35th Annual
Western Aquatic Plant Management Society
Annual Conference

March 21 – March 23, 2016

San Diego Del Mar ~ Del Mar, CA

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Past WAPMS Meetings Sites and Presidents

2015	Portland, OR	Patrick Akers
2014	Reno, NV	Cody Gray
2013	Coeur d'Alene, ID	Mark Sytsma
2012	San Diego, CA	Toni Pennington
2011	Westminster, CO	Thomas Moorhouse
2010	Seattle, WA	Robert Leavitt
2009	Honolulu, HI	Tom McNabb
2008	Tahoe City, CA	Scott Shuler
2007	Coeur d'Alene, ID	Ross O'Connell/ Lars Anderson
2006	San Diego, CA (25th Meeting)	Jenifer Parsons
2005	Denver, CO	George Forni
2004	Bellevue, WA	Terry McNabb
2003	Sacramento, CA	Shaun Hyde
2002	Coeur d'Alene, ID	Mike Mizumoto
2001	Las Vegas, NV	Ron Crocket
2000	Bozeman, MT	Valerie Van-Way
1999	Reno, NV	Stuart Perry
1998	San Diego, CA	Kathy Hamel
1997	Seattle, WA	Mark Sytsma
1996	Portland, OR	Vanelle Peterson
1995	Sacramento, CA	Fred Ryan
1994	Coeur d'Alene, ID	Paul Beatty
1993	Tucson, AZ	Lars Anderson
1992	Salt Lake City, UT	David Spencer
1991	Seattle, WA	Richard Thiery
1990	Sparks, NV	Tom McNabb
1989	Honolulu, HI	Barbra H. Mullin
1988	Fresno, CA	Fred Nibling
1987	Boise, ID	Winn Winkyaw
1986	San Diego, CA	Randall Stocker
1985	Phoenix, AZ	Nate Dechoretz
1984	Spokane, WA	Les Sonder
1983	Las Vegas, NV	Terry McNabb
1982	Denver, CO	First Business Meeting Terry McNabb (President); Paul Beaty (VP)
1981	Formation Interest meeting, San Diego, CA - Floyd Colbert and Lars Anderson (Co-chairs)	

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The objectives of the Society shall be to:

1. Establish a forum for the exchange of information on aquatic vegetation management techniques, strategies, and research through periodic meetings and other appropriate means.
2. Cooperate with local, state, regional, and national agencies, both public and private, in the identification of and solution to aquatic vegetation problems.
3. Promote uniformity and coordination of activities among agencies concerned with the regulatory aspects of aquatic plant management.
4. Encourage scientific research and assist in promoting the control and management of aquatic plants through scientifically sound procedure.
5. Recognize and promote scientific advancement of the members and facilitate the education of aquatic plant scientists through scholarship and other assistance programs.
6. Extend and develop public interest in, and understanding of, aquatic plant management problems and solutions.
7. Cooperate with local chapters and other organizations with similar and related interests.

The Western Aquatic Plant Management Society geographic region includes the states of:
Alaska, Arizona, California, Colorado, Hawaii, Idaho, Oregon, Nevada, New Mexico, Montana, Utah, Washington, and Wyoming

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PROGRAM

Monday, March 21

2:00 - 4:00	**Board of Directors Meeting** (Steeplechase)
4:00 - 6:00	**Registration**(Belmont Foyer)
2:00 - 6:00	**Exhibitor Setup**(Salon CDEF)
6:00 - 8:00	**President's Reception, hosted by Joe Vassios, President, WAPMS** (Lower Courtyard)

Tuesday, March 22

8:00 - 8:40	**Continental Breakfast**(Salon CDEF)
Session I (Derby)	**Moderator: Scott Nissen (Vice-President, WAPMS), Colorado State University, Fort Collins, CO**
8:30 - 8:40	**Welcome:** Joe Vassios (President, WAPMS), UPI, Rocklin, CA
8:40 - 9:00	**Aquatic Ecosystem Restoration Foundation Update** Carlton Layne, Executive Director, Aquatic Ecosystem Restoration Foundation, Marrieta, GA
9:00 - 9:20	**The Aquatic Plant Management Society Update** Rob Richardson, President APMS, North Carolina State University, Raleigh NC
9:20 – 10:00	**Management Options for *Prymnesium parvum*** Alyssa Calomeni* and John Rogers, Clemson University, Clemson, SC
10:00 – 10:20	**Break** (Salon CDEF)

<u>Session II</u>	**Moderator - TBD**
10:20 – 11:00	**Inland Water Quality Issues Caused By Harmful Algal Blooms in California: Recent Events and New Monitoring Approaches** Meredith Howard, Senior Scientist, Southern California Coastal Water Research Project, Costa Mesa, CA
11:00 –11:40	**Remote Sensing and Modeling for Improving Operational Aquatic Plant Management** David Bubenheim, NASA, Ames Research Center, Moffet Field, CA
11:40 – 1:00	**Lunch** (On Your Own)
<u>Session III</u>	**Moderator - TBD**
1:00 - 1:20	**Managing the TMDL in Big Bear Lake: "We still do not know one thousandth of one percent of what nature has revealed to us."** Mike Stephenson*, General Manager and James Bellis, Lake Manager, Big Bear Municipal Water District, Big Bear, CA
1:20 - 1:40	**Combating Algae Toxins in Western Lakes, Case Studies** Terry McNabb, Aquatechnex, LLC, Bellingham, WA
1:40 – 2:00	**The Impact of Terrestrial N-Fixing species (and other anthropogenic influences on the water quality of the Clatsop Plains, Oregon** Laura Costadone* and Mark Systma, Portland State University, Portland, OR
2:00 - 2:20	**Developing Effective Use Patterns For Peroxide Based Algaecides (GreenClean Liquid 5.0 and GreenClean PRO)** Tom M. Warmuth, BioSafe Systems, Kernersville, NC
2:20–2:40	**Bridging the Gap Between Chemical & Biological Treatments in Aquatic Environments** Patrick A. Simmsgeiger, Diversified Waterscapes Inc., Laguna Niguel, CA
2:40 - 3:00	**Break** (Salon CDEF)
3:00 - 3:20	**NPDES/WOTUS National Update** Carlton Layne, AERF Executive Director, Marietta, GA
3:20 – 3:40	**When Following the Label is Not Enough: The California NPDES Aquatic Pesticide Permit** Michael Blankinship, Blankinship and Associates, Inc., Davis, CA.
3:40 – 4:00	**Aeration as a Lake Management Tool** Bob L. Robinson. Kasco Marine, Minneapolis, MN
4:00 – 4:45	**Annual Business Meeting** (Derby)
5:30 – 6:00	**Reception** (Salon EF)
6:00 – 8:30	**WAPMS Annual Banquet** (Salon EF)

Wednesday, March 23

7:30 - 8:20	**Continental Breakfast** (Salon CDEF)
Session IV	**Moderator - TBD**
8:00 - 8:20	***Bacoparotundifolia* in the Columbia River: to Kill or Not to Kill?** Mark D. Sytsma*, Portland State University, Portland, OR
8:20 - 8:40	**Biological Control of Water Hyacinth: Status and Future Prospects** Paul D. Pratt[1]*, Mike Pitcairn[2], and Patrick Moran, [1]USDA-ARS Riverdale MD, [2]California Department of Food and Agriculture, Sacramento, CA, [3]USDA-ARS, Albany, CA
8:40 - 9:00	**Determining Water Hyacinth Mechanical Harvester Removal Rates** Thomas J. McNabb, Clean Lakes, Inc., Martinez, CA
9:00 - 9:20	**The Sacramento/San Joaquin River Delta Area Wide Project: Adaptive Management of Invasive Aquatic Plants** John D. Madsen[1]*, Patrick J. Moran[2], Paul D. Pratt[3], David L. Bubenheim[4], and Edward J. Hard[5]; [1]USDA-ARS, Davis, CA; [2]USDA-ARS Albany, CA; [3]USDA-ARS, Riverdale, MD; [4]NASA, Moffet Field, CA; and [5]California Department of Parks and Recreation, Sacramento, CA
9:20 –9:40	**Flowering Rush in the Columbia River system** Jenifer Parsons[1]*, Peter Rice[2], Mark Porter[3], Mark D. Sytsma[4], Thomas E. Woolf[5], and Jennifer Andreas[6]; [1]Washington Department of Ecology, Yakima WA; [2]University of Montana, Missoula, MT; [3]Oregon Department of Agriculture, Enterprise, OR; [4]Portland State University, Portland, OR; [5]Idaho State Department of Agriculture, Boise, ID, and [6]Washington State University, Puyallup, WA.
9:40 - 10:00	**Drawdown Applications for Control of Flowering Rush** John D. Madsen[1]*, Kurt D. Gettsinger[2], Thomas E. Woolf[3], and Brad Bleumer[4], [1]USDA-ARS, Davis, CA; [2]USACE, Vicksburg, MS; [3]Idaho State Department of Agriculture, Boise, ID; and [4]Bonner County Public Works Department, Sandpoint, ID
10:00 – 10:20	**Break** (Salon CDEF)
Session V	**Moderator - TBD**
10:20 - 10:40	**The Use of Copper EDA for Aquatic Plant Management in Reservoirs in the Southern United States** Paul Westcott[1]*, Ryan M. Wersal[1], Gray Turnage[2], William Ratajczyk[1], and Harry Knight[1]; [1]Applied Biochemists: A Lonza Business, Germantown, WI, and [2]Mississippi State University, Starkville, MS
10:40 - 11: 00	**Weed and Algae Control at Turlock Irrigation District** Chris Hardin, Turlock Irrigation District, Turlock, CA

11:00 - 11:20	**Procellacor™– A Novel Herbicide Technology in Development for Aquatic Plant Management** Mark Heilman*, Tyler Koschnick, Ben Willis; SePRO Corporation, Carmel, IN
11:20 - 11:40	**Evaluating the Sensitivity of Representative Aquatic Plants to Procellacor™Herbicide** Robert J. Richardson[1]*, Michael Netherland[2], Erika Haug[1], and Mark A. Heilman[3]; [1]North Carolina State University, Raleigh, NC: [2]USACE, Gainesville, FL; and [3]SePRO Corporation, Carmel, IN
11:40 - 12:00	**Correlation of Hydroacoustic Signature to Submersed Plant Biomass** Andrew Howell*and Rob Richardson, North Carolina State University, Raleigh, NC
12:00 - 1:20	**Lunch** (On Your Own)
<u>**Session VI**</u>	**Moderator: TBD**
1:20 - 1:40	**Treating Hydrilla with Fluridone in a Lotic System: Responses of Target and Non-target Species** Shannon M. Auell*, Robert J. Richardson, and W. Gregory Cope; North Carolina State University, Raleigh, NC
1:40 - 2:00	**Absorption Rates of 2,4-D Butoxy Ethyl Ester and 2,4-D Amine by Eurasian Watermilfoil** Mirella Ortiz[1]*, Kallie Kessler[1], Scott J. Nissen[1], Ryan Wersal[2] and William Ratajczyk[2]; [1]Colorado State University, Fort Collins, CO and [2]Applied Biochemists: A Lonza Business, Germantown, WI
2:00 - 2:20	**Variable-Leaf Milfoil in Washington, Will We Ever Get to Eradication?** Jenifer Parsons, Washington State Department of Ecology, Yakima, WA
2:20 –2:40	**Wisconsin Lakes Case Study Evaluations Controlling Eurasian Watermilfoil, Hybrid Watermilfoil and Curlyleaf Pondweed**. Cody J. Gray, UPI, Peyton, CO
2:40 - 3:00	**Elimination of Bulrush from a Southern California Irrigation Pond by Manual Removal followed by Shading** Tom G. Moorhouse, Clean Lakes, Inc., Westlake Village, CA
3:00 – 3:20	**Increasing Cooperation Between Applicators and the Public** Dave Kluttz, Lakeland Restoration, Priest River, ID
2:30 – 4:00	**Vendor and Exhibitor Breakdown** (Salon CDEF)
3:30 – 5:00	**WAPMS Board of Directors Meeting** (Steeplechase)

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ABSTRACTS
In Alphabetical Order by Presenting Author

Shannon M. Auell*, Robert J. Richardson, and W. Gregory Cope. **Treating Hydrilla with Fluridone in a Lotic System: Responses of Target and Non-target Species**. North Carolina State University, Raleigh, NC

Hydrilla (*Hydrilla verticillata*) is an invasive aquatic weed that has been spreading throughout North Carolina's lakes and reservoirs since it was first discovered in 1980. It is now invading increasingly dynamic and high biodiversity systems such as rivers and natural lakes. One recent site of invasion is the Eno River system in the Piedmont region of the state. The Eno is a tributary of the Neuse River, and is home to several rare species including the panhandle pebblesnail (*Somatogyrus virginicus*). It also serves as a significant source water for Falls Lake, the drinking water reservoir for the City of Raleigh, NC and several surrounding areas. In 2015, an aquatic herbicide treatment with fluridone (Sonar Genesis) was conducted in the Eno River, marking the first metered herbicide treatment of hydrilla within a riverine system in the state. We evaluated the herbicide treatment impacts to selected target and non-target aquatic species. Efforts included quantitative sampling of *H. verticillata*, *S. virginicus*, and *Podostemum ceratophyllum* (the native vegetation and habitat of *S. virginicus*) at seven spatially separated sites along the Eno River. Biweekly vegetation monitoring and monthly snail sampling began in late May, two weeks before treatment, and continued through December. *H. verticillata* shoot lengths were significantly reduced during treatment from an average of 23.4 cm to 10.6 cm. Average density of *S. virginicus* was significantly different among sites, ranging from 5,537 snails/m^2 to 1,782.4 snails/m2 . Monthly snail density averaged among all sites differed over the course of the sampling season, with lower densities found in October and December. Average monthly snail densities during treatment months did not differ significantly. *P. ceratophyllum* densities differed between treated and untreated sites with means of 13,736 and 10,682 stems/m^2, respectively. Overall, fluridone effectively reduced hydrilla density within the treated area with no apparent negative impact to the studied non-target species.

Michael Blankinship. **When Following the Label is Not Enough: The California NPDES Aquatic Pesticide Permit**. Blankinship and Associates, Inc., Davis, CA.

Intentional introduction of pesticides into Waters of the US to control algae and aquatic weeds requires an NPDES permit, not just compliance with the label. Compliance with the permit requires that you know what herbicides to use and where (and where not to) apply them. Details, tools and examples will be presented to help you recognize if you need a permit and if you must have one, how to comply with it in a cost-effective manner.

David L. Bubenheim. **Remote Sensing and Modeling for Improved Operational Aquatic Plant Management**. NASA Ames Research Center, Earth Science Division, Moffett Field, CA

Management of aquatic weeds in complex watersheds and river systems present many challenges to assessment, planning and implementation of management practices. Remote sensing technologies and associated image analysis offer an opportunity to gain a comprehensive view of the problem provided: the species of interest can be identified (many aquatic weeds are submerged or in mixed communities if floating), the images are available on a time scale supportive of operational decision making and implementation, the costs of image acquisition and processing are not prohibitively expensive. Other tools available to aide in developing management strategies include modeling at local through watershed scales to understand the ecology of the system. We are applying both remote sensing and modeling technologies in the California San Joaquin-Sacramento Delta River system as part of a USDA sponsored area-wide project. We will discuss remote sensing tools developed for mapping of floating and submerged aquatic weeds and how these capabilities enhance planning and operational efficiency. Modeling efforts to define the complex interaction of land-use types, water management, and climate and drought induced impacts on water quality (at watershed and local scales) and how these affect invasive and native aquatic plant ecology will be presented. These tools individually affect weed management operations but potentially most important is the synthesis and ability to inform science-based, decision-making. These techniques provide for quantitative assessment, strategic planning informed by ecological understanding of the system, consideration of alternative management practices, monitoring of management practice effectiveness, and refinement of decision support system

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Alyssa Calomeni and John Rodgers. **Management Options for *Prymnesium parvum***. Clemson University, Clemson, SC

Recently *Prymnesium parvum* N. Carter has become more widespread and prevalent in the southern United States posing unique problems for water resource managers. Since the potential impacts of *P. parvum* are relatively well known as well as its capabilities to severely affect fish in important fresh and brackish water resources, managers have sought efficacious, environmentally sound and socially acceptable strategies for managing this noxious species. For critical, multiple use water resources, adaptive water resource management is needed and all potentially viable approaches for intervening are considered as these haptophytes colonize an aquatic system. As fish mortalities accumulate and the causative agent is accurately identified, applications of algaecides are capable of controlling *P. parvum* if intervention occurs early in the invasion process. We used laboratory testing to identify an efficacious algaecide for control of *P. parvum.* Samples of *P. parvum* from Texas, Arizona, Florida, North Carolina and South Carolina were evaluated for their responses to US EPA registered algaecides. *P. parvum* from all of these locations uniformly responded to single pulse exposures of Cutrine®-Plus at 200 µg Cu/L. *P. parvum* from West Virginia and Florida has been controlled using Phycomycin. This information has been integrated into field strategies and has been successful for controlling *P. parvum* at several sites. Given the spread of this haptophyte, site-specific strategies will be needed. As these strategies are implemented, strategic monitoring can provide data to improve decisions made through adaptive water resource management.

Laura Costadone* and Mark Sytsma. **The impact of terrestrial N-fixing species (and other anthropogenic influences) on the water quality of the Clatsop Plains, Oregon**.
Environmental Science and Resources, Portland State University, Portland, OR

During the past decades invasive aquatic weeds have been a significant problem in many of the shallow, interdunal lakes of the Clatsop Plains on the northern Oregon Coast. The increased development around the lakes, the use of septic tanks for sewage treatments, fertilized lawns, golf courses and the presence of terrestrial N-fixing species (scotch broom and red alder) significantly incremented nutrient inputs. We estimated that septic tanks and scotch broom are contributing 102,384 Kg/y and 23,158 kg/y respectively to the annual nitrogen budget of the region. It was also estimated that the total nitrogen produced by different land uses and vegetation types within the region is 4,993,209 kg/y. Quaternary beach and dune sand is the predominant geologic unit of the Clatsop Plains. Therefore, this area is highly sensitive to erosion and water pollution as nutrient pollutants can flow through the soil and enter surface water via shallow groundwater, exacerbating the eutrophic conditions of the freshwater systems. Previous studies have found these lakes to be seasonally nitrogen limited based on the N:P ratio. N limitation becomes more important during the summer when denitrification rates and internal P loading are high. Under these conditions the lakes are at high risk of developing serious algal blooms if N inputs increase. Managing aquatic plants through reduction of nutrient and silt runoff from fields or other sources of pollution at the watershed scale can greatly reduce potential problems. This study is designed to address the hypotheses that primary productivity of phytoplankton and macrophytes in Clatsop Plains lakes are nitrogen limited; terrestrial N-fixing plants contribute to the N-budget of N-limited lakes; and management of terrestrial N-fixing vegetation on the Clatsop Plains would reduce productivity of lakes, phytoplankton blooms and aquatic plant problems.

Cody J. Gray. **Wisconsin Lakes Case Study Evaluations: Controlling Eurasian Watermilfoil, Hybrid Watermilfoil and Curlyleaf Pondweed**. UPI, Peyton, CO

Eurasian watermilfoil and curlyleaf pondweed have long been problematic invasive aquatic species across the northern tier of the United States. Water managers have battled these species for multiple years using a variety of techniques including herbicide applications, mechanical techniques, and biological control. Recently, a new species has started to become extremely problematic, hybrid watermilfoil. Hybrid watermilfoil is a hybrid cross between the non-native Eurasian watermilfoil and the native Northern watermilfoil. The hybrid species takes on characteristics of both parent species. Research has found many traditional applications using auxin herbicides has not been effective in controlling hybrid watermilfoil. This presentation will outline multiple lake management strategies from Wisconsin targeting Eurasian watermilfoil, hybrid watermilfoil and curlyleaf pondweed.

Mark Heilman*, Tyler Koschnick, and Ben Willis. **Procellacor™ A Novel Herbicide Technology in Development for Aquatic Plant Management**. SePRO Corporation, Carmel, IN

Aquatic weed control is challenged by the low numbers of herbicides registered for aquatic use. History has shown that discovery and registration of new herbicide actives suitable for direct application to water is a difficult process. It is extremely rare to discover a candidate product with sufficient herbicidal activity on one or more key aquatic weeds and strong environmental profile necessary to pursue aquatic registration. With increasing regulation of herbicide use and growing technical challenges with herbicide resistance, new weed species introductions, threatened and endangered species and infestations in higher exchange systems, new herbicide technology is much-needed to sustain the long-term success of past and current management efforts. Procellacor™ is a brand new active ingredient under development as an aquatic herbicide. Procellacor has unique, low-rate, systemic activity on the major submersed weeds hydrilla (*Hydrilla verticillata*) and Eurasian watermilfoil (*Myriophyllum spicatum*). It also has strong activity on the major floating weed, water hyacinth (*Eichhornia crassipes*) and newer floating/emergent weed threats such as crested floating heart (*Nymphoides cristata*), invasive primrose (mulitiple *Ludwigia* spp.) and several other difficult-to-control species through either in-water or foliar application. Procellacor has an excellent environmental profile for use in water with registration studies indicating wide margins of safety to fish and wildlife and development efforts demonstrating strong selectivity to native aquatic plants. The technical properties of Procellacor for its major weed control uses and its developmental status will be reviewed.

Meredith Howard. **Inland Water Quality Issues Caused By Harmful Algal Blooms in California: Recent Events and New Monitoring Approaches**. Senior Scientist, Southern California Coastal Water Research Project, Costa Mesa, CA

Cyanobacteria blooms and other nuisance freshwater harmful algal blooms (HABs) have become increasingly problematic globally due to various anthropogenic factors (such as climate change, nutrient loading, water residence time and other physical factors).Cyanobacterial blooms and associated toxins (cyanotoxins) cause a variety of harmful effects that impair beneficial uses of waterbodies and cause illness and mortality in humans, domesticated animals (livestock, pets), and wildlife. The impact of cyanotoxins can extend well beyond freshwater systems and downstream of their biological origin, causing issues in marine and estuarine ecosystems.

Due to the growing recognition that HABs can severely impact water quality, the U.S. Environmental Protection Agency has recently released health advisory thresholds for cyanotoxins in drinking water and has listed three cyanotoxins on the Contaminant Candidate List 3. USGS has recently prioritized 12 cyanotoxins as the highest priority for inclusion in ambient water monitoring in the US. Most water quality management programs focus on chemical contaminants, but exclude HAB toxins from the list of analytes routinely monitored, thereby making it difficult to determine the status and trends of HAB issues in inland waters. In addition, the approaches used in these water quality programs were developed for chemical contaminants, however, such approaches may not be appropriate to characterize the risk from HAB toxins.

Despite the health risks associated with cyanotoxins, little is known about the predominance of cyanotoxins and cyanobacteria in most California waterbodies (except several toxin hotspots such as Klamath River and Estuary, San Francisco Bay and Delta areas and Monterey Bay). Recent screening assessments in California revealed widespread prevalence of microcystins from a variety of waterbody types including streams (benthic algae), depressional wetlands, lakes, reservoirs, coastal lagoons and estuaries. The first large-scale study to examine cyanotoxin concentrations accompanied by cyanobacterial community composition from wadeable stream benthic algal samples, indicated that microcystins were detected in one-third of streams in California and multiple cyanotoxins (cylindrospermopsin, anatoxin-a, and saxitoxin) were also detected at a subset of sites. Monitoring and assessment studies from other lentic waterbodies had similar results, with simultaneous detection of multiple toxins at some sites, several of which exceeded health advisory thresholds. These results suggest multiple terrestrial sources of cyanotoxins, including benthic cyanobacteria from wadeable streams, as potential loading sources to downstream coastal waters in California.

Traditional sampling approaches have been shown to miss toxic events and to be poor indicators of the temporal variability of toxins in the ecosystem. In response to this challenge, several intensive studies in were conducted that successfully used passive samplers, Solid Phase Adsorption Toxin Tracking (SPATT), to capture the prevalence of microcystins in a diverse array of waterbodies. The results from these screening assessments indicated that microcystins are pervasive in California, and missed by traditional sampling approaches.

Andrew Howell* and Rob Richardson. **Correlation of Hydroacoustic Signature to Submersed Plant Biomass**. North Carolina State University, Raleigh, NC

Invasive submersed aquatic vegetation (SAV), such as *Hydrilla verticillata,* can negatively impact reservoirs and lotic systems by impeding recreational activities, power generation, and significantly disrupting native ecological function. An excess of $100 million dollars are spent annually in the US for aquatic weed management, which includes those costs associated with scouting, eradicating and controlling the invasions. Early SAV detection and accurate mapping is critical to formulating management decisions and timely incorporation of management practices. Traditional i*n situ s*ampling techniques have been widely utilized, but often require significant labor, which limits the scale of sampling and the rapidness of processing. It can also be difficult to approximate specific plant biomass levels using these methods, especially in scenarios of high plant diversity. Recent advances in hydroacoustic technology and data processing offer the opportunity to estimate SAV biomass at scale with reduced labor requirements. Research was conducted at two North Carolina reservoirs to compare estimated SAV biomass from consumer grade hydroacoustic technology to measured biomass. Biovolume and biomass were found significantly positively correlated in both data sets, with a Pearson correlation coefficient of 0.8343 ($p < 0.0001$) at Shearon Harris and .5129 ($p < 0.0001$) at Roanoke Rapids test sites. Results from this study suggest that as biovolume increases, so does SAV biomass in a non-linear trend.

Dave Kluttz. **Increasing Cooperation Between Applicators and the Public**. Lakeland Restoration, Priest River, ID

Aquatic treatments are relatively new in the Pacific Northwest. Some of the first treatments were conducted in the Mid 90s in Northern Idaho and Eastern Washington. Some lake communities have embraced this practice annually to insure lake health. The Pacific Northwest has thousands of lakes. Populations are low, with the majority of the population are on the lakes. A 900 acre lake may have 300 residents. Residents, and the general public have questions and concerns when permits are applied for, and applications are conducted. Education is ongoing as treatments progress. This is a talk about a contest. "Beach Blanket Bingo " was the original theme. A contest to challenge the residents to display artwork relating to that theme, and a Newsletter published prior to treatment.

John D. Madsen[1]*, Kurt D. Getsinger[2], Thomas E. Woolf[3], and Brad Bluemer[4]. **Drawdown Applications for Control of Flowering Rush**. [1]USDA-ARS, Davis, CA; [2]USACE, Vicksburg, MS; [3]Idaho State Department of Agriculture, Boise, ID; and [4]Bonner County Public Works Department, Sandpoint, ID

Flowering rush (*Butomus umbellatus* L.) is an invasive weed to shallow water and moist soil environments. In the West, it is spreading primarily in Washington, Idaho, and Montana along the Flathead, Clark Fork, Pend Oreille, and Columbia River systems, with scattered populations elsewhere in this region. Since the plant grows well in shallow water (up to 4 m deep) to moist soil environments, it thrives well in western reservoirs that experience significant water level fluctuations. For this species, multiple herbicide use patterns and an assortment of products will be needed to manage the plant in a variety of habitats, and under a wide range of regulatory restrictions due to federal and state herbicide restrictions, including endangered species issues. In this study, we evaluated the use several herbicides on moist soil sites of a scheduled drawdown in Pend Oreille Lake, Idaho. Fifteen plots (0.1ha) were established at the Clark Fork River delta, with three replicates each of four treatments and an untreated reference. The treatments included imazapyr (5.6 L/ha), with and without the addition of 2,4-D (1.8 L/ha); and imazamox (2.8 L/ha), with and without the addition of 2,4-D (1.8 L/ha). All treatments also received 2.8 L/ha of a nonionic surfactant. The herbicides were applied by ATV prior to predicted rain, just after the emergence of new flowering rush growth in the spring (late April). Plots were evaluated using both estimated percent cover, and with ten biomass samples per plot using a 0.18 m^2 core sampler. Biomass samples were sorted to rhizomes and shoots, and the number of rhizome buds was counted. Samples were taken before treatment in March, and at 12 weeks after treatment. By 12 WAT, imazamox or imazapyr treatments alone significantly reduced aboveground biomass. The addition of 2,4-D did not enhance the treatments with either imazamox or imazapyr. We plan to further evaluate these treatments at 52 and 66 WAT.

John D. Madsen[1]*, Patrick J. Moran[2], Paul D. Pratt[3], David L. Bubenheim[4], and Edward J. Hard[5]. **The Sacramento/San Joaquin River Delta Area Wide Project: Adaptive Management of Invasive Aquatic Plants**. [1]USDA-ARS, Davis, CA; [2]USDA-ARS Albany, CA; [3]USDA-ARS, Riverdale, MD; [4]NASA, Moffet Field, CA; and [5]California Department of Parks and Recreation, Sacramento, CA

The Sacramento/San Joaquin River Delta, more commonly known as the "Delta," is formed by the confluence of the Sacramento and San Joaquin Rivers. Commonly described as the waterways in a triangle from Suisan Bay, Sacramento, Stockton, it is a vast network of waterways and islands formed by the construction of levees. The Delta is critical to the ecology and life history of many aquatic species, but it is also the hub of the California Water Project and a navigation arterial to the Port of Stockton. A vast waterway located near several million people, it is also important to recreational fishing and boating. California Division of Boating and Waterways has been managing waterhyacinth (since 1982) and egeria (since 1997) under specific legal authorizations. In 2014, legislation empowered the CDBW to manage other invasive species, such as curlyleaf pondweed, pending review by California Department of Fish and Wildlife. Beginning in 2014, a USDA ARS Area Wide program was approved to develop an adaptive management program to control invasive aquatic plants in the Delta, improve cooperation among agencies, and evaluate the ecological benefits and impacts of invasive species management. Management options included in the Integrated Plant Management assessment include biological, chemical, mechanical, and physical controls, and intense study of the ecology and life history of the target species (waterhyacinth, egeria, curlyleaf pondweed, and South American spongeplant) to optimize the timing and efficacy of management, and develop approaches to assess long-term population management. In addition, remote sensing technologies such as aerial and satellite imaging, hydroacoustic monitoring, sensor networks, and telemetry are being investigated to develop decision-support tools for management of these species. Development of an ecosystem-based adaptive IPM plan will be conducted in consultation with the US Fish and Wildlife Service and the National Marine Fisheries Service to ensure that management is consistent with Endangered Species Act concerns for rare, threatened, and endangered species, both resident and migratory, including Delta Smelt, Green Sturgeon, Chinook Salmon, and others.

Thomas J. McNabb. **Determining Water Hyacinth Mechanical Harvester Removal Rates**. Clean Lakes, Inc., Martinez, CA

Water hyacinth biomass in the Sacramento San Joaquin Delta (California) is measured and determined based on the area (length times width) of coverage, as well as height above and below the water line, and is expressed as acres and or cubic yards of infestation. Trials were conducted in late 2015 and early 2016 to determine the amount of water hyacinth removed per day expressed in cubic yards (yd^3) (volume). Water hyacinth is compressed and compacted during the harvesting process. The actual volume of water hyacinth removed cannot be accurately expressed via the unit measurement of cubic yards or acres removed in the harvester's load container, as the volume has been reduced via compression and compaction. Water hyacinth is compressed during the collection process when the harvesting head enters the water hyacinth mat and compresses the plant as the harvester moves forward during the collection process, and is again compressed and compacted when the plant is stacked in the harvester's load container. The data collected during these trials will be discussed.

Tom G. Moorhouse. **Elimination of Bulrush from a Southern California Irrigation Pond by Manual Removal followed by Shading.** Clean Lakes, Inc., Westlake Village, CA

Based on design and construction irrigation ponds can require varying degrees of aquatic plant management including emergent vegetation management. Bulrush is a common emergent aquatic plant in southern California gradually colonizing areas initially then rapidly once established. Control approaches typically include mechanical, manual or aquatic herbicide control. Due to client and project requirements regrowth may or may not be tolerated, especially in irrigation ponds. This paper will review the elimination of Bulrush from an irrigation pond implementing manual removal followed by limited herbicide use and shading.

Mirella Ortiz[1]*, Kallie Kessler[1], Scott J. Nissen[1], Ryan Wersel[2] and William Ratajczyk[2].
Absorption Rates of 2,4-D Butoxy Ethyl Ester and 2,4-D Amine by Eurasian Watermilfoil.
[1]Colorado State University, Fort Collins, CO and [2]Applied Biochemists: A Lonza Business, Germantown, WI

The rate at which herbicides move from the water column into targeted aquatic weeds is important for several reasons. Rapid herbicide absorption would theoretically shorten the concentration exposure time and allow a herbicide to perform well even in areas with high water exchange or as a spot treatment. The herbicide, 2,4-D, is often recommended for Eurasian watermilfoil (*Myriophyllum spicatum*) management because it is cost effective and selective. The dilemma often faced by applicators is whether to make whole lake treatments at reduced rates or high rate applications as spot treatments. The objective of this project was to determine the rates of 2,4-D absorption as a function of the two most popular formulations, butoxy ethyl ester (BEE) and amine, to provide applicators with some research based information about herbicide behavior as a function of formulation. Herbicide absorption was evaluated over a time course of 192 hours using ^{14}C 2,4-D acid mixed with commercial 2,4-D amine or ^{14}C 2,4-D BEE mixed with cold herbicide both at a rate of 1 μg mL^{-1}. The amine formulation of 2,4-D showed a near linear increase in absorption without reaching maximum 192 hours after treatment (HAT), while 2,4-D BEE reached maximum absorption in the first 6 HAT. Herbicide translocation to milfoil roots was very limited for both formulations. These data suggest that in absence of photo-degradation, 2,4-D BEE is well suited for treating areas with high water exchange and for spot treatment because of rapid absorption. Eurasian watermilfoil treated with 2,4-D amine had slower absorption, but given enough time actually accumulated more herbicide.

Jenifer Parsons[1]*, Peter Rice[2], Mark Porter[3], Mark D. Sytsma[4], Thomas E. Woolf[5], and Jennifer Andreas[6]. **Flowering Rush in the Columbia River System.** [1]Washington Department of Ecology, Yakima WA; [2]University of Montana, Missoula, MT; [3]Oregon Department of Agriculture, Enterprise, OR; [4]Portland State University, Portland, OR; [5]Idaho State Department of Agriculture, Boise, ID; and [6]Washington State University, Puyallup, WA.

Flowering rush (*Butomus umbellatus*) continues to spread through the Columbia River system. Efforts to control its spread and coordinate various entities managing the large river system are challenging and will be highlighted. In addition, an update on a control trial using diquat in Washington and control trials using imazapyr and imazamox in Montana, as well as an update on biocontrol research will be provided.

Jenifer Parsons. **Variable-Leaf Milfoil in Washington. Will We Ever Get to Eradication?**
Washington Department of Ecology, Yakima, WA

Control of variable-leaf milfoil (*Myriophyllum heterophyllum*) in 5 Washington lakes began with state funding in 2009. One lake with a small initial population has seen successful eradication using hand methods. The other four still host reduced but persistent populations. A combination of herbicides including triclopyr, diquat and 2,4-D, have been tried over the years, with varying levels of success. Three lakes have been reduced to spot treatment and hand control. The fifth lake, where we have had the most trouble reducing the population, has a short residence time, making efficacious treatment with herbicides more challenging.

Paul D. Pratt[1]*, Mike Pitcairn[2], and Patrick Moran[3]. **Biological control of water hyacinth: status and future prospects**. [1]USDA-ARS Riverdale MD, [2]California Department of Food and Agriculture, Sacramento, CA, [3]USDA-ARS, Albany, CA.

The Sacramento-San Joaquin River Delta is a critical water resource in draught stricken northern California. Services provided by the Delta are severely limited as a result of water hyacinth (*Eichhornia crassipes)*. Three biological control agents were released in 1983 and a fourth was released in 2013. Little is known concerning which of these insects established persistent populations or their resulting distributions across the complex and dynamic aquatic landscape. Monthly surveys of 16 locations across the Delta were initiated in June 2015. Samples to date indicate that only a single biological control agent is uniformly established throughout the Delta: the weevil *Neochetina bruchi*. Densities of the weevil vary widely over time, with populations experiencing local extinctions in areas when mobile host plants were transported out of the system or during winter when host plants degraded due to cold damage and submerged below the water surface. Highest population densities of *N. bruchi* were observed in the fall (September), reaching nearly 6 individuals (adults and larvae) per plant when averaged across all sites. Variation among sites was also observed, with peak weevil densities of 17.6 weevils at site 14 in September while the nearby site 4 (~ 20 km) peaked at 3.2. As reported previously, *Megamelluss cutallaris* is also established at a single site (Folsom Lake) but has not dispersed into other regions. Hypotheses are presented to explain patterns in species establishment, *N. bruchi* distribution, and mechanisms to improve biological control.

Robert J. Richardson[1]*, Michael Netherland[2], Erika Haug[1], and Mark A. Heilman[3].
Evaluating the Sensitivity of Representative Aquatic Plants to Procellacor™ Herbicide.
[1]North Carolina State University, Raleigh, NC: [2]USACE, Gainesville, FL; and [3]SePRO Corporation, Carmel, IN

New herbicide chemistry is currently under development for aquatic weed management. 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)-5-fluoro-pyridine-2-benzyl ester (common name pending) is identified as the active or in formulated forms for aquatic use as Procellacor™. Greenhouse research at NC State University was conducted to evaluate the effect of Procellacor and an acid metabolite on seven aquatic plant species: alligatorweed [*Alternanthera philoxeroides* (Mart.) Griseb.], Carolina waterhyssop [*Bacopa monnieri* (L.) Pennell], fanwort (*Cabomba caroliniana* Gray), monoecious hydrilla [*Hydrilla verticillata* (L. f.) Royle], parrotfeather [*Myriophyllum aquaticum* (Vell.) Verdc.], variable watermilfoil (*Myriophyllum heterophyllum* Michx.), and American waterwillow [*Justicia americana* (L.) Vahl]. In-water applications of Procellacor (as 300 gL^{-1} SC) and its acid metabolite (analytical grade material) were applied at rates of 0 to 81 μgL^{-1}. Fanwort was not controlled by Procellacor at the rates tested, in contrast to the other species evaluated. Dry weight 50% effective concentration (EC_{50}) values were < 1 μgL^{-1} of Procellacor for alligatorweed, monoecious hydrilla, parrotfeather, and variable watermilfoil. Carolina water hyssop and American waterwillow EC_{50} values for Procellacor were 5.0 μgL^{-1} and 5.2 μgL^{-1} respectively. These six species were less sensitive to the acid metabolite with dry weight EC_{50} values of 1.6 μgL^{-1} to 77.1 μgL^{-1}. Plant control ratings also indicated that response of the six sensitive species increased from 2 to 4 weeks after treatment. Overall, Procellacor appears to provide highly effective control of some of the most troublesome invasive aquatic plants in the US.

Bob L. Robinson. **Aeration as a Lake Management Tool**. Kasco Marine, Minneapolis, MN

Aeration and circulation have long been used effectively my lake managers to accomplish improvements in overall water quality. In the last 30 years there have been many additions concerning product offerings as well as those offering product.
This talk will focus on techniques, successes, failures, recent outside of the box applications, as well as what aeration can and cannot do. It must be understood that aeration is only one of the tools in the toolbox for aquatic managers. When used appropriately and in many cases in combination with other treatment techniques, successes can be achieved.

Patrick A. Simmsgeiger. **Bridging the Gap Between Chemical & Biological Treatments in Aquatic Environments**. Diversified Waterscapes Inc., Laguna Niguel, CA

Undesirable Aquatic plants can have a plethora of undesirable effects on aquatic ecosystems. These negative effects run the gamut from aesthetic, such as unatractive water coloration and foul odors, to the ecological, including lowered D.O. levels and interruption of natural food chain. The solution has been the application of herbicide to achieve high degrees of success. Knowing this, we intend to show how we cut the costs of herbicide application without sacrificing overall effectiveness. In our study, we demonstrate how combination of the herbicide, algaecide and biological products have achieved the same degree of efficacy while using lower doses of herbicide. By achieving this, we have ensured the most cost-effective and potent treatment to maintain a balanced aquatic ecosystem.

Mark D. Systma. ***Bacopa rotundifolia* in the Columbia River: to kill or not to kill?** Portland State University, Portland, OR

Bacopa rotundifolia, disk water hysop, was recently found in the Columbia River near McNary Dam. This species has not been reported in Oregon or Washington previously. The plant is considered native and imperiled in Idaho and Montana, upstream of the McNary Dam population. The plant has exhibited weedy characteristics in rice fields in California. The new population of *B. rotundifolia* poses some management questions. Is this a natural range expansion or is it the result of an intentional introduction that could become invasive? Should the newly discovered population be eradicated? This presentation will end with an open discussion of these questions to inform management decisions.

Tom M. Warmuth**. Developing Effective Use Patterns For Peroxide Based Algaecides (GreenClean Liquid 5.0 and GreenClean PRO).** BioSafe Systems, Kernersville, NC

As use and regulatory restrictions on copper algaecides increase and some local governments have banned the use, it is becoming ever more important to find and develop alternative treatments for control of nuisance algae growth. Biosafe Systems offers several peroxide based algaecides that give applicators alternatives to copper where restrictions are in place, however the labeled usage rates are very broad, making selection of an appropriate rate difficult. The objective of this project was to begin developing effective usage patterns for GreenClean algaecides to target benthic and floating filamentous, blue-green algae). Two sites of similar size and algae community were selected for the treatment. One received a high label rate of GreenClean Pro (85% sodium carbonate peroxyhydrate) followed by a mid-label rate of GreenClean 5.0 (5% peroxy acetic acid). The second site was treated with a mid-label rate of GreenClean Pro followed by a lower-label rate of GreenClean 5.0. Both treatments were followed up 48 HAT by treatments with the lower label rate of GreenClean 5.0. Efficacy was assessed by percent algal coverage of both benthic sediments and the water surface at weekly intervals after the treatment until regrowth was observed.

Paul Westcott[1]*, Ryan M. Wersal[1], Gray Turnage[2], William Ratajczyk[1], and Harry Knight[1]. **The Use of Copper EDA for Aquatic Plant Management in Reservoirs in the Southern United States**. [1]Applied Biochemists: A Lonza Business, Germantown, WI, and [2]Mississippi State University, Starkville, MS

Copper EDA (ethylenediamine complex) has been a tool in aquatic plant management for many years primarily as a tank mix partner with diquat for control of hydrilla. Though effective, this combination tends not to be very selective in mixed aquatic plant communities. Over the past several years we have worked to establish use patterns for copper EDA treatments for hydrilla control in both small and large scale applications that could offer more selectivity than combination treatments. We have also established more non-selective use patterns for copper EDA treatments in drinking water reservoirs where nuisance relief of mixed aquatic plant communities is desired. In mesocosm trials, copper EDA liquid alone at both 0.5ppm and 1.0 ppm provided 80% control of hydrilla, while American lotus increased in biomass. These same concentrations provided 60-75% when applied under operational conditions in Pickwick Lake, AL. Copper EDA has been used in the Ross Barnett Reservoir, MS in a maintenance management program since 2010 where hydrilla has been kept to between 0.6 and 1.5% frequency occurrence with little to no tuber production. In Calafornia, a granular copper EDA was used in a 5 acre plot at a concentration of 0.75 ppm on a mixed native plant community resulting in 60-80% and nuisance relief. In this demonstration a differential response between species was observed; (from least tolerant to tolerant) *P. crispus*, *P. foliosus*, *M. spicatum*, and *P. richardsonii*. These small and larger scale treatments indicate that copper EDA can be used alone or in a rotational program for a variety of aquatic plant management situations.

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