QUAGGA AND ZEBRA MUSSEL ERADICATION AND CONTROL TACTICS

1. INTRODUCTION

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.

OVERVIEW

This series of six information sheets has been developed to help managers of water bodies prepare for and implement eradication and control tactics for quagga and zebra mussels in lakes, reservoirs and irrigation canals. Others have developed information for controlling mussel infestations in water and power facilities, including intake lines, trash racks and other infrastructure. Here, we complement facilities-based information by addressing eradication and control of *source populations* of mussels residing in water bodies (Fig. 1-1). In this information sheet we discuss 1) the concept of eradicating a pest population versus controlling it, 2) the importance of being proactive against aquatic pests, and 3) how using an integrated pest management strategy can greatly increase the success of eradication and control efforts. Also included are some tips on getting started, along with website links to additional resources. (Note: websites are hyperlinked within the text as well as cited in full at the end of each information sheet).

The other five information sheets in this series address:

- Manual & Mechanical Removal
- Oxygen Deprivation
- Chemical Application
- Emerging Technologies
- Permitting & Regulatory Processes

Figure 1-1. Mussel infestation exposed on rocks after a water draw-down. El Capitan Reservoir, San Diego County, CA.
Photo Credit: Carolynn Culver

While this series of information sheets is focused on eradication and control of quagga and zebra mussels specifically, the information is broadly applicable to all types of aquatic pests. Invasive freshwater mussels serve as a model to illustrate general concepts and specific steps required for taking action against AIS.

ERADICATION VS CONTROL: WHAT IS THE GOAL?

Once an established pest population has been detected, management actions are needed to reduce impacts on the system and to minimize the chance that it will spread to other systems. Defining the

goal of the eradication or control action is an important first step. Depending on the situation, you may only be able to achieve control rather than complete eradication. This should be considered when developing a management strategy.

Eradication

Eradication is the complete elimination of a pest population. Although eradication of aquatic pest populations has proven difficult, success stories exist for various species. In general, eradication has been achieved when a pest population has been contained within a fairly small area, allowing for targeted eradication efforts.

Such efforts require that the population be reduced to a point where it can no longer sustain itself. Because it is extremely difficult to know exactly how many individuals from a pest population will need to be removed before the population collapses, it is recommended that as many individuals as possible be eliminated. Often this requires applying eradication tactics not only to those areas where you can readily see the individual pests, but also to areas where the pests may occur that are difficult to access or see (e.g., in rocky crevices among riprap). Given the difficulty of completely eliminating a pest population, continuing surveys over many years is an essential component of an eradication effort. This is required to ensure that no pests remain and no new larvae are being produced.

In Southern California, quagga mussel larvae are continually entering many water bodies via the Colorado River Aqueduct. As a result, at this point in time eradication of quagga mussels is not possible at such locations unless incoming water can be effectively treated to eliminate larvae. Despite this, proactive control measures are still necessary and important. Effort will not be wasted if a control strategy takes into account the inflow of larvae. While directly reducing the source of larvae may be difficult, timing the implementation of control tactics, based on when larvae are entering and settling in the system, will greatly improve chances of control.

Control

When eradication is not feasible, control measures can be implemented. Control means reducing the pest population and containing it at as low a level as possible. By implementing control tactics the economic and environmental impacts can be significantly reduced. As with eradication efforts, careful consideration of the pest's life cycle and other species in the system is required when developing a control strategy.

Developing a Management Strategy

Proactive Approach

A proactive approach can greatly enhance the ability to manage an aquatic invasion. Preventative measures are an important first step and are in use at many locations. However, aquatic pests have continued to spread, despite sound prevention programs. Proactive measures that address newly detected and established pest populations are critical components of a successful management strategy. Many steps can be taken prior to detecting an aquatic pest to improve the chances of successfully eradicating or controlling it. The first step is to develop a carefully thought-out management strategy that fits the situation.

Integrated Pest Management

We recommend using the Integrated Pest Management (IPM) approach when developing a management strategy for AIS. IPM has long been used to manage pests in agriculture and buildings and it is the framework used for this series of information sheets. In general, IPM calls for management ***strategies*** that use a combination of ***tactics***, such as physical, mechanical, biological, chemical and cultural, to target one or more life stages of the pest. As illustrated in the IPM pyramid (Fig. 1-2), the approach requires using more benign tactics whenever possible (bottom of pyramid). The most toxic tactics (chemical, top of pyramid) are used sparingly to reduce impacts on the environment and human health. Good record-keeping, ongoing evaluation of the success of implemented tactics, and replacing, supplementing or modifying them as needed are also critical components of an IPM strategy.

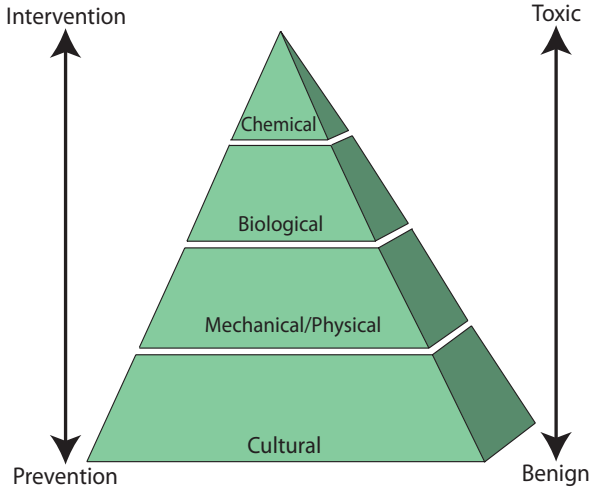

Figure 1-2. Pyramid of Integrated Pest Management (IPM) Tactics. Pennsylvania State University. 2012. IPM-Pyramid of Tactics

We highly recommend developing a carefully thought-out IPM strategy[1] regardless of whether an aquatic pest that requires management actions has been detected in the water body. By evaluating potential tactics and how they can be combined, managers will be able to identify next steps and ways to prepare for implementing eradication and control tactics. Begin by considering 1) the pest's life cycle, 2) location and status of the infestation, 3) presence of other species, and 4) feasibility of eradication/ control tactics given the situation. For pests of concern that are not yet present, consider the most likely point of entry and establishment. If the pest is already established, consider areas where it is highly abundant and develop a plan that includes details of how to implement eradication/control strategies. Consider employing more than one tactic to target more than one life stage of the pest. The other information sheets can help with identifying and evaluating potential tactics.

Management Plan Tips

1. Timing is important. Haphazard pest removal efforts can be detrimental, leading to further spread and increased densities of the pest. That is, doing "*something*" can be worse than doing nothing. For example, efforts to remove Asian kelp, *Undaria pinnatifida*, are believed to have spread the invasive seaweed because it was removed when it was actively reproducing (releasing spores). This example illustrates how the timing of eradication and control efforts is extremely important, requiring knowledge of the pest's biological characteristics.

2. Act when the population is small. Instead of waiting to see what "might" happen, consider taking action while the population is small. For example, in some cases newly detected pest populations may appear to be contained and not increasing in number. Waiting to see whether they will increase may prove to be very costly in the long run. Such costs can be avoided if simple actions are taken while the population is small. In other cases, a pest population may be cyclic, increasing quickly to high numbers ("boom") followed by a rapid decline ("bust") in the population. The population is vulnerable during

the "bust" phase. Thus, consider implementing simple eradication/control measures during this phase when the pest population is small by targeting areas with high concentrations of the pest. Doing so can vastly reduce chances that the pest will be able to increase and reach high densities ("boom") again.

Rapid Response Plans

Once mussels have been detected in a California water body, managers are required by the California Department of Fish and Wildlife (formerly California Department of Fish and Game) to submit a rapid response plan (sometimes called "Response Plans"). These are comprehensive documents that discuss which and how eradication/control tactics will be launched, communication systems, and other administrative details associated with managing the incident. Various agencies have developed rapid response plans that can be used as templates to assist managers with their own plans including:

- Quagga/Zebra Mussel Infestation Prevention and Response Planning Guide
- Bay Delta Rapid Response Plan For Dreissenid Mussels
- The Columbia River Basin Interagency Invasive Species Response Plan

This series of information sheets can be useful in preparing and implementing a rapid response plan. They are step-by-step resource guides for considering which eradication and control tactics are best suited for a situation. They also contain tips for organizing resources needed for implementing various actions.

Getting Started

Developing an IPM strategy and implementing eradication/control tactics can be daunting. The additional sheets in this series include steps that can be taken **now**, whether or not the water body you oversee has become infested. Listed below are some activities that may be helpful before and during the implementation process (in no particular order). This list was partially created by participants in the *Quagga and Zebra Mussel Eradication and Control Workshop*, held in San Diego, CA in February 2012. It reflects on-the-ground advice from people who have dealt with, or are currently preparing to deal with, quagga and zebra mussels and other invasive species.

- Develop a matrix of eradication and control options and what can/cannot work in specific areas.
  - Develop an "expert" network of people with experience in eradication and control of AIS and specific tactics of interest.
  - Look at existing cases where the tactics have been implemented.
  - Identify potential detrimental effects—ecological impacts to nontarget species, impacts on humans and recreation.
- Identify a timeline for implementing specific tactics.
  - Consider the need for partial or total lake closure during eradication/control efforts.
- Do a pilot study or dry run prior to implementing the strategy.
- Assess the situation. Determine the pest source (if possible), density and distribution of the pest, affected habitats, and water fluctuation patterns (seasonal and draw-down schedules).
- Develop a budget, including costs for continued monitoring (see general costs outlined in specific tactic information sheets).
- Identify and coordinate with appropriate agencies.

- Develop an action team and associated member tasks.
  - Form a working group to handle permit issues.
  - Designate a spokesperson.
- Get buy-in from local government, stakeholders and public.
  - Identify persons who may be able to help with permitting and funding.
  - Reach out to key representatives of fishing clubs.
    - Will help get word out to other members.
    - May help with lobbying for funding.

POTENTIAL FUNDING SOURCES

Managing AIS is costly, and funding or in-kind support will undoubtedly help with securing necessary equipment or staff. When searching for funding it is important to consider industries and federal agencies, as well as state, regional, and local governments likely to be adversely impacted by the presence of invasive mussels or other aquatic species. By determining who will be most economically impacted you may identify partners who could provide financial or in-kind support for eradication and control efforts. Ongoing legislative efforts, such as the California bill AB2443 passed in 2012, which increases vessel registration fees to help fund preventative measures, may provide additional funding support. The following sources also may be useful.

- Grants
  - State/federal education and research grants
  - Local Fish and Wildlife Fines Committee grants
  - Corporate sponsorship/grants (e.g., Patagonia™ , Bass Pro Shops™)
  - Local nonprofit organizations and foundations that have an interest in fresh water resources, community development, watershed protection
- Donations from stakeholders
- Fees and/or fines
  - Raising usage rates, boat launching fees, and water rates, and adding the increased revenue to the maintenance budget for use in AIS control
  - Citation and violation fines (if mussels are found)
- In-kind resources (e.g., staff or equipment from other organizations, volunteers)

CITED WEB LINKS

Bay Delta Rapid Response Plan For Dreissenid Mussels - http://www.dfg.ca.gov/invasives/quaggamussel/
California Department of Fish and Wildlife (Guidance Documents) - http://www.dfg.ca.gov/invasives/quaggamussel/
Columbia River Basin Interagency Invasive Species Response Plan - http://100thmeridian.org/ActionTeams/Columbia/CRB%20Dreissenid%20Rapid%20Response%20Plan%20OCTOBER%201%202008.pdf
IPM (Pyramid of Tactics) - http://extension.psu.edu/ipm/schools/educators/elementary/pyramid/homepyramid/
Quagga and Zebra Mussel Eradication and Control Workshop – http://ca-sgep.ucsd.edu/quaggazebra_mussel_control/new_workshop
Quagga/Zebra Mussel Infestation Prevention and Response Planning Guide - http://nature.nps.gov/biology/Quagga/index.cfm

[1] De Leon, Ricardo, William Taylor and Paul A. Rochelle. 2012. Management of invasive quagga mussels in a large water supply system. Quagga and Zebra Mussel Eradication and Control Workshop. Presenter Abstracts.

Acknowledgements
We gratefully acknowledge the following people and organizations for providing information and/or review of this educational material.

- Steve Chavoya, Cachuma Lake, County of Santa Barbara, Community Services Department
- Gillian Clague, California Sea Grant Extension, University of California, Santa Barbara
- Susan Ellis, California Department of Fish & Wildlife
- Joann Furse, California Sea Grant
- Liz Gaspar, Cachuma Lake, County of Santa Barbara, Community Services Department
- Marsha Gear, California Sea Grant
- Jennifer LaBay, California Department of Fish & Wildlife
- Michelle Lande, University of California Agriculture and Natural Resources, Cooperative Extension
- Louanne McMartin, U.S. Fish and Wildlife Service
- Dominique Norton, California Department of Fish & Wildlife
- Ron Smith, U.S. Fish and Wildlife Service
- Jonathan Thompson, U.S. Fish and Wildlife Service
- Martha Volkoff, California Department of Fish & Wildlife

Sponsors This educational material was supported in part by the National Sea Grant, Aquatic Invasive Species Initiative, Project No. NA2233-C; California Sea Grant, NOAA Grant No. NA100AR4170060; University of California Agriculture and Natural Resources; University of California Cooperative Extension; County of San Diego; and the Marine Science Institute, University of California, Santa Barbara. The statements in this information sheet are those of the authors and not necessarily those of the sponsors or reviewers. The mention of consultants or commercial products, their source, or their use in connection with material reported herein, is not to be construed as actual or implied endorsement.

Carolynn Culver, California Sea Grant Aquatic Resources Specialist, University of California
Heather Lahr, California Sea Grant Research Assistant, University of California
Leigh Johnson, Coastal Resources Advisor, University of California ANR, Cooperative Extension
Jodi Cassell, Natural Resources Advisor, University of California ANR, Cooperative Extension

California Sea Grant College Program Report No. T-076/UCCE-SD Technical Report No. 2013-1

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