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Mussel Literature Review/Synthesis

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Acronyms and Abbreviations

SME = Subject Matter Expert

Executive Summary

When mussels were first detected at Lake Mead 2007, it was suggested that a comprehensive literature review or synthesis to capture, in one place, all of the most current available technologies pertinent to invasive mussels was needed. The objective of this project was to create such a resource that is regularly updated which would continually inform Reclamation's mussel research direction going forward. A comprehensive literature review was conducted and entered into an accessible database, Mendeley. The PI and his team conducted a comprehensive literature search and compiled an extensive invasive mussel on past research and available technologies. When possible, a full text PDF and all references on invasive mussel biology, spread, and control from scientific literature and government reports were collected for this project. This Mussel Literature Synthesis database will include key word search capability and will be easily updated by the RDLES team in the future. Team members have also pursued other database share options such as Zotero, SharePoint, or a Share Drive location to ensure easy access for all SMEs. A final platform for the literature database has not yet been decided upon. A current bibliography will be available to the Research and Development Office, as well as other SMEs within Reclamation.

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Main Report

When mussels were first detected at Lake Mead 2007, one early suggestion was to conduct a comprehensive literature review or synthesis to capture, in one place, the available technologies pertinent to invasive mussel management. The objective of this project was to create such a literature resource that is regularly updated with the latest research and available technologies involving invasive mussels. The goal of this comprehensive literature review of synthesis is to capture, in one place, as much available information as possible on past research and available technologies pertinent to detection, biosuitability, and management and control of invasive mussels. This resource will be maintained and regularly updated to provide the most current information to Reclamation decision makers of invasive mussel research.

A comprehensive literature review was conducted and entered into an accessible database, Mendeley. The PI and his team conducted a comprehensive literature search and compiled an extensive invasive mussel on past research and available technologies. When possible, a full text PDF and all references on invasive mussel biology, spread, and control research from scientific literature and government reports were collected for this project. Over 70 mussel related publications have been compiled in the mussel literature database, and the current list is attached in this report. The current bibliography will be available to the Research and Development Office, as well as other SMEs within Reclamation.

This Mussel Literature Synthesis database will include key word search capability and will be easily updated by the RDLES team in the future. The data currently resides in Mendeley; however, team members have pursued other database share options such as Zotero, SharePoint, or a Share Drive location to ensure easy access for all SMEs. At the time of this report, the final literature database platform has not been decided upon. However, the PI is leaning towards Zotero due to the capability of the program and the needs of the agency. The final product will be made available to the Research and Administration Office, as well as other SMEs within Reclamation.

FY2016 Literature References

- Ackerman, J.D., Sim, B., Nichols, S.J., and Claudi, R. (1994). A review of the early life history of zebra mussels (*Dreissena polymorpha*): comparisons with marine bivalves. *Canadian Journal of Zoology* 72, 1169–1179.
- Ackerman, J.D., Ethier, C.R., Spelt, J.K., Allen, D.G., and Cottrell, C.M. (1995). A wall jet to measure the attachment strength of zebra mussels. *Canadian Journal of Fisheries and Aquatic Sciences* 52, 126–135.
- Ackerman, J.D., Cottrell, C.M., Ethier, C.R., Allen, D.G., and Spelt, J.K. (1996). Attachment Strength of Zebra Mussels on Natural, Polymeric, and Metallic Materials. *Journal of Environmental Engineering* 122, 141–148.
- Afanasyev, S., Shcherbak, S., Gusak, P., Ross, S., and Gromova, J. (2005). Technology for Eliminating *Dreissena* Biofouling in Hydrofacilities. *Water Quality Research Journal of Canada* 142–148.
- Aldridge, D.C., Elliott, P., and Moggridge, G.D. (2006). Microencapsulated BioBullets for the Control of Biofouling Zebra Mussels. *Environ. Sci. Technol.* 40, 975–979.
- Anderson, M.A. (2010). Risk Assessment and Response Plan for Zebra Mussels (*Dreissena polymorpha*) and Quagga Mussels (*Dreissena bugensis*) in Lake Elsinore and Canyon Lake (Lake Elsinore & San Jacinto Watersheds Authority).
- Bender, M.D. (2010). Zebra and Quagga Mussel Scoping to Incorporate Mussels in Flow and Water Quality Models (US Bureau of Reclamation).
- Britton, D.K., and Dingman, S. (2011). Use of quaternary ammonium to control the spread of aquatic invasive species by wildland fire equipment. *Aquatic Invasions* 6, 169–173.
- Broderick, S., and Hosler, D. (2012). Biological Suitability of Rye Patch Reservoir for Dreissenid Mussel Infestation (US Bureau of Reclamation).
- Campbell, T., Verboomen, T., Montz, G., and Seilheimer, T. (2016). Volume and contents of residual water in recreational watercraft ballast systems. *Management of Biological Invasions* 7.
- Carmon, J., Keele, J., Pucherelli, S.F., and Hosler, D. (2014). PCR Detection of Quagga Mussel Intracellular DNA and Dissolved DNA Research and Development Office (US Bureau of Reclamation).
- Chakraborti, R.K., Madon, S., and Kaur, J. (2016). Costs for Controlling Dreissenid Mussels Affecting Drinking Water Infrastructure: Case Studies.

Journal - American Water Works Association 108, E442–E453.

Chandra, S., Wittmann, M., Caires, A., Kolosovich, A., Schladow, G., Moore, J., and Thayer, T. (2009). Quagga Mussel Risk Assessment - An experiment test of quagga mussel survival and reproductive status using Lake Tahoe water with a prediction of invasion into Western water bodies - Google Search (Tahoe Regional Planning Agency).

Chen, D., Gerstenberger, S., Ann Mueting, S., Hing Wong, W., Gerstenberger, S.L., and Mueting, S.A. (2011). Environmental factors affecting settlement of quagga mussel (*Dreissena rostriformis bugensis*) veligers in Lake Mead, Nevada-Arizona, USA. *Aquatic Invasions* 6, 149–156.

Choi, W.J., Gerstenberger, S., McMahon, R., and Wong, W.H. (2013). Estimating survival rates of quagga mussel (*Dreissena rostriformis bugensis*) veliger larvae under summer and autumn temperature regimes in residual water of trailered watercraft at Lake Mead, USA. *Management of Biological Invasions* 4, 61–69.

Claudi, R., and Prescott, K. (2011). Examination of Calcium and pH as predictors of Dreissenid Mussel Survival in the California State Water Project (Prepared for the California Department of Water Resources, Division of Operations and Maintenance, Aquatic Nuisance Species Program).

Claudi, R., and Prescott, T. (2009). Assessment of the Potential Impact of Invasive Mussels on Water and Power System Facilities and Structures and Recommendations for Control-Pueblo Reservoir, Fryingpan-Arkansas Project.

Claudi, R., Graves, A., Taraborelli, A.C., Prescott, R., and Mastitsky, S. (2012). Impact of pH on survival and settlement of dreissenid mussels. *Aquatic Invasions* 7, 21–28.

Claudi, R., Eng, T.P.P., Mastitsky, S., and Coffey, H. (2014). Efficacy of copper based algacides for control of Quagga and Zebra Mussels (RTN Consulting).

Cohen, A. (2009). Managing the exotic mussels *Dreissena polymorpha*, *Dreissena bugensis*, *Limnoperna fortunei* and *Mytilopsis leucophaeata* in SFPUC's Reservoirs (East Bay Municipal Utility District).

Cohen, A.N. (2007). Potential Distribution of Zebra Mussels (*Dreissena Polymorpha*) and Quagga Mussels (*Dreissena Bugensis*) in California: Phase 1 Report (California Department of Fish and Game).

Comeau, S., Rainville, S., Baldwin, W., Austin, E., Gerstenberger, S., Cross, C., and Wong, W.H. (2011). Susceptibility of quagga mussels (*Dreissena rostriformis bugensis*) to hot-water sprays as a means of watercraft decontamination. *Biofouling* 27, 267–274.

Conn, D.B., Ricciardi, A., Babapulle, M.N., Klein, K.A., and Rosen, D.A. (1996).

- Chaetogaster limnaei (Annelida: Oligochaeta) as a parasite of the zebra mussel *Dreissena polymorpha*, and the quagga mussel *Dreissena bugensis* (Mollusca: Bivalvia). *Parasitology Research* 82, 1–7.
- Costa, R., Elliott, P., Saraiva, P.M., Aldridge, D., and Moggridge, G.D. (2008). Development of sustainable solutions for zebra mussel control through chemical product engineering. *Chinese Journal of Chemical Engineering* 16, 435–440.
- Costa, R., Moggridge, G.D., and Aldridge, D.C. (2012). Improved mussel control through microencapsulated BioBullets. In *Operational and Environmental Consequences of Large Industrial Cooling Water Systems*, (Springer), pp. 273–286.
- Culver, C., Lahr, H., Johnson, L., and Cassell, J. (2013). *Quagga and Zebra Mussel Eradication and Control Tactics* (California Sea Grant College Program).
- Davis, C.J., Ruhmann, E.K., Acharya, K., Chandra, S., and Jerde, C.L. (2015). Successful survival, growth, and reproductive potential of quagga mussels in low calcium lake water: is there uncertainty of establishment risk? *PeerJ* 3, e1276.
- De Leon, R. (2008). *The silent invasion: Finding solutions to minimize the impacts of invasive quagga mussels on water rates, water infrastructure and the environment*.
- DiVittorio, J., Grodowitz, M., Snow, J., and Manross, T. (2012). *Inspection and cleaning manual for equipment and vehicles to prevent the spread of invasive species*.
- Edwards, W.J., Babcock-Jackson, L., and Culver, D.A. (2000). Prevention of the spread of zebra mussels during fish hatchery and aquaculture activities. *North American Journal of Aquaculture* 62, 229–236.
- Edwards, W.J., Babcock-Jackson, L., and Culver, D.A. (2002). Field testing of protocols to prevent the spread of zebra mussels *Dreissena polymorpha* during fish hatchery and aquaculture activities. *North American Journal of Aquaculture* 64, 220–223.
- Fears, C., and Mackie, G.L. (1995). *Efficacy of low level electric current (AC) for controlling quagga mussels in the Welland Canal* (Electric Power Research Inst., Palo Alto, CA (United States)).
- Glomski, L.M. (2015). *Zebra Mussel Chemical Control Guide* (Environmental Laboratory, U.S. Army Engineer Research and Development Center).
- Grutters, B.M.C., Verhofstad, M.J.J.M., van der Velde, G., Rajagopal, S., and Leuven, R.S.E.W. (2012). A comparative study of byssogenesis on zebra and quagga mussels: the effects of water temperature, salinity and light–dark cycle. *Biofouling* 28, 121–129.

- Hanna, L. (2014). ISI Cylindrical Screen Performance (US Bureau of Reclamation).
- Heiner, B. (2013). Integration of High-Pressure Jets & Automated Trashrack Cleaners for Mussel Removal (US Bureau of Reclamation).
- Hofius, J., Mandella, C., and Rackl, S.M. (2015). Evaluation of watercraft quagga mussel decontamination in saltwater. *Management of Biological Invasions* 6, 277–286.
- Holdren, C. Factors Affecting the Spread of Dreissenid Mussels in Western Reservoirs.
- Hosler, D. (2013). Improving Accuracy in the Detection of Dreissenid Mussel Larvae (US Bureau of Reclamation).
- Hosler, D.M. (2011). Early detection of dreissenid species: Zebra/Quagga mussels in water systems. *Aquatic Invasions* 6, 217–222.
- Karp, C., and Thomas, R. (2014). Summary of Laboratory and Field Experiments to Evaluate Predation of Quagga Mussel by Redear Sunfish and Bluegill (US Bureau of Reclamation).
- Keele, J., Carmon, J., and Hosler, D. (2014). Optimization of Early Detection of Invasive Mussels with Polymerase Chain Reaction (US Bureau of Reclamation).
- Leuven, R., Collas, F., Koopman, K.R., Matthews, J., and van der Velde, G. (2014). Mass mortality of invasive zebra and quagga mussels by desiccation during severe winter conditions. *Aquatic Invasions* 9, 243–252.
- Link, C. (2014). Demonstration of Biweekly Zequanox Treatments to Control Invasive Mussel Populations at Hoover Dam - Google Search (Marrone Bio Innovations, Inc.).
- Merten, B.J. (2013). Review of Mussel Adhesion Mechanism and Scoping Study (US Bureau of Reclamation).
- Mills, E.L., Rosenberg, G., Spidle, A.P., Ludyanskiy, M., Pligin, Y., and May, B. (1996). A Review of the Biology and Ecology of the Quagga Mussel (*Dreissena bugensis*), a Second Species of Freshwater Dreissenid Introduced to North America. *American Zoologist* 36, 271–286.
- Moffitt, C.M., Stockton-Fiti, K.A., and Claudi, R. (2016). Toxicity of potassium chloride to veliger and byssal stage dreissenid mussels related to water quality. *Management of Biological Invasions* 7, 257–268.
- Molloy, D.P., and Mayer, D.A. (2007). Overview of a Novel Green Technology: Biological Control of Zebra and Quagga Mussels with *Pseudomonas fluorescens*.

- Molloy, D.P., Mayer, D.A., Gaylo, M.J., Morse, J.T., Presti, K.T., Sawyko, P.M., Karatayev, A.Y., Burlakova, L.E., Laruelle, F., Nishikawa, K.C., et al. (2013). *Pseudomonas fluorescens* strain CL145A - a biopesticide for the control of zebra and quagga mussels (*Bivalvia*: *Dreissenidae*). *Journal of Invertebrate Pathology*.
- Montz, G., and Hirsch, J. (2016). Veliger presence in residual water – assessing this pathway risk for Minnesota watercraft. *Management of Biological Invasions* 7, 235–240.
- Mortensen, J.D. (2013). Resistance of Protective Coatings to High Pressure Water Jets for Invasive Mussel Removal (US Bureau of Reclamation).
- Nelson, S.M., and Nibling, F. (2013). Monitoring invasive quagga mussels, *Dreissena rostriformis bugensis* (*Bivalvia*: *Dreissenidae*), and other benthic organisms in a western US aqueduct. *Management of Biological Invasions* 4, 51–59.
- Pucherelli, S.F., Keele, J., and Hosler, D. (2015a). Using Microsatellite Analysis to Track Genetic Changes in Quagga Mussel Populations in the Western United States (US Bureau of Reclamation).
- Pucherelli, S.F., O’Meara, S., Bloom, K., and Kirsch, J. (2015b). Habitat Suitability Parameters for Quagga Mussels in the Lower Colorado River System and at Reclamation Managed Facilities (US Bureau of Reclamation).
- Rager, A. (2015). Scanning Electron Microscope (SEM) Imaging and Anaglyphs of Invasive Mussel Veligers (US Bureau of Reclamation).
- Rochelle, P.A., and Ph, D. (2015). Monoclonal Antibodies for Improved Detection of Quagga Mussel Larvae.
- Schloesser, D.W., and Schmuckal, C. (2012). Bibliography of *Dreissena polymorpha* (Zebra Mussels) and *Dreissena rostriformis Bugensis* (QUAGGA Mussels): 1989 to 2011. *Journal of Shellfish Research* 31, 1205–1263.
- Skaja, A.D. (2014). Durable Foul Release Coatings Final Report 2012-2013 (US Bureau of Reclamation).
- Skaja, A.D. (2015). Coatings for Invasive Mussel Control – Final Report (US Bureau of Reclamation).
- Smythe, G., and Miller, A. (2003). Pulse-Power: A Possible Alternative to Chemicals for Zebra Mussel Control; Summary of 2000 Field Studies (U.S. Army Engineer Research and Development Center).
- Sousa, R., Novais, A., Costa, R., and Strayer, D.L. (2014). Invasive bivalves in fresh waters: impacts from individuals to ecosystems and possible control strategies. *Hydrobiologia* 735, 233–251.

Spidle, A., Mills, E., and May, B. (1995). Limits to tolerance of temperature and salinity in the quagga mussel (*Dreissena bugensis*) and the zebra mussel (*Dreissena polymorpha*). *CANADIAN JOURNAL OF FISHERIES AND AQUATIC SCIENCES* 52, 2108–2119.

Sykes, C.L. (2009a). Efficacy of potassium chloride and formalin for removing quagga mussel veligers from transport tanks at Willow Beach National Fish Hatchery. Final Report to the Lower Colorado River Multi-Species Conservation Program. Bureau of Reclamation, Boulder City, NV.

Sykes, C.L. (2009b). Efficacy of potassium chloride and formalin for removing quagga mussel veligers from transport tanks at Willow Beach National Fish Hatchery.

Sykes, C.L., Caldwell, C.A., and Gould, W.R. (2011). Physiological effects of potassium Chloride, formalin, and handling stress on Bonytail. *North American Journal of Fisheries Management* 31, 291–298.

Tordonato, D.S. (2011). Investigation of Overcoating Coal Tar Enamel with Foul Release Coatings (US Bureau of Reclamation).

Tordonato, D.S. (2015). Foul-Release Coatings Scale-Up Testing — Parker Dam Trashrack.

Tordonato, D.S., and Skaja, A.D. (2011). Investigation of Molybdenum Disulfide and Tungsten Disulfide as Additives to Coatings for Foul Release Systems. 14–14.

Ussery, T.A., and McMahon, R.F. (1994). Comparative Study of the Desiccation Resistance of Zebra Mussels (*Dreissena polymorpha*) and Quagga Mussels (*Dreissena bugensis*). *Proceedings: Fourth International Zebra Mussel Conference* 351–369.

Waller, D.L., Luoma, J.A., and Erickson, R.A. (2016). Safety of the molluscicide Zequanox (R) to nontarget macroinvertebrates *Gammarus lacustris* (Amphipoda: Gammaridae) and *Hexagenia* spp. (Ephemeroptera: Ephemeridae). *Management of Biological Invasions* 7, 269–280.

Watters, A., Gerstenberger, S.L., and Wong, W.H. (2013). Effectiveness of EarthTec(®) for killing invasive quagga mussels (*Dreissena rostriformis bugensis*) and preventing their colonization in the Western United States. *Biofouling* 29, 21–28.

Wells, S.W., Counihan, T.D., Puls, A., Sytsma, M., and Adair, B. (2010). Prioritizing zebra and quagga mussel monitoring in the Columbia River Basin (Bonneville Power Administration and the Pacific States Marine Fisheries Commission).

White, J.D., Hamilton, S.K., Sarnelle, O., and Tierney, K. (2015). Heat-induced mass mortality of invasive zebra mussels (*Dreissena polymorpha*) at sublethal water temperatures. *Canadian Journal of Fisheries and Aquatic Sciences* 72, 1221–1229.

Wong, W.H., and Gerstenberger, S. (2011). Quagga mussels in the western United States: Monitoring and Management. *Aquatic Invasions* 6, 125–129.

Wong, W.H., Gerstenberger, S., Miller, J.M., Palmer, C., Moore, B., Gerstenberger, S.L., and Palmer, C.J. (2011). A standardized design for quagga mussel monitoring in Lake Mead, Nevada-Arizona A standardized design for quagga mussel monitoring in Lake Mead, Nevada- Arizona. *Aquatic Invasions* 6, 205–215.

Wong, W.H., Gerstenberger, S., Baldwin, W., and Moore, B. (2012). Settlement and growth of quagga mussels (*Dreissena rostriformis bugensis* Andrusov, 1897) in Lake Mead, Nevada-Arizona, USA. *Aquatic Invasions* 7, 7–19.

Wright, D.A., Setzler-Hamilton, E.M., Magee, J.A., Kennedy, V.S., and McIninch, S.P. (1996). Effect of Salinity and Temperature on Survival and Development of Young Zebra (*Dreissena polymorpha*) and Quagga (*Dreissena bugensis*) Mussels. *Estuaries* 19, 619–619.