MODEL RAPID RESPONSE PLAN

FOR

AQUATIC NUISANCE SPECIES

Prepared for the Western Regional Panel on Aquatic Nuisance Species by:
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EXECUTIVE SUMMARY

When a newly introduced species threatens to become a nuisance, it must be addressed rapidly if there is to be much hope of preventing it from spreading. This document presents instances where responses to new problems were relatively successful and other instances where the response struggled. It also identifies factors that affect the likelihood of a successful response, and problems that may preclude success. The plan also presents a model system, which functions via two organizations at the state level.

The elements that need to be addressed in a response include:

1. Authority, leadership, and organization
2. Coordination and cooperation among parties in the response
3. Funding and resources
4. Quarantine establishment and enforcement
5. Environmental regulatory compliance
6. Public awareness and education; outreach to decision makers as well as to affected property owners and parties
7. Delimitation survey and mapping
8. Review of biology and controls
9. Implementation of eradication or other management methods
10. Assessments of treatments and modification if necessary
11. Environmental monitoring
12. Restoration/mitigation

A rapid response can occur in a setting of complex and controversial issues, but in most instances a response must be initiated quickly and forcefully if there is to be a hope of eradication. Although debate and consensus building are important for public policy, if they slow the initiation of a response they may become counterproductive to the goal of eradication. A goal of this plan is a system where debate and consensus building largely occur before an introduction of an invasive species. Once an introduction occurs, the system should provide a forum where remaining issues may be resolved rapidly and a decision made to proceed with eradication or some other management option. A final goal is to put competent pest management personnel on the ground and permit them to focus on the infestation with the persistence that successful eradication efforts require.

The approach to these goals employs a two-level organization. The first level, the state council, focuses on the debate and on preparing for vigorous responses. This council must function with the support of high-level state officials and with participation of affected federal and local interests. Its decisions should provide the authority to carry out its course of action. The second level of organization focuses on the operations on the ground. It also investigates the issues and options surrounding invasive species and informs the first level about them, and uses that information to prepare for introductions. Adequate resources for responses need to be available on short notice, within this structure or through a separate fund.

In the model system, a state creates Aquatic Nuisance Species Council through legislation. The Council includes the major departments responsible for the resources threatened by invasive species, and departments that regulate control actions. Its members should be executive level officials or their designee in order that their deliberations carry weight down to staff. The

Council should include regional federal counterparts of these state officials because federal issues are often involved. Finally, the Council should include the public representation.

This Council identifies priority species, outlines general goals for each, reviews authority for actions, and broadly addresses the means to resolve environmental issues. The Council should identify and provide advice related to major policy and funding issues, and they should be available for deliberating on difficult situations.

At the level where projects are implemented, only one agency should have final authority on any given project. The Department responsible for program operations develops the details of a response to any particular infestation and plans for new introductions. It may also address the technical aspects of environmental compliance, monitoring, and, when appropriate, restoration. This Department must have experienced professional staff to check the results of control strategies on the ground and make necessary modifications.

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PURPOSE

Rapid response is essential when a new organism is discovered in an area and it displays a high potential for developing into a nuisance species. At the request of the Western Regional Panel, this document presents examples of successful responses and others that struggled; it identifies factors that affect the probability of developing a successful response, and it identifies common problems that may preclude success. This plan also presents a model system, which functions via two organizations at the state level. The first organization is a statewide council. Comprehensive statewide overview is essential to provide authority, establish priorities, and provide adequate funding. The second organization exists within a state department and specializes in on-the-ground projects. Finally, this document provides appendices, which should be updated annually, that will help the field biologist find some assistance in responding to a possible introduction.

Containment and eradication activities require focus and commitment, and they cannot proceed efficiently in an environment of complex demands and uncertain requirements. The goal of the model system is to create a consensus-driven decision process, but one where discussions about general strategies occur before the arrival of a new invader. The council makes the decision as to the general course of action when a nuisance species arrives. This decision provides the on-the-ground manager clear goals to obtain. Because each situation tends to include unique conditions related to the species and the environment, this plan is general in nature, and it does not attempt to address specific regional or national processes.

BACKGROUND AND RATIONALE

Aquatic nuisance species are organisms that create problems in and around the water. They may cause problems for people directly, such as weeds that interfere with boating. They may cause problems for the environment, such as weeds that overgrow a site and decrease oxygen in the water when they decay. Often they do both, such as northern pike that devour threatened native species as well as desirable game fish. While a native organism might occasionally cause problems, this plan addresses non-native species. A non-native species is one that has moved from its home range into areas where it never existed before. In most instances people are responsible for moving these species, either intentionally or accidentally.

Aquatic nuisance species can cause severe problems. Available solutions are often expensive and less than satisfactory. There are numerous examples, but a few will illustrate the scope of the problems. 1) Hydrilla is a water weed, and it can reduce the flow of water in a canal by 90 to 95 percent. In Florida, the hydrilla infestation increased from 50,000 acres in 1992 to 100,000 acres in 1994, despite the state spending 6million a year for its control. The estimated cost to adequately manage the infestation was about $11 million in 1992. By 1997, the cost increased to about $15 million. 2) Another water weed, water hyacinth, can cause the shutdown of power plants or pumps by blocking the water intakes. California spends about $5 million a year to control it in the Sacramento Delta, where only a couple of thousand acres exist. 3) In the Great Lakes, zebra mussels caused the shutdown of power plants and other facilities that move water, and their sharp shells cut swimmers' feet and caused beach closures. The mussel also has suppressed native species, leading to a decrease in biodiversity. There is no method to control zebra mussels over wide areas, although water and power utilities have implemented some procedures to mitigate some of its impacts on their operations. These methods are expensive and they do not eliminate the problem, so they must be employed on an ongoing basis. For example, in response to a poll, 23 nuclear power plants indicated that they spent an average of

about $787,000 each on zebra mussel control between 1989 and 1995. 4) Beginning in 1999, mitten crabs swarmed into pumping stations that supply water to much of Southern California. The station operators could not keep the crabs out of special pens that separate fish from the water flow so they are not forced through the huge pumps. In the pens, the moving water drove the fish against the hard, sharp shells of the crabs, killing many of them. These fish included several endangered species. The stations spent several hundred thousand dollars on equipment and alterations to keep the crabs out of the pens. The crabs have declined as a problem in the fish facilities in the last few years, partly due to the improvements made to the facility and changes in the way water flow is managed, and partly, the population has declined after the very favorable environmental conditions in 1999. Surveys show, however, the population has begun to increase again as the crab extends its range. As these examples demonstrate, aquatic nuisance species often cause problems that continue year after year.

Aquatic nuisance species can cause large and ongoing costs when they invade new locations, but those costs can be avoided if the species can be kept out of those new areas. This approach of avoiding problems is the general concept behind a variety of programs. It was first applied in public health with the old quarantine laws, and then in agriculture where it was given the name "Pest Prevention." Now the concept is being adopted to protect some natural resources as well.

Rapid response is one aspect of pest prevention, which is generally considered to have the following components: 1) keeping pests from entering the United States or restrict interstate movement (officially termed "exclusion"); 2) searching to find any new infestations that get by the exclusion screen ("detection," which includes the ability to rapidly identify suspicious organisms); 3) rapid response; and 4) public awareness. Rapid response involves assessing the size of the infestation ("delimitation") relative to the resources and tools that are available to completely destroy or otherwise remove the infestation ("eradication"). Eradication is always the primary goal of rapid response. Anything less than eradication means that the pest and the problems it may cause are here to stay. In many cases, however, eradication may not be feasible. This is particularly true in aquatic systems where detection and control are difficult and pests may spread rapidly. Rapid response in these instances involves assessing which goals are attainable and most cost effective. The final response may have one of several possible goals, such as containing the problem entirely to a given area, or suppressing the population to slow its spread, or, in some cases, learning to live with the problem.

LESSONS FROM RECENT RESPONSE EFFORTS

The three significant requirements for a successful eradication effort are: 1) access to the target organism, 2) persistence of effort, and 3) adequate tools to control the populations. Any response will have a higher chance of success where these requirements are easier to meet. Conversely, in responses where these requirements are not adequately met, the chance of failure will be high. Many interdependent factors influence whether the requirements for a rapid response are met. Major ones include: funding and other resources, legal authority, will to act, regulatory hurdles, interagency and public cooperation, experienced oversight, biology of the pest, available control methods and size of the project.

Rapid response efforts are not new and lessons can be learned about the elements that lead to success or failure by considering efforts that have proceeded relatively smoothly or not so smoothly. Two recent efforts that have captured attention are the responses to a marine seaweed (*Caulerpa*) near San Diego, California, and to an aquatic fern (*Salvinia*) in the lower

Colorado River near the United States/Mexico border. The two responses differed in their initial success, but they both followed much of the same approach. Success differed due to differences in the size of the infestations and environmental complications, as well as variations in funding and perceptions of the seriousness of the threat relative to the costs of control. Neither response provides an optimal model. As an example of a different approach, we will also outline the response to hydrilla in California. California has a long successful history of rapid response to new hydrilla invasions. The model system outlined at the end of this document addresses the weaknesses pointed out by the examples.

Caulerpa in Coastal Southern California

Caulerpa taxifolia is a saltwater alga (a seaweed) that is native to tropical waters, where it typically grows to small size and in limited patches. In the late 1970's, the species became popular in the aquarium trade because it is fast growing and decorative. The Stuttgart Aquarium in Germany selected a clone of the species that seemed promising, and they provided it to aquariums in France and Monaco. Around 1984, the clone apparently escaped from an aquarium into the Mediterranean, and it rapidly spread from a patch of about one square yard to over two acres by 1989. By 1997, it blanketed more than 11,000 acres of the northern Mediterranean coastline. Genetic analysis suggests that all *Caulerpa taxifolia* plants in the Mediterranean are clones of the original aquarium plant. In areas where the species becomes well established, it forms a dense carpet that overwhelms and eliminates native seaweeds, seagrasses, reefs, and other communities. In the Mediterranean, it harmed tourism and pleasure boating, devastated recreational diving, and has had a costly impact on commercial fishing by driving fish from the infested areas and by fouling fishing equipment. In a 1998 letter to Secretary of the Interior Bruce Babbitt, over 100 scientists and field biologists expressed their alarm about the damaging potential of this plant.

On June 12, 2000, a biologist from a marine consulting firm noticed unusual seaweed in Aqua Hedionda Lagoon in Carlsbad, California. Suspicious of the seaweed's identity, the firm sent a sample to a specialist who, on June 15, confirmed that it was identical in appearance with the invasive *Caulerpa*. This was the first find of *Caulerpa taxifolia* in North or South America. Although no one knows for certain, someone emptying an aquarium may have unintentionally released the Caulerpa into the lagoon or contaminated container used for bait or other products derived from the sea.

Once the plant was identified, the firm contacted a variety of agencies that address invasive species, water, and wildlife issues, and discussions began about possible responses. Several different groups began researching control possibilities by June 22. More importantly, the group immediately launched into action guided by their earliest discussions. The local power generator, which owns the lagoon, provided $123,000 to the project effort. The consulting firm, under contract with the power generator, determined that the infestation consisted of about 0.5 acres of plants scattered over an area of about five acres. On June 28, representatives from federal, state, and local agencies met and agreed to cooperatively develop a response. Biologists from the consulting firm began initial treatments by June 29. The selected treatment was to cover the patches with heavy tarps and pump in chlorine. By the end of June, the group outlined an action plan that was released on July 12 as the Southern California Caulerpa Action Team (SCCAT) Rapid Response Program. By then, the infested area within the lagoon had been cordoned off and the local police and game wardens were helping enforce the closures. In addition, intensive public outreach efforts had been initiated.

In the ensuing weeks and months, SCCAT continued to focus on eradicating the population and reaching out to other public and private organizations. The local Regional Water Quality Control Board declared *Caulerpa* to be a pollutant. They took the lead on the governmental side and tapped their Pollutant Spill Emergency Fund to provide $700,000 for the project effort. Two federal agencies contributed another $220,000. By September 18, all the known patches in the lagoon had been treated.

In early August, another small infestation was found in Huntington Harbor, near Los Angeles. The Regional Water Quality Control Board in that area also obtained $700,000 from its emergency spill clean-up fund to treat that population, and they initiated delimitation and treatment. Then SCCAT approached the California Legislature and obtained another $950,000 for continuing research on control methods, outreach and education, and detection beyond the known infested areas.

The description of the response might give the impression that there was a strong central authority, with a clear strategy and unquestioned lines of command from the outset. However, in retrospect this was not the case. The group had a diversity of opinions and agendas and it developed its strategies through a consensus approach. A different set of people spearheaded the different components of the response on a voluntary basis according to their abilities.

Although there was a diversity of opinions on many topics, the group was tied together by the conviction that eradication was the goal. There was a core of deeply concerned people who dedicated themselves to the response even though they had many other duties. They settled early on the most promising control strategies and they accepted that the treatment would damage other organisms under the tarps, although the tarps limited the extent of the effects. They identified one competent group to carry out the control operations and then everyone else helped pick up all the other necessary activities that surrounded the response, such as regulatory compliance, obtaining funding, interacting with other interested parties, and carrying out public outreach. In this manner, the control team was able to focus on the actual destruction of the pest without many distractions.

The response effort was fortunate in a number of ways. First, they were extremely fortunate to be able to identify and tap a very significant fund, over $900,000, to treat an infestation totaling a little more than one-half acre. By comparison, the California Department of Food and Agriculture (CDFA) has a budget of about $1.5 million per year for its eradication program on all its highest priority terrestrial weeds, occurring on over 800 sites covering over 7,000 acres. They were also very fortunate that the infestation was small and contained in a privately owned lagoon, so they could act without the difficulty of determining which agency had jurisdiction. Finally, they were fortunate in that no endangered species occurred in the lagoon and that some of the regulatory agencies embraced the threat and actively participated in the response.

Salvinia in the Lower Colorado River

Salvinia molesta is a small, Brazilian fern that floats upon the water. Unfortunately, its growth rate, ease of spread, and tendency to clump more than make up for its small size. In favorable conditions, a population will double in a week or less. For example, eight plants became established in a one-fourth-acre spring-fed pond in Moselle, Mississippi. Six weeks later they had covered the water's surface. Mats of salvinia commonly cover the water surface completely and may reach up to three feet in thickness. These mats destroy native habitats in several ways. They compete with and shade out native vegetation, completely cutting light to the water. The mats prevent oxygen in the air from entering the water, and dying salvinia drops to the

bottom where it consumes the remaining dissolved oxygen as it decays. The most notable change in the landscape is the obliteration of open water, such that migrating birds may not recognize or stop at water bodies covered with salvinia. Salvinia also directly affects people when it clogs water intakes, which interferes with irrigation, municipal water supplies, and electrical generation. The floating mats also provide excellent habitat for mosquitoes, and anglers abandon once-popular fishing spots because there is no open water to fish.

Despite all the problems it can cause, salvinia is an attractive plant in small quantities. With the current interest in water gardens, it has sometimes entered the nursery trade and been offered for sale as an ornamental. In most cases where infestations have been found in public waterways, salvinia has been offered for sale at nurseries in the state.

There already were well established infestations of salvinia in Florida, Louisiana, and Texas, and the word was spreading about the seriousness of the potential problem when, on August 4, 1999, a biologist for the United States Fish and Wildlife Service (USFWS) noticed thousands of free-floating plants on the Colorado River as it passes through the Imperial National Wildlife Refuge, about 25 miles north of the United States/Mexico border. The plants were quickly confirmed to be salvinia. On August 20, over 50 agency representatives and other interested people attended a meeting to consider the situation and plan a course of action. The USFWS was identified as the lead agency for the project. The group decided to quickly and cooperatively expand the search for the plant, and they completed the delimitation survey by September 15, when a second planning meeting occurred. The survey showed that the plants were scattered along 35 miles of the main river channel, 25 miles of the "old" river channel, and about 26 miles of drainage ditch coming from the northwest near the vicinity of Blythe. The ditch was clearly the headwaters of the infestation. The infested area included two federal wildlife refuges and habitat of two endangered fish and two endangered birds. One of the birds, the Yuma clapper rail, regularly uses emergent vegetation such as bulrushes and cattails.

At the second meeting the group established a task force and encouraged all land managers in the infested area to undertake "...whatever actions they could to control salvinia within existing and pertinent regulatory constraints," while the task force began development of an Action Plan. The CDFA agreed to begin treatments in the ditch. By October 13, the group had prepared a "program plan" that discussed the issues related to the infestation, control options, and factors affecting the selection of controls. The group intended the program plan to lay the foundation for the Action Plan, along with recommendations from a Science/Management Advisory Panel. The Panel consisted of five experts in aquatic plants and their control from across the United States. They visited the infestation on October 13 and 14, and recommended in their November 1 report that the response be "...a comprehensive, integrated and aggressive control program whose objectives are...to eliminate (their emphasis) populations in the river and all waters of the Western states."

Momentum for an all-out eradication program failed to materialize. Serious environmental concerns created a difficult situation, because two wildlife refuges, four endangered species, and major water supply all required special consideration. Although the USFWS took on the role of lead agency for the response, a variety of agencies have jurisdictions along the river, and there was no consensus about an overall approach to treatment throughout the infestation. The institutions that became involved all had difficulty finding funds, and as a result, the resources were not sufficient to provide a dedicated project manager, other staff, and necessary support. Everyone involved tried to participate in the response in addition to all his/her normal duties. Part of the difficulty for the federal agencies was that any use of their funds for herbicide treatments would likely trigger the need for an Environmental Impact Statement, with the

attendant delays. Another factor was that biological control holds out hope for a less painful option. In some parts of the world, a Brazilian weevil, highly specialized for feeding on salvinia, has provided very effective control. In addition, for some unclear reason, but probably related to water chemistry, salvinia has not thrived in the Colorado River itself, although it does well in the ditch. These latter two factors made the situation appear less threatening, reducing the incentive to eradicate.

The consensus of the group was to eradicate the infestation in the ditch by mechanically removing plants and associated obstructions from the banks and when necessary treating the salvinia with herbicides. The group also supports public outreach as a high priority. Once the infestation in the ditch is eradicated, the group hopes that the population in the river will lessen, but the next steps are unclear. No Action Plan has been produced, although a draft was circulating as of March 2001 and the hope was to finish it during the summer.

A Summary of the Response to Caulerpa and Salvinia

The approach used in the two responses was very similar. Someone found an infestation because of heightened public awareness and he/she sent a sample to an expert. Once the problem was confirmed, different agencies and local groups that might be affected or could assist in the response were contacted. Representatives of the interested parties met to consider the situation. Delimitation proceeded quickly while the control options were quickly reviewed with input from expert biologists and managers. At this point, the two responses diverged radically, although the potential threat from both species was extremely high. The difference in response was not due to the approach; it was different because of differences between the groups themselves and in the difficulty of the situations facing them. No mechanism was available to resolve those difficulties promptly and definitively.

Hydrilla in California

Hydrilla is a submersed aquatic plant native to the warmer areas of Asia. Its growth habit allows it to compete effectively for sunlight and it will establish in an area and crowd out native aquatic plants. Hydrilla is very efficient at reproducing and maintaining itself, even during adverse conditions. For example, if a stem fragment has even a single whorl of leaves, almost 50 percent of the time it can sprout a new plant and each plant can produce a new population.

Hydrilla causes major impacts on water use. In drainage canals it greatly reduces flow, which can result in flood damage. In irrigation canals it cuts water delivery and clogs pumps. Hydrilla can severely interfere with boating and swimming and it can adversely impact fish populations. For instance, largemouth bass begin to suffer when hydrilla covers more than 30 percent of a water body. The economic impacts to real estate values, tourism and user groups can be staggering. For example, an economic study on Orange Lake in North Central Florida showed that the economic activity generated by the lake was almost $11.0 million per year. In years when hydrilla completely covered the lake, these benefits were almost completely lost. Cost of hydrilla management is also extremely high, as was described in the introduction.

Hydrilla has been discovered in California a number of times. California law declares hydrilla a noxious weed and charges the director of the CDFA to "...immediately investigate the feasibility of eradication. If eradication is feasible, the director shall perform the eradication...taking those steps and actions the director deems necessary" (California Food and Agriculture Code 6048

and 6049). To date, the agency's response to hydrilla has been aggressive and persistent, with good success.

For example, hydrilla was discovered in the irrigation system of the Imperial Valley in 1977. The CDFA initiated chemical and mechanical treatments in cooperation with the county and the Imperial Irrigation District, and they initiated a research program on other treatment methods in cooperation with a number of state and federal agencies, including the University of California. Despite the initial treatments, by 1988 over 600 miles of canals were infested and flow in some was reduced 90 to 95 percent. The method that led to the collapse of the infestation was when they were able to introduce sterile triploid grass carp into the system after their research program had satisfied the California Department of Fish and Game that the fish were sterile and would not become a problem themselves. Stocking began in 1988, and by about 1998 the program had reduced the population to a handful of plants each year in isolated canals and drains. The stocking and survey system continues today to suppress any remnants of the infestation and to provide general weed control.

In another large infestation, 26 miles of the Chowchilla River and the upstream end of Eastman Lake were found infested in 1989. Over 100,000 visitors used the lake each year but the CDFA quarantined and closed the lake, lowered the water level and treated the infested lake bottom with a soil fumigant. After follow-up treatments with aquatic herbicides, the lake was re-opened to visitors in 1992. As for the river, fortunately it runs low much of the year, which allowed effective treatment of the infestation. With chemical treatments, digging, and dredging, the population of plants in the river was reduced to 6,500 in 1993, to less than 50 in 1998 and five in 2001. Eradication work continues, mostly depending upon physical removal of the plants by hand pulling and dredging. No plants have been detected in 2002.

In still other smaller infestations, the CDFA has gone so far as to fill in ponds. For example, in 1985 hydrilla appeared in a series of ponds within a few hundred feet of the Sacramento River in the Redding area. This infestation presented such an extreme threat to the state that the Governor's office declared it an emergency. The CDFA buried three small-infested ponds inside the levees during the course of that eradication program.

The most challenging infestation in California has been the one in Clear Lake, a shallow, warm, murky, natural lake of about 43,000 acres, approximately 60 miles north of the Bay Area. The shore of the lake is heavily developed and lake-related recreation is a major source of income for the area. Hydrilla was discovered in the lake in 1994, but the CDFA did not restrict access to the lake to avoid the economic disruption the restriction would have created. The CDFA crews surveyed and marked off the infested locations and began a public awareness program to prevent the spread of the weed, as well as initiating regular treatments with copper and later with fluridone when it became available. The number of plants has been greatly suppressed but small new infested sites continue to appear at the rate of one to approximately two per year, probably as a result of fragments from already infested sites. With persistent effort, however, the hydrilla has begun to disappear from many of the previously infested sites, and eradication appears to be within grasp.

The responses to hydrilla have been successful for a number of reasons. California law gives the CDFA a clear mandate and they make the eradication of hydrilla a top priority. They dedicate a crew to major infestations and even in small infestations a knowledgeable biologist will guide the work. They will use all available control methods and they support work to develop new ones. They are persistent, they cooperate with anyone interested in helping with an eradication campaign, and in general, they have received good support from the community.

The law that gave them their authority provided few funds, but they have always been provided adequate funding, though it sometimes comes from a variety of sources. Nonetheless, the program faces the same kinds of problems that beset many agencies. For instance, much of their funding sunsets in the next few years and they must begin the process of renewing those resources. Similarly, in the last several years the agency has felt more pressure from environmental hurdles and the costs they may bring.

ELEMENTS INFLUENCING SUCCESS OR FAILURE OF A RESPONSE

The above examples illustrate some of the elements that influence the success or failure of a response. Other elements may be found in other analyses of rapid response. For example, the excellent document, "A Rapid Response Toolbox: Strategies for the Control of ABWMAC Listed Species and Related Taxa in Australia" (The Toolbox), could serve as a model for general planning for rapid response, although it is specific to marine organisms. This document may be found at www.marine.csiro.au/CRIMP/reports/Toolbox.pdf. The Toolbox goes beyond the scope of the present document by outlining possible controls for a wide array of taxonomic groups but in its introduction, the authors analyze several other recent responses to invasive species, including the eradication of *Mytilopsis sallei*, a relative of the zebra mussel, from three isolated marinas. They explore the factors that influence the decision to eradicate and the factors that affect success once the decision is made.

Influences on Success

Once the numbers of pests expand beyond the level where they can be individually removed, one of the main problems for eradication is a lack of highly specific control techniques. Optimally, a control method should be highly selective for the target pest, cost-effective, easy to use and have no long-term negative effects on the environment or non-target species. Highly specific controls usually require detailed knowledge of the particular physiology, habitats and/or ecology of the target pest. Such detailed knowledge about an aquatic, invasive species is rarely available, even for the most widely recognized problem species. However, eradication technologies need not be as specific if their impacts on non-target species can be minimized in some way, such as when they are limited to a restricted area or have transitory effects that allow recovery.

The authors of The Toolbox state that eradication requires: early detection; a supportive legal framework; a capacity to act (requiring suitable funding and local/national support); an ability to quarantine the infested area if necessary; and the tools to eradicate the isolated population. In the successful eradication of the zebra mussel relative, other factors that contributed to the success included: rapid initiation of control efforts; legal capacity to enter, modify, or eliminate infested property; small water bodies isolated from the local marine environment; ability to track exposed vessels; and pre-existing information on chemical treatments for related taxa.

Interestingly, at the time The Toolbox was written, the authors believed that the Caulerpa response in San Diego was likely to fail, citing little pre-existing knowledge on control of the species, no clear lines of authority, no ready source of funding, and a lack of appropriate permits, all of which were true. Only by good cooperation and hard work were these problems avoided. Progress could still be in jeopardy if cooperation and focus break down among the many parties in the group, most of who have a full range of duties to perform outside the response.

The Decision to Eradicate

In making the decision to eradicate, the authors of The Toolbox note that, with current available control methods, eradication is generally feasible only for small populations. Such populations generally represent an early stage in the invasion of a new area by a non-native species. An eradication program occurs in an environment of diverse laws and regulations, where private and public organizations, government agencies, industry, interest groups, and private individuals all interact. These interdependent groups often have differing interests. The limits of what can be achieved in an eradication program are set by available technology, and often some groups create the demand for a treatment technology while others oppose its use. Further, there is rarely time to gather enough information to accurately and objectively estimate the costs and benefits of a particular eradication attempt, particularly if there is no history with the target species. The decision to attempt eradication of a non-native pest can be difficult, as it may require balancing conflicting social, political, and legal issues in a situation where good information is likely to be scarce. A number of factors influence the decision.

Factors to Consider When Deciding to Eradicate

A. Is there knowledge of the risk of reintroduction, and is the risk low enough to justify eradication?

B. Taken overall, can controls be initiated rapidly?

1. Was the invasion detected early? That is, the infestation is small and there are only a few locations?
2. Was the invader rapidly and accurately identified?
3. Is information on species biology and management quickly available?
4. Are treatment methods available?
5. Are there serious environmental issues or regulatory hurdles that will lead to delays or greatly increase the cost of treatment?
6. If permits are needed, can they be obtained in a timely fashion?
7. Has the species been prioritized for response and is there a pre-existing action plan?

C. Taken overall, is there a will to act?

1. Are there decision-making procedures and structures with the power to determine whether eradication should proceed, how, and who should fund it?
2. Has there been a clear assessment of technical, field, administrative, funding, and legal resources available for an eradication campaign?
3. Is there acceptance of the need to proceed on the best information available?
4. Is there acceptance of short-term, local impacts in return for long-term, wide-area benefits?
5. Is there acceptance that the "no action" response has serious impacts and is a poor option?
6. Do a preponderance of the agencies (and their staff) feel they have a clear responsibility to act, or does one agency have a clear mandate and authority to act?
7. Is there recognition and acceptance that the eradication effort can be a long-term effort, almost always taking years in the case of plants or other organisms with resistant resting stages?

D. Taken overall, is organization adequate?

1. Is there an ability to quarantine the infested area?
2. Is there a capacity to survey, to determine whether the pest is restricted to the quarantine area?
3. Will program staff with experience in pest management and eradication be assigned to direct the control efforts and monitor results?
4. Are funding sources adequate and of sufficient duration?
5. Is there effective collaboration among the parties carrying out the effort?
6. Is there regional collaboration where infestations cross jurisdictions?
7. Are there provisions for monitoring in order to modify, expand, or end an eradication campaign?

E. Other factors

1. Is there support for the effort by affected parties, including the public?
2. Is there effective outreach and education for both the public and government decision makers?

Clearly, many of these factors are related but they all bear on ready access to the target, availability of adequate tools, and the ability to persist in the effort long enough to achieve eradication.

In the current sociopolitical environment in the United States, the initiation and success of a rapid response can depend strongly on the extent of the infestation, ease of control, and the groups involved in the response. If the general requirements that are needed to initiate an eradication program are anticipated and preparations are made to meet those needs, the initial response can be implemented in an effective and timely manner. For example, in agriculture, the responses to some pests such as the Mediterranean fruit fly in general or the gypsy moth and hydrilla in California, are often aggressive and effective though they are not without their opponents at times. In the realm of aquatic nuisance species, an excellent example of a beginning in this direction for the Western Region outside of California is the hydrilla prevention plan for Oregon entitled, "Hydrilla Management in Oregon: Options, Obstacles, and Required Action" (Appendix 3). The pests mentioned above are well-recognized pests with a history of responses to them, so more information is available for them. In the introduction of a more novel pest, each situation is likely to be unique. There may be a large variety of unknowns with no distinct treatment options.

UNDERTAKING A RAPID RESPONSE

A rapid response program is a variation of an integrated pest management program. The major difference between a rapid response program and a pest management program is that the goal of rapid response is to reduce the population to zero (eradication), where the goal in pest management is to maintain the population below an economic threshold (the point where potential damage outweighs the cost of control). Also, an eradication program is based upon an intentional trade-off of short-term, localized impacts for long-term, wide-area benefits; so, an eradication effort may require accepting higher levels of non-target damage than a pest management program. Eradication programs become less desirable as they require more widespread treatment and cause longer-term damage.

The elements of a basic rapid response are relatively straightforward. The usual steps in a basic response to a known threat are: 1) rapid confirmation of the identity of a suspicious organism; 2) survey (delimitation) to determine the extent of the infestation; 3) quarantine of the infested area if possible; 4) a very quick review of the available control options to choose the one best suited for the treatment conditions; 5) application of the chosen control options, with at least a visual evaluation of the results on the target and non-target species; and 6) modification of the control strategy as indicated by the results (sometimes called "adaptive management"). For a less well-known pest, there would be additional steps. Once the pest was identified, a rapid literature survey of the biology and control of the organism might be needed, as well as quick tests of the potential control options to identify the most promising ones. The first applications of the chosen options might be made on a limited basis with at least a visual evaluation of the results on the target and non-target species to check that the treatment works as expected. The treatment might be modified as indicated by the results of the early applications or experiments and then general application would begin with continued evaluation and modification as before. Some of these steps can be progressing at the same time.

Eradication efforts run the gamut from destroying a handful of individuals in one small spot to applying controls over large areas against millions of organisms. As the size of the population and area increase, complexity and cost increase rapidly, and the chance of success falls. Because of the rapid increase in impacts and complexity, it is important to catch an invasion when it is small and can be treated more or less as a part of normal maintenance operations on a property. Large responses invite multiple agendas and all the difficulties that often attend them. The best situation is where a land manager recognizes a potential problem early and either takes care of it personally or enlists the advice and aid of the single agency that has the greatest interest in seeing the pest eradicated. This situation is common for terrestrial weeds in cases where a local biologist or manager is aware of a potential threat. Unfortunately, it is much less likely in the realm of aquatic nuisance species because of the mobility of the species, their cryptic natures, the open nature of many water bodies, and the extreme value and sensitivity of water habitats.

In almost all situations involving aquatic nuisance species, the circumstances of the response will probably be complex. In a complex situation, the elements of a response that need to be considered include:

1. Authority, leadership, and organization (that is, who has the legal ability to act, as well as who has the operational capability)
2. Coordination and cooperation among the different parties
3. Funding, resources
4. Quarantine establishment and enforcement
5. Environmental regulatory compliance: obtaining permits, developing documentation
6. Public awareness and education; outreach to affected property owners and parties
7. Delimitation survey (possibly also widespread detection survey) and mapping; evaluation of risk of spread
8. Review of knowledge on biology and controls; convening a science/management/environment advisory panel; research and technology transfer; identification of potential treatment methods
9. Implementation of eradication methods, including persistent survey and treatment to ensure eradication
10. Treatment assessment and adaptation. Accountability for progress towards eradication.

11. Environmental monitoring
12. Restoration/mitigation

As was shown by the salvinia and caulerpa examples, a response generally begins when a biologist or land manager, who is going about his/her other business, happens to notice something unusual and sends a sample to a university, museum, agriculture department, or other public agency to have it identified. Eventually, either the field or the lab person finds a responsive person in some agency. In a complex situation, a number of agencies and interested parties come together and try to organize a response. Often it is a challenge to find an agency with clear authority, or, even better, the mandate and resources to respond to the introduction. As a result, the group tries to identify a lead agency and resources in an ad hoc, non-binding fashion. Either intentionally or not, they will also address some of the response elements listed above, often embodying the results in a consensus-based action plan.

OTHER RECENT EXAMPLES OF GENERAL RESPONSE PLANS

As this pattern holds quite frequently in responses to non-agricultural invasive species, there have been efforts to formalize this process. For instance, in July 2001, the National *Caulerpa taxifolia* Conference proposed the following model for cualerpa:

Discovery of new infestation
↓
Report/Notice to Agency
↓
Agency contacts others that should be notified (agencies with jurisdiction or regulatory authority, stakeholders, local experts)
↓
Convene Science Panel (five to seven members)
↓
Localized resource meeting/site visit and review (attended by Science Panel, Agency and appropriate others)
↓
Science Panel meeting to discuss problem and develop a statement of facts and anticipated direction
↓
Public meeting to do presentation on problem, Science Panel introduction and release of statement, and take public input/comment
↓
Science Panel issues report to Agency

They further stated that the Science Panel might be reconvened to do peer review of the eradication program or recommend new treatment options as they become available or as needed. The panel members should include experts on biology of the species in question, on the ecology of the habitat under invasion, on invasion ecology, and on eradication and management methods.

A model with a somewhat broader view came out of the National Giant Salvinia Conference in March 2001:

1. Set up a standing incident command structure (ANS Council) with representatives from state and federal agencies, environmental organizations and universities. This body will be responsible for establishing a general response structure for their state in advance of an infestation and responding appropriately when detection is reported [to] the lead entity.

   General Response Structure:

   - ξ Identify who will be notified of reports.
   - ξ Identify who will do the identification of organisms.
   - ξ Develop procedure to determine whether or not a rapid response will be undertaken.

2. Set up an Emergency Response Fund dedicated to supporting the activities deemed necessary by the ANS Council.

3. If a report is taken and the General Response Structure is followed and rapid response is necessary:

Organize Task Force:	Include local parties interested/affected by infestation
Delimitation Survey:	Extent, source, site ownership, resource needs, and regulatory needs.

4. Use all information to evaluate options – convene a Science/Management Panel

5. Develop Action Plan

Pertinent Topics:	Treatment Plan; Media Plan; Outreach/Education Plan; Research Needs; Intercepting Pathways; Monitoring Plan; Regulatory Compliance

6. Obtain resources needed to implement Plan

7. Implement Action Plan

8. Monitor effectiveness and impacts of treatments

9. Modify approach if indicated by monitoring program

The salvinia model anticipates many of the problems identified in this document and addressed by the model system. Many other recent documents on pest prevention routinely identify the same sets of concerns about exclusion and rapid response capabilities as they currently stand. Clearly, except for some agricultural pests or other pests of long-standing importance, pest prevention currently has a number of weaknesses. These weaknesses begin with exclusion, which is outside of the scope of this plan. Beyond exclusion, the problems begin with detection capabilities, which are extremely important to success in rapid response. In rapid response itself, the problems center on a lack of clear authority, funding, resolution of environmental issues, and planning. These are problems that have been recognized at the national level and they have been identified as issues in the "National Invasive Species Management Plan"

released by the National Invasive Species Council in November 2000. The Council is a Cabinet-level group created by President Clinton's Executive Order of February 3, 1999.

THE MODEL SYSTEM

The model system proposed here attempts to address the weaknesses that have been identified in current rapid response efforts. It uses a two-level approach, both organized within the state government. The first level works on a statewide basis to address authority, policy, funding, and priorities. The second level addresses the details of implementing specific projects, particularly the need for experienced supervision. Either embodied in this structure or through a separate fund, adequate resources for responses also need to be available on short notice because new introductions are unpredictable. The goal of this approach is to create a system where, for a given introduction, the question of whether to eradicate is decided at the outset or even prior to introduction and if the decision is to eradicate, then all aspects of the eradication are provided for. The system should address the response elements listed above (page 11), which currently are typically addressed in an ad hoc action plan developed by a volunteer group as the response unfolds.

In the model system, a state creates a statewide aquatic nuisance species (or invasive species) council through legislation. The members of the council should come from the departments that might have a concern in a rapid response. They should be executive level or their designee in order that the results of their deliberations will carry weight down to the staff level. The council should include representatives of the major departments responsible for the resources that are threatened by invasive species or that may have responsibility to weigh the effects of control actions. Such departments should include those responsible for agriculture, fish, game, water, or other biological resources, as well as the departments responsible for pesticide regulation and other potential impacts, such as channel modification. The counterparts of these state representatives in the regional federal government might also be on or associated with the council because federal issues and funds are often involved in a response. Finally, some members of the public should be on the council, representing landholders, affected industries such as aquaculture and water conveyance, and environmental concerns. The goal is to create a board that will consider the ramifications of a response and whose decisions will represent a broadly supported determination of the best option.

This council identifies priority species, outlines general response goals for each species, reviews authority for actions, and broadly addresses the means to resolve environmental issues that may arise during a response. In the list of response elements (page 11), the council should address authorization, organization, collaboration, and funding (Response Elements 1, 2, and 3), the general aspects of quarantine, environmental compliance and documentation, and public awareness and outreach (Response Elements 4, 5, 6), and possibly the general aspects of environmental monitoring and restoration (Response Elements 11, 12). Most of the work should be done at the staff level and most situations and issues may be resolved there as well, but the council should identify and provide advice related to major policy and funding issues on a regular basis, and members of the council should be available for deliberating on and deciding difficult or controversial situations.

At the level where projects are implemented, either a single state department should be identified as the operational leader for all responses, or different situations or taxa could be assigned to different agencies. Only a very few agencies should have operational capacity, however, to avoid confusion and ambiguities. Ultimately, on any given eradication project, only

one agency should have final responsibility and authority. The operations department could either develop treatment expertise in its own structure and carry out control operations itself or it could develop a network of contractors to carry out work under its direction, as long as the department has experienced professional staff to evaluate the results of field operations and make any necessary modifications to control strategies. The operations department would have responsibility for developing the details of the response to any particular infestation and planning for new introductions, subject to the guidance of the state council. The operations department would address delimitation survey, development of treatment methods, implementation of eradication methods, and treatment assessment and adaptation (Response Elements 7, 8, 9, and 10). They would also address the technical aspects of resources needed for the response, quarantine, and public outreach and awareness and education (Response Elements 3, 4, and 6) that are specific to the situation. The operations department may also address the technical aspects of environmental compliance, environmental monitoring, and restoration (Response Elements 5, 11, and 12), or they may require assistance from other departments that specialize in these fields.

South Carolina provides one model of a coherent system to manage aquatic nuisance plants. The South Carolina Legislature established three interlocking entities in their system: the Aquatic Plant Management Council, the Aquatic Plant Management Program, and the Aquatic Plant Management Trust Fund. The Aquatic Plant Management Council is composed of representatives from state agencies with water resource management responsibilities, Clemson University, and the Governor's Office. The Water Resources Division of the South Carolina Department of Natural Resources chairs the Council. The Council provides interagency coordination and serves as the principal advisory body to the South Carolina Department of Natural Resources on all aspects of aquatic plant management and research in South Carolina. The Council establishes management policies, approves all management plans, and advises the Department on research priorities.

The Water Resources Division of the South Carolina Department of Natural Resources runs the Aquatic Plant Management Program. The Department is responsible for developing an aquatic plant management plan that outlines the procedures for problem identification and analysis, selection of control methods, program development, and implementation of operations. The plan also identifies problem areas, prescribes management practices, and sets management priorities

The Aquatic Plant Management Trust Fund receives and expends funds for the prevention, management, and research of aquatic plant problems. The fund may receive state appropriations, federal and local government funds, and funds from private sources. The Water Resources Division of the South Carolina Department of Natural Resources administers the fund, which is kept separate from other state funds.

Oregon has recently passed a law that may lead to a similar system. It creates a council centered around the directors of the departments of agriculture and fish and wildlife, the President of Portland State University, and the head of the Sea Grant College of Oregon State University. These four members appoint another eight members from local and federal government, as well as industry and public representatives. The Council's job is to increase public awareness about invasive species by developing Internet sites and educational materials. It is also charged with developing an invasive species management plan. Their first task in preparing the plan is to review state authority needed to exclude and eradicate invasive species. The council may also direct work on invasive species projects by providing grants. The law also creates a fund that acts as a permanent account to hold funds over from one budget year to the

next, so they are not lost back to the state's general fund. The law does not identify a department to carry out eradication operations, identify a mechanism to resolve environmental and other issues, or explicitly address many of the elements that are important to a successful rapid response program, and it does not appropriate many resources. However, these gaps may be filled if the council forcefully represents the requirements of successful rapid response programs and clearly identifies the deficiencies of current laws and authorities.

NATIONAL INITIATIVES

In addition to setting up a statewide system for addressing rapid response, relatively modest efforts at the national level could help tremendously. The most cost-effective would be developing reviews of biology and control methods for various high priority species or higher taxonomic groups to be used as the basis for control projects. Many of these species are of concern for many different parts of the country and the general pest biology and the range of control options are usually very similar from place to place. It makes little sense for each state to have to develop this information for itself. Many authorities have repeatedly noted the importance of ready access to technical information in the success of an eradication effort.

SUMMARY

A rapid response can occur in a complicated social and environmental setting, but in most instances a response must be initiated quickly and forcefully if there is to be a hope of eradication. Debate and consensus building are important means to construct public policy. If they slow the initiation of a response they may be counterproductive to the goal of eradication. One goal of this plan is to create a system where this debate and consensus building largely occur before an introduction of an invasive species, at least on a general basis. Once an introduction occurs, the same system should provide a forum where remaining issues may be resolved rapidly and a decision made to proceed with eradication, or with some other management action, or to allow the invasion to take its course. If the decision is made to eradicate, the final goal of this plan is to put competent pest management personnel on the ground and give them the freedom to focus on the infestation with the persistence that is required to achieve eradication.

The approach to these goals employs a two-level organization. The first level, the state council, focuses on the debate and on preparing the way for vigorous response efforts. This level must occur at a high level of state management and with participation of affected federal and local interests. Its decisions on a course of action should provide the state authority to achieve those goals. The second level of organization focuses on the operations on the ground. It also identifies the various issues and options surrounding invasive species and informs the first level about them, and further uses that information to prepare for introductions. Once the first level outlines a course of action, the second level focuses its knowledge and experience on the field operations needed to achieve the goals.

A successful response to an invasive aquatic species requires access to adequate tools, access to the target species, and, often, dedicated persistence. Sometimes these requirements are not convenient or inexpensive for society, and extra costs fall on the people and habitats caught up in the area of infestation. The decision to eradicate or otherwise respond to an invasive species can be difficult, and it needs to have a forum that reflects the importance of the issues involved. Once the decision is made to eradicate or suppress an introduced population, however, the managers on the ground need to put their full energies on finding and removing the target

species. This plan attempts to address these dual needs and maximize success against invasive aquatic nuisance species.

APPENDICES

Notes on Using the Contact Information Lists (Appendices 1 and 2):

Appendix 1 and 2 provide contact information for people who specialize in invasive species in some way and who may be able to help in a response to a new introduction. These appendices are meant to help the field biologist or land manager that faces an unfamiliar challenge in the form of a new invasive species and who needs some assistance or guidance in initiating a response. The two appendices between them give a broad representation of the people in the West who study invasive species or manage invasive species programs.

The contact information in these appendices was gathered by using references from the Western Regional Panel members and by contacting agencies in the various states. Contacts were asked to provide a brief description of their specialties or positions. While we have made an effort to ensure this information is accurate, identifying people involved in invasive species proved difficult. Few people work solely on invasive species and on aquatic nuisance species in particular. Often a person's duties include some aspect of work on invasive species as part of broader duties. For these reasons, the lists should be viewed as a place to start. Similarly, people often appear in both appendices.

Appendix 1 provides information on people who focus on the identification of species, their biology, and possibly their control. Appendix 2 provides information on agencies that would likely be involved in a response, depending upon the situation and species. Agencies might be involved either in the control work or in regulating the control work. Each appendix is organized by state. Following each appendix are two indices. One is sorted by the names of the persons in the appendix, and the other is sorted by the person's specialties. Both give reference to the state in which that person or specialty will be found.

The Appendices will be updated periodically to keep the information current. For the latest contact information, check the Western Regional Panel web site: http://answest.fws.gov.

APPENDIX 1: SPECIALISTS IN IDENTIFICATION AND BIOLOGY

Alaska

PERSON/INSTITUTION	Bruce Wing – NMFS Auke Bay
PHONE	(907) 759-6043
ADDRESS	11305 Glacier Hwy, Juneau, AK 99801-8626
E-MAIL	Bruce.wing@noaa.gov
SPECIALIZATION	Aquatic plants

PERSON/INSTITUTION	Bob Piorkowski, Division of Commercial Fisheries, Alaska Department of Fish and Game, 1255 W. 8th Street Juneau, AK 99801
PHONE	(907) 465-6150
E-MAIL	bob_piorkowski@fishgame.state.ak.us
SPECIALIZATION	All aquatic plants and animals

PERSON/INSTITUTION	Gary Sonnevil, Project for Kenai Fisheries Resource Office, US Fish and Wildlife Service, PO BOX 1670, Kenai, AK 99611
PHONE	(907) 262-9863
E-MAIL	Gary_sonnevil@mail.fws.gov
SPECIALIZATION	fish

Arizona

PERSON/INSTITUTION	Dr. Kevin Fitzsimmons
PHONE	(520) 626-3324
E-MAIL	kevfitz@ag.arizona.edu
SPECIALIZATION	fishes, animals

PERSON/INSTITUTION	Stewart Jacks
PHONE	(520) 367-1953 ext. 20, Bus Fax: (520) 367-1957
ADDRESS	PO Box 39, 1684 E White Mtn Blvd #7, Pinetop AZ 85935
E-MAIL	Stewart_Jacks@fws.gov
SPECIALIZATION	AZ fishes

PERSON/INSTITUTION	Rob Clarkson
PHONE	(602) 216-3858; Bus Fax: (602) 216-4006
ADDRESS	2222 West Dunlap, PO Box 81169, Phoenix, AZ 85069-1169
E-MAIL	rclarkson@lc.usbr.gov
SPECIALIZATION	Fishes and aquatic animals

PERSON/INSTITUTION	Ed Northam
PHONE	(602) 542-3309
ADDRESS	Plant Services Division, 1688 West Adams, Phoenix, Arizona
E-MAIL	ed.northam@agric.state.az.us
SPECIALIZATION	Noxious plants

PERSON/INSTITUTION	Jim Garza
PHONE	(623) 869-2333
E-MAIL	jgarza@cap-az.com
SPECIALIZATION	Aquatic plants

PERSON/INSTITUTION	Dr. Fred Nibbling, US Bureau of Reclamation, Denver
PHONE	(303) 445-3639
E-MAIL	fnibling@do.usbr.gov
SPECIALIZATION	Plants

California

PERSON/INSTITUTION	California Department of Food and Agriculture, Plant Pest Diagnostics Center, 3294 Meadowview Road, Sacramento, CA 95832
PHONE	(916) 262-1100
E-MAIL	
SPECIALIZATION	Plants, insects, plant pathogens, some gastropods, other arthropods.
COMMENT	Samples may also be submitted at any County Agricultural Commissioner's Office

PERSON/INSTITUTION	Lawrence L. Lovell, Collection Manager, William A. Newman, Curator, Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive Mailcode 0244, La Jolla, CA 92093-0244
PHONE	(858) 822-2818 (Lovell); (858) 534-7313
E-MAIL	llovell@ucsd.edu; wnewman@ucsd.edu
SPECIALIZATION	Benthic invertebrates

PERSON/INSTITUTION	Philip A. Hastings, Curator, Marine Vertebrates Collection, Scripps Institution of Oceanography, University of California, San Diego 0208, 9500 Gilman Drive, La Jolla, CA 92093
PHONE	(858) 534-2199
E-MAIL	phastings@ucsd.edu
SPECIALIZATION	marine vertebrates

PERSON/INSTITUTION	Prof. M. D.Ohman, Curator, Scripps Pelagic Invertebrates Collection
PHONE	
E-MAIL	mohman@ucsd.edu
SPECIALIZATION	marine invertebrates

PERSON/INSTITUTION	Terrence Gosliner, Sr. Curator, Dept. of Invertebrate Zoology and Geology, California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118
PHONE	
E-MAIL	izg@calacademy.org
SPECIALIZATION	molluscs, echinoderms, other invertebrates

PERSON/INSTITUTION	Department of Ichthyology, California, Academy of Sciences, Golden Gate Park, San Francisco, California 94118
PHONE	(415) 750-7047
E-MAIL	mhoang@calacademy.org
SPECIALIZATION	fishes

PERSON/INSTITUTION	Cohen, Andrew N., San Francisco Estuary Institute, 1325 South 46th Street, Richmond, CA 94804
PHONE	(510) 231-9423
E-MAIL	acohen@sfei.org, website: http://www.sfei.org/invasions.html
SPECIALIZATION	Marine and estuarine invertebrates in general

PERSON/INSTITUTION	Lars Anderson, United States Department of Agriculture Research Service, One Shield Ave., Davis, CA 95616
PHONE	(530) 752-6260
E-MAIL	lwanderson@ucdavis.edu
SPECIALIZATION	aquatic plants and their management

Colorado

PERSON/INSTITUTION	Colorado Division of Wildlife, Species Conservation Section, 6060 Broadway, Denver, CO 80216
PHONE	(303) 291-7466
E-MAIL	
SPECIALIZATION	All vertebrates, mollusks, and crustaceans.

PERSON/INSTITUTION	Denise M. Hosler, Ecological Research & Investigations Group, Bureau of Reclamation, Denver Federal Center, Denver, CO 80225-0007
PHONE	(303) 445-2195
E-MAIL	Dhosler@do.usbr.gov
SPECIALIZATION	plants

PERSON/INSTITUTION	David Sisneros, Ecological Research & Investigations Group, Bureau of Reclamation, Denver Federal Center, Denver, CO 80225-0007
PHONE	(303) 445-2228
E-MAIL	dsisneros@do.usbr.gov
SPECIALIZATION	plants

Kansas

PERSON/INSTITUTION	Greg Frieman - University
PHONE	(785) 864-4493
E-MAIL	
SPECIALIZATION	botanist

PERSON/INSTITUTION	Tom Sim, Bill Scott - Kansas Department of Agriculture
PHONE	(785) 862-2180
E-MAIL	bscott@kda.state.ks.us
SPECIALIZATION	All animals / plants

PERSON/INSTITUTION	Steve Adams or Tom Mosher– Kansas Department of Wildlife and Parks
PHONE	(785) 296-0019 / (620) 342-0658
E-MAIL	stevea@wp.state.ks.us / tomm@wp.state.ks.us
SPECIALIZATION	Aquatic animals, fish

PERSON/INSTITUTION	Bill Busby, Kansas Biological Survey, 2041 Constant Ave, Lawrence, KS 66047-2906
PHONE	(785) 864-7692
E-MAIL	busby@falcon.cc.ukans.edu
SPECIALIZATION	Plant, Invertebrates

PERSON/INSTITUTION	Denise M. Hosler, Ecological Research & Investigations Group, Bureau of Reclamation, Denver Federal Center, Denver, CO 80225-0007
PHONE	(303) 445-2195
E-MAIL	Dhosler@do.usbr.gov
SPECIALIZATION	plants

PERSON/INSTITUTION	David Sisneros, Ecological Research & Investigations Group, Bureau of Reclamation, Denver Federal Center, Denver, CO 80225-0007
PHONE	(303) 445-2228
E-MAIL	dsisneros@do.usbr.gov
SPECIALIZATION	plants

Manitoba

PERSON/INSTITUTION	Dr. Bruce Ford, University of Manitoba (Botany Department)
PHONE	(204) 474-8132
E-MAIL	
SPECIALIZATION	Aquatic macrophytes

PERSON/INSTITUTION	Hedy Kling, c/o Department of Fisheries and Oceans, Freshwater Institute, Winnipeg
PHONE	(204) 983-5216
E-MAIL	
SPECIALIZATION	Algae

PERSON/INSTITUTION	Dr. Ken Stewart, University of Manitoba (Zoology Department)
PHONE	(204) 474-9245
E-MAIL	
SPECIALIZATION	Fishes

PERSON/INSTITUTION	Dr. Brian McKillop, Museum of Man and Nature
PHONE	(204) 956-2830
E-MAIL	
SPECIALIZATION	Mollusks

Montana

PERSON/INSTITUTION	David Richards / Dr. Dan Gustafson, Dept. of Ecology, Montana State University
PHONE	(406) 582-9388
E-MAIL	davidr@montana.edu
SPECIALIZATION	New Zealand mud snail

PERSON/INSTITUTION	EcoAnalysts, Inc., Moscow, ID
PHONE	(208) 882-3588
E-MAIL	eco@moscow.com
SPECIALIZATION	Fish and invertebrate identification

New Mexico

PERSON/INSTITUTION	New Mexico Department of Game and Fish, Conservation Services, Fisheries, or Wildlife divisions
PHONE	All can be reached at (505) 827-9904
E-MAIL	blang@state.nm.us cpainter@state.nm.us dpropst@state.nm.us gschmitt@state.nm.us swilliams@state.nm.us
SPECIALIZATION	Brian Lang, mollusks and crustaceans; Charlie Painter, herpetiles; David Propst, fishes; Greg Schmitt, mammals; Sandy Williams, birds

North Dakota

PERSON/INSTITUTION	Jim Grier, Professor, North Dakota State University, Fargo ND
PHONE	(701) 231-8444
E-MAIL	James_Grier@ndsu.nodak.edu.
SPECIALIZATION	Mussels

PERSON/INSTITUTION	Malcolm Butler, Professor, North Dakota State University, Fargo ND
PHONE	(701) 231-7398
E-MAIL	Malcolm_Butler@ndsu.nodak.edu
SPECIALIZATION	Invertebrates

Oklahoma

PERSON/INSTITUTION	William Mathews, Oklahoma State University
PHONE	
E-MAIL	wmathews@ou.edu
SPECIALIZATION	Fishes

PERSON/INSTITUTION	Bruce Hoagland, University of Oklahoma Biological Survey
PHONE	(405) 325-4034
E-MAIL	bhoagland@ou.edu
SPECIALIZATION	Wetlands botany

PERSON/INSTITUTION	Caryn Vaughn, University of Oklahoma Biological Survey
PHONE	(405) 325-4034
E-MAIL	cvaughn@ou.edu
SPECIALIZATION	Mollusks

Oregon

PERSON/INSTITUTION	Mark Sytsma, Environmental Biology Department, Portland State University, Portland, OR 97207-0751
PHONE	(503) 725-3833, Fax: (503) 725-3888
E-MAIL	sytsmam@pdx.edu; SYTSMAM@PSU4.PDX.EDU
SPECIALIZATION	Aquatic freshwater plants

PERSON/INSTITUTION	John Chapman, Department of Fisheries and Wildlife, Oregon State University, Hatfield Marine Science Center, 2030 S. Marine Science Dr., Newport, Oregon 97365-5296
PHONE	(541) 867-0235, (541) 867-3335
E-MAIL	John.chapman@newportnet.com John.Chapman@HMSC.ORST.EDU
FAX	(541) 867-0105
SPECIALIZATION	Invertebrates, marine zooplankton. Expert on the criteria for introduced species, in particular, introduced marine and estuarine peracaridan crustaceans

PERSON/INSTITUTION	Dr. Sylvia Yamada, Zoology Department, Oregon State University, Corvallis, OR 97331-2914
PHONE	(541) 737-5345
E-MAIL	yamadas@ava.bcc.orst.edu
FAX	(541) 737-0501
SPECIALIZATION	European Green Crab, Carcinus maenas, and possibly Nuttalia obsucrata and Japanese eelgrass, Zostera japonica

PERSON/INSTITUTION	Bruce E. Coblentz, Dept. of Fisheries and Wildlife, Nash Hall 104, Oregon State University, Corvallis, OR 97331-3803
PHONE	
E-MAIL	Bruce.Coblentz@orst.edu
SPECIALIZATION	Bullfrogs, large mammals

PERSON/INSTITUTION	Costello, Dr Mark J., Ecological Consultancy Services Ltd (EcoServe), 17 Rathfarnham Road, Terenure, Dublin 6w, Ireland
PHONE	353-1- 490 32 37
E-MAIL	http://www.ecoserve.ie , E-mail: mcostello@ecoserve.ie
SPECIALIZATION	Peracaridan Crustacea of Europe

PERSON/INSTITUTION	Don Cadien
PHONE	
E-MAIL	dcadien@lacsd.org, musicmr@aol.com
SPECIALIZATION	Marine and estuarine molluscs and crustacea of S. California

PERSON/INSTITUTION	Carlton, James T., Maritime Studies Program, Williams - Mystic, Mystic Seaport, Mystic, CT 06355
PHONE	(860) 572-5359
E-MAIL	JCarlton@williams.edu
SPECIALIZATION	Marine and estuarine invertebrates in general

PERSON/INSTITUTION	Cohen, Andrew N., San Francisco Estuary Institute, 1325 South 46th Street, Richmond, CA 94804
PHONE	(510) 231-9423
E-MAIL	acohen@sfei.org , website: http://www.sfei.org/invasions.html
SPECIALIZATION	Marine and estuarine invertebrates in general

PERSON/INSTITUTION	Harris, Leslie H, Los Angeles County Museum of Natural History, Allan Hancock Fndn, Polychaete Collection, 900 Exposition Blvd, Los Angeles, CA 90007
PHONE	(213) 763-3234
E-MAIL	lhharris@bcf.usc.edu
SPECIALIZATION	Polychaeta, Annelida of the world

PERSON/INSTITUTION	Mills, Claudia E., Friday Harbor Laboratories, University of Washington, 620 University Road, Friday Harbor, WA 98250
PHONE	
E-MAIL	cemills@u.washington.edu; http://faculty.washington.edu/cemills/
SPECIALIZATION	Jellyfish

PERSON/INSTITUTION	Chad Hewitt
PHONE	chad.hewitt@marine.csiro.au
E-MAIL	
SPECIALIZATION	Bryozoans, Ectoprocts, and fouling species of Australia:

South Dakota

PERSON/INSTITUTION	Too many to list. Lead persons in agency list will provide a reference to most appropriate taxonomic specialist. See: David J. Ode, Dennis Unkenholz, Ron Moehring
PHONE	
E-MAIL	
SPECIALIZATION	

Texas

PERSON/INSTITUTION	Earl Chilton, Texas Park and Wildlife Department, Inland Fisheries
PHONE	(512) 389-4652
E-MAIL	earl.chilton@tpwd.state.tx.us
SPECIALIZATION	Plants, grass carp

PERSON/INSTITUTION	Rhandy Helton, Texas Park and Wildlife Department, Inland Fisheries
PHONE	(409) 384-9965
E-MAIL	
SPECIALIZATION	Plants

PERSON/INSTITUTION	Bon Howells, Texas Park and Wildlife Department
PHONE	(830) 866-3356
E-MAIL	
SPECIALIZATION	Zebra mussel

PERSON/INSTITUTION	Michael Smart, US Corps of Engineers
PHONE	(972) 436-2215
E-MAIL	
SPECIALIZATION	Plants

PERSON/INSTITUTION	Mike Grodowitz, US Army Corps of Engineers
PHONE	(601) 634-2972
E-MAIL	
SPECIALIZATION	Insects – for control of vegetation

PERSON/INSTITUTION	Colette Jacono, USGS - Florida Caribbean Science Center, 7920 NW 71st Street, Gainesville, FL
PHONE	(352) 378-8181 ext. 315
E-MAIL	colette_jacono@usgs.gov
SPECIALIZATION	Plants

Utah

PERSON/INSTITUTION	Steve Dewey, Plants and Soils, Utah State University, Logan, UT 84322
PHONE	(435) 797-2256
E-MAIL	
SPECIALIZATION	Plants

Washington

PERSON/INSTITUTION	Mike Klaus, Washington Department of Agriculture Pest Program
PHONE	(509) 454-4189
E-MAIL	
SPECIALIZATION	Entomologist

PERSON/INSTITUTION	Greg Haubrich, Washington Department of Agriculture Pest Program
PHONE	(509) 576-3039
E-MAIL	
SPECIALIZATION	Noxious weed specialist, terrestrial weeds

PERSON/INSTITUTION	Kathy Hamel / Jenifer Parson, Washington Department of Ecology
PHONE	(360) 407-6562
E-MAIL	kham461@ecy.wa.gov / jenp@ecy.wa.gov
SPECIALIZATION	Aquatic plants

PERSON/INSTITUTION	Blaine Parker, Columbia River Inter-Tribal Fish Commission
PHONE	(503) 731-1268; Fax: (503) 235-4228
E-MAIL	parbe@critfc.org
SPECIALIZATION	Freshwater fishes found in the Columbia River

PERSON/INSTITUTION	Washington Department of Fish and Wildlife has several biologists that can identify animal species
PHONE	
E-MAIL	
SPECIALIZATION	

PERSON/INSTITUTION	Washington State University and University of Washington both have several zoologists and biologists
PHONE	
E-MAIL	
SPECIALIZATION	

Wyoming

None Listed.

Index Sorted by Name

Name	State
Adams, Steve	Kansas
Anderson, Lars	California
Busby, Bill	Kansas
Butler, Malcolm	North Dakota
Cadien, Don	California, Oregon
Carlton, James	Oregon
Chapman, John	Oregon
Chilton, Earl	Texas
Clarkson, Rob	Arizona
Coblentz, Bruce	Oregon
Cohen, Andrew	California
Costello, Mark	Oregon
Dewey, Steve	Utah
EcoAnalysts, Inc.	Montana
Fitzsimmons, Kevin	Arizona
Ford, Bruce	Manitoba
Frieman, Greg	Kansas
Garza, Jim	Arizona
Godowitz, Mike	Texas
Gosliner, Terrence	California
Grier, Jim	North Dakota
Gustafaon, Dan	Montana
Hamel, Kathy	Washington
Harris, Leslie	California, Oregon
Hastings, Philip	California
Haubrich, Greg	Washington
Helton, Rhandy	Texas
Hewitt, Chad	Oregon
Hoagland, Bruce	Oklahoma
Hosler, Denise	Colorado, Kansas
Howells, Bon	Texas
Jacks, Stewart	Arizona
Jacono, Colette	Texas
Klaus, Mike	Washington
Kling, Hedy	Manitoba
Lang, Brian	New Mexico
Lovell, Lawrence	California
Mathews, William	Oklahoma
McKillop, Brian	Manitoba
Mills, Claudia	Oregon, Washington
Moehring, Ron	South Dakota
Mosher, Tom	Kansas

Nibbling, Fred	Arizona
Northam, Ed	Arizona
Ode, David	South Dakota
Ohman, M.	California
Painter, Charlie	New Mexico
Parker, Blaine	Oregon, Washington
Parson, Jenifer	Washington
Piorkowski, Bob	Alaska
Plant Pest Diagnostics Laboratory	California
Propst, David	New Mexico
Richards, David	Montana
Schmitt, Greg	New Mexico
Scott, Bill	Kansas
Sim, Tom	Kansas
Sisneros, David	Colorado, Kansas
Smart, Michael	Texas
Sonnevil, Gary	Alaska
Species Conservation Section	Colorado
Stewart, Ken	Manitoba
Sytsma, Mark	Oregon
Unkenholz, Dennis	South Dakota
Vaugh, Caryn	Oklahoma
Washington Dept. of Fish and Wildlife	Washington
Williams, Sandy	New Mexico
Wing, Bruce	Alaska
Yamada, Sylvia	Oregon

Index Sorted by Specialty

Specialty	Name	State
Algae	Kling, Hedy	Manitoba
Amphibians	Coblentz, Bruce	Oregon
Animals	Fitzsimmons, Kevin	Arizona
	Scott, Bill	Kansas
	Sim, Tom	Kansas
Aquatic animals	Adams, Steve	Kansas
	Clarkson, Rob	Arizona
	Mosher, Tom	Kansas
	Piorkowski, Bob	Alaska
Aquatic invertebrates	Butler, Malcolm	North Dakota
	Chapman, John	Oregon
	EcoAnalysts, Inc.	Montana
	Howells, Bon	Texas
	Lovell, Lawrence	California
	Species Conservation Section	Colorado
Aquatic plants	Anderson, Lars	California
	Ford, Bruce	Manitoba
	Garza, Jim	Arizona
	Hamel, Kathy	Washington
	Kling, Hedy	Manitoba
	Parson, Jenifer	Washington
	Piorkowski, Bob	Alaska
	Sytsma, Mark	Oregon
	Wing, Bruce	Alaska
Aquatic vertebrates	Species Conservation Section	Colorado
Birds	Williams, Sandy	New Mexico
Crustaceans	Costello, Mark	Oregon
	Lang, Brian	New Mexico
	Species Conservation Section	Colorado
Fish	Adams, Steve	Kansas
	Chilton, Earl	Texas
	Clarkson, Rob	Arizona
	EcoAnalysts, Inc.	Montana
	Fitzsimmons, Kevin	Arizona
	Jacks, Stewart	Arizona
	Mathews, William	Oklahoma
	Mosher, Tom	Kansas
	Parker, Blaine	Oregon, Washington
	Propst, David	New Mexico
	Sonnevil, Gary	Alaska
	Stewart, Ken	Manitoba
Provides references	Moehring, Ron	South Dakota

	Ode, David	South Dakota
	Unkenholz, Dennis	South Dakota
Herpetiles	Painter, Charlie	New Mexico
Insects	Godowitz, Mike	Texas
	Klaus, Mike	Washington
	Plant Pest Diagnostics Laboratory	California
Invertebrates	Busby, Bill	Kansas
Jellyfish	Mills, Claudia	Oregon, Washington
Mammals	Coblentz, Bruce	Oregon
Mammals	Schmitt, Greg	New Mexico
Marine crustaceans	Cadien, Don	California, Oregon
	Yamada, Sylvia	Oregon
Marine invertebrates	Carlton, James	Oregon
	Cohen, Andrew	California
	Gosliner, Terrence	California
	Hewitt, Chad	Oregon
	Ohman, M.	California
Marine molluscs	Cadien, Don	California, Oregon
Marine plants	Yamada, Sylvia	Oregon
Marine vertebrates	Hastings, Philip	California
Molluscs	Lang, Brian	New Mexico
	McKillop, Brian	Manitoba
	Species Conservation Section	Colorado
	Vaugh, Caryn	Oklahoma
Mussels	Grier, Jim	North Dakota
Noxious plants	Northam, Ed	Arizona
Plant pathogens	Plant Pest Diagnostics Laboratory	California
Plants	Busby, Bill	Kansas
	Chilton, Earl	Texas
	Dewey, Steve	Utah
	Frieman, Greg	Kansas
	Helton, Rhandy	Texas
	Hoagland, Bruce	Oklahoma
	Hosler, Denise	Colorado, Kansas
	Jacono, Colette	Texas
	Nibbling, Fred	Arizona
	Plant Pest Diagnostics Laboratory	California
	Scott, Bill	Kansas
	Sim, Tom	Kansas
	Sisneros, David	Colorado, Kansas
	Smart, Michael	Texas
Snails	Gustafaon, Dan	Montana
	Richards, David	Montana
Terrestrial weeds	Haubrich, Greg	Washington
Vertebrates	Washington Dept. of Fish and Wildlife	Washington

Worms	Harris, Leslie	California, Oregon
Zebra mussel	Howells, Bon	Texas
Zooplankton	Chapman, John	Oregon

APPENDIX 2: PEOPLE IN AGENCIES THAT MAY RESPOND TO A NEW INTRODUCTION

Alaska

(Major contacts are Bob Piorkowski and Gary Sonnevil):

AGENCY	Alaska Department of Fish and Game
OFFICE / DIVISION	Division of Commercial Fisheries (Chief Fisheries Scientist/Research)
RESPONSIBLE PERSON	Bob Piorkowski
PHONE	(907) 465-6150; (907) 465-4210 operator)
ADDRESS	1255 W. 8th Street Juneau, AK 99801 or PO BOX 25526, Juneau, AK, 99802
FAX	(907) 465-2604
E-MAIL	bob_piorkowski@fishgame.state.ak.us
COMMENTS	All aquatic plants and animals

AGENCY	Alaska Department of Environmental Conservation
OFFICE / DIVISION	Division of Environmental Health
RESPONSIBLE PERSON	Katy McKerney
PHONE	(907) 465-5302
E-MAIL	Katy_mcKerney@envircon.state.ak.us
COMMENTS	Bioinvasive spp., bacteria, viruses

AGENCY	Alaska Department of Natural Resources
OFFICE/DIVISION	Division of Agriculture
RESPONSIBLE PERSON	Bob Wells – division director
PHONE	(907) 745-7200
ADDRESS	1800 Glenn Highway, Suite 12, Palmer, AK 99645-6736
FAX	(907) 745-7112
COMMENTS	Terrestrial invasive species

Federal Offices:

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	Project for Kenai Fisheries Resource Office
RESPONSIBLE PERSON	Gary Sonnevil
PHONE	(907) 262-9863 PO BOX 1670, Kenai, AK 99611
E-MAIL	Gary_sonnevil@fws.gov
COMMENTS	

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	Fisheries and Habitat Conservation
RESPONSIBLE PERSON	Denny Lassuy
PHONE	(907) 786-3520 1011 E. Tudor Road, Anchorage, AK 99503
E-MAIL	Denny_lassuy@fws.gov
COMMENTS	

AGENCY	US DOA – National Forest Service
OFFICE/DIVISION	National Fisheries
RESPONSIBLE PERSON	Ron Dunlap; Dave Cross
PHONE	(907) 586-8806; (202) 205-0951

E-MAIL	rldunlap@fs.fed.us
COMMENTS	National Level (policies regarding IS)

AGENCY	US Army Corps of Engineers
OFFICE/DIVISION	Environmental Section
RESPONSIBLE PERSON	Guy McConnell
PHONE	(907) 753-2614

AGENCY	NATIONAL SEA GRANTS
OFFICE/DIVISION	
RESPONSIBLE PERSON	Jody Kessel (marine advisory); Karen Hart McDonell (UC Davis)
PHONE	(650) 871-7559; (510) 622-2398
E-MAIL	www.csgc.ucsd.edu
COMMENTS	Fund research work, some control; Publication "Ballast Exchange"

Other public or private organizations

ORGANIZATION	Prince William Sound Regional Citizens Advisory Council
RESPONSIBLE PERSON	Marilyn Leland; Bery Green
PHONE	(907) 273-62312; (907) 277-7222; (907) 277-7222
ADDRESS	752 W 2nd Ave Suite 100, Anchorage AK 99501-2168
FAX	(907) 277-4523
E_MAIL	pwsrcac@alaska.net
COMMENTS	Representing: Prince William Sound Regional Citizens Advisory Council: coordinate state, federal and private agencies

Arizona

AGENCY	Arizona Game and Fish Department
OFFICE/DIVISION	Fisheries Branch
RESPONSIBLE PERSON	Larry Riley; Joe Janisch
PHONE	(602) 789-3258; (602) 942-3000
ADDRESS	2221 W Greenway Rd, Phoenix AZ 85023-4399
E-MAIL	lriley@gf.state.az.us; jjanisch@gf.state.az.us
FAX	(602) 789-3258; (602) 789-3265
COMMENTS	Fisheries Branch Chief; Fisheries Branch WRP rep.; WRP rep.

AGENCY	Department of Agriculture
OFFICE/DIVISION	Noxious Weed Program
RESPONSIBLE PERSON	Ed Northam; Cathie Cianim
PHONE	(602) 542-3309; (602) 542-0979
E-MAIL	Ed.northam@agric.state.az.us
COMMENTS	Noxious weeds; Invertebrates + vertebrates

Federal Offices

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	Region 2, Albuquerque, NM
RESPONSIBLE PERSON	Bob Pitman, Invasive Species Coordinator
PHONE	(505) 248-6471
E-MAIL	bob_pitman@fws.gov
COMMENTS	Chairman, Lower Colorado River Salvinia Task Force

AGENCY	US Department of Agriculture – APHIS
OFFICE/DIVISION	State Support Officer
RESPONSIBLE PERSON	Bruce Shambaugh
PHONE	(602) 414-4748
E-MAIL	Bruce.a.shambaugh@aphis.usda.gov
COMMENTS	Federal Noxious Weed List
AGENCY	Bureau of Land Management
OFFICE/DIVISION	
RESPONSIBLE PERSON	Karen Richord; Eddie Walker
PHONE	(520) 317-3200; (435) 688-3242
E-MAIL	
COMMENTS	Salvinia in Colorado River; State Noxious Weed Coordinator

California

(Main Contacts: Susan Ellis, Robert Leavitt)

AGENCY	CA Dept. of Food and Agriculture
OFFICE/DIVISION	Integrated Pest Control Branch, Plant Pest Prevention Div.
RESPONSIBLE PERSON	Robert Leavitt (Sr. Weed Biologist), Larry Bezark (Program Supervisor), Nate Dechoretz (Branch Chief)
PHONE	(916) 654-0768 (for all; ask for name)
ADDRESS	
E-MAIL	roconnel, lbezark, or ndechore @cdfa.ca.gov
COMMENTS	CDFA deals with agricultural pests, mostly terrestrial. Some aquatic weeds including hydrilla, salvinia, and caulerpa.

AGENCY	CA Dept. of Fish and Game
OFFICE/DIVISION	State Nuisance Species Coordinator
RESPONSIBLE PERSON	Susan Ellis
PHONE	(916) 653-8983
ADDRESS	
E-MAIL	sellis@dfg.ca.gov
COMMENTS	New position intended to be central coordinator for IS that might affect wildlife. Also, CDFG manages wildlife reserves, and would become directly involved with infestations on their lands.

Federal Offices:

AGENCY	US Dept. of Agriculture - Animal and Plant Health Inspection Service (APHIS)
OFFICE/DIVISION	
RESPONSIBLE PERSON	Danny Hammon
PHONE	(916) 857-6258
ADDRESS	9550 Micron Ave, Suite F, Sacramento, CA 95827-2621
E-MAIL	Danny.j.hamon@usda.gov
COMMENTS	

AGENCY	Bureau of Reclamation
OFFICE/DIVISION	Environmental Compliance
RESPONSIBLE PERSON	Jim Scullin
PHONE	(916) 978-5038
ADDRESS	MP-150, 2800 Cottage Way, Sacramento, CA 95825

E-MAIL	jscullin@mp.usbr.gov
COMMENTS	

AGENCY	US Army Corps of Engineers
OFFICE/DIVISION	
RESPONSIBLE PERSON	Phil Turner
PHONE	(415) 977-8058
ADDRESS	333 Market Street, San Francisco, CA 94105-2195
E-MAIL	pkaaturner@ccio.com
COMMENTS	

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	
RESPONSIBLE PERSON	Erin Williams
PHONE	(209) 946-6400 ext.321
ADDRESS	4001 N. Wilson Way, Stockton, CA 95205-2486
E-MAIL	Erin_williams@fws.gov
COMMENTS	

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	Regional IPM / Invasive Species Coordinator
RESPONSIBLE PERSON	
PHONE	(503) 872-2763
E-MAIL	
COMMENTS	

Colorado

(Main Contact: Gary Skiba)

AGENCY	Department of Natural Resources
OFFICE/DIVISION	Colorado Division of Wildlife
RESPONSIBLE PERSON	Gary Skiba
PHONE	(303) 291-7466
ADDRESS	6060 Broadway, Denver CO 80216
E-MAIL	gary.skiba@state.co.us
FAX	(303) 294-0874
COMMENTS	Invertebrates + vertebrates; Aquatic plants

AGENCY	Department of Natural Resources
OFFICE/DIVISION	Colorado Division of Wildlife
RESPONSIBLE PERSON	Tom Nesler
PHONE	(970) 472-4384
ADDRESS	317 W Prospect, Ft. Collins CO 80526
E-MAIL	tom.nesler@state.co.us
COMMENTS	Fishes

AGENCY	Department of Agriculture
OFFICE/DIVISION	State Weed Coordinator
RESPONSIBLE PERSON	Eric Lane
PHONE	(303) 239-4182
	700 Kipling Street Suite 4000, Lakewood CO 80215-5894

E-MAIL	Eric.lane@ag.state.co.us
COMMENTS	weeds

Federal Offices:

AGENCY	US Bureau of Reclamation
OFFICE/DIVISION	
RESPONSIBLE PERSON	Krista Doebbler; Deby Iberts
PHONE	(303) 445-2801; (303) 445-2217
ADDRESS	Attn: D-8220, PO Box 25007 (D-5100), Denver CO 80225-0007
E-MAIL	Kdoebbler@do.usbr.gov
FAX	(303) 445-6465
COMMENTS	

AGENCY	US Fish & Wildlife Service
OFFICE/DIVISION	Denver Office
RESPONSIBLE PERSON	Lee Carlson
PHONE	(303) 275-2343
E-MAIL	Leroy_Carlson@fws.gov
COMMENTS	

AGENCY	US Fish & Wildlife Service
OFFICE/DIVISION	Region 6 Regional Office (CO, KS, MT, UT, WY, NE, SD, ND)
RESPONSIBLE PERSON	Bettina Proctor
PHONE	(303) 236-7862, ext. 260
E-MAIL	bettina_proctor@fws.gov
COMMENTS	

Hawaii

No contacts identified

Idaho

Contacts for aquatic nuisance species not identified. Persons involved in weed control are:

Glen Secrist: (208) 332-8536
Taylor Cox, Idaho Dept. of Agriculture, (208) 332-8540, tcox@agri.state.id.us

Kansas

AGENCY	Kansas Department of Agriculture
OFFICE/DIVISION	
RESPONSIBLE PERSON	Tom Sim – animals / Bill Scott – plants
PHONE	(785) 862-2180
E-MAIL	bscott@kda.state.ks.us
COMMENTS	

AGENCY	Kansas Department Wildlife & Parks
OFFICE/DIVISION	Fish and Wildlife Division

	Emporia Research Office/Secretary's Office
RESPONSIBLE PERSON	Tom Mosher / Steve Adams
PHONE	(620) 342-0658 / (785) 296-0019
E-MAIL	tomm@wp.state.ks.us / stevea@wp.state.ks.us
COMMENTS	Research supervisor/environmental services coordinator

AGENCY	Kansas Department Wildlife & Parks Kansas Dept. Health & Environment
OFFICE/DIVISION	
RESPONSIBLE PERSON	Chris Mammoliti / Bob Angelo
PHONE	(620) 672-5911 / (785) 296-8027
E-MAIL	Chrism@wp.state.ks.us/ bangelo@kdhe.state.ks.us
COMMENTS	Environmental services coordinator/head of water quality. Regulations on control methods.

Federal Offices:

AGENCY	US Army Corp. of Engineers
OFFICE/DIVISION	District Office / Planning Section
RESPONSIBLE PERSON	Bob Rauf
PHONE	(816) 983-3141
E-MAIL	
COMMENTS	

AGENCY	US Fish & Wildlife Service
OFFICE/DIVISION	Region 6 Regional Office (CO, KS, MT, UT, WY, NE, SD, ND)
RESPONSIBLE PERSON	Bettina Proctor
PHONE	(303) 236-7862, ext. 260
E-MAIL	bettina_proctor@fws.gov
COMMENTS	

AGENCY	US Fish & Wildlife Service
OFFICE/DIVISION	Manhattan Field Office
RESPONSIBLE PERSON	William Gill
PHONE	(785) 539-3474
E-MAIL	
COMMENTS	

Manitoba

AGENCY	Manitoba Conservation
OFFICE/DIVISION	Programs Division (Water Quality, Fisheries Branch, Wildlife Branch)
RESPONSIBLE PERSON	Dwight Williamson, Joe O'Connor, Jim Duncan
PHONE	(204) 945-7030, (204) 945-7814, (204) 945-7465
E-MAIL	Dwilliamso@gov.mb.ca ; joconner@gov.mb.ca ; jduncan@gov.mb.ca
COMMENTS	Evaluate provincial legislation and policy involving ANS introductions

AGENCY	Manitoba Conservation
OFFICE/DIVISION	Programs Division (Water Quality, Fisheries Branch)
RESPONSIBLE PERSON	Wendy Ralley, Shelley Matkowski
PHONE	(204) 945-8146; (204) 945-7789
E-MAIL	wralley@gov.mb.ca ; smatkowski@gov.mb.ca

COMMENTS	Monitor and evaluate ANS programs; also evaluate proposals for funding

AGENCY	Department of Fisheries and Oceans
OFFICE/DIVISION	Environmental Sciences Division; Central and Arctic Region
RESPONSIBLE PERSON	Dennis Wright
PHONE	(204) 983-5204
E-MAIL	Wrightdg@dfo-mpo.gc.ca
COMMENTS	Coordinator for environmental science issues including ANS in the prairie region

AGENCY	Manitoba Conservation; Manitoba Agriculture
OFFICE/DIVISION	Fisheries Branch, Water Branch, Policy Branch
RESPONSIBLE PERSON	Shelley Matkowski, Dwight Williamson
PHONE	(204) 945-7789; (204) 945-7030
E-MAIL	smatkowski@gov.mb.ca ; dwilliamso@gov.mb.ca
COMMENTS	Deleterious fishes and mollusks are listed under the Manitoba Fisheries regulations (regulation under the Federal Fisheries Act). Deleterious substances, such as might be used in a control program, are controlled under the Manitoba Environment Act

AGENCY	Department of Fisheries and Oceans; Department of Environment
OFFICE/DIVISION	Fisheries Habitat; Central and Arctic Region
RESPONSIBLE PERSON	Cathy Fisher
PHONE	(204) 983-5000
E-MAIL	Fisherc@dfo-mpo.gc.ca
COMMENTS	Review and assessment of all activities, which may be deleterious to fish or fish habitat.

Montana

AGENCY	Department of Fish, Wildlife and Parks
OFFICE/DIVISION	Fisheries
RESPONSIBLE PERSON	Tim Gallagher
PHONE	(406) 444-2448; 1420 E. 6th Ave., Helena, MT 59620-0701
E-MAIL	Tgallagher@state.mt.us
COMMENTS	Montana has an approved ANS Management Plan, approved by ANS Task Force November, 2002

Nebraska

No contacts identified

Nevada

AGENCY	Nevada Division of Wildlife
OFFICE/DIVISION	Fisheries
RESPONSIBLE PERSON	Anita Cook
PHONE	(775) 688-1532; 1100 Valley Road, Reno, NV 89512
E-MAIL	Acook@govmail.state.nv.us
COMMENTS	

AGENCY	New Mexico Department of Game and Fish
OFFICE/DIVISION	Conservation Services, Fisheries, or Wildlife divisions
RESPONSIBLE PERSON	Brian Lang
PHONE	(505) 476-8108; 1085-A Richards Ave., Santa Fe, NM
E-MAIL	Blang@state.nm.us
COMMENTS	Endangered Invertebrates Biologist; T&E mollusks and crustaceans statewide

AGENCY	Department of Energy, Minerals and Natural Resources
OFFICE/DIVISION	State Parks Division
RESPONSIBLE PERSON	Steve Cary
PHONE	(505) 476-3386
E-MAIL	scary@state.nm.us
COMMENTS	

North Dakota

AGENCY	North Dakota Game and Fish Department
OFFICE/DIVISION	
RESPONSIBLE PERSON	Lynn Schlueter; Terry Steinwand
PHONE	(701) 662-3617; (701) 328-6313
ADDRESS	100 N. Bismark Expressway, Bismark, ND 58501-4095
E-MAIL	lschluet@state.nd.us; tsteinwa@state.nd.us
FAX	(701) 328-6352
COMMENTS	Contact for ANS issues; WRP rep.

AGENCY	North Dakota Department of Agriculture
OFFICE/DIVISION	
RESPONSIBLE PERSON	John Lepard
PHONE	(701) 328-2379
E-MAIL	
COMMENTS	Noxious Weeds

AGENCY	Health Department
OFFICE/DIVISION	
RESPONSIBLE PERSON	Mike Sauer
PHONE	(701) 328-5210
E-MAIL	
COMMENTS	Chemical Application permits; Vegetation removal is often done by county Water Resource Boards and permitted by the North Dakota Health Department

Federal Offices:

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	Fisheries Assistance Office
RESPONSIBLE PERSON	Steve Krentz
PHONE	(701) 250-4419
E-MAIL	Steven_Krentz@fws.gov
COMMENTS	Regional Fisheries Biologist

Oklahoma

AGENCY	Oklahoma Department of Wildlife Conservation
OFFICE/DIVISION	Oklahoma Fishery Research Lab
RESPONSIBLE PERSON	Jeff Boxrucker; Jean Gilliland
PHONE	(405) 325-7288 ext. 7248
E-MAIL	jboxrucker@aol.com; gillokla@aol.com
COMMENTS	marine vertebrates, invertebrates; plants

AGENCY	Oklahoma Department of Agriculture
OFFICE/DIVISION	Plant Industry
RESPONSIBLE PERSON	Don Molnar
PHONE	(405) 522-5909
E-MAIL	dmolnar@oda.state.ok.us
COMMENTS	Agricultural situations (terrestrial, not aquatic), nuisance insects

Federal Offices:

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	Fishery Research Office
RESPONSIBLE PERSON	Brent Bristow
PHONE	(580) 384-5710
E-MAIL	
COMMENTS	Fishery Biologist/Hazard Analysis and Critical Control Points Team Member

AGENCY	US Army Corps of Engineers
OFFICE/DIVISION	
RESPONSIBLE PERSON	Everett Laney
PHONE	(918) 669-7582
E-MAIL	
COMMENTS	

Oregon

AGENCY	Oregon Department of Agriculture
OFFICE/DIVISION	Plant Division Division director; Manager of Noxious Weed Program
RESPONSIBLE PERSON	Dan Hilburn; Tim Butler
PHONE	(530) 986-4663; (503) 986-4621
E-MAIL	dhilburn@oda.state.or.us; tbutler@oda.state.or.us
COMMENTS	Invasive species; Agricultural land, noxious weeds; Hotline: 1-866-INVADER

AGENCY	Oregon Department of Fish and Wildlife
OFFICE/DIVISION	Wildlife Division; Marine Resources Program
RESPONSIBLE PERSON	Larry Cooper; Jim Golden
PHONE	(503) 872-5260 ext.5347; (541) 867-0300 ext.230
E-MAIL	Larry.D.COOPER@state.or.us; jim.golden@hmsc.orst.edu
COMMENTS	Vertebrates; Importation permits, marine organisms

AGENCY	Oregon State University
OFFICE/DIVISION	Department of Fish and Wildlife
RESPONSIBLE PERSON	John Chapman
PHONE	(541) 867-0235; Fax: (541) 867-0105
E-MAIL	John.chapman@hmsc.orst.edu
COMMENTS	Estuary invertebrates and introduced fish species

AGENCY	Oregon State University – Extension Sea Grant
OFFICE/DIVISION	
RESPONSIBLE PERSON	Paul Heimowitz
PHONE	(503) 722-6718
E-MAIL	Paul.heimowitz@orst.edu
COMMENTS	Marine environment, invertebrates; Technical assistance, organization of volunteers, education

AGENCY	Portland State University
OFFICE/DIVISION	Center for Lakes and Reservoirs
RESPONSIBLE PERSON	Mark Sytsma
PHONE	(503) 725-3833; Fax: (503) 725-3888
E-MAIL	sytsmam@pdx.edu
COMMENTS	Aquatic plants; main contractor for OR Dept of Ag. on IS

AGENCY	Columbia River Inter-Tribal Fish Commission
OFFICE/DIVISION	Fish Management
RESPONSIBLE PERSON	Blaine Parker
PHONE	(503) 731-1268; Fax: (503) 235-4228
E-MAIL	parbe@critfc.org
COMMENTS	Fish, zebra mussels, mitten crabs; Tribes: Yakama Nation, Nez Perce, Warm Springs, Umatilla, in Oregon and Washington

Federal Offices:

AGENCY #	National Oceanic and Atmospheric Administration
OFFICE/DIVISION	NOAA/National Marine Fisheries Service/Fish Ecology Division
RESPONSIBLE PERSON	Robert Emmett
PHONE	(541) 867-0109
E-MAIL	bemmett@sable.nwfsc-hc.noaa.gov
COMMENTS	Marine issues; NOAA doesn't have any RR team, did not develop any RR plan

AGENCY	US Army Corps of Engineers
OFFICE/DIVISION	N. Pacific Division
RESPONSIBLE PERSON	Jim Athearn
PHONE	(503) 808-3723
E-MAIL	jim.b.athearn@usace.army.mil
COMMENTS	

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	Regional IPM / Invasive Species Coordinator
RESPONSIBLE PERSON	
PHONE	
E-MAIL	
COMMENTS	

South Dakota

AGENCY	South Dakota Department of Game, Fish & Parks
OFFICE/DIVISION	Wildlife Division
RESPONSIBLE PERSON	Jeff Shearer
PHONE	(605) 773-2743
E-MAIL	Jeff.shearer@state.sd.us
COMMENTS	

AGENCY	South Dakota Department of Game, Fish & Parks
OFFICE/DIVISION	Wildlife Division
RESPONSIBLE PERSON	Dennis Unkenholz
PHONE	(605) 773-4508
E-MAIL	Dennis.Unkenholz@state.sd.us
COMMENTS	Chief of Fisheries

AGENCY	SD Department of Agriculture
OFFICE/DIVISION	Agricultural Services Division - Plant Protection Program
RESPONSIBLE PERSON	Ron Moehring
PHONE	(605) 773-3796
E-MAIL	Ron.Moehring@state.sd.us
COMMENTS	Possible only if the Aquatic Nuisance Species was a plant officially listed as a state noxious weed or a quarantined plant.

AGENCY	SD Department of Game, Fish and Parks
OFFICE/DIVISION	Wildlife Division
RESPONSIBLE PERSON	Leslie Petersen
PHONE	(605) 773-6208
E-MAIL	Leslie.Petersen@state.sd.us
COMMENTS	Permits Coordinator - The GFP Commission is responsible for reviewing projects and issuing permits for chemical control of aquatic species.

AGENCY	SD Department of Environment and Natural Resources
OFFICE/DIVISION	Surface Water Quality Program
RESPONSIBLE PERSON	John Miller
PHONE	(605) 773-3351
E-MAIL	John.Miller@state.sd.us
COMMENTS	State DENR has lead responsibility for issues involving water quality in so far as a control program might affect surface water quality.

Federal Offices:

AGENCY	US Department of Agriculture - Animal and Plant Health Inspection Service
OFFICE/DIVISION	Plant Protection and Quarantine Program
RESPONSIBLE PERSON	Bruce Helbig
PHONE	(605) 224-1713
E-MAIL	Bruce.Helbig@aphis.usda.gov
COMMENTS	Dependent upon which species was involved and whether APHIS had taken the lead, e.g. Giant Salvinia (*Salvinia molesta)*

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	Ecological Services Field Office
RESPONSIBLE PERSON	D. Pete Gober
PHONE	(605) 224-8693
E-MAIL	Pete.Gober@fws.gov
COMMENTS	State Director

Texas

AGENCY	Texas Park and Wildlife Department
OFFICE/DIVISION	Inland Fisheries
RESPONSIBLE PERSON	Earl Chilton; Jody Gray; Larry McKinney
PHONE	(512) 389-4652; (512) 389-8037; (512) 389-4636
ADDRESS	4200 Smith School Road, Austin TX 78744
E-MAIL	earl.chilton@tpwd.state.tx.us; larry.mckinney@tpwd.state.tx.us
FAX	(512) 389-4394
COMMENTS	Plants, all other aquatics; WRP rep

Federal Offices:

AGENCY	US Army Corps of Engineers
OFFICE/DIVISION	Aquatic Invasive Species Program Manager
RESPONSIBLE PERSON	James Barrows
PHONE	(409) 766-3068
E-MAIL	James.m.barrows@swgo2.usace.army.mil
COMMENTS	

AGENCY	Bureau of Reclamation
OFFICE/DIVISION	
RESPONSIBLE PERSON	Carlos Lopez
PHONE	(512) 916-5647
E-MAIL	
COMMENTS	

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	Region 2 (Albuquerque, NM)
RESPONSIBLE PERSON	Bob Pitman, Invasive Species Coordinator
PHONE	(505) 248-6471
E-MAIL	bob_pitman@fws.gov
COMMENTS	Chairman, Lower Colorado River Salvinia Task Force

Utah

AGENCY	Utah Division of Wildlife Resources
OFFICE/DIVISION	Aquatic Program
RESPONSIBLE PERSON	Don Archer; Randy Radant
PHONE	(801) 538-4817; (801) 538-4760
ADDRESS	1596 West North Temple, Salt Lake City UT 84116
E-MAIL	nrdwr.rradant@state.ut.us
COMMENTS	All aquatic species; State WRP rep.; ANS Action Team

AGENCY	Department of Agriculture
OFFICE/DIVISION	
RESPONSIBLE PERSON	Mark Martin; Steve Burningham
PHONE	(801) 538-7046; (801) 538-7183
ADDRESS	350 N. Redwood Rd., PO Box 146500, Salt Lake City UT 84114
E-MAIL	Agmain.martin@email.state.ut.us
COMMENTS	Animals; plants

Utah also has an Aquatic Nuisance Species Action Team with state and federal members. Contact Randy Radant or Don Archer.

Washington

AGENCY	Washington Department of Fish and Wildlife
OFFICE/DIVISION	ANS Coordination
RESPONSIBLE PERSON	Scott Smith; Pamala Meacham
PHONE	(360) 902-2741; (360) 902-2741 Phone, (360) 902-2845 Fax
ADDRESS	600 Capitol Way N, Olympia, WA 98501-1091
E-MAIL	smithsss@dfw.wa.gov; meachpmm@dfw.wa.gov
COMMENTS	ANS Coordinator for WA State; Asst. Aquatic Nuisance Species Coord.

AGENCY	Washington Department of Fish & Wildlife
OFFICE/DIVISION	Fish / Wildlife
RESPONSIBLE PERSON	Morris Barker / Dave Brittell
PHONE	(360) 902-2826 / (360) 902-2504
E-MAIL	
COMMENTS	Prevent, control and monitor spread of Aquatic nuisance plants or animals. Workers from the habitat division often work with weed infestations on state lands.

AGENCY	Washington Department of Fish and Wildlife
OFFICE/DIVISION	Cooperative Project funds (ALEA grants)
RESPONSIBLE PERSON	Dave Gadwa
PHONE	(360) 902-2802
E-MAIL	
COMMENTS	Dave manages work done under ALEA grant program that funds volunteer groups on cooperative projects, some of which include monitoring and control of ANS

AGENCY	Washington Department of Agriculture
OFFICE/DIVISION	Pest Program (insects/weeds), Assistant Director
RESPONSIBLE PERSON	Mary Toohey
PHONE	(360) 902-1907
E-MAIL	
COMMENTS	Pest program administration manager

AGENCY	Washington Department of Agriculture
OFFICE/DIVISION	
RESPONSIBLE PERSON	Kyle Murphy
PHONE	(360) 902-1923
E-MAIL	
COMMENTS	Spartina coordinator

AGENCY	Washington Department of Agriculture
OFFICE/DIVISION	Noxious Weed Control Board
RESPONSIBLE PERSON	This will vary. Each County has a weed board
PHONE	
E-MAIL	
COMMENTS	

AGENCY	Washington Department of Agriculture
OFFICE/DIVISION	Pest Management
RESPONSIBLE PERSON	
PHONE	
E-MAIL	
COMMENTS	WSDA is the lead agency for control of spartina and purple loosestrife. They also do projects under the ALEA grant program.

AGENCY	Washington Department of Agriculture
OFFICE/DIVISION	Executive Secretary, Washington Noxious Weed Board
RESPONSIBLE PERSON	Steve McGonigal
PHONE	(360) 902-2053
E-MAIL	
COMMENTS	WSDA may establish quarantines for particularly noxious plants.

AGENCY	Washington Department of Agriculture
OFFICE/DIVISION	Pesticide management
RESPONSIBLE PERSON	Bob Arrington
PHONE	(360) 902-2011
E-MAIL	
COMMENTS	Determine what pesticides, fungicides, herbicides, etc. may be used.

AGENCY	Washington Department of Natural Resources
OFFICE/DIVISION	Resource Protection
RESPONSIBLE PERSON	Randy Acker
PHONE	(360) 902-1011
E-MAIL	
COMMENTS	Manager – Resource protection

AGENCY	Washington Department of Natural Resources
OFFICE/DIVISION	Varies, depends on whether aquatic or timber resources threatened
RESPONSIBLE PERSON	Wendy Brown
PHONE	(360) 902-1090
E-MAIL	Wendy.brown@wadnr.gov
COMMENTS	Wendy currently manages the Spartina control program for WDNR

AGENCY	Washington Department of Ecology
OFFICE/DIVISION	Water Quality Program / Aquatic Weeds Program
RESPONSIBLE PERSON	Megan White / Kathy Hamel
PHONE	(360) 407-6405; (360) 407-6562
E-MAIL	
COMMENTS	Manager

AGENCY	Washington Department of Ecology
OFFICE/DIVISION	aquatic weed management program
RESPONSIBLE PERSON	Kathy Hamel
PHONE	(360) 407-6562
E-MAIL	kham461@ecy.wa.gov
COMMENTS	This program provides grants to NGO's (lakes associations, etc.) for cleaning up infestations of aquatic plants.

AGENCY	Washington Department of Ecology
OFFICE/DIVISION	Water Quality
RESPONSIBLE PERSON	Mike Herold
PHONE	(360) 407-6300
E-MAIL	
COMMENTS	Issues permit of the use of herbicides in aquatic environments.

AGENCY	Puget Sound Water Quality Action Team
OFFICE/DIVISION	Office of the Governor
RESPONSIBLE PERSON	Kevin Anderson
PHONE	(360) 407-7324
E-MAIL	
COMMENTS	"Protects and restores the biological health and well being of Puget Sound." Prepares two-year work plans for state implementation of long-range management plan.

Federal Offices

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	Nonindigenous Coordinator, Region 1
RESPONSIBLE PERSON	
PHONE	
E-MAIL	
COMMENTS	Manages projects and dispersal of NISA funding in region 1.

AGENCY	US Army Corps of Engineers
OFFICE/DIVISION	N. Pacific Division
RESPONSIBLE PERSON	Jim Athearn
PHONE	(503) 808-3723
E-MAIL	jim.b.athearn@usace.army.mil
COMMENTS	

AGENCY	Washington Sea Grant
OFFICE/DIVISION	Seattle
RESPONSIBLE PERSON	Andrea Copping
PHONE	(206) 685-8209
E-MAIL	
COMMENTS	

Wyoming

AGENCY	Wyoming Game and Fish Department
OFFICE/DIVISION	Fish Division
RESPONSIBLE PERSON	Mike Stone; Steve Wolff
PHONE	(307) 777-4559; (307) 777-4673
ADDRESS	5400 Bishop Blvd, Cheyenne, WY 82006
E-MAIL	mike.stone@wgf.state.wy.us; steve.wolff@wgf.state.wy.us
FAX	(307) 777-4611; (307) 777-4611
COMMENTS	Fish, amphibians; Aquatic Habitat Manager; Fisheries Chief; WRP rep.

AGENCY	Wyoming Department of Agriculture
OFFICE/DIVISION	Noxious Weed Control Coordinator
RESPONSIBLE PERSON	Roy Reichenback; Grant Stumbaugh
PHONE	(307) 777-6585; (307) 777-6579
ADDRESS	2219 Carey Ave, Cheyenne WY 82002
E-MAIL	gstumb@state.wy.us
FAX	(307) 777-6593
COMMENTS	Plants; plants

Federal Offices:

AGENCY	US Fish and Wildlife Service
OFFICE/DIVISION	State Office Project Leader
RESPONSIBLE PERSON	Michael Long
PHONE	(307) 772-2374 ext. 34; 4000 Airport Parkway, Cheyenne, WY 82001
E-MAIL	michael_long@fws.gov
COMMENTS	

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Name	State
Acker, Randy	Washington
Adams, Steve	Kansas
Anderson, Kevin	Washington
Angelo, Bob	Kansas
Archer, Don	Utah
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Barrows, James	Texas
Bezark, Larry	California
Boxrucker, Jeff	Oklahoma
Bristow, Brent	Oklahoma
Brittell, Dave	Washington
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Burningham, Steve	Utah
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Carlson, Lee	Colorado, Kansas
Cary, Steve	New Mexico
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Chilton, Earl	Texas
Cianim, Cathie	Arizona
Cook, Anita	Nevada
Cooper, Larry	Oregon
Copping, Andrea	Washington
Cox, Taylor	Idaho
Cross, Dave	Alaska
Dechoretz, Nate	California
Doebbler, Krista	Colorado
Dulap, Ron	Alaska
Duncan, Jim	Manitoba
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Emmett, Robert	Oregon
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Gadwa, Dave	Washington
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Herold, Mike	Washington
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Krentz, Steve	North Dakota
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Lassuy, Denny	California, Oregon, Washington
Lawg, Michael	Wyoming
Leavitt, Robert	California
Leland, Marilyn	Alaska
Lepard, John	North Dakota
Loeffler, Chuck	Colorado
Lopez, Carlos	Texas
Mammoliti, Chris	Kansas
Martin, Martin	Utah
Matkowski, Shelley	Manitoba
McConnell, Guy	Alaska
McDonell, Karen	national
McGonigal, Steve	Washington
McKerney, Katy	Alaska
McKinney, Larry	Texas
Meacham, Pamala	Washington
Miller, John	South Dakota
Moehring, Ron	South Dakota
Molnar, Don	Oklahoma
Mosher, Tom	Kansas
Mullin, Barbara	Montana
Murphy, Kyle	Washington
Nesler, Tom	Colorado
Northam, Ed	Arizona
O'Connor, Joe	Manitoba
Ode, David	South Dakota
Parker, Blaine	Oregon, Washington
Petersen, Leslie	South Dakota
Piorkowski, Bob	Alaska
Pitman, Bob	Arizona, New Mexico, Texas
Radant, Randy	Utah
Ralley, Wendy	Manitoba
Rauf, Bob	Kansas

Reichenback, Roy	Wyoming
Richord, Karen	Arizona
Riley, Larry	Arizona
Sauer, Mike	North Dakota
Schlueter, Lynn	North Dakota
Scott, Bill	Kansas
Scullin, Jim	California
Secrist, Glen	Idaho
Shambaugh, Bruce	Arizona
Sim, Tom	Kansas
Smith, Scott	Washington
Sonnevil, Gary	Alaska
Stampl, Mike	Kansas
Steinwand, Terry	North Dakota
Stone, Mike	Wyoming
Stumbaugh, Grant	Wyoming
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Toohey, Mary	Washington
Turner, Phil	California
Unkenholz, Dennis	South Dakota
Walker, Eddie	Arizona
Webb, Kim	California
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Wells, Bob	Alaska
White, Megan	Washington
Williamson, Dwight	Manitoba
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Wright, Dennis	Manitoba

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	Name	State
Agency coordination	Green, Bery	Alaska
	Leland, Marilyn	Alaska
	Molnar, Don	Oklahoma
Amphibians	Stone, Mike	Wyoming
Animals	Martin, Martin	Utah
	Sim, Tom	Kansas
ANS coordinator	Meacham, Pamala	Washington
	Smith, Scott	Washington
Aquatic animals	Piorkowski, Bob	Alaska
Aquatic habitat manager	Wolff, Steve	Wyoming
Aquatic herbicide permits	Herold, Mike	Washington
Aquatic nuisance species	Archer, Don	Utah
	Schlueter, Lynn	North Dakota
Aquatic plants	Piorkowski, Bob	Alaska
	Sytsma, Mark	Oregon
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Aquatic species	Chilton, Earl	Texas
	Gray, Jody	Texas
Aquatic weeds	Hamel, Kathy	Washington
Control, monitoring	Barker, Morris	Washington
	Brittell, Dave	Washington
Cooperative projects	Gadwa, Dave	Washington
Ecological services	Gober, Pete	South Dakota
Education, outreach	Copping, Andrea	Washington
	Heimowitz	Oregon
Environmental services coordinator	Adams, Steve	Kansas
	Mammoliti, Chris	Kansas
Executive secretary, WA noxious weed board	McGonigal, Steve	Washington
Fish	Chapman, John	Oregon
	Nesler, Tom	Colorado
	Stone, Mike	Wyoming
Fish management	Parker, Blaine	Oregon, Washington
Fisheries	Janisch, Joe	Arizona
	Krentz, Steve	North Dakota
	Riley, Larry	Arizona
	Unkenholz, Dennis	South Dakota
Funding of proposals	Ralley, Wendy	Manitoba
Funding research, education, control	Kessel, Jody	national
	McDonell, Karen	national
Hazard analysis	Bristow, Brent	Oklahoma
Importation permits	Golden, Jim	Oregon

Insect/weed program manager	Toohey, Mary	Washington
Insects	Molnar, Don	Oklahoma
Invasive species	Ellis, Susan	California
	Hammon, Danny	California
	Hilburn, Dan	Oregon
	Scullin, Jim	California
Invasive species coordinator	Cook, Anita	Nevada
	Lassuy, Denny	California, Oregon, Washington
	Pitman, Bob	Arizona, New Mexico, Texas
	Webb, Kim	California
Invasive species policy issues	Cross, Dave	Alaska
Invasive species program manager	Barrows, James	Texas
Invertebrates	Cianim, Cathie	Arizona
	Loeffler, Chuck	Colorado
Legislation	Duncan, Jim	Manitoba
	O'Connor, Joe	Manitoba
	Williamson, Dwight	Manitoba
Marine invertebrates	Boxrucker, Jeff	Oklahoma
	Chapman, John	Oregon
Marine issues	Emmett, Robert	Oregon
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Marine vertebrates	Boxrucker, Jeff	Oklahoma
Microorganisms	McKerney, Katy	Alaska
Noxious weeds	Bezark, Larry	California
	Butler, Tim	Oregon
	Cox, Taylor	Idaho
	Dechoretz, Nate	California
	Lane, Eric	Colorado
	Leavitt, Robert	California
	Lepard, John	North Dakota
	Moehring, Ron	South Dakota
	Mullin, Barbara	Montana
	Northam, Ed	Arizona
	Secrist, Glen	Idaho
	Shambaugh, Bruce	Arizona
	Walker, Eddie	Arizona
Office of governor	Anderson, Kevin	Washington
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Pesticide management	Arrington, Bob	Washington
Pesticides permits	Sauer, Mike	North Dakota
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	Chilton, Earl	Texas
	Gilliland, Jean	Oklahoma
	Ode, David	South Dakota
	Reichenback, Roy	Wyoming

	Scott, Bill	Kansas
	Stumbaugh, Grant	Wyoming
Project evaluation	Matkowski, Shelley	Manitoba
	Ralley, Wendy	Manitoba
Puget Sound, long-range plans	Anderson, Kevin	Washington
Quarantine	Helbig, Bruce	South Dakota
Representative to Western Regional	Athearn, Jim	Oregon, Washington
	Janisch, Joe	Arizona
	McKinney, Larry	Texas
	Radant, Randy	Utah
	Riley, Larry	Arizona
	Steinwand, Terry	North Dakota
Research supervisor	Mosher, Tom	Kansas
Resource manager	Carlson, Lee	Colorado, Kansas
	Doebbler, Krista	Colorado
	Dulap, Ron	Alaska
	Gill, William	Kansas
	Iberts, Deby	Colorado
	Kimball, John	Utah
	Laney, Everett	Oklahoma
	Lopez, Carlos	Texas
	McConnell, Guy	Alaska
	Rauf, Bob	Kansas
	Sonnevil, Gary	Alaska
	Stampl, Mike	Kansas
	Turner, Phil	California
Resource protection	Acker, Randy	Washington
Review of projects affecting fish	Fisher, Cathy	Manitoba
Salvinia	Richord, Karen	Arizona
Science of aquatic nuisance species	Wright, Dennis	Manitoba
Spartina coordinator	Brown, Wendy	Washington
	Murphy, Kyle	Washington
State coordinator	Lawg, Michael	Wyoming
State Parks	Cary, Steve	New Mexico
T&E molluscs and crustaceans	Lang, Brian	New Mexico
Terrestrial animals	Wells, Bob	Alaska
Terrestrial plants	Wells, Bob	Alaska
Tribal interests	Parker, Blaine	Oregon, Washington
Vertebrates	Cianim, Cathie	Arizona
	Cooper, Larry	Oregon
	Loeffler, Chuck	Colorado
Water quality	Angelo, Bob	Kansas
Water quality issues	Miller, John	South Dakota
Water quality program	White, Megan	Washington

APPENDIX 3: HYDRILLA MANAGEMENT IN OREGON

Hydrilla Management in Oregon: Options, Obstacles, and Required Action

Center for Lakes and Reservoirs
Portland State University

Hydrilla Management in Oregon: Options, Obstacles, and Required Action

Prepared for

Oregon State Weed Board

Oregon Department of Agriculture

Mark D. Sytsma
Center for Lakes and Reservoirs
Environmental Sciences and Resources
Portland State University
PO Box 751
Portland OR 97207

September 1995

Hydrilla Management in Oregon: Options, Obstacles, and Required Action

Mark D. Sytsma
Center for Lakes and Reservoirs
Portland State University

Abstract

Hydrilla verticillata (hydrilla) is an invasive, non indigenous submersed aquatic plant that has infested waterbodies across the South and up the east coast as north as Washington D.C. Found in California in 1976, hydrilla has infested waterbodies in 17 California counties. Hydrilla was found in Washington in 1994. Hydrilla has not been found in Oregon, however, the aggressive spread and robust growth of hydrilla in Washington and California indicates that the plant could have a severely damage aquatic ecosystems and block water flow in conveyance systems throughout the state.

Potential impacts of hydrilla on aquatic systems in Oregon include blockage of flow, changes in dissolved oxygen, pH, and temperature profiles, alteration of the structure of the aquatic plant community and consequent changes in trophic dynamics and fish populations, interference with recreation, and decreased lakefront property values. Economic impacts are not easily estimated, however, states with a management (as opposed to eradication) strategy for hydrilla face an expanding infestation and costs well in excess of those associated with eradication efforts.

Several actions are required prior to hydrilla invasion to ensure an effective response, including: increased surveillance efforts, lead agency designation, establishment of an Aquatic Plant Management Council and Trust Fund to advise the lead agency on management priorities and fund management efforts, contracting of suppliers to ensure rapid response to detection of hydrilla, facilitation of permitting for hydrilla control, completion of necessary environmental impact statements, and development of public education on aquatic weed impacts and management.

Introduction

Hydrilla (*Hydrilla verticillata (L.F) Royle)* is an invasive, non indigenous plant that entered the United States in 1958 and has since spread across the South and up the east coast to Washington D.C. Discovered on the west coast in California in 1976, hydrilla has spread to 17 California counties. California has spent approximately $2 million per year for hydrilla detection and eradication over the past five years. The most recent hydrilla infestation in California, Clear

Lake, may push the annual hydrilla eradication budget to $5 million (Nate Dechoretz, personal communication). Hydrilla was discovered in Washington in September 1994. The Washington infestation is extremely robust, biomass doubled between July 15 and 31, 1995 (M.D. Sytsma, unpublished data), but appears to be restricted to two lakes in King County. Eradication of hydrilla from the lakes will cost approximately $100,000 in 1995 and $75,000 in 1996 (Kathy Hamel, Washington Department of Ecology). Costs for treatment past 1996 have not been estimated.

Hydrilla has not been reported in Oregon, however, the high growth rate and aggressive establishment of hydrilla in California and Washington indicates that hydrilla has the potential to seriously damage aquatic systems in the state. The history of the hydrilla invasion of the United States makes clear that failure to aggressively eradicate pioneer infestations leads to degraded fish habitat and recreational opportunities, clogged intake screens on water intakes, flooding and increased cost for weed control in and water conveyance systems and aquatic ecosystems.

This report describes the biology and impacts of hydrilla and outlines management options and obstacles Oregon. The type and intensity of measures for control of invasive, non indigenous plants is determined by a number of factors including: biology of the invader, size of the population, risk to the resource, and social and environmental impacts of the management activities. Site-specific management plans that consider all these factors will be required for effective treatment of a hydrilla infestation.

Hydrilla Biology

Hydrilla is a monocot in the Hydrocharitaceae family. A native of Australia, Asia, and Central Africa (Cook and Luond 1982, Cook 1985), recent work on the biogeography of hydrilla in its native range suggests that the plant has the potential to grow anywhere in North America, including Canada and parts of Alaska (Balciunas and Chen 1993). The original introduction to the USA and most of the spread of hydrilla across the South was the dioecious biotype. The more northern infestations, including those in the Potomac River, northern California, and Washington are the monecious biotype.

The Hydrocharitaceae is a highly aquatic-adapted family that also contains several other genera that are very similar morphologically to hydrilla, e.g., *Elodea*, *Egeria*, *Lagarosiphon* (Anderson 1987), which complicates detection efforts. *Egeria densa* (Brazilian elodea) is perhaps the most widespread and abundant aquatic macrophyte in Oregon. The native macrophyte *Elodea canadensis* is also common and widely distributed. Several morphological features distinguish hydrilla from its cogenors and are key to correct identification (Table 1). Presence of subterranean

turions, or tubers, and small (0.2 to 0.5 mm) axillary scales (squamula intravaginalis) are distinguishing characteristics of hydrilla (Cook and Luond 1982, Yeo et al. 1984, Anderson 1987).

Table 1. Distinguishing features of *Hydrilla verticillata* (From Anderson 1987).

Character	Precautions
Serrated leaf margins	Under some conditions no or few serrations are present (e.g., very young growth).
Small spines on lower (abaxial) leaf midrib	Often not distinct but presence is distinguishing character of hydrilla
Axillary leaf scales	Best seen with a 10x hand lens, may be reddish, scales at youngest (apical) nodes may not have pigment
Subterranean propagules (tubers)	Distinguishing feature normally found in late summer to spring
Axillary turions	Green propagules in leaf axils. Elodea and Egeria also form compact axillary buds
Male flowers	Present on monecious plants only. Formed at leaf axils and later released to float to the surface. Formed in late summer and fall.

Monecious and dioecious hydrilla plants have different growth habits. Dioecious plants typically grow to the surface rapidly with little branching. Branching occurs at the surface forming a dense canopy. Most dioecious hydrilla biomass is concentrated in the upper part of the water column. Monecious plants typically branch profusely near the sediment and spread laterally with rhizomes. Biomass of monecious plants is distributed more evenly in the water column.

Hydrilla has characteristics of annual and perennial plants, depending upon the latitude, climate, and hydrological characteristics of the system (Anderson 1987). Both biotypes grow well at temperatures between 20 and 32 C (Barko and Smart 1981). In warm climates biomass persists throughout the year, although maximum biomass typically occurs in late summer (Anderson and Dechoretz 1982). The monecious biotype has a more annual life cycle than the dioecious plants,

with little or no biomass present in the water column between December and April (Anderson 1987).

Perennation of hydrilla in temperate latitudes is primarily by subterranean tubers and turions. Tubers are produced in late summer when day length is less than about 12 hours, however, tuber production was noted in the Washington population in late July, when day length was approximately 15 hours (M. D. Sytsma, unpublished data). Monecious hydrilla does set seed, and although seeds do not appear to be a primary method of perennation, they do provide a long-term survival strategy (Stewart 1993, Lal and Gopal 1993).

Hydrilla produces several propagules that aid in dispersal in addition to seeds, including tubers, axillary turions, stem turions, and stem fragments (Anderson 1987). Tubers, which are formed in the sediment and are heavier and less easily distributed by water currents, provide a means of maintaining dominance of established populations (Spencer et al. 1987, Spencer and Ksander 1991, Spencer and Rejmanek 1989). Tubers and turions are produced abundantly and are not impacted by herbicides after they are formed. Tubers can survive longer than four years in the sediment (Anderson 1992). The tuber bank is a major consideration in planning a hydrilla eradication program.

Hydrilla Invasion and Impacts

Hydrilla invasion of Oregon could occur by several mechanisms. Hydrilla has been introduced to California through contaminated shipments of water lily tubers from hydrilla infested areas. Aquatic plants sold through pet stores for aquarium use could also be contaminated. If aquariums are dumped into local waterways, hydrilla could be introduced. Hydrilla could enter Oregon from infested areas on fishing gear, boats, and boat trailers. Water fowl could be a vector for hydrilla seeds, tubers, turions, and stem fragments. Waterfowl can transport propagules on mud-incrusted feet and in their crop. As many as 1300 viable turions have been collected from the crop of a single duck (Stratford Kay, University of North Carolina, personal communication).

Hydrilla infestation has economic and ecological impacts. Hydrilla's low light-compensation point, rapid growth rate, and ability to use bicarbonate as a carbon source increases pH and allows hydrilla to competively displace native species. Dense hydrilla increases diurnal variation in dissolved oxygen and pH (Spencer et al. 1994), which influences habitat quality and can contribute to eutrophication of aquatic systems by increasing nutrient release from sediments. The development of a dense mass of plant material in the water column alters fish habitat quality and trophic relationships, which can lead to changes in fish population structure, and interfere with recreation (Carpenter and Lodge 1986). Masses of hydrilla can block intake screens on irrigation

and hydroelectric plants blocking flow and causing shutdowns. In 1991, hydrilla blocked the intakes on the St. Stephen Hydroelectric facility on Lake Moultrie, South Carolina forcing shutdown and loss of revenue from power generation (South Carolina Department of Natural Resources 1995).

Economic impacts of a hydrilla infestation in Oregon are difficult to estimate; an assessment of the costs associated with lost recreational opportunities and tourism, and reduced agricultural efficiency due to aquatic weed growth in Oregon has never been done. Costs of invasive aquatic plant infestations have been assessed in other states and provinces. Loss of power production at St. Stephen's hydroelectric plant in South Carolina necessitated $1.2 million for emergency treatment (South Carolina Department of Natural Resources 1995). Reduced visitation to Lake Seminole, Georgia, due to a 400 percent increase in hydrilla coverage between 1983 and 1992 was estimated to cause a loss of about $13 million per year to the local economy (Joe Knight, Corps of Engineers, as cited in MidSouth Aquatic Plant Mangement Society Newsletter 1993).

In a study done in the Okanagan Valley of British Columbia, where Eurasian watermilfoil (a nonnative aquatic weed also present in Oregon) has invaded, about 30 percent of the visitors to the region indicated that they would cancel their visit if water-based recreation were restricted by plant growth (B.C. Ministry of Environment, Lands, and Parks 1991). The study estimated that reduced visitation due to aquatic weeds in 1991 would translate into losses of $85 million (Canadian) annually; a reduction of 26.5 percent in total 1989 revenues, and about 46.5 percent of 1989 revenues between June and August. Lake front property values were estimated to be reduced by 2 percent by uncontrolled aquatic weeds. Total reduction in government revenues due to the impact of aquatic weeds on property, sales, room, and corporate tax collection in British Columbia was estimated to be $3 million (Canadian) annually.

An aggressive detection and eradication program will have occasional high costs for treatment of pioneer infestations, however, the long-term costs and benefits of an eradication strategy outweigh the management costs and environmental damage of widespread hydrilla infestation. Management strategies that neglect pioneer colonies or attempt to manage growth in infested lakes almost always lead severe disruption of aquatic systems and to long-term, escalating management costs (Anderson 1987). South Carolina, for example, spends over $2.8 million to manage about 40 percent of the total hydrilla infestation. Costs of South Carolina's hydrilla management program have escalated in recent years as the hydrilla infestation has grown faster than the management effort. An estimated 50,000 acres of hydrilla was treated in 1995 (Dr. Steve deKozlowski, South Carolina Department of Natural Resources). Florida has estimated that $11 million are needed to adequately manage hydrilla, but only $6 million are available (Jeff Schardt, Florida Department of

Environmental Protection). Hydrilla coverage in Florida increased from 50,000 acres in 1992 to 100,000 acres in 1994. It is estimated that in 1996-1997 Florida will need to spend $15 million to manage its hydrilla infestation. The cost of hydrilla management in Florida could have been reduced substantially if adequate funds had been made available when the infestation was smaller (Jeff Schardt, Florida Department of Environmental Protection). In 1985, Florida could have treated its entire hydrilla infestation with $2.5 million. In comparison, California's eradication program costs $2 to 5 million per year, and the program treats all infested waterbodies. The eradication program in California has limited the infestation to managable levels, prevented hydrilla spread, and protected the state's water resources at a lower total cost than the management programs in place in Florida and South Carolina.

Hydrilla Management

Management options for hydrilla include environmental manipulation, physical removal, chemical treatment, and biological control. Each option includes a number of variations. For example, physical removal may occur by drag line, mechanical harvester, hand-pulling, or diver-dredging. The challenge of managing an hydrilla invasion of Oregon is in integrating the management techniques available with the ecological and hydrologic characteristics of the infested system. The overall goal of any strategy should be the protection of the water resources of Oregon through eradication of hydrilla.

Management techniques

Drawdown

Water is, of course, necessary for the growth of hydrilla. Drawdown and exposure of sediments may be used to eliminate dispersal of hydrilla fragments by water currents and to kill leaf and stem tissues. Drawdown will not kill tubers. Tuber production by hydrilla is, in fact, an adaptation to seasonal wet and dry periods in its native range (Lal and Gopal 1993). The effectiveness of drawdown for long-term management of hydrilla growth is, therefore, highly dependent upon timing. A drawdown will always reduce the threat of spread of an infestation; however, if drawdown occurs after tubers have formed, substantial regrowth should be expected upon refill. The applicability of draw down is limited. While most reservoirs and man-made water conveyance systems can be drawn down, most natural systems cannot. Drawdown may be used to facilitate treatment of hydrilla. For example, drawdown may be used to enable dredging and chemical treatment of sediment.

Bottom barriers

Bottom barriers restrict plant growth by reducing light levels and by physical contact with the sediment (Perkins *et al.* 1979). Bottom barriers can be of many materials including burlap, fiberglass screen, plastic, and other manmade materials. Bottom barriers immediately remove plants from the water column and would reduce the threat of hydrilla spread. Bottom barrier costs, however, are high and the technique is typically used on small infestations or in areas that cannot be treated by other means. Bottom barriers also require periodic maintenance to ensure that plants do not grow through, or root on top of, the barrier. Because of the small areas typically treated, bottom barriers have minimal environmental impacts.

Water column dyes

Dyes are available that reduce light penetration and inhibit plant growth. Dyes are nontoxic, may last for weeks to months and no special equipment is needed for application. Dyes can only be used in closed systems and are not effective when plants are near the surface. Dyes are slow-acting and would not be an effective strategy for hydrilla management.

Physical removal

Physical removal by dredging may be effective when combined with drawdown, however, removal by dredging, hand-pulling, rotovation, and mechanical harvesting are not recommended when fragment dispersal is an important management consideration. Physical removal of hydrilla by hand-pulling or diver-dredging may be an effective strategy for eradicating a small, pioneer infestation. Diver-dredging can increase turbidity, however, these impacts are temporary and can be minimized using sediment curtains and other techniques.

Biological control

Although several insect species have been investigated as biocontrol agents for hydrilla, none have proven effective in areas with even relatively mild winters (Godfrey et al. 1994). Triploid grass carp have been used to reduce the hydrilla infestation in the Imperial Irrigation District in southern California (Anderson 1990). High stocking rates maintained for several years could be used to control and eventually eradicate hydrilla in most aquatic systems. Although hydrilla is a preferred species, grass carp are non selective feeders when plant densities are low. At the stocking densities required for hydrilla control, all aquatic plants would likely be eliminated from a system. Grass carp are difficult to remove from a system and their impacts on nontarget plants cannot be prevented.

Chemical control

Several herbicides are available for managing hydrilla in aquatic systems including endothal, copper complexes, diquat, acrolein, and fluridone. The efficacy of the compounds depends upon site-specific characteristics. For example, although acrolein may be effective in water supply canals, it cannot be used in natural systems. California has used chelated-copper and fluridone in their hydrilla eradication program. Chemicals without an aquatic label may be used as one component of an integrated hydrilla management plan, e.g., California has used metam-sodium to kill tubers after drawdown of reservoirs (Nate Dechoretz, personal communication).

Management considerations

Ownership and Cooperation

A significant obstacle to prompt and effective control of hydrilla in Oregon is the lack of communication links between water resource management agencies. Protection of, and management for, beneficial uses are split among several local (municipalities, irrigation, drainage, and water improvement districts) state (Department of Fish and Wildlife, Marine Board, Department of Environmental Quality, Water Resources, Health Department, Department of Agriculture, Division of State Lands, Parks and Recreation) and federal (Fish and Wildlife, Bureau of Land Management, Forest Service, Corps of Engineers) agencies. The significance of the hydrilla threat to all surface waters in Oregon necessitates a coordinated response to from all involved agencies, however, designation of a lead agency with authority to react promptly to a hydrilla find and interagency cooperation is critical to a successful hydrilla eradication program.

Size/age of infestation

Eradication of recently introduced, small infestations of hydrilla can be done effectively, inexpensively, and with minimal environmental impacts. As the age and size of the infestation increase, the chance of spread to other water bodies increase, environmental impacts of management, and management options are reduced. Diver-dredging, herbicides, and/or bottom barriers, for example, could be used to eradicate a pioneer infestation. Management options for a whole-lake infestation, e.g., herbicides, grass carp, or drawdown, have higher environmental and economic costs.

Plant biology

Effective hydrilla management must consider the phenology and biology of the plant. Spread of a hydrilla infestation is primarily by stem fragments, therefore, destruction of stem tissues is

critical to containment of an infestation, particularly in flowing-water systems. Since tubers are the primary means of maintaining a population, prevention of tuber production, which occurs in late July in the Northwest, is an important management concern.

Waterbody characteristics

Physical, hydrological, geographical, chemical, and biological characteristics and use of a waterbody influence management decisions. A hydrilla infestation in an open, flowing system, for example, is more difficult to treat with herbicides and has a higher risk of spread than an infestation in a small, closed pond. Similarly, physical factors such as water temperature and photoperiod influence plant phenology (timing of spring growth and tuber production), which in turn influence management strategies. Presence of threatened and endangered species in a hydrilla-infested waterbody must also be considered in a hydrilla management plan. Hydrilla infestation of a drinking water reservoir will require a different management strategy than an infestation in an irrigation or flood control reservoir.

Cost of management

Hydrilla management decisions have direct and indirect costs. Direct costs include the cost of the management operation e.g., herbicide application, divers, signage, etc. Indirect costs include the losses incurred by local merchants and users. Quarantine of a lake with high recreation use, for example, would impact marinas and other merchants that supply goods and services to recreationalists. Loss of this revenue could have severe economic consequences for communities that are highly dependent upon tourism. Both indirect and direct costs must be considered in a hydrilla management plan.

Opposition to management

A hydrilla management plan must consider potential restrictions on management options. Some management strategies, most notably herbicides, may meet with objections from local groups. Similarly, restrictions on herbicide use in USFS and BLM lands could restrict management options. Public education about the threat and management options are key to forestalling opposition to control of hydrilla.

Components of a Hydrilla Management Strategy

Planning for management of a hydrilla invasion can be broken into discrete components as described below (Figure 1).

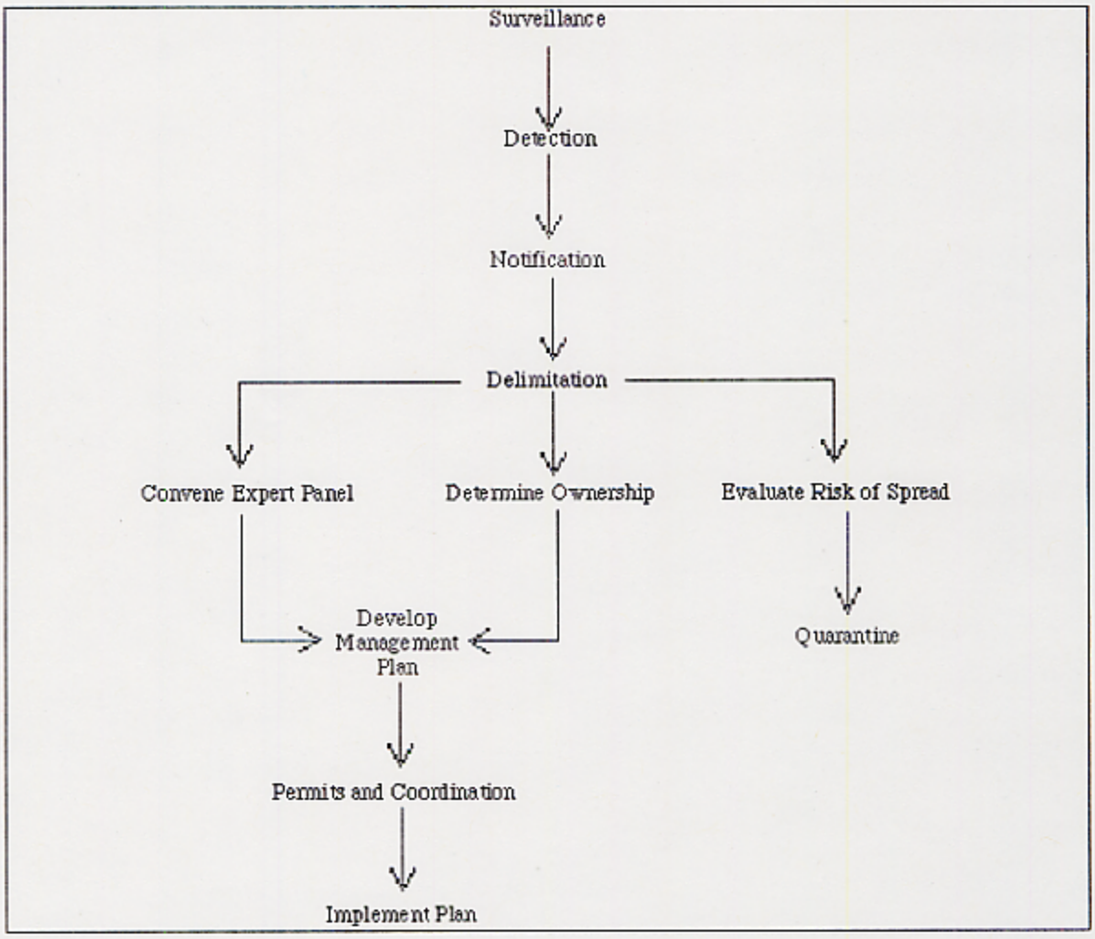

Figure 1. Flow chart of major components of a hydrilla management plan in Oregon.

Public Education

Public education is critical to an effective hydrilla detection and management effort. A public that is informed about hydrilla adds considerably to surveillance and detection capabilities with low cost. Furthermore, public awareness of the benefits and drawbacks of various management options prior to finding an infestation should facilitate development and implementation of a site-specific management plan. The Oregon Department of Agriculture has developed a brochure on hydrilla that should be distributed by all cooperating agencies.

Prevention

Prevention of an infestation is the most cost-effective management strategy for hydrilla in Oregon. A signage program and public service announcements on radio and television are needed to encourage people to inspect and remove plants from fishing gear, boats, and trailers. Wholesalers and retailers of aquatic plants should be asked to cooperate in a prevention program by carefully inspecting all shipments. Sale of hydrilla and other non indigenous aquatic plants and transport of all aquatic plants between waterbodies should be illegal.

Surveillance and Detection

Control of a hydrilla invasion requires early detection of the pioneer population and prompt eradication. An intensive detection program that includes active and passive surveillance efforts should be developed. Passive detection efforts could be conducted by an informed public and state and federal agency personnel as part of their regular daily activities. Experience in British Columbia suggests, however, that active detection efforts for aquatic weeds are more effective than passive efforts. Active detection refers to searchers whose primary objective is the detection of hydrilla.

The Oregon Department of Agriculture funded one full-time and one part-time position in the summer of 1995 for active hydrilla detection. Hydrilla surveillance efforts in 1995 have focused on high-use lakes and reservoirs that were considered succeptible to infestation. Susceptibility was determined by use frequency (Oregon State Marine Board 1993), presence of a warm water (Oregon Department of Fish and Wildlife 1995) or trout (Johnson et al. 1985) fisheries, and the presence of nonindigenous plants (observation and unpublished data). Eighty sites in 36 waterbodies have been surveyed in 1995 (Table 3). Surveillance efforts focused on coastal lakes because they were judged highly succeptible to invasion by all three criteria.

Table 2. Distribution of waterbodies surveyed for hydrilla in 1995.

Region	Percent of all sites
Coast	39
Willamette Valley	17
Cascades	25
Eastern	19

Three levels of hydrilla surveillance were employed (Table 3). The level of effort at a site was proportional to an assessment of the succeptibility to invasion. Sites with a higher succeptibility received a high level of surveillance. In addition, shipments of aquatic plants to aquarium plant

suppliers were inspected, and aquatic plant nurseries and aquatic weed infested drainage districts in the Portland metropolitan area were visited. The surveillance efforts found no hydrilla in Oregon in 1995. Since early detection is critical to eradication, these efforts should be expanded to provide more thorough coverage of the water resources of the state.

Table 3. Hydrilla surveillance efforts used in 1995.

Level	Activities
1	Walk shoreline around the boat ramp looking for plant fragments Cast the plant rake around the ramp Wade shallows in area around ramp to check for plants Make a plant list and collect specimens for a herbarium Total inspection time 10 to 20 minutes
2	Level 1 surveillance plus, Extend survey area to at least 100 ft on both sides of boat ramp Total inspection time 20 to 90 minutes
3	Level 2 surveillance plus, Use boat, wading, and snorkeling to extensively survey area out from shore Use the boat to examine any visible plant mats Total inspection time 1.5 to 4 hours

Notification

After a hydrilla infestation is discovered, all agencies with an interest or responsibility in water resource management in Oregon should be notified. In addition, local governments and private interest groups should be notified and public meetings held to ensure that the public is well-informed about the problem and potential management options.

Delimiting Survey

A delimiting survey should be conducted immediately to determine the size of the infestation. The "connectedness" of an infected water body will determine the effort required to delimit the infestation. An infestation discovered in a flowing system, such as the Willamette River will require a more extensive delimiting survey than one discovered in a small, closed farm or golf course pond. Oregon Department of Fish and Wildlife may be able to provide boats and divers for the delimiting

survey. An attempt should be made to identify the source of the infestation. Identification of the source is important in redirecting and optimizing detection efforts.

Evaluate risk of spread

The risk of spread of hydrilla is a function of the type of water body in which an infestation is discovered. Infested waterbodies with high-use boat launch facilities, such as Lake Billy Chinook or the Tenmile Lakes pose a greater risk of spread than waterbodies that do not have boat launch facilities. Infested waterbodies with a high-risk of spreading hydrilla should be quarantined until the risk of spread is reduced. Economic impacts on the local economy may prohibit use of a whole-lake quarantine. At a minimum, if the delimiting survey indicates that hydrilla is localized in a waterbody, areas with hydrilla should be cordoned-off and closed to boating, and inspection stations established at boat launches to prevent spread of hydrilla on trailers. The Department of Agriculture has clear authority to impose quarantines for situations where hydrilla might be found. To impose a quarantine, the Director of the Department of Agriculture must have the opinion that hydrilla "...is liable to spread and become detrimental to the plant or animal life of this state...", and must obtain the consent of the Governor. Posting of waterbodies and closure to boating should coordinated with the Marine Board, which may be able to provide "no boating" bouys.

Determine Ownership

A number of state and federal agencies have water resource management responsibilities that could be impacted by hydrilla invasion, however, the agency responsible for aquatic weed management in Oregon is not clearly defined. Since hydrilla threatens a variety of beneficial uses a coordinated response from water resource management agencies is appropriate. Developing and implementing hydrilla control efforts would, howver, benefit greatly from the definition of a lead agency with overall decision-making responsibility and interagency cooperation in implementing the management plan.

South Carolina may provide a model for interagency coordination of aquatic plant management in Oregon. The South Carolina Aquatic Plant Mangement Council, the South Carolina Aquatic Plant Mangement Program, and the South Carolina Aquatic Plant Mangement Trust Fund were established by legislation for statewide management of nuisance aquatic plants in public waters. The Aquatic Plant Management Council is composed of representatives from state agencies with water resource management responsibilities. Clemson University, and the Governor's Office. The Council is chaired by the representative from the Water Resources Division of the Department of Natural Resources. The Council provides interagency coordination and serves as the principal advisory body to the Department of Natural Resources on all aspects of aquatic plant management

and research in South Carolina; the Council establishes management policies, approves all mangement plans, and advises the Department on research priorities.

The aquatic Plant Management Program is run by the Water Resources Division of the Department of Natural Resources. The Department is responsible for developing an annual Aquatic Plant Mangement Plan that outlines the procedures for problem identification and analysis, selection of control methods, program development, and implementation of operational strategies. The Plan also identifies problem areas, prescribes management practices, and sets management priorities.

The South Carolina Aquatic Plant Management Trust Fund was created to receive and expend funds for the prevention, management, and research of aquatic plant problems in public waters of the State. The fund is eligible to receive State appropriations, federal and local government funds, and funds from private sources. The SC Water Resources Division of the Department of Natural Resources administers the fund, which must be kept separate from other funds of the State.

Expert consultation

A panel of experts with hydrilla management expertise should be convened to assist in development of site-specific hydrilla management plans. Recommended panelists include:

Mr. Nate Dechoretz	California Department of Food and Agriculture, Sacramento, CA
Dr. Lars Anderson	USDA/ARS Aquatic Weed Laboratory, Davis, CA
Ms. Kathy Hamel	Department of Ecology, Olympia, WA
Dr. Ken Langeland	University of Florida, Gainesville, FL
Dr. William Haller	University of Florida, Gainesville, FL
Dr. Curt Getsinger	US Army Corps of Engineers, Vicksburg, MS
Dr. Randall Stocker	University of Florida, Gainesville, FL
Dr. Steve deKozlowski	South Carolina DNR, Columbia, SC

Evaluate management options and develop management plan

Every waterbody in Oregon is vulnerable to hydrilla infestation, and it is impossible to develop management plans that prescribe actions for each type of waterbody and situation. A management plan for a hydrilla invasion must be site-specific. Waterbody types and potential management options are listed below (Table 4). The overall strategy in every case should be to prevent infestation of additional waterbodies and to eradicate hydrilla.

The size of the infestation and type of waterbody are the major constraints on hydrilla management. A large infestation can only be economically treated with drawdown, dredging, and/or grass carp. Smaller infestations can be treated with herbicides, bottom barriers, or diver dredging. In most cases, a combination of management techniques would be used to eradicate hydrilla. For example, herbicide treatments may be used to reduce the population to a size that could be managed using diver-dredging. Other site-specific factors can further constrain options. Infestation of a drinking water reservoir, for example, would limit chemical treatment and drawdown options.

Table 4. Waterbody types and potential hydrilla management options.

Type and size of infestation	Management Options Available
Natural lakes with large infestations	Quarantine, herbicide applications, grass carp stocking
Natural lakes with small, isolated infestation	Boating restrictions, herbicide application
Natural lakes with pioneer infestation	Boating restrictions, diver-dredging, bottom barriers
Reservoirs	Drawdown, dredging, sediment sterilization, herbicides, grass carp, quarantine/boating restrictions
Irrigation/drainage canals	Drawdown, dredging, sediment sterilization, herbicides, grass carp
Wetlands	Drawdown, herbicides
Retention/detention basins	Drawdown, dredging, grass carp, herbicides
Streams	Herbicides, dredging
Rivers	Herbicides, dredging

Permits

Management plans that require major environmental manipulations, e.g., drawdown, dredging, or grass carp stocking, will require permits. The Oregon Division of State Lands and the US Army Corps of Engineers issue dredging permits under Section 401 of the Clean Water Act. No permits are required from the Department of Water Resources for an emergency reservoir drawdown, however, the Department of Environmental Quality may have operational requirements on dams that maintain downstream turbidity, dissolved oxygen, and temperature. A rapid drawdown for hydrilla containment and control would likely require an emergency rule to modify water quality standards, which is issued by the Environmental Quality Commission. The Oregon Department of Fish and Wildlife would require a permit for grass carp stocking. No permits are required for herbicide

application in Oregon. Permits required for activities related to hydrilla management should be expedited by the permitting agency to ensure a rapid and effective response to invasion.

Implementation

Rapid and effective implementation of the hydrilla management plan is essential for successful control. Potential obstacles to rapid implementation of a plan include lack of interagency cooperation, public opposition, logistic problems, and availability of funds. Public opposition to herbicide application may be expected, although California has not experienced serious problems in implementing their aggressive hydrilla eradication program that includes herbicide treatments (Nate Dechoretz, personal communication). The Washington hydrilla infestation was treated with fluridone after a public comment period, in which there was more public opposition to the use of grass carp than to herbicide application for hydrilla management in Washington (Kathy Hamel, personal communication). The Washington program may have benefited from an effective public education program and familiarity with aquatic weed problems and management.

Although many state agencies have management responsibilities for some aspect of the state's water resources, no agency has the equipment, resources, or personnel to implement a hydrilla management program on its own. Much of the management activities would have to be contracted. Licensed herbicide applicators, dredge operators, bottom barrier suppliers and installers, and other services should be available on short notice, which may require having contractors on retainer for services on an "as needed" basis.

Funding of hydrilla control activities is perhaps the most problematic aspect of hydrilla management in Oregon. Under the Oregon Administrative Rules, a County governing body may create a weed control district for managing noxious weeds. These special districts could partially fund hydrilla eradication. Hydrilla, however, has the potential to impact beneficial uses in every waterbody in Oregon, and its eradication is a statewide concern. Furthermore, the costs of a hydrilla eradication program may exceed the funding ability of local weed control districts. An emergency fund for hydrilla eradication of $250,000 should be established to ensure rapid and effective response to hydrilla in Oregon. The Interstate Compact on Pest Control may also be a source of emergency funds for hydrilla control. Development of an integrated program for managing aquatic weed problems, modeled on the South Carolina program, should be a goal of water resource management agencies in Oregon.

Long-term Monitoring and Treatment

California requires three consecutive years without finding plants before eradication is considered complete. Such a protocol should also be adopted by Oregon. Until an infestation is eradicated, a site will require intensive monitoring and retreatment. Without a long-term commitment to management, hydrilla control in Oregon will fail. Failure to eradicate hydrilla has long-term implications for Oregon's water resources including loss of critical warm-water and salmonid habitat, degradation of water quality, increased costs for weed management in drainage and irrigation systems, and loss of water-based recreation. Uncontrolled hydrilla growth has secondary impacts on water resources as well. Oregon's current aquatic weed problems and lack of integrated management program has resulted in ad hoc, private applications of herbicides to Oregon's public waters, which may impact human and ecosystem health. An uncontrolled hydrilla infestation will exacerbate these problems.

Required Actions

Several tasks must be accomplished prior to hydrilla invasion to ensure an effective response.

- Increase surveillance and detection efforts.
- Designate lead agency for hydrilla eradication in Oregon.
- Establish an Oregon Aquatic Plant Mangement Council to advise the lead agency on management priorities.
- Establish an Oregon Aquatic Plant Management Trust Fund for hydrilla management in Oregon.
- Contract suppliers of aquatic weed management products and services to enable a rapid response to hydrilla detection.
- Develop a public education program describes the role of aquatic vegetation in aquatic ecosystems, the impact of non indigenous species, and aquatic weed management options.
- Complete necessary environmental impact assessments for all management options.
- Facilitate and streamline permitting for hydrilla management activities.

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