QUAGGA AND ZEBRA MUSSEL ERADICATION AND CONTROL TACTICS

3. OXYGEN DEPRIVATION

Revised June 2013

This series of information sheets is provided for educational purposes only. It is intended to provide a general overview of what is required for implementing tactics to eradicate and control aquatic invasive species (AIS). Although prevention is the best approach, it also is important to be prepared to respond quickly to new infestations and to reduce risks posed by existing infestations. No work should be conducted without first consulting the California Department of Fish and Wildlife (formerly California Department of Fish and Game) and the Regional Water Quality Control Board or, if in another state, the lead local resource management and water quality agencies for the AIS you are interested in managing. Consult the California Department of Pesticide Regulation or corresponding agency in another state before applying chemical tactics.

TACTIC

Depriving mussels of oxygen through the application of "tarps," also known as bottom/benthic mats or barriers, is a fairly benign physical control tactic. Thus, it is placed low on the Integrated Pest Management (IPM) pyramid. "Tarping" involves installing tarps over pest populations, typically on lake bottoms, and weighing or anchoring the tarps down with sandbags or rebar respectively. Tarps also can be installed around large rocks, pylons, docks, etc. Oxygen depletion under the tarps kills the pest. In the case of invasive mussels, tarps are used to target the attached juvenile and adult mussel stages. Chemicals or biocides, such as chlorine or potassium chloride, may be applied under tarps to accelerate the extermination process. However, using such chemicals requires additional permits and considerations (see Chemical Application and Permitting and Regulatory Processes information sheets).

WHEN TO USE TACTIC

This tactic is best used for low to moderate mussel infestations as a site-specific eradication and control method. When there are too many mussels to remove by hand, or they are situated in hard-to-reach locations (crevices), tarping offers an efficient way to cover and thereby eventually exterminate mussels in selected areas. Shells of the deceased mussels will remain in the water body, reducing the cost of disposal but potentially providing substrate for new mussel infestations and leaving sharp surfaces that can harm swimmers and fishing gear. Consider enhancing the effectiveness of this management strategy by taking an IPM approach, which combines this tactic that targets adults and juveniles with another tactic that targets the larval stage. Tarping has been used to control the Asian clam, *Corbicula fluminea*, in Lake Tahoe, CA (see "Success Story").

STEPS TO BE TAKEN

Prior to Discovering a New Mussel Infestation and/or Implementing Tactic

The following steps can be taken to reduce the time required to implement this tactic.

1. **Organize Divers and Boat Operators.** Identify and train current dive staff or other local dive groups to assist with underwater application of tarps (see Manual & Mechanical Removal

information sheet for list of divers and suggested training). Identify potential boat operators with current boat captain licenses. Collaborating with staff of other lakes in the region may reduce overall costs and help with the development of a team trained to implement this tactic.

2. **Locate Needed Supplies.** Work with managers of nearby lakes to develop a supply list and locations to purchase needed materials for implementing this tactic. A basic list of suggested supplies is provided at the end of this information sheet. If funds are available, develop a ready-to-use tarping tool kit that includes the necessary materials.

3. **Review the Need for Area Closures.** Consider the need to close various areas of the water body where tarps are installed. Closures may be required in high-traffic and shallow areas where other activities may interfere with the tarps, potentially making them ineffective if they are not continually secured. If you believe closures may be required, explore the potential for adding chemicals under the tarps to shorten the process (see Step 5 in the "Implementing Tactic" section).

Implementing Tactic

1. **Determine the Distribution of Mussels.** Have divers conduct surveys to determine the extent of the quagga or zebra mussel infestation. Identify specific areas with high densities of mussels ("hot spots") and areas that can easily be covered with tarps. For areas where mussels are found, have divers conduct additional surveys to determine how far out the infestation radiates from the spot. Based on the surveys, determine the size of the desired treatment area. For more information and assistance with conducting diver surveys contact California Department of Fish and Wildlife (CDFW).

2. **Conduct Pre-Implementation Survey.** Consult with agency or university biologists to develop pre- and post-surveys as part of your monitoring program. These surveys are necessary for a before-and-after comparison of the effects of the tactic on mussels and selected indicator species. Have trained divers and staff conduct both visual and tactile underwater dive or remotely operated vehicle (ROV) surveys and deploy and monitor artificial substrates.

3. **Conduct a Pilot Study.** Start with a small pilot study or test area to perfect tarping techniques and confirm that the materials are deployed and secured effectively.

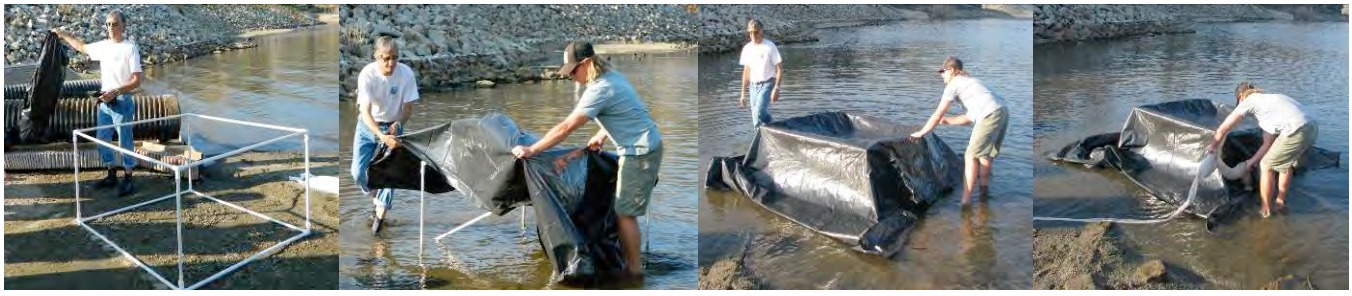

Figure 3-1. Tarping demonstration by Dr. Lars Anderson and Dan Daft at El Capitan Reservoir in San Diego County, CA. This series of pictures shows building a frame from PVC pipe to provide structure for tarps (used to cover large rocks or objects), rolling the tarp over the frame and then securing the tarp to the lake bottom with sand bags. *Photo Credit:* Jodi Cassell and Marsha Gear

4. **Install Tarps.** Install tarps over infested areas of the lake bottom, over large rocks, or wrapped about docks/pylons. Frames can be built with PVC pipe to support the tarps if large rocks or other objects are present (Fig. 3-1).

Depending on the location of the mussels and the depth of the water, the assistance of divers may be required. For ease of installation, large rolls of tarps can be lowered to the infested area from a boat. Divers, with the assistance of floatation devices, can unroll the tarps over the infested surface and secure them with large sand bags or rebar anchors (Fig. 3-2 and Fig. 3-3), as was done for Asian clams in Lake Tahoe, CA (see video).

To adequately reduce the oxygen available to the mussels, tarps should be left intact for a minimum of one month.[1] Depending on the situation, it may be necessary to prevent lake users from entering the area and interfering with the tarps. For example, fast moving boats, water skiing, or "wake boarding" can dislodge the tarps.

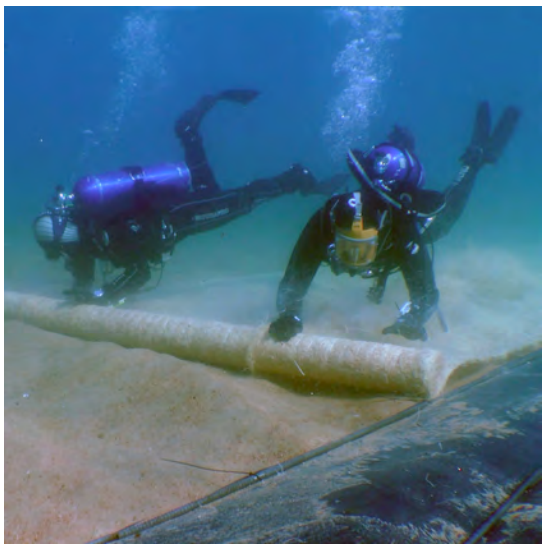

Figure 3-2. Divers rolling out mats made from aspen shavings (see "Success Story"). *Photo Credit:* Jim Brockett, Tahoe Resource Conservation District

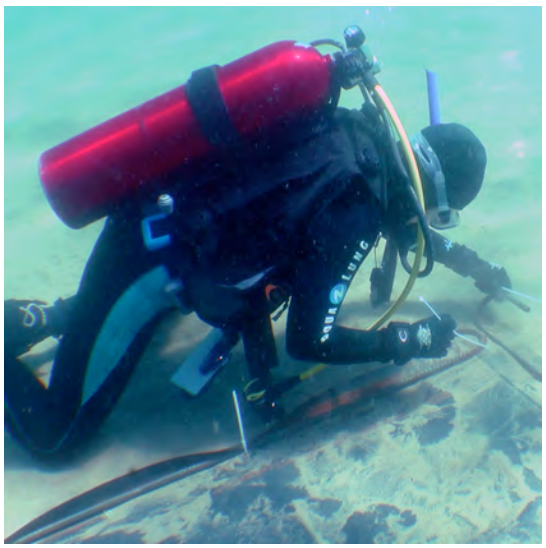

Figure 3-3. Diver securing tarps to the bottom of the lake with rebar. *Photo Credit:* Jim Brockett, Tahoe Resource Conservation District

5. **Add Chemicals/Biocides (if needed).** In high traffic areas, where prolonged closures would negatively impact the lake/reservoir operations, chemicals or biocides may be used to accelerate the extermination process and decrease the amount of time the tarps need to stay in place. In this case, chemicals or biocides are pumped under the tarp after the initial installation process. If using chemicals/biocides, additional permits and considerations will apply, potentially slowing implementation of this control tactic (see Chemical Application and Permitting & Regulatory Processes information sheets).

6. **Monitor During Installation.** Have divers continue visual and tactile monitoring around tarps to ensure the mussel population has been completely enclosed. If a dissolved oxygen probe is available, take weekly readings under the tarp to ensure the area beneath it remains anoxic (without oxygen).

7. **Remove Tarp.** Have divers remove a section of tarp and test for survivorship of the mussels. If the mussels are alive, replace the tarp and leave it for a longer period of time. If the mussels are dead, remove the tarp.

8. **Decontaminate Persons and Gear.** Be sure divers and boat operators decontaminate themselves and their gear in order to minimize the possibility of transferring live mussel larvae, juveniles or adults to other water bodies. Consider following the CDFW decontamination protocol before leaving the water body. Or, review the Hazard Analysis and Critical Control Point (HACCP) planning guidelines by the U.S. Fish and Wildlife Service, which aim to reduce or eliminate the spread of undesirable species through proper planning.[2]

9. **Evaluate Tactic Success.** Conduct follow-up surveys (e.g., diver, remotely operated vehicle [ROV], substrate sampling) to evaluate the effectiveness of the removal efforts. Within the first year of the project, conduct follow-up surveys frequently (quarterly at a minimum) to measure the initial effectiveness of the effort. **If eradication was the goal,** frequent assessments are critical and will allow rapid follow-up measures to be implemented as needed. If the eradication effort appears to be successful after one year, surveys can then be conducted once a year. Annual surveys are critical for determining the long-term success of the effort. It is important to budget for and conduct surveys for 5 to 10 years because it is often difficult to detect low infestations. **If control was the goal,** continual monitoring will help determine how long the tactic was effective, thereby identifying how often it will need to be reapplied. Consider using a third-party agency or university biologist when designing and conducting surveys to validate the scientific design and findings.

SAFETY

Proper safety precautions are essential when conducting any eradication or control tactic. We support these and other recommendations covered in the National Park Service Quagga/Zebra Mussel Infestation Prevention and Response Planning Guide:

1) No work should be started unless appropriate safety controls are in place;
2) Have a safety professional review your implementation plan; and
3) Make sure employees are properly trained, well-rested and alerted to hazards before starting.

Chemicals

When chemicals are used, managers should consult with chemical suppliers about the risks associated with each chemical and about the proper procedures regarding potential exposure to humans.

Dive Safety Plan

Anyone involved in the project (divers, volunteers, dive support staff, biologists, etc.) must know all natural and man-made hazards or potential hazards in the area where they will be working (e.g., intake structures, nearby energized equipment, boat traffic). They must also be trained in and follow all applicable Occupational Safety and Health Administration (OSHA) and industry safety requirements and guidelines, that can be found on the ADCI website. If volunteer divers are involved, the project

manager and lead diver must brief them on potential risks and safety issues. Liability waivers may also be required in some situations.

COSTS TO CONSIDER

Many costs are associated with implementing this eradication and control tactic. The following list highlights some of the primary equipment and staffing needs, along with some additional expenses that may be incurred when using this tactic.

Equipment

- Sheets or rolls of PVC/plastic tarps (non gas-permeable) or black pond liners (at least 20 mil thick) to cover infested areas
- Sandbags, bags of gravel, or rebar to weigh or anchor the tarps to the bottom
- Boats for deploying tarps (this may require a larger, barge-type boat, as well as smaller dive-tender boats)
- Dissolved oxygen loggers to measure levels under tarp (optional)

Staffing (Technical/Volunteer)

- Professional and/or scientific divers (for installation of tarps)
  - See list of qualified divers in Manual & Mechanical Removal information sheet
- Boat operator(s)
- Third party agency or university biologist to assist with survey design and to validate results

Additional Costs to Consider

- Follow-up surveys (water sample collection and analyses; substrate sampling and monitoring)
- Permits (see Permitting & Regulatory Processes information sheet)
- Public outreach materials
- Signage (closure signs, information signs)
- Lost revenue due to closures (if implemented)

SUCCESS STORY

Lake Tahoe, CA

In 2010, a team of divers supported by two boats and a barge deployed large rolls of aspen shavings covered by non gas-permeable tarps on the lake bottom to control Asian clams in specific areas (Fig. 3-2). The aspen shavings absorb oxygen, thereby decreasing the amount of time the tarps need to stay in place. Nearly half an acre (~2,000 square meters) of the lake bottom was covered with the tarps, which were left in place for 120 days (July-November). Upon removal, the Asian clam population was reduced by 98% and remained significantly reduced (>90%) one year later.[3]

CITED WEB LINKS

ADCI - http://www.adc-int.org/
Decontamination protocol - http://www.dfg.ca.gov/invasives/quaggamussel/
Diver surveys - http://pubs.usgs.gov/of/2010/1308/
Hazard Analysis and Critical Control Point (HACCP) planning guidelines - http://training.fws.gov/EC/Resources/pdf/HACCP%20Manual.pdf
National Park Service Quagga/Zebra Mussel Infestation Prevention and Response Planning Guide - http://home.nps.gov/applications/digest/headline.cfm?type=Announcements&id=5488&urlarea=npsnews
OSHA - http://www.osha.gov/SLTC/commercialdiving/index.html
Video - http://digitaljournal.com/article/294522

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[1] The one-month time period is based on an experiment in Lake George, NY. Personal communication, Dr. Sandra Nierzwicki-Bauer, Darrin Fresh Water Institute, February 2, 2012.

[2] HACCP training is available from the U.S. Fish and Wildlife Service at the National Conservation Training Center.

[3] Wittmann, M.E., S. Candra, J.E. Reuter, G.S. Schladow, B.C. Allen and J. Webb. 2012. The control of an invasive bivalve, *Corbicula fluminea*, using gas impermeable benthic barriers in a large natural lake. *Environmental Management* 49 (6): 1163-1173.

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http://ca-sgep.ucsd.edu/quaggazebra_mussel_control