Restoration and Maintenance of Fish Spawning Reefs

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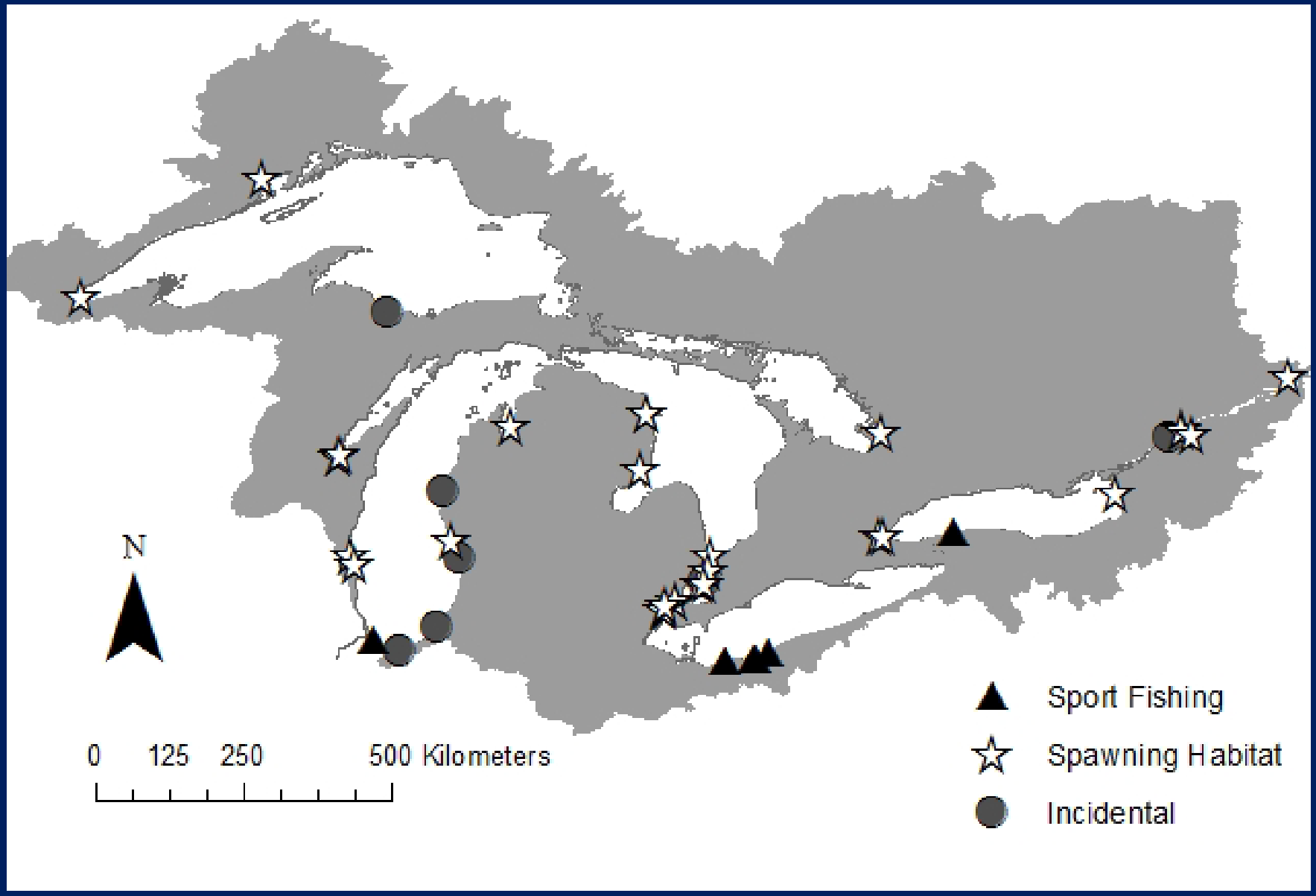
Presentation Outline

- Constructed reefs in Great Lakes
- St. Clair-Detroit River System (SCDRS) reefs
  - Need for reefs
  - Construction
  - Assessment
  - Performance
  - Need for maintenance
- Reef maintenance techniques development
- Conclusions

Great Lakes Constructed Reefs

(McLean et al. 2016; Roseman et al. 2017)



Great Lakes Reefs Monitoring

(McLean et al. 2016; Roseman et al. 2017)

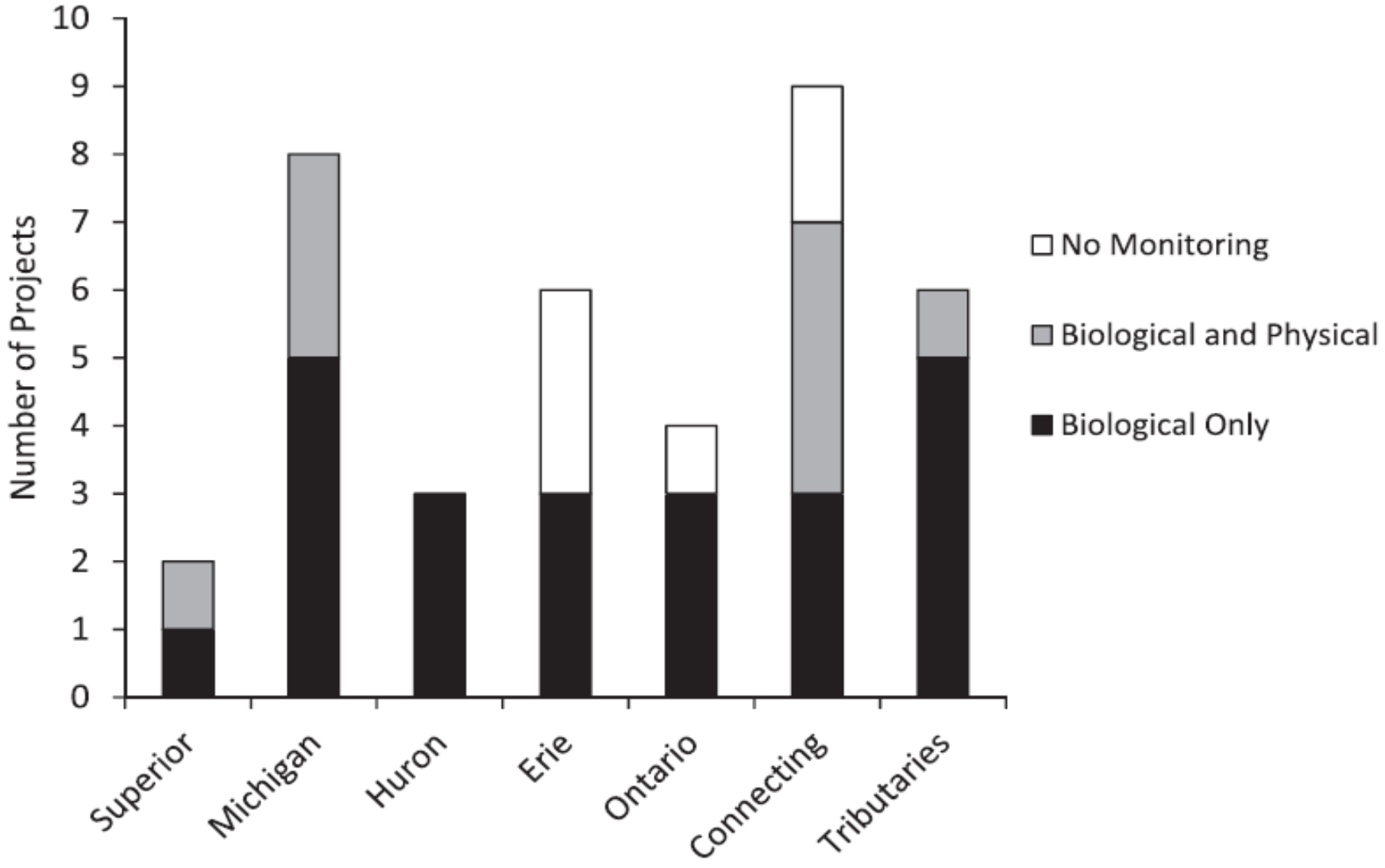


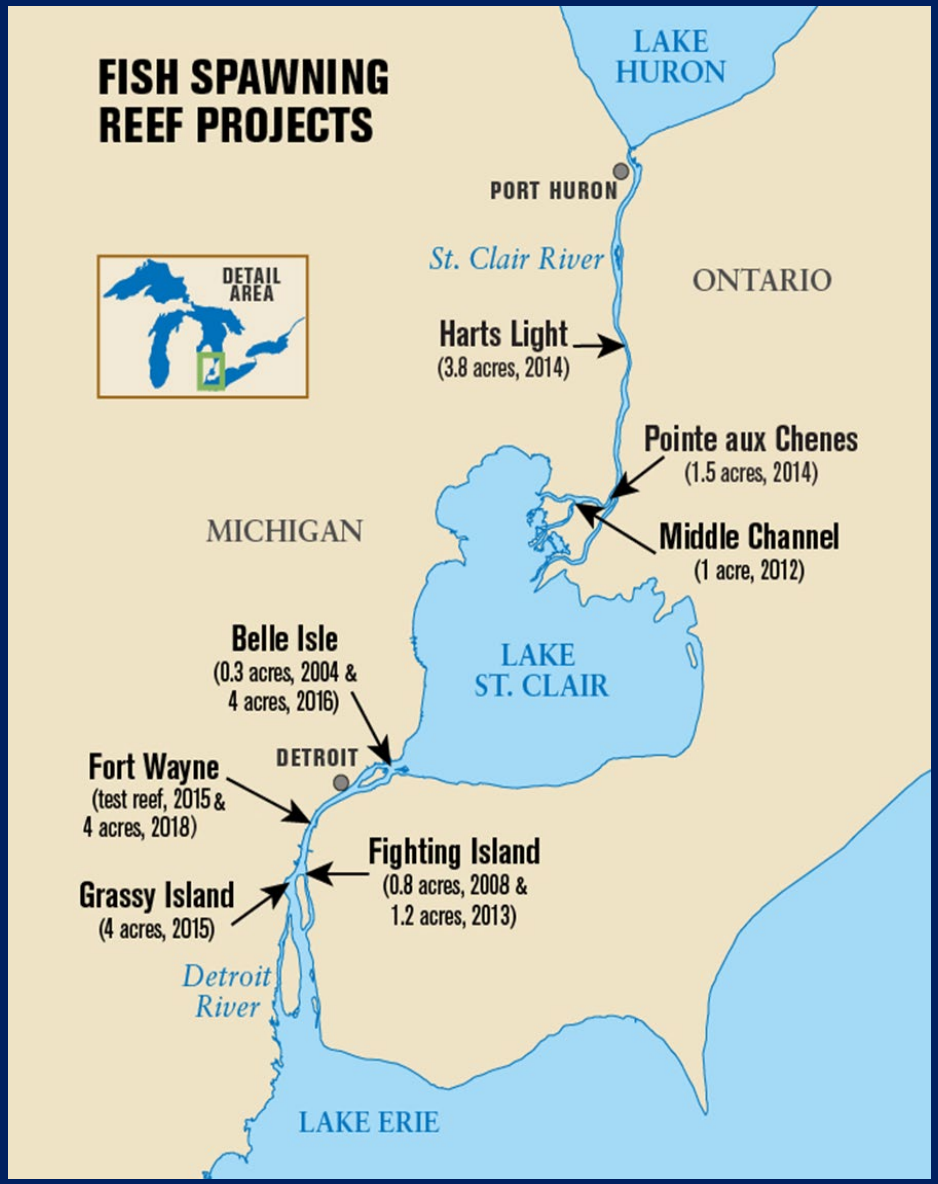
Fig. 2. Artificial reef monitoring conducted in the Great Lakes.

Constructed Reefs in the Great Lakes

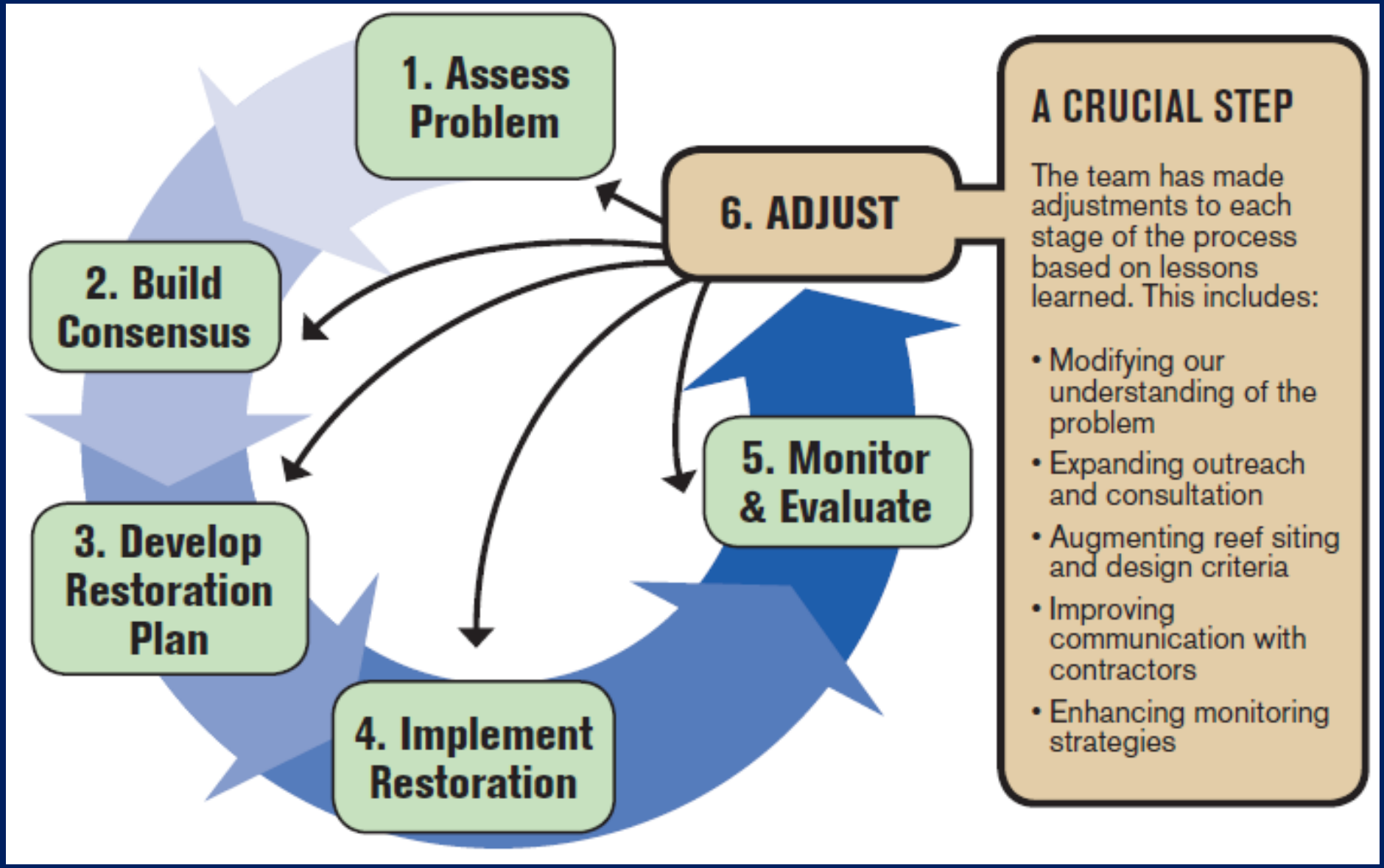
- *Summarized in McLean et al (2014) and Roseman et al. (2017).*
- *42 reefs constructed since early 1800s.*
- *Objectives, materials, & level of monitoring varied.*
- **Conclusions:**
  - **Lack of long-term evaluation of reef performance; except in SCDRS.**
  - **Need to develop standard protocols for monitoring biological and physical attributes of artificial structures.**
  - **Need to develop maintenance protocols for degraded and poorly functioning reefs.**

Constructed Reefs in SCDRS

- 7 Reef Complexes
  - > 20 acres
- St. Clair River (~6 acres)
  - Middle Channel (2012)
  - Pointe aux Chenes (2014)
  - Harts Light (2014)
- Detroit River (~14 acres)
  - Belle Isle (2016)
  - Fighting Island (2008, 2013)
  - Grassy Island (2015)
  - Ft. Wayne (2018)



Adaptive Management Framework



Also see Manny et al. 2015; Vaccaro et al. 2016, Hartig et al. 2018

Who Decided Reefs in SCDRS?

Multiple Agencies and Organizations

USGS science for a changing world

Sea Grant Michigan

FRIENDS of the DETROIT RIVER www.detroitriver.org

U.S. FISH & WILDLIFE SERVICE DEPARTMENT OF THE INTERIOR

WATER CENTER UNIVERSITY OF MICHIGAN

MICHIGAN ENGINEERING UNIVERSITY of MICHIGAN

DEPARTMENT OF NATURAL RESOURCES DNR MICHIGAN

System-wide Consensus

St. Clair - Detroit River System Initiative

P. A. C. Detroit River Public Advisory Council

St. Clair River BINATIONAL PUBLIC ADVISORY COUNCIL

Scientific Support

Who decided reefs in SCDRS?

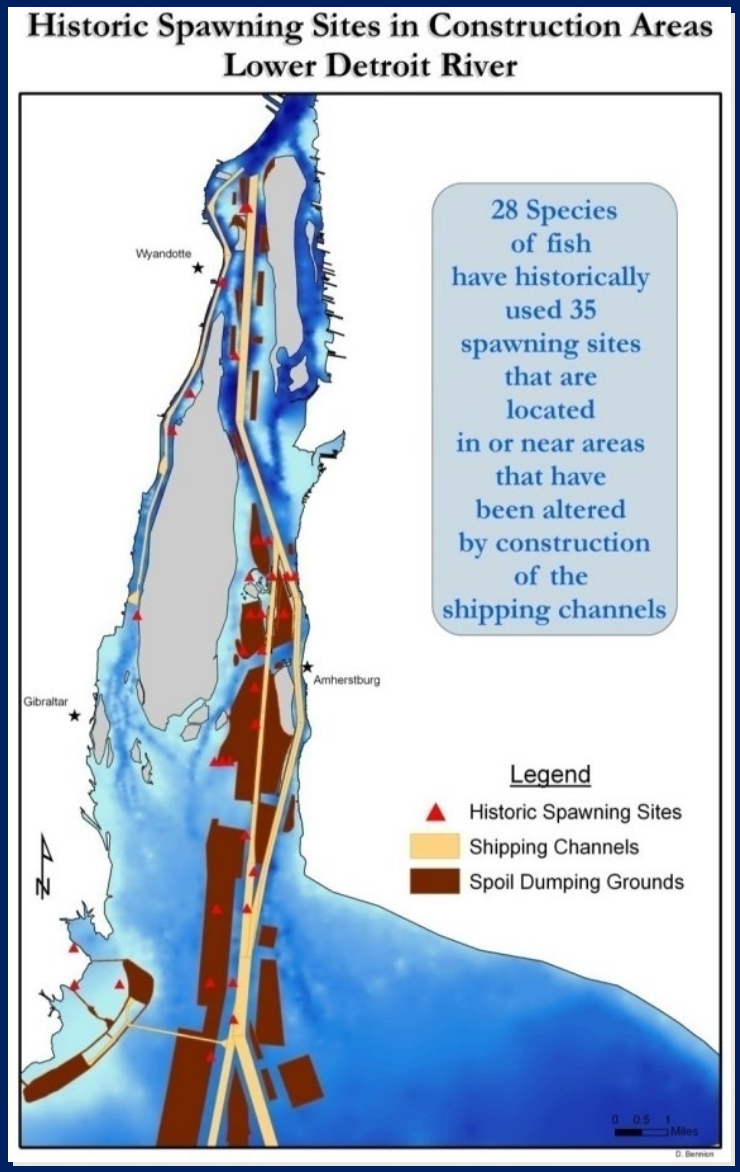
- Friends of the St. Clair River, SCR Binational Public Advisory Council, Friends of the Detroit River, Detroit River Public Advisory Council, state and provincial management agencies.
- **Designated reef restoration as a management action toward BUI delisting.**
- Required approval from state, federal, provincial governments, International Joint Commission, landowners, stakeholders, Lake Carriers Association, & others.

Why reefs in SCDRS?

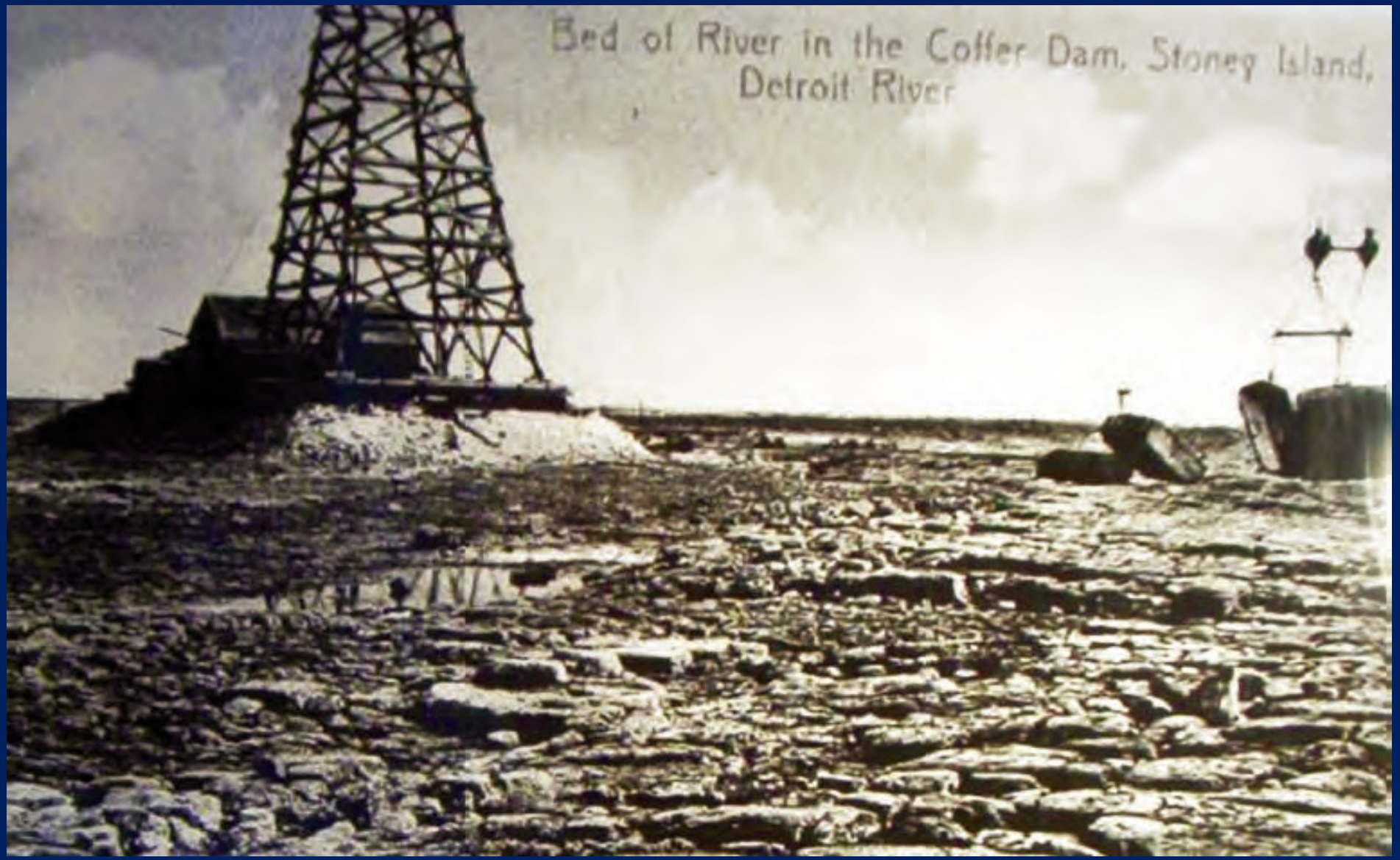
- Natural spawning habitat lost (next slide graphic).
- Research showed that fish recruitment limited by spawning habitat, lake sturgeon as focal species.
- Examples, successes from other systems (WI, St. Lawrence River, etc.).
- Managers, researchers, & stakeholders reached consensus via Detroit River Public Advisory Council (http://www.detroitriver.org) & SCDRS Initiative process (www.scdrs.org; Vaccaro et al. 2016) as BUI delisting criteria.

Construction of Shipping Channels

- Loss of spawning substrates
- 46,200,000 m^3 substrate removed
- 4,050 ha covered with dredge spoils
- Bennion & Manny (2011).



Loss of Spawning Habitat 1900-1912



Loss of Spawning Habitat 1900-1912

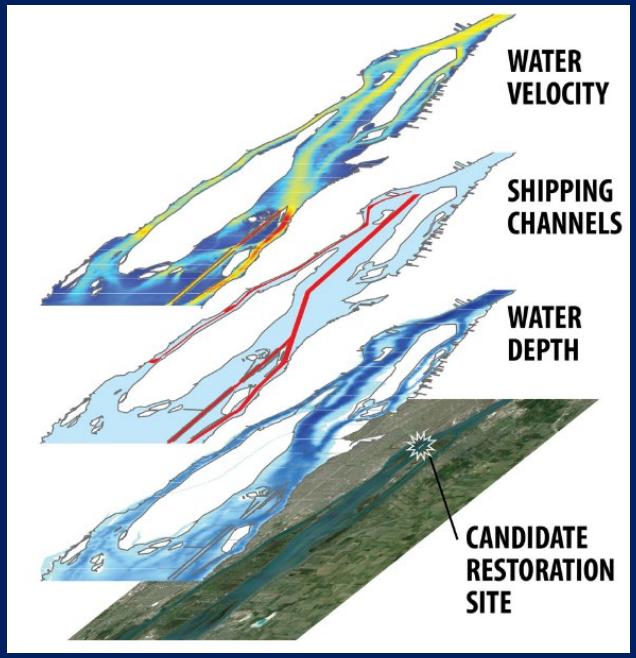
Livingstone Channel
lower Detroit River

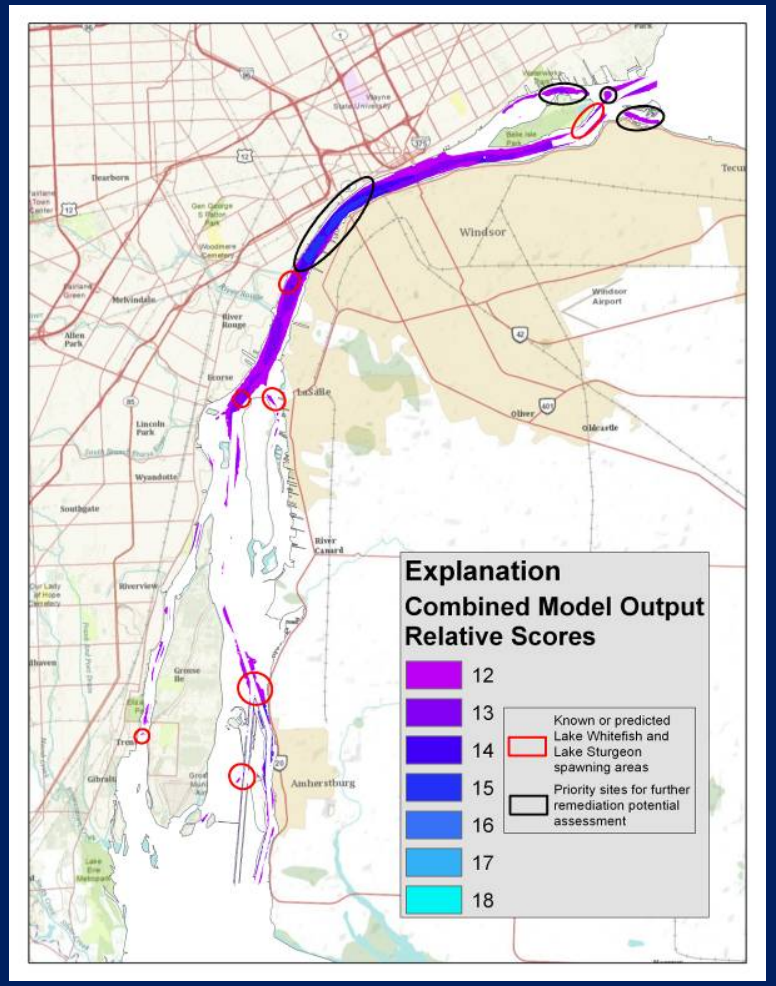
Where do SCDRS reefs get placed?

- Biophysical model to predict best locations
  - Bennion & Manny (2014).
  - Spawning requirements of the fish (literature review, research).
  - Depth, velocity, slope, existing substrate (reported values).
  - Validated by Fisher et al. (2015) with field measurements.
- No construction on existing spawning areas.
- No construction in or near shipping channels.

Prioritizing Restoration Areas

GIS model to find deep, fast flowing areas





Additional considerations:

- **Proximity to historic or current spawning sites**
- **Connectivity to nursery habitats**
- **Known contamination**

Bennion and Manny 2014, Journal of Great Lakes Research 40: 43-51

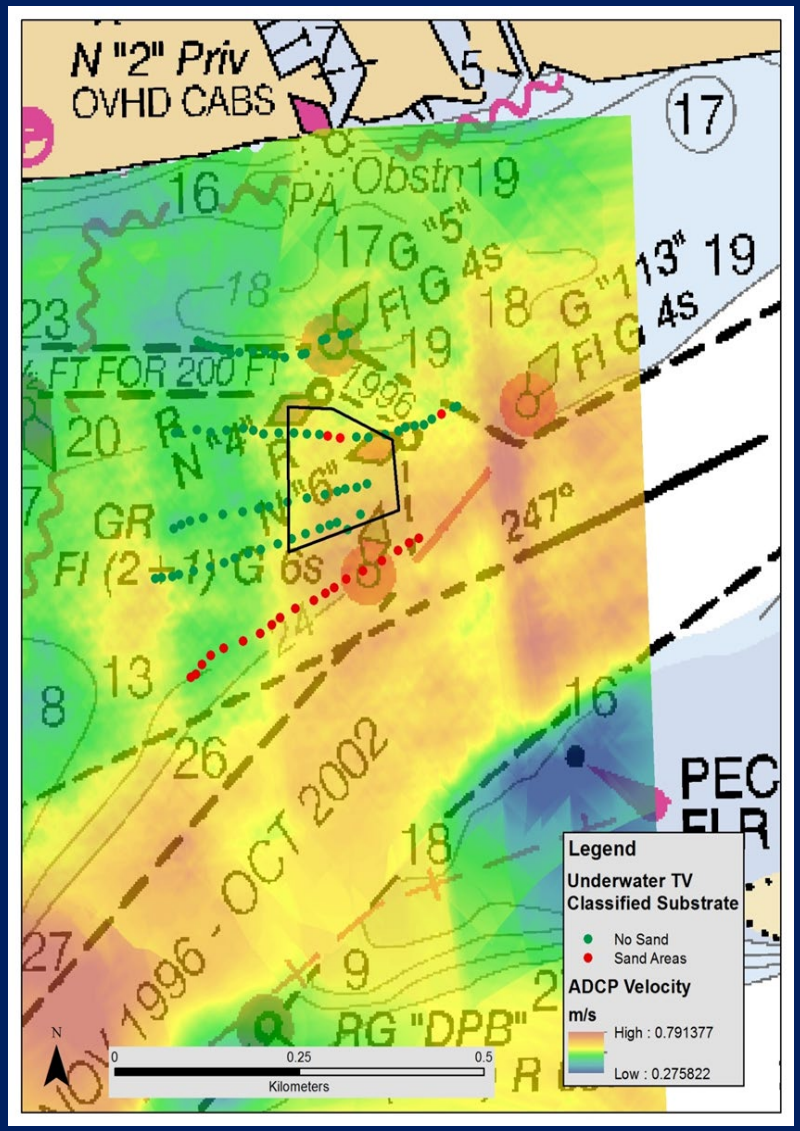
Selecting Reef Coordinates

Field Investigations:

- **Water velocity**
  - **ADCP**
- **River bottom topography and sediments**
  - **Side scan sonar**
  - **Underwater video**
  - **Scuba diving**
- **Biological activity**
  - **Egg collection**
  - **Adult fish surveys**

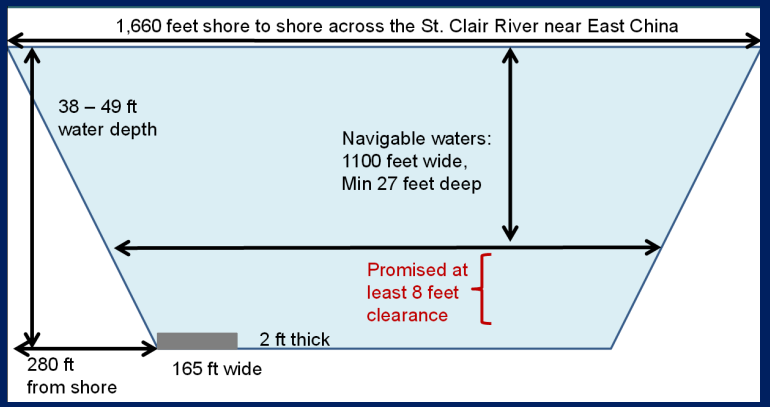
Hydrodynamic Modeling:

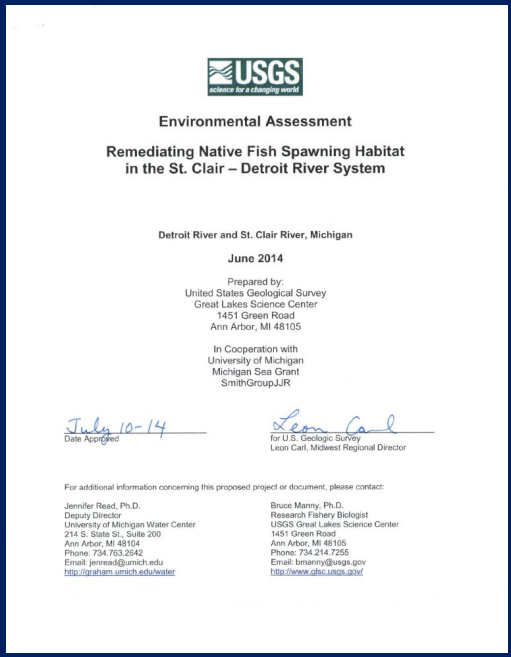
- **USGS Geomorphology and Sediment Transport Laboratory**



Project Permitting

- State permit (MDEQ)
  - Adjacent landowner permission
- Federal permit (USACE)
  - Public comment
  - Letter from Lake Carriers Association
- International review (DoS and DFAIT)
  - Water levels and flows
- National Environmental Protection Act
  - Environmental Assessment
  - State Historic Preservation Office review
  - Rare species review (MNFI)





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Environmental Assessment

Remediating Native Fish Spawning Habitat
in the St. Clair – Detroit River System

Detroit River and St. Clair River, Michigan

June 2014

Prepared by:
United States Geological Survey
Great Lakes Science Center
1451 Green Road
Ann Arbor, MI 48105

In Cooperation with
University of Michigan
Michigan Sea Grant
SmithGroupJJR

July 10-14
Date Approved

for U.S. Geologic Survey
Leon Carl, Midwest Regional Director

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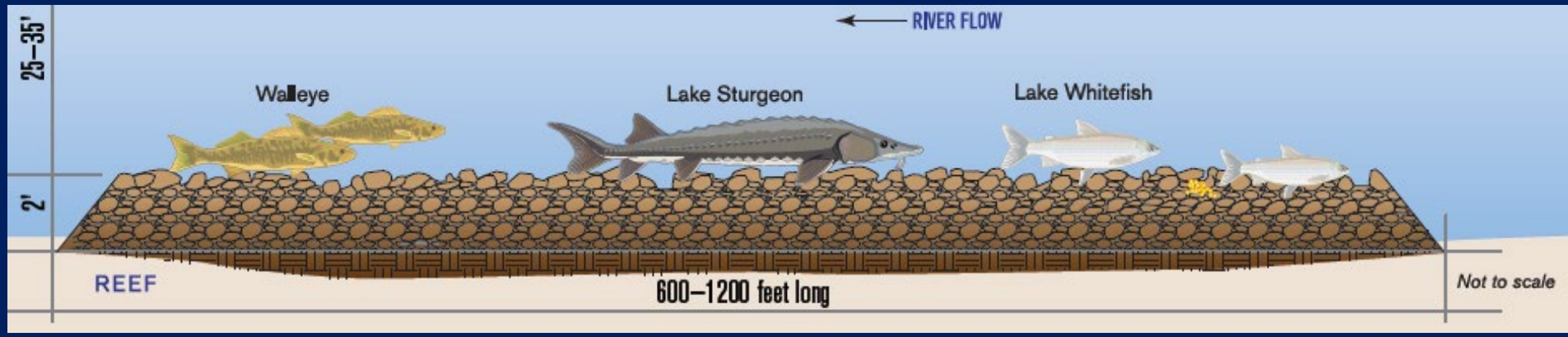
Engineering and Design

- **Old “no-miss” design across entire channel flawed.**
- **Oriented lengthwise with river flow.**



Engineering and Design

Contracted to private company.

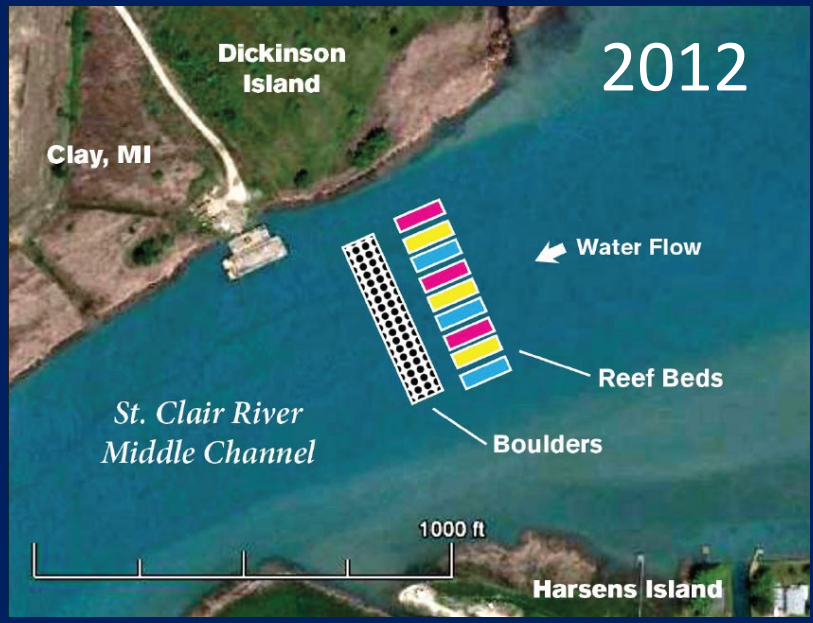
Size, shape, arrangement, orientation.

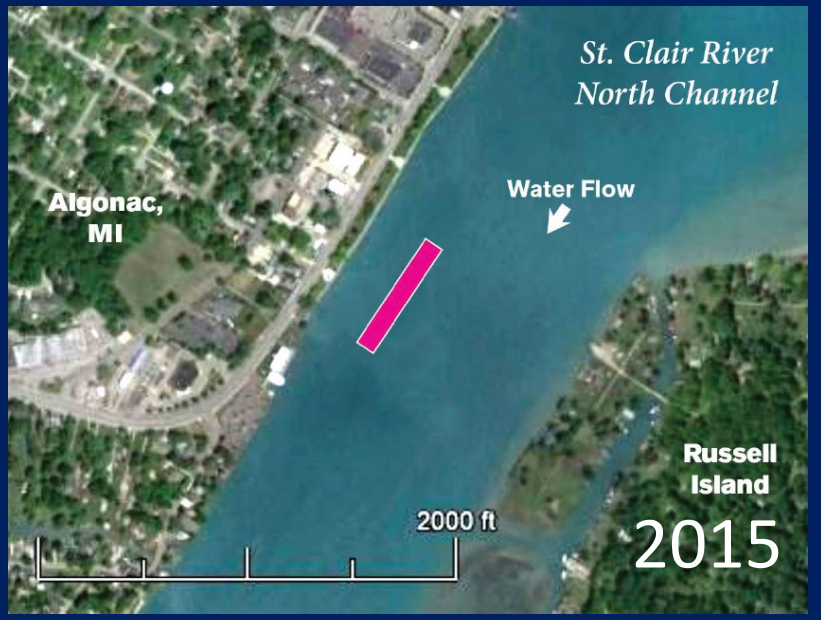
Initial Projects - Experimental

- Multiple reef beds, materials
- Spanned the channel
  "no-miss" design

Recent Projects – Refined

- One large reef
- Optimally located within the channel
- Avoid depositional areas





Material Selection

- **Life history and spawning preferences.**
- **Larger than preferred for Sea Lamprey (*Petromyzon marinus*).**
- **Experimental design at Belle Isle (2004) and Fighting Island.**
  - **Different rock types (fractured limestone, field stone, mixed rock, coal cinders.**
  - **No statistically significant difference in egg deposition.**
- **Cost also considered.**

Material Selected

- **100 –200 mm angular native limestone.**
- **Local, clean, affordable**
- **Fish use it**

Material Deployment

Crane and clamshell bucket

Dump barge

What determines reef viability & performance?

- Fish use
- Physical integrity

Lake Sturgeon Eggs at Middle Channel Reef
photo credit: Jeff Allen USGS

Monitoring

- Techniques that match the system
- Comprehensive monitoring (biological and physical)
- Coordinated across agencies
- Focused research with universities
- Robust evaluation of changes

How are reefs assessed?

- Control sites, before & after construction for most reefs (BACI).
- Biological
  - Spawning activity (several publications)
  - Fish production (several publications on larval drift)
  - Creel survey (Castle et al., in review)
  - Genetic aspects of lake sturgeon (Marranca et al. 2015; Hunter et al., in review)
- Physical status (Fisher et al. pubs and in review)
  - Size, permanence, sediment, infilling, scour, etc.

Immediate and repeated spawning

● **Eggs**

■ **Ripe adults**

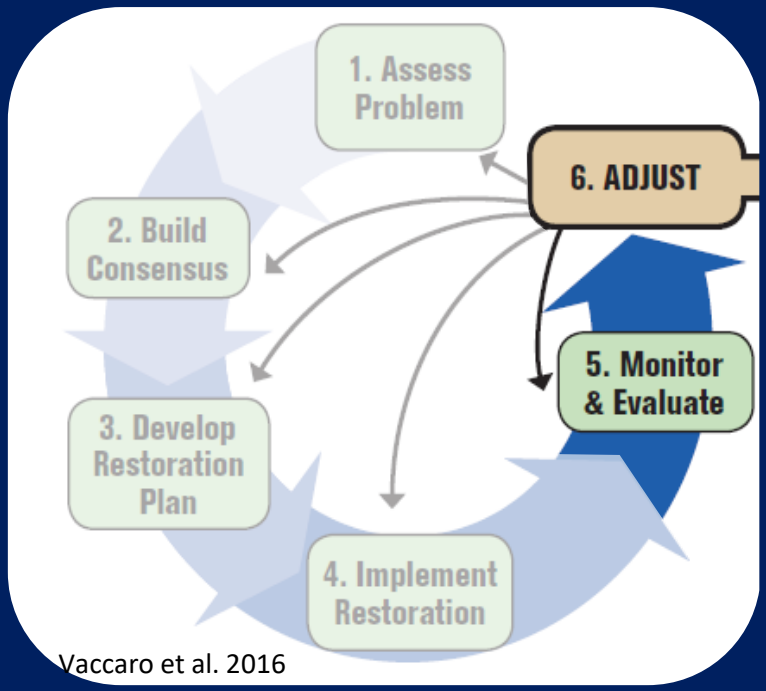
▲ **Other life stage**

	Belle Isle	Fighting Island	Middle Channel	Pointe Aux Chenes	Harts Light
Fish that show signs of spawning activity on reefs					
Black redhorse*		■			
Emerald shiner	●		▲		
Golden redhorse*			■	▲	
Lake sturgeon	■	● ▲	● ▲	● ▲	● ▲
Lake whitefish	● ▲	● ▲			
Northern hog sucker*	● ■			▲	
Quillback*	●	■			
Rock bass	■	▲	▲	▲	▲
Round goby (non-native)	▲	● ▲	▲	▲	▲
Shorthead redhorse*	● ■	▲	■	▲	▲
Silver redhorse*	● ■	■	■	■	
Smallmouth bass	▲	■			
Stonecat		▲	■		▲
Trout-perch	●	●			
Walleye	● ■	● ■	● ■	● ■	● ■
White bass ^	■	■	■		
White perch (non-native) ^	■	■			
White sucker*	● ■	■	■	■	■

Vaccaro et al. 2016. *"Science in Action: Lessons Learned…"* University of Michigan.

Need for Physical Monitoring

- Restoration is a large initial investment
  - Ensure return on investment (e.g., objectives are meet)
- Reef longevity is finite
  - Large lakes and rivers are dynamic
- Determine if maintenance is required
- Essential part of the adaptive management cycle



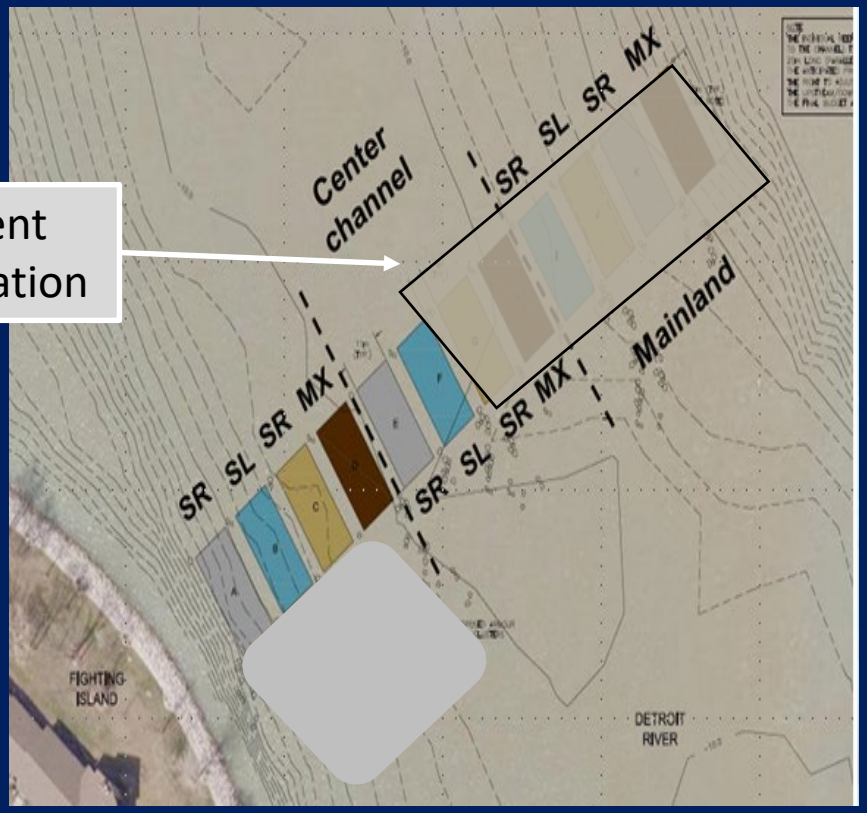
Vaccaro et al. 2016

Sand Accumulation on Early Reefs

Middle Channel

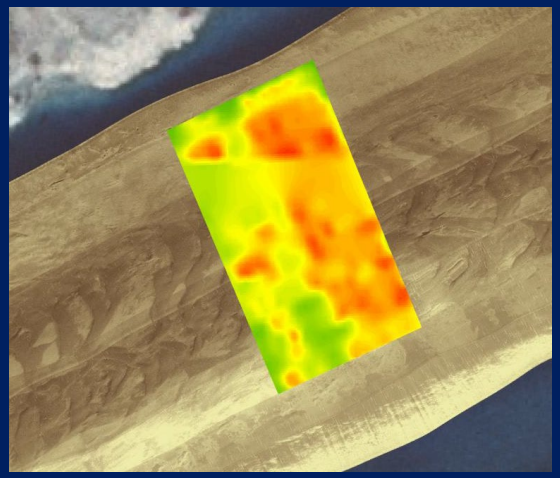
Sediment Accumulation

Fighting Island



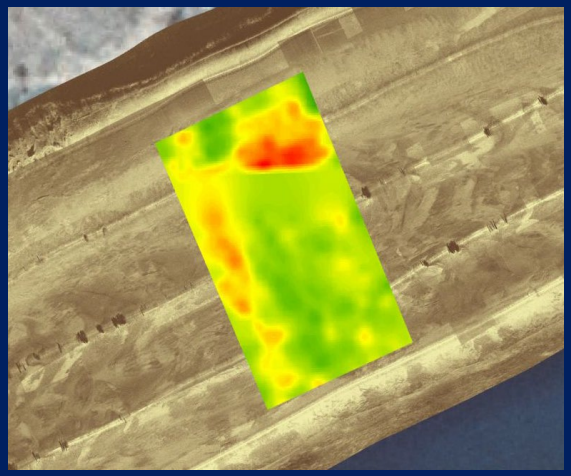
Decreased Reef Performance

- Infilling, burial, decline & cessation of fish spawning.
- Occurred within 2 years after construction.
- Degree of infilling/sedimentation varies annually.



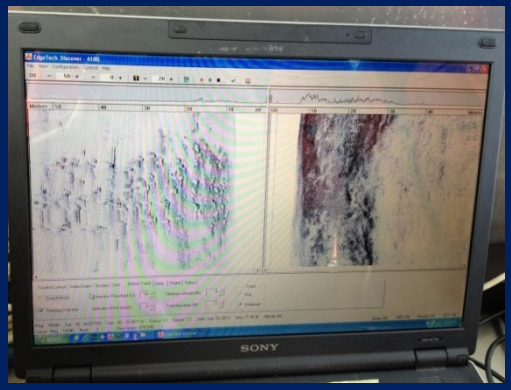
Hardness Index
Middle Channel SCR
(Todd Wills, MDNR)

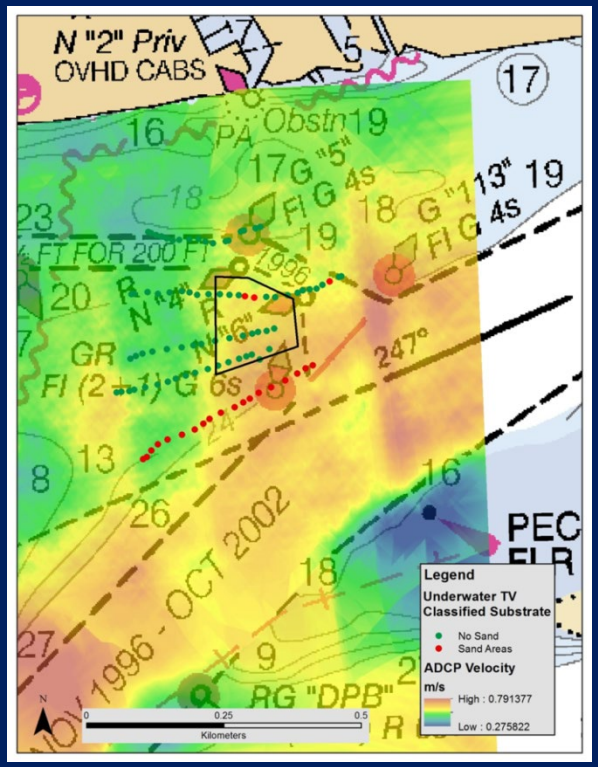
Red – most hard
Green – least hard



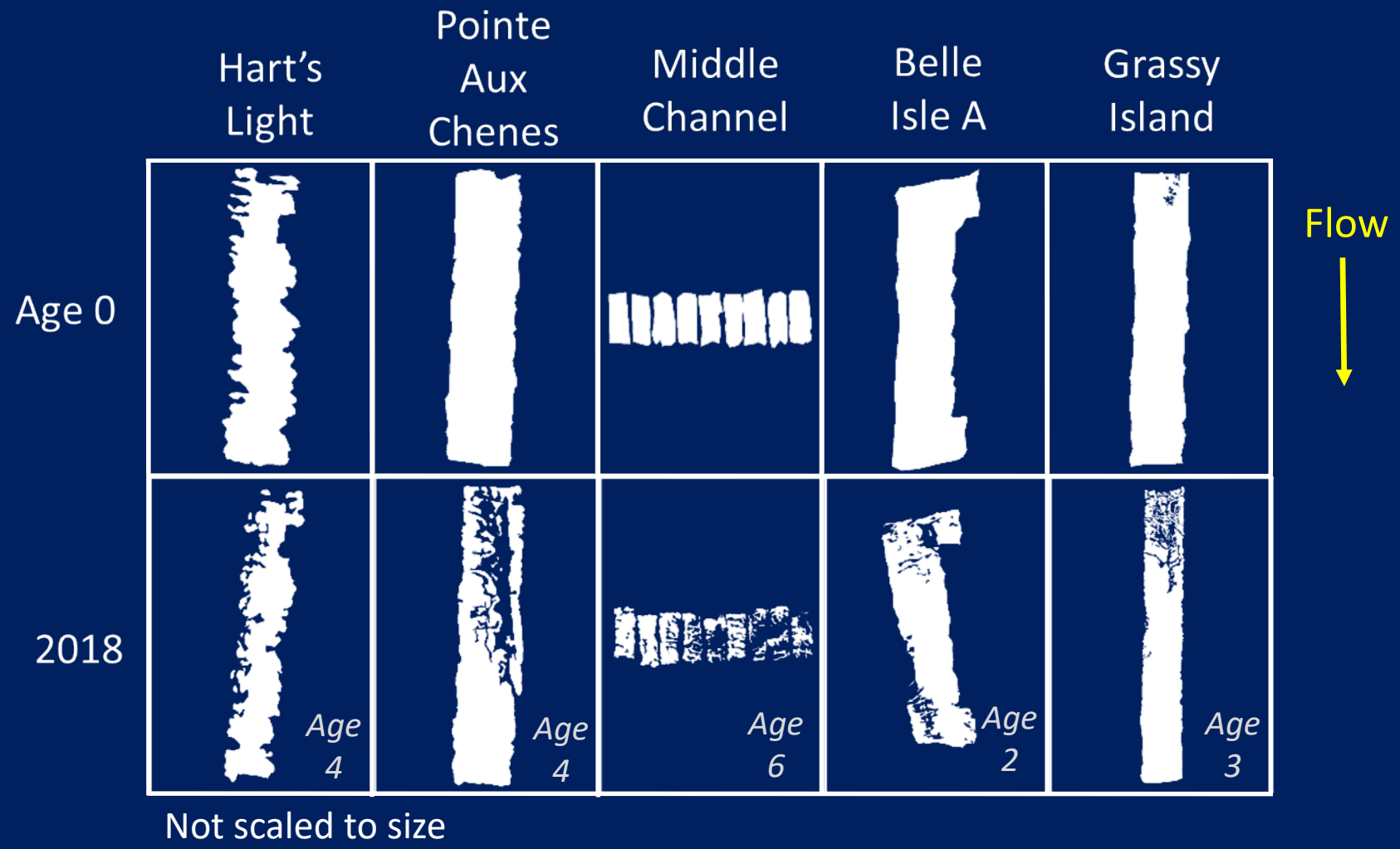
Enhanced Physical Assessment

- Side scan sonar
- Underwater video
- ADCP (flow)
- Hydrodynamic modeling
- Scuba diving
- Upstream sediment sources
- Dredging records



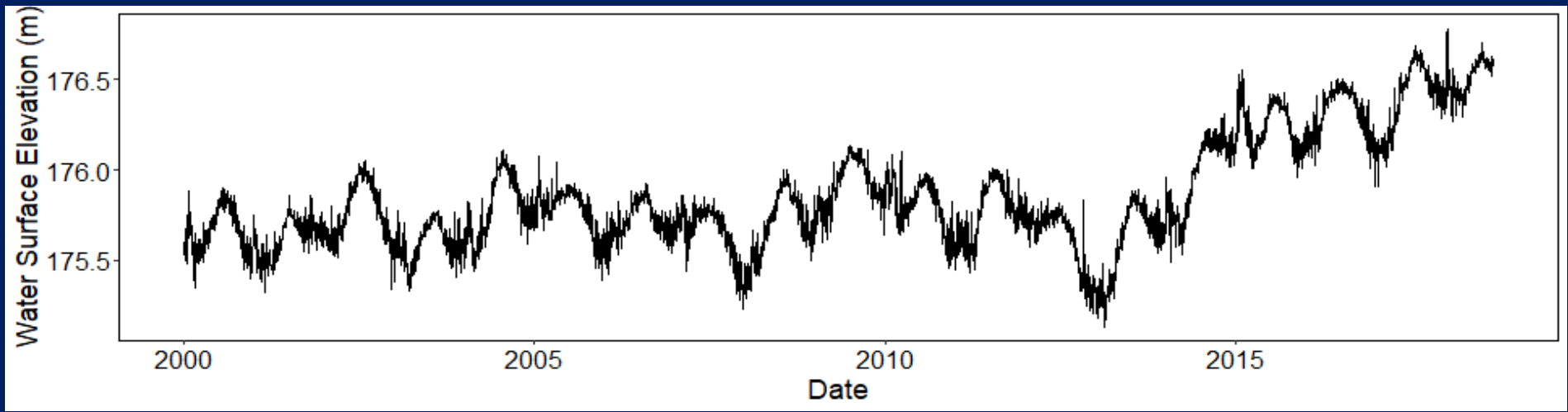


Reef Area Decreasing



Potential Sediment Sources

1. Small, but persistent bedload
   - SCDRS is “sediment starved”
2. Increased sediment from episodic events
   - Ice jam
     - Occurred Jan. 2018
   - Record high water levels



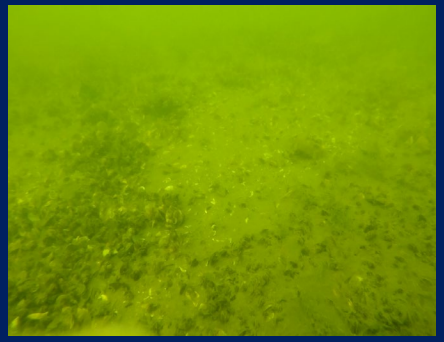
Reef Degradation Across the Great Lakes

- Biological fouling
  - Clog interstitial spaces
  - Deplete oxygen and create waste

ex: Cladophora & Dressenid mussels

- Sedimentation
  - Clog interstitial spaces
  - Prevents flow of oxygen rich water

ex: resuspension & runoff



How can we maintain/repair poorly functioning reefs?

- GLRI sponsored project FY18-19.
- Wide-spread interest & applicability across Great Lakes.
- Partnered with Purdue University.
  - Testing 2 different techniques to clean reefs.

- Objectives:
  - Portable, affordable methods to clean reefs
- Measure of success:
  - Positive response by fish

Prototype Methods to Remove Sediment and Biofouling (Purdue)

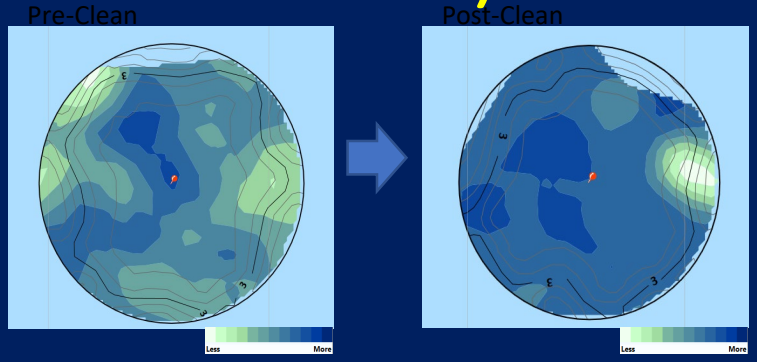
Propulsion Sled

Hydro-Jet Sled

Reef Maintenance Preliminary Results

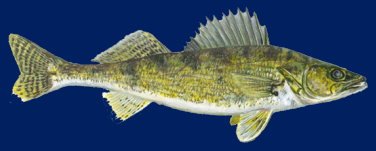
(Alex Gatch - Purdue)

- Relative hardness
  - Post > pre
  - Propulsion > Jet



- Egg deposition:
  - Lake whitefish
    - Treated > control
    - Propulsion > Jet

  - Walleye
    - Propulsion > Jet at North Island



- 2019 Workplan
  - Additional cleaning and monitoring for fall spawners

Literature review of reef repair and maintenance (Baetz – USGS)

- Marine and freshwater
- Marine engineering, archaeology, navigation industries

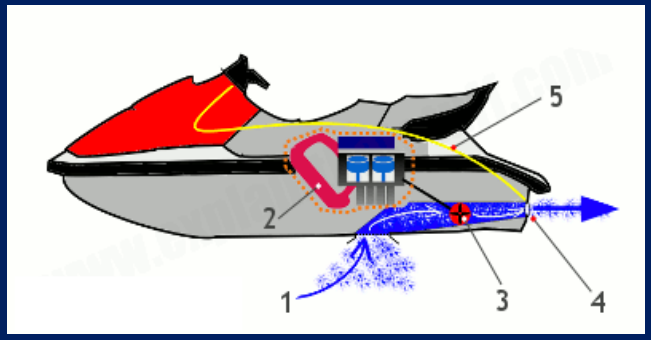
Induction Dredging

Air Lift

Sandsucker Dredge

Reef Blaster for Lotic Systems

- Jet ski powered propulsion water blaster.
- Allows for reef cleaning without contact with reef, dragging bottom, diving.



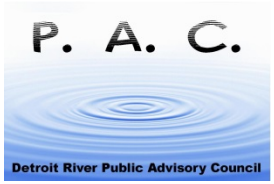
Summary and Conclusions: Measurable Impacts of Restoration

- Based on BUI delisting criteria, all reef projects are completed.
- Immediate & continued use of restored spawning reefs.
- More lake sturgeon being caught
  - MI DNR & USFWS surveys, Anglers
- Diversified Spawning Stock Portfolio
  - Walleye, Lake Whitefish, Lake Sturgeon
  - Population resilience
- Public Satisfaction
  - Creel survey results, high angler use
  - Excellent walleye, lake sturgeon fishing

Summary

- Functional spawning habitat can be restored.
  - Immediate & repeated response by several native species.
  - If physical integrity remains, fish will spawn.
- Spawning reef restoration is a viable component of the renaissance for urban waterways.
  - Reviving economic, social, & cultural values.

Many Partners to Thank



Michigan Coastal Management Program