

Draft
**Guidelines to Reduce the Risk
of Quagga/Zebra Mussels
in California Aquaculture**

Workshop Report
California Department of Fish and Game
2008



Cover photos courtesy of Dennis Faria and Devin Bartley
Photo of fish hauling © Dennis Faria
Photo of fish tanks © Devin Bartley
Background photo © Devin Bartley

Copyright reserved by the California Department of Fish and Game. Permission is granted to aquaculture facilities, public agencies and educators to reproduce and distribute for non-commercial purposes.

Draft

**Guidelines to
Reduce the Risk of Quagga/Zebra Mussels
in California Aquaculture**

Compiled by

**Devin M. Bartley, Heather McIntire and Martha Volkoff
with assistance from workshop participants**

Cover photos courtesy of Dennis Faria and Devin Bartley

**California Department of Fish and Game
2008**

TABLE OF CONTENTS

| | |
|--|----|
| Background | 1 |
| Basic quagga/zebra mussel biology and tolerances | 1 |
| Aquaculture and quagga/zebra mussels in other states | 2 |
| Overview of the guidelines | 3 |
| Draft Guidelines | 5 |
| <i>I. If your facility is in an infested county</i> | 5 |
| Identify risk | 5 |
| Develop HAACP | 5 |
| Monitor and report | 5 |
| Treat intake water | 7 |
| Treat transport water | 7 |
| Develop an on-farm water management plan | 8 |
| Develop low risk delivery procedures | 8 |
| Clean and dry equipment | 9 |
| <i>II. If your facility is in an uninfested county</i> | 9 |
| Develop HAACP | 9 |
| Monitor and report | 9 |
| Treat | 9 |
| <i>III. If mussels are found</i> | 10 |
| <i>IV. Importation of fish from out of state</i> | 10 |
| <i>V. Spread the word</i> | 10 |
| VI. Monthly Record Keeping for Quagga/Zebra Mussel Monitoring and Reporting | 12 |
| Appendices | |
| I. Treatments to reduce the risk of spreading quagga/zebra mussels | 14 |
| II. Contacts and on-line information sources | 16 |
| III. List of participants | 18 |

Background

As part of a state and federal response to the invasion of quagga and zebra mussels in California, aquaculture staff, the Fisheries Branch and the Invasive Species Program of the California Department of Fish and Game organized and convened a workshop to:

- increase general awareness of the risks that the quagga and zebra mussels pose to California aquaculture;
- examine practical means to reduce the risk of spreading the mussels to and from aquaculture facilities; and
- develop practical and effective aquaculture guidelines.

These guidelines are based on currently available information presented at a workshop convened by the California Department of Fish and Game June 11-12, 2008, at the University of California Riverside, Palm Desert Campus, Palm Desert California. The participants of the workshop helped develop the guidelines and approved the contents. It is recognized that as information on treatment, impacts, and distribution of the mussels improves, the guidelines will evolve to reflect the best available information.

Quagga (*Dreissena bugensis*) and zebra (*D. polymorpha*) mussels arrived in the Great Lakes from European waters via ballast water in the 1980's. Since that time, they have spread to many eastern rivers, canals and water bodies causing billions of dollars of damage to the environment and water delivery facilities. These mussels have moved westward. Quagga mussels were found in Lake Mead Arizona in early 2007 and have since spread throughout the Colorado River system; in the summer of 2007 they were found in the Colorado River Aqueduct and are now in several water bodies in California. In January 2008, zebra mussels were found in San Benito County, California. The most likely mechanism for transfer between non-contiguous water bodies in the US is through contaminated boats. Introduction can occur when adult mussels are brought on boat hulls or through veliger-infested water contained in bilges, motors or trailers.

To date no quagga/zebra mussels have been found in any California aquaculture facility, nor has aquaculture in other parts of the USA been implicated in the spread of quagga or zebra mussels. However, the potential for aquaculture operations to become infested and/or spread invasive mussels exists.

Basic quagga/zebra mussel biology and tolerances

The zebra and quagga mussels are small (< 2 inches), freshwater mussels which usually have alternating dark and light brown stripes, but can also be solid light or dark brown. The mussels are very similar to each other, but quagga mussels have wider environmental tolerances. These mussels are only found in freshwater (< 2 parts per thousand salinity); zebra mussels usually occur at depths of 2 to 7 meters but quagga mussels can occur in much deeper waters (to 400 m). A single female can produce millions of eggs. Upon hatching, planktonic larvae called veligers float in the water

column until settling out and attaching to a hard substrate after one to several weeks, depending on temperature and food availability.

Juvenile and adult quagga/zebra mussels can survive temporarily in unfavorable conditions because of their ability to “close up”. However they can be killed by temperatures below 0° C and above 30° C and salinities above 15ppt. Their lower oxygen requirement appears to be around 4mg/l at 18° C (Table 1).

Table 1. Basic quagga/zebra mussel tolerances

| | |
|----------------------------|--|
| Temperature – lower limits | Mussels do not survive freezing. Gametogenesis does not occur < 2° C; 10-12° C lower limit for spawning, based on literature review |
| Temperature – upper limits | 24° C zygote mortality; 30-32° C lethal to adults or veligers; 100% mortality at 40° C |
| Salinity | Depends on temperature and acclimation, but salinities > 15ppt were lethal |
| pH | 6.5 to 9.5 |
| Dissolved oxygen | 4 mg/l lethal lower limit for adults at 18° C; 1.5 mg/l perfectly unsuitable |
| Out of water time | Depends on temperature, veligers die after a few hours, juveniles after a few days, but adult mussels may be able to last 21 days under ideal conditions |

Aquaculture and quagga/zebra mussels in other states

Although quagga/zebra mussels have established in fish farms outside of California, in only a few instances have they caused significant problems to fish farmers. Apparently, these invasive mussels do not readily establish in fish farms in infested areas, possibly due to high concentrations of mussel predators (e.g. catfish, cyprinids, trout), type of rearing system (raceways seem to be more vulnerable to infestation than ponds), water temperatures that are lethal to the mussels and basic good farming practices.

This is encouraging news for California fish farmers. However, California should not be complacent; the situation could be different for California farming systems, the species farmed and California’s climate. Some aquaculture facilities outside of California that have become infested have been forced to cease operations and undergo expensive changes to their water supply system to ensure that mussels will not be re-introduced to their facilities. Therefore, members of the aquaculture industry, food fish purchasers, and the California Department of Fish and Game developed the following guidelines to ensure that these invasive species do not adversely impact the industries and natural resources of the state.

These guidelines are for California aquaculture facilities and will form an important part of a quagga mussel management plan for California aquaculture and the California Aquatic Invasive Species Management Plan (January 2008).

Overview of the guidelines

Quagga/zebra mussels are in some waters within California, therefore there is a risk that they may enter aquaculture facilities and be spread unless actions are taken. However, not all farms face the same risk, and an individual farm's risk will change over time as the mussels spread.

To date, no mussels have been found in California aquaculture facilities. Aquaculture has also never been implicated in the spread of quagga or zebra mussels. However, aquaculture may potentially spread the mussels; therefore, state regulatory agencies and the aquaculture industry are taking pro-active steps to reduce the risk of acquiring and spreading these mussels.

These guidelines are at present *draft guidelines*; they are voluntary and rely on individual farms to:

- assess their risk of acquiring and spreading the mussels,
- monitor and report presence and absence of the mussels,
- take precautionary measures in high risk areas,
- take appropriate action if an infestation is found, and
- spread information on good farming practices throughout the industry.

Purchasers, including the Department of Fish and Game, that purchase live fish from California's aquaculturists need to be assured that there is minimal risk of receiving these mussels. It is reasonable to assume that purchasers, who may have options as to where they buy fish, may prefer to do business with farms that adhere to these guidelines and can demonstrate good farming practices. By following these guidelines the risk of spreading the mussel will be greatly reduced, facilities can continue to distribute and receive product, and aquaculture's good record will be maintained.

These guidelines provide a risk-based approach to managing quagga/zebra mussels, that includes development of a Hazard Analysis and Critical Control Point (HAACP) plan. The basic elements of the guidelines are listed below, with more detail in the following section.

For facilities in infested counties:

- Facilities within infested counties but that have not found mussels at their facility or in their water supply should, at a minimum, conduct regular monitoring and reporting.
- If mussels are found in the immediate water supply of a farm, at a minimum a water management plan should be developed, transport water must be treated and regular monitoring and reporting should be conducted.
- If mussels are found in a facility, then disinfection, quarantine and other measures as appropriate must be taken.

For facilities in un-infested counties:

- Facilities should develop HAACP.
- Facilities should conduct regular monitoring and reporting.
- Treat as appropriate.

Actions a farm must take will depend on the level of risk and the distribution of the invasive mussels. Actions will change as the distribution of the mussel changes.

Draft Guidelines

The first step is to determine if your aquaculture facility is in a county where the mussels are present. Quagga mussels have been found in the following counties: San Bernardino, Imperial, San Diego, Orange, and Riverside. These counties receive Colorado River water and are infested with quagga mussels. In addition, zebra mussels have been found in one reservoir in San Benito County. An updated map of mussel sightings is available at <http://nas.er.usgs.gov/taxgroup/mollusks/zebramusel/maps/CaliforniaDreissenaMap.jpg>.

I. If your facility is in an infested county you should take the following steps:

- **Identify Risk** – Determine potential pathways for mussels to enter your facility, including:
 - *Source water* – Determine if your source water is mussel-free.
 - *Incoming transport water* – Determine if your supplier is mussel-free or if the supplier ensures veliger-free transport water.
 - *Delivery equipment* – Determine if equipment used to deliver fish is at risk of contamination.
 - *Other pathways* – Determine if there are other pathways that mussels might enter your facilities.

- **Develop a HAACP** – A Hazard Analysis and Critical Control Point (HAACP) plan should be specific for your aquaculture facility. A HAACP plan is a framework that defines in operational terms how a farm will analyze and deal with the potential risk of spreading the mussels. The items described below should be made explicit for specific facilities and would form the HAACP plan. General guidance on HAACP is provided at <http://seagrant.umn.edu/ais/haccp>.

- **Monitor and Report** – Identification of mussels and likely distribution pathways, monitoring presence and absence of the mussels, and reporting this information to a central location are important factors in evaluating the risk posed by this invasive species.
 - *Monitoring*
 - Learn to identify quagga/zebra mussels
 - Identify critical control points (CCP's) on your farm. These are areas where mussels are likely to enter, attach and grow, and where the mussels can be monitored and treated. Mussels prefer dark areas, flow rates of 1-6 feet/sec and hard substrates including pumps, pipes, aerators, raceways and equipment. Simple structures such as “test plates” can be placed in water supply canals, ponds or other waterbodies to help detect the presence of veligers by providing a place for them to settle. These may be placed at various locations within a farm or just outside a farm if water districts permit.

- Routine on-farm sampling of water for veligers is not practical for most farms because it requires special expertise or costly laboratory analysis to detect and identify planktonic veligers. If veligers are suspected to be present, a laboratory experienced in their detection should be contacted to devise a sampling and diagnosis plan.
- Monthly monitoring of CCP's for presence of juvenile and adult mussels should be a routine part of good farming practices. If mussels are detected, the Department of Fish and Game and local water districts should be notified immediately (see below).

For more information/assistance on setting up a monitoring program contact the DFG Quagga Mussel expert in your region (Appendix II).

Quagga Mussel
Dreissena bugensis



- Shell: D-shaped and triangular; fragile; smooth or shallowly ridged; solid light to dark brown or dark concentric rings; paler near hinge.
- Will not sit flat on ventral side (arrow).
- Attaches to hard and soft surfaces.

Zebra Mussel
Dreissena polymorpha



- Shell: D-shaped and triangular; thin and fragile to thick and sturdy; smooth or shallowly ridged; solid light to dark brown or striped.
- Sits flat on ventral side (arrow).
- Attaches to hard surfaces.



Color variation in mussels (left and center). Substrate sampling plates (right).

From the California Department of Water Resources *Monitoring Instructions for Zebra/Quagga Mussel Plate Samplers*, April 2, 2008

○ *Reporting*

- Aquaculture facilities should submit monitoring results to the Aquaculture Coordinator on a quarterly basis. A standard reporting

format has been developed by the Department and industry and is attached. **ATTENTION: it is important to document the ABSENCE of mussels as well as to report if any mussels are found.**

- Information submitted by farms will be used in a restricted database maintained by the California Invasive Species Program in order to help the state map the distribution of the mussels. The information from individual farms will not be available to the public. If a farm reports the presence of the mussels, the Aquaculture Development Committee and the Aquaculture Disease Committee will be notified and an appropriate course of action will be determined that will protect both industry and the environment (Section III).
- **Treat intake water** – Using untreated surface water known to contain mussels poses a high risk of acquiring mussels. If the farm has a high risk of encountering veligers in intake water, precautionary measures should be followed. Where possible, consider options such as using ground water, or filtration or sterilization of intake water to remove veligers. Farms should develop a water management plan (see below) that identifies treatment options. Filtering large quantities of water is expensive and sometimes impractical. A water management plan identifies options for when and where water entering the facility could be treated. For example, it could identify periods when lower water volumes are needed and how they could be treated effectively. Filtering options might include:
 - Sock filters for intake for ponds
 - Drum filters
 - Sand filters

Sterilization by ozone or hydrogen peroxide may be effective; however, may not be practical on large volumes of water. Heat treatment to temperatures above 90°F will kill veligers, but higher temperatures for longer periods of time are required to kill juveniles and adults.

Farms are encouraged to use a variety of options as operations and circumstances permit.

- **Treat transport water** – Managing transport water for farms in infested counties is an essential component of these guidelines. Farms in infested counties will have a high risk of introducing veligers into their farm. Although the use of ground water is less risky than using untreated Colorado River water, animals, birds, equipment and people can still transport veligers to farms that use ground water. The level of treatment of transport water will depend on the facility's risk.
 - **Ground water** – Where possible and practical farms should use fresh ground water that has not been part of the production process for transporting live fish.

- **Filtration** – Where ground water is not available, the use of filters such as portable sand filters is recommended. Filters should be designed to remove particles to 10 microns (veligers can be as small as 32 microns) (Appendix I). Specific protocols for filtration are being researched and tested by California fish farmers to determine how they will work in the state.
- **Chemicals** – In other States the use of certain chemicals has been effective at killing veligers and not harming fish during transport (Appendix I). Specific protocols for chemical treatment are being researched and tested by California fish farmers to determine how they will work in the state. Discharge requirements are also being examined
- **Combination of filtering and chemical treatment** – For facilities that have a high risk of passing veliger larvae, a combination of filtering and chemical treatment should be undertaken (Appendix I).
- **Develop an on-farm water management plan** – A water management plan can reduce the risks of veligers entering a farm through intake water and then spreading within a farm’s water distribution system. The water management plan will be essential in developing a farm specific HAACP.

A water management plan is operational actions to reduce veliger introduction, survival and distribution and could include:

- **Intake water** - Reducing intake during times of year when veligers are abundant in supply source of water, e.g. recirculate more during periods of high larval abundance. This may allow for increased practicality and effectiveness of filtration and sterilization.
- **Water temperature** - Maintain water temperatures that are lethal to veliger larvae. Larvae cannot tolerate temperatures above 90°F or below freezing for extended periods of time. Through recirculation, heating/cooling, or other means, farms can create conditions that will prevent veliger survival.
- **Pond management** - Fallowing and drying ponds, raceways, pumps and water supply lines to prevent veligers from settling and growing.
- **Quarantine** - Isolating growing systems that become infested.
- **Develop low-risk delivery procedures** – Mussels may be transported to or from a water body by water and equipment during delivery. Because fish may be delivered to water bodies in infested counties, there is a risk of bringing veligers from an infested waterbody back into the aquaculture facility on transport vehicles and equipment.

- **Transport water** - For many deliveries of live fish, transport water is released along with the fish into the receiving waterbody. Therefore, clean or filtered transport water (above) is recommended.
 - **Stocking** - When stocking, transport vehicles and personnel should avoid contact with receiving waterbodies.
 - **Fish acclimation (tempering)** - When stocking a potentially infested waterbody do not acclimate fish prior to stocking by adding water from the receiving waterbody to transport containers. If acclimation is necessary, clean and dry all transport equipment once fish have been stocked.
 - **Equipment** - Transport containers and equipment should be cleaned and dried following fish release.
- **Clean and dry equipment** – Mussels can be transported on and in production, transport and personal equipment. Anything in the aquaculture facility that would provide mussels a substrate to settle on or where water can collect should be cleaned and dried. Hot water (140°F) high pressure washing is effective at killing mussels; chlorine is also effective. All water and foreign material such as plants and garbage should be removed from equipment. Production equipment to be inspected and cleaned could include: aerators, floats, nets, pumps, inlet and outlet structures, fish screens, fish pumps, etc. Transport equipment includes trucks, tanks, trailers, nets, etc. Personal equipment includes waders, boots, gloves, etc. HAACP Training Manual (<http://seagrant.umn.edu/ais/haccp>. See appendix 1 starting on page 42) has additional information on cleaning equipment.

II. If your facility is in an uninfested county there is still a risk that the mussels could be introduced to your farm.

Aquaculture facilities in uninfested counties should take the following steps:

- **Develop a HAACP** - A Hazard Analysis and Critical Control Point plan should be specific for your aquaculture facility. This will include identification of possible sources of the mussels from outside your area (e.g. do you purchase fish from an infested area?), how they may be introduced to your facility and what steps your facility may take to prevent infestation or spread.
- **Inspect and report** - Learn to identify quagga/zebra mussels and make regular inspections of your farm. Use the reporting form included here and mail to the Aquaculture Coordinator even if you have found no mussels.

- **Treat** - Treat water, fish and equipment as described in these guidelines if personnel, equipment or vehicles from your facility come in contact with water from an infested county.

III. If mussels are found

Although these guidelines are at present voluntary, it is a violation of Title 14 (671) and the Fish and Game Code (2301) to possess, import, transport or introduce quagga/zebra mussels. If mussels have settled on structures within the farm or on equipment, the following additional actions to treat the infestation must be taken:

- **Stop** all transport of live fish.
- **Notify** the Department of Fish and Game and local water district immediately.
- **Notify** customers that may have received infested fish.
- **Isolate** the infested area or equipment from the rest of the farm.
- **Treat** infested facilities and equipment (see Appendix I).

The Aquaculture Development Committee and the Aquaculture Disease Committee will be notified and an appropriate course of action will be determined that will protect both industry and the environment. In evaluating treatment the Department and the above advisory committees will consider the level of infestation on the farm and treat these mussels similarly to a disease or pathogen.

IV. Importation of fish from out of state

Some groups import fish from areas that are known to have quagga/zebra mussels; to date this has not resulted in any known occurrence of the mussels in California. In evaluating importation of fish from these areas the Department will consider these mussels in a similar manner to a disease or pathogen that could endanger the businesses or resources of the state. However, farmers can also reduce the risk by requesting that out of state suppliers provide information on their mussel management and prevention program and by purchasing fish from those suppliers that follow better management practices and can demonstrate they do not transport the mussel.

V. Spread the word

Aquaculture facilities should regularly check with local water boards, irrigation districts and the Department of Fish and Game regional biologists on the current status of the of the quagga/zebra mussels (see appendix II) .

There are over 200 registered aquaculture facilities in California; most of them are small companies selling less than \$25,000 worth of product. Larger companies that have access to current information and can attend workshops on preventing the spread of the

mussels should pass on such information as widely as possible. When selling, distributing or buying fish, share these guidelines and inform colleagues on how to identify the mussels and the simple and effective means to avoid spreading them.

MORE INFORMATION CAN BE FOUND AT
<http://www.dfg.ca.gov/invasives/quaggamussel/>

Or by contacting

Devin M. Bartley, PhD
Aquaculture Coordinator
California Department of Fish & Game
1416 9th Street
Sacramento, CA 95814
dbartley@dfg.ca.gov
(916) 651 7824

and

Martha Volkoff
Statewide Quagga/Zebra Mussel Monitoring Coordinator
Invasive Species Program
California Department of Fish & Game
1416 9th Street, 12th Floor
Sacramento, CA 95814
mvolkoff@dfg.ca.gov
(916) 651-8658

and

Appendix II of these guidelines

VI. Monthly Record Keeping for Quagga/Zebra Mussel Monitoring and Reporting

Voluntary Quagga/Zebra Mussel Monitoring Form

Name of Operation _____

Owners Name _____

Aquaculture Registration Number: _____

County _____

Town/City _____ ZIP _____

Phone Number () _____

Monthly Inspection Dates _____
(Farms should monitor monthly and report quarterly)

No mussels found

Mussels found

Discovery Date: _____
(Contact Aquaculture Coordinator immediately)

MUSSEL DISCOVERY- ADDITIONAL INFORMATION

Water Source: _____

Where Inspected: (Check all that apply)

Standpipe Screen Aerator Float

Plants Filter Equipment Boat/Trailer

Ponds Vats Tanks

Other _____

Type of Substrates: (Circle all that apply)

Concrete Metal PVC Plant Wood Plastic

Adult Mussel Found:

Monthly Record Keeping for Quagga/Zebra Mussel Monitoring and Reporting
Voluntary Quagga/Zebra Mussel Monitoring Form - continued

Possible source of introduction (For previous 6 to 12 months)

Possible introductions to other ponds/facilities/waterbodies:

Actions Taken:

Effectiveness:

Collected by _____

Identified by _____

Comments, Notes or Map:

Comments could include for example, estimated mussel density or size, water temperature, DO, water quality information, were fish present and at what density

Please send completed form to:

Devin M. Bartley, PhD
State Aquaculture Coordinator
California Department of Fish & Game, 12th Floor
1416 9th Street
Sacramento, CA 95814
Tel: (916) 651-7824
Email: dbartley@dfg.ca.gov

(email submissions are recommended where possible)

Treatments to reduce the risk of spreading quagga/zebra mussels¹

The following treatments have been used to reduce the risk of mussel infestation in areas outside of California. ***They have not been completely tested or validated in California aquaculture conditions*** as to their efficacy in reducing quagga/zebra mussels.

Boats and field equipment

Physical treatments

- Scrubbing/scraping: juvenile and adult life stages should be scraped from any infested surface and crushed.
- Hot water: contaminated equipment should be rinsed with 140 F water for 20-30 minutes using high pressure sprayer.
- Drying: equipment should be dried for 5 days, although adults can last 21 days under ideal conditions.
- Freezing: freeze for 2 days before reusing contaminated equipment.

Chemical treatments – Efficacy of chemical treatments will depend on how they are applied and local conditions. More site specific research is needed in this area. After application, disinfectant should be properly disposed.

- 100% vinegar dip for 20 minutes
- 200-250 mg/L chlorine bleach for 60 minutes
- 250 mg/L ROCCAL (benzalkonium chloride) for 15 minutes
- 500 mg/L hydrogen peroxide for 60 minutes
- 167 mg/L formalin for 60 minutes
- 4 mg/L potassium permanganate for 60 minutes
- 1% table salt (based on 312 g per cup sodium chloride) for 24 hours

Fish Production Facilities

To remove all life stages from raceways, tanks and ponds without fish

- Drain as much water as possible and treat with:
 - 1-5 mg/l Rotenone for 24 hours, or
 - 2mg/l chelated copper for 48 hours

To kill veligers in waters without fish

- Drain as much water as possible and treat with:
 - 167 mg/l formalin, 500 mg/l hydrogen peroxide, or 4 mg/l potassium permanganate for 1 hour.

¹ From Gunderson, J.L., and R. E. Kinnunen. 2004. AIS-HAACP, Aquatic Invasive Species – Hazard Analysis and Critical Control Point Training Curriculum. 2nd Edition. Minnesota SeaGrant, Duluth, MN. www.seagrant.umn.edu.

To control veligers and settlers during transport and holding

Some low regulatory priority (LRP) chemicals that have been approved by the US Food and Drug Administration are effective prophylactics in treating mussels and will not harm fish. Local conditions will determine the effectiveness of the treatments and site specific research is needed.

- Sodium chloride
 - 10,000 mg/l for 24 hours at 12°C (**safe for:** rainbow trout, lake trout, brown trout, fathead minnow, channel catfish, smallmouth bass, bluegill, yellow perch, and walleye).
 - 20,000 mg/l for 6 hours at 17°C (**not safe for:** rainbow trout, channel catfish, bluegill, or fathead minnow).
- Calcium chloride
 - 10,000 mg/l for 24 hours at 12°C (**safe for:** smallmouth bass, bluegill, walleye and lake trout; **not safe for:** rainbow trout, channel catfish, yellow perch, or fathead minnow).
- Potassium chloride
 - 2,500 mg/l for 24 hours at 12°C (**safe for:** lake trout, rainbow trout, brown trout, channel catfish, smallmouth bass, and fathead minnow; **not safe for:** walleye or yellow perch).
 - 10,000 mg/l for 6 hours at 12°C (**safe for:** lake trout, brown trout, channel catfish, bluegill, yellow perch, and fathead minnow; **not safe for:** rainbow trout, smallmouth bass or walleye).
 - 750 mg/l for 1 hour followed by 25 mg/l formalin for 2 hours at 20°C (**safe for:** fingerling (50-75 mm) walleye, saugeye, sunshine bass, largemouth bass, and channel catfish (25-30 mm), and larger (150-200 mm) rainbow trout, golden trout, brown trout, and muskellunge). Note: adding 0.5% sodium chloride decreased formalin's effectiveness at killing veligers.
- Formalin
 - 100 mg/l for 2 hours at 20°C (**safe for:** fingerling (50-75 mm) largemouth bass, channel catfish (25-30 mm), and larger (150-200 mm) rainbow trout, golden trout, brown trout, and muskellunge). Note: adding 0.5% sodium chloride decreased formalin's effectiveness at killing veligers.

In high risk areas, a combination of chemical, filtration and dewatering can be used to reduce the risk of transporting mussels. In one out-of-state hatchery the stocking process begins by filling the tank on a stocking truck with water that has been passed through both a 10 micron sand filter and a 20 micron filter sock to remove any mussels or their veligers. Then the fish to be stocked are soaked in a salt bath for an hour before they are moved into the tank after being dewatered just to be sure no mussels survive the move. With those steps complete, the fish are ready to be released into the destination water. This procedure should be adapted to California conditions.

Contacts and On-line Information Sources

DFG Quagga Mussel Regional Contacts

Region 1 – Northern Region

Counties: Del Norte, Humboldt, Lassen, Mendocino, Modoc, Shasta, Siskiyou, Tehama, and Trinity
601 Locust Street, Redding, CA 96001
L. Breck McAlexander
LMCALEXANDER@dfg.ca.gov
Office: (530) 225-2317
Fax: (530) 225-2381

Region 2 – North Central Region

Counties: Alpine, Amador, Butte, Calaveras, Colusa, El Dorado, Glenn, Lake, Nevada, Placer, Plumas, Sacramento, San Joaquin, Sierra, Sutter, Yolo and Yuba
1701 Nimbus Road, Rancho Cordova, CA 95670
Jason Roberts
JDROBERTS@dfg.ca.gov
Office: (916) 358-2895
Fax: (916) 358-2912

Region 3 – Bay Delta Region

Counties: Alameda, Contra Costa, Marin, Napa, Sacramento, San Mateo, Santa Clara, Santa Cruz, San Francisco, San Joaquin, Solano, Sonoma, and Yolo
4001 North Wilson Way, Stockton, CA 95205
Catherine Mandella
CMANDELLA@dfg.ca.gov
Office: (209) 942-6107
Fax: (209) 946-6355

Region 4 – Central Region

Counties: Fresno, Kern, Kings, Madera, Mariposa, Merced, Monterey, San Benito, San Luis Obispo, Stanislaus, Tulare and Tuolumne
1234 E. Shaw Avenue, Fresno, CA 93710
Mark Watson
MWATSON@dfg.ca.gov
Office: (559) 243-4017 x244
Fax: (559) 243-4022

Region 5 – South Coast Region

Counties: Los Angeles, Orange, San Diego, Santa Barbara and Ventura
4949 Viewridge Avenue, San Diego, CA 92123
Daniel Schrimsher
DSCHRIMSHER@dfg.ca.gov
Office: (858) 467-6926
Cell: (858) 437-4177
Fax: (858) 467-4299

Region 6 – Inland Deserts Region

Counties: Imperial, Inyo, Mono, Riverside and San Bernardino
P.O. Box 2160, Blythe, CA 92226
David Vigil
DVIGIL@dfg.ca.gov
Office: (760) 922-4928
Fax: (760) 922-5638
Rick Francis
RFRANCIS@dfg.ca.gov
Cell: (760) 828-7582
Fax: (760) 922-5638

Headquarters

California Department of Fish and Game

Devin M. Bartley, Ph. D.
State Aquaculture Coordinator,
California Department of Fish & Game
1416 9th Street, 12th Floor
Sacramento, CA 95814
Office: (916) 651-7824
Email: dbartley@dfg.ca.gov

Headquarters

California Department of Fish and Game

Martha Volkoff
Statewide Quagga/Zebra Mussel
Monitoring Coordinator
California Department of Fish & Game,
Invasive Species Program
1416 9th Street, 12th Floor
Sacramento, CA 95814
Office: (916) 651-8658
Email: mvolkoff@dfg.ca.gov

General information

California Department of Fish and Game Invasive Species Program: Quagga and Zebra mussels. <http://www.dfg.ca.gov/invasives/quaggamussel/>

One hundredth Meridian Initiative to halt the spread of zebra mussels. <http://www.100thmeridian.org/>

California Department of Water Resources: Overview of California's Zebra Mussel Watch Program http://www.des.water.ca.gov/zmwatch/program_overview/index.cfm

The California Department of Water Resources Monitoring Instructions for Zebra/Quagga Mussel Plate Samplers, April 2, 2008. <https://nrmsecure.dfg.ca.gov/FileHandler.ashx?DocumentID=4953>

The Zebra Mussel and Bait Fish Aquaculture, R. Kastner, C.G. Lutz and M. Barrett-O'Leary. <http://www.sgnis.org/publicat/papers/msslutz.pdf>

USGS Nonindigenous Aquatic Species Web-site. Dreissinid Mussels <http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=95>

Mississippi River Basin Control Methods and Background Information for Selected Aquatic Invasive Species in the Mississippi River Basin – Very good information on invasive mussels. <http://wwwaux.cerc.cr.usgs.gov/micra/PC%20AIS%20Control%20Methods%20Final.htm>

Management plans

California Aquatic Invasive Species Management Plan <http://www.dfg.ca.gov/invasives/plan/>

Zebra Mussel Management Strategy for Northern Ireland 2004-2010. <http://www.invasivespeciesireland.com/files/public/General%20Information/Zebra%20Mussel%20Management%20Strategy.pdf>

Best Management Practices, HAACP and Treatment:

Gunderson, J.L., and R. E. Kinnunen. 2004. AIS-HAACP, Aquatic Invasive Species – Hazard Analysis and Critical Control Point Training Curriculum. 2nd Edition. Minnesota SeaGrant, Duluth, MN. <http://www.seagrants.umn.edu> , and <http://seagrants.umn.edu/ais/haccp> See appendix 1 starting on page 42.

LIST OF PARTICIPANTS

**Reducing Quagga/Zebra Mussel Risks in California Aquaculture
California Department of Fish and Game Workshop, June 11-12, 2008
University of California Riverside, Palm Desert California**

Industry

Craig Elliott
Imperial Catfish
PO Box 188
Imperial, CA 92251
craig@craigelliott.com

Arturo Esparza
Imperial Catfish
PO Box 188
Imperial, CA 92251
imperialcatfish@yahoo.com

Dennis Faria
Imperial Catfish
PO Box 188
Imperial, CA 92251
imperialcatfish@yahoo.com

Iva Gaglione
Star Milling Co.
PO Box 1982
Perris, CA 92572
iva@starmilling.com

Chris Graham
22555 Olympiad Road
Mission Viejo, CA 92626
cgraham@lakemission.org

Scott Kraetil
22555 Olympiad Road,
Mission Viejo, CA 92626
skraetil@lakemission.org

George Ray
Fish Producers, Inc.
PO Box 1004
Niland, CA 92257
Fishproducers2@earthlink.net

Oscar Sandz
PO Box 399
Desert Hot Springs, CA 92241
Blue beyond Fisheries LLC
Oscarsan60@hotmail.com

Jentry Spear
Pacific Aquafarms
(760) 354-1533

Jose Victoria
Lakeview Ranch
PO Box 647
Desert Center, CA 92239
(760) 408-0799

Department of Fish & Game

Devin Bartley
1416 9th Street
Sacramento, CA 95814
dbartley@dfg.ca.gov

William Cox
2111 Nimbus Road
Rancho Cordova, CA 95670
wtcov@dfg.ca.gov
phone: 916-358-2827
fax: 916-358-2825

Terry Foreman
830 S Street
Sacramento, CA 95811
tforeman@dfg.ca.gov

Rick Francis
PO Box 2160
Blyth, CA 92226
rfrancis@dfg.ca.gov
Cell: (760) 828-7582
Fax: (760) 922-5638

Mike Giusti
33792 Viewpoint Road
Winchester, CA 92596
mgiusti@dfg.ca.gov

Dwayne Maxwell
4665 Lampson Ave.
Los Alamitos CA 90720
dmaxwell@dfg.ca.gov

Breck McAlexander
4949 Viewridge
San Diego, CA 92123
lmcalexander@dfg.ca.gov

Heather McIntire
830 S Street
Sacramento, CA 95811
hmcintire@dfg.ca.gov

Matthew Unyi
PO Box 1282
Niland, CA 92257
mjunyi@dfg.ca.gov

David Vigil
P.O. Box 2160, Blythe, CA
92226
dvigil@dfg.ca.gov
Office: (760) 922-4928
Fax: (760) 922-5638

Martha Volkoff
1416 9th Street
Sacramento, CA 95814
mvolkoff@dfg.ca.gov

Invited expert

Greg Lutz
Louisiana State University
P.O. Box 25100
Baton Rouge, LA 70894
Office (504)388-2152
glutz@aqcenter.lsu.edu

