

Aquatic Pesticide Monitoring Program

APMP Alternatives Program

Executive Summary

Ben K. Greenfield



San Francisco Estuary Institute
7770 Pardee Lane, 2nd Floor
Oakland, CA 94621

March 2004

EXECUTIVE SUMMARY

The Aquatic Pesticide Monitoring Program Alternatives Program was established to develop practical recommendations for alternative aquatic pest control methods that may be used in California waters. The end-users of this information include the California State Water Quality Control Board, special interest groups, and the state, local, and private agencies that control aquatic plants. The APMP Alternatives Project aims to help understand the feasibility of non-chemical aquatic plant control methods as alternatives to chemical control in California waters. It includes three components, each of which are summarized here and presented in separate reports:

1. A thorough review of alternative aquatic pest control methods for potential use in California waters (Greenfield et al. 2003).
2. Research projects that evaluate effectiveness and potential environmental impacts of different control methods (SFEI et al. 2003).
3. Evaluation of the cost-effectiveness of different control methods, using a rigorous economic methodology (Mann and Wittmann 2003).

Alternatives Project Methods Review

The APMP Alternatives Program methods review (Greenfield et al. 2003) is an exhaustive compendium of alternative methods for control of aquatic vascular plants, algae, and mosquitoes. It summarizes the findings from 177 journal articles, reports, and web documents and from interviews with 77 aquatic resource managers from California and other U.S. states. The methods review is intended for practitioners wishing to identify alternative methods for aquatic pest control that may not require NPDES permitting. The review critically evaluates aquatic pest control methods, discussing environmental impacts, feasibility, and areas for future research. This review also includes general information on regulatory and permitting requirements. Finally, it includes an Appendix presenting recommendations for specific species and water body types.

In addition to registered pesticides, aquatic pest managers can use biological control methods, physical and mechanical control methods, and non-conventional

Aquatic Pesticide Monitoring Program
Aquatic Pesticide Alternatives Project
Executive Summary

chemical control methods. Additionally, preventive measures may be implemented to reduce the probability of infestations occurring in a water body. Table 1 presents a complete list of potential control methods discussed in the APMP Alternatives Project methods review. Many methods are currently being explored or developed for use by California practitioners in specific management circumstances. These include manual removal, acetic acid amendment, predatory fishes for mosquito control, and bottom barriers. Many methods are commercially available from California private contractors. The review includes a list of contractors who regularly perform control using methods including mechanical harvesting, cutting, rotovation, and sediment removal. California has a Triploid Grass Carp permitting program, which is appropriate for some management conditions.

Table 1. Methods available for control of aquatic pests in California waters.

Physical and Mechanical Control Methods

Mechanical Harvesting
Mechanical Cutting
Rotovation and Rototilling
Hydroraking
Weed Rollers
Lake Sweepers
Diver-operated Suction Dredging
Sediment Removal
Shading
Piping
Bottom Barriers
Manual Removal
Water Level Manipulation
Channel Clearing
Mechanical Excavation
Exposure to Extreme Environmental Conditions
Aeration, Oxygenation, and Water Circulation
Nutrient Removal

Non-conventional Chemical Controls

Calcium based Products
Aluminum based products
Nitrate
Aquashade
Salt (Sodium Chloride)

Biological Control Methods

Triploid Grass Carp
Other Herbivorous Fishes
Fish Biomanipulation
Terrestrial Herbivorous Mammals
Gastropod Mollusks
Insects
Non-Insect Crustaceans (for mosquito control)
Predatory fishes (for mosquito control)
Commercially Available Biocontrol Agents
Microbial Pathogens (e.g., cyanophages)
Fungal Pathogens
Organic Material Amendment
Acetic Acid
Plant Competition

Preventive Measures

Early Detection
Quarantine
Regulation
Education and Outreach
Riparian Buffer Strips
Retention Pond or Wetland Construction
Watershed Best Management Practices

Like permitted chemical pesticides, alternative aquatic pest control methods, when used improperly, can present environmental risks to aquatic ecosystems. Environmental impacts can include adverse effects on local animal communities, and

effects on water chemistry. As with chemical control, alternative control methods can sometimes be difficult to obtain permits for use in specific California waters. Often times, many agencies must be contacted with permitting requests, requiring considerable initial effort for trying new methods.

In some situations, mechanical methods such as harvesting and rotoation could actually increase an aquatic plant infestation over the long-term, or cause the infestation to spread more rapidly to new areas. Caution is particularly warranted with introduction of non-native biocontrol species, given the fact that introduced plants or animals could reproduce and spread to new water bodies, causing permanent ecological changes in widespread areas.

Research Projects in 2003

In 2003, the APMP Alternatives Program conducted four separate research projects to evaluate alternative aquatic plant control methods in a variety of management scenarios. These projects are presented in SFEI et al. (2003) and summarized in Table 2.

Table 2. Control methods evaluated by APMP research projects in 2003.

Method Evaluated	Target Plants	Environmental Studies	C/E Study?	Ref.
Hand Held Power Cutters	Emergent	Water Quality	Yes	1
Gypsum Application	Benthic Algae	Water and Sediment Quality	Yes	2
Alum Application	Benthic Algae	Water and Sediment Quality	Yes	2
Goat Grazing	Riparian and Emergent	Water Quality	Yes	1
Mechanical Harvesting	Submerged and Algae	Water Quality and Fish Mortality	No	3
Mechanical Shredding	Floating (Water Hyacinth)	Water Quality	Yes	In Prep.
Mechanical Excavation	Floating	Water Quality	Yes	1
Chemical and Mechanical	Floating	Water Quality	Yes	1

1. Blankinship et al. 2003; 2. Grabow et al. 2003; 3. David and Greenfield 2003.

Note: C/E Study indicates whether cost-effectiveness data were evaluated.

All APMP Alternatives research projects evaluated the water quality impacts of aquatic plant control methods. In general, water quality impacts were temporary or were not apparent. Mechanical harvesting operations caused temporary increases in turbidity and nutrients in northern California lake systems (e.g., **Figure 1**). In water bodies where harvesting was conducted routinely, the effects on water quality appeared to be short-

Aquatic Pesticide Monitoring Program
 Aquatic Pesticide Alternatives Project
 Executive Summary

lived, and unlikely to adversely affect beneficial uses (David and Greenfield 2003). Similarly, mechanical excavation and operation of hand-held power cutters for vegetation removal had only short-lived effects on water quality of small streams and irrigation drainages. Temporary increases were observed in turbidity, and were sometimes observed in total phosphorus and total Kjeldahl nitrogen (Blankinship et al. 2003). Goat grazing operations in or adjacent to small streams, caused temporary increases to turbidity, as well as total and fecal coliform (Figure 2; Blankinship et al. 2003).

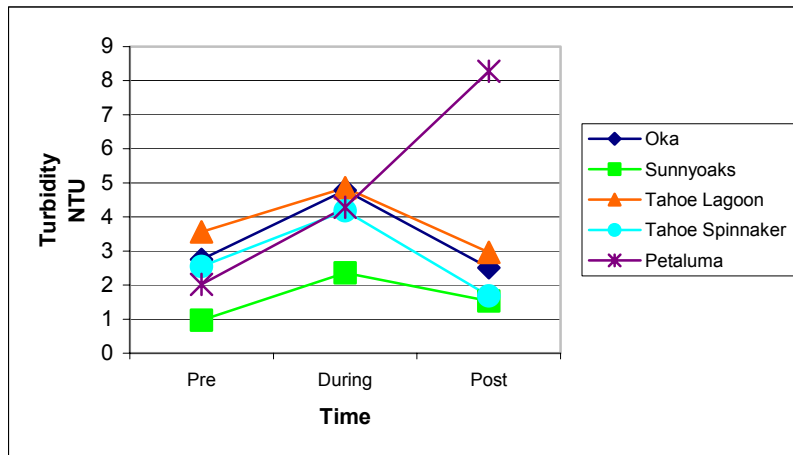


Figure 1. In 4 of 5 California water bodies, turbidity increased immediately after mechanical harvesting but returned to pre-harvesting conditions within 3-6 days of sampling (David and Greenfield 2003).

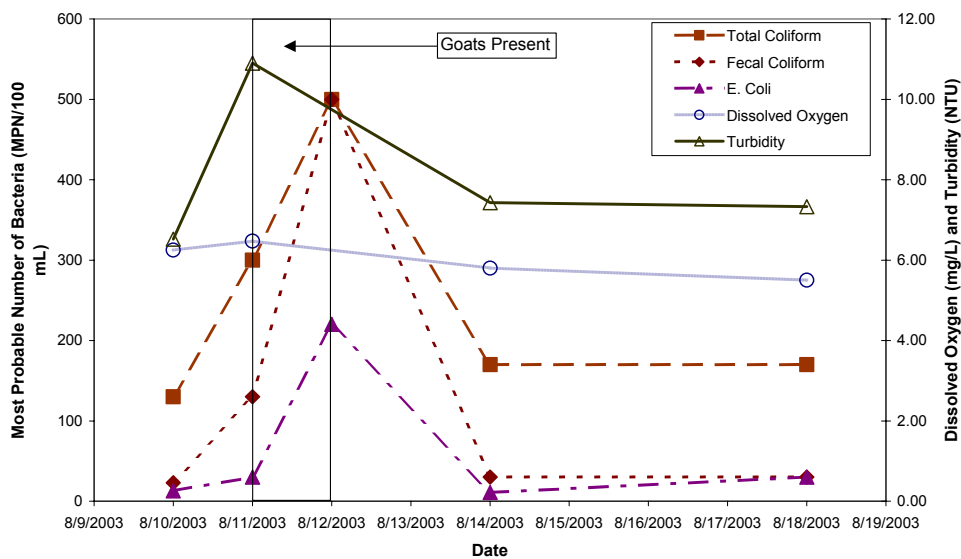


Figure 2. Temporary increases were observed in turbidity and bacteria density (total coliform, fecal coliform, and *E. Coli*) after goat grazing in a California stream (Blankinship et al. 2003).

Aquatic Pesticide Monitoring Program
Aquatic Pesticide Alternatives Project
Executive Summary

The APMP Alternatives Program included an evaluation of alum and gypsum for potential use in controlling nuisance benthic algae in a culinary reservoir (Grabow et al. 2003). The alum and gypsum study was inconclusive with respect to the expected environmental impact of application of these alternative chemicals. Results indicated both beneficial and adverse effects of chemical application for control of taste and odor producing nuisance algae. In laboratory aquaria, application of alum and gypsum reduced water and sediment total phosphorus concentrations. Gypsum also reduced benthic algae coverage. Nevertheless, a taste and odor producing compound of concern to culinary water management districts (geosmin) was increased in the alum and gypsum treated aquaria, relative to control aquaria (Grabow et al. 2003).

Mechanical shredding to control water hyacinth generates a substantial amount of organic material, which is released back into the water body (**Figure 3**). Consequently, shredding appeared to have significant water quality impacts in backwater sloughs. Water quality was reduced after shredding in an irrigation ditch containing dense water hyacinth stands. Field sampling indicated significant decreases in dissolved oxygen, with corresponding increases in nutrients, dissolved organic carbon, and biological oxygen demand. Water quality was not significantly affected after shredding in a tidally influenced wetland (Ben Greenfield, in preparation).



Note: photo credit: Bob Case, Contra Costa County Department of Agriculture.

Figure 3. Mechanical shredding research pilot. Shredded hyacinth fragments are released into the water body

Effects to fishes, wildlife, and other non-target species can be a concern for all aquatic pest management methods. David and Greenfield (2003) documented that mechanical harvesting operations removed numerous small fishes, crayfish, and tadpoles from several California water bodies. However, sensitive or endangered species were not harvested, and only one adult sport fish was harvested. These findings suggested a relatively small overall impact of routine harvesting on aquatic animal populations in California waters (David and Greenfield 2003).

Economic Evaluations

Corresponding with the field research projects, APMP Alternatives Program researchers also collected and evaluated preliminary data on cost-effectiveness of alternative control methods (Table 2). It was not possible to make broad generalizations regarding the relative cost-effectiveness of conventional chemicals, versus alternative methods.

Aquatic Pesticide Monitoring Program
Aquatic Pesticide Alternatives Project
Executive Summary

Depending on the management circumstance and methods used, alternative methods varied significantly in terms of relative cost effectiveness, when compared to conventional pesticide application. For control of emergent and riparian vegetation, goat operations were similar or better in cost-effectiveness, when compared to conventional chemical application. In contrast, use of hand-held power cutters was significantly more costly than either chemicals or goat grazing (Blankinship et al. 2003). For control of benthic algae, application costs for alum or gypsum were generally comparable to the costs of copper application (Grabow et al. 2003). If alum or gypsum prove to be effective in controlling taste and odor producing compounds associated with benthic algae, they may be a cost-effective alternative to copper. Mechanical shredding cost-effectiveness varied substantially depending on the size of the water hyacinth plants to be controlled. For moderate sized plants (two foot stem length), shredding may be reasonably cost-effective. For large plants typical of areas having several years of growth (four through five foot stem length), shredding efficiency is extremely low, and shredding will not be cost-effective (Ben Greenfield, in preparation). For low flow irrigation canals, mechanical excavation, either alone or in combination with chemical application, was substantially more costly than chemical treatment alone (Blankinship et al. 2003).

An Environmental Economics workgroup met several times in 2003 to develop a methodology for evaluating the cost-effectiveness of alternative aquatic plant control methods. The methodology was conceived and written by Roger Mann (2003) and peer reviewed by workgroup participants. The methodology presents detailed guidance for how to conduct cost-effectiveness analyses and cost-benefit analyses to compare potential aquatic plant control methods. Practitioners wishing to formally compare the potential costs of potential management options can use Mann (2003) as a guiding framework.

Mann (2003) discusses environmental costs not routinely included in evaluations of the cost-effectiveness of potential pest control options. Guidance is included regarding how to estimate the dollar value of environmental costs (Mann 2003). Environmental cost determination can be extremely difficult and costly to undertake, and limited quantitative information is currently available on the dollar values of environmental costs associated with aquatic plant control methods.

As with the research studies, statewide data compilations indicated that the relative cost-effectiveness of conventional pesticides versus alternative methods varied among different management scenarios (Wittmann 2003). Wittmann (2003) calculated the relative cost-effectiveness of chemical versus various non-chemical control methods for four local aquatic plant management problems in California waters. For two management scenarios (control of floating or submerged aquatic plants in different Delta water bodies), conventional pesticides proved most cost-effective or feasible. For one management scenario (control of Eurasian water milfoil in Big Bear Lake), a combination of chemical application and mechanical harvesting was determined to be most cost-effective. For one management scenario (control of emergent wetland vegetation in the Kern National Wildlife Refuge), mowing was determined to be most cost-effective.

Project Directions in 2004

For the APMP Alternatives Program, additional funds remain to conduct more work in 2004. Planned allocations of remaining funds are as follows:

Further evaluation of mechanical shredding. Mechanical shredding is likely to be substantially more cost effective in spring or summer than the 2003 shredding date (late September, 2003). Applications have been submitted for permits to conduct shredding on a pilot basis in spring or summer of 2004.

Additional research projects. The following research projects are under consideration for the APMP Alternatives Program in 2004

1. Determining the viability of fragments produced when non-native *Spartina* are controlled by mechanical rotovation.
2. Evaluation of the LakeSweeper, a hydraulically driven series of rakes for control of submerged aquatic vegetation around docks.
3. Field evaluation of a mechanical chopper that pulls submerged plants at the root ("the Crusher").
4. Determination of potential water quality impacts from the use of grass carp to control aquatic vegetation

5. Field evaluation of the effectiveness of acetic acid for the control of aquatic vegetation
6. Water level manipulation for mosquito control

References

(Reports and Chapters Produced For the APMP Alternatives Project)

Blankinship, M., Monheit, S., Webber, B., Jefferies, C. and Stein, N. 2003. Evaluation of Mechanical Excavation, Manual Cutting, and Goats For Vegetation Removal in Bay-Delta Streams. *In* San Francisco Estuary Institute (SFEI), Blankinship and Associates, Marin Municipal Water District, Reclamation District 999, and Contra Costa County Public Works Department. 2003. Field Evaluations of Alternative Pest Control Methods in California Waters. B. K. Greenfield, *Ed.* APMP Technical Report. SFEI Contribution #95. San Francisco Estuary Institute, Oakland, CA. pp. 39 – 76.

David, N., and Greenfield, B. K. 2003. Environmental Effects of Mechanical Harvesting in Freshwater Lakes and Ponds. *In* San Francisco Estuary Institute (SFEI), Blankinship and Associates, Marin Municipal Water District, Reclamation District 999, and Contra Costa County Public Works Department. 2003. Field Evaluations of Alternative Pest Control Methods in California Waters. B. K. Greenfield, *Ed.* APMP Technical Report. SFEI Contribution #95. San Francisco Estuary Institute, Oakland, CA. pp. 3 – 20.

Grabow, L. J., Apinis, L. L., Mitchell, J. P., Nanney, C. R., and Nerviani, R. C. 2003. Evaluation of Gypsum and Alum For Benthic Algae Control in Drinking Water Reservoirs. *In* San Francisco Estuary Institute (SFEI), Blankinship and Associates, Marin Municipal Water District, Reclamation District 999, and Contra Costa County Public Works Department. 2003. Field Evaluations of Alternative Pest Control Methods in California Waters. B. K. Greenfield, *Ed.* APMP Technical Report. SFEI Contribution #95. San Francisco Estuary Institute, Oakland, CA. pp. 21-38.

Greenfield, B. K., David, N., Hunt, J., Wittmann, M., and G. Siemering. 2003. Review of Alternative Aquatic Pest Control Methods For California Waters. APMP Technical Report SFEI Contribution #96. San Francisco Estuary Institute, Oakland, CA.

Mann, R. 2003. Methodology For Aquatic Plant Management Economics. *In* Mann, R. and M. Wittmann. 2003. Determining Economic Impacts of Aquatic Plant Management in California Waters. APMP Technical Report. SFEI Contribution #94. San Francisco Estuary Institute, Oakland, CA and RMEcon, Davis, CA. pp. 2 - 68.

Mann, R. and M. Wittmann. 2003. Determining Economic Impacts of Aquatic Plant Management in California Waters. APMP Technical Report. SFEI Contribution #94. San Francisco Estuary Institute, Oakland, CA and RMEcon, Davis, CA.

San Francisco Estuary Institute (SFEI), Blankinship and Associates, Marin Municipal Water District, Reclamation District 999, and Contra Costa County Public Works

Aquatic Pesticide Monitoring Program
Aquatic Pesticide Alternatives Project
Executive Summary

Department. 2003. Field Evaluations of Alternative Pest Control Methods in California Waters. B. K. Greenfield, *Ed.* APMP Technical Report. SFEI Contribution #95. San Francisco Estuary Institute, Oakland, CA.

Wittmann, M. 2003. Cost Effectiveness of Different Control Methods In California Waters. *In* Mann, R. and M. Wittmann. 2003. Determining Economic Impacts of Aquatic Plant Management in California Waters. APMP Technical Report. SFEI Contribution #94. San Francisco Estuary Institute, Oakland, CA and RMEcon, Davis, CA. pp. 69 – 98.