Rapid Response Plan For Invasive Aquatic Plants, Fish, and Other Fauna

PART 2: FISH AND OTHER FAUNA PROTOCOL

Maine Department of Inland Fisheries and Wildlife

In coordination with the

Maine Department of Environmental Protection

January 2006

Acknowledgements

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Interagency Agreement

The Departments of Environmental Protection and Inland Fisheries and Wildlife agree to implement this plan when responding rapidly to new introductions of aquatic invasive species.

ADOPTED BY:

David Littell, Commissioner Department of Environmental Protection	Roland D. Martin, Commissioner Department of Inland Fish and Wildlife
_____ Date	_____ Date

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Introduction

This Rapid Response Plan implements a key task identified in Maine's *Action Plan for Managing Invasive Aquatic Species*, which was adopted by the Interagency Task Force on Invasive Aquatic Plants and Nuisance Species and the Land and Water Resources Council in 2002. It is intended to ensure that appropriate protocols, trained personnel, equipment, permits, and other resources are ready to go to contain or eradicate newly detected illegal aquatic plant or animal introductions as they are reported to or discovered by agency personnel.

The plan is an administrative blueprint for appropriate state agencies to work together and separately. The Department of Inland Fisheries and Wildlife (DIFW) has lead responsibility for fish and aquatic fauna; and the Department of Environmental Protection (DEP) has the same for aquatic plants. Both agencies will work with the Department of Conservation when surface use restrictions or other response initiatives affect state facilities and are needed to facilitate rapid control or eradication. They will also inform and include the public and affected parties, to the extent practical or as stipulated in statute, in the process.

Rapid response goes hand-in-hand with early detection. The Maine Department of Environmental Protection (DEP) in partnership with the Maine Volunteer Lake Monitoring Program and Maine Center for Invasive Aquatic Plants has established the Plant Patroller Program to train professionals and lake watchers to be on the lookout for invasive aquatic plants. Wildlife and Fisheries Biologists of the Department of Inland Fisheries (DIFW) receive reports about fish and other fauna.

Rapid Response Goals

The primary goal of rapid response deployment is to initiate eradication efforts (which may take years to complete) or critical interim measures to achieve effective containment while a longer term eradication or suppression strategy is formulated. This means mobilizing and deploying as quickly as possible to address a newly detected aquatic invasive plant *within the first season of detection, and, preferably, to treat the infestation in less than 30 days*. Inherent in rapid response is the need to use physical techniques or chemical treatments that can knock out an invasive species before it has a chance to proliferate, providing such techniques or treatments are practical and pose little risk to rare or endangered species or human health. We acknowledge that, in the short run, commonly occurring native communities may be compromised, or surface uses may be curtailed, but believe that these are acceptable tradeoffs to avoid spreading such harmful species to other parts of a water body or other waters of the state.

To the extent possible, treatment plans which are developed during rapid response operations will look beyond the first season of detection to identify a longer term strategy that will best take into account the nature of the species, site conditions, and efficacy of treatment and monitoring methods.

Principles

To achieve rapid response, the agencies will follow the principles below. Rapid response initiatives will:

1. reflect sound biology and the particular situation;
2. strive for eradication as the primary goal of all rapid response deployments; be prepared to shift to a longer term "management" strategy if needed to achieve eradication or, if unsuccessful, shift to suppression;
3. facilitate fast action and interagency decision-making at the lowest level possible;
4. be a priority for staff attention so that water use restrictions may be lifted as soon as possible;
5. minimize infringement on public access, parks, and other facilities;
6. be fair and safe to all users;
7. use personnel and resources efficiently; and
8. be flexible, varying the protocol to accomplish steps concurrently or out of order as needed.

The agencies will consult the public early in the process, to the extent practical. In some instances, the agencies may need to proceed with minimal public notification in order to protect valued public resources and/or public safety, even if a proposed treatment plan is controversial.

Plan Organization

The plan is organized into two parts by area of responsibility.

Part 1. The protocol that will guide DEP in rapid response initiatives for plants is contained in Part 1, under separate cover. Appendices pertain to treatment techniques, species-appropriate techniques, and interagency agreements that facilitate fast action. In the future, there may also be appended operations checklists for selected techniques and a general permit for the application of herbicides under prescribed conditions.

Part 2. Part 2, under separate cover, contains similar information to guide the Department of Inland Fisheries and Wildlife (DIFW). While this plan focuses on fish, it does not preclude the department from using the same kind of procedures to respond quickly to other faunal infestations such as zebra mussels, though the appropriate treatment techniques will vary and must be further researched. Part 2 appendices include an analysis of treatment options, a draft general permit for rotenone application, and a bibliography.

Planning Process

DEP and DIFW initially formed a steering committee for the purpose of creating a streamlined and coordinated approach to mounting rapid response efforts. DEP contracted with H. Dominie Consulting for assistance in facilitating the process and drafting the plan.

The first step was to collect information and discuss issues of mutual concern. Toward this end, H. Dominie Consulting (Dominie) and E/PRO Engineering and Environmental Consulting, LLC (E/PRO), surveyed the literature and contacted people with experience on rapid response

planning and eradication techniques. Dominie also worked with the steering committee and DOC's Boating Facilities Program staff to identify issues and an approach for the imposition of surface use restriction orders as well as the placement of regulatory markers. In addition, E/PRO consulted with DEP and DIFW to identify the legal obstacles which now prevent DEP from issuing a general permit to apply a herbicide in rapid response. E/PRO also drafted a general permit for rotenone for application if such obstacles are overcome.

When this information was compiled, the team drafted response protocols for plants and fish. Each agency representative was responsible for making sure that others in their agency reviewed relevant provisions of their part of the plan as it was developed.

The final step will be for the Commissioners of DEP, DIFW, and DOC to review the plan and meet to discuss any concerns and/or desired changes they may wish to make. Following agreement on final provisions, and assuming no intransigent issues, the Commissioners will adopt the plan and charge their respective staffs with its coordinated implementation.

Plan Update, Evaluation, and Monitoring

DEP will be responsible for initiating an interagency effort to review the effectiveness of the plan at least every five years, but each agency may insert new information or make other adjustments excepting policy changes to their respective parts at any time with consultation with other agencies. It is to be a working and evolving document, improved over time through experience in Maine and elsewhere. Each agency will informally monitor how well the plan works. They will engage participants in evaluating the results of each specific rapid response initiative to learn from, and make adjustments to, the process.

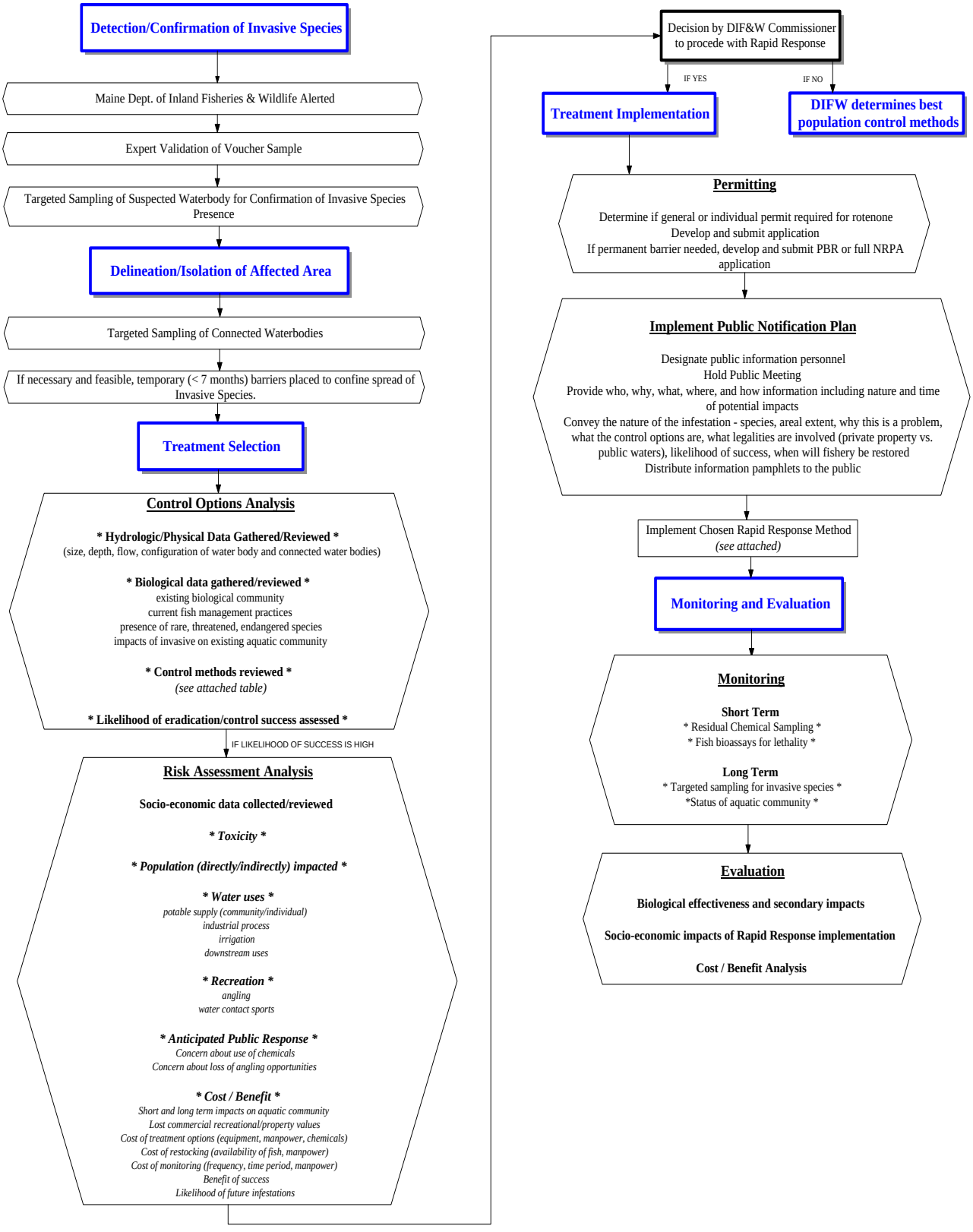
The agencies will report progress annually to their Commissioners and the Invasive Aquatic Species Task Force, and recommend policy changes as necessary. The report will cover such topics as:

1. number, type, and results of response initiatives undertaken;
2. interagency coordination;
3. procedures and techniques;
4. staff training and responsiveness;
5. availability and deployment of resources;
6. overall costs and benefits of the approach;
7. unforeseen obstacles to the implementation of the plan and steps taken to overcome such obstacles; and recommendations for changes to the plan.

Overview of Invasive Aquatic Fish and Other Fauna Protocol

The Department of Inland Fisheries and Wildlife (DIFW) will follow the procedures described in this part of Maine's Rapid Response Plan in responding to a newly detected invasive aquatic fish introduction, unless unusual circumstances dictate otherwise. Regional fisheries biologists, in most cases, will manage the response to a new introduction, according to the following steps.

Rapid Response Flow Diagram for Fish



Detection/Confirmation of Invasive Species

The DIFW website and other information distributed to the public, other agencies, and organizations will direct people who detect a suspected invasive aquatic fish to contact the appropriate Regional Fisheries Biologist and if possible provide a sample specimen. Once a regional biologist is alerted to the possibility of the existence of an invasive species, he/she will notify the Management Supervisor and the Director of Fisheries Operations.

DIFW will record all relevant information regarding the sighting/capture on the *Invasive Fish Species Initial Contact Information Form* contained in Appendix A. Such information includes: the specific location within the waterbody of the sighting/contact, the date and time of the sighting/capture, contact information (phone number, address, e-mail) for the person calling about the sighting/capture, and any information about the method of introduction that is known.

If a specimen is available, qualified DIFW personnel will make a positive identification. If the specimen cannot be identified by DIFW personnel, it will be sent to a fisheries expert for identification.

Once a positive identification has been made, DIFW staff, including the Regional Fisheries Biologist, Management Supervisor, and Director of Fisheries Operations will use their professional judgment to make a preliminary determination regarding the feasibility of reclamation or mitigation in the waterbody. If the waterbody is deemed potentially treatable, a targeted sampling of the waterbody will be undertaken to verify the presence of the invasive species. This sampling will be done visually, through angling, and/or by electrofishing, netting, or trapping. If invasive species presence is verified, then DIFW will continue the rapid response procedure. If no specimen is available for identification, or if presence verification is unable to be made, DIFW will periodically monitor the waterbody for invasive species presence.

Delineation/Isolation of Affected Areas

Once the presence of an invasive species presence in a waterbody is verified, DIFW will assess the likelihood of the species accessing connecting water bodies. If warranted and where feasible, DIFW will install fish exclusion barriers at logical locations to prevent the spread of the invasive species to the adjacent water bodies.

NRPA Permit. No permit is required for a temporary fish barrier which is to be in place for a period of less than 7 months and which meets the standards of the Natural Resources Protection Act (NRPA). If a temporary barrier is put in place, DIFW will inform the appropriate Maine Department of Environmental Protection (DEP) regional office of its placement and location.

For any fish barrier to be installed for a period longer than 7 months, DIFW will submit a Notification of Intent (NOI) to DEP under the NRPA Rules, Chapter 305 (Permit-by-Rule), Section 13, Habitat Creation or Enhancement and Water Quality Improvements. In addition to filing the NOI, DIFW will provide an opportunity for public comments.

If it appears that installation of a fish exclusion barrier may violate one or more of the standards of the Natural Resources Protection Act, DEP may invoke its discretionary authority and require that an individual NRPA permit be obtained by DIFW. This will be determined in a pre-application meeting with DEP.

If there is a chance that the invasive species has already spread to adjacent water bodies, a targeted sampling, as described above, of those water bodies will be undertaken.

Treatment Selection

A review of the literature, and empirical experience throughout the United States, indicates that the only treatment option with a reasonable and cost-effective likelihood of eradication of an invasive species is treatment with rotenone (see Appendix B). Even with rotenone, however, success is not guaranteed, and compounding factors must be taken into consideration. Rotenone treatments are typically whole-waterbody treatments and, as such, the entire aquatic community may be impacted by the treatment. This is particularly true because rotenone is a non-target biocide that affects gill-breathing organisms including both fish and aquatic insect species.

Control Options Analysis. To determine if rotenone is an appropriate eradication technique for a particular waterbody, all available physical, hydrological, and biological information for that waterbody will be gathered and reviewed. Waterbody configuration and hydrologic connection to other water bodies (including ground water) need to be factored into a decision of treatment suitability. In addition, the presence of rare, threatened, or endangered species, the current and future fish management practices for the waterbody, and the potential impacts of the invasive species on the entire aquatic community need also be considered. If the biological and hydrological conditions are such that the likelihood of successful eradication of the invasive species using a rotenone treatment is high, then the response team will move to the next step and evaluate the potential social and economic impacts of such treatment.

If rotenone treatment is determined to be infeasible, containment may be the only other rapid response option.

Risk Assessment Analysis. DIFW will take into account toxicity, socio-economic losses of water uses during treatment, and treatment costs when determining the feasibility of treatment.

Much research has been directed at the potential public health effects of rotenone. Although rotenone has some toxicity to all oxygen-breathing animals, it is selective to fish and other gill-breathing organisms at the concentrations used for fish eradication treatments. In general, most common aquatic invertebrates are less sensitive than fish to rotenone.

The research has established that rotenone does not cause birth defects, reproductive dysfunction, or cancer. When used according to label instructions for the control of fish, rotenone poses little, if any, hazard to public health. The USEPA has concluded that the use of rotenone for fish control does not present a risk of unreasonable adverse effects to humans and the environment. However, tolerances for rotenone in potable and irrigation water have not as yet been established by USEPA. As a result, water containing residues of rotenone cannot be legally allowed for use

as a domestic water source or on crops. During the treatment and for the period of time that rotenone residues are present, alternative water sources must be used for domestic and irrigation uses. Depending on initial rotenone concentration and environmental factors (*e.g.*, temperature - the half-life of rotenone increases inversely with temperature), this period can vary from 1 to 8 weeks (*Rotenone Use in Fisheries Management* 2000).

Based on an assessment of the toxicology data and exposure level, USEPA has ruled that a re-entry interval was not needed for persons who swim in waters treated with rotenone. The re-entry statement on the product labels "do not swim in rotenone treated water until the application has been completed and all the pesticide has been thoroughly mixed into the water according to labeling instructions" is an indication of the safety of rotenone for fish control (*Rotenone Use in Fisheries Management* 2000).

Interruption of short-term water uses will be a major factor in the risk analysis. These must be weighed against the longer term impacts that may result from an invasive fish introduction. While rotenone is considered to have low toxicity to birds and mammals and does breakdown relatively quickly, it nonetheless can render a waterbody unusable for domestic and irrigation uses for several weeks depending on the number of applications, the dosage applied, water temperature and whether or not neutralization is used. If the waterbody being considered for treatment is a potable water supply, or is the source of irrigation water (or potentially of industrial process water), then the inability to use the water for those purposes for a period of time must be taken into account. Similarly, if the waterbody is used for recreational purposes, any activities that will have to be suspended for at least the short term, (and in the case of angling, perhaps for a much longer period until the desired fish stocks are replenished) must be considered. The public's response to these restrictions and the DIFW staff-time dealing with public relations issues must also be considered.

In addition to the non-use aspects of treatment, the actual monetary costs of treatment can be significant. Costs include the chemicals (rotenone and potassium permanganate if neutralization is required), any specialized application equipment that may be required, and personnel considerations (including training and for contingency activities). Following application, the personnel associated with chemical monitoring and the restocking effort can be a significant cost as can be the cost of the restocked fish themselves.

All these costs, monetary and otherwise, will be measured against the potential benefits of a successful eradication effort and the likelihood that reinvasion might occur sometime in the future.

DIFW Commissioner Decides Whether to Proceed with Rapid Response

If the Commissioner decides not to proceed, DIFW will determine the best population control methods. However, if the Commissioner decides to proceed with Rapid Response, DIFW will move into the Treatment Implementation stage.

Treatment Implementation

Permitting. In order to legally discharge pollutants, in this case rotenone (and potassium permanganate if rotenone neutralization is required), to the waters of the State, the discharger must first obtain a Maine Pollutant Discharge Elimination System (MPDES) permit from the DEP. If the use of rotenone qualifies for a General Permit for the Application of Aquatic Pesticides, DIFW will submit a Notification of Intent (NOI) to DEP. The NOI consists of some basic information about the proposed project and includes a notification process to area residents. In order to qualify for a General Permit, the DIFW must also agree to abide by some pre-determined conditions related to application procedures, dosages, follow-up monitoring etc. The General Permit process is estimated to take 2-4 weeks to complete.

If a General Permit process is not in place, or if for some reason a particular project does not qualify for the General Permit, then DIFW will apply for an individual MPDES permit. The individual permit process will entail development of a much more detailed application, and the review time at DEP could take 6 months or more.

Implement a Public Notification Plan. Depending on the waterbody being treated, the application of rotenone may generate significant public interest, and possibly strong opposition. A comprehensive public notification plan will be implemented to deal with the publics' questions and concerns and to address the public notification process that will be required as part of the permitting process. Specific aspects of the plan will include: a strategy for notifying adjacent landowners and other interested parties, and, holding a public meeting to explain the need and purpose of the rotenone treatment as well as to address the public health concerns and waterbody constraints. The notification plan will also entail the posting of signs around the waterbody, and the development of public notices, website postings, and pamphlets for general distribution alerting the public to the fact that rotenone will be applied during a certain time frame and explaining the associated use constraints. It should be remembered that in making the decision to implement a rapid response, the DIFW Commissioner has determined, after considering the associated biological and socio-economic issues, that the plan is warranted. Therefore, the purpose of the public notification effort is to inform, not to seek opinions or to debate the issue. The appropriate regional fisheries biologist will be responsible for the notification plan and all dealings with the public relative to the rotenone treatment.

Implement Chosen Rapid Response Method. To assure that all aspects of a rotenone treatment project are adequately addressed, DIFW may use for guidance as appropriate, the *Rotenone Use In Fisheries Management: Administrative and Technical Guidelines Manual* (see Appendix C, Bibliography) and/or other professionally accepted practices in planning and executing any rotenone treatments that it undertakes. The manual covers preliminary and intermediate project planning, project implementation and management, and treatment. The manual also covers technical procedures such as dosage determination, applicator safety, monitoring, neutralization,

crisis management, and fish collection and disposal. Project assessment, both short and long term, is also addressed. All DIFW treatment personnel and/or contractors will be appropriately trained in the application of rotenone and will follow, before, during, and after the treatment, permit requirements and such practices as are found in the aforementioned manual or which are applicable to Maine and the particular circumstance.

Monitoring and Evaluation

An important part of the Rapid Response Program is monitoring and evaluation.

Monitoring. Monitoring during and after the application of rotenone assures that an effective treatment is achieved, limits potential litigation, and assesses the impact on, and recovery of, aquatic resources. Monitoring studies can also help allay public fears about the treatment.

DIFW will utilize appropriate and accepted monitoring methods and practices to detect residues of rotenone and other compounds, and to assess the impact of the treatment on biological resources. Depending upon the particulars of the treatment, environmental samples may be collected to document the initial application concentration and degradation of rotenone over time and associated compounds (*e.g.*, the breakdown product rotenolone, and dispersants and emulsifiers if liquid formulations are used).

Following the treatment and prior to restocking the waterbody, DIFW will use live cages of fish to check for residual rotenone and byproducts.

Evaluation. In addition to the monitoring undertaken to determine if the eradication of the invasive species has been successful, a total project evaluation will be conducted. As soon as possible after the treatment has been completed, DIFW will hold a meeting to solicit input from all personnel involved in the treatment to determine the efficiency and efficacy of the project. The objective of the meeting is to provide a basis for improving the planning and implementation of future projects.

All aspects of the treatment process will be reviewed with regard to the objectives of each project component and whether the activities were carried out as originally planned or modified *in situ*. The review may include such topics as: scheduling, pre-treatment planning, project logistics, treatment mechanics, treatment effectiveness, monitoring, public notification, perception, and response, project safety, project security, fish removal and disposal, spill contingency, rotenone neutralization, internal project communications, restocking, records maintenance, cost accounting, socio-economic impacts, and any other aspects that warrant discussion.

Following the meeting, the Fisheries Biologist will prepare a summary report documenting lessons learned as a reference document for future projects.

Project results will be provided to interested parties.

Rapid Response Steps for Other Fauna

The Rapid Response Steps for Other Fauna will generally be the same as fish, with refinements to be made in subsequent revisions.

Appendix A:

Protocol for Handling Initial Contacts

Invasive Species Initial Contact Information Form	
Date Contact Made:	
Call Received By:	
Invasive Species Reported By . . .	
Name:	
Address:	
Telephone:	
E-Mail:	
Date of Sighting:	
Type of Fish or Other Fauna:	
Waterbody Name and Midas #:	
Waterbody Location (Town, County, and Latitude/Longitude):	
Location Within Waterbody:	
Comments:	

Appendix B:

Summary of Treatment Options

Includes:
- Analysis of Treatment Options for Fish -
- Table 2.B.1: Summary of Response Technique Options -
- Personal Communication Notes -

Analysis of Treatment Options for Fish

The following table summarizes research surveyed in the literature and through personal contacts on rapid response techniques for the eradication of invasive fish. It is organized by technique, and lists the advantages, limitations, some additional information, and specific references for each. At the end is a list of personal contacts with fisheries people in several states and provinces regarding their experiences with rapid response and/or reclamation projects. The bibliography for the references is located in Appendix D, which contains approximately one hundred twenty-five references that were reviewed in full, read as abstract only, or cited in the literature, but not reviewed.

From this review, rotenone appears to be the overwhelming eradication technique of choice.

Of the numerous other techniques investigated, several have been used with varying degrees of success for population control/management, but only rarely have they been used for total eradication purposes. The reason they have not been used is that, other than under very unique conditions (e.g., ability to completely drain a waterbody, very small waterbody), they have proven to be ineffective.

One effective alternative to rotenone that is sometimes used is the piscicide chemical antimycin. While effective, antimycin has significant limitations, largely because it is complicated to use and difficult to obtain in large quantities. In addition, one contact predicted that antimycin, which is currently going through the EPA pesticide re-registration process, may not be re-registered due to lack of adequate data on its use and potential impacts on human health and environmental safety standards. The same party recommended that, due to the difficulties associated with antimycin use, Maine should "Stay away from it."

As for rotenone, an abundance of information is available on its use and handling, including a comprehensive 2000 publication by the American Fisheries Society entitled *Rotenone Use in Management: Administrative and Technical Guidelines Manual*. Rotenone is also currently undergoing re-registration at EPA and is reported to be proceeding without any glitches as all data requirements have been met. Re-registration is to the point where EPA just needs to take final action; however, bureaucracies being what they are, an informed source's best guess estimate for actual re-registration is 2005-6.

The literature search and personal contacts have indicated that even rotenone, as effective as it is, does not guarantee eradication success. This fact, coupled with the cost of treatment, and the distinct potential for reintroductions of invasive species, has led some agencies to the discouraging conclusion that in many cases no form of reclamation, including rapid response, with the goal of eradication is worth the effort.

TABLE 2.B.1: SUMMARY OF RESPONSE TECHNIQUE OPTIONS AND ASSESSMENT OF VIABILITY

Method	Target Species	Type of water body	Expected Results	Duration of Control	Advantages	Limitations	References
1)Barriers • Structural • Electrical • Acoustic • Nets	General	Streams, Rivers, lakes, ponds	Population isolation	Permanent or semi-permanent installations	• Can protect a reclaimed area from re-colonization from adjoining water bodies • Can partition a watershed for management purposes • Limited impacts to aquatic community	• May impact migratory species by limiting movement in a watershed • Costly to construct and maintain • Not always 100% effective at containing or excluding target species (Harig et. al. 2000) • Can compromise watercraft passage on otherwise navigable waters, depending on morphometry/ physiography, and type of barrier used.	• Amaral et. al. 2001 • Barwick and Miller 1996 • Baxter et. al. 2002 • Coutant 2000 • Dunning et. al. 1992 • Feist and Anderson 1991 • Guilfoos 1995 • Hanson et. al. 1997 • Harig et. al. 2000 • Hilderbrand and Kershner 1999 • Johnson and Hoffman 2000 • Maceina et al 1999 • McCauley et. al. 1996 • Moy, Phil Pers. Comm. • Muth, Robert Pers. Comm. • Palmisano and Berger 1988 • Patrick et. al. 1985 • Rischbieter 2000 • San Luis… 1999 • Savino et. al. 2001 • Swink 1999 • Thompson and Rahel 1997 • Verrill and Berry 1995 • Weigmann et. al. 2003 • Smith-Root, Inc. • Hydroscreen

Method	Target Species	Type of water body	Expected Results	Duration of Control	Advantages	Limitations	References
2)Physical Removal: • Gill-Netting • Trap Netting • Electro-Shocking	Generally adult fish (or those of a minimum size class)	Small, shallow, isolated ponds, to small selected locations on larger water bodies	Population reduction to partial eradication	Several years to continuous	• Can target specific species or size classes • Can be implemented in some remote and inaccessible locations • Generally publicly acceptable	• Time / labor intensive • Limited by lake morphometry (netting) • Population may fill in once control efforts cease • Economically unsustainable as a reclamation technique • Outcome affected by several variables: such as population dynamics • Could impact non-target species (depending on method of removal) • May cause biomass and size-class shifts, depending on gear type and size-class selection (Beckman 1941, Grice 1958, Kinman 1983, Weidel 2003)	• Bayley and Austen 2002 • Beamesderfer and Nigro 1989 • Beamesderfer and Ward 1994 • Beamesderfer et. al. 1996 • Beckman 1941 • Coble 1988 • Grice 1958 • Hanson et. al. 1983 • Hill, Murray Pers. Comm. • Hoffarth and Conder 1967 • Horel and Huish 1960 • Jenkins 1956 • Kinman 1983 • Knapp and Matthews 1998 • Kulp and Moore 2000 • Meacham, Pam Pers. Comm. • Muth, Robert Pers. Comm. • Parker 1958 • Petersen 2002 • Rieman and Beamesderfer 1990 • Roberts and Tilzey 1996 • Thompson and Rahel 1996 • Ward 1999 • Weidel et. al. 2003
3)Regulations • "Must kill" laws • Bounty fishing	Generally sport fish species	Those open to fishing	Small population effect	Continuous	• More publicly acceptable than toxins • Less expensive than other measures • Has been successful in reducing predation, by northern pike, on salmonid species in the Columbia River (Friesen and Ward 1999, Oregon DFW)	• Difficult to police • Some people object to killing fish • Little resultant effect on target population • Selective to angler-targeted fish	• Beamesderfer et. al. 1996 • Coble 1988 • Friesen and Ward 1999 • Hill, Murray Pers. Comm. • Meacham, Pam Pers. Comm. • Paul et. al. 2002 • Petersen 2002 • Takata and Ward 2002 • Oregon Department of Fish and Wildlife, Columbia River Investigations

Method	Target Species	Type of water body	Expected Results	Duration of Control	Advantages	Limitations	References
4)Explosives	General (some species more sensitive than others)	Isolated areas within standing bodies of water	Localized ("spot") effect	Multiple treatments	• Inexpensive • Localized to a specific area	• Can harm non-target species (both flora and fauna) • Can damage adjacent properties / structures • Some species more resistant than others	• Bass and Hitt 1977 • Bayley and Austen 1988 • Burmester 2001 • Carlsen et. al. 2001 • CDFG 2002 • Copeland 1958 • Layer and Maughan 1984 • Metzger and Shafland 1986
5)Biological Controls	General	General	Shifts in population dynamics of the invasive species and its prey and/or competitors	Depends on control method	• Can be inexpensive • Possibility for long-term control of target species with little continuous effort after initial introduction	• Difficult to control or predict results • Can involve controversial introduction of non-native species • Can involve genetic manipulations, such as triploidy (Grewe 1997, Hinds and Pech 1997) that raise ethical concerns • Predator/prey controls often involve introductions of the species (such as northern pike, bass, muskellunge) that Maine is attempting to control/eliminate (Gammon and Hassler 1965, Irwin et. al. 2003, Powell 1973, Schmitz and Hetfeld 1965, Snowe 1968)	• Carlander 1958 • Carpenter et. al. 1995 • Charles 1957 • Gammon and Hassler 1965 • Goeman and Spencer 1992 • Grewe 1997 • Hinds and Pech 1997 • Irwin et. al. 2003 • Meacham, Pam Pers. Comm. • Panek 1978 • Powell 1973 • Schmitz and Hetfeld 1965 • Snowe 1968 • Wiley and Wydoski 1993

Method	Target Species	Type of water body	Expected Results	Duration of Control	Advantages	Limitations	References
6)Water Level Management • Drawdowns • Dewatering	General	Those that have mechanisms for water level control, or those that can be feasibly drained	Population control to nearly complete (<100%) eradication	Single to multiple drawdown or dewatering events	• Inexpensive • Dewatering is the only known method of "complete" reclamation / eradication without the use of toxins • Annual drawdown regimes can be implemented to affect specific habitats of some target species	• Raises public concern • Disrupts entire aquatic habitat within dewatered zone • Kills non-target flora and fauna • Very few ponds can be completely drained to accomplish eradication • Complete dewatering difficult – some pools may remain where fish can survive dewatering events • Drawdown regimes can incite public controversy	• Heman et. al. 1969 • Lantz et. al. 1967 • Lewis and Robinson 1968 • Maronek et. al. 1996 • Pierce et. al. 1965 • Ploskey 1986 • Rogers and Bergersen 1995 • Verrill and Berry 1995
7)Reverse Aeration (Experimental)	Game fish such as walleye	Small eutrophic or hypereutrophic ponds prone to winterkill, or near winterkill conditions	Partial eradication of game fish species	Single treatment to annual events	• Potential mode of eradication without use of toxins • Significantly less expensive than rotenone or antimycin	• Experimental in Minnesota: studies are not complete and are indicating that this is not going to be an effective method, except under very specific conditions • Little to no data exists on its use, effectiveness, and later results on the ecosystem	• Hirsche Pers. Comm. • Shroyer 2002 - 603 proposal 02.doc • Shroyer 2003 - 603prog03 • Shroyer, Steve Pers. Comm.
8)Chemical Reclamation: *Rotenone*	General (toxic to all fish with some variation by species)	Small lakes, ponds, and flowing waters. Spot treatments in larger water bodies.	Nearly complete (<100%) eradication	Multiple treatments	• Most widely publicly accepted method for total reclamation • Extensive available data on usage, impacts, toxicity, etc. • Extensive data on case studies and historical applications • Considered safe for humans and non-aquatic fauna in areas of application. • Degrades (detoxifies) relatively quickly, and can be neutralized. • No residual effects after breakdown • Possible oral bait (poisoned food items) in development to target specific species (Gehrke 1997) • Some fish can be revived if collected immediately upon	• Use of toxins raises public concern • Kills all fish in treated area, not just target species • Can kill other aquatic fauna (Chandler and Marking, 1982, Fontenot et. al. 1994) • Can repel some fish species, which may possibly enable escape (Dawson et. al. 1998, Hogue 1999) • Expensive, particularly for large applications	• Archer, 2001 • Bandow 1980 • Baxter 1987 • Bayley and Austen 1988 • Bomford and O'Brien 1995 • Boogaard et. al. 1996 • Cailteux et. al. 2001 • CDFG 1994 • Chadderton et. al. 2001 • Chandler and Marking 1982 • Connel et. al. 2002 • Cook and Moore 1969 • Dawson et. al. 1991 • Dawson et. al. 1998 • Demong 2001 • Demong, Leo Pers. Comm. • Engstrom-Heg and Colesante 1979 • Fajt and Grizzle 1993

Method	Target Species	Type of water body	Expected Results	Duration of Control	Advantages	Limitations	References
					treatment (Chadderton et. al. 2001) • Available in liquid and powdered formulations: powdered formulation avoids additional ingredients (including aromatic petroleum solvents) required for liquid formulation. • Low mobility in soils		• Finlayson et. al. 2000 • Finlayson et. al. 2001 • Finlayson, Brian Pers. Comms. • Fontenot et. al. 1994 • Foye 1956 • Gehrke 2001 • Gilderhus 1972 • Gilderhus and Dawson 1986 • Gilderhus and Dawson 1988a • Gilderhus and Dawson 1988b • Hill, Murray Pers. Comm. • Hogue 1999 • Holden 1991 • Keller 2003 • Laarman 1979 • Lennon et. al. 1970 • Ling 2003 • Lintermans and Raadik 2001 • Marking 1988 • Marking 1992 • Maronek et. al. 1996 • McClay 2000 • Meacham, Pam Pers. Comm. • Meadows 1973 • Morrison 1977 • Roberts and Tilzey 1996 • Rotenone Stewardship Program 2001 • Schnick 1974 • Sousa et. al. 1987 • Tate et. al. 2003 • Thompson et. al. 2001 • Tompkins and Mullen 1958 • Washington DFW 2002a • Washington DFW 2002b • Whelan 2002

Method	Target Species	Type of water body	Expected Results	Duration of Control	Advantages	Limitations	References
9)Chemical Reclamation: *Antimycin*	General (toxic to all fish with broader range of species sensitivity than rotenone)	Small streams, shallow ponds, alpine lakes, remote areas	Nearly complete (<100%) eradication	Multiple treatments	• Rapid breakdown (hours) especially in direct sunlight or moving waters • No residual effects after breakdown • Little or no impact on aquatic fauna other than fish • Due to differing sensitivities, scaled fish may be removed while sparing bullhead and catfish species • Greater toxicity than rotenone; can be used in smaller amounts	• Complex to use • Difficult to get in large quantities • More expensive than rotenone • Less recent / extensive data than rotenone on impacts, effects, toxicity, etc. • Neutralizes in streams with high gradients • Organic matter reduces toxicity • Toxicity decreases with increasing pH, and decreasing temperature (ineffective at or above Ph 9.0, and at or below 5º C)	• Boogaard et. al. 1996 • Burress 1971 • Davis 1979 • Dawson et. al. 1998 • Demong, Leo Pers. Comm. • Derse and Strong 1963 • Finlayson et. al. 2002 • Finlayson, Brian Pers. Comms. • Gilderhus 1972 • Gresswell 1991 • Houf and Campbell 1977 • Jacobi and Degan 1977 • Lee et. al. 1971 • Marking 1975 • Marking 1992 • Minckley and Mihalick 1981 • Rach et. al. 1994 • Roberts and Tilzey 1997 • Tiffan and Bergersen 1996

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	Barrier	Removal	Regs	Explosives	Biol Cont	Water level	Rev Aer
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DeMong, Leo. Fisheries Biologist. NY Department of Environmental Conservation, Raybrook, NY							
Finlayson, Brian. Fisheries Biologist, Rotenone and Antimycin Expert. California Department of Fish and Game, Pesticide Investigations Unit, Rancho Cordova, CA							
Good, Shawn. Fisheries Biologist. Vermont Agency of Natural Resources, Fish and Wildlife Division. Pittsford, VT							
Hill, Murray. Director of Inland Fisheries, Pictou, Nova Scotia, Canada		X	X				
Hirsche, Steve. Minnesota DNR, Division of Fish and Wildlife, Section of Fisheries							
Horns, Bill. Great Lakes Fisheris Specialist, Wisconsin Department of Natural Resources, Madison, WI							
Meacham, Pam. ANS Program Coordinator, Washington Department of Fish and Wildlife, WA		X	X		X		
Moy, Phil. Fisheries and Non-indigenous Species Specialist, University of Wisconsin Sea Grant Institute, Manitouoc, WI	X						
Muth, Robert. Director of Upper Colorado River Endangered Fish Recovery Program, USFWS, Denver, CO	X	X					
Palmer, Eric. Director of Fisheries. Vermont Fish and Wildlife Department, Waterbury, VT							
Propst, David. New Mexico Department of Game and Fish							
Shroyer, Steve. Fisheries Research Biologist. Department of Natural Resources, Minnesota							X

*
1: Barriers: Including electric, air-bubble, sonic, barrel, and various other types of exclusion and/or containment barriers
2: Removal: Including netting, electrofishing, angling, and various other techniques for target species removal
3: Regulations: Use of fishing regulations to deplete a target species
4: Explosives: Use of explosives for spot eradication and population depletion

References	Subject *						
	1	2	3	4	5	6	7
	Barrier	Removal	Regs	Explosives	Biol Cont	Water level	Rev Aer
5: Biological Control: Including predator introductions, genetically altered introductions, and other techniques of biological control							
6: Water Level: Including drawdowns for management to dewatering for reclamation							
7: Rev Aer: Experimental studies using "reverse aeration" to reclaim small, eutrophic ponds							
8: Rotenone: Use of the chemical rotenone to perform eradication/reclamation							
9: Antimycin: Use of chemical antimycin for selective eradication/reclamation							
10: General: References that address several management techniques							

Revised: June 28, 2004

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1: Barriers: Including electric, air-bubble, sonic, barrel, and various other types of exclusion and/or containment barriers

2: Removal: Including netting, electrofishing, angling, and various other techniques for target species removal

3: Regulations: Use of fishing regulations to deplete a target species

4: Explosives: Use of explosives for spot eradication and population depletion

5: Biological Control: Including predator introductions, genetically altered introductions, and other techniques of biological control

6: Water Level: Including drawdowns for management to dewatering for reclamation

7: Rev Aer: Experimental studies using "reverse aeration" to reclaim small, eutrophic ponds

8: Rotenone: Use of the chemical rotenone to perform eradication/reclamation

9: Antimycin: Use of chemical antimycin for selective eradication/reclamation

10: General: References that address several management techniques

Revised: June 28, 2004