RECLAMATION

Managing Water in the West

Nuisance Aquatic Vegetation Control in Water Delivery Systems: mapping and monitoring vegetation biomass

Research and Development Office
Science and Technology Program
(Final Report) ST-2017-1725 -01

U.S. Department of the Interior
Bureau of Reclamation

September 2017

Mission Statements

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REPORT DOCUMENTATION PAGE		*Form Approved* *OMB No. 0704-0188*
T1. REPORT DATE: SEPTEMBER 2017	**T2. REPORT TYPE:** RESEARCH	**T3. DATES COVERED**
T4. TITLE AND SUBTITLE Nuisance Aquatic Vegetation Control in Water Delivery Systems: mapping and monitoring vegetation biomass		**5a. CONTRACT NUMBER** **RY154WS201521725**
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER 1541 (S&T)
6. AUTHOR(S) Dale Lindeman Bureau of Reclamation Pacific Northwest Regional Office 1150 N. Curtis Road Boise ID 83706		**5d. PROJECT NUMBER** ST-2017-1725-01
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER PN-6605
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Dale Lindeman, Bureau of Reclamation, Pacific Northwest Region		**8. PERFORMING ORGANIZATION REPORT NUMBER** NA
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Research and Development Office U.S. Department of the Interior, Bureau of Reclamation, PO Box 25007, Denver CO 80225-0007		**10. SPONSOR/MONITOR'S ACRONYM(S)** **R&D:** Research and Development Office **BOR/USBR:** Bureau of Reclamation DOI: Department of the Interior
		11. SPONSOR/MONITOR'S REPORT NUMBER(S) ST-2017-1725-01

12. DISTRIBUTION / AVAILABILITY STATEMENT
Final report can be downloaded from Reclamation's website: https://www.usbr.gov/research/

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 words)*
This study tested and assessed the feasibility of using recreational-grade sonar mounted on a small, remote-controlled boat as a tool for mapping nuisance aquatic vegetation (NAV) in irrigation canals. The expectation was that survey information could enhance NAV treatment planning effectiveness. Study results showed that the methodology was inefficient for canal surveys. Additionally, the algorithm used for calculating bio-volume was not applicable in canals. Small, wireless sonar devices developed for anglers may be a potential alternative to rake surveys. Comparing the two methods would determine which provides the most benefit.

15. SUBJECT TERMS Nuisance aquatic vegetation, irrigation canal, sonar

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT** U	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Dale Lindeman
a. REPORT U	**b. ABSTRACT** U	**c. THIS PAGE** U			**19b. TELEPHONE NUMBER** 208-378-5320

S Standard Form 298 (Rev. 8/98)
P Prescribed by ANSI Std. 239-18

BUREAU OF RECLAMATION

Research and Development Office
Science and Technology Program

GIS and Remote Sensing, Pacific Northwest Region

(Final Report) ST-2017-1725-01
Nuisance Aquatic Vegetation Control in Water Delivery Systems: mapping and monitoring vegetation biomass

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Executive Summary

Sonar equipment developed and produced for use by anglers and recreational boaters is increasingly being used as a cost-savings means to conduct aquatic surveys; primarily bathymetric. A methodology of mapping vegetation in waterbodies (e.g., lakes, reservoirs, and large ponds) using recreational-grade sonar has been developed and offered as commercial services; surveys, and data processing. This study tested and assessed the feasibility of using this methodology as a tool for mapping nuisance aquatic vegetation (NAV) within large canals delivering irrigation water. Recreational-grade sonar equipment was mounted on a small, remote-controlled boat in order to navigate the relatively constrained survey area of an irrigation canal. The purpose of this mapping effort was to gather information on the amount and distribution of NAV within a water delivery system. The expectation was that the information could enhance treatment planning and result in more efficient and effective NAV control.

Though the technology was easily transferred by scaling down the platform from a full-sized boat, the efficiency of the methodology did not translate into the new application. The return on effort, in terms of ratio of survey time to area surveyed, was perceptively far lower for canal surveys than for those conducted in other waterbodies. Additionally, the algorithm used for calculating plant bio-volume is based on plant characteristics in water bodies. Processing data collected in areas of flowing water would not yield accurate bio-volume estimates.

This study tested an areal survey approach to mapping NAV in canal systems. The standard method of rake surveys, sampling at intervals along the canal, is a more efficient method of data collection and may be the best approach. A potential alternative to rake surveys are small, wireless sonar devices developed for anglers; these are baseball-sized and the shape of a bobber. Comparing information gained from the wireless unit with that of current rake surveys, would determine whether it provides additional benefit in tracking NAV growth rate and development within a canal system.

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Introduction

This study sought to develop affordable, cost-effective tools that could provide managers of irrigation entities the means to monitor nuisance aquatic vegetation (NAV) in water delivery systems (canals and associated water bodies). The premise was that information on location and quantity of NAV within the water delivery system would lead to more efficient and effective NAV control. Essentially, “what, when, where, and how” are critical considerations managers make in optimizing treatment of the target NAV, maintaining environmental quality, and allocating limited operational and management resources.

Background

The Western United States is highly dependent on a network of reservoirs and delivery canals for agricultural water distribution. Widespread and dense growth of NAV in these water delivery systems greatly reduces or completely obstructs the flow of water. In addition, NAV can impair the performance of intake structures and pumps or otherwise cause serious damage to structures and equipment. In order to maintain adequate flows and avoid damage, canal operators and irrigation districts must employ physical labor to remove plant material from the systems or purchase and apply aquatic herbicides. These continual NAV control efforts are becoming increasingly costly and difficult to implement. Tracking and mapping NAV growth in water delivery systems would provide information on the distribution, density and growth stage of NAV which could be directly applied to improving control within a water delivery system.

A scoping project was undertaken to identify comprehensive solutions for NAV control (Lindeman 2014). Initially, the goal was to acquire adequate information to develop a research plan that identifies conditions and factors which influence NAV growth and distribution. The hypothesis was that manipulating modifiable influences of the growth-environment could serve as alternatives or complimentary methods to discourage NAV growth, minimize herbicide use, and reduce control costs. Previous research has shown relationships exist between environmental variables and proliferation of NAV. Nevertheless, the scoping project team concluded that translating these findings into implementable actions would not lead to practical, cost-effective solutions for controlling NAV. Information gathered over the course of the scoping effort suggested mapping NAV growth and distribution in water delivery systems would provide useable information that could be directly applied in improving existing management approaches of herbicide treatment. Since this project was undertaken, these concepts have been developed into commercial services – survey and treatment applications for NAV within large waterbodies (e.g., BioBase and UPI Treatment Tool, Clean Lakes Inc. aquatic ecosystem and monitoring, SePRO SeMAPS system). Similar services have not been developed for flowing surface water systems.

The prototype developed in this was study was based on techniques used by the Central Arizona Project (CAP) to map NAV distribution and density within an area of Lake Havasu impacting the Mark Wilmer pumping plant intake channel (Figure 1). Sonar data was collected along a series of transects within the survey area using a 15-foot motorboat equipped with a LowranceTM FishFinder. The sonar data was then uploaded to an online data processing service. Resultant bathymetry and bio-volume data products were generated and made viewable online. The Mark Wilmer pumping plant is a component of the water delivery system for both Phoenix and Tucson. As such, mechanical removal of NAV as a means of control is required in lieu of chemical treatment in this domestic water supply. The bio-volume maps identified areas that required attention from the NAV removal team.

Figure 1. CAP NAV survey area on Lake Havasu, Arizona.

Methods

The CAP survey technique was applied in this study by mounting a LowranceTM Elite-7 Chirp Fishfinder and 50/200 kilohertz (kHz) thru-hull, flush-mount transducer on a 48-inch catamaran style gas-powered remote control boat (Figure 2). This remotely-piloted system (RPS) used the same sonar equipment, data processing, and information products as in the Lake Havasu survey, yet was navigable in canals.

Figure 2. RPS: vehicle, sonar, and navigation controls.

The prototype remotely-piloted vehicle (RPV)[1] was initially field tested in a small pond at the base of Lucky Peak Dam in Ada County, Idaho. These field tests where used to tune carburation and become familiar with navigational settings and controls prior to operating the RPV in a swift-water environment. After completing initial field tests, the RPV was operated within two 900-meter (2,953-foot) reaches of the New York Canal in Ada County, Idaho (Figures 3 and 4) to collect data. Survey site selection took public exposure into consideration to avoid drawing attention, particularly to what could appear as using hobby craft within the canal. Local safety initiatives warn people not to play in or around canals. This message was emphasized in an interview conducted and aired by local media. Within these reaches, the canal averages 26 meters (86 feet) in width and 3.5 meters (8 feet) in depth. Maximum flowrate in the canal is 2,400 cubic feet per second.

[1] Remote-controlled boat (RC boat) is referred to as a remotely-piloted vehicle (RPV) to differentiate it from a hobby craft and promote it as equipment. A remotely-piloted system (RPS) is a collection of equipment, in this case, vehicle, sonar, and navigational radio controls. Industry would call it an unmanned surface vehicle/vessel (USV).

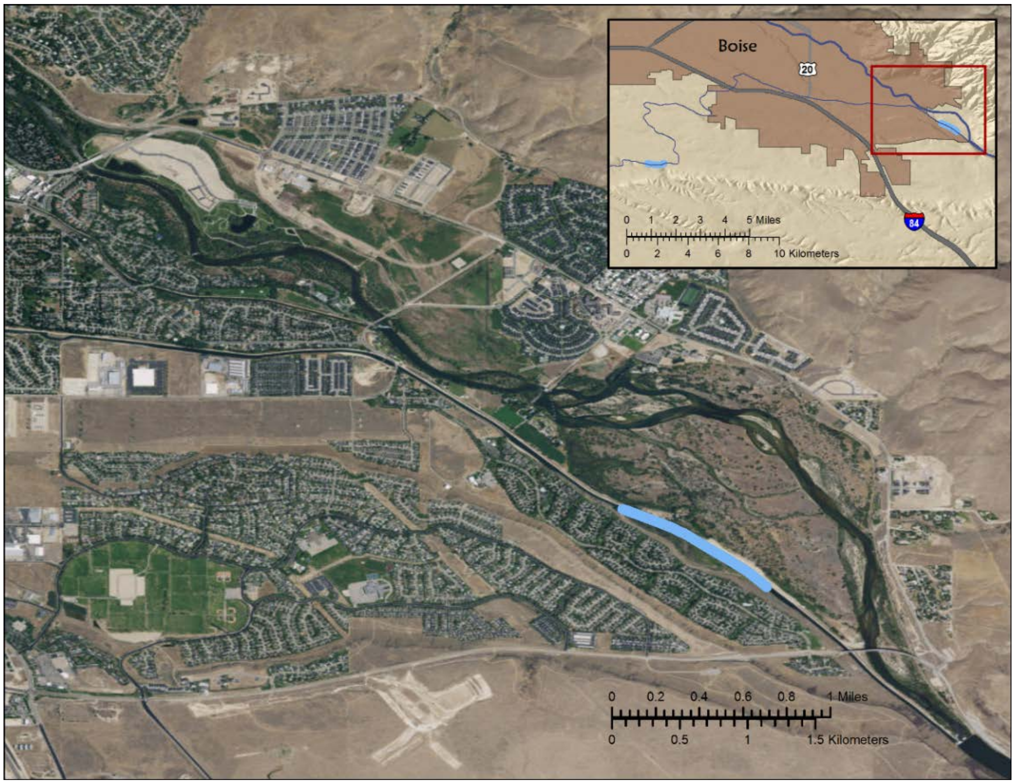

Figure 3. “MC2” Survey Reach.

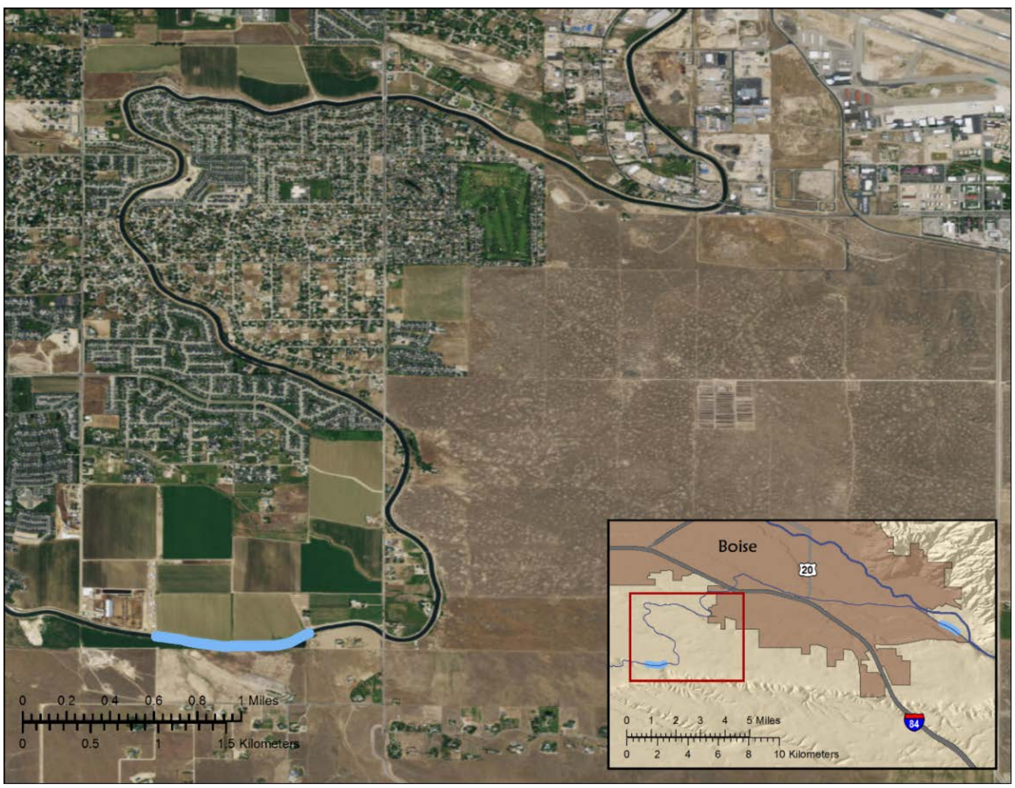

Figure 4. “Third Cole Crossing” Reach.

Sonar equipment settings were adjusted as follows to meet specifications for subsequent data processing (Contour Innovations 2013):

Frequency: 200 kHz

Range: Auto

Bytes per Sounding: 3200

Fishing Mode: Shallow Water

Survey transects were oriented longitudinally in the canal, spaced to collect data across the full width of the canal, and run at less than 12 miles per hour. Data were uploaded for processing following each survey.

Results and Discussion

It was anticipated the contributions of the survey data to planning and decisions for NAV treatments would be the focus of study results. In actuality, RPV design and appropriateness of the survey methodology for use in canals emerged as the ultimate considerations. Result assessments focus on efficiency and cost-effectiveness of implementing and undertaking the approach investigated in this study. Secondarily, results in the performance of the RPV provide factors to consider in using this technology to conduct aquatic surveys in general.

Equipment

Field tests revealed two equipment-related issues – performance of the RPV and the inability of survey crew to interact with the sonar unit while actively collecting data. Performance issues affected data quality and were therefore critical. Survey missions in the canal could be accomplished with sonar unit configurations set at launch and no monitoring during navigation, though this might not hold true for larger streams, waterbodies, or other large scale missions.

RPV Performance

Navigation of the RPV in the canal under high flow conditions could be reasonably controlled, though not adequately enough for quality data collection. The bow of the RPV would raise out of the water during acceleration causing the transducer to deviate from a plane parallel to the canal bottom. False readings of the bathymetry were generated, processed into the data products with skewed interpolations between transects (Figure 5). In lateral profile, processed bathymetry suggests canal bottom and sides form a trapezoid. The deeper contours of the upper-right track are the result of the bow coming up as the RPV, traveling from the upper-left corner down to the lower-right, was accelerated into the current.

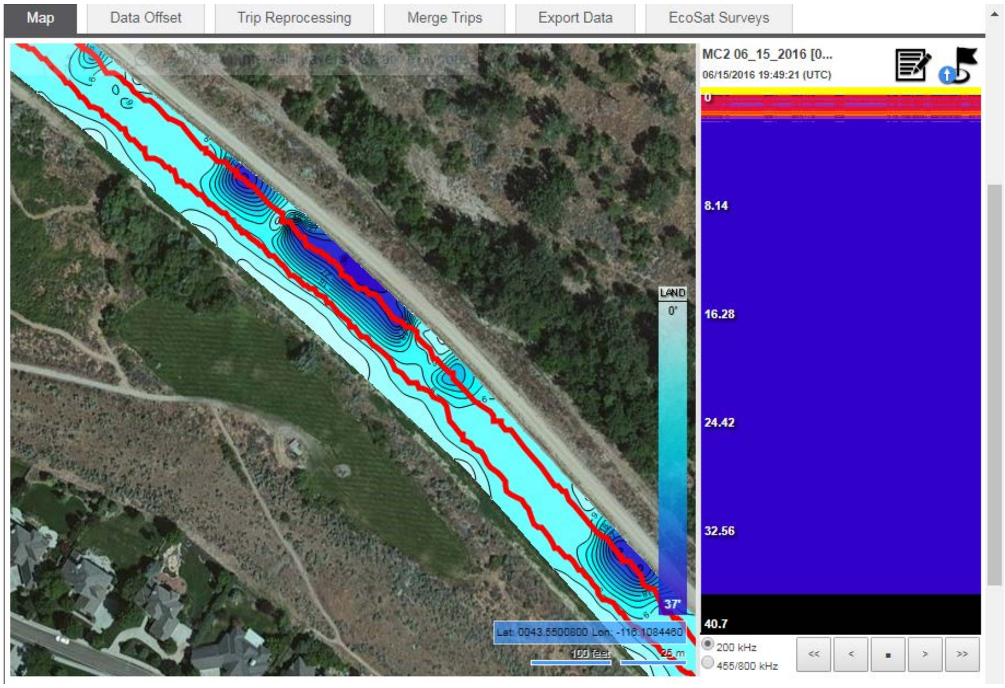

Figure 5. False readings due to transducer angle.

In another run published by C MAP Genesis, the RPV operator coasted the vehicle downstream with the current, parallel attitude to the canal bottom was maintained, and a more realistic representation of the bathymetry was mapped (Figure 6).

Figure 6. Bathymetry results when proper RPV and transducer attitude are maintained.

Attitude issues encountered when operating sonar-enabled RPVs can be corrected using data from an inertial movement unit (IMU) (Giordano et al., 2015), though some researchers find it to be of minor importance in shallow water and unnecessary to correct (Buscombe et al., 2014). Surface water disturbance is a typical cause of attitude issues. In this case, propulsion was the cause of error and should be the focus for solution rather than considering or pursuing IMU corrections. There were also discussions about adding trim tabs or additional weight to the bow of the RPV. Nevertheless, directly addressing the propulsion is likely the best solution.

The RPV used in this study was a commercial off-the-shelf product with a gas-powered, single propeller propulsion system. A gas-powered RPV was selected over an electric powered model for the benefit of longer run time. However, the propulsion system proved to be a navigational disadvantage because the small-engine throttle was not sensitive enough to counter flow velocity without a surge in acceleration resulting in pitch. Commercially produced vehicles for use in aquatic and marine survey are typically equipped with electric powered, twin-thruster propulsion systems. This type of propulsion is associated with robotics (e.g., www.bluerobotics.com) while propellers, both engine- and motor-driven, are dominant in the hobby craft industry. Options for motor size allow tailoring overall power of the RPV, twin thrusters provide more power and maneuverability than a single-prop design, and control of power to the motors can be more measured than a carburetor throttle mechanism.

Sonar Control

With typical use of recreational sonar, the operator is on-board navigating the craft, monitoring the sonar, making navigational adjustments based on screen output, and possibly tuning sonar settings in order to use the full functionality of the unit. The system used in this study lacks the wireless capability for users to operate the sonar from shore, whereas commercial-grade sonar and unmanned surface vehicles (USV) have this capability. The capability is useful in monitoring progress and status of the mission and particularly, assuring the survey is being conducted effectively (i.e., data collection proceeding with proper settings and transect spacing). Though possible to develop (Giordano et al., 2015, Klemens 2017), such a system requires specialized, advanced skills and seems not to be widely reported as being undertaken in “build” projects.

Data

Consistent with the CAP NAV survey techniques, the ciBioBase data processing subscription was used for data processing and viewing. Their data products include bathymetry, biovolume heat mapping, and bottom hardness (composition). Considering the objectives of this study, the service is useful for irrigation districts who do not have data processing capabilities or would otherwise use the service out of convenience.

Biovolume maps, the data product of interest in this study, are processed using the geostatistical procedure of kriging (Contour Innovations 2013, C-Map 2017). Soundings are read (to a minimum depth of 2.4 feet) and processed into a raster of 1-meter resolution. Of particular importance to this study, biovolume is calculated as “percent volume inhabited” and based on plant height to water depth (Contour Innovations 2013, C-Map 2017).

Waterbodies generally do not have an appreciable flow of water that would force aquatic vegetation from an upright tendency in the water column. In contrast, flowing water will force submerged aquatic vegetation into a recumbent position; to what extent depends on factors such as the force of the water and buoyancy, rigidity, and surface area of the plant. Under these circumstances, biovolume estimates using vertical relationship of plant to water could be misleading. The premise of this study was that monitoring biovolume on a regular basis would provide information on rate and stages of NAV growth that could in turn be applied in refining NAV treatment plans. Data processed with an algorithm based on a plant to height ratio might under report growth rate, or fail to detect it entirely. This lead to considerations about data processing in general.

Data collected with recreational grade sonar are written into proprietary format specific to the manufacturer of that unit. Access to the raw data is blocked and processing is limited to the services and immutable algorithms provided by the manufacturer. There are third-party software programs that read and process data collected with recreational-grade sonar, though with cost and limited functionality. Open-source software has been developed to read, export, display, and analyze data collected with Humminbird TM sonar equipment, and being open-source, can be customized by users (Buscombe et al. 2016, Buscombe 2017). The software is being updated to include processing capabilities for LowranceTM file formats (D. Buscombe, personal communication, August 24, 2017).

Conclusions and Recommendations

This study sought to develop an affordable, cost-effective tool managers of irrigation entities could use to monitor the location and quantity of NAV in canals delivering irrigation water. It was thought the information could lead to more efficient and effective NAV control. The study focused testing and assessing the feasibility of using an RPV equipped with recreational-grade sonar to serve as such a tool. Focus shifted to applicability of the survey method and RPV performance issues.

Though the survey method was found to be inefficient for use in canals, the need for informative survey techniques for NAV in canals remains to be addressed. Small, wireless sonar units identified late in this study have potential for use in NAV and sedimentation survey. These applications will be independently investigated (M. Meyers, personal communication, September 11, 2017). At minimum, a systematic approach to rake surveys would be beneficial.

Unmanned surface vehicles for aquatic survey are a promising technology for use in conducting various types of survey in water bodies (i.e., reservoirs). High equipment costs force centralization of services for economy; yet due to logistics, may in turn discourage local applications of this technology. Encouraging the technical capacity to develop USV resources and capabilities could lead to more widely distributed and resident resources based on need. Unmanned surface vehicle development is often a component of programs or projects using the technology (Giordano et al. 2015, Holden n.d., Klemens 2017, Van Retergem 2016) and resources are available through a wider community (BlueRobotics n.d.).

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