ANALYSIS OF THE EFFICACY AND ECOLOGICAL EFFECTS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROJECT IN CLEAR LAKE, CALIFORNIA

Project Information

1. **Proposal Title:**

   ANALYSIS OF THE EFFICACY AND ECOLOGICAL EFFECTS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROJECT IN CLEAR LAKE, CALIFORNIA

2. **Proposal applicants:**

   Nathan Dechoretz, California Department of Food and Agriculture
   J Robert Leavitt, California Department of Food and Agriculture
   Patrick Akers, California Department of Food and Agriculture
   Steve Schoenig, California Department of Food and Agriculture

3. **Corresponding Contact Person:**

   Robert Leavitt
   California Department of Food and Agriculture
   CDFA-Integrated Pest Control Branch 1220 'N' Street, Room A-357 Sacramento, CA 95814
   916 654-0768
   rleavitt@cdfa.ca.gov

4. **Project Keywords:**

   Aquatic Ecology
   Nonnative Invasive Species
   Pesticides

5. **Type of project:**

   Monitoring

6. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

7. **Topic Area**:

   Non-Native Invasive Species

8. **Type of applicant:**

State Agency

9. **Location - GIS coordinates:**

Latitude:	39.027
Longitude:	-122.771
Datum:	NAD 27

Describe project location using information such as water bodies, river miles, road intersections, landmarks, and size in acres.

Clear Lake, California

10. **Location - Ecozone:**

10.1 Cache Creek, Code 16: Inside ERP Geographic Scope, but outside ERP Ecozones

11. **Location - County:**

Lake

12. **Location - City:**

Does your project fall within a city jurisdiction?

No

13. **Location - Tribal Lands:**

Does your project fall on or adjacent to tribal lands?

Yes **If yes, please list the tribal lands:** Big Valley Rancheria, Robinson Rancheria,

14. **Location - Congressional District:**

California 1st

15. **Location:**

California State Senate District Number: 02

California Assembly District Number: 01

16. **How many years of funding are you requesting?**

3

17. **Requested Funds:**
    a) Are your overhead rates different depending on whether funds are state or federal?

No

If no, list single overhead rate and total requested funds:

Single Overhead Rate: 21.19

Total Requested Funds: 2323827.18

b) Do you have cost share partners already identified?

No

c) Do you have potential cost share partners?

No

d) Are you specifically seeking non-federal cost share funds through this solicitation?

No

If the total non-federal cost share funds requested above does not match the total state funds requested in 17a, please explain the difference:

18. **Is this proposal for next-phase funding of an ongoing project funded by CALFED?**

No

Have you previously received funding from CALFED for other projects not listed above?

Yes

If yes, identify project number(s), title(s) and CALFED program.

ERP-99-F08	**Purple Loosestrife Prevention, Detection & Control in the Sac/SJ Delta & Associated Hydrologic Units**	**Non-native Invasive Species**

19. **Is this proposal for next-phase funding of an ongoing project funded by CVPIA?**

No

Have you previously received funding from CVPIA for other projects not listed above?

No

20. **Is this proposal for next-phase funding of an ongoing project funded by an entity other than CALFED or CVPIA?**

No

Please list suggested reviewers for your proposal. (optional)

Pat Thalken	**Ca. Dept. of Boating and Waterways**	**916-263-8141**	**pthalken@dbw.ca.gov**

Mark Sytsma **Portland State Univ.** **503-725-3833** **sytsmam@pdx.edu**

Jeff Janek **Ca. Dept. of Water Resources**

Stuart Perry **Perry Lake Management** **209-467-4123**

21. **Comments:**

Environmental Compliance Checklist

ANALYSIS OF THE EFFICACY AND ECOLOGICAL EFFECTS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROJECT IN CLEAR LAKE, CALIFORNIA

1. **CEQA or NEPA Compliance**
   a) Will this project require compliance with CEQA?

      No

   b) Will this project require compliance with NEPA?

      No

   c) If neither CEQA or NEPA compliance is required, please explain why compliance is not required for the actions in this proposal.

      This proposal is for a research project to evaluate and monitor the California Department of Food and Agriculture Clear Lake Hydrilla Eradication Project. The actual herbicide applications done in the Clear Lake Hydrilla Eradication Project are not a part of this proposal. This proposal includes environmental monitoring activites but does not involve actual environmental intervention.

2. **If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).** *If not applicable, put "None".*

   <u>CEQA Lead Agency:</u>
   <u>NEPA Lead Agency (or co-lead:)</u>
   <u>NEPA Co-Lead Agency (if applicable):</u>

3. **Please check which type of CEQA/NEPA documentation is anticipated.**

   CEQA
   -Categorical Exemption
   -Negative Declaration or Mitigated Negative Declaration
   -EIR
   Xnone

   NEPA
   -Categorical Exclusion
   -Environmental Assessment/FONSI
   -EIS
   Xnone

   If you anticipate relying on either the Categorical Exemption or Categorical Exclusion for this project, please specifically identify the exemption and/or exclusion that you believe covers this project.

4. **CEQA/NEPA Process**
   a) Is the CEQA/NEPA process complete?

None

b) If the CEQA/NEPA document has been completed, please list document name(s):

5. **Environmental Permitting and Approvals** (*If a permit is not required, leave both Required? and Obtained? check boxes blank.*)

LOCAL PERMITS AND APPROVALS

Conditional use permit

Variance

Subdivision Map Act

Grading Permit

General Plan Amendment

Specific Plan Approval

Rezone

Williamson Act Contract Cancellation

Other

STATE PERMITS AND APPROVALS

Scientific Collecting Permit

CESA Compliance: 2081

CESA Compliance: NCCP

1601/03

CWA 401 certification

Coastal Development Permit

Reclamation Board Approval

Notification of DPC or BCDC

Other

FEDERAL PERMITS AND APPROVALS

ESA Compliance Section 7 Consultation

ESA Compliance Section 10 Permit

Rivers and Harbors Act

CWA 404

Other

PERMISSION TO ACCESS PROPERTY

Permission to access city, county or other local agency land.
Agency Name:

Permission to access state land.
Agency Name:

Permission to access federal land.
Agency Name:

Permission to access private land.
Landowner Name:

6. **Comments.**

Land Use Checklist

ANALYSIS OF THE EFFICACY AND ECOLOGICAL EFFECTS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROJECT IN CLEAR LAKE, CALIFORNIA

1. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

2. **Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?**

   Yes

3. **Do the actions in the proposal involve physical changes in the land use?**

   No

   If you answered no to #3, explain what type of actions are involved in the proposal (i.e., research only, planning only).

   This is a research proposal to evaluate and monitor an on-going activity, the California Department of Food and Agriculture Clear Lake Hydrilla Eradication Project. No land aquisition in involved in either the Clear Lake Hydrilla Eradication Project or in the evaluation and monitoring activities.

4. **Comments.**

Conflict of Interest Checklist

ANALYSIS OF THE EFFICACY AND ECOLOGICAL EFFECTS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROJECT IN CLEAR LAKE, CALIFORNIA

Please list below the full names and organizations of all individuals in the following categories:

- Applicants listed in the proposal who wrote the proposal, will be performing the tasks listed in the proposal or who will benefit financially if the proposal is funded.
- Subcontractors listed in the proposal who will perform some tasks listed in the proposal and will benefit financially if the proposal is funded.
- Individuals not listed in the proposal who helped with proposal development, for example by reviewing drafts, or by providing critical suggestions or ideas contained within the proposal.

The information provided on this form will be used to select appropriate and unbiased reviewers for your proposal.

Applicant(s):

Nathan Dechoretz, California Department of Food and Agriculture
J Robert Leavitt, California Department of Food and Agriculture
Patrick Akers, California Department of Food and Agriculture
Steve Schoenig, California Department of Food and Agriculture

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

If yes, please list the name(s) and organization(s):

Lars Anderson	USDA-ARS Exotic and Invasive Weed Research Lab
Mike Schaver	Big Valley Rancheria
David Spencer	USDA-ARS Exotic and Invasive Weed Research Lab
Joel Trumbo	California Dept. of Fish and Game
Mark Lockhart	Lake County Agricultural Commissioner

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

If yes, please list the name(s) and organization(s):

Lars Anderson **USDA-ARS Exotic and Invasive Weed Research Lab**

Mark Lockhart **Lake County Agricultural Commissioner**

Mike Schaver **Big Valley Rancheria**

Joel Trumbo **California Dept. of Fish and Game**

David Spencer **USDA-ARS Exotic and Invasive Weed Research Lab**

Mary-Ann Warmerdam **Yolo County Flood Control and Water Conservation District**

Comments:

Budget Summary

ANALYSIS OF THE EFFICACY AND ECOLOGICAL EFFECTS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROJECT IN CLEAR LAKE, CALIFORNIA

Please provide a detailed budget for each year of requested funds, indicating on the form whether the indirect costs are based on the Federal overhead rate, State overhead rate, or are independent of fund source.

Independent of Fund Source

Year 1												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary** *(per year)*	**Benefits** *(per year)*	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	Conduct initial survey of Clear Lake Region and establish study parameters, Proposal 1	1548	32031.56	8500.34	8000	5000	0	5000	0	58531.9	12402.91	70934.81
2	Conduct extensive literature review, Proposal 1	1118	19541.78	4628.51	500	1000	0	0	0	25670.29	5439.53	31109.82
3	Preliminary diver study, Proposal 2	1032	17789.96	4085.45	8000	0	25000	15000	1000	70875.41	15018.50	85893.91
4	Preliminary maps and statistics, Proposal 2	172	5368.98	1664.38	0	5000	0	0	0	12033.36	2549.87	14583.23
5	Long term fluidone monitoring study started, Proposal 3	1204	22537.16	5557.08	8000	5000	25000	15000	1000	82094.24	17395.77	99490.01
6	Preliminary lab/greenhouse hydrilla growth req./fluridone studies, Proposal 3	172	5368.98	1664.38	250	0	50000	0	0	57283.36	12138.34	69421.70
7	Preliminary water column/hydroil study done, Proposal 3	172	5368.98	1664.38	250	0	25000	10000	0	42283.36	8959.84	51243.20
8	Baseline monitoring of aquatic plants, fish, birds, invertebrates, establish permanent transects, Proposal 4	1290	23418.66	5651.66	8000	5000	50000	10000	1000	103070.32	21840.60	124910.92

9	Fluridone hydrosoil samples and monitoring, Proposal 4	1290	23418.66	5651.66	2000	5000	25000	10000	100	71170.32	15080.99	86251.31
10	Preliminary lab/greenhouse studies on aquatic life response to fluridone, Proposal 4	258	8364.36	2592.95	250	0	50000	0	0	61207.31	12969.83	74177.14
11	Interim reports, all proposals	172	5368.98	1664.38	0	2500	0	0	0	9533.36	2020.12	11553.48
12	Economic analysis started, Proposal 1	258	8364.36	2592.95	0	0	10000	5000	0	25957.31	5500.35	31457.66
		8686	176942.42	45918.12	35250.00	28500.00	260000.00	70000.00	3100.00	619710.54	131316.65	751027.19

Year 2

Task No.	Task Description	Direct Labor Hours	Salary *(per year)*	Benefits *(per year)*	Travel	Supplies & Expendables	Services or Consultants	Equipment	Other Direct Costs	Total Direct Costs	Indirect Costs	Total Cost
1	On site study, water samples, depths, etc data collected, Proposal 1	2580	46837.32	11303.33	8000	1000	9000	15000	1000	92140.65	19524.60	111665.25
2	Research Studies conducted on hydrilla growth paratmeters, Proposal 1	258	8364.36	2592.95	250	0	35000	0	0	46207.31	9791.33	55998.64
3	Economic analysis, year 2	258	8364.36	2592.95	250	0	10000	5000	0	26207.31	5553.33	31760.64
4	First year of diver study, Proposal 2	1204	22537.16	5557.08	13000	0	100000	20000	1000	162094.24	34347.77	196442.01
5	First year maps and statistics, Proposal 2	172	5368.98	1664.38	0	5000	0	0	0	12033.36	2549.87	14583.23
6	Continued long term monitoring study, Proposal 3	1204	22537.16	5557.08	8000	1000	25000	0	1000	63094.24	13369.67	76463.91

7	Conduct fluridone-hydrilla dose response study, Proposal 3	172	5368.98	1664.38	250	0	35000	0	0	42283.36	8959.84	51243.20
8	Conduct fluridone water column study, proposal 3	172	5368.98	1664.38	250	0	35000	0	0	42283.36	8959.84	51243.20
9	Monitoring for aquatic plants, fish, birds, invertebrates vs. management unit, cont'd, Proposal 4	1290	23418.66	5651.66	8000	2000	50000	0	1000	90070.32	19085.90	109156.22
10	Continue to monitor fluridone concn. in hydrosoil, Proposal 4	1290	23418.66	5651.66	8000	1000	25000	0	1000	64070.32	13576.50	77646.82
11	Full scale lab/greenhouse testing of dose respone curves to fluridone in hydrosoil, Proposal 4	172	5368.98	1664.38	250	0	35000	0	0	42283.36	8959.84	51243.20
12	Interim Reports, all proposals	172	5368.98	1664.38	0	2500	0	0	0	9533.36	2020.12	11553.48
		8944	182322.58	47228.61	46250.00	12500.00	359000.00	40000.00	5000.00	692301.19	146698.61	838999.80

Year 3												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary** ***(per year)***	**Benefits** ***(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	Field research study completed, Proposal 1	2408	40846.56	9446.19	8000	5000	0	0	1000	64292.75	13623.63	77916.38

2	Economic study completed, maps generated showing probablility of hydrilla in each study zone and probable economic and ecological cost of same, Proposal 1	520	8935.98	2047.12	0	1000	10000	0	0	21983.1	4658.22	26641.32
3	Write and publish final report, Proposal 1	172	5368.98	1664.38	0	15000	0	0	0	22033.36	4668.87	26702.23
4	Second year diving study, Proposal 2	1204	22537.16	5557.08	8000	0	100000	0	1000	137094.24	29050.27	166144.51
5	Second year maps and statistics, Proposal 2	172	5368.98	1664.38	0	2000	0	0	0	9033.36	1914.17	10947.53
6	Final report written and published, Proposal 2	172	5368.98	1664.38	0	15000	0	0	0	22033.36	4668.87	26702.23
7	Complete long term fluridone monitoring study, Proposal 3	1204	22537.16	5557.08	8000	500	25000	0	1000	62594.24	13263.72	75857.96
8	Complete all map making and statistical analysis, Proposal 3	606	11931.36	2975.69	0	2000	0	0	0	16907.05	3582.60	20489.65
9	Write and publish final report, Proposal 3	172	5368.98	1664.38	0	15000	0	0	0	22033.36	4668.87	26702.23

10	Complete monitoring of aquatic life in managment units, Proposal 4	1290	23418.66	5651.66	8000	2000	50000	0	1000	90070.32	19085.90	109156.22
11	Complete fluridone hydrosoil monitoring study, Proposal 4	1290	23418.66	5651.66	8000	1000	25000	0	1000	64070.32	13576.50	77646.82
12	Repeat lab/greenhouse studies on aquatic life vs. fluridone in hydrosoil, Proposal 4	172	5368.98	1664.38	250	0	35000	0	0	42283.36	8959.84	51243.20
13	Complete maps and statistics for Proposal 4 studies	172	5368.98	1664.38	0	2000	0	0	0	9033.36	1914.17	10947.53
14	Write and publish final report for Proposal 4	172	5368.98	1664.38	0	15000	0	0	0	22033.36	4668.87	26702.23
		9726	191208.40	48537.14	40250.00	75500.00	245000.00	0.00	5000.00	605495.54	128304.50	733800.04

Grand Total=2323827.03

Comments.

The total budget for Proposal 1 is $469,963.52 The total budget for Proposal 2 is $521,073.39 The total budget for Proposal 3 is $527,931.94 The total budget for Proposal 4 is $804,858.43

Budget Justification

ANALYSIS OF THE EFFICACY AND ECOLOGICAL EFFECTS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROJECT IN CLEAR LAKE, CALIFORNIA

Direct Labor Hours. Provide estimated hours proposed for each individual.

6.7 seasonal workers (each 9 months max) = 13940 hours (3 years) 1 Assoc. Agricultural Biologist = 6192 hours (3 years) 0.33 Assoc. Agricultural Biologist = 2064 hours (3 years) 1 Senior Environmental Res. Scientist = 2064 (in 3 years) 1 Senior Environmental Res. Scientist = 1032 (in 3 years) 1 Senior Biologist/Statistician = 1032 (in 3 years) 1 Senior Biologist/Mapmaker = 1032 (in 3 years)

Salary. Provide estimated rate of compensation proposed for each individual.

Seasonal $10.25/hr Assoc. level $27.60/hr Senior level $34.83/hr

Benefits. Provide the overall benefit rate applicable to each category of employee proposed in the project.

Ssasonal 10.73% Assoc. and Senior levels 31%

Travel. Provide purpose and estimate costs for all non-local travel.

Vehicles, lease: 3 heavy duty trucks for 3 years = $30,000 Scientific Meetings: 4 Seniors per year for 3 years = $24,000

Supplies & Expendables. Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.

Supplies and expendables include sample tubes, sampling equipment, cold boxes for storage and transport of samples, all paper and notebooks for documentation, server time for electonic storage of data, fuel for boats, repair to boats, bouys for transects, copy costs for data sheets, filing cabinets for hard copies of data, etc.

Services or Consultants. Identify the specific tasks for which these services would be used. Estimate amount of time required and the hourly or daily rate.

Diving 1125 hrs @ $200/hr Soil and water chemistry analysis 620 samples @ $200/sample Soil/water fluridone analysis 310 samples @ $200/sample Fish counts $10,000/yr for 3 yrs = $30,000 Bird counts $10,000/yr for 3 yrs = $30,000 Soil invertebrate analysis 100 samples @ $200/sample Soil fluridone toxicity samples/tests 50 samples @ $800 each Establish transects $30,000 Lab/greenhouse studies of hydrilla growth parameters $125,000 Lab/greenhouse studies of hydrilla dose response to fluridone in hydrosoil $150,000 Economist consulting 100 hrs @ $150/hr Statistician consulting 50 hrs @ $150/hr

Equipment. Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items.

Computers, 2 @ $5000 each GIS units, 2 @ $5000 each Data loggers and water quality monitors, 3 @ $5000 each Airboats, 2 @ $30,000 each fish boat, 1 @ $20,000

Project Management. Describe the specific costs associated with insuring accomplishment of a specific project, such as inspection of work in progress, validation of costs, report preparation, giving presentatons, reponse to project specific questions and necessary costs directly associated with specific project oversight.

Local oversight by Lake County Ag Commisioner, 3 yrs @ $2500/yr Interim reports publication costs, 2 @ $2500 each Final reports publication costs, 4 @ $15,000 each

Other Direct Costs. Provide any other direct costs not already covered.

Local warehouse and office space, 3 yrs @ $2000/yr

Indirect Costs. Explain what is encompassed in the overhead rate (indirect costs). Overhead should include costs associated with general office requirements such as rent, phones, furniture, general office staff, etc., generally distributed by a predetermined percentage (or surcharge) of specific costs.

Indirect costs include all of the above mentioned, all cost needed in operating a state program, general office requirements, administration, contracting, etc. Note: The Department submits a proposal/memo each year to determine what overhead needs are --- a set rate is determined/set each year for all agencies. All forms can be filled out as requested.

Executive Summary

ANALYSIS OF THE EFFICACY AND ECOLOGICAL EFFECTS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROJECT IN CLEAR LAKE, CALIFORNIA

Hydrilla (Hydrilla verticillata) is a noxious weed under active eradication by the California Department of Food and Agriculture (CDFA). The CDFA Hydrilla Eradication Program consists of four components: survey and detection of hydrilla in the waters of the State, exclusion, quarantine, and control. Control methods are mechanical, cultural, biological, or chemical. Hydrilla has been under eradication in Clear Lake since it was detected in 1994. Survey is by boat, using visual detection of plants and mats, and grappling hooks to detect plants growing on the lake bottom. Control is primarily chemical, using copper and fluridone herbicides. Monitoring of the efficacy, water quality impacts, and ecological impacts of the CDFA Hydrilla Eradication Program is identified as a Multi-Regional Priority in the CALFED Draft I implementation publication. Basic studies are needed 1). as to the ecological and economic impact of hydrilla in Clear Lake and the Clear Lake region should it be allowed to grow unchecked, 2). to evaluate and improve the efficacy of the Clear Lake Hydrilla Eradication Program's survey and treatment protocols, 3). determine the actual concentrations of fluridone herbicide the Program is maintaining in the hydrosoil and boundary layer in which hydrilla plants germinate, and 4). the long-term impacts of the Program on aquatic plant, fish, bird and invertebrate populations and species diversity, and long-term dissipation of fluridone in the hydrosoil. The potential ecological and economic impact of hydrilla in Clear Lake and surrounding region would be estimated by locating and studying the chemical and physical parameters of Clear Lake itself and the water bodies within a 10 mile radius. A projection would be made as to the potential for each body to support hydrilla growth. The economic impacts of the spread of hydrilla, based on the above, would be quantified. The efficacy of the Clear Lake Hydrilla Program would be studied by analyzing the effectiveness of the current protocol used for hydrilla detection by sending divers down into the lake to obtain exact counts of hydrilla infestations and sizes. This data would be compared to that given by the current protocol. This data and analysis will also be used to help design improved survey and treatment protocols. The Clear Lake Hydrilla Eradication Program has been successful in reducing the populations of hydrilla from numerous, dense mats to just two dozen plants this year. However, a better understanding of the concentrations of fluridone in the hydrosoil, in the boundary layer, and in the water column could be used to improve the current treatment protocol. The Clear Lake Hydrilla Eradication Program has been treating large areas of the lake with copper and fluridone herbicides since 1994. It is anticipated that the long-term effects of these applications on aquatic plant, fish, bird, and invertebrate populations and species diversity will be minor, but studies specifc to Clear Lake are lacking. Several areas in Clear Lake will be released next year from active treatment. These units can be monitored as to changes in aquatic plant, fish, bird, and invertebrate populations and species. These populations will also be compared to similar populations in units of the lake which have never been a part of the Hydrilla Eradication Program (controls). In addition, the fluridone dissipation in the hydrosoil will be monitored as units are released from active treatment.

Proposal

California Department of Food and Agriculture

ANALYSIS OF THE EFFICACY AND ECOLOGICAL EFFECTS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROJECT IN CLEAR LAKE, CALIFORNIA

Nathan Dechoretz, California Department of Food and Agriculture
J Robert Leavitt, California Department of Food and Agriculture
Patrick Akers, California Department of Food and Agriculture
Steve Schoenig, California Department of Food and Agriculture

Title

ANALYSIS OF THE EFFICACY AND ECOLOGICAL EFFECTS OF THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROJECT IN CLEAR LAKE, CALIFORNIA.

Introduction and Background Information

Hydrilla (*Hydrilla verticillata* (L.f.) Royle) is a submersed aquatic plant that spreads locally by way of stolons creating large mats of vegetation (Madsen J.D. and D.H. Smith 1999). Once hydrilla enters an accommodating aquatic ecosystem it quickly out competes all other native and introduced aquatic vegetation, creating a monoculture. Because of the stolons, hydrilla monocultures produce immense mats of vegetation, which can fill an entire water column up to 35 feet deep. These mats can impede the flow of water in canals and laterals up to 90%; interfere with, block, and damage water diversion and control structures; impede boat and ship travel; hinder or stop hydroelectric turbines; reduce fish and bird populations; and endanger human health by increasing the risk of drowning and increase standing water which serves as breeding grounds for mosquitoes. (California Department of Food and Agriculture 2000; California Department of Food and Agriculture 2001; California Department of Food and Agriculture, Hydrilla, Egeria, and Elodea).

Hydrilla can occur in two biotypes, monoecious and a dioecious. The dioecious biotype, besides having male and female flowers on the separate plants, is more robust and has a more upright growth habit. Dioecious hydrilla tends to grow upright toward the water surface beginning in the spring, after germination. Upon reaching near the top of the water column, it can branch out forming large mats. The monoecious biotype tends to form low mats just above the hydrosoil in the spring before growing upright. The monoecious biotype also tends to be more fragile than the dioecious biotype, and therefore more prone to fragmentation. Both biotypes occur in California. Both types result in large, dense thick growths and mats if left uncontrolled. (Langeland, K.A. 1996).

Hydrilla can grow in freshwater and somewhat brackish water (7% salinity). It can grow in both low nutrient and high nutrient conditions. Hydrilla is somewhat winter hardy, and its optimum growth temperature is 20 to 27 degrees centigrade. (Center for Aquatic and Invasive Plants, Hydrilla verticillata). These parameters seem ideal for hydrilla growth in the Sacramento Delta, though a formal study quantifying the risk of hydrilla damage to the Sacramento Delta or its watersheds, such as Clear Lake, has never been done.

Hydrilla can spread over long distances by way of three kinds of reproductive structures: tubers (below ground swollen stems), turions (above ground swollen apical buds), and plant fragments (as small as one inch in length). In Florida, it is estimated that hydrilla tubers can lie dormant in the hydrosoil for as long as seven years (Florida Department of Environmental Protection 2001). In California, turions sprout in the spring, about 30 days before tubers (Spencer D.F. and G.G. Ksander 2001). These reproductive structures can move in flowing water, but the primary long distance transport agent is man. Hydrilla fragments can be transported on infested boats, boat trailers (and associated vehicles), shoes, clothing, etc. They can also be transported by moving infested hydrosoil used for construction of dams, culverts, etc. Hydrilla can also be spread through infested aquariums, water gardens, and associated plants. In fact, it is presumed that hydrilla was introduced into California through the aquarium and water garden trade.

Because it is believed that hydrilla would cause unacceptable ecological and economic losses to the state of California if it were allowed to spread in the State, hydrilla has been classified by the California Department of Food and Agriculture (CDFA) as a noxious weed. CDFA has also been mandated, by statute, to eradicate hydrilla wherever it is found in the State. The two relevant sections of the California Food and Agriculture Code are:

> "Section 6048. (a) The plant Hydrilla (Hydrilla verticillata) is a noxious aquatic weed not native to the State of California. The Legislature hereby declares that the further introduction and spread of this serious aquatic weed pest would be detrimental to the state, causing irreparable damage to the agricultural industry and recreational use of streams, lakes, and waterways and further that the eradication of this aquatic weed pest is essential to the preservation of the environment.
> (c)The director shall conduct an ongoing survey and detection program for hydrilla. Whenever and wherever hydrilla is discovered, the director shall immediately investigate the feasibility of eradication. If eradication is feasible, the director shall perform the eradication in cooperation with federal, city, county, and other state agencies taking those steps and actions the director deems necessary."
>
> "Section 403. The Department shall prevent the introduction and spread of injurious insect or animal pests, plant diseases, and noxious weeds."

In order to implement these mandates, CDFA has established the Hydrilla Eradication Program, which is conducted in coordination with the California County Agricultural Commissioners. The Hydrilla Eradication Program has the following goals and objectives:

> "<u>Program Roles and Missions</u>
> 1. Keeping California's aquatic resources free from the establishment of hydrilla through an effective and aggressive detection and eradication program.
> 2. Promote and support research on effective methods of controlling hydrilla.

> 3. Provide training, technical assistance and specialized services to counties, cities, etcetera, involved in the control or eradication of hydrilla" (Program Statement 2000 Season Hydrilla Program).

These eradication projects have four broad components: exclusion, survey (detection), quarantine, and control (eradication).

Once hydrilla is found in any water body in the state, the entire water body is surveyed for hydrilla by professional CDFA personnel. All water bodies within a reasonable proximity (upstream, downstream, within flight distance of vegetation eating waterfowl and including high recreational use lakes) are also regularly surveyed by the same personnel. Many non-infested water bodies, such as the Sacramento Delta, are also regularly surveyed by CDFA. Surveys are also made of garden and pet stores in the area to determine if hydrilla have infested aquariums and water gardens. In addition, many hydrilla finds have been made by the public and reported to CDFA. CDFA personnel also train public and private water resource professionals in identifying hydrilla and reporting procedures. Positive identification of plant samples is made by the CDFA Plant Taxonomist at the CDFA Plant Pest Diagnostic Laboratory. This proposal specifically focuses on the survey techniques used in the Clear Lake Hydrilla Eradication Program (described below).

After hydrilla has been positively identified in a water body, exclusion and quarantine procedures are established to prevent transport to other water bodies. Boats, trailers, and other vehicles are screened by hydrilla at the California Border Stations. Signs, brochures, and other literature are produced and distributed to educate the public to identify hydrilla and report it if located. Quarantine procedures can include physical barriers (screens) and legal restrictions on water use. Quarantines can be total (no water use) to partial (restricted water use, proscriptions as to cleaning propellers, boats, clothing, etc.). Quarantines also include legal prohibitions of sale or trade of hydrilla in the state for any purpose, including the aquarium trade. Quarantines are imposed by the local County Agricultural Commissioners, in consultation with CDFA.

Once hydrilla is located, control programs are immediately started. Experience has shown that hydrilla can be eradicated from an infested water body with a concerted and dedicated effort using various control measures. Control measures which have been used successfully include diving and dredging (mechanical control), drawdown and draining of lakes and ponds (cultural control), use of triploid (sterile) grass carp in canals gated at both ends (biological control), and treatment with herbicides such as metam-sodium, copper, and fluridone.

Using surveys, quarantines, and control programs, CDFA has been effective in eradicating hydrilla from various ponds, lakes, and streams in 13 California counties (CDFA Hydrilla Program Annual Progress Report).

The Clear Lake environment presents some special problems for hydrilla eradication. Clear Lake is the largest natural fresh water body completely located in the state of California. It covers approximately 43,000 surface acres and is in depth to only about 20 feet. Its deepest point, not counting several pits and fumaroles, is about 31 feet. Clear Lake is used for transportation, tourism, and fishing. The water (above a given elevation referred to as zero Rumsey) is used for irrigation in Lake and Yolo Counties. Clear Lake also floods in high rainfall years. The lake waters are highly turbid and algal blooms (blue-green algae) are frequent. For these reasons, visibility is often very limited. This makes the use of divers and dredges as a primary control methodology problematic. Drawdown and/or drainage are impossible.

To date, all of the hydrilla found in Clear Lake is of the monoecious biotype. This can make detection difficult in the spring when the plant is mostly forming low mats on the surface of the hydrosoil. Because the monoecious biotype is more prone to fragmentation, this means that there is a greater chance that the hydrilla in Clear Lake could fragment and move with flowing water.

A concern with hydrilla fragments would be that they could migrate with flowing water into Cache Creek. Fortunately, during the summer months, there is no direct hydraulic connection between Clear Lake (Cache Creek) and the Sacramento Delta for the reason that the water is used by the Yolo County Flood Control and Water Conservation District. However, it might be possible, under flood scenarios, for summer floodwater to move from Clear Lake through Cache Creek into the Sacramento Delta. It is only during the winter months that there is direct hydraulic connection between Clear Lake and the Sacramento Delta, but water movement in Clear Lake at this time is generally slow. However, winter flood events, which fill tributaries of Cache Creek, could conceivably move any hydrilla fragments that were to make their way into the mouth of Cache Creek into the Delta.

There is some evidence that hydrilla in moving in Clear Lake toward Cache Creek. The initial finds of hydrilla in Clear Lake in 1994 were almost all in the upper lake arm. Since then, though the total number of plant finds in Clear Lake has declined (Table 1), the number found in the Oaks arm and the lower lake arm (toward Cache Creek) has increased (Map A).

In addition, the high recreational use of Clear Lake by tourists, fishermen, and residents increases the probability of hydrilla movement to other water bodies attached to boats, trailers, and vehicles. This risk is probably even greater than the risk of movement in water.

Because of the special problems described above, the CDFA Hydrilla Eradication Project at Clear Lake has adopted specific survey and control protocols. Clear Lake has been divided into 80 management units (Map A) based on specific geographic references (for ease of location). Each of these units is surveyed regularly (approx. once every two weeks) from early spring until late fall. At the present time, surveys for hydrilla in Clear

Lake are done by 1). visual search for floating plant and plant fragments, 2). visual search for mats of hydrilla at or near the lake surface, and 3). throwing a modified grappling hook into the lake along random transects and examining the plants recovered for hydrilla. These surveys are done in each of 80 different geographic units. Each unit is surveyed every two weeks starting in the spring when the hydrilla germinates and ending in the fall when the water temperatures are too cool to support active hydrilla growth. (These surveys are referred to as the 'standard survey protocol' in the rest of this document.)

In order to control germinating plants, each of the infested units is treated regularly with fluridone granules. Rates of application are such as to achieve a 20-ppb fluridone concentration in the bottom 6 feet of the water column (assuming all the granules were to dissolve immediately after treatment). When plants or plant fragments are found in the surveys (described above) a five-acre block (minimum) around the find site is treated initially with copper to control the topgrowth. (However, copper has no effect on the tubers in the hydrosoil and so only gives a temporary 'knockdown'.) The copper treatment is followed by fluridone treatments (20 ppb) every two weeks to control germinating plants. The fluridone treatments continue until the unit is 'hydrilla free' for three years.

In addition, periodic surveys are made of adjacent and near-by water bodies for hydrilla, and annual surveys are done on the lower section of Cache Creek, the main water outlet from Clear Lake (Map B.). Hydrilla has not been detected in these water bodies.

The standard survey protocol has been very effective in detecting large mats and large clumps of hydrilla plants, as judged by the success of the program to date (Table 1). However, these large mats have been controlled, and the number of hydrilla finds is now less than two dozen in a year. In addition, most of these finds are single plants or plant fragments that are quite small, most less than 6 inches in length. Almost all of these fragments, when found, are also highly chlorotic. While the standard survey protocol surveys all of the surface of Clear Lake, the underwater surveys (grappling hook) may not be finding all the few, small plants that are now germinating and growing because only a relatively small part of the total bottom surface of the lake is surveyed. It may be possible to better quantify the percentage of small hydrilla plants detected and to improve the survey protocols to increase the efficiency of detection. It is necessary to locate any and all plants for an eradication program to be ultimately successful. In addition, it is important to locate any and all plants, and to control them, before fragments exit Clear Lake into Cache Creek.

Likewise, the standard treatment protocol has been very effective in controlling the large mats and clumps of hydrilla plants originally found in the lake, as judged by the success of the program to date. The reduced number and chlorotic nature of the current hydrilla finds indicate that the copper and fluridone treatment protocol (described above) is effective in reducing both the number and size of individual plants and plant mats. But now that the size and number of hydrilla finds is small, it may be possible to further refine the treatment protocols to reduce the amount of herbicide used and/or to maximize the effectiveness of the treatments.

Improved survey and treatment protocols might also be used in other water bodies infested with hydrilla and to help control and manage other types of aquatic weeds.

The Clear Lake Hydrilla Eradication Project depends upon several key assumptions. First and foremost is that the cost of eradicating hydrilla from the lake is small in comparison to the ecological and economic damage that would be done if hydrilla were allowed to spread uncontrolled. Second, the survey methods assume that they are adequate to find any and all hydrilla plants in the lake. Third, the treatment protocol assumes that the fluridone concentration in the hydrosoil and the boundary layer just above the hydrosoil is high enough over a long enough period of time (and the retreatments made often enough) to control any germinating plants before they can produce new tubers, turions, or fragments. And fourth, that the treated areas, once released from hydrilla eradication, will return to an ecologically acceptable state in terms of copper and fluridone concentrations, plant, fish, and bird species and populations.

Four individual proposals follow below. All four are for research/monitoring projects to gain information that can be used to assess and improve the CDFA Hydrilla Eradication Project in Clear Lake through a process of adaptive management. This information would also be applicable to other aquatic plant management programs in California, especially those in the Sacramento/San Joaquin Delta watershed.

Proposal No. 1

PROBLEM.

Based on the known impacts of hydrilla in the Southern and southeastern U.S., it is assumed that the ecological and economic damage that would occur to California if hydrilla should be allowed to spread unchecked would be enormous and would far exceed the cost of the CDFA Hydrilla Eradication Project. However, there are no formal studies to quantify either the ecological or economic damage that would be done. In particular, there are no formal studies that quantify the ecological and economic damage that would be done to Clear Lake and the Clear Lake region if hydrilla were to grow in Clear Lake unchecked or be allowed to escape from Clear Lake and spread into surrounding water bodies unchecked. A study of the ecological and environmental costs of hydrilla if left to spread unchecked in Clear Lake and the Clear Lake region, could also serve as a model for the ecological and economic costs from hydrilla in other regions of California and the nation.

> (The CALFED Draft I Implementation publication identifies cost/benefit analysis of eradication and control techniques for NIS [nonnative invasive species] aquatic vegetation as a Multi-Regional Priority.)

JUSTIFICATION

Conceptual Model

Hydrilla is a Federal and State noxious weed because of the ecological and economic damage that it causes in states such as Florida in which it has become established. In Florida, the total annual public expenditure to control hydrilla is $13.3 million (Florida Department of Environmental Protection 2001). It is estimated that the sum of public plus private expenditure to be twice that (approx. $26 million) and that the total impact to the state of Florida if left uncontrolled would be in the billions (Jeff Schardt, Florida Dept. of Environmental Protection, personal communication). It is known from past experience that hydrilla, both the monoecious and dioecious biotypes, are adapted to California. Therefore, it is assumed that if hydrilla were to be allowed to spread unchecked that within a few years it would spread into the major state waterways and cause enormous ecological and economic damage. In particular, spread of hydrilla from Clear Lake, which is a major infestation, would cause flood control and irrigation problems in Yolo County as well as diminish water holding capacity and fish and wildlife populations of surrounding ponds and reservoirs. Possible movement of hydrilla fragments in flood events to the Sacramento Delta is also a major concern.

Hypothesis

It is hypothesized that hydrilla, a difficult-to-control, noxious aquatic weed, would cause major ecological and economic losses, far exceeding the costs of eradication, were it allowed to grow and spread unchecked in Clear Lake and in surrounding ponds, streams, and rivers.

APPROACH

This hypothesis will be tested by analyzing the ecological and economic impact of hydrilla on Clear Lake and the Clear Lake region as follows:

Clear Lake and the area surrounding Clear Lake would be divided into concentric zones of 1 miles, 5 miles, and 10 miles. In these zones, all bodies of water greater than 1 acre, including Clear Lake, would be identified from aerial (space) maps and catalogued. These water bodies would be classified as small ponds, large ponds, lakes, streams and rivers, irrigation systems, and delta. Representative members of each class would be sampled and studied in detail as to the water depth, water velocity, soil types, water temperatures, etc. Clear Lake would be a class of its own. These physical parameters would be compared to known and published growth requirements for hydrilla. Each representative water body would be broken down into a grid in which a determination is made (from the physical parameters and growth requirements) as to the ability of the water/soil ecosystem in that grid to support hydrilla growth. Each grid segment would be classified as 1). Not likely to support hydrilla, 2) likely to support sparse, non-economic populations, 3) likely to support dense populations that would serve as hot spots for further spread. An estimation, based on published data, would be made in each grid as to the effect of the hydrilla population on such ecological and economic factors as plant species abundance, fisheries, bird life, boat and ship navigation, irrigation, etc.

Once the potential effects of hydrilla infestation are estimated for the representative water bodies, this information would be used to estimate the effects on all similar water bodies in the study area. This would be based on published physical and chemical data for each water body, and/or a less intensive sampling and analysis than that described above.
In addition, estimates would be made of the rate of spread of hydrilla from Clear Lake to the other identifies water bodies in the study area. These estimates would be made on known and published rates of spread of hydrilla in other states and areas of the world.

FEASIBILITY
This project is feasible in that it uses known economic and ecological models and survey techniques. The CDFA Integrated Pest Control Branch GIS Lab is experienced in making maps from GIS/GPS data. Water samples will be analyzed by either the CDFA Analytical Labs or private contractors experienced in water analysis. The USDA-ARS Exotic and Invasive Weed Research Labs in Davis, CA are very experienced in growing hydrilla and testing growth parameters. The CDFA Integrated Pest Control Branch also has Steve Schoenig, an experienced biostatistician on staff.

PERFORMANCE MEASURES:

Performance measures: Maps of study area, list of selected representative water bodies including clear Lake, maps of representative areas divided into study grids, physical and chemical analysis of each grid, literature review of published hydrilla growth data, literature reviews of physical and chemical data on water bodies in the study area, final reports of probabilistic estimates of the ecological and economic losses that would result from not eradicating hydrilla from Clear Lake.

Metrics: Estimates of economic effects would be in dollars, and ecological effects in terms of acres of displaced native habitat.

Targets: not applicable.

DATA HANDLING AND STORAGE

Data will be recorded on ‘data entry forms’ by hand and entered into Microsoft Access or similar database. Duplicate copies of all hard data will be warehoused, and all electronic data storage will have 'back-up'. All samples will be given sequential bar code numbers for ease of tracking. Duplicate samples will be taken for each sampling event, and the duplicate stored and analyzed if needed. (Selected duplicate samples will be analyzed for quality control).

EXPECTED PRODUCTS/OUTCOMES

The expected product/outcome of this project is a document giving quantifiable estimates of the ecological and economic damage that hydrilla could cause in Clear Lake and the Clear Lake region, if it were to be allowed to grow unchecked in Clear Lake and escape into the Clear Lake region. This would quantify the cost/benefit ratio of the CDFA Clear Lake Hydrilla Eradication Program. It would also serve as a model for estimating the effects of hydrilla and other exotic, invasive species in other watersheds in the CALFED management zones.

WORK SCHEDULE

Year 1 (2002/2003)

In Year 1 of this study, maps of Clear Lake and surrounding environs will be obtained/developed of all the water bodies and streams. This water bodies for 'intensive study' will be chosen and 'on-water' surveys made. Grids will be developed. In addition, extensive literature searches will be conducted of the 1) water chemistry data of the identified water bodies and 2) of the growth parameters of hydrilla and 3) the ecological and economic damage inflicted by hydrilla in areas in which it is endemic, such as Florida. If any growth parameters lack adequate definition, research studies will be contracted with the USDA-ARS Exotic and Invasive Weed Research Lab in Davis, CA. A 'Preliminary Report' will be written.

Year 2 (2003/2004)

In Year 2 of this study, water samples, water depths, etc. will be collected. Any research studies needed to better define the growth characteristics of hydrilla will be started. Preliminary maps will be generated showing where hydrilla could be expected to grow, and preliminary estimates as the ecological and economic damage this would cause will be completed. A 'Preliminary Report' will be written.

Year 3 (2004/2005)

In Year 3 of this study, a second year of water samples, etc. will be taken, and research studies completed. Maps will be generated showing the 'most likely', 'likely', and 'least likely' areas where hydrilla would be expected to grow if allowed to escape from Clear Lake. Estimates will be made as to the ecological and economic damage that this would cause. A 'Final Report' will be written.

Proposal No. 2

PROBLEM.

More information is needed to quantify how effective the standard hydrilla survey protocol used by the CDFA Hydrilla Team at Clear Lake is in actually finding hydrilla, especially small plants on the lake bottom. If the efficiency of the survey protocol were well quantified and the distribution of hydrilla plants around 'finds' known, then the number and location of the 'finds' could be used to statistically estimate the distribution of hydrilla plants on the lake bottom. Knowing the distribution of hydrilla on the lake bottom in relation to 'finds' could be used to design an improved survey protocol in terms of efficiency (cost) and effectiveness (maximum knowledge gained). An improved survey protocol could also be of benefit to hydrilla eradication programs out of the Clear Lake region, and could also be of benefit to surveys of other aquatic weeds.

(The CALFED Draft I Implementation publication identifies an analysis of the efficacy of the CDFA Hydrilla Eradication Project as a Multi-Regional Priority.)

JUSTIFICATION

Conceptual Model

The standard protocol involves three detection methods, visual observation for floating plants, visual observation for submerged/emerged mats of hydrilla, and bottom samples using a modified grappling hook. The lake water surface is surveyed several times during the year, but the lake bottom is only surveyed by the grappling hook. The grappling hook is thrown from a fishing boat, pulled about 100 meters, and retrieved. The retrieved aquatic vegetation is inspected for the presence of hydrilla. If found, the survey records indicate a 'find', if not found, the records indicate 'not found'. In this way, the current survey protocol is binary, detecting and recording a 'yes' or 'no' response. After cleaning the grappling hook, and bagging any hydrilla for disposal back on land, the survey crews repeat the process several times in each of the 80 management units. However, at best only a small percentage of the lake bottom is actually surveyed, and therefore, a small percentage of the actual number of hydrilla plants are actually detected. The distribution of hydrilla plants on the lake bottom outside of the small total area actually surveyed is unknown. Not knowing the exact location of individual plants on the lake bottom has not prevented the eradication program to be a success so far (Table 1) because it is was not necessary to know the location of individual plants when the targets were large mats and clumps of hydrilla. However, at the present time, most hydrilla finds are small, chlorotic plants or plant fragments. Knowing the distribution of hydrilla on the lake bottom, in relation to known 'finds' would allow the development of more effective survey protocols, and more effective treatment protocols. (The treatment protocols implicitly assume that hydrilla in Clear Lake occurs in large, easy to find mats which are more or less evenly distributed around the lake. This is no longer the case.) It would not be possible or cost effective to map the entire bottom of Clear Lake for hydrilla plants. And new plants germinate everyday during the growing season. However, a knowledge of distribution of hydrilla around 'finds' in a few defined study areas, would allow the construction of statistical models of hydrilla distribution in the lake based upon survey finds. These statistical models could be used to develop improved survey techniques (probably using GIS/GPS), and improved treatment protocols. These statistical models and improved survey techniques could also be used in hydrilla eradication efforts elsewhere in California, and also in the control of aquatic weeds other than hydrilla.

Hypothesis.

It is hypothesized that statistical models (map) relating the distribution of hydrilla on the bottom of Clear Lake to hydrilla 'finds' (using the Clear Lake Hydrilla Eradication Program's standard survey protocol) can be used to design improved survey and treatment protocols in terms of increased

effectiveness and efficiency (greater percentage of 'finds' and more targeted treatments) and improved water quality (less total herbicide used).

APPROACH

This hypothesis will be tested by analyzing the effectiveness of the survey techniques used by the CDFA Clear Lake Hydrilla Eradication Project by sending divers into selected management units to do an exact plant count. The exact count would then be used to compare to the CDFA surveys done of the same areas, both before and after the divers. Statistical/probabilistic techniques will then be developed to estimate the total hydrilla load of Clear Lake, and the distribution of hydrilla around 'finds' using the standard survey protocol. The exact count: CDFA survey data would also be used to develop, using GPS/GIS, a more effective survey protocol. This improved protocol could also be used in other hydrilla eradication projects and in control project for other aquatic weeds in the CALFED management zones.

The effectiveness of the current survey protocol would be tested by sending divers into Clear Lake to count the number and size of hydrilla plants in given areas and compare these numbers to those determined by the standard survey protocols in the same area. A total of 6 different areas would be chosen one each in 6 different management units. Because of the turbidity of the water, each test area would be only 1/2 to 1 acres in size. The divers will have to follow predetermined grids, about 24 to 36 inches apart. Divers will be trained to recognize hydrilla, and plant samples will be taken for confirmation. GIS/GPS coordinates will be recorded for each detection. Within one week before the divers start in a given area, the same area will be surveyed by the Clear Lake Hydrilla Eradication Team using their standard protocol, described above. And within one week after the divers finish in a given area, this standard survey will be repeated. The 6 different management units will include at least 2 controls (in which hydrilla has never been found), 2 units in which hydrilla has recently been detected, and 2 in which hydrilla has not been detected since the previous year. (The best time of the year to conduct the dives may be the late spring after the hydrilla in Clear Lake germinates, and before the lake waters get so murky and turbid that visibility is severely limited. Also, late in the year the growth of other aquatic weeds, such as *Eurasian watermilfoil*, could prevent the divers from making any forward progress.) These data will be used to build a statistical/probabilistic model of the lake, using the exact counts vs. the standard counts, and using the standard survey counts of the entire lake. This model will give a "most likely" and a "maximum probable" estimates of the distribution of hydrilla in Clear Lake. Using the same data, the CDFA Hydrilla Eradication Project personnel and the CDFA IPC GIS Laboratory will design, with the aid of the statistical model, a more effective survey protocol. This protocol may include non-random transects, grids, etc. in which the survey boats are guided by GPS coordinates.

FEASIBILITY

This project is feasible because it uses standard diving techniques and exact counts. The principal scientist, Nate Dechoretz, has years of experience working with divers for aquatic weed detection. The CDFA Integrated Pest Control Branch GIS lab is very experienced in map making. The CDFA Integrated Pest Control Branch has a Biostatistician on staff, Steve Schoenig.

PERFORMANCE MEASURES:

Performance measures: Reports and tables of the diver's exact counts. Comparisons of these exact counts to the results of the standard surveys. Statistical/probabilistic estimates of the distribution of hydrilla in Clear Lake, given the comparisons above and the historical and present finds of hydrilla given the current, standard survey protocols. An improved protocol, probably including GPS/GIS monitored transects and grids, to survey Clear Lake.

Metrics: Number and size of hydrilla finds in the divers exact count, number and finds of hydrilla in the standard surveys, probabilistic estimates of the distribution of hydrilla in the entire lake, and an improved protocol.

Targets: an improved protocol for surveying Clear Lake by boat and an improved herbicide treatment protocol.

DATA HANDLING AND STORAGE

Data will be recorded on ‘data entry forms’ by hand and entered into Microsoft Access or similar database. GIS/GPS data will be taken using Trimble equipment and the data will be manipulated with ArcView software. Statistical analysis and probabilistic estimates will be done with SAS software. All 'hard copy' will be stored in duplicate (in separate locations) and all electronic data will be 'backed up'.

EXPECTED PRODUCTS/OUTCOMES

The expected product/outcome of this project would be 1). a statistical model of the distribution of hydrilla plants at the bottom of Clear Lake as related to the ‘finds’ using the standard survey protocol and 2). an improved survey protocol for the Clear Lake Hydrilla Eradication Project in terms of probability of detecting small hydrilla plants and 3) improved treatment protocols in terms of efficacy and water quality, that is, lower herbicide loads in the lake.

WORK SCHEDULE

Year 1 (2002/2003)

    Preliminary Diver Study

The first year the techniques will be developed and tested to do the underwater survey, exact counts, and GIS locations and mapping. In this preliminary study, a 1-acre site in a known hydrilla infested area will be chosen. This area will be divided into a grid and the divers will test their ability to detect and locate hydrilla. The locations of each find will be recorded and mapped. The results will be compared to the standard survey protocol conducted before and after the dives. Should unexpected difficulties arise, the preliminary study will be repeated on a second 1-acre site to improve the techniques. A 'Preliminary Study Report' will be written which will include the statistical distribution of hydrilla around known 'finds'.

Year 2 (2003/2004)

First Year of full study

The second year of this study will be the first full year of diving and detection. The full diving protocol, perfected and tested in Year 1, will be used in all six of the study areas as described above (2 controls, 2 known hydrilla find areas, 2 old hydrilla find areas). The divers exact counts will be mapped and compared to the results of the standard survey protocol conducted before and after the dives. A 'First Year Interim Report' will be written that will include statistical distribution of hydrilla located by the divers to known finds by the standard protocol. Probabilistic estimates will be made as to the efficacy of the standard protocol to detecting hydrilla will also be developed and included in the report. If possible, suggestions to improve the survey protocols will be made.

Year 3 (2004/2005)

Second Year of full study

The work done in Year 2 will be repeated. Divers will do exact counts on all six-study areas and results compared with the standard survey protocol. If improvements to the survey protocols are made in Year 2, then these improved survey protocols will be tested in Year 3, and the resulting finds compared to the divers exact counts and the standard survey protocol. A 'Final Report' will be written which will include 1) the number of hydrilla located by the divers in each area for each year and comparisons between years, 2) probabilistic estimates of the efficacy of the standard survey protocols, 3) probabilistic estimates of the efficacy of any improved protocol tested in Year 3, and 4) further recommendations to improve the survey protocols.

Proposal No. 3

PROBLEM

While the current, standard fluridone treatment protocol in Clear Lake has been effective in reducing the number and size of hydrilla plants, the actual concentration over time for fluridone in the hydrosoil and bottom lake water immediately surrounding the germinating hydrilla is incompletely known. The available measurements are either too scanty (concentrations above and below bottom sediments), or were not entirely appropriate (because water velocity measurements have not been made at the bottom of the lake), or have never been done (hydrilla mortality when fluridone is limited to a narrow zone). If the minimum concentration over time to control germinating hydrilla were better understood, then it might be possible to design better treatment protocols in terms of efficacy and water quality, that is, less total product used. This data could also be used in other hydrilla eradication projects and in control of other aquatic weeds in the CALFED management zones.

(The CALFED Draft I Implementation publication identifies the monitoring of water quality impacts of the CDFA Hydrilla Eradication Project as a Multi-Regional Priority.)

JUSTIFICATION

Conceptual Model

The current, standard treatment protocol for eradication of hydrilla in Clear Lake is application of copper to large plants followed by repeat applications of fluridone. Fluridone was chosen because of its success in controlling hydrilla in Florida. In Clear Lake, fluridone is generally applied in a slow-release pellet formulation. This treatment protocol has been successful in reducing the large biomass of hydrilla that was present in Clear Lake in 1994 to a very low level today.

The 'nominal' application rate for fluridone used by the Clear Lake Hydrilla Eradication Team is 20 ppb in the bottom 6 feet of the water column. Applications are repeated every 14 days until a maximum, additive season concentration of 140 ppb is achieved. The Clear Lake Hydrilla Eradication Team prepares and applies enough fluridone slow release pellets to give these concentrations, assuming all the fluridone were to dissolve immediately. However, the actual concentrations in the hydrosoil and bottom water of the lake achieved by this protocol are only incompletely known partially because of the slow release nature of the formulation, and partially because of water currents in the lake.

A study of water movement in Clear Lake implied a very high level of mixing. Water velocities were measured at various depths within the lake, but at least one-meter above the bottom sediments. The velocity varied regularly throughout the day but was often in the range of 2-8 cm/sec (72-288 m/hr) for several hours each day. Treatment areas make up a small (<2%) proportion of the total area of Clear Lake. Consistent with a rapid exchange of water, fluridone levels have rarely been very high within treatment areas in Clear Lake, when they have been measured in the water column more than a few centimeters above the bottom. They rarely reach even 9 ppb within a treatment zone and are often 1 ppb or less, although the target concentration is 20 ppb. The levels are low enough that control would be unlikely, yet the hydrilla succumbs to the fluridone.

In a previous study, fluridone concentrations were measured a few centimeters above and below the surface of the bottom sediments, inside and outside treatment areas. Outside treatment areas, concentrations were non-detects. Inside treatment areas, there was high variability due to the small numbers of samples, but concentrations were about 28 ppb below the surface sediments and about 39 ppb in the water just above the sediments (Anderson, Lars W.J. and C. Pirosko 2001). These levels appeared to maintain themselves for at least two months after treatment (a fluridone treatment of an area is a series of applications made over several weeks or months in order to maintain an adequate concentration over an adequate time to achieve mortality). Since fluridone levels seem to be very much lower farther above the bottom, this result implies there is a boundary layer of relatively still water just above the bottom of the lake and that fluridone in the lake is largely isolated to within the treatment areas and to that narrow zone. It also raises the possibility of achieving mortality while decreasing the amounts of fluridone.

Hypothesis

It is hypothesized that better, more complete information on the concentrations over time of fluridone actually achieved by the Clear Lake Hydrilla Eradication Program's standard treatment protocol in the zone immediately surrounding germinating hydrilla in Clear Lake, in conjunction with more information on the susceptibility of germinating hydrilla in Clear Lake to fluridone, can be used to design a better treatment protocol, both in terms of efficacy and water quality (less total herbicide product used).

APPROACH

This hypothesis will be tested by dividing the zone immediately surrounding germinating hydrilla into 1) the boundary layer of water and 2) the hydrosoil. This hypothesis will also be tested by determining the dose response curve for germinating hydrilla in "Clear Lake conditions" in a laboratory or greenhouse setting.

1) Boundary layer: Determine whether a boundary layer of still water exists at the bottom of Clear Lake by measuring water velocity at the bottom, as well as one meter and three meters above the bottom. In a preliminary study, a probe was developed that can be inserted into the hydrosoil that consists of two water filled chambers with semipermeable membranes. After insertion, the bottom chamber equilibrates with the fluridone concentration in the hydrosoil, and the upper chamber equilibrates with the fluridone concentration in the boundary layer (Anderson, Lars W.J. and C. Pirosko 2001). This method can be complemented and extended by using grab samples of both the hydrosoil and water at various depths.

2) Concentration profile of fluridone above and below the top of the bottom sediments through time: This study would expand on the previous study described above, both in the scope of sampling and in the range of distances above and below the bottom. In the

preliminary study, the samples were taken from actual treatment areas, where the timing and rates of the treatment were not under the control of the experimenter. It is of interest to sample in areas that have undergone treatments for different periods of time or received different total amounts of fluridone over several years. But it is also of interest to follow the build-up and decrease of fluridone in newly treated areas where the rate and timing of applications are under the control of the experimenter.

3) Demonstrate effectiveness of a concentrated layer of fluridone in causing hydrilla mortality. Presumably, since fluridone has controlled hydrilla in Clear Lake and it appears to be isolated to a layer near the lake bottom, a concentrated layer should kill hydrilla. This has never been tested. Since we cannot and do not want to allow hydrilla to grow in open water for testing, this test will have to be done under artificial conditions. The approach will be to use flow-through chambers in which to grow the hydrilla and apply the treatments, with flow rates similar to those in the lake, and a bottom with sediments similar to the lake. The concentration of fluridone will be characterized above and below the sediments, similarly to the process in the lake. Finally, hydrilla will be grown in the tanks and applications of slow-release fluridone will be made to the tanks at rates similar to those used at Clear Lake, and in decreasing amounts until a level is reached at which complete mortality of the hydrilla cannot be achieved.

PERFORMANCE MEASURES

Performance measures: Reports of fluridone concentrations in the water column in Clear Lake over depths and time; Improved treatment protocols for the Clear Lake Hydrilla Eradication Project

Metrics: concentrations of fluridone in ppb in water and soil matrices

Targets: improved treatment protocols.

FEASIBILITY

As most of these methods have already been used in similar studies and are available to us, this study is readily achievable. The USDA-ARS Exotic and Invasive Weed Research Lab is very proficient in growing hydrilla. The same lab has already developed and tested the main technique that would be used for measuring fluridone concentrations in the hydrosoil and in the water in the boundary layer.

DATA HANDLING AND STORAGE

Data will be recorded on ‘data entry forms’ by hand and entered into Microsoft Access or similar database. GIS/GPS data will be taken using Trimble equipment and the data will be manipulated with ArcView software. Statistical analysis and probabilistic estimates will be done with SAS software.

EXPECTED PRODUCTS/OUTCOMES

These studies will result in 1) a better understanding the of the distribution of fluridone in the water column, especially at the interface between the boundary layer and the hydrosoil, 2) a better understanding of the concentration of fluridone in the ‘growing zone' of germinating hydrilla in treatment units of the Clear Lake Hydrilla Eradication Project, and 3) a better understanding of the effects of long term, low level exposure on the growth and germination of hydrilla from tubers. This information will then be used to better evaluate the Clear Lake Hydrilla Eradication Program and make suggestions for improved treatment protocols.

WORK SCHEDULE

Year 1 (2002/2003)

The long-term study will be initiated in Year 1 of this project. This long-term study will be for the concentration of fluridone in the hydrosoil and the boundary layer. Sites for monitoring will be established and marked with buoys and GIS. Monitoring for fluridone will begin in the spring of Year 1 and continue uninterrupted for three years. Sites will include control units as well as hydrilla control (fluridone use) units.

Also in year 1, preliminary studies as to the growth requirements of germinating hydrilla will be done in order to model the Clear Lake hydrilla treatment units. This will include dredging some hydrosoil and transporting to the lab.
In addition, a preliminary study on the concentration of fluridone throughout the water column will be done to determine the best procedural methods.

Year 2 (2004/2005)

In Year 2, the long-term monitoring study will continue and a 'preliminary report'. The first full year of the study on the effects on low levels of fluridone on the growth of germinating hydrilla will be done using the key learning from the preliminary study done in Year 1.

In addition, in Year 2 an intensive study of the concentration of fluridone in the water column following fluridone application for hydrilla control will be carried out.

Year 3 (2005/2006)

In Year 3, the long-term fluridone concentration study will be completed and a final report written.

Proposal No. 4

PROBLEM

CDFA needs to use the herbicides copper and fluridone to eradicate hydrilla efficiently in the Clear Lake Hydrilla Eradication Program. However, some concerns have been raised by some members of the public that those treatments could cause lasting ecological damage. Though available data indicate this is not the case (SePRO Corporation 2001, Washington State Department of Health 2000), there are no studies that are specific to the Hydrilla Eradication Program treatments in Clear Lake. A more complete understanding of the effects of the herbicide treatments in Clear Lake on aquatic plant, fish, bird, and invertebrate life would not only give quantifiable estimates of these effects in Clear Lake, but could also serve as a model for other hydrilla eradication programs and control of other aquatic weeds.

(The CALFED Draft I Implementation publication identifies an evaluation of the ecological impacts of the CDFA Hydrilla Eradication Project as a Multi-Regional Priority.)

JUSTIFICATION

Conceptual Model

CDFA works under the assumption that it causes less long-term ecological damage to control an incipient hydrilla infestation than it does to allow it the infestation to spread. One specific ecological concern about the Clear Lake Hydrilla Eradication Program is that it simply replaces one non-native invasive weed, hydrilla, with others, by controlling all the hydrilla in an area and leaving an ecological vacuum that another invasive weed is most likely to exploit. (This concern implicitly assumes that hydrilla is no worse than other aquatic plants that may replace it.) In addition, another ecological concern about the Clear Lake Hydrilla Eradication Program is that the treatments are damaging the biology of non-target organisms (fish, birds, invertebrates, and other aquatic plant life) in the treated areas in terms of population numbers and species diversity. Another specific concern is that the herbicides used in the Clear Lake Hydrilla Eradication Program may leave long-lasting toxic residues in the hydrosoil that can cause direct toxicity to aquatic plant and animal life for some time after the Eradication Program ceases. CDFA believes that its herbicide treatments do not cause significant lasting damage because the target application rate for fluridone in the Clear Lake Hydrilla Eradication Program, 20 ppb at each application, is far below published levels toxic to fish, birds, and invertebrates (SePRO Corporation 2001). However, no ecological studies of copper or fluridone specific to Clear Lake are known.

Hypotheses

The hypothesis is that the herbicide treatments used in the CDFA Clear Lake Hydrilla Eradication Program's standard treatment protocol, copper and fluridone, cause no long-term degradation of aquatic habitats, in terms of aquatic plant, fish, bird and invertebrate life (populations and species diversity), and in terms of long-term residues in the hydrosoil (toxicity and phytotoxicity).

APPROACH

This hypothesis will be tested by monitoring the changes to the populations and species diversity of aquatic plant, fish, bird, and invertebrate organisms in Clear Lake Hydrilla Eradication Program management units as they are released from active treatment. In year 2002, several management units will be released from active treatment for the reason that no hydrilla has been detected in them for the last three years. Several of these units will be monitored in 2002 to establish a baseline, and changes in aquatic life will monitored for the next 2 years. Aquatic plant populations will be measured by conducting survey transects, similar to those now used by the Program to detect hydrilla, only cataloguing all aquatic plants observed visually or retrieved by grappling hook. These transects would be selected at random in each unit, but established permanently by GIS/GPS. The same transects will be followed in subsequent years (Elzinga, C.L, D.W. Salzer, and J.W. Willoughby 1998). Fish populations would be measured in each unit by the electroshock method. Bird populations will be measured visually at frequent intervals during the season. Invertebrate measurements will be done in hydrosoil samples taken along the same transects. In addition, the aquatic life (populations and species diversity) can be compared between treated and non-treated management units using the same methodology. (This comparison can not be exact because there are few non-treated areas and they may not be strictly comparable to treated areas. However, monitoring of degrees of similarity and differences can be at least partially accounted for using statistical techniques and the judgement of the investigators.) In addition, the long-term effects of fluridone residues in the hydrosoil can be determined in the laboratory or greenhouse by determining the ability of dredged hydrosoil adjusted to various concentrations of fluridone to support aquatic life (plants and invertebrates). Also, the residual concentration of fluridone in the hydrosoil of treated areas can be monitored along the same transects as described above in the treated units as these units are released from active treatment, and compared to non-treated areas (with similar adjustments as described above). In order to determine environmental factors that might effect rates of fluridone dissipation and aquatic plant, fish, bird, and invertebrate populations and diversity, water and soil samples for water chemistry, soil texture, water temperature, etc. will also be taken along each transect and at regular intervals in each selected management unit. In addition, records as to Clear Lake water depths and flow rates will be obtained from the Lake County Dept. of Public Works.

PERFORMANCE MEASURES

Performance measures: Reports of the distribution of aquatic plant, fish, invertebrate, and bird life between hydrilla treatment units and untreated areas; reports of the growth of aquatic plants on hydrosoil taken from treated and non-treated units, reports of the change in aquatic plant, fish, invertebrate, and bird populations of ‘old’ hydrilla treatment units as they come off active treatment and begin non-treatment status.
Metrics: population counts, percent cover, and biodiversity measurement
Targets: no long-term effect of the Clear Lake Hydrilla Eradication Project on the population or diversity of aquatic organisms in Clear Lake

FEASIBILITY

This study will be conducted with the cooperation of the Environmental Quality Team at Big Valley Rancheria and the California Department of Fish and Game, both of whom are experienced with the aquatic plant, bird, and fish life at Clear Lake. In addition, the USDA-ARS Exotic and Invasive Weed Research Lab in Davis, CA has such facilities for testing the growth of aquatic plants and expertise in ecological studies in the aquatic environment. The studies as outlined are very feasible.

DATA HANDLING AND STORAGE

Data will be recorded on ‘data entry forms’ by hand and entered into Microsoft Access or similar database. GIS/GPS data will be taken using Trimble equipment and the data will be manipulated with ArcView software. Statistical analysis and probabilistic estimates will be done with SAS software. All samples will be collected in duplicate. One sample of each pair will be analyzed for the parameters of interest, and the other archived to be analyzed if needed. (Selected duplicate samples will be analyzed as a quality control measure.) All hard copy data will be kept in duplicate, in separate areas, and all electronic data will be 'backed up'.

EXPECTED PRODUCTS/OUTCOMES

This project will result in a comparison of the populations and diversity of aquatic life between hydrilla eradication and control units in Clear Lake. It will also result in a better understanding of the long-term effects of fluridone use on the plant populations that will grow in hydrosoil from the hydrilla treatment units vs. control units. There will also be a report as to the change in aquatic populations and diversity (plants, fish, birds, and invertebrates) that result from the cessation of fluridone treatments in a previous active treatment area.

WORK SCHEDULE

Year 1 (2002/2003)

In Year 1, the baseline monitoring of the populations of aquatic plants, fish, birds, and invertebrates would be done in selected management units to be released from active treatment. Treated and non-treated-control units would also be monitored. Permanent transects would be established by GIS/GPS. Hydrosoil samples for fluridone monitoring will also be taken. Range finding tests and methodology development would be done for the lab/greenhouse dose response tests of aquatic plants and invertebrates to fluridone. A 'Preliminary Report' will be written.

Year 2 (2003/2004)

In Year 2, the monitoring of selected active treated, non-treated, and released from treated management units would continue for aquatic plants, fish, bird, and invertebrates (populations and species diversity) and for concentrations of fluridone in the hydrosoil. Full scale lab/greenhouse testing of aquatic plant and invertebrate dose response curves in the hydrosoil would be done. An 'Interim Report' will be written.

Year 3 (2004/2005)

In year 3 the monitoring of the selected management units will be continued. The lab/greenhouse dose response tests will be repeated. Statistical techniques will be run on the data to determine what factors most influence fluridone dissipation and aquatic plant, fish, bird, and invertebrate populations and diversity. A 'Final Report' will be written.

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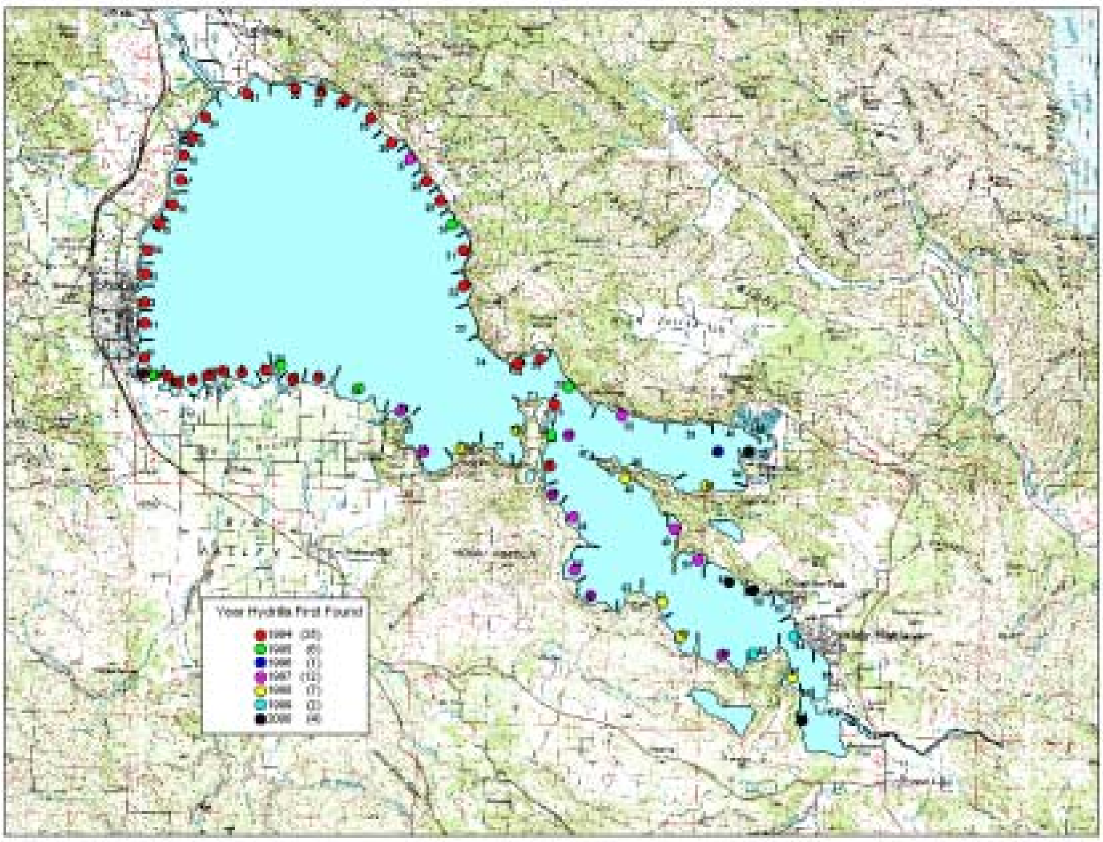
Tables and Maps

Table 1.
HYDRILLA PLANT 'FINDS' IN CLEAR LAKE, CALIFORNIA 1994-2001**

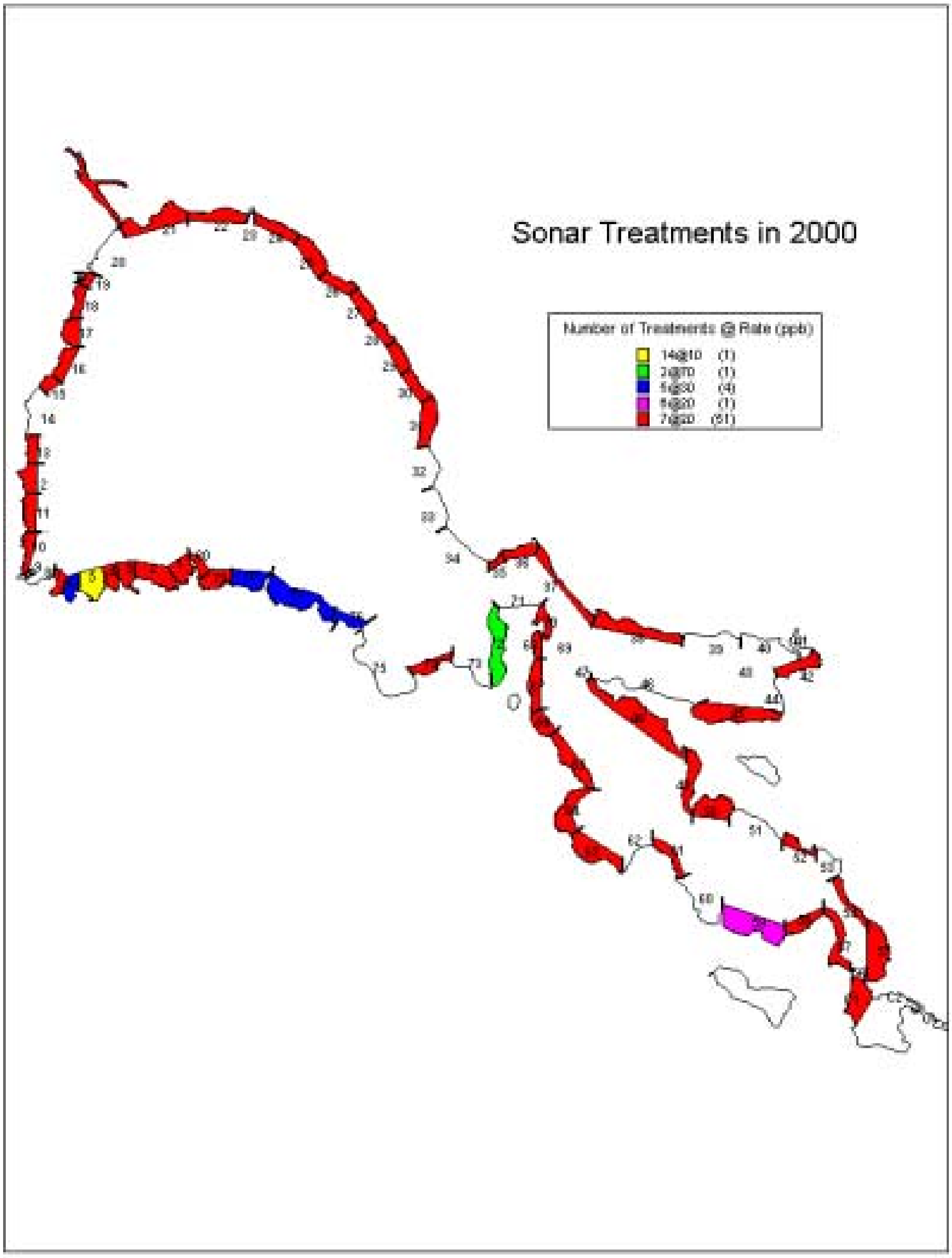
Year	No. of hydrilla finds*
1994-1996	to numerous to count
1997	208
1998	193
1999	142
2000	67
2001	21 (as of 9/26/01, about the end of the season)

*a hydrilla plant 'find' refers to a specific detection event. This detection event could be a single 3 inch plant fragment or a clump of plants.
**Data source: California Dept. of Food and Agriculture, Integrated Pest Control Branch, unpublished data.

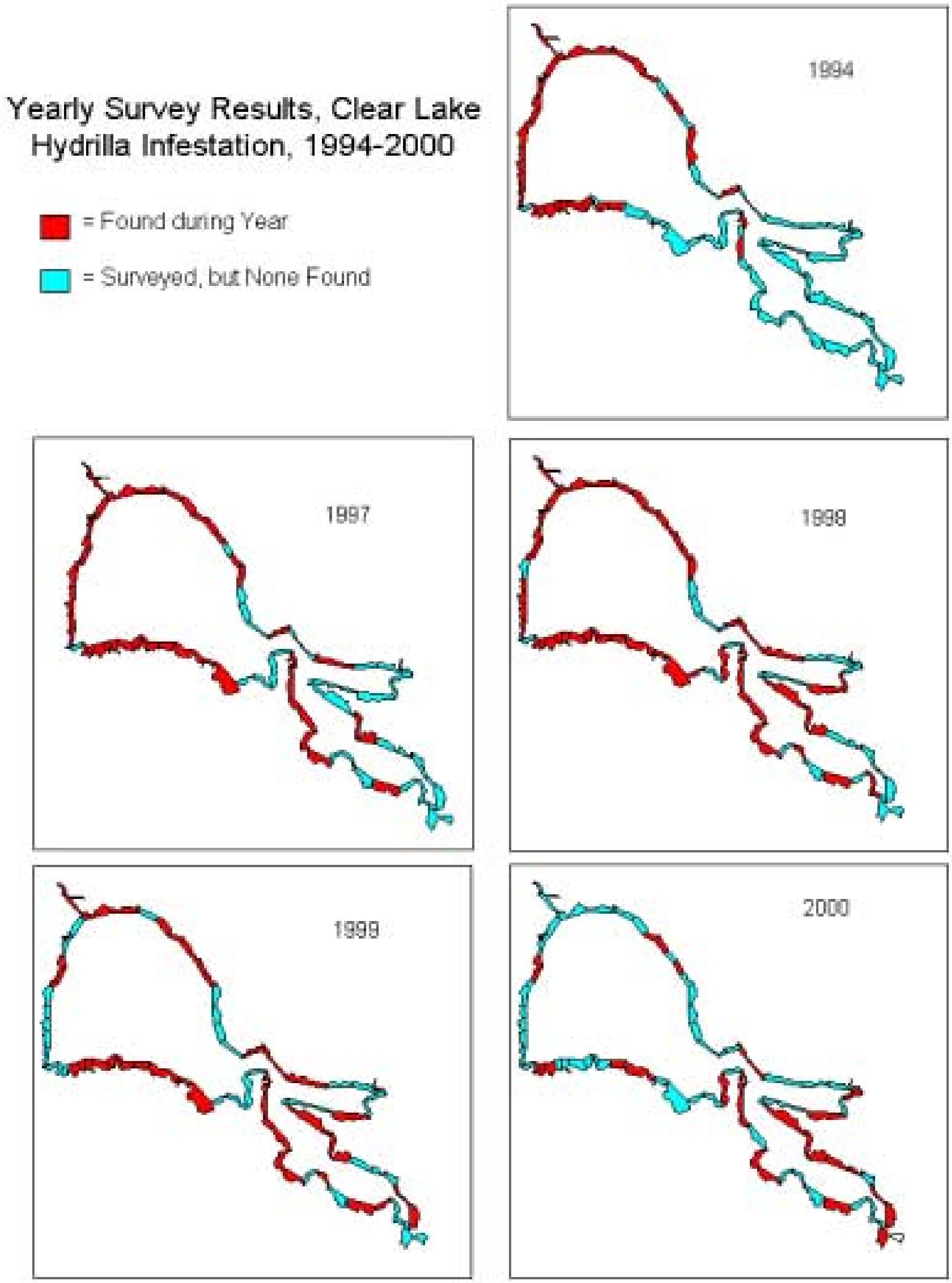
Map A. A map of Clear Lake showing the 80 hydrilla control management units. (Map produced by the California Dept. of Food and Agriculture GIS/GPS Lab, from California Department of Food and Agriculture 2001)



Map B. A map of the Sonar treatments. (Map produced by the California Dept. of Food and Agriculture GIS/GPS Lab, from California Department of Food and Agriculture 2001)



Map C. A map showing net movement of the hydrilla finds toward Cache Creek. (Map produced by the California Dept. of Food and Agriculture GIS/GPS Lab, from California Department of Food and Agriculture 2001)



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List of Qualifications

Nate Dechoretz, Principle Investigator

Experience includes over 30 years working in the field of aquatic weed control. Received B.S. in Biological Science from the University of Arizona in 1967. From 1967 to 1987 managed and conducted research at the USDA Aquatic Weed Control Research Laboratory in Davis, CA. Since 1987 has served as Program Supervisor for the Weed and Vertebrate Control, Hydrilla Eradication and Biological Control Programs, and the Weed Information, Mapping, and GIS Project at the CDFA. Has successfully organized and conducted research on hydrilla, water hyacinth, as well as, many other noxious weeds. Has conducted numerous workshops, given countless presentations, and has authored/co-authored over 50 publications, abstracts, and reports in the field of weed management. Currently Chairs the California Interagency Noxious Weed Coordinating Committee and is a lead member of the Western Weed Coordinating Committee. Is also a member of the Weed Science Society of America, Western Society of Weed Science, Western Aquatic Plant Management Society, and Aquatic Plant Management Society.

J Robert C. Leavitt, Co-Principal Investigator

Dr. Leavitt has more than 27 years in weed control research and operations. Dr. Leavitt received his Ph.D. in Agronomy with a focus in Weed Control from Michigan State Univ. in 1978. He was then on the faculty of the Univ. of Nebraska doing herbicide dissipation research until fall, 1980. In 1980 he joined E.I. DuPont de Nemours and Co., Inc. where he held various positions in herbicide research and development. During his tenure at DuPont, Dr. Leavitt spent most of 4 years working on aquatic herbicides. From Jan. 2000 to Aug. 2001, Dr. Leavitt was in the California Department of Pesticide Regulation, Pesticide Registration Branch, and Plant Physiologist Office. During this time, he worked on the efficacy evaluation and registration of several aquatic herbicides. Dr. Leavitt is now a Senior Environmental Research Scientist in the Integrated Pest Control Branch of the California Department of Food and Agriculture. His current responsibilities include supervision of the CDFA Hydrilla Eradication Program.

Pat Akers, Co-Principal Investigator

Dr. Akers has more than 12 years experience as an entomologist, biologist, and environmental scientist. He received his Ph.D. in Entomology with an emphasis in silviculture from the University of California at Berkeley. His has expertise in GIS/GPS, database management, biology, and NPDES monitoring and compliance.

Steve Schoenig, Project Biostatistician

Has 15 years experience in the fields of biological pest control weed education/research. In 1981 received B.S. in Biology of Natural Resources from UC Berkeley. At UC Davis earned two Master's degrees in Statistics and Entomology in 1981 and 1987, respectively. From 1991 to 1995 provided Departmental statistical consultation and implemented biological pest control projects/studies while serving as Associate Environmental Research Scientist with the Biological Control Program at CDFA. 1996 to present, serves as lead Senior Environmental Research Scientist for the Weed Information, Mapping, and GIS Project within the Integrated Pest Control Branch at the CDFA. Duties include: supervising 6 people, oversees mapping, database, education, research, and interagency weed management coordination projects. Has given countless presentations on weed education/control, authored/co-authored over 20 publications. Currently a board member of the California Exotic Pest Plant Council, and a member of the American Statistical Association, and the California Native Plant Society.

California Department of Food and Agriculture

The California Department of Food and Agriculture (CDFA) has statutory responsibility for the prevention of exotic agricultural and environmental pests from entering the State. The CDFA is concerned with invasive weeds, insects, animals, and diseases. The Department's pest prevention strategy consists of four major components:

1) *Exclusion*- preventing exotic pests from entering California
2) *Detection*- locating existing pest populations
3) *Eradication*- eliminating existing pest populations
4) *Education*, informing the public about the importance of keeping California pest-free.

Integrated Pest Control Branch

Pest prevention is a major part of the CDFA's many different functions, particularly in the Plant Health and Pest Prevention Service (PHPPS). PHPPS is divided into four branches, including the Integrated Pest Control Branch (IPC). The IPC has four major programs that are directly involved in weed control:

1) *Weed and Vertebrate Program*
2) *Hydrilla Eradication Program*
3) *Biological Control Program*
4) *Noxious Weed Information, Mapping, and GIS Project*

IPC works closely with the County Agricultural Commissioner Offices, local Weed Management Areas (local weed management action and coordination groups) and other State and Federal agencies in prevention, education, detection, and control efforts. The Integrated Pest Control Branch has a long history of weed management actions and has taken the lead in noxious weed prevention, detection, education, and control in California. The Weed and Vertebrate Program is largely focused on the detection and eradication of A-rated, listed State Noxious Weeds. This group surveys the entire Delta annually for hydrilla. The Hydrilla Eradication Program has eradicated hydrilla from 9 out of 17 infested Counties and is nearing eradication in the others. The Biological Control Program, in cooperation with the USDA and the University of California, brings natural enemies of pests into the State to permanently reduce pest populations. The Noxious Weed Information, Mapping, and GIS Project has developed a GIS and database system for mapping and tracking A-rated weed populations. This group has also facilitated formation of local Weed Management Areas throughout the State and produces a quarterly interagency weed control newsletter sent to 1500 subscribers, the "Noxious Times."