

Final Report for
100th Meridian Initiative at the Lake Mead National Recreation Area 2007-2008

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Overview

Zebra and quagga mussels and other ANS can easily attach to trailered boats and consequently, be introduced into new environments making boater education an imperative part of preventing the spread of aquatic nuisance species (ANS). Boater surveys are a form of boater education and can also reveal boater travel patterns to predict the location of the next zebra/quagga invasion. Contact surveys were conducted by interviewers with a standard form including questions that asked: 1) where boaters were from and where they had previously launched their boat; 2) where they were launching their boat next; 3) if they clean their boat between launchings; and 4) if they were aware of zebra or quagga mussels or other ANS. Mail-in surveys were placed on vehicle windshields. The last portion of the 100th Meridian survey project included trailer counts. The trailer count involves researchers counting and recording the state of origin of trailers at boat ramps and in marina parking lots. From September 2007-September 2008, 236 contact surveys were completed with 86.4% answering that they clean their boats between launchings and 18% of boaters had no awareness of zebra or quagga mussels or any other aquatic nuisance species. Approximately 61% (n=145) of boaters interviewed said they only launch in Lake Mead, and had no plans to launch in any other body of water. Of the 888 mail-in surveys distributed, 57 were returned for a 6.4% return rate. Only two (3.5%) participants had no prior knowledge of zebra or quagga mussels; 81% of boaters cleaned their boat between launchings; and 56% only launch their boats in Lake Mead. A total of 1864 trailer license plate state of origins were recorded from 12 Nov 07 to 28 Feb 09. Over 97% of states documented were Nevada (64.9%), California (26.1%), Utah (3.1%) or Arizona (3.0%). The percentage of boaters

aware of quagga mussels increased significantly since 2003 (35% to 82%), it is still below desirable levels and hence, boater education should continue at Lake Mead.

Review of 2003 Project

As part of the nationwide initiative, the aforementioned surveys were conducted by employees of the University of Nevada Las Vegas from 01 September 2002 to 31 March 2003 at Lake Mead. Boat launch ramps at Hemenway Harbor, Lake Mead Marina, Las Vegas Bay, Callville Bay, Echo Bay, and Overton Beach were identified as survey locations (McCoy 2003). During the study period, researchers interviewed 246 boaters with the contact survey, left 3,005 mail-in surveys on vehicle windshields and counted 6,799 trailers. Only 1.2% of boaters interviewed came from zebra mussel infested states, 78.6% of boaters cleaned their boat between launchings, and awareness of zebra mussel was low (34.2%) (Gerstenberger et al. 2003). Of the 3,005 mail-in surveys distributed 132 (4.2%) were returned. The self-surveyed boaters were more aware of zebra mussels (48.1%) and cleaned their boats less (76.3%). Only 45 trailers of the 6,799 counted were from states infested with zebra mussels (Gerstenberger et al. 2003). When this study was conducted, there were no quagga mussels in Lake Mead. The discovery of the quagga mussel in Lake Mead in January 2007 sparked a new interest in studying boater behaviors. The following questions, objectives and hypotheses describe the study conducted in 2007 and 2008 that closely mimic the 2003 study.

Objectives

- The survey data will determine if boaters that use LMNRA clean their boats and are aware of quagga mussels.
- Survey data will determine what bodies of water are at the highest risk for invasion due to boaters traveling there after they have launched at LMNRA.
- Comparing 2007-2008 data to 2003 data will determine any differences between boater behaviors in the different study periods.

Hypotheses

Boater Cleaning Habits

- The majority of boaters (>66%) interviewed will clean their boats after every launch.

Quagga Mussel Awareness

- Boat owners with an angling boat will be more aware of quagga mussels than other types of boaters because they are typically more involved in learning about the aquatic ecosystem they are utilizing.
- Boaters interviewed in 2007-2008 will be more aware of quagga mussels than boaters interviewed in 2003 due to increased advertising and more information available than in 2003.

Boater Traveling Habits

- Most boaters (>66%) that use LMNRA will only use LMNRA; they will not travel to other bodies of water due to long travel times and distances to get to other water bodies.

Methodology

Contact Surveys

Surveys were conducted at LMNRA from October 2007 to September 2008. All survey administrators received the proper collaborative institutional training in accordance with UNLV's Institutional Review Board (IRB). The protocol for research was approved on 03 July 2007 by UNLV and was awarded the number 0706-2391. The National Park Service also approved the project and awarded the study number LAME-00063 and the protocol number LAME-2007-SCI-0020. Researchers went to launch ramps at Lake Mead National Recreation Area (n=4: Echo Bay, Callville Bay, Boulder Harbor, and Hemenway Harbor) (Figure 1) to administer the contact surveys. Boaters were approached by survey administrators and asked to participate in a short survey (Appendix). If a boater agreed, they read the informed consent form and verified it with their signature. After this, one of the administrators would ask the boater the questions on the official 100th Meridian survey obtained from the 100th Meridian website at www.100thmeridian.org (Appendix). If boaters were not aware of the threats of quagga mussels to the lake and to their boats, administrators would inform them and give them a Zap the Zebra brochure (Appendix) for further information.

Mail-in Surveys

At the same launch ramps and marinas where contact surveys were conducted plus the Overton Beach launch ramp (n=5), mail-in surveys were placed on the windshield of vehicles with a boat trailer attached (Appendix). If a boater chose to participate, they would fill in the survey then deposit it in the nearest mail box with prepaid postage to UNLV.

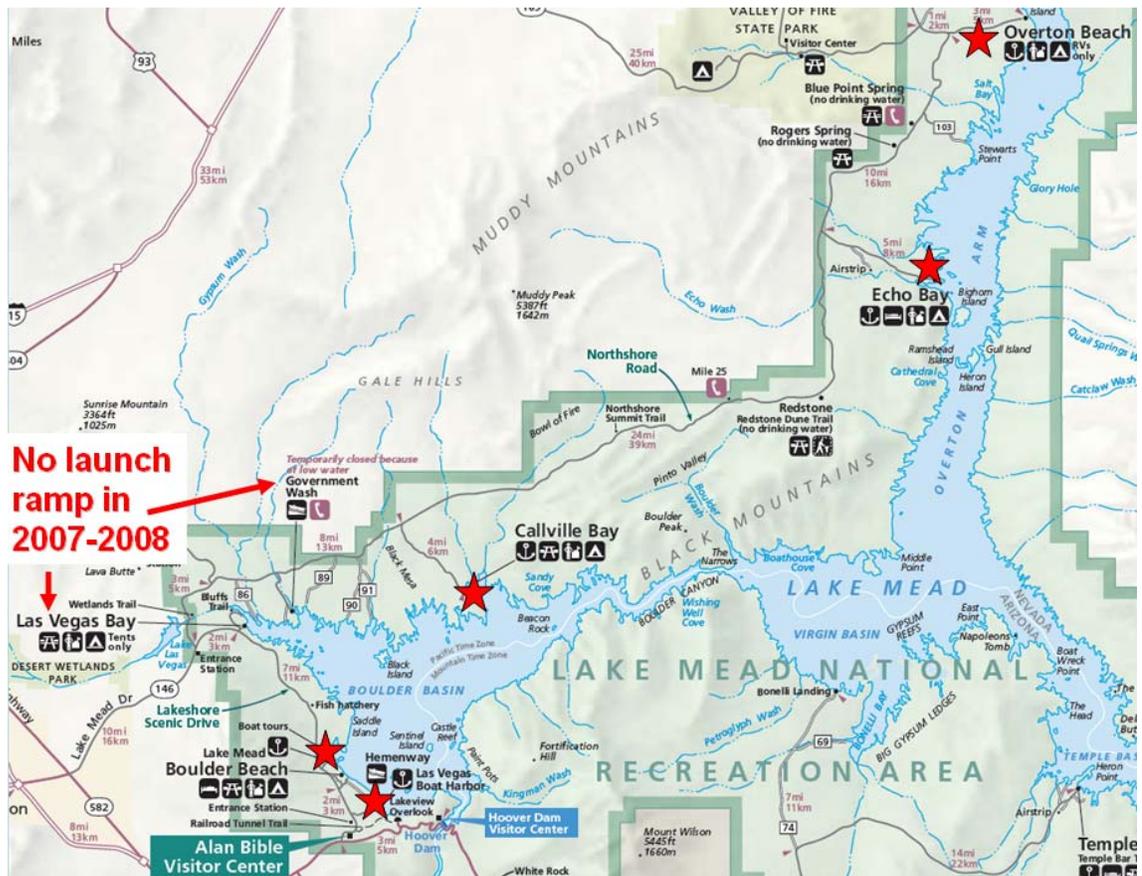


Figure 1. Locations of 100th Meridian Surveys at Lake Mead 2007-2008. Interview surveys were conducted at locations indicated by stars: Hemenway Harbor, Boulder Beach, Callville Bay and Echo Bay. Mail-in surveys were distributed and trailer license plate states were documented at these locations plus Overton Beach. Map source: <http://www.nps.gov/lame/planyourvisit/maps.htm>.

Trailer Counts

In the parking lots of the launch ramps and marinas (n=5), researchers documented the state of origin of boat or Personal Water Craft (PWC) trailers and recorded the counts on the 100th meridian official sheet (Appendix). A review of boater destinations after their time at LMNRA was used to determine if currently non-infested waters are at high risk for contamination.

Statistics

Contact survey data were used to create contingency tables to further understand the relationships between boater types and cleaning habits and boater types and quagga mussel awareness. Contingency tables were also created to compare expected and observed trends of awareness and cleaning habits in 2003 vs. 2007-2008. Chi-square analyses were conducted on these contingency tables using SPSS version 16.0 to compare the observed and expected frequencies at the significance level $p \leq 0.05$. In the event of a cell in the contingency table containing an expected count less than 5, the likelihood ratio statistic (G^2) was reported; otherwise the chi-square statistic (χ^2) was reported.

Results

Contact Surveys

Contact surveys began on 25 Oct 07 and continued through 01 Sept 08 culminating in a total of 236 surveys were completed, while 31 people declined to participate. The surveys were administered at launch ramps at Echo Bay (n=23), Callville Bay (n=60), Boulder Harbor (n=109) and Hemenway Harbor (n=44). Most of the boaters interviewed owned pleasure boats (69%), others had angling boats (21%), some had PWCs (7%) and 3% owned a craft classified as “other.” The boaters were primarily from Nevada (n=192), but there were some from out-of-state: CA (n=22), UT (n=7), AZ (n=6), WY (n=2), WA (n=2), LA (n=1), IL (n=1), MI (n=1), OK (n=1) and PA (n=1). Most boaters (86.4%) said they clean their boats between launchings and 18% of boaters had no awareness of zebra or quagga mussels or any other aquatic nuisance species.

Approximately 61% (n=145) of boaters interviewed said they only launch in Lake Mead, and had no plans to launch in any other body of water.

When comparing mussel awareness between boater types, no significant difference was found ($G^2=1.028$, $p=0.794$). All boat owners had the same level of quagga and zebra mussel knowledge. The cleaning habits of different types of boat owners was significantly different ($G^2=13.120$, $p=0.004$). Boat owners with a craft classified as other cleaned at a significantly lower frequency than boat owners with an angling boat, pleasure boat or PWC.

Significantly more boaters interviewed in 2007 or 2008 always launched their boats in Lake Mead than boaters interviewed in 2003 ($\chi^2=18.668$, $p<0.001$). The chi-square analysis determined that boater cleaning habits did not change between the study years ($\chi^2=0.949$, $p=0.330$). Mussel awareness increased significantly overall from 2003 to 2007 and 2008 ($\chi^2=106.5$, $p<0.001$).

Mail-in Surveys

Mail-in surveys were placed on windshields of vehicles with trailers attached from 10 Nov 07 through 14 Feb 09 at five launch ramps throughout LMNRA. Of the 888 surveys distributed, 57 were returned for a 6.4% return rate. The majority of people that returned the survey were from Nevada (62.5%; n=35), but others were from CA (n=10), UT (n=4), ID (n=2), AZ (n=2), WI (n=1), ND (n=1) and MT (n=1). Pleasure boats were the most common type of boat owned (54.8%; n=34), followed by angling (35.4%; n=22) and PWC and other were both at 4.8%. Only two (3.5%) participants had no prior knowledge of zebra or quagga mussels; 81% of boaters cleaned their boat between launchings; and 56% only launch their boats in Lake Mead.

Trailer Counts

A total of 1864 trailer license plate state of origins were recorded from 12 Nov 07 to 28 Feb 09. Figure 2 gives detailed geographic distributions of boaters found at Lake Mead. Briefly, 97% of states documented were Nevada (64.9%), California (26.1%), Utah (3.1%) or Arizona (3.0%).

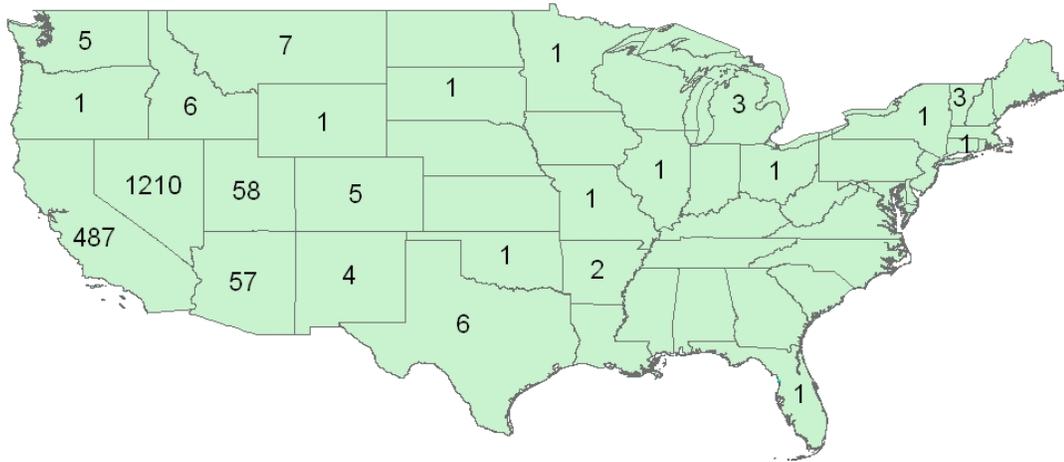


Figure 2. Trailer count distribution. All but seven of these states currently have a quagga or zebra mussel infestation (ID, MT, NM, OR, TX, WA, WY).

Discussion

It is of the utmost importance for people to clean, drain and dry their boats after each launch into a body of water due to the fact that mussels have been found to survive out of water for more than 10 days at less than 15°C and high humidity (Britton and McMahon 2005). This may allow live, adult mussels to be transferred to non-infested bodies of water and dominate the aquatic system. Theoretically, it only takes two

mussels to produce millions of veligers leading to exponential growth and colonization in a new environment. Boater surveys and boater education may assist in the prevention of invasion and the prediction of where the next infested body of water may be.

This study found that a large percentage of boaters (81%) clean their boats after each launch, and this may contribute to the prevention of the spread of aquatic invasive species. Different boaters may have different perspectives on what “clean” exactly means. An additional question was added to the survey to gain an improved understanding of a boater’s definition of “clean.” If a boater answered that they cleaned their boat after each use, survey administrators then asked how they cleaned their boat. There were a wide variety of answers, but the most common answers were: wipe down or dry boat after use (25%), use soap and water (19%), use a vinegar and water solution to wash boat (16%) or use a pressure wash (15%). Other answers included: rinsing off boat with a hose, taking the boat to a carwash, using bleach, or spraying down boat with Pink Stuff, Windex or Simple Green. According to www.ProtectYourWaters.net, an informative boater website ran by the USFWS, a boat should be cleaned using the following procedure: 1) remove all visible mud, plants, and fish or animals from the boat, trailer and all equipment; 2) eliminate water from all equipment; and 3) clean and dry anything that came into contact with the water with a 100% vinegar solution or a salt solution or with water that is at least 104°F (40°C) (USFWS 2009).

The hypothesis that angling boaters have an enhanced awareness of mussels than other types of boaters was rejected. All types of boaters were found to have the same amount of prior knowledge about zebra and quagga mussels. A large portion of boaters (61%) interviewed only launch in Lake Mead, but this is slightly lower than the

hypothesized value of 66%. The long distances to other bodies of water in the southwestern United States may prevent people from traveling to other waters.

Between the study in 2003 and the current study, awareness increased from 35% to 82%. The increase in boater awareness in this study from the one in 2003 may be explained by an increase in press about mussels. There are signs stating “Don’t Move a Mussel Clean, Drain and Dry Your Equipment” and “Stop Aquatic Hitchhikers” at each entrance to the park and at every launch ramp. Numerous newspaper articles and television interviews have been conducted on the serious problems quagga mussels have on the lake since the discovery of the quagga mussel in Lake Mead in January 2007.

The most popular destination for boaters after launching in Lake Mead was Lake Mohave (n=29). Lake Havasu was second (n=25) and Lake Powell in Utah was third (n=8) according to the boater surveys. In the Appendix, all future destination replies are listed. Lakes Mohave and Havasu already have quagga mussel infestations, but Lake Powell does not. Officials at Lake Powell should be ready for an influx of boaters coming from Lake Mead and be prepared to inspect boats for aquatic invasive species to protect Lake Powell. Based on the trailer counts, most boaters are coming to Lake Mead from Nevada, California, Utah and Arizona, all of which currently contain bodies of water infested with quagga mussels. These bodies of water were not infested at the beginning of this study. It is possible that boaters from Lake Mead went back to their home state and infected untainted waters.

Increased boater awareness will help prevent the spread of aquatic invasive species and the 100th Meridian Initiative is an excellent way to not only educate boaters, but also to collect relevant data on future mussel invasions. The results from this study

will assist lake managers and operators in deciding the course of preventative action they need to take to defend their lake against invaders. Due to 19% of people interviewed not aware of zebra or quagga mussels, this education/research initiative should be continued to ensure the protection of other lakes from the damages of aquatic invasive species. The study conducted by Britton and McMahon (2005) identified “high-risk” bodies of water for mussel invasion, informed lake officials, and helped to prepare lakes for invasion. This preparation saved the park money and raised invasive species awareness. The preservation of natural waters is vital for the conservation of native species and the prevention of quagga mussel invasions will assist in this preservation.

Acknowledgements

The United States Fish and Wildlife Service through the Western Regional Panel for Aquatic Invasive Species funded this project. Lanisa Pechacek and Joanna Kramer assisted in administration of surveys.

Appendix

100th Meridian Survey Materials

Contact Survey

Zebra Mussel **100TH MERIDIAN INITIATIVE TO PREVENT THE WESTWARD EXPANSION OF ZEBRA MUSSELS**
Interview Form for Trailered Boat Survey



Interviewer: Last name		First name			
Date:		Time:		AM / PM	
Water Body:			State:		
Launch Site:			Survey Type: <input type="checkbox"/> Contact <input type="checkbox"/> Observation		

Where are you from?

Home State:		Zip Code:		Personal <input type="checkbox"/> Type of Transport	
How many times have you launched in the last year?				Commercial <input type="checkbox"/> ↓	
Do you always launch in the same water body? Yes <input type="checkbox"/>				Other <input type="checkbox"/> explain	
Type of Boat: <input type="checkbox"/> Angling <input type="checkbox"/> Pleasure <input type="checkbox"/> Jet Ski <input type="checkbox"/> Canoe <input type="checkbox"/> Other explain					

Where else have you launched recently?

Water Body:	State:	County:	Date:
1.			
2.			
3.			

Where will you launch next?

Water Body:	State:	County:	Date:
1.			
2.			

Do you clean your boat and trailer between launchings? <input type="checkbox"/> Yes <input type="checkbox"/> No <i>if so, how?</i>
Is your boat kept on land or in water when not in use? <input type="checkbox"/> On Land <input type="checkbox"/> In Water
If in water, where is it kept? Water body: For how long? State:

Do you know the approved method to clean your vessel?
Information Exchange: Viewed? Read? Both? Boater asked questions
 Boater already aware of threats of... Zebra Mussels Any ANS

Boat Inspection Results: Inspection Rejected
 Nothing Found: Undertaken by: Party Interviewer Both

	Zebra Mussels	Still Alive	Vegetation	Other Exotics	Describe Other	Action Taken
Boat Deck	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Boat Hull	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Bilge & Bait Wells	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Motor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Trailer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Fishing Equipment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		

Comments:

Mail-in Self Survey

LOCATION _____ STATE _____ DATE _____



The Zebra Mussel

100th MERIDIAN INITIATIVE TO PREVENT THE WESTWARD EXPANSION OF ZEBRA MUSSELS BOATER SELF-SURVEY

The 100th Meridian Initiative is a multi-agency partnership effort to prevent the westward spread of zebra mussels and other aquatic nuisance species to western North American waters. The U.S. Fish & Wildlife Service is sponsoring and coordinating education outreach and voluntary trailered boat surveys with other agencies in the states on the 100th meridian. Surveys similar to this are being conducted in Texas, Oklahoma, Kansas, Nebraska, South Dakota, North Dakota and the Canadian Province of Manitoba. This survey is now being extended to the Colorado River. You as a boater are being asked to voluntarily inspect your trailer, boat and related equipment for any transported aquatic species, such as the **zebra mussel**, which may be carried accidentally to new locations. Your assistance and participation is appreciated in completing this survey and returning it in the provided, stamped envelope to the agency that is conducting this survey for the U.S. Fish and Wildlife Service. Please review the enclosed information on introduced aquatic species and boat and trailer inspections. Be sure to clean your boat, trailer and equipment after hauling-out the boat and before leaving the ramp area. Thanks for your help!

The following instructions will help you complete the survey.

Part One – Where are you from? (Any information provided is voluntary and anonymous.)

Please state the purpose of your visit, and fill in the boxes relating to your boat and home state. Your most recent launches are very important information, so please be as complete as possible.

Part Two – Where are you going?

Please indicate where you will be launching next after you leave this lake. Do not list further launchings at this lake. Again, please be as complete as possible in filling out this section.

Part Three – Returning the survey.

That's all there is to it! All you need to do is place this page in the provided, stamped, return envelope, seal it, and drop it in the mail.

SURVEY INFORMATION (Please Print)

PART ONE: Where are you from?	Home State:	Zip Code:
Type of Boat:	<input type="checkbox"/> Angling <input type="checkbox"/> Pleasure <input type="checkbox"/> Jet Ski <input type="checkbox"/> Canoe <input type="checkbox"/> Other	explain

How many times have you launched in the last year?			
Do you always launch in the same water body? <input type="checkbox"/> Yes <input type="checkbox"/> No			
If no, please list below where else you have launched recently.			
Water Body:	State:	County:	Date:
1.			
2.			
3.			

PART TWO: Where are you going? Please list below where you plan to launch next.			
Water Body:	State:	County:	Date:
1.			
2.			

Are you already aware of threats of zebra mussels? <input type="checkbox"/> Yes <input type="checkbox"/> No	
Or any other aquatic nuisance species? <input type="checkbox"/> Yes <input type="checkbox"/> No	
Do you clean your boat and trailer between launchings? <input type="checkbox"/> Yes <input type="checkbox"/> No	
Is your boat kept on land or in water when not in use? <input type="checkbox"/> On Land <input type="checkbox"/> In Water	
If in water, where is it kept? Water body:	State:
Any Comments:	

Trailer Count Form



Zebra Mussel

**THE 100TH MERIDIAN INITIATIVE TO PREVENT THE WESTWARD SPREAD OF ZEBRA MUSSEL
TRAILER COUNTS FOR LAUNCH AREAS & RELATED FACILITIES**

Surveyor: last _____ first _____	Date: _____	Time: _____	am / pm
Location: _____	State: _____		

LIST STATES AND NUMBERS OF TRAILERS COUNTED

	(Your State)	States and Numbers of Trailers								
SITE										
TOTALS (by state):										
TOTAL (All):						Your State		TOTAL (from your state)		
TOTAL (Out of State):						Percent Out of State:				
Self-Interview Forms Distributed:										

Organisms:

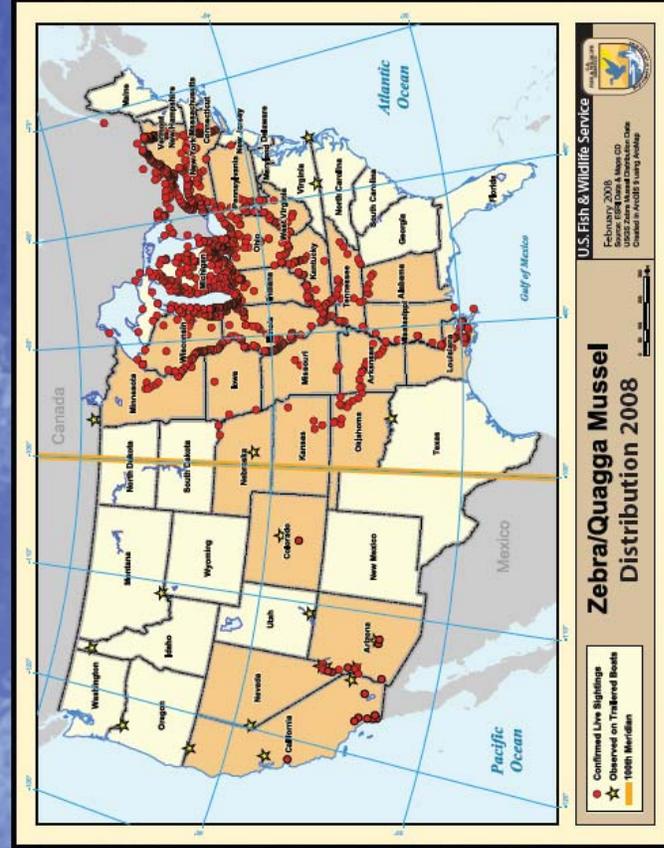
Nothing Found: <input type="checkbox"/>	Zebra Mussels: <input type="checkbox"/>	States of Origin: _____
	Vegetation: <input type="checkbox"/>	States of Origin: _____
	Other: <input type="checkbox"/>	States of Origin: _____

If other is checked indicate types of organisms found: _____

Invasive Mussels: Expensive Damage
 When zebra or quagga mussels invade our local waters, they clog power-plant and public-water intakes and pipes. Routine treatment is necessary and very expensive: this leads to increased utility bills. If you use water and electricity, then you do not want zebra/quagga mussels!



Zebra/Quagga Mussels May Use Your Boat to Invade Additional Waters
 If your boat has been in infested waters, it could be carrying invasive mussels. These creatures usually spread to new habitats on boats trailered by the public or by commercial haulers. Zebra and quagga mussels attach to almost anything: boats, aquatic plants, bait buckets, and other aquatic recreational equipment. You could unintentionally transport microscopic mussel larvae in water in your live well or bilge. An adult female zebra mussel can release up to 1,000,000 eggs in a lifetime. Please take the precautions outlined in this brochure to reduce the chance that zebra or quagga mussels will spread to uninfested areas.



Zebra/Quagga Mussels Harm Native Aquatic Life



Zebra/Quagga Mussels Encrust Any Hard Surface



What are they?

Zebra and quagga mussels are invasive freshwater mollusks (clams) that infest waters in large numbers, attaching to any hard surface.

Where do they come from?

Black and Caspian Sea drainages in Eurasia.

What size are they?

From microscopic up to about two inches long—usually found in clusters.

Why “zebra” mussels?

These species are both sometimes referred to as “zebra” mussels because they have light and dark alternating stripes. Quagga mussels are actually a separate (but similar) species named after an animal related to zebras.

Boater Destinations After Leaving Lake Mead

Water Body	State	Number of people
Lake Mohave	AZ	29
Lake Havasu	AZ	25
Lake Powell	UT	8
Clear Lake	CA	2
Lake Alamo	AZ	2
Lake Piru	CA	1
Catalina Island	CA	1
Lake Pleasant	AZ	1
San Vincinta	CA	1
Pangwich	UT	1
Apache Lake	AZ	1
San Halo	UT	1
San Dimas	CA	1
Isabel	CA	1
Minorsville	UT	1
Pittsburg	CA	1
Flaming Gorge	UT	1
Buffalo Bill Reservoir	WY	1
Baja	CA	1
Long Beach	CA	1
Big Bear	CA	1
Puget Sound	WA	1

References

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