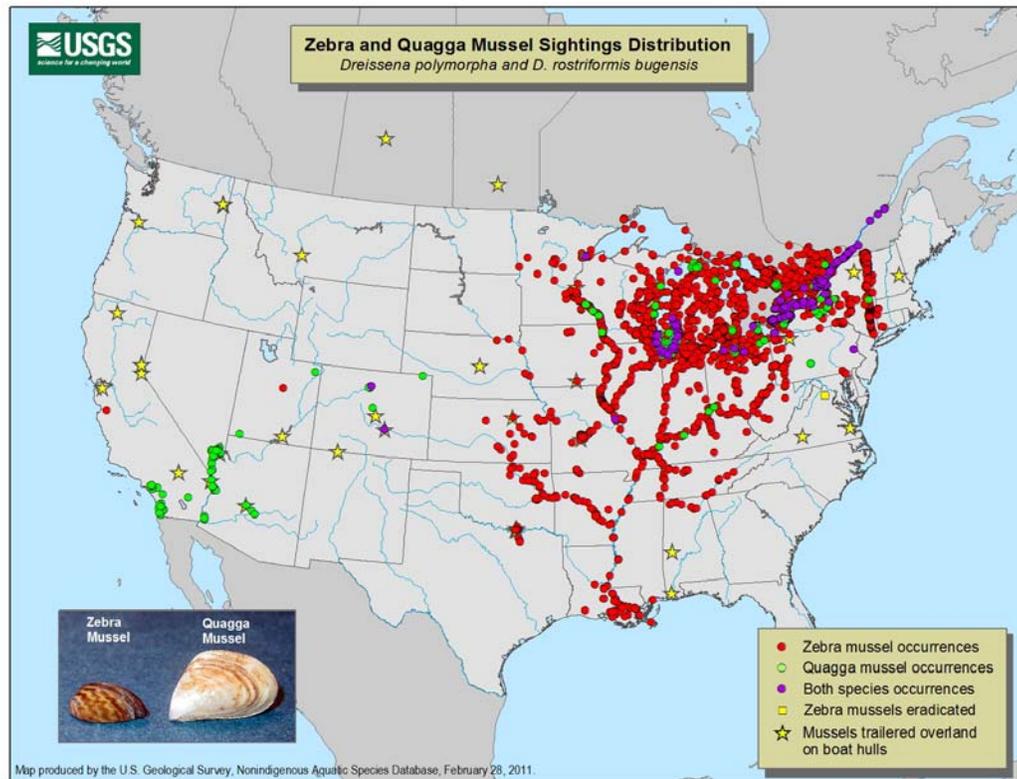


Figure 3. A USGS map showing the distribution of zebra mussels as of February, 2011.

DCR & MA DFG 2009). Laurel Lake lies in the towns of Lee and Lenox in Berkshire County and is situated in the Housatonic River watershed. Soon after their discovery, the Massachusetts Department of Conservation and Recreation, Lakes and Ponds Program commissioned a study to conduct a Phase I Assessment of 17 Berkshire County lakes and the main stem of the Housatonic River for the presence of zebra mussels. The assessment, conducted by Biodrawversity LLC, revealed that in addition to the infestation of Laurel Lake, zebra mussels were also present in Laurel Brook, an outlet of Laurel Lake, and the Housatonic River below the confluence with Laurel Brook. Adult zebra mussels were generally found in the River along a one mile long reach downstream of Laurel Brook with a single mature adult found approximately 7 miles downstream (Biodrawversity 2009).

In October 2010, zebra mussels were discovered in Lakes Lillinonah and Zoar as part of a study funded by FirstLight Power Resources in fulfillment of a Federal Energy Regulatory Commission (FERC) license obligation (FERC 2004). On October 15, 2010 the CT DEEP issued a press release alerting the public that small numbers of zebra mussels had been found in Lakes Lillinonah and Zoar (CT DEEP 2010b). The press release outlined a number of steps that CT DEEP was taking, including seeking active cooperation with boaters and anglers in preventing further spread, and posting signs at the two infected lakes, as well as nearby lakes, to alert lake users of the threat. The press release also contained information on actions anglers

and boaters can take to prevent the spread of zebra mussels.

By 2011 adult zebra mussels were found in the Housatonic River seventeen miles below Laurel Lake. In addition, zebra mussel veliger sampling was conducted with positive results as far south as Rocky River in New Milford, CT. Although established adult populations have not been found throughout the length of the Housatonic River, zebra mussels in some life stage have been observed in most of the River.

Potential Colonization at Candlewood, Lillinonah, and Zoar

There are a number of water quality characteristics that have been used to gauge the susceptibility of an inland water resource to an infestation of zebra mussels. These include pH, total hardness, calcium levels, water temperature, turbidity (Secchi transparency), dissolved oxygen levels, water velocity, substrate size, nutrients, and conductivity (O'Neill 1996, Cohen & Weinstein 2001, Whittier *et al.* 2008). Of these, calcium concentrations appear to be one of the more commonly used characteristics in determining susceptibility and the potential distribution of zebra mussels.

Differences among scientific research and reports regarding colonization potential levels and their designated calcium concentration range do exist (see Table 2). Cohen and Weinstein (2001) reported that 20 mg L⁻¹ Ca was a functional minimum calcium concentration needed for zebra mussels

Table 2. Calcium-based colonization potential / invasion risk for zebra mussels published in scientific papers or reports.

Colonization Potential	O'Neill (1996)	Whittier et. al. (2008)	Biodrawversity (2009)
	mg / liter of Ca		
Very Low	< 9	< 12	---
Low	9 - 20	12 – 20	< 12
Moderate/Medium	20 – 25	20 – 28	12 – 20
High	25 – 125	> 28	> 20

to establish reproducing colonies. It was also reported that zebra mussel occurrences in water bodies with calcium concentrations $< 20 \text{ mg L}^{-1}$ had relatively low abundances or are likely to be population sinks, which are defined as a breeding group that does not produce enough offspring to maintain itself in coming years without recruitment from other populations (Whittier *et al.* 2008).

Most of New England is considered to be very low or low risk for invasion of zebra mussels based on calcium concentrations (Whittier *et. al.* 2008). Laurel Lake has reported concentrations of 44 mg L^{-1} (Biodrawversity, 2009) and 28 mg L^{-1} are reported at East Twin Lake (Canavan & Siver 1994). The calcium levels measured at East Twin Lake were the highest concentrations observed in a 1994 survey of 60 drainage lakes in Connecticut (Canavan & Siver 1994). By comparison calcium levels of 75 mg L^{-1} are observed at Lake Mead, NV.

Calcium levels have been routinely measured at four sites in Candlewood Lake and one site in Squantz Pond since 1992 (Fig. 4). At the Danbury, New Fairfield and Sherman sites calcium levels have averaged, since 1992, about 16 mg

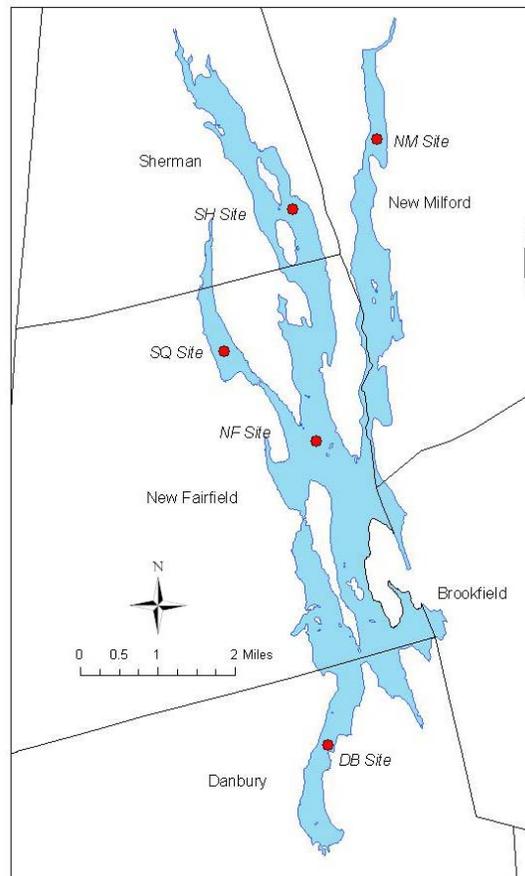


Figure 4. Locations for the four water quality monitoring sites on Candlewood Lake and one site on Squantz Pond. DB Site – Danbury Site; NF Site – New Fairfield Site; NM Site – New Milford Site; SH Site – Sherman Site; and SQ – Squantz Pond Site.

L⁻¹ with most of the measured concentrations falling below 20 mg L⁻¹. At the New Milford site however, the average concentration since 1992 was 18 mg L⁻¹ with almost a third of the measured values exceeding 20 mg L⁻¹. The Squantz Pond site calcium concentration has averaged about 9.5 mg L⁻¹ with no measured concentrations exceeding 12 mg L⁻¹ (see Appendix H).

There is good indication that the calcium levels are slowly increasing lake-wide (M. Wagener, personal communication, February 28, 2011). Mean levels from 2000 through 2010 are approximately 18 mg L⁻¹ at the Danbury, New Fairfield and Sherman sites; 20 mg L⁻¹ at the New Milford site; and 10 mg L⁻¹ at the Squantz Pond site. A regression analysis of the data more definitively revealed an increasing trend (see Appendix H).

While geology determines in large part background levels of dissolved salts like calcium in surface waters, it has also been shown that cultural practices and development within the watersheds of lakes, reservoirs, and rivers will also increase their dissolved salt levels (Siver et. al. 1999). Applications of lime (calcium oxide) for agriculture, lawn care, and the building industry can significantly increase watershed calcium sources, and leaching of calcium from those and background sources are known to increase significantly with the acidity of rainwater (Health Canada 1987 and references therein).

Based on this information, there does appear to be a risk of invasion at Candlewood Lake, particularly in the New

Milford arm of the lake. However, the risk appears to be low to moderate, depending on the colonization potential scale used. The low to moderate calcium levels in Candlewood Lake brings to bear the question of whether populations started in the lake could expand on their own (i.e. reproduce) without constant upstream recruitment. It appears unlikely that populations will become established at Squantz Pond, although calcium concentrations are slowly increasing there as well (See Appendix H).

Recent data on calcium levels in Lakes Lillinonah and Zoar were not available at the time this report was being drafted. Calcium data were collected in 1992 for Lakes Candlewood, Housatonic, Lillinonah, and Zoar and the Housatonic River as part of a zebra mussel invasion potential study conducted in the early 1990s (Murray *et al.* 1993). Data from that report and characterization of the habitat as it pertains to successful zebra mussel colonization is provided in Table 3.

Hard surfaces are the preferred habitat for the establishment of adult zebra mussel colonies. The bottoms of Lakes Candlewood, Lillinonah and Zoar tend to be silty and do not provide optimal conditions. However, the upper shoreline reaches of the lake tend to have rocky hard surfaces that are more suitable for colonization.

In addition to low to moderate calcium levels, the annual winter drawdowns performed at Candlewood Lake may act to prevent the establishment of high density colonies in the areas that are

Table 3. Calcium concentration, pH and assessment of habitat for zebra mussel colonization from Murray et al., 1993.

Waterbody	Calcium (mg L ⁻¹)	pH	Zebra Mussel Colonization?
Housatonic River (Norfolk)	24	7.4	Probable
Housatonic River (Cornwall)	28	8.3	Probable
Housatonic River (Kent)	21	7.7	Probable
Lake Housatonic	21.2	n/a	Probable
Lake Lillinonah	23.1	7.6	Probable
Lake Zoar	16.8	7.5	Possible
Candlewood Lake	17.2	7.4	Possible

exposed. Every other year, the lake is drawn down by eight to ten feet for management of Eurasian watermilfoil (*Myriophyllum spicatum*) and by four to five feet in the alternate year. The prolonged time out of the water and exposure to winter elements is known to kill zebra mussels and winter drawdowns have been suggested in some situations as a means to control zebra mussels (ENSR 2005).

Lake level fluctuations also occur at Lakes Lillinonah and Zoar but are typically of much shorter duration, are done for shoreline maintenance or flood management, and do not provide the control that the drawdowns at Candlewood Lake provides.

Potential Impacts on Water Resources

It is difficult to project the kinds of impacts zebra mussels would have on Candlewood Lake if they were to be-

come established, or the damage they will have on Lakes Lillinonah and Zoar if those populations expand. This is due, in large part, to the uncertainty of the water chemistry, habitat suitability, and other conditions specific to each lake (e.g. winter drawdown at Candlewood) as they pertain to zebra mussel colonization. Nonetheless, it is important to understand the potential impacts if populations do thrive, as is described in much of the literature that was reviewed by the Task Force.

Potential impacts generally fall into one of three categories that are not mutually exclusive of each other: ecological, recreational, and economic. Zebra mussels are highly effective filter feeders that can deplete much of the microscopic plants (or phytoplankton) and small animals (zooplankton) from the water. This can compromise other organisms that depend on that size plankton as a food source and can also result in higher concentrations of inedible or

toxic phytoplankton (Strayer 2009). It can also increase the clarity of the water allowing more light to reach greater depths, thereby creating more habitats for native aquatic plants and non-native nuisance plants (e.g. Eurasian watermilfoil) on the lake bottom in deeper waters.

Like many non-native invaders, the zebra mussel can reduce biodiversity by outcompeting and displacing the native mussel species. They can also attach themselves to other hard-bodied organisms (e.g. native mussels, crayfish) causing those organisms to exert more effort to accomplish the normal activities necessary to survive, making it more difficult to maintain their body temperature, and making the native animals more susceptible to parasites and disease.

Impairments of lake recreational assets are regularly depicted in the printed media with portions of boat engines shown encrusted with hundreds or thousands of adult zebra mussels. They will generally attach to any stationary, manmade, or natural hard surfaces: boat engines, vessel hulls, docks, rocks, logs, etc. Zebra mussels can negatively affect vessel performance and can cause engine damage if attaching organisms clog cooling water inlets.

Zebra mussels can make swimming unpleasant or difficult at swimming areas with a hard rock or other solid bottoms because of the high density of sharp shells that can accumulate. Swimmers, SCUBA divers, and people wading along the shoreline can be injured if mussels are attached to rocks, docks, and/or other structures. Mussels have shells with sharp edges that can injure unprotected skin and can cause damage to SCUBA equipment. In addition, SCUBA equipment must be decontaminated after diving in water that is infested with mussels to prevent spreading them to other locations. Chemical and hot water decontamination methods can damage SCUBA equipment.

Economic impacts are often associated with commercial or municipal facilities where zebra mussels can clog water intakes. The cost to power plants and municipal drinking-water plants alone in North America, from 1989 through 2004, was \$267 million (Connelly *et al.* 2007). Economic losses can occur from impairments that deter tourism, e.g. from the loss of sport fisheries. Impairments of property amenities such as readily available boating and swimming can also impact property values and local economics (Fishman *et al.* 1998; DeLoughy & Marsicano 2001).

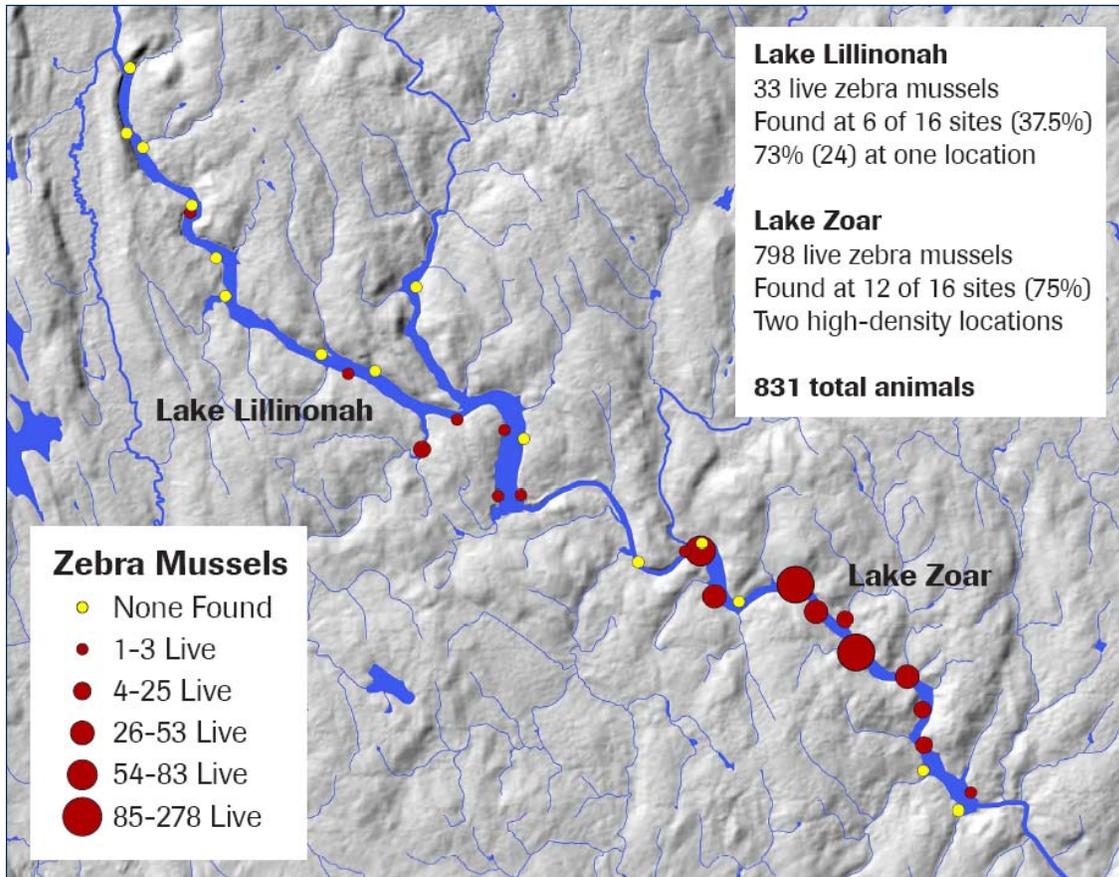


Figure 5. Observations of zebra mussels in Lakes Lillinonah and Zoar (Biodrawiversity, 2010).

Zebra Mussel Task Force Recommendations

The recommendations of the Task Force are divided into five subgroups: early detection and monitoring; education and outreach; prevention and containment; legislation; and funding.

1. Early Detection and Monitoring

As discussed above, zebra mussels have not been documented or observed in Candlewood Lake. Zebra mussels were documented at Lakes Lillinonah and Zoar (see Fig. 5) with the observed individuals hand removed by SCUBA divers.

What was not determined is whether the observed populations represented all of the zebra mussels at Lakes Lillinonah and Zoar and whether those were reproducing and/or expanding. The Task Force agreed that established methods of early detection and monitoring should be used at all three lakes to determine the presence or absence of zebra mussels; to determine if populations are expanding at Lake Lillinonah and Zoar; and determine if population are reproductive.

The Task Force makes the following recommendations:

- **SCUBA / Dive Team Survey:** The Task Force agreed on the deployment of a team of trained and experienced SCUBA divers to conduct underwater searches for adult zebra mussel using established methods (e.g. Adams 2010). It was recommended that the dive team perform a thorough underwater reconnaissance of ten proposed survey areas in Candlewood Lake beginning at the Main Dam in New Milford. Other sites at Candlewood Lake will include high use ramp areas (e.g. State Launches). The divers will be looking at the hard substrate areas that are free of heavy silt. See Appendix I for details. Additional dive teams will be coordinated at Lakes Lillinonah and Zoar. Dives will be planned so as to complement those dives contracted by the CT DEEP with Biodrawiversity. There may also be opportunity to dovetail the required SCUBA training of local police and fire departments with zebra mussel monitoring.

- **Provide Professional Environmental Support For The Volunteer Dive Team:** The Task Force agreed to have the environmental professionals at Biodrawiversity provide guidance for the professional volunteer team working in Lakes Candlewood, Lillinonah, and Zoar.

- **Establish A Zebra Mussel Early Detection / Monitoring Program:** The Task Force agreed that an ongoing program be developed for Lakes Candlewood, Lillinonah, and Zoar and the upper reaches of the Housatonic River in Connecticut. The program will include regular sampling and

analyses of water samples for zebra mussel veligers.

Note: Details on sites, site visits, and frequency of sample collections will be determined in consideration of funding, site accessibility, and other necessary resources and cooperation with stakeholders.

2. Education and Outreach

Many of the zebra mussel programs the Task Force reviewed in the literature relied heavily on an early detection program, and equally as important, a robust public education and outreach program. Accordingly, the Task Force recommends a multi-faceted education and outreach program for the communities that utilize and/or live around Lakes Candlewood, Lillinonah, and Zoar. A similar program should be encouraged for areas of the upper and lower Housatonic River, as well as East and West Twin Lakes.

The specific recommendations of the Task Force include:

- **Develop Informative Signage:** The Task Force recommended and developed informative signage for municipal, State, local and commercial marina launch facilities, as well as other car top launch points (e.g. Dykes Point). The signage supplemented that used by the CT DEEP at State launch facilities. (See samples in Appendix A.)

- **Develop and Distribute Informative Brochures:** The Task Force developed both an informative brochure and a boat cleaning guide to educate lake

users of the impacts of zebra mussels, Best Management Practices (BMPs) on how to prevent their spread, and methods for decontaminating vessels and equipment if it has been in waters where zebra mussels are present. (See sample in Appendix B.) The literature was distributed to lake communities, boat launches, bait and tackle shops, park & recreation departments, town halls, marinas, and libraries, and will be available to other interested groups.

- **Marinas And Launches:** The Task Force recommends distributing educational materials to the users of docks and launches at both marinas and municipal locations.
- **Create and Support A Lake Community Database:** The Task Force supported the creation and updating of a database of lake communities, associations and tax districts around Lakes Candlewood, Lillinonah, and Zoar. The database will include current contact information, approximate dates of annual meeting, and information on community facilities e.g. launch ramps, docks, etc. The list will be used to facilitate the distribution and tracking of zebra mussel educational materials, signage and other information. (Also applicable under Prevention and Containment.)
- **Develop Educational Materials For Lake Communities and Tournament Fishing Clubs And Organizations Requesting Marine Event Permits:** Task Force members supported the development and distribution of educa-

tional packets, including a DVD on zebra mussels, to lake communities surrounding Lakes Candlewood, Lillinonah, and Zoar. They further supported providing assistance to the Connecticut Bass Federation Nation in the development of self-certification, decontamination, and other educational materials for distribution to their membership. Finally, the Task Force members supported having organizations seeking to hold marine events in infected and threatened waters be educated on decontamination protocols.

- **Develop A Coordinated Media Release Plan To Improve Public Awareness:** The Task Force agreed that a coordinated plan be developed to disseminate information through the media regarding zebra mussels and the work of the Task Force.
- **Schedule / Coordinate Public Meetings:** The Task Force scheduled and coordinated public meetings where the findings and recommendations of the Task Force were shared and commented on by the community. Meetings were held on April 4, 2011 at the Southbury Town Hall and on April 6, 2011 at Western Connecticut State University.
- **Get Task Force Information on Websites:** The Task Force supported updating the CLA, CT DEEP, Housatonic Valley Association and other websites with new zebra mussel information. Existing information for each website is available at:

- www.candlewoodlakeauthority.org (Zebra Mussel Tab) for the CLA website
 - <http://www.ct.gov/dep/cwp/view.asp?a=2696&q=322690&depNavGID=1630> for the CT DEEP website
 - <http://www.hvatoday.org/show.cfm?page=ZebraAlert.htm> for the HVA website
- **Establish Partnerships With National Zebra Mussel and Aquatic Nuisance Species Organizations:** The Task Force established collaborative relationships with other regional and national organizations with expertise and experience in preventing the spread of zebra mussels. Some of these included:
- The 100th Meridian Initiative at www.100thmeridian.org/
 - Protect Your Waters at www.protectyourwaters.net/
 - The California Department of Fish and Game Invasive Species Program at www.dfg.ca.gov/invasives/quaggamusel/
 - The Aquatic Nuisance Species Task Force at www.ANSTaskForce.gov

3. Prevention and Containment

The Task Force supported the research and development of measures to prevent the introduction of zebra mussels into Candlewood Lake and/or contain them once introduced into a waterbody such as Lakes Lillinonah and Zoar. Examples from elsewhere across the country have shown that education and public awareness themselves are key factors in supporting prevention and contain-

ment measures. In addition, the following recommendations are made.

- **Research And Develop A Clearing-house of Zebra Mussel Prevention and Containment Information:** The Task Force agreed upon the development of a resource list including websites and documents that provide a clear message on the prevention and/or containment of zebra mussels. The list will be updated as new information becomes available. Some methods include drawdowns, manual removal, pH level adjustments, heat, chlorine, CO₂ diffusion, etc. These will be fully researched for their appropriateness at Lakes Candlewood, Lillinonah and Zoar (For samples see Appendix E.)
- **Determine And Promote Appropriate Decontamination/Cleaning Best Management Practices:** The Task Force researched and developed literature on Best Management Practices (BMPs) for decontamination of boats, personal watercraft, equipment (including SCUBA), pets and other items that come in contact with waters known to harbor zebra mussels. These will be made available to the general public via printed materials and appropriate websites.
- **Facilitate The CT DEEP's Invasive Investigators Program:** The Task Force agreed to partner with the CT DEEP to help promote and facilitate the *Invasive Investigator's Program*. Training programs began at the beginning of the 2011 boating season (see Appendix G for more information). The Task Force's will continue to enlist

community volunteers, assist in scheduling and coordinating training programs, and coordinate efforts at municipal and community ramps.

- **Endorse Expansion of CT DEEP's Boating Education Assistants:** The Task Force endorses the expanded role of the CT DEEP's Boating Education Assistants in monitoring ramps for aquatic nuisance species. The Task Force also endorses the increased staffing of BEA's at State launches at Lakes Candlewood, Lillingtonah and Zoar.
- **Develop a Mentor Program for New Invasive Investigators:** To better prepare the volunteer Invasive Investigators, it was recommended that a mentoring program be developed where a new Invasive Investigator could pair up with an experienced volunteer or BEA.
- **Develop an Incentive Program for Invasive Investigators:** The Task Force agreed on the development of an incentive program for Invasive Investigators to elicit more time monitoring the ramps. Examples included cookouts and gift certificates.
- **Assist In The Development And Endorse Self-Certification Programs:** The CT DEEP has developed programs to prevent the spread of zebra mussels via fishing tournaments and organized boating events. The Task Force will endorse those programs. The Task Force assisted in the development and supports the Connecticut Bass Federation Nation's self-

certification program. (See samples in Appendix C)

- **Investigate Commercial Cleaning And Boat Wash Options:** In some parts of the country, commercial car/boat wash facilities are available to help ensure that a vessel is zebra mussel free before entering a waterbody. The Task Force agreed to investigate these and present reasonable options to the Subcommittee at a later date. Options and recommendations should be developed for both boats leaving known infected waters as well as boats intending to use uninfected lakes.
- **Investigate Commercial Control Products:** The Task Force agreed on investigating and tracking the progress of commercial products that are in the process of getting federal approval, e.g. Zequenox and BioBullets, for the treatment and control of zebra mussels. The Task Force will also investigate potential partnerships with commercial and government entities looking for inland water resources to test these kinds of products.
- **Work with FirstLight in Investigating Modifications of the Candlewood Lake Pump-up:** The Task Force agreed to investigate and recommend modifications to the pump-up of Candlewood Lake. The research should focus on feasibility of not pumping water from the Housatonic River to Candlewood Lake during times when veligers are likely present in the River (see Appendix K), or other modifications to the operations

of the Rocky River power station which would seek to prevent the transport and release of veligers from the river to the lake.

The Task Force also recognizes the value of the biennial deep winter drawdowns by Rocky River in controlling Eurasian watermilfoil, and as a potential control of zebra mussels and other aquatic invasive species. Any operational modification taken to prevent the spread of zebra mussels or other aquatic nuisance species should attempt to balance both lake environmental issues and the economic factors of the Rocky River Facility.

- **FERC License:** FERC is aware of zebra mussel issues at Lakes Lillinonah and Zoar through discussion with FirstLight and through their subsequent submission of the Nuisance Plant Monitoring Plan in April of 2011. FirstLight Power Resources and the Zebra Mussel Task Force remain committed to working within the FERC license obligations to address zebra mussel challenges. Presently, this includes the Littoral Zone and Nuisance Plant Monitoring Plans.
- **Develop A Rapid Response Plan:** The Task Force will work to develop a rapid response plan that is lake appropriate to meet the zebra mussel challenges that present themselves and Lakes Candlewood, Lillinonah, and Zoar.

4. Legislation

A number of states were found to have laws or regulations addressing the

spread and transport of zebra mussels. In addition to acting as a deterrent, a Connecticut law or regulation would demonstrate the State's resolve and determination at limiting the spread of zebra mussels in Connecticut waters.

The specific recommendations of the Task Force include:

- **Engage Local and State Elected Leaders:** The Task Force supported the engagement of State and local elected leaders to help investigate possible legislative / regulatory methods of preventing the transport of zebra mussels and ensuring their containment. (See Appendix D.)
- **Support Proposed Amendments To CT DEEP's Regulations:** The CT DEEP has proposed amendments to their Fish and Wildlife regulations regarding importation/possession of fish and invasive aquatic invertebrates. These include regulating the importation, liberation, and/or use as bait of certain nuisance aquatic invertebrates including zebra mussels (see Appendix D). The Task Force submitted comments for the public hearing held in March of 2011.

5. Funding

Many of the recommendations listed above and efforts in the future will require ongoing sources of funding. The Task Force makes the following recommendations as it pertains to funding both currently available and potentially available in the future. It should be noted that during 2011 funding was provided by the CT DEEP and CLA for

signage, brochures, zebra mussel monitoring, meetings and training programs; and by FirstLight Power Resources for funding zebra mussel monitoring.

- **Federal:** The Task Force supports the investigation and pursuit of federal funding sources, e.g. US FWS Aquatic Nuisance Species Task Force.
- **State:** The Task Force supports the investigation and pursuit of State of CT funding sources, including direct funding or those developed through partnerships, e.g. CT Institute of Water Resources.
- **CT DEEP:** The Task Force recommends following up with CT DEEP

Inland Fisheries Division on available seed money for an early detection / monitoring program.

- **Aquatic Invasive Species Boat Sticker Program:** The Task Force supports investigating a possible statewide Aquatic Invasive Species Boat Sticker Program with funds collected to be held in escrow, solely for aquatic invasive species control, or lake ecology related issues.
- **Other:** The Task Force supports the investigation and pursuit of other funding options, e.g. fundraisers, other grants, etc.

Next Steps

The purpose of this interim report was twofold:

- First to provide a working understanding of zebra mussel biology, their ecology, and the threat they pose to the region
- Second, to provide a set of recommendations to control the populations that may be established at Lakes Lillinonah and Zoar and to prevent and control possible additional infestation elsewhere, including Candlewood Lake. Many recommendations have already been implemented (see Appendix L).

Some recommendations already implemented are a work in process. Results from implementation of other recommendations (e.g. veliger early detection and monitoring) are forthcoming and will be reported on in the future. There are a number of future undertakings for the Task Force still in the development phase. Some of the undertakings will include the review and refining of recommendations already implemented and the continued development of a comprehensive yet dynamic regional plan of action for prevention and control of Zebra Mussels.

Some *Next Steps* discussed by the Task Force include:

- Development of a rapid response plan. Rapid response plans for aquatic nuisance species from across the country are currently being col-

lected for review by the Task Force in efforts to develop a plan for this region.

- Assessment of available zebra mussel control and eradication methods. Literature on these methods is also being collected for review.
- Standardization of methods used in surveying and monitoring for zebra mussel adults and veligers. A number of parties are engaged in collection and analysis of samples for the presence of zebra mussel in western Connecticut waters. In the interest of evaluating and comparing results from the different collections, methods need to be standardized.
- Participation in a joint Massachusetts / Connecticut forum on zebra mussel spread prevention. The Housatonic Valley Association has proposed developing a forum for stakeholders from Western Connecticut and Massachusetts, and other experts during the winter of 2011/2012. The purpose would include a science-based update on the regional issue; updates on the various management, monitoring, and education programs; and a panel discussion to brainstorm on the future directions, efforts, and collaborations among the various vested agencies and organizations

The Task Force itself will need to meet sometime in the fall of 2011 to plan for the implementation of recommendations and other possible activities in 2012. Through out the series of Task Force meetings it has become clear to many members that the model it has

created for the Lakes Candlewood, Lillingtonah and Zoar area in response to zebra mussels will be applicable for the other aquatic invasive species that are anticipated to invade in the future. All three lakes already suffer from introductions and in some cases infestations of aquatic nuisance plants, like Eurasian watermilfoil. The evolution of this Zebra Mussel Task Force into an Aquatic Nuisance Species Commission is another *Next Step* under consideration.

References

Adams, Noah. 2010. Procedures for conducting underwater searches for invasive mussels (*Dreissena* sp.): U.S. Geological Survey Open-File Report 2010-1308, 44 p.

Benson, A. J. and D. Raikow. 2011. *Dreissena polymorpha*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL.
<http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=5> Revision Date: 7/8/2010

Biodrawversity. 2009. Zebra Mussel Phase I Assessment: Physical, Chemical and Biological Evaluations of 20 Lakes and the Housatonic River in Berkshire County, Massachusetts. Prepared for the Massachusetts Department of Conservation and Recreation, Lakes and Ponds Program.
[www.biodrawversity.com/pubs/Zebra Mussel Phase I Assessment.pdf](http://www.biodrawversity.com/pubs/Zebra_Mussel_Phase_I_Assessment.pdf)

Biodrawversity. 2010. Zebra Mussels in the Housatonic River Watershed: sources, dispersal and regional susceptibility. Presentation by Ethan Nedeau at Science at Night Seminar at Western Connecticut State University on November 15, 2010.
www.candlewoodlakeauthority.org/claupload/Zebra%20Mussel%20Presentation%20-%20Ethan%20Nedeau%20-%20November%202010.pdf

Canavan IV, RW & PA Siver. 1994. Chemical and Physical Properties of Connecticut Lakes with Emphasis on Regional Geology. *Lake and Reserv. Manage.* 10:173-186.

Cohen, A.N. and Weinstein A. 2001. Zebra mussel's calcium threshold and implications for its potential distribution in North America. Richmond, CA: San Francisco Estuary Institute. <http://www.sfei.org/node/2048>

Connecticut Department of Energy and Environmental Protection. 2010a. Zebra Mussels Invade CT: East and West Twin Lakes; Monitoring and educational efforts by CT DEEP. Presentation by Peter Aarrestad at Science at Night Seminar at Western Connecticut State University on November 15, 2010.
www.candlewoodlakeauthority.org/claupload/zebra%20mussel%20powerpoint%20-%20Peter%20Aarrestad%20-%20November%202010.pdf

Connecticut Department of Energy and Environmental Protection. 2010b. DEP Reports Zebra Mussels Discovered in Lake Zoar and Lake Lillinonah: *First New Confirmation of this Invasive Species in Connecticut Since 1998*. Press Release.
<http://www.ct.gov/dep/cwp/view.asp?Q=467116&A=3847>

Connelly, NA, CR O'Neill Jr., BA Knuth and TL Brown. 2007. Economic impacts of zebra mussels on drinking water treatment and electric power generation facilities. *Environ Manage* 40:105-112.

DeLoughy, ST. and Marsicano, LJ. 2001. Economic Evaluation of Candlewood Lake with Alternative Water Quality Categories. Candlewood Lake Authority, Sherman, CT.

ENSR. 2005. Rapid Response Plan for the Zebra Mussel (*Dreissena polymorpha*) in Massachusetts. Prepared for the Massachusetts Department of Conservation and Recreation. Boston, MA. 11 pp.

Federal Energy Regulatory Commission. 2004. Order issuing new license re Northeast Generation Services Co's Housatonic Project et al under P-2576 et al. FERC Issuance no. 20040623-3052. 65 pp.

<http://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=10175085>

Fishman, K J., R. L. Leonard and F .A. Shah. 1998. Economic Evaluation on Connecticut Lakes With Alternative Water Quality Levels. Connecticut Department of Environmental Protection, Bureau of Water Management, Lakes Management Program.

Health Canada. 1987. Calcium. http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/calcium/index-eng.php#ref_3

Mackie, GL and GW Schloesser. 1996. Comparative biology of zebra mussels in Europe and North America: An overview. Amer. Zool. 36:244-258

Massachusetts Department of Conservation and Recreation and Massachusetts Department of Fish and Game. 2009. Massachusetts Interim Zebra Mussel Action Plan. www.mass.gov/dcr/watersupply/lakepond/downloads/zebra_mussel_interim_action_plan.pdf

Murray, TE, PH Rich, and EH Jokinen. 1993. Invasion Potential of the Zebra Mussel, *Dreissena polymorpha* (Pallas), in Connecticut: Predictions from Water Chemistry. Connecticut Institute of Water Resources. Special Reports No. 36. Storrs, CT. 33 pp. http://digitalcommons.uconn.edu/ctiwr_specreports/34

O'Neill, C.O., Jr. 1996. The Zebra Mussel: Impacts and Control. Cornell Cooperative Extension Information Bulletin 238. Ithaca, NY. 62 pp.

Ram, J.L. and R.F. McMahon. 1996. Introduction: The biology, ecology, and physiology of zebra mussels. Amer. Zool. 36:239-2243.

Ram, J.L., P.P. Long, and G.W. Garton. 1996. Physiological aspects of zebra mussel reproduction: maturation, spawning and fertilization. Amer. Zool. 36:326-338.

Siver, P.A., A.M. Lott, E. Cash, J. Moss, and L.J. Marsicano. 1999. Century Changes in Connecticut, U.S.A., Lakes as Inferred from Siliceous Algal Remains and their Relationships to Land-Use Change. *Limnol. Oceanogr.* 44:1928-1935

Strayer, D.L. 2009. Twenty years of zebra mussels: lessons from the mollusk that made headlines. *Front Ecol Environ* 7(3): 135–141.

Whittier, T.R. P.L. Ringold, A.T. Herlihy, and S.M. Pierson. 2008. A calcium-based invasion risk assessment for zebra and quagga mussels (*Dreissena* spp). *Front Ecol Environ* 6:180-184.