Hydro-Optic

Water treatment with HOD UV technology

October, 2016

Imagination at work

GE Proprietary Information—Class III (Confidential)
Export Controlled—U.S. Government approval is required prior to export from the U.S., re-export from a third country, or release to a foreign national wherever located.

Macro & Micro bio-fouling & bio-corrosion problem

3.1 M$

Cost of zebra mussels alone in the 1993-1999 period in the US
Source: US Congressional researchers

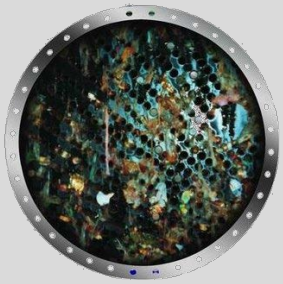
376,000 $

Annual impact of zebra mussels per generating station in Canada
Source: Ontario Hydro

250-300 M$

Annual cost if zebra & quagga mussels invade the Columbia River
Source: 2012, US Fish & Wildlife service

Heat exchanger
Macro-bio-fouling



Cut tubes
Corrosion &
Bio-fouling

Invasive species cause significant $$$ in economic & environmental damage

See tutorial regarding confidentiality disclosures. Delete if not needed.

Proven control for macro & micro bio- fouling and bio-corrosion

AQUATIC INVASIVES SPECIES

Mussels (zebra, quagga, clams, barnacles)

- Enter cooling water circuit

➔ **Flow blockage**

ALGAE

Hydrozoa Cordylophora caspia

IRON BACTERIA

FERO BACTERIA

- Attach to the heat exchanger or water lines

➔ **Heat transfer coefficient drop**

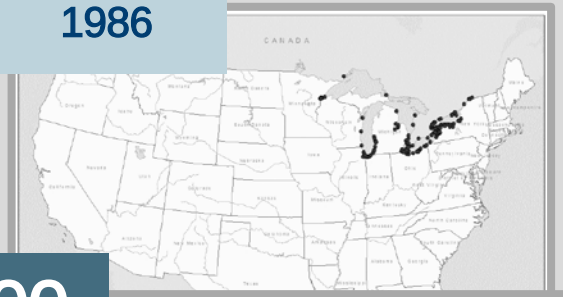
➔ **Unexpected cleaning increase**

Decrease in availability & revenue - Increase in maintenance cost

See tutorial regarding confidentiality disclosures. Delete if not needed.

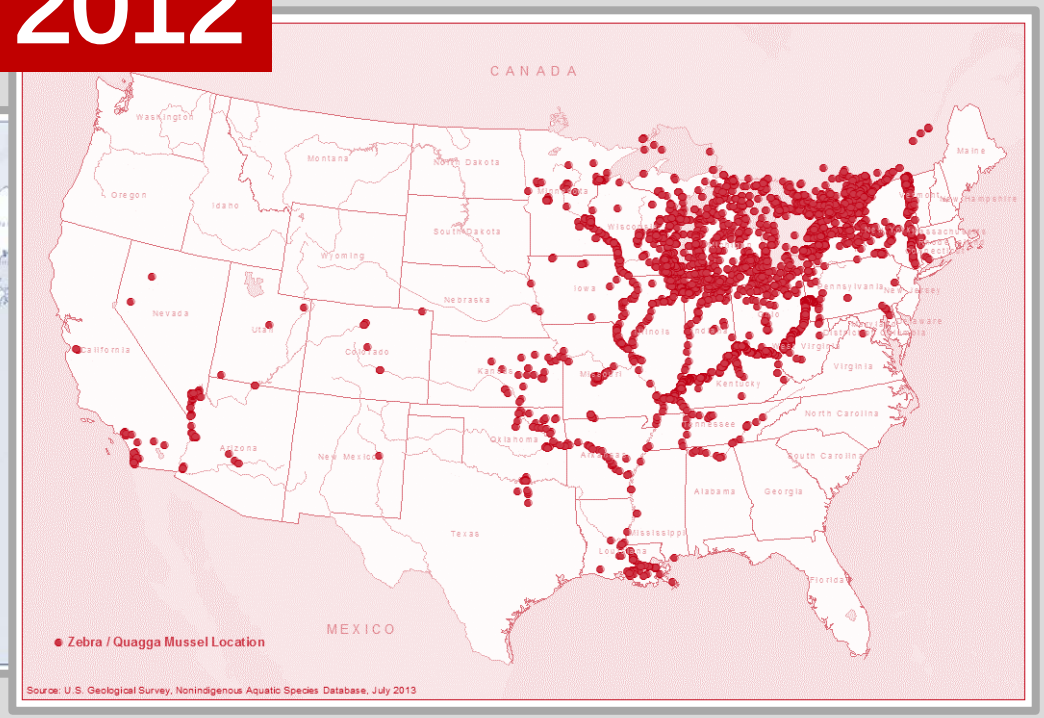
Aquatic Invasive Species (AIS) growth problem | North America

1986



2000

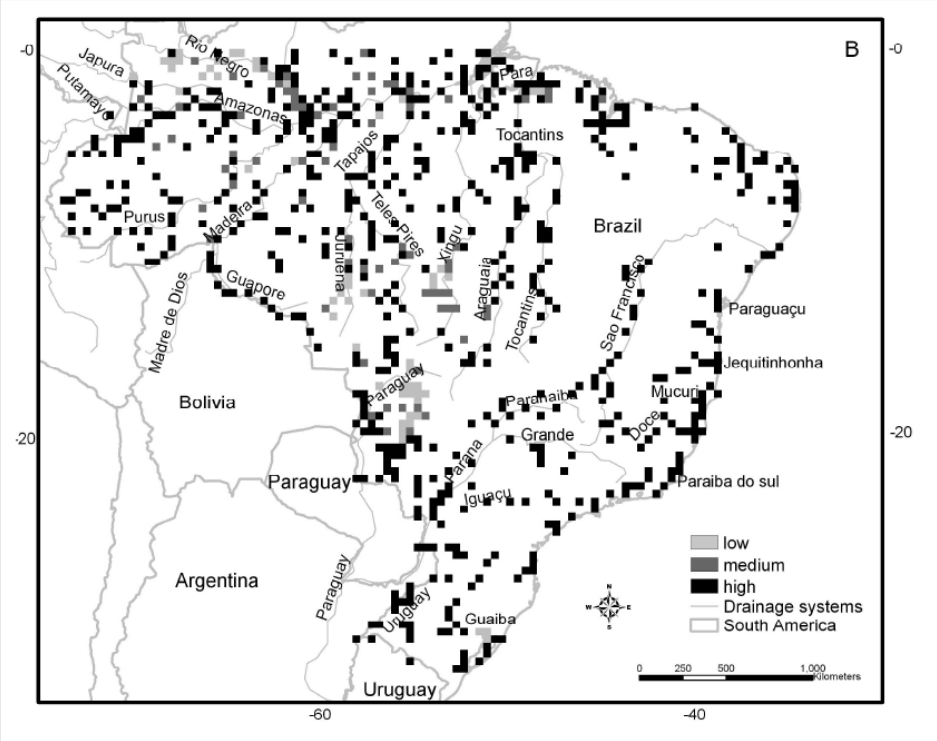
2012



A fast growing threat in North America since 1990

Macro & Micro bio-fouling & bio-corrosion problem | South America

South America

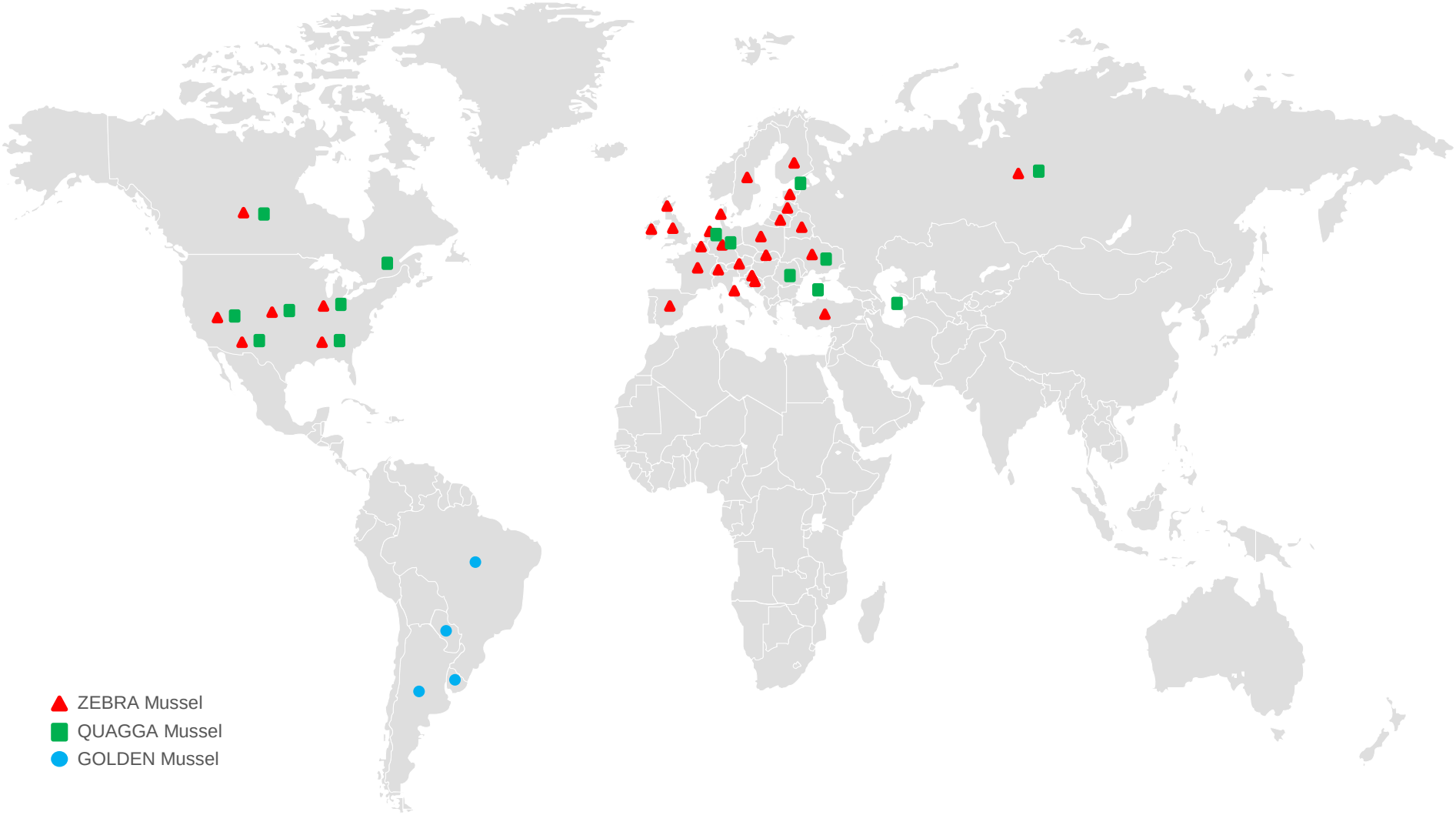


Argentina

Introduced in Argentina in 1991 → spread upriver at a rate of 240 km per year

Currently established in 5 south American countries

Invasive species DISTRIBUTION - World map



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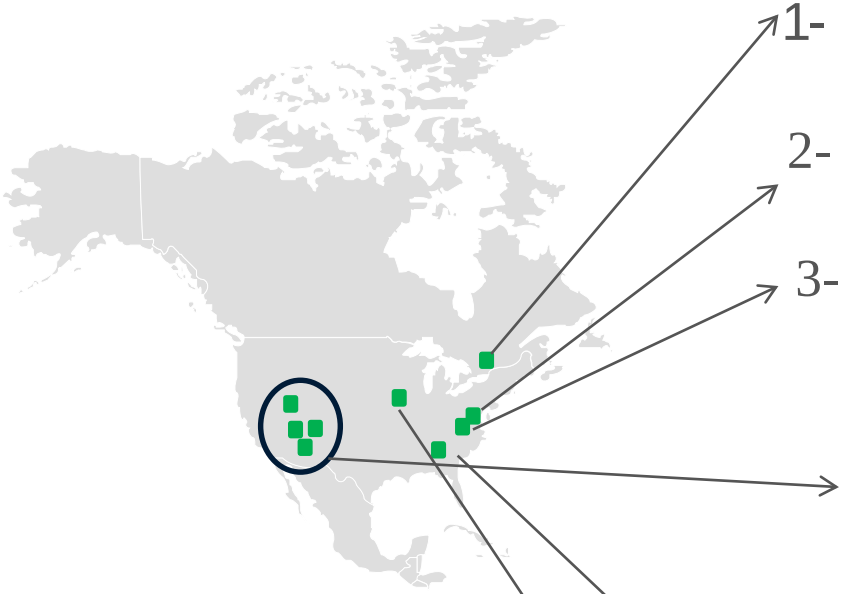
ATLANTIUM INSTALLATIONS IN NORTH AMERICA



1- Decew falls / **OPG** / 2 x 140 mw / source water ; 12 miles creek

2- Stevenson / **Firstlight H2O power** / 4 x 7 mw / Housatonic river

3- Shepaug / **Firstlight H2O Power** / 1 x 42 mw / Housatonic river

4- Hoover Dam / **USBR** / colorado river

5- Parker Dam / **USBR** / colorado river

6- Davis Dam / **USBR** / colorado river

7- Glen Canyon / **USBR** / colorado river

Southern Company (coal and combine cycle plant)
–Plant Bowen, Plant Harris and Plant Daniel

Louiseville Gas and Electric
Trimbl county (coal plant)

See tutorial regarding confidentiality disclosures. Delete if not needed.

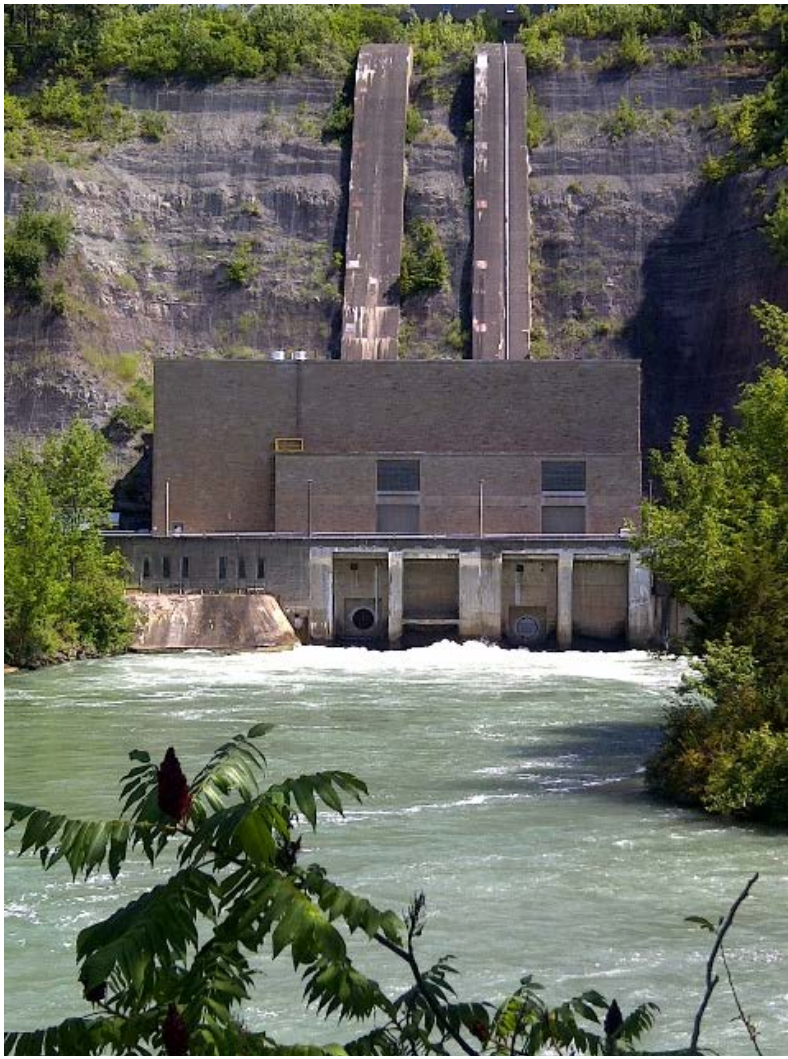
DECEW NF23 GENERATION STATION

Type of Utility: Hydro Electric Power Plant

- Number of generating units: 2
  - Nameplate capacity total: 140 MW

Source Water: 12 Mile Creek

ONTARIO POWER GENERATION



SHEPAUG HYDRO GENERATION STATION

Type of Utility: Hydro Electric

Power Plant

- Number of generating units: 1
  - Nameplate capacity total: 42 MW

Source Water:

Housatonic river

FirstLight Power Resources GDF SUEZ

STEVENSON HYDRO GENERATION STATION

Type of Utility: Hydro Electric

Power Plant

- Number of generating units: 4
  - Nameplate capacity total: 32 MW

Source Water:

Housatonic river

FirstLight Power Resources GDF SUEZ

DAVIS DAM HYDRO GENERATION STATION

Type of Utility: Hydro Electric

Power Plant

- Number of generating units: 4
  - Nameplate capacity total: 250 MW

Source Water:

Colorado river

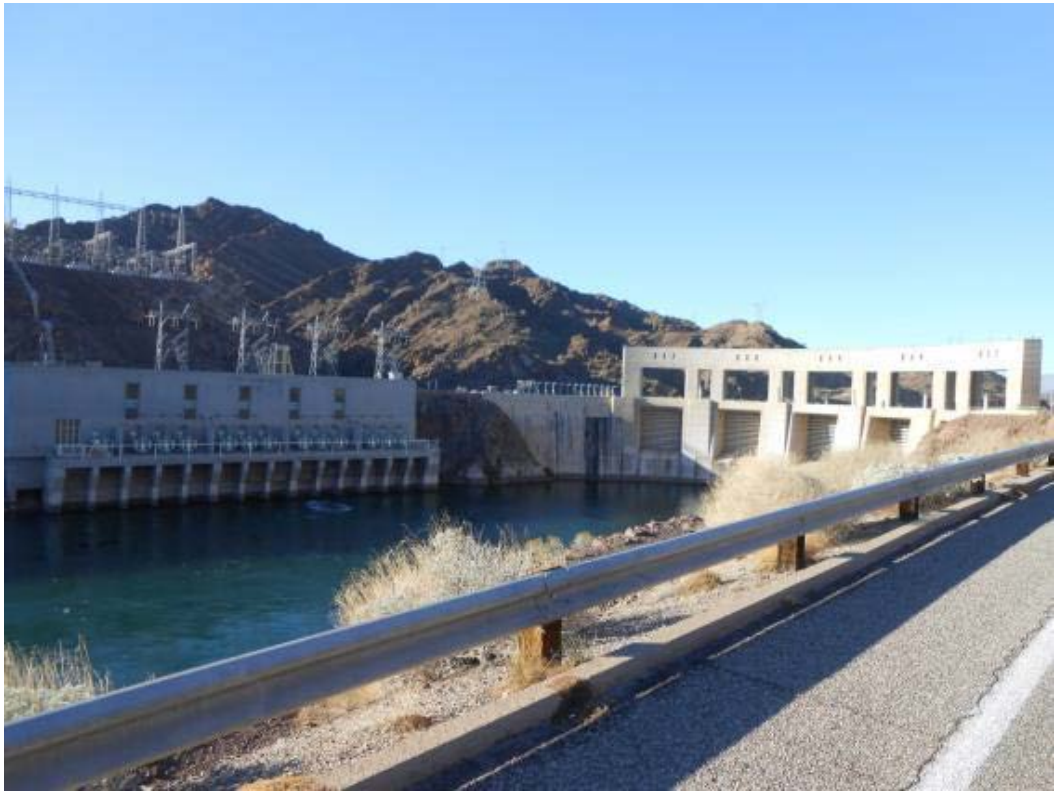
U.S. Department of the Interior
Bureau of Reclamation

PARKER DAM HYDRO GENERATION STATION

Type of Utility: Hydro Electric

Power Plant

- Number of generating units: 4
  - Nameplate capacity total: 30 MW



Source Water:

Colorado river

U.S. Department of the Interior
Bureau of Reclamation

HOOVER DAM HYDRO GENERATION STATION

Type of Utility: Hydro Electric

Power Plant

- Number of generating units: 19
  - Nameplate capacity total: 2080 MW

Source Water:

Colorado river

U.S. Department of the Interior
Bureau of Reclamation

GLEN CANYON DAM HYDRO GENERATION STATION (ENGINEERING PHASE STAGE ONLY)

Type of Utility: Hydro Electric

Power Plant

- Number of generating units: 8
  - Nameplate capacity total: 1320 MW

Source Water:

Colorado river

U.S. Department of the Interior
Bureau of Reclamation

HOD UV
is used in water treatment
by many other type of industries

Nuclear

Pharmaceutical

Food and

Beverage

Thermal

Aqua culture

Potable water for city

Etc…

Coca-Cola, PEPSI, Nestlé, DANONE, Schweppes, Carlsberg, Corona Extra, BULMERS, TUBORG, EFES Pilsener, Humana, Galliker's, ARBOREA, GROUPE LACTALIS, SODIAAL

frasai navieras, marineharvest excellence in seafood, BEAUTE FOOD, PINAR, SELONDA, CPF, Palma aquarium, MONASH University, Resorts World SENTOSA SINGAPORE, Gold Coast Tiger Prawns, tafi

TEVA, NICE PAK, Pfizer, Lilly, Sanovel, KAMADA

MEKOROT DEVELOPMENT & ENTERPRISE LTD., Lunenburg Massachusetts, AQUA, New York State

THANK YOU

Invasive Mussel Collaborative

Connecting People, Science and Management

Erika Jensen
Program Manager
Great Lakes Commission

Hydraulic Power Committee
October 25, 2016 | Green Bay, Wisconsin

1986
CANADA
MEXICO
Washington
Oregon
Idaho
Montana
North Dakota
Minnesota
South Dakota
Wyoming
Nebraska
Iowa
Wisconsin
Michigan
Nevada
Utah
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Colorado
Kansas
Missouri
Illinois
Indiana
Ohio
Pennsylvania
New York
Vermont
New Hampshire
Maine
Massachusetts
Rhode Island
Connecticut
New Jersey
Delaware
Maryland
District of Columbia
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Tennessee
North Carolina
South Carolina
Arizona
New Mexico
Oklahoma
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Georgia
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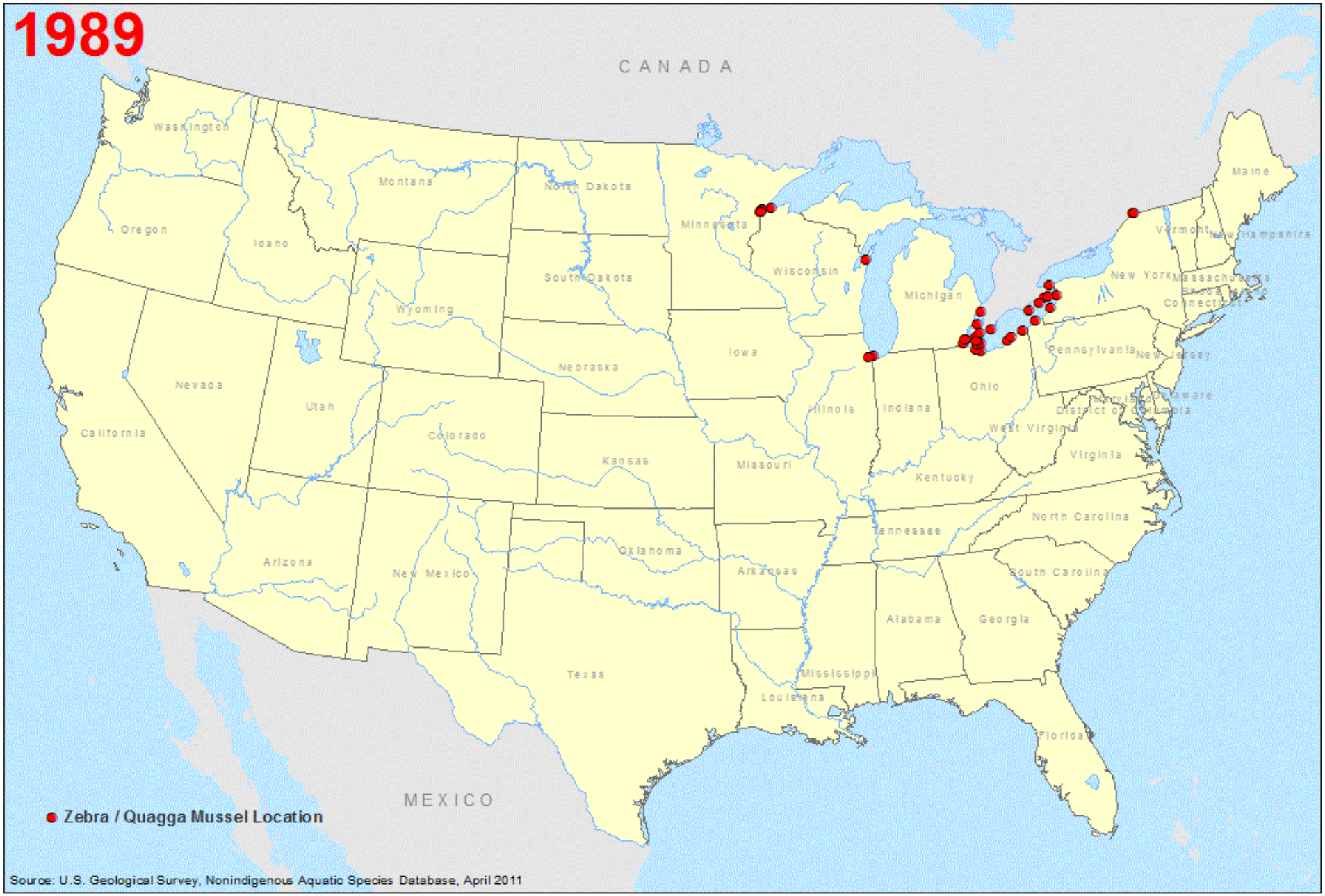
Zebra / Quagga Mussel Location
Source: U.S. Geological Survey, Nonindigenous Aquatic Species Database, April 2011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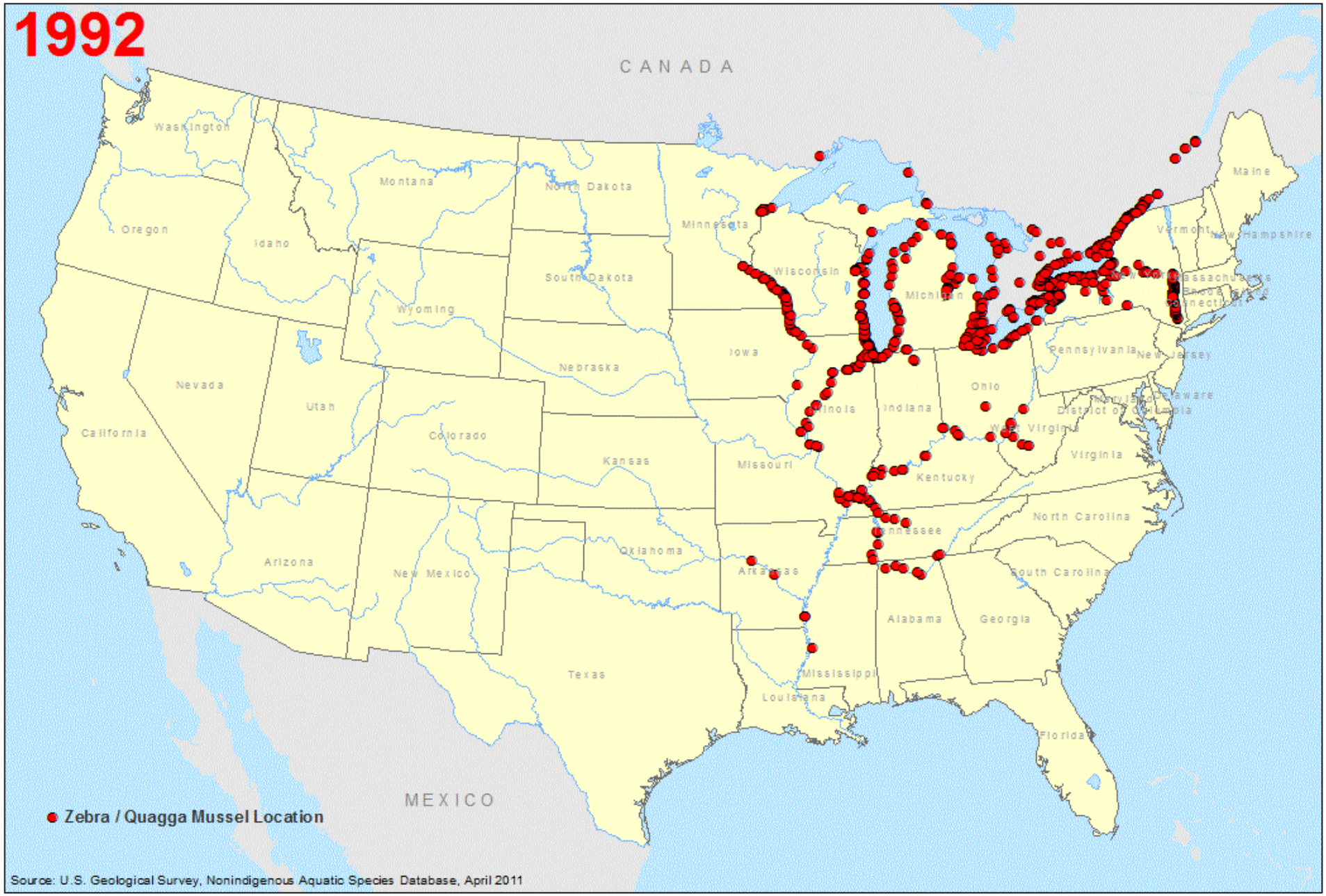
Zebra / Quagga Mussel Location
Source: U.S. Geological Survey, Nonindigenous Aquatic Species Database, April 2011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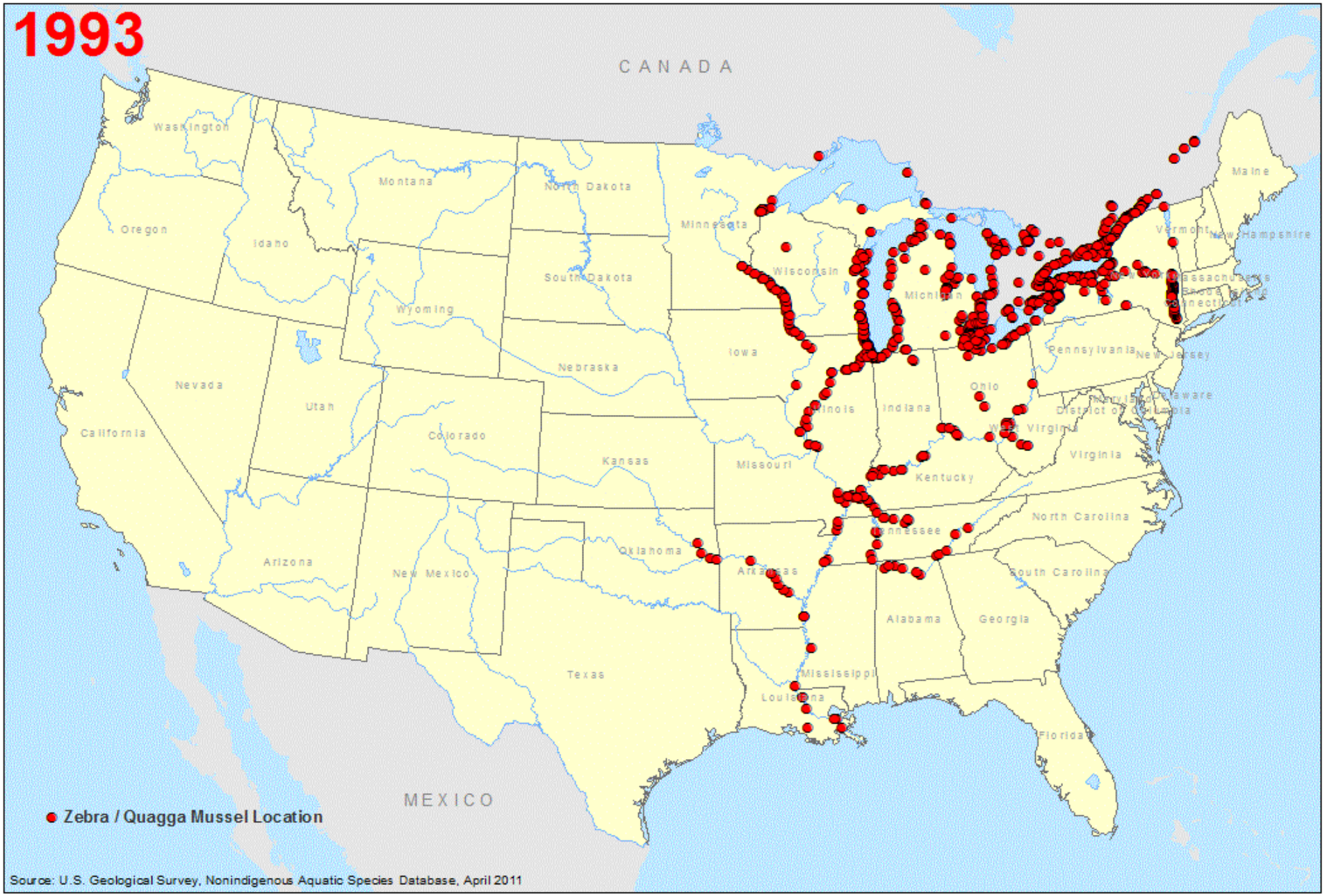
District of Columbia
Zebra / Quagga Mussel Location
Source: U.S. Geological Survey, Nonindigenous Aquatic Species Database, April 2011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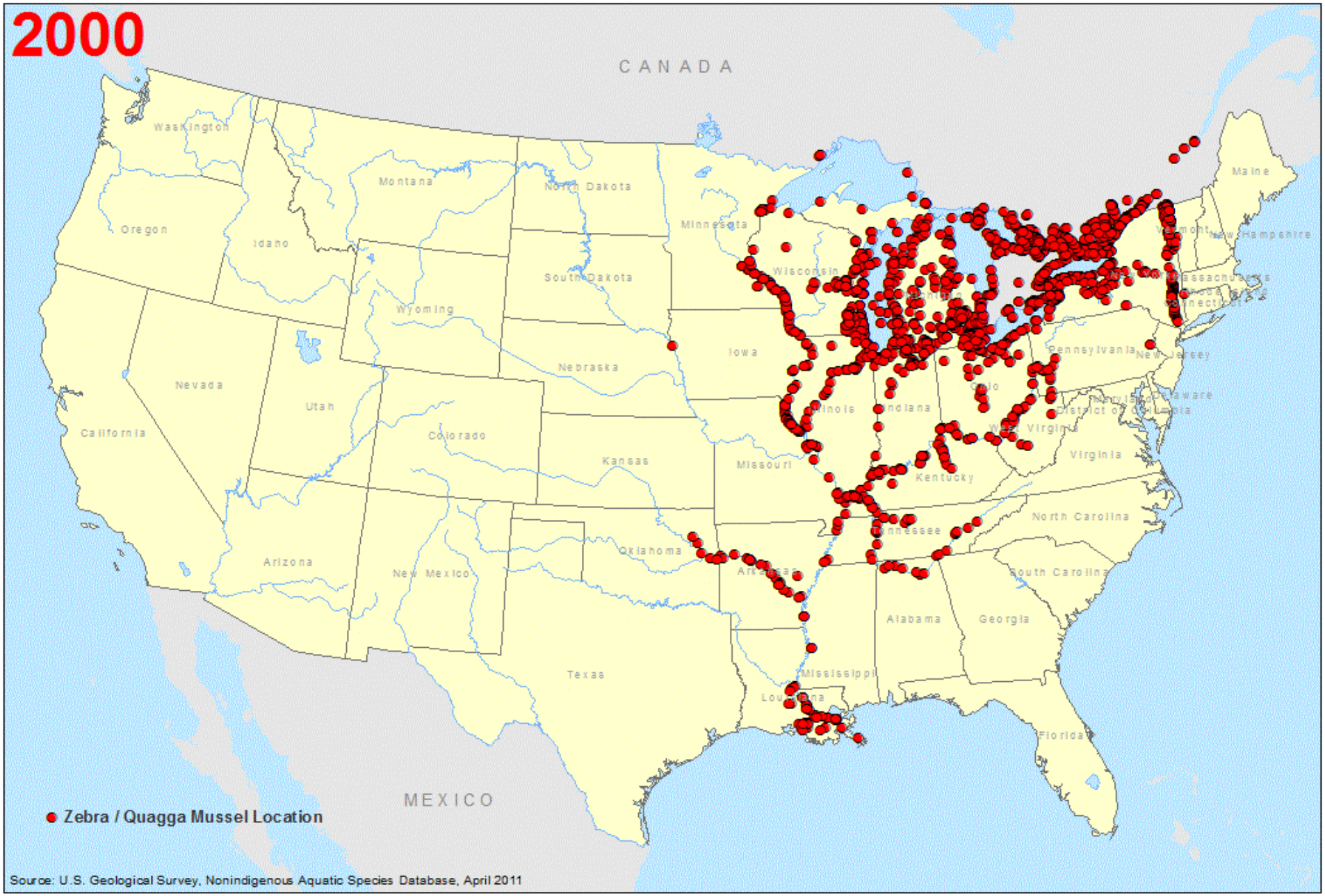
Source: U.S. Geological Survey, Nonindigenous Aquatic Species Database, April 2011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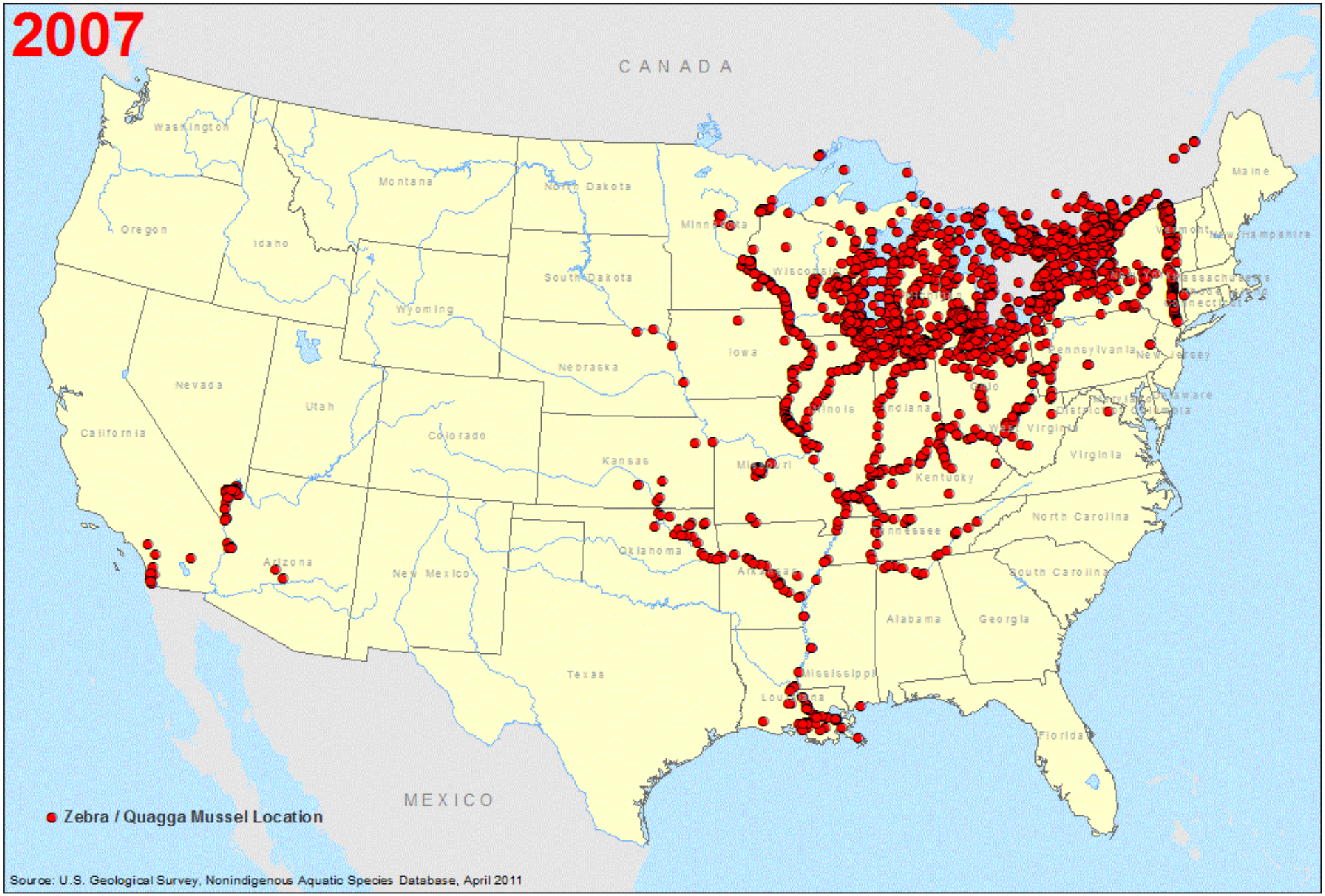
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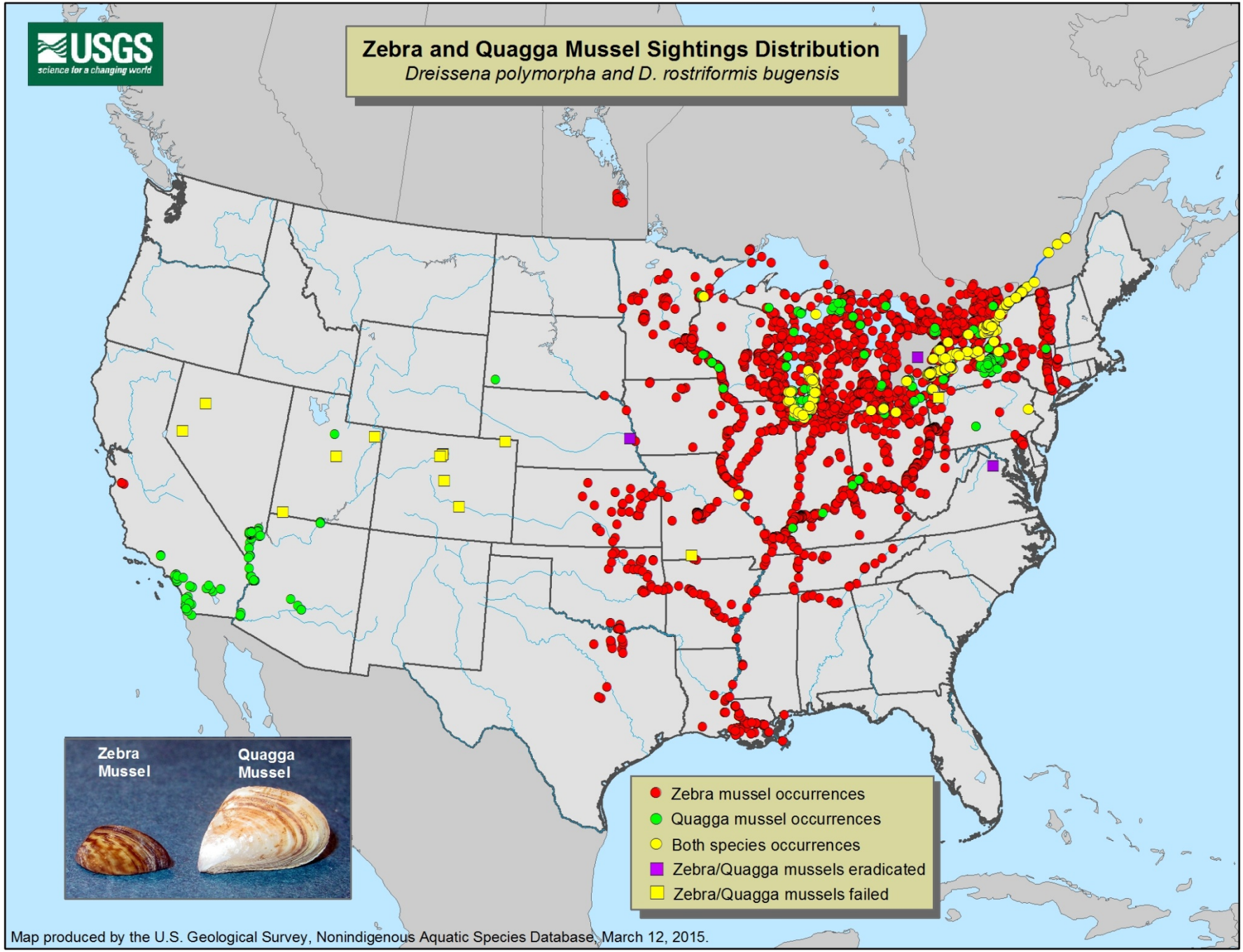
South Carolina
Zebra / Quagga Mussel Location
Source: U.S. Geological Survey, Nonindigenous Aquatic Species Database, April 2011


USGS
science for a changing world
Zebra and Quagga Mussel Sightings Distribution
Dreissena polymorpha and D. rostriformis bugensis
Zebra Mussel
Quagga Mussel
Zebra mussel occurrences
Quagga mussel occurrences
Both species occurrences
Zebra/Quagga mussels eradicated
Zebra/Quagga mussels failed
Map produced by the U.S. Geological Survey, Nonindigenous Aquatic Species Database, March 12, 2015.

Widespread Impacts

Credit: NOAA

USGS science for a changing world
Great Lakes Commission des Grands Lacs
NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce
Protecting Our Fishery Great Lakes Fishery Commission Science • Sea Lamprey Control • Partnerships

CLEAN BOATS CLEAN WATERS
CLEAN DRAIN DRY YOUR BOAT
HELP STOP THE SPREAD OF INVASIVE SPECIES
IDAHO STATE LAW
ALL WATERCRAFT MUST STOP
OPEN
STOP AQUATIC HITCHHIKERS!™
Prevent the transport of nuisance species.
Clean all recreational equipment.
www.ProtectYourWaters.net
DON'T MOVE A MUSSEL
DONTMOVEAMUSSEL.CA
ZEBRA MUSSELS.
DON'T BE A CARRIER.
CLEAN, DRAIN AND DRY YOUR BOAT.
Lake George
Boat Inspections
Lake George Park Commission
LOOK FOR MUSSELS HERE
Anchor
Dock Lines
Live Wells
Bilge
Trailer
Vehicle
Rollers
Hull
Axle
Motor
CHECK YOUR BOAT, TRAILER AND VEHICLE
CLEAN IN
CLEAN OUT
BE A HERO TRANSPORT ZERO
FIGHT THE SPREAD OF AQUATIC INVADERS

- Limited options for response, containment or eradication in open waters
- New potential for management: Zequanox®[1]
  - Trial applications
- Ongoing investments to develop other technologies
- Apply collective impact principles
  - Bring multiple interested parties into a **common understanding and agenda**
  - Use **management and science** to create potentially powerful management tools

Effects of biocontrol application

A colony of zebra mussels attached to a native mussel. The native mussel survives the application of biocontrol; the zebra mussels do not.

[1]Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Mission

Advance scientifically sound technology for invasive dreissenid mussel control to produce measurable ecological and economic benefits.

Provide a framework for communication and coordination, identify the needs and objectives of resource managers, prioritize the supporting science, recommend communication strategies and **align science and management goals into a common agenda for invasive mussel control**.

Invasive Mussel Collaborative

Steering Committee

29 member orgs from U.S. and Canada Federal, Tribal, state, provincial and local agencies; NGOs; industry, academia

Core Team

Great Lakes Commission, Great Lakes Fishery Commission, National Oceanic & Atmospheric Administration & U.S. Geological Survey

Science Team

12 members representing research agencies and institutions

Neutral backbone support and coordination
Great Lakes Commission

USGS science for a changing world

Great Lakes Commission des Grands Lacs

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

Protecting Our Fishery Great Lakes Fishery Commission Science • Sea Lamprey Control • Partnerships

Steering Committee

- **Identify** needs and objectives of resource managers
- **Prioritize** science and research questions
- Assist with **communication** strategies
- Provide input on development of products or tools that **advance adaptive management**
  - Management decision support tools, monitoring protocols, data analysis, etc.
- Provide **guidance and direction** to the Collaborative Science Team

Science Team

- Establish **current state** of the science
  - Add your project / publication! http://invasivemusselcollaborative.net/research
- Develop a **research agenda**
- Provide **support for research** projects to address pressing needs
- Work with resource managers to **guide adaptive management** and research at a range of scales and environments
- Broad topics
  - Understand ecosystem effects
  - Develop and refine control strategies
  - Develop models and decision support tools
  - Examples: effectiveness and Zequanox application issues, food web changes and fishery production, HABs link, socioeconomic considerations

Collaborative Communication Tools

- Website: **www.invasivemusselcollaborative.net**
- Email list-serv: **invasivemussels@great-lakes.net**
- Webinar Series:
  - Recordings Available:
    - Lessons learned from Zequanox applications (July 2015)
    - Non-Zequanox control case studies (January 2016)
    - Zebra Mussel Response in Lake Winnipeg (April 2016)
    - Case Studies in Integrated Pest Management (Sept. 2016)

Invasive Mussel Collaborative

www.invasivemusselcollaborative.net

THANK YOU!

USGS science for a changing world

Great Lakes Commission des Grands Lacs

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

Protecting Our Fishery Great Lakes Fishery Commission Science • Sea Lamprey Control • Partnerships

RECLAMATION

Managing Water in the West

Hydraulic Power Committee Retreat
Green Bay, WS – October 2016

Taking No Prisoners
Beating Back Invasive Species

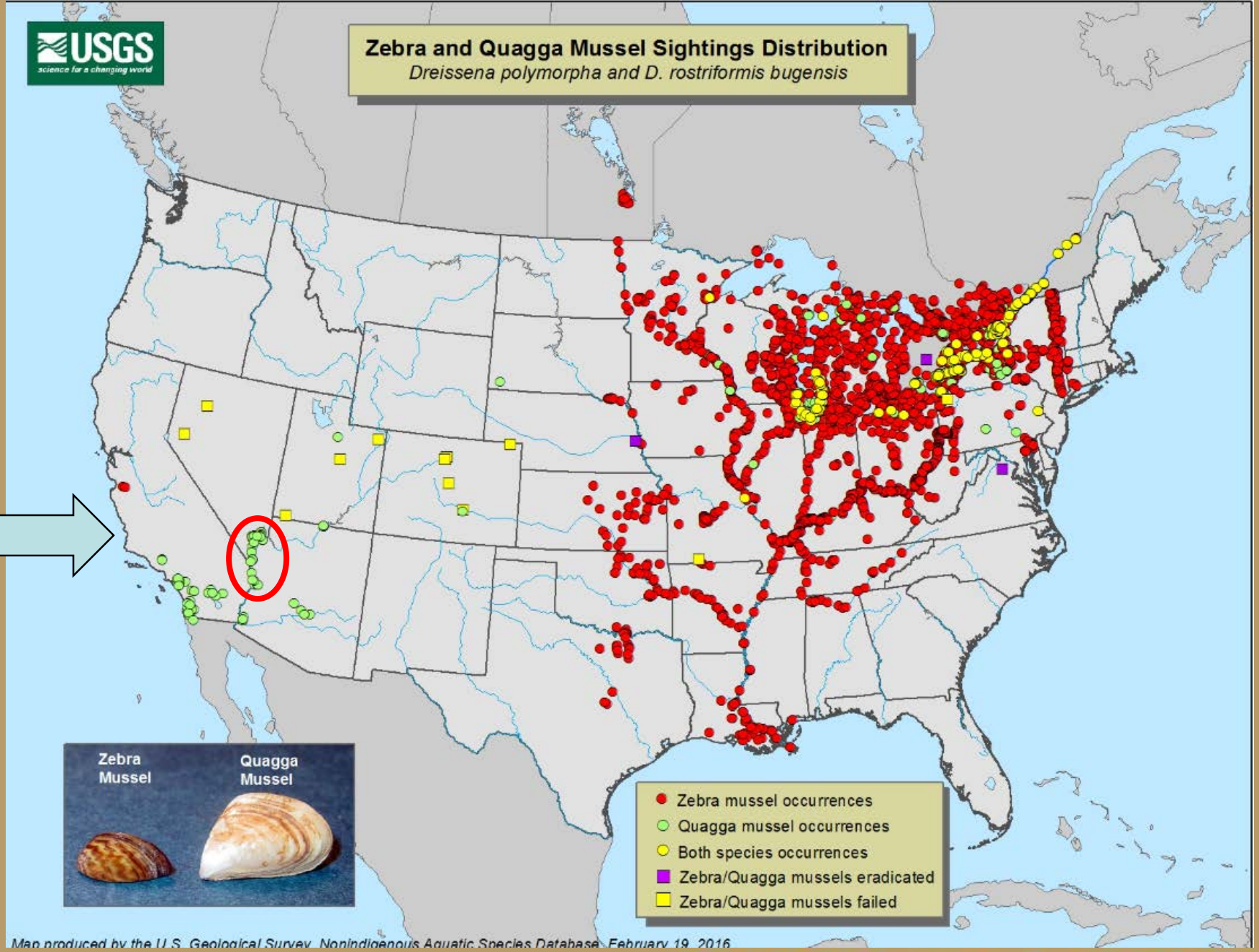
Leonard Willett
Hoover Dam
Lower Colorado Region

U.S. Department of the Interior
Bureau of Reclamation

Background:

- January 2007 adult quagga mussel found in Lake Mead (assumed to be from a mussel infested house boat)
- Fall of 2007 – Reclamation's Lower Colorado Dams (LCDO) office completed facility review
- Findings from review and updated activities of the lower Colorado river dams
- Research activities and control barriers that are environmentally friendly

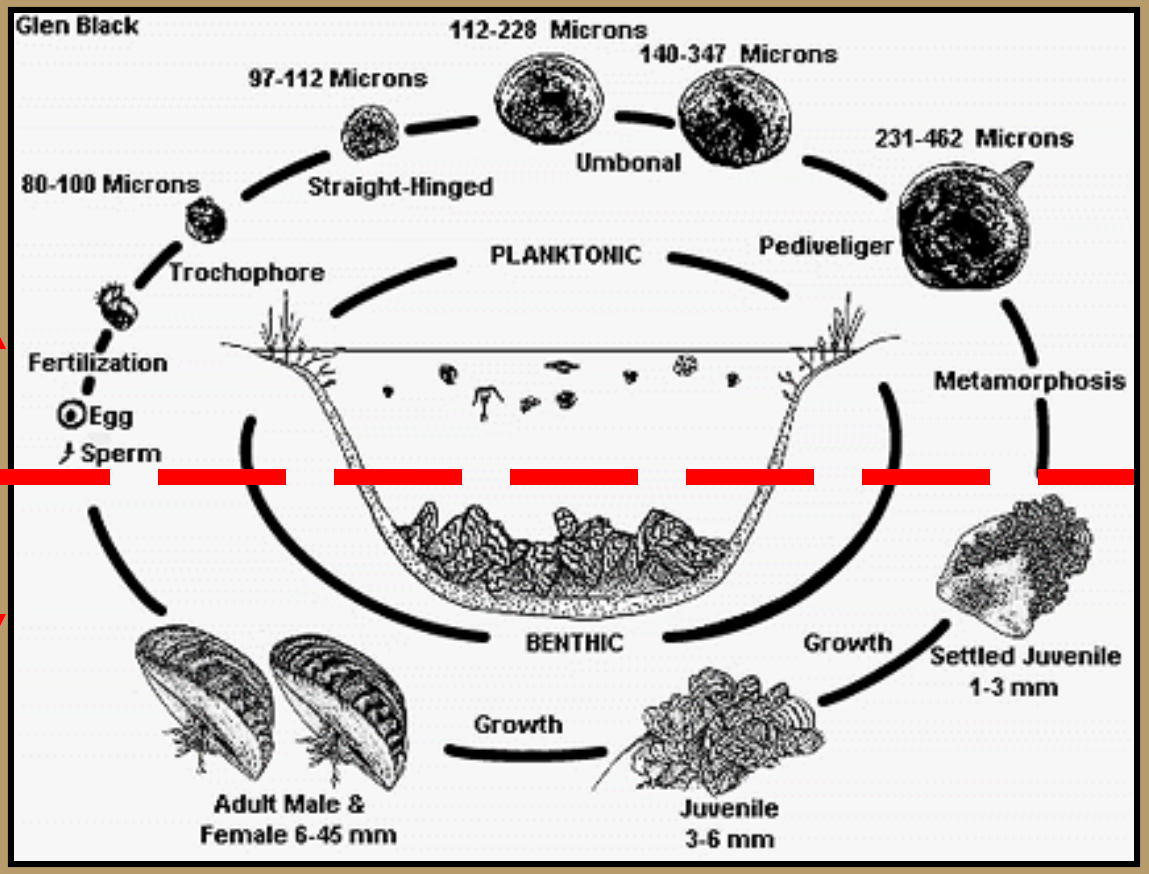
RECLAMATION



RECLAMATION

Control Strategies

- **Proactive:**
  - **Preventive**



Reproduction starts 10C or 50F

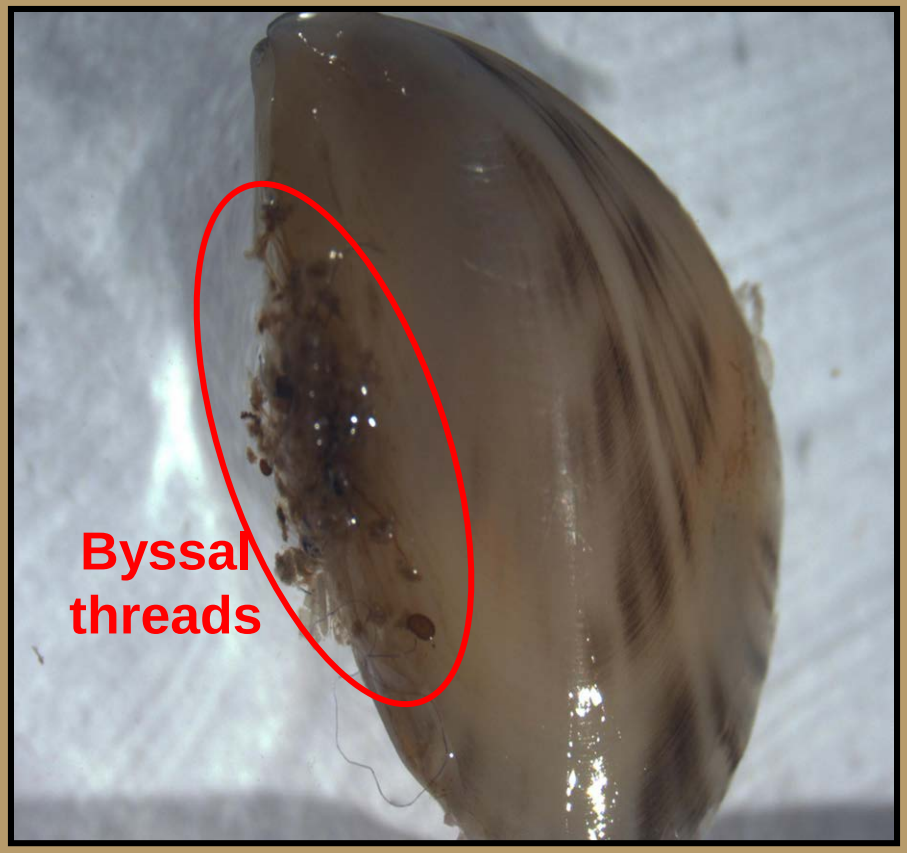
- **Reactive**
  - **"Clean" after establishing**
  - **Can be labor intensive**

- **Redesign/Retrofit**

RECLAMATION

Forms of Problems

- Flow restriction
  - Roughening (Friction loss)
  - Blockage
- Chemical degradation
  - corrosion
- Biological/Environmental
  - Food chain
  - Habitat
  - Water quality
  - Water resource industry
  - Toxic accumulations



Quagga mussel, Lake Havasu – Jan. 2007

RECLAMATION

Hoover Dam Pressure Relief Valve Shaft Corrosion – April 2013

RECLAMATION

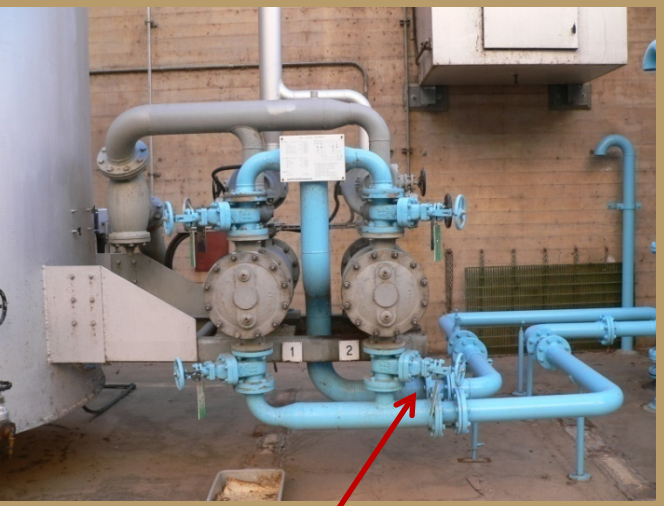
Trash Rack- Parker Dam - Jan 2013

RECLAMATION

Davis Dam Fixed Wheel Gate - Oct 07

RECLAMATION

Fire protection and other cooling water systems need protection



Transformer cooling water

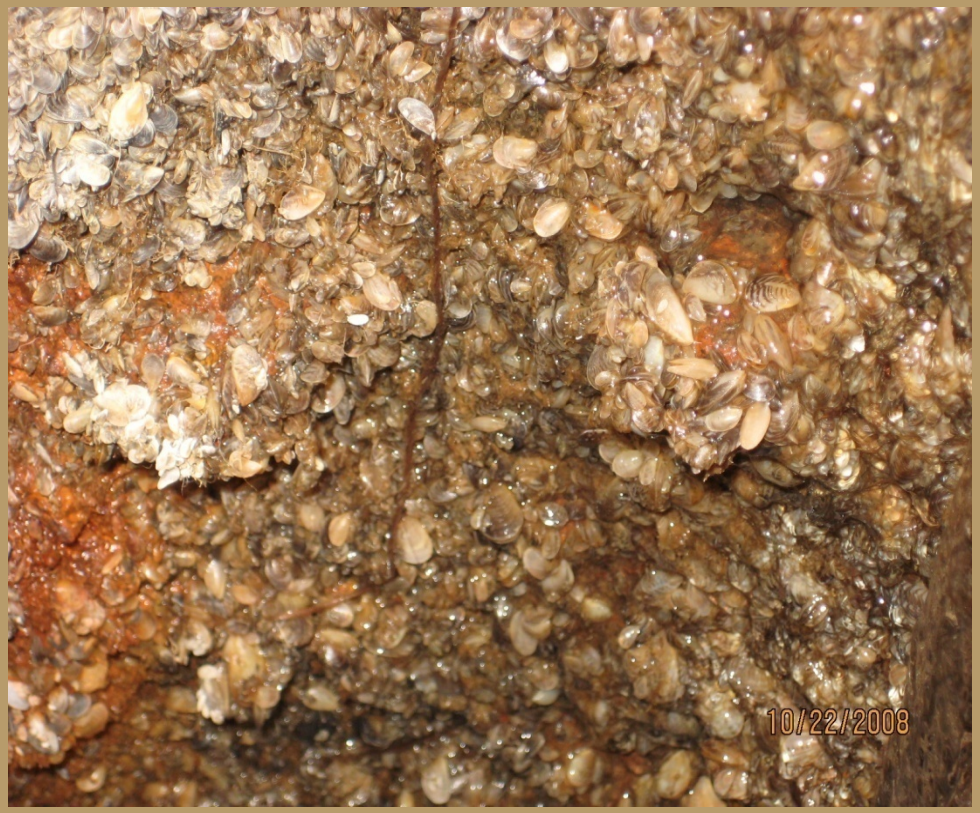
Fire nozzles

RECLAMATION

Penstock Interior Surfaces Inspection

Mussel Shell Debris in Penstock serving Multiple Laterals

Penstock Drain – Heavy Settling

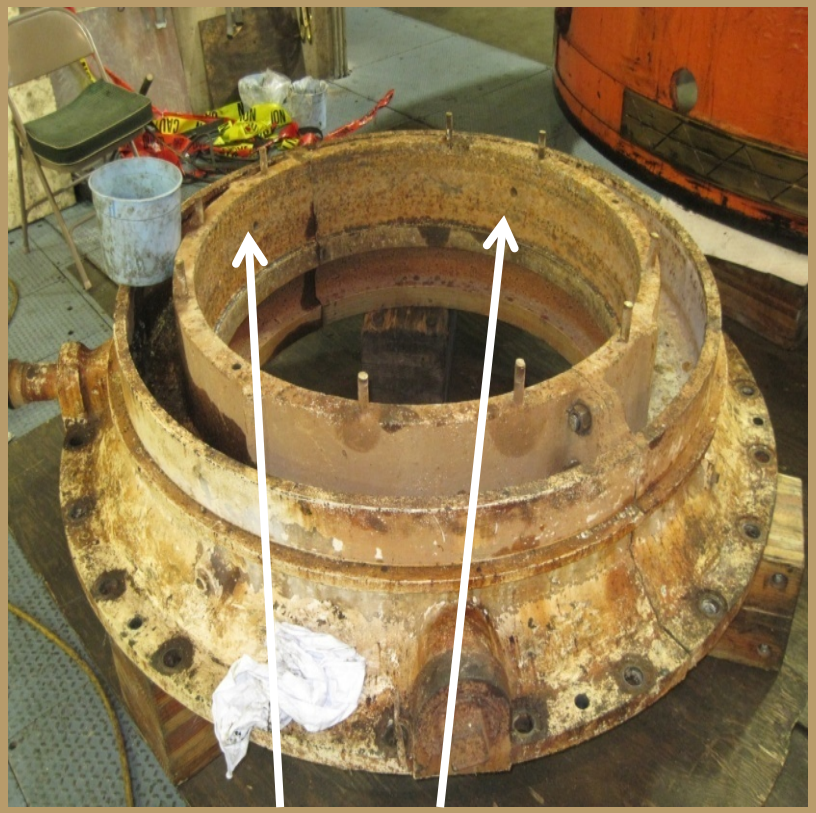


RECLAMATION

Penstock belly drain – Oct 2010

RECLAMATION

Hoover Dam Generator Packing Area Problematic Mussel Fouling



Small water opening to supply packing stuffing box

RECLAMATION

Shell Debris - Oil and Bearing Coolers

Clogged thrust bearing cooler

Shell debris from thrust bearing cooler piping

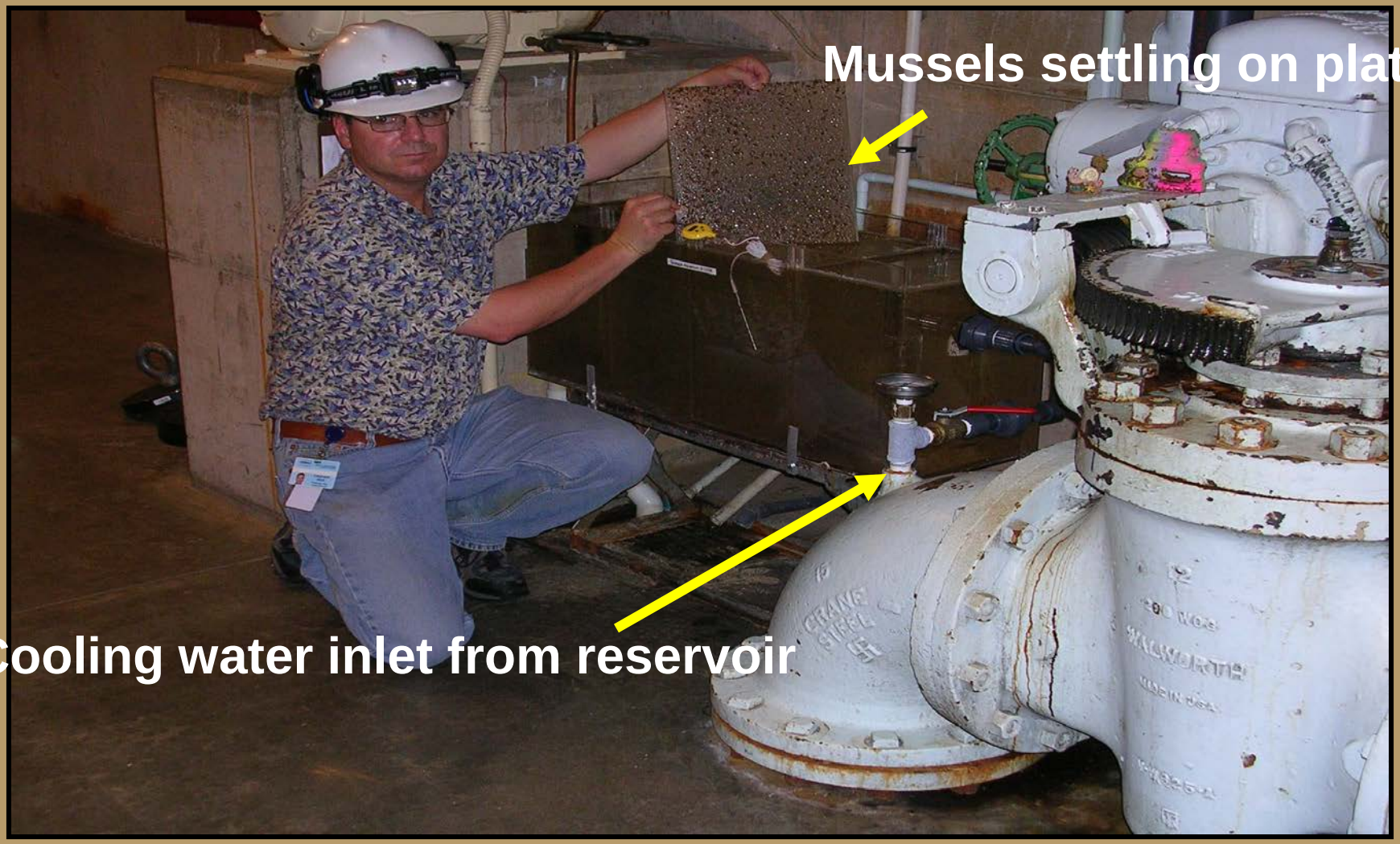
RECLAMATION

Reclamation Lower Colorado Region Research Activities

- Installed bio-boxes
- Tested micro-filtration systems (40-80 micron) completed
- Evaluating anti-foul coatings and materials to resist mussels (Dr. Allen Skaja, TSC Denver – 8 year study on going)
- Evaluation of Zequanox treatment (completed)
- Copper Evaluation as Molluscicide (completed)
- Evaluating Atlantium (HOD) ultra-violet light treatment (completed)
- Evaluation of Atlantium (HOD) treatment on freshwater colonial hydroid (Cordylophora Caspia)

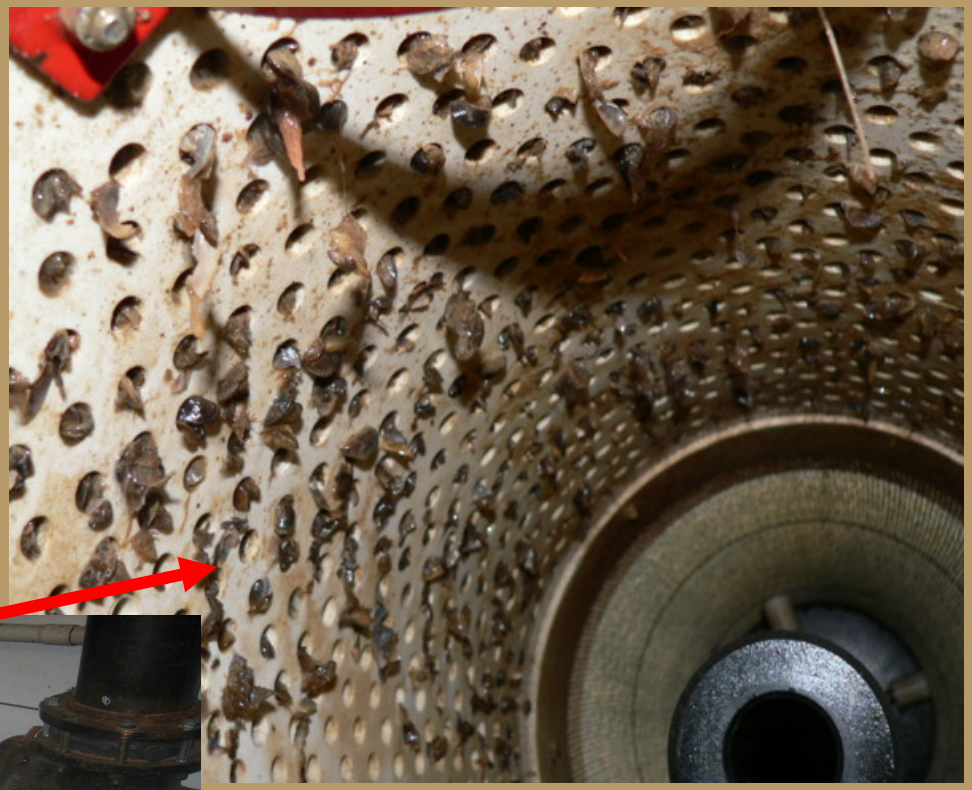
RECLAMATION

Installed Bio-Box Sampler for Monitoring



RECLAMATION

Self Cleaning Ballast Safe Filter

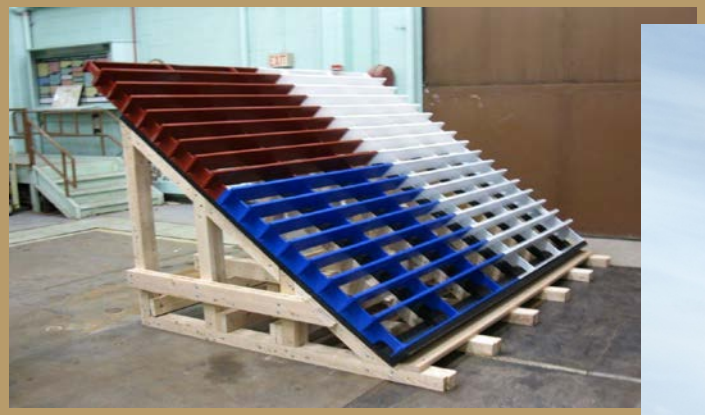


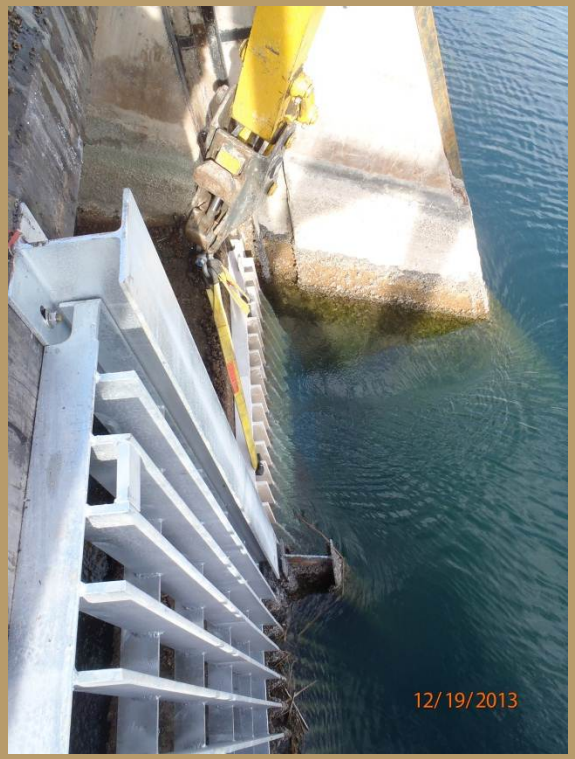
Pre-strainer (filter)

Filter Cartridge – 40 micron

RECLAMATION

Parker Dam Trash Rake Coating Research Summer 2013



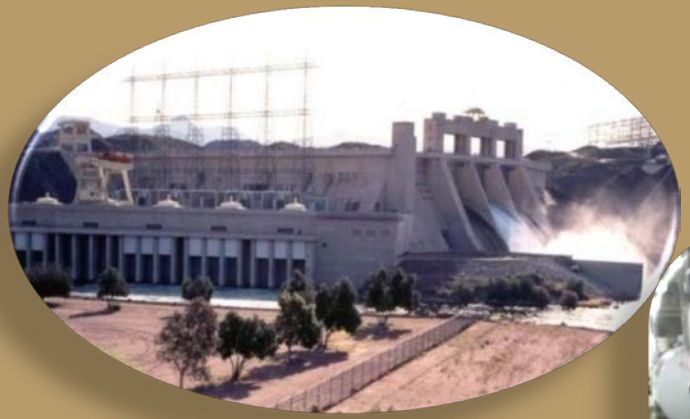


RECLAMATION

Controlling Mussels at Davis Dam

US Bureau of Reclamation, Davis Dam

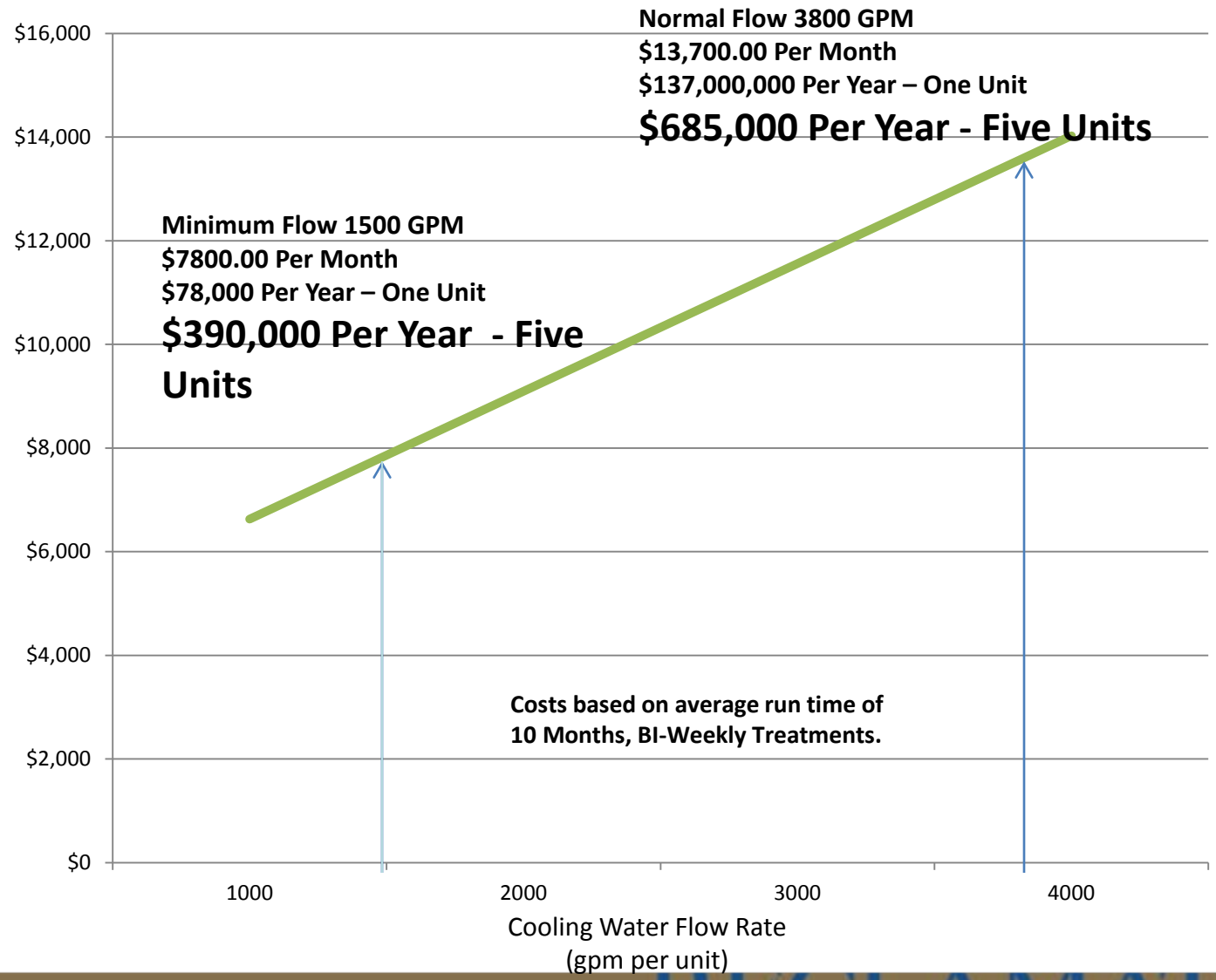
- Bullhead City, AZ; Colorado River
- Five turbine, 240 MW hydropower facility
- Each subsystem has a separate cooling water system
- 5000 gpm per cooling water subsystem



RECLAMATION

Treatment – Monthly/Yearly Product Pricing for Davis Dam (January 2013)

ZEQUANOX® Invasive Mussel Control



RECLAMATION

Copper Ion Generator Unit

Molluscicide Approved for open waters

Molluscicide Applications

- Anecdotal Reports of Quagga and Zebra Mussel Kill When EarthTec Was Used for Algae and Organic Pretreatment
- Funded Successful Academic Research at UNLV
- EPA Label Approved for EarthTec QZ Formulation as Molluscicide (August, 2013)

EARTHTEC

RECLAMATION

Hoover Dam Cooling Water Mussel Control Traditional UV System

RECLAMATION

Hoover Dam Cooling Water Mussel Control Traditional UV System (research)

Started August 2010
2 lamps

Renata Claudi (RNT Consulting)
starting 4 lamp evaluation

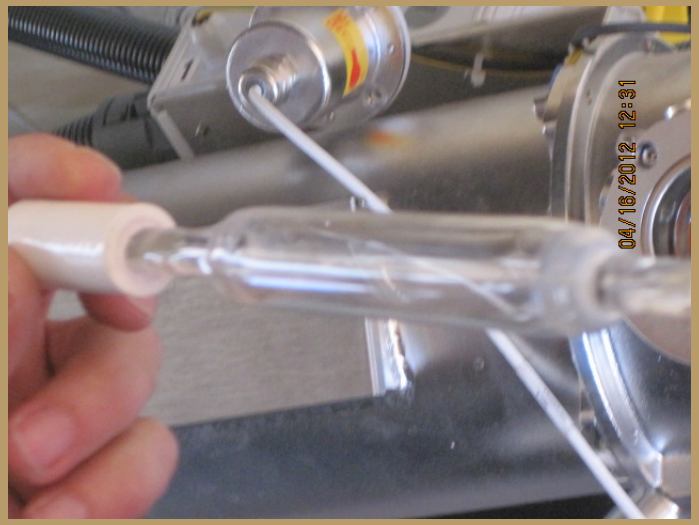
Upgrade to 4 lamps to increase
dosage April 2011
Cost - $125K

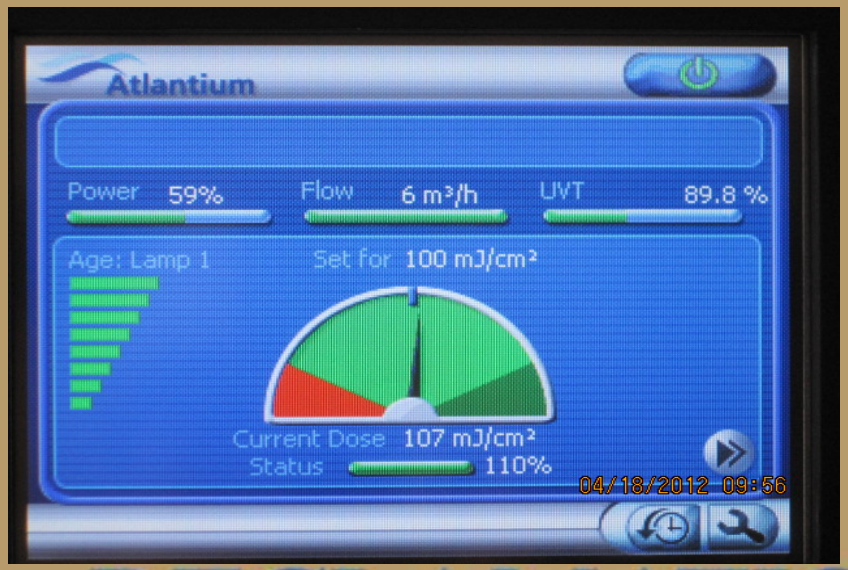
RECLAMATION

UV dosage response evaluation for settlement prevention of mussels

HOD UV equipment cost $62K
1250 gpm- UVT of 85- dose 100 mj/cm2
Power operational cost $2500/yr
$0.035/kwhcost for traditional UV

HOD UV equipment cost $120K
4000 gpm with UVT of 85
dosage of 100 mj/cm2





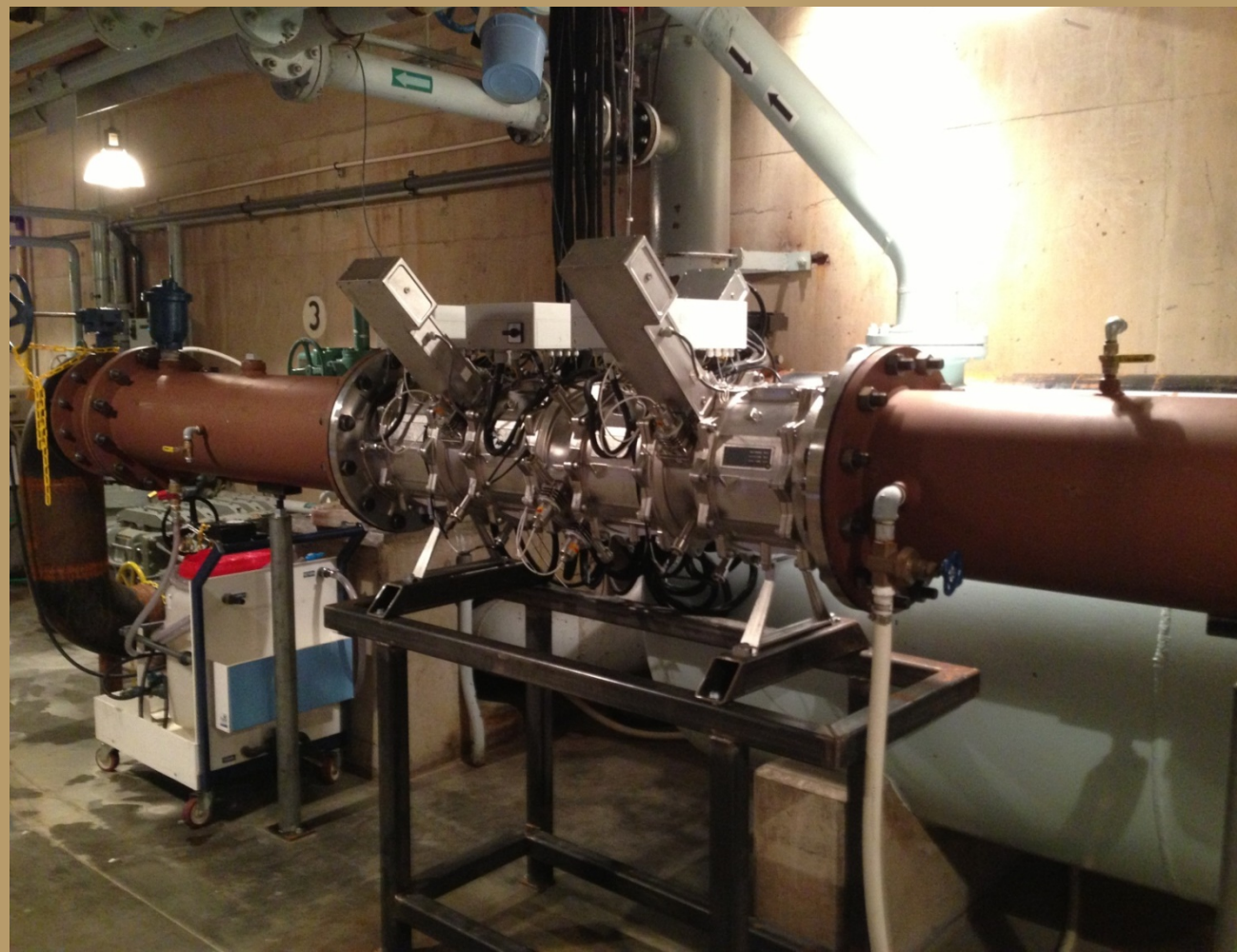
Renata Claudi (RNT Consulting)

RECLAMATION

Power Plant Mussel Control System
Atlantium (HOD) UV Light System

HOD UV Cooling Water System installed July 2013 on a 4000 GPM

$120K
with UVT of 85
dosage of 100 mj/cm2



Power Plant Parker Dam Mussel Control System Atlantium (HOD) UV Light System

UV Cooling Water System installed Nov. 2015 on a 1600 GPM system

Self Cleaning Strainer

RECLAMATION

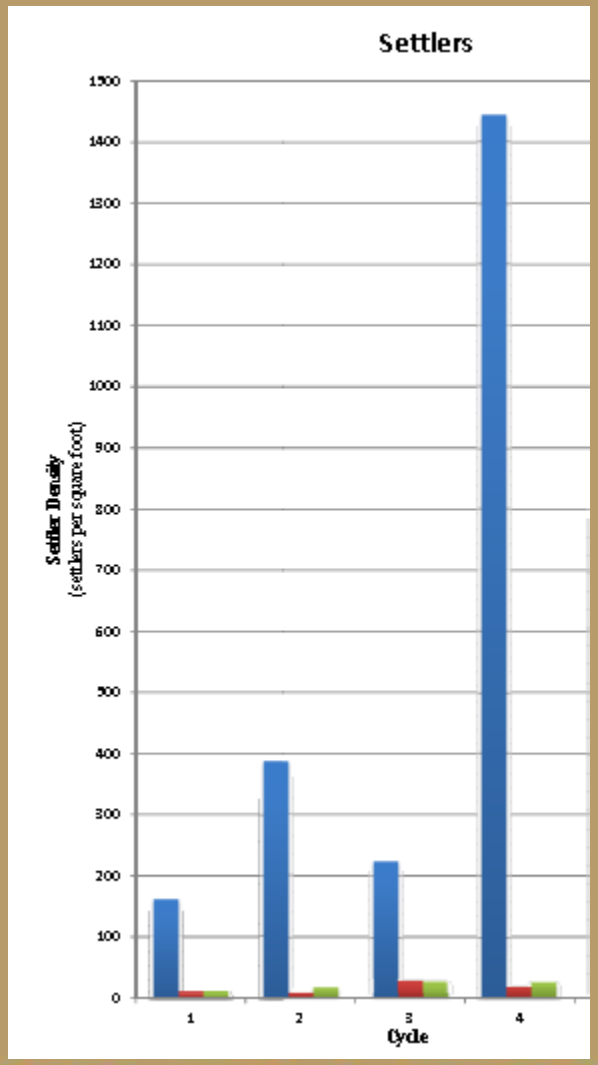
Full Scale results

Strainer w/o HOD

Strainer with HOD

Settlement control – SUCCESS!!

EXTROADINARY VERY LOW DOSES

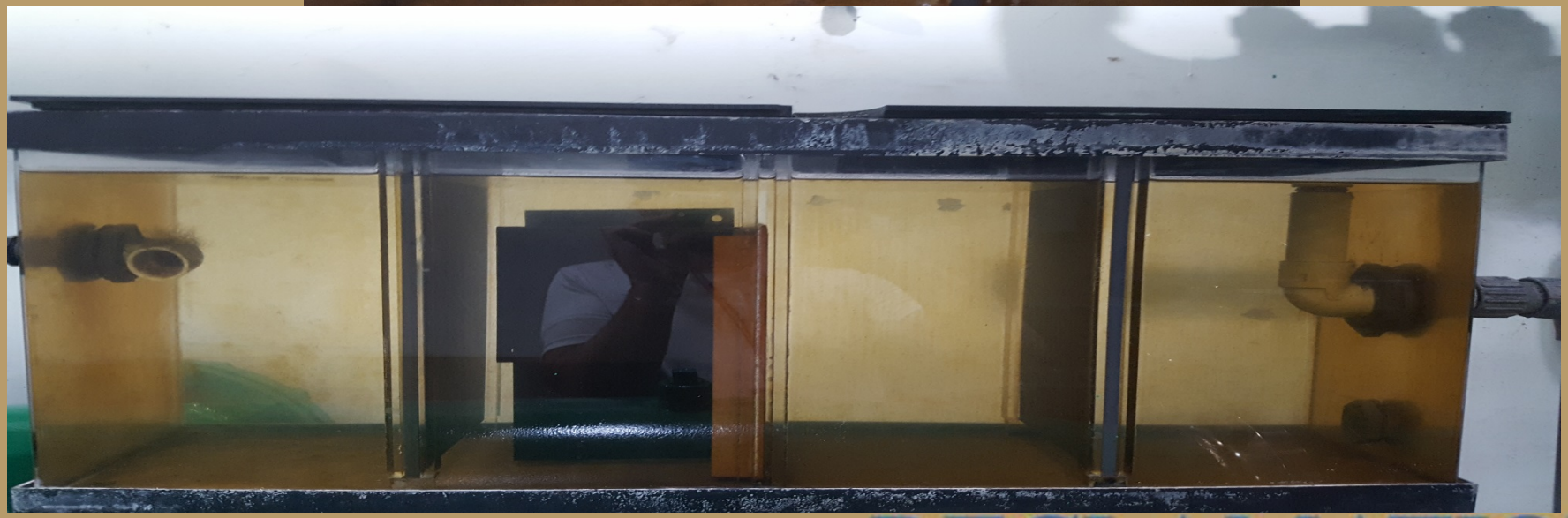


RECLAMATION

Freshwater Colonial Hydroid – Prior to HOD UV

RECLAMATION

Hydroid Study Before and After HOD UV Treatment

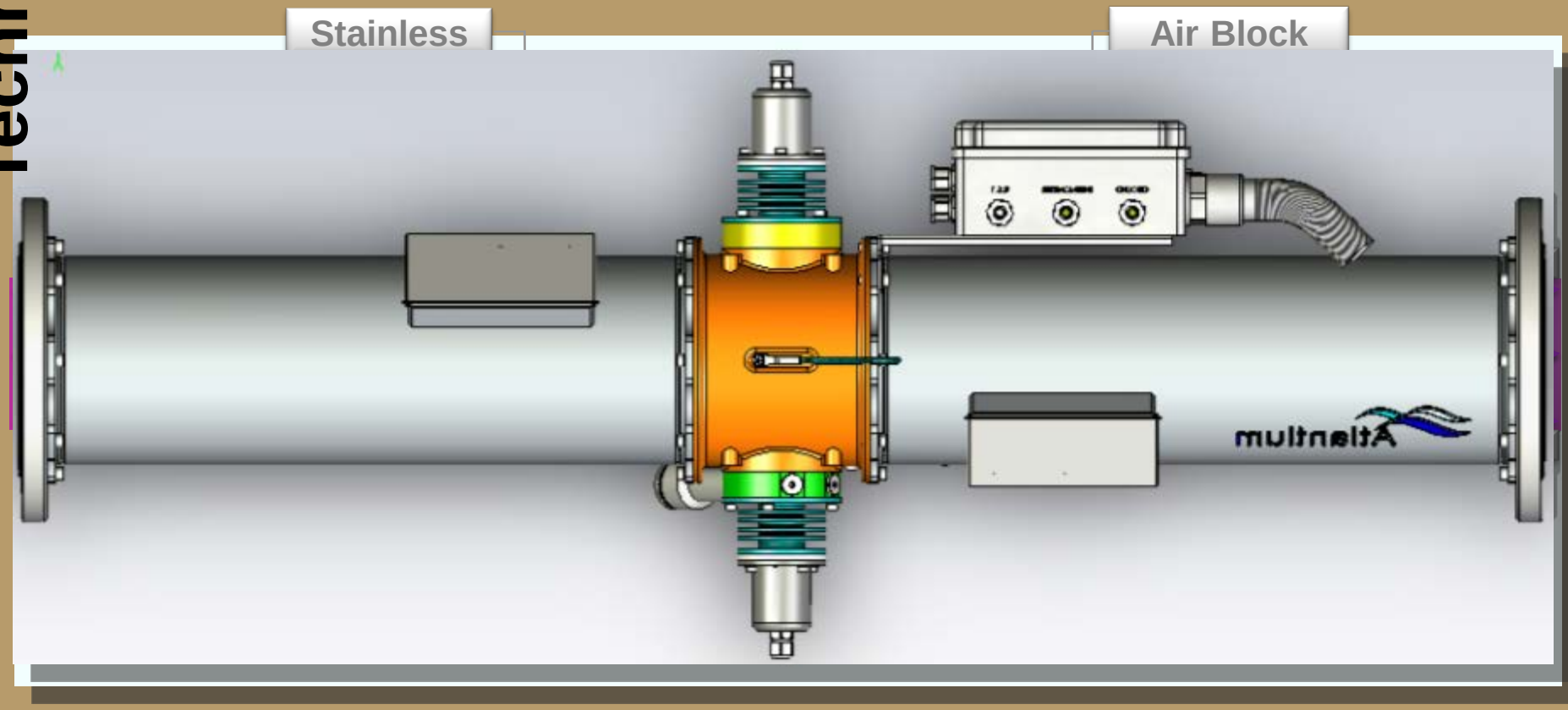


RECLAMATION

Technology

Operation principles: HOD system cross section

RZ104-11 a member of RZ series HOD system



Conventional

RECLAMATION

FALL CONFERENCE UPDATE

Phase #2 presentation at next National Hydro Association event in Green Bay Wisconsin, USA , October 25-27

✓RNT update on Freshwater Colonial Hydroid / Bryozoan control w/HOD UV

✓RNT update w/HOD UV summer control @ Stevenson and Shepaug Dam

Acknowledgements

- Bureau of Reclamation Technical Service Center (Denver)
- Davis Dam Operations Personnel – Bullhead City, AZ
- Reclamation Researcher – Sherri F. Pucherelli
- RNT Consulting – Renata Claudi

Suppliers

- GE Renewable & Atlantium

RECLAMATION

QUESTIONS – VALIDATION REPORTS

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http://www.rntconsulting.net/Publications/Articles.aspx

RECLAMATION