



Engineering for Conservation: *Aquatic Systems*

Liz Gilles, School Programs Supervisor



Our mission: to connect people, animals, and the natural world to save wildlife

Agenda

- Why STEM at the Zoo?
- The ZOO's STEM Program (ZOOMS)
- Engineering for Aquatic Systems
 - Bycatch Reduction Design
 - Marine Water System Engineering
 - Mussel Conservation Project
- Wrap Up/Questions





Minnesota Zoo

Located on 485 acres in suburban Minneapolis-St. Paul.

Home to more than 4700 animals and award-winning exhibits

484,000 participants in our education programs last year, including 90,000 school programs participants.



Why STEM at the Zoo?

- Creating a highly engaging, positive, learning experience
- Allowing students to see STEM outside of formal academic environment
- Providing unique context to study STEM and life science content
- Application of STEM to solve environmental and/or conservation challenges
- Providing opportunities and resources not available in the classroom



The Minnesota Zoo's Integrated STEM Program





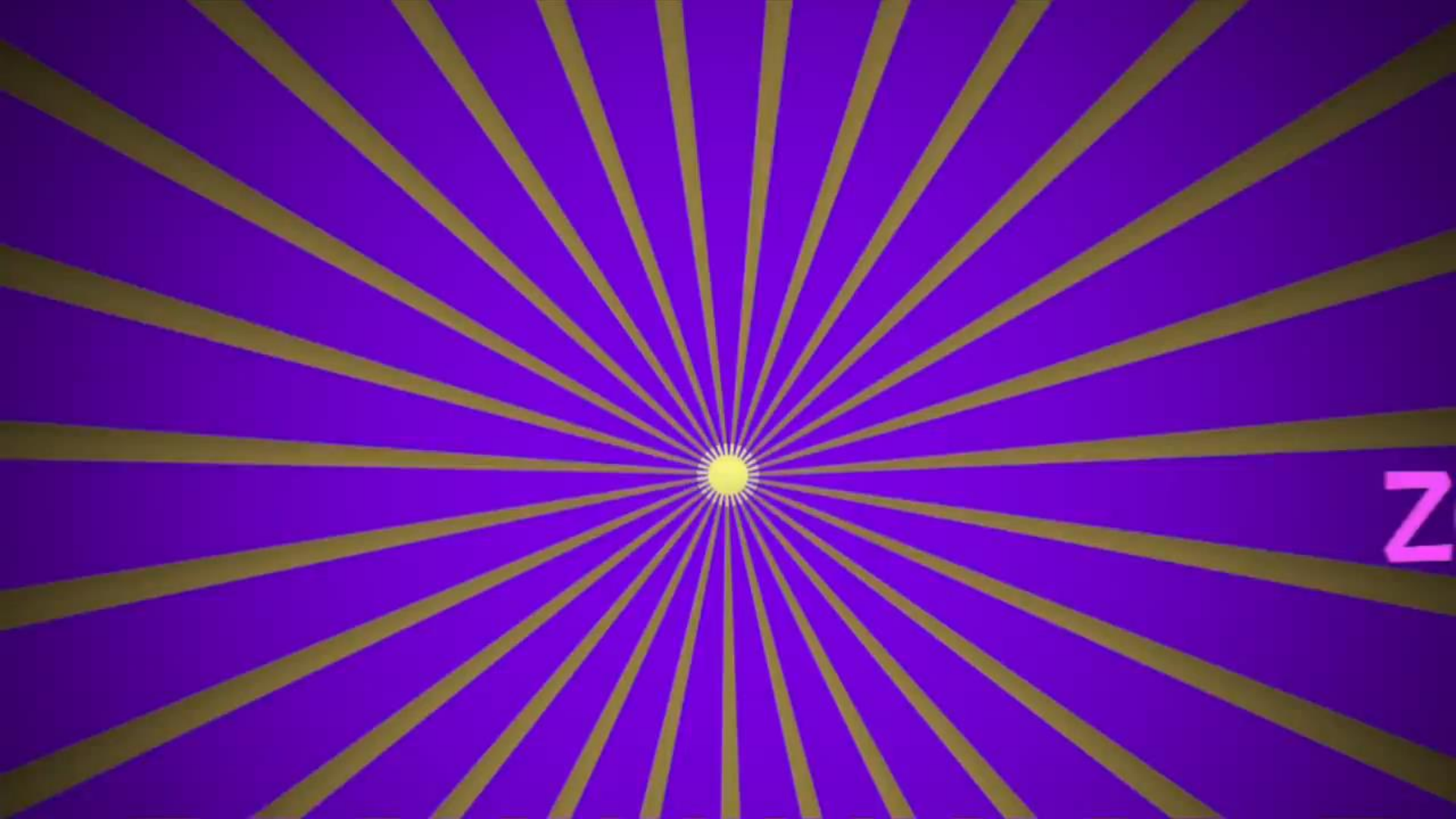
Zoo Math and Science

Engineering a Modern Zoo



- ZOOMS is an interdisciplinary, zoo-based integrated STEM program that supports the mission of the Minnesota Zoo to connect people, animals, and the natural world to save wildlife.
- ZOOMS programs support Minnesota State Academic Standards and the Next Generation Science Standards.
- ZOOMS includes:
 - ZOOMS Design Challenge presented by Flint Hills Resources
 - Zoo Classes and tours
 - Teacher Professional Development
 - Zoomobile Programs
 - Curriculum





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ZOOMS Design Challenge presented by Flint Hills Resources



2018-2019 ZOOMS Design Challenge

Looking for ways to engage your students in integrated STEM? Register your class to develop a solution to a real problem at the zoo! This year, both challenges are focused on the endangered Moose. **A FREE design challenge teacher workshop will be offered on Tuesday September 25th from 9 am- 3 pm** to offer resources, activity ideas, and background knowledge of each challenge to help support implementation of the design challenge in to your classroom. If you are unable to attend, communication will be continued through an online basecamp community of design challenge participants throughout the year. The first 10 Elementary and 10 Middle School teacher's to register receive a \$200 stipend upon meeting design challenge guidelines.

Enrichment Design Challenge

Level 1: 3rd – 5th Grade

Level 2: Middle School

Meet the Enrichment Goals for Minnesota Zoo's Moose

The Minnesota Zoo became the new home to six abandoned moose calves in the summer of 2014 – Grant, Marais, Mack, Matilda, Alice, and Aurora. These calves, two male and four female, all came to the Zoo when they were 7-9 weeks old, needing around the clock care for the first few months as they settled into their new home. Keepers need help meeting their enrichment goals through new innovative enrichment ideas that not only encourage moose natural behaviors, but also consider their individual needs, safety, and exhibit use.



[Enrichment Design Challenge Guidelines](#)

ZOOMS Design Challenge presented by Flint Hills Resources



Exhibit Design Challenge

Level 1: 3rd – 5th Grade

Level 2: Middle School

Pitch new ideas to the Minnesota Zoo to redesign the Moose Exhibit

The Minnesota Zoo is home to six abandoned moose calves that arrived in the summer of 2014. Currently visitors may see either one or two moose roaming at a time in their habitat along the Northern Trail. As the 40th year anniversary of the Minnesota Zoo is underway, the zoo is looking to revitalize the moose exhibit to highlight the amazing conservation work being done to save the declining wild moose population in Minnesota. Although planning for a moose exhibit is only in the brainstorming phase, zoo exhibit designers hope to split the exhibit in 2 to allow for more than 1-2 moose to be visible for visitors at a time. They'd also like new interpretive theming, more immersive visitor spaces, and better viewing angles. Keepers are also hoping for a better training and enrichment area to improve visibility during scheduled demonstrations available to the public. The Minnesota Zoo would love to see some creative design ideas to help guide their brainstorm of what a new moose exhibit could look like while better accommodating the needs of the moose, keepers, and visitors.



[Exhibit Design Challenge Guidelines](#)



The MN Zoo's Approach to STEM



Engineering for Conservation



Introduce a conservation issue and then engineer a solution...

1) In the Wild



2) At the Zoo



3) In Minnesota

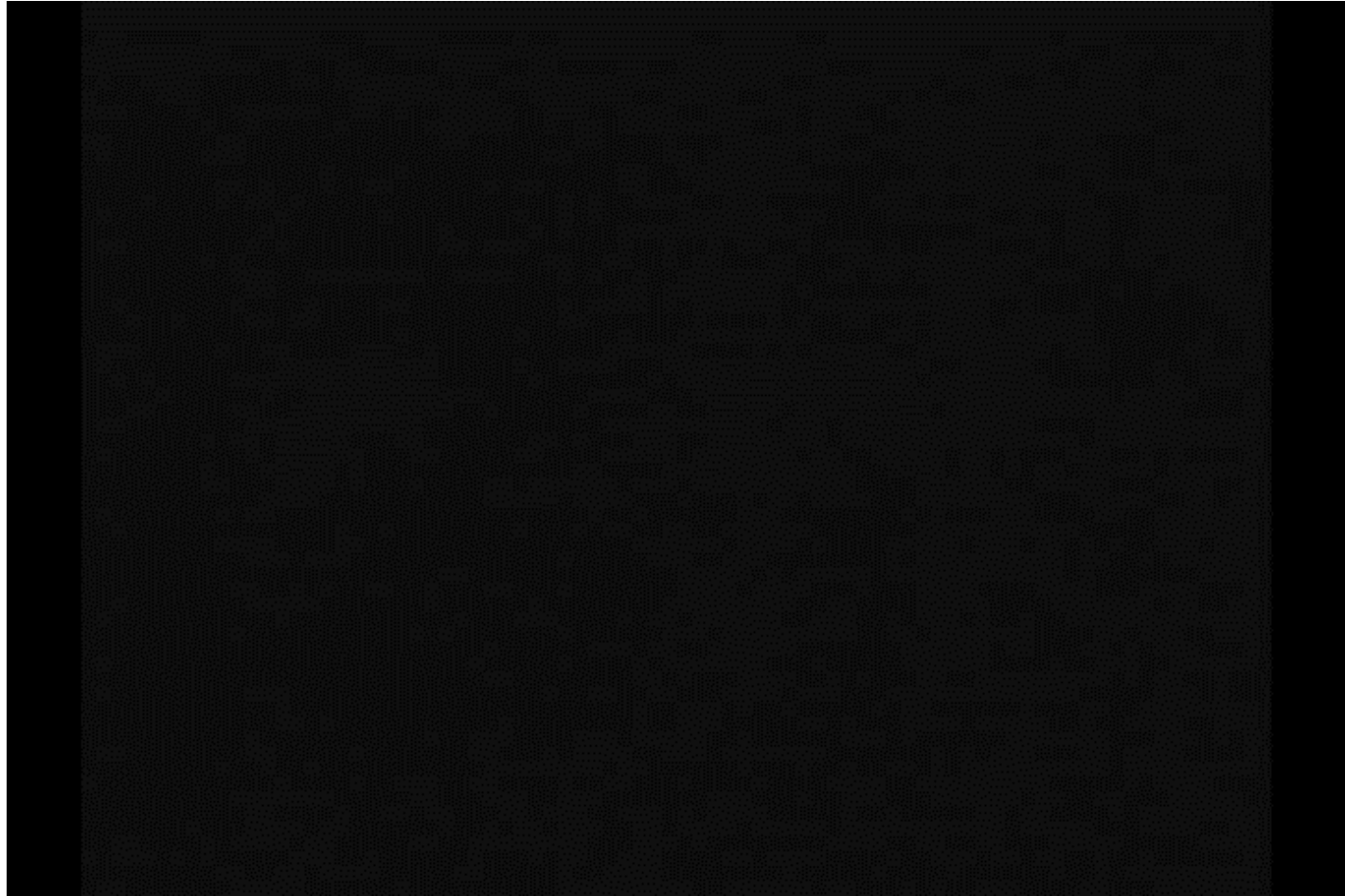


What is Bycatch?



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ZOO MS!



Why is Bycatch a Problem?

- Global bycatch may amount to 40 percent of the world's catch, totaling 63 billion pounds per year
- An estimated 17-22 percent of U.S. catch is discarded every year
- Bycatch in the U.S. could amount to 2 billion pounds every year, equivalent to the entire annual catch of many other fishing nations around the world.



Bycatch Online Resources: noaa.org and oceana.org

Why is Bycatch a Problem?

- It is an ecological and economic problem.
 - Animals that are discarded often die and cannot reproduce, impacting vulnerable ecosystems.
 - Bycatch can also slow the rebuilding of overfished stocks and place protected species at further risk.
 - Bycatch of one species may limit opportunities to fish for other species. This creates uncertainty and economic costs for fishermen.



Bycatch Online Resources: www.noaa.org and www.oceana.org

Why is Bycatch a Problem?



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US BYCATCH



TOTAL US BYCATCH:

Almost 2 billion pounds*

**Based on 2011 National Bycatch Report*

NEEDLESS WASTE

Approximately 20 percent of the U.S. catch is thrown away each year.

LACK OF OBSERVER COVERAGE

The severity of bycatch in many fisheries remains unknown. In some fisheries, as few as 1 in 100 fishing trips are observed, while other fishing trips are not monitored at all.

POOR QUALITY DATA

Less than 5 percent of U.S. fisheries report bycatch with the accuracy and precision recommended by federal guidelines.

What is Being Done?



NOAA FISHERIES
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

40 YEARS **MAGNUSON STEVENS ACT**
A Journey to Sustainable Fisheries
#MSA40—LEARN MORE



ZOOVMS!



Tracking Bycatch

National Bycatch Report
National Observer Program



Encouraging Innovation

Bycatch Reduction Engineering Program
Turtle Excluder Devices
Understanding Fishing Gear



Reducing Bycatch

Protected Resources Interactions
Fishery Management Plans
Take Reduction Plans
National Seabird Program

Encouraging Innovation



- **Technological Innovation** – Developing effective technologies, gear modifications, and improved fishing practices in recreational and commercial fisheries
- **Release or Discard Mortality** – Understanding and reducing post-release mortality in recreational and commercial fisheries.
- **Fishing Gear and Corals** – Understanding the amount and severity of interactions, and ways to reduce harmful interactions, between fishing gears and corals, sponges, and other structure-forming invertebrates.
- **International Best Practices** – Informing conservation engineering in U.S. fisheries through analyses or research of international bycatch practices.



Bycatch Reduction Engineering Program

Grants for Innovated Solutions

- Researchers in Florida are developing **timed-release chemical shark repellants** that could reduce shark bycatch by 18 to 35 percent depending on the type and intensity of repellent used.
- In the North Pacific, researchers have found that by using **illumination** they can reduce Chinook salmon bycatch by attracting the fish toward escape areas in Pacific hake midwater trawl nets.
- In the Northwest, researchers found that using a **sorting grate** that allow the smaller, target fish to pass through leads to a 26 percent reduction in widow rockfish bycatch.



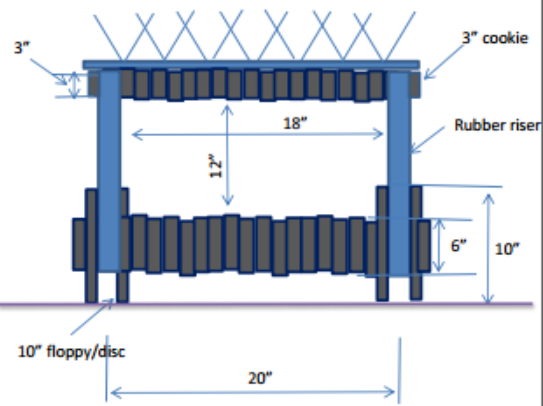
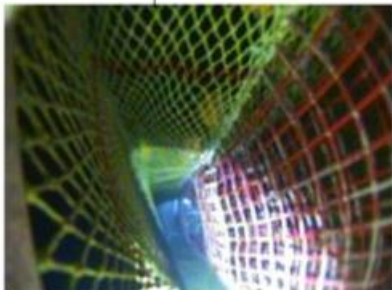
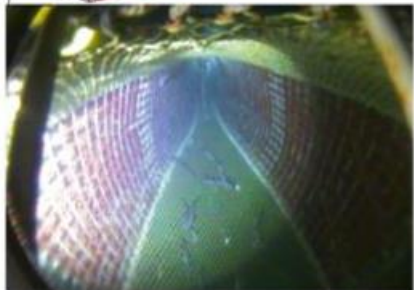
BRD's: Bycatch Reduction Device



Exit ramp and escape area

Fore

Aft



Activity: Bycatch Reduction Design

Task: Engineer a new fishing net to reduce bycatch while targeting tuna.



| Material | Species |
|---------------|--------------------|
| Marble | Tuna (Target Fish) |
| Ping Pong | Dolphin |
| White Bean | Herring |
| Red Bean | Squid |
| Garbanzo Bean | Shrimp |

Activity: Bycatch Reduction Design



| | # individuals of target species caught | # individuals of non-target species caught | Total # individuals caught | % target species (# target/total #) | % non target species) (# non- target/total #) | Types of non target species caught |
|-------------|--|--|----------------------------------|---|--|--|
| Prototype 1 | | | | | | |
| Prototype 2 | | | | | | |
| Prototype 3 | | | | | | |

Engineering for Conservation



Introduce a conservation issue and then engineer a solution...

1) In the Wild



2) At the Zoo



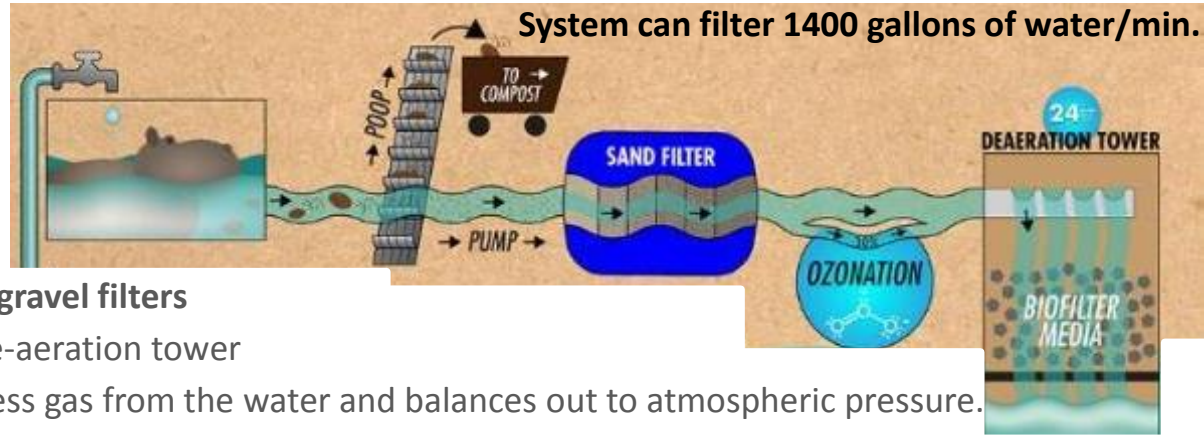
3) In Minnesota



Life Support Operations



Water Filtration



- **1. Rapid Sand and gravel filters**
 - 90% runs to a de-aeration tower
 - Releases excess gas from the water and balances out to atmospheric pressure.
 - This water is then is redirected back to the exhibit.
- **2. Ozonation**
 - 10% of water goes to ozonation tower (a more animal friendly alternative to chlorine)
 - Breaks up proteins that would discolor the water (would be yellow otherwise)
 - Because ozone is toxic, it is then sent to a de-aeration tower where it is removed by a vacuum.
- **3. Sub-sand biological filtration**
 - Nitrifying bacteria introduced to break down dangerous ammonia and nitrogen compounds.
 - This water is then is redirected back to the exhibit.

Life Support = Water System Engineer

- Water is checked by the staff 3 times per day and is tested for temperature, PH, salinity, total and free chlorine and nitrogen ammonia to ensure a stable and lean environment.
- In the Hawaiian Monk Seal water system, additional bacteria and fecal coliforms samples are submitted to the animal health lab 3 times per week for analysis.



Life Support = Water System Engineer



Challenges in Maintaining Minnesota Zoo Water Systems


- Keeping salinity just right: salt water mixed with instant ocean and Minnesota city water.
- Monitors and maintains 5 miles of pipes, 70 pumps and 66 tanks holding from 20 to 1 million gallons of water.
- On call 24/7 365 days a year.
- Adjusts water chemistry as needed to meet the **very diverse and sensitive** needs of fish and mammals.



Engineering Water Systems for Marine Animals



- **AZA sets acceptable water conditions for animals in zoos (Husbandry Manuals)**
 - >1000 coliform per 100 ml water
 - Water testing guidelines
 - Water turnover rates for filtration
 - Turbidity level (water clarity)
- **Larger bodies of water are slower to change.**
 - External conditions must be considered
 - Outdoor vs. indoor
 - Humidity levels (Tropics)
 - Air Temperature
- **Range of acceptable water conditions varies from animal to animal**
 - Fish tend to be more sensitive to slight changes

| Hawaiian Monk Seal | |
|--|--|
|  | |
| Background and Habitat Considerations | Water Chemistry |
| <ul style="list-style-type: none">• Hawaiian monk seals inhabit the coasts of the Hawaiian Islands. They rest and breed on atolls and sandy beaches, but spend most of their time in the water.• Monk seals are mammals that need to breathe air, but they are known to dive to depths of over 1,800 feet.• Once a year, these seals stay on land for a few weeks and shed their fur and the upper layer of skin in a process called molting.• Long term exposure to fresh water has been known to cause <i>corneal edema</i> (swelling of the cornea) in seal species.• Monk Seals require ample space for territories, especially males. | <p>Salinity Range 27-35 ppt</p> <p>Temperature Range 68-82 °F</p> <p>PH Level Range 7.5 - 8.1</p> |

Find missing Salinity – Tank A and C



| TANK A | |
|--------------------|--------------------------|
| Salinity | |
| PH | 8.00 |
| Temperature | 75 |
| Water Volume | 82,500 gallons |
| Exhibit Dimensions | 24 ft. x 60 ft. x 12 ft. |

| TANK C | |
|--------------------|-------------------------|
| Salinity | |
| PH | 8.05 |
| Temperature | 74°F |
| Water Volume | 450 gallons |
| Exhibit Dimensions | 8 ft. x 2.5 ft. x 3 ft. |

Refractometer

Tool used by Life Support and Aquarists to monitor changes in salinity



Measures in ppt (parts per thousand)

Marine Animals and Water Systems

| | TANK A | TANK B | TANK C | TANK D | TANK E | TANK F | TANK G | TANK H |
|--------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Sand Tiger Shark | | | | | | | | |
| Bat Ray | | | | | | | | |
| Bubble Coral | | | | | | | | |
| African Penguin | | | | | | | | |
| Red Sea Star | | | | | | | | |
| Sea Otter | | | | | | | | |
| Zebra Shark | | | | | | | | |
| Hawaiian Monk Seal | | | | | | | | |

Engineering for Conservation



Introduce a conservation issue and then engineer a solution...

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Native Freshwater Mussel Conservation Project

Minnesota Zoo/DNR



Key Ecological Role: Habitat Engineers





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ZOOMS!

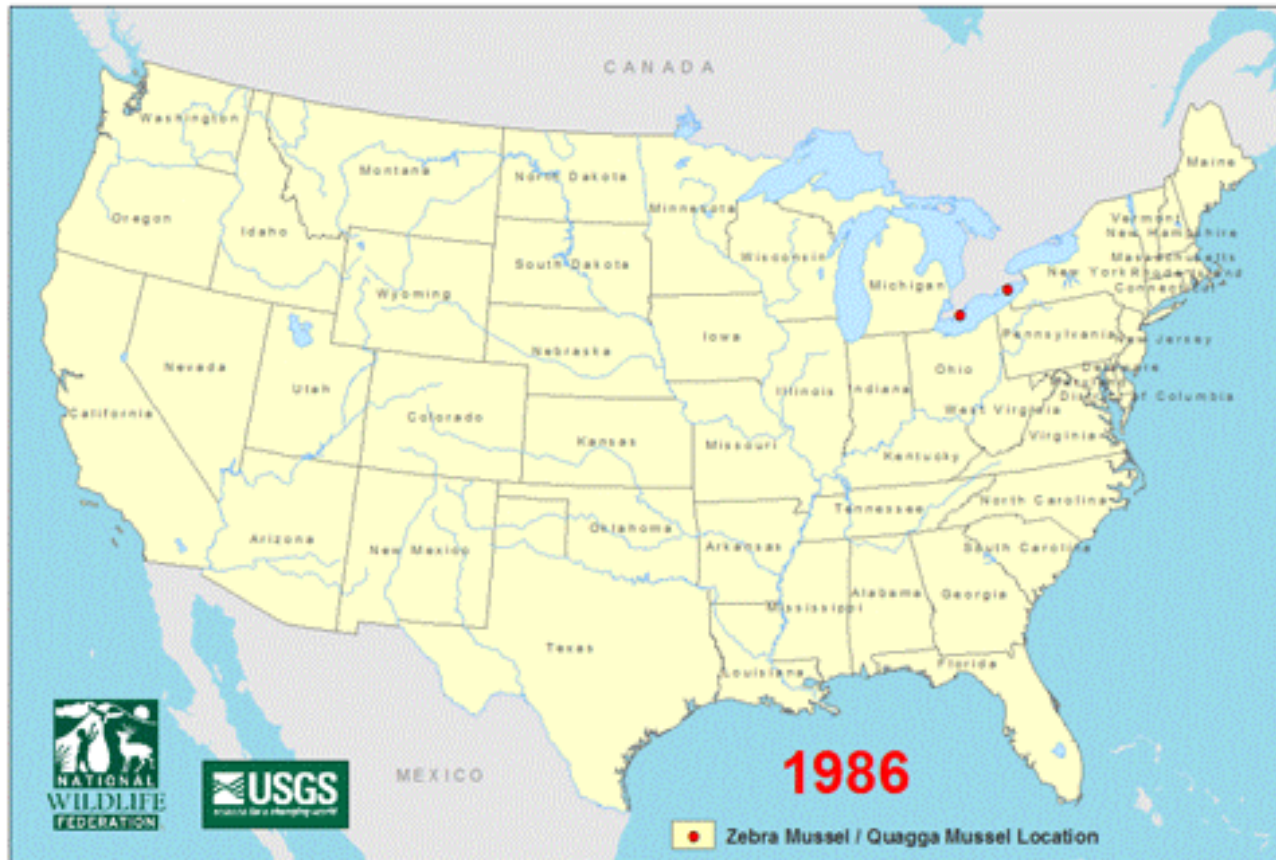
Status



- There are approximately **297** species of freshwater mussels in North America. Of those, **213** are endangered, threatened, or of special concern.
- Of the roughly 50 species native to Minnesota, 25 are endangered, threatened, or special concern.

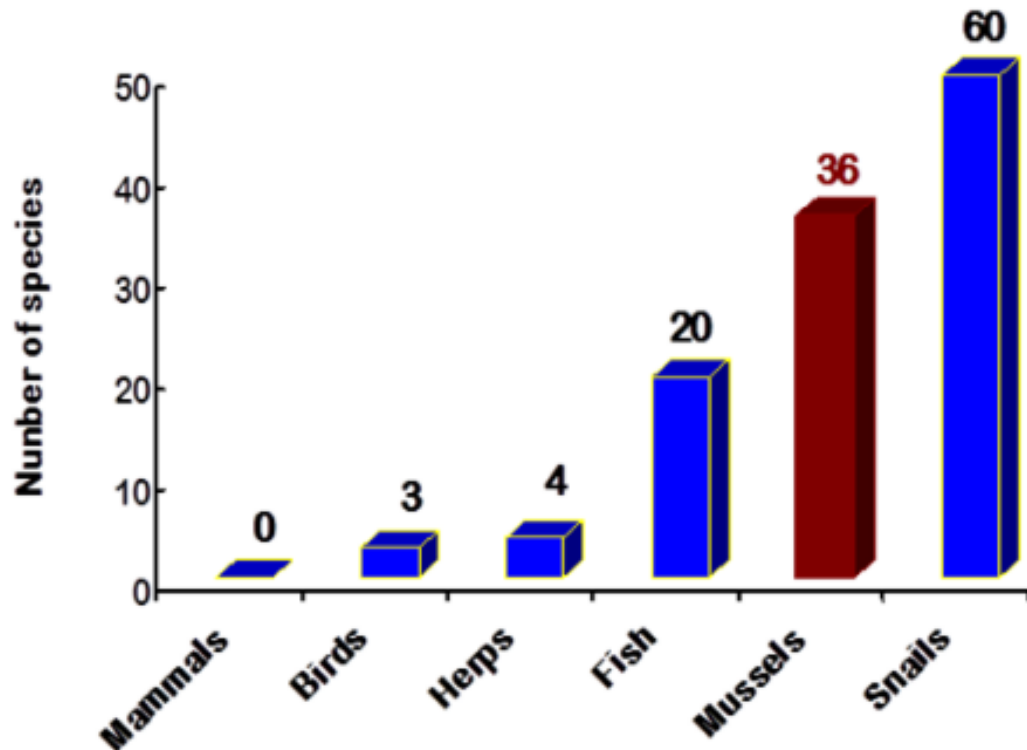


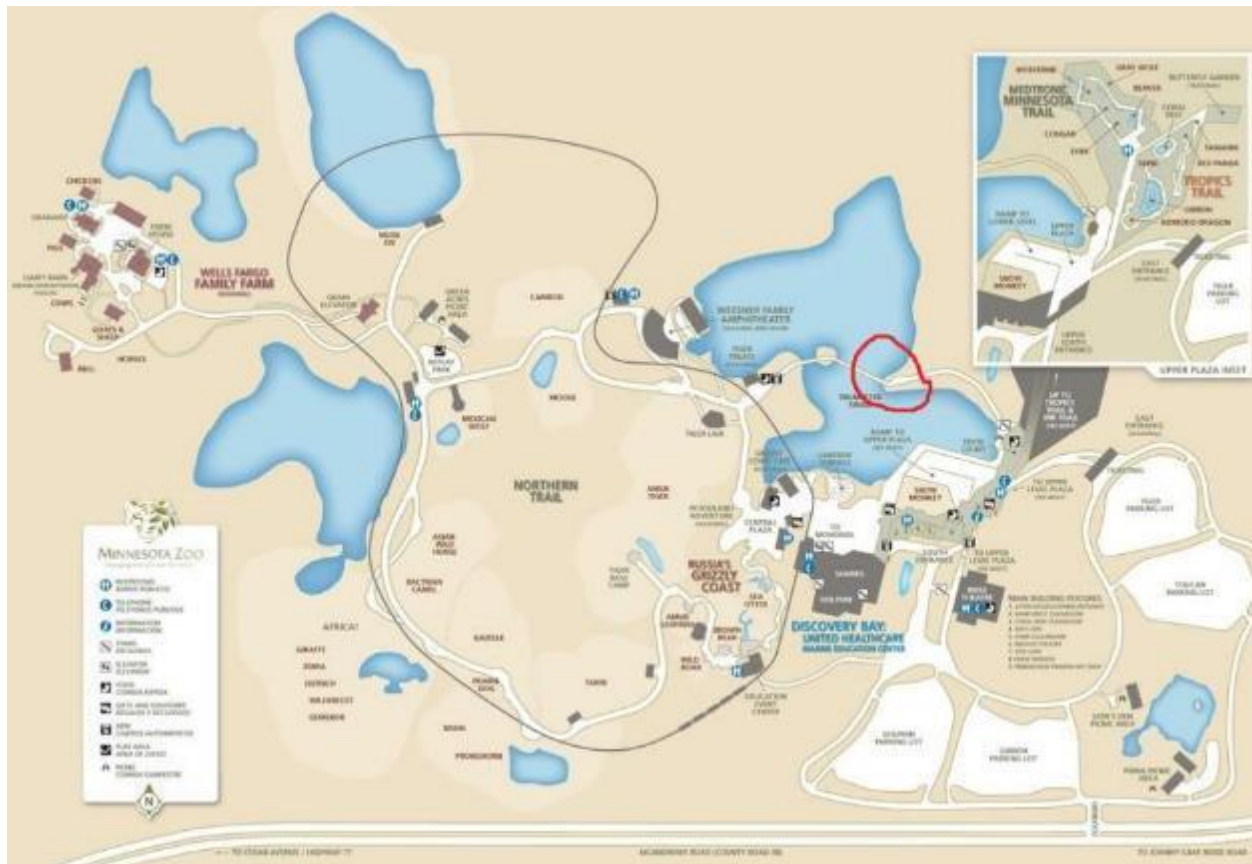
Status



Status

Recent North American Extinctions







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ZOOMS!

Installation and Operation.

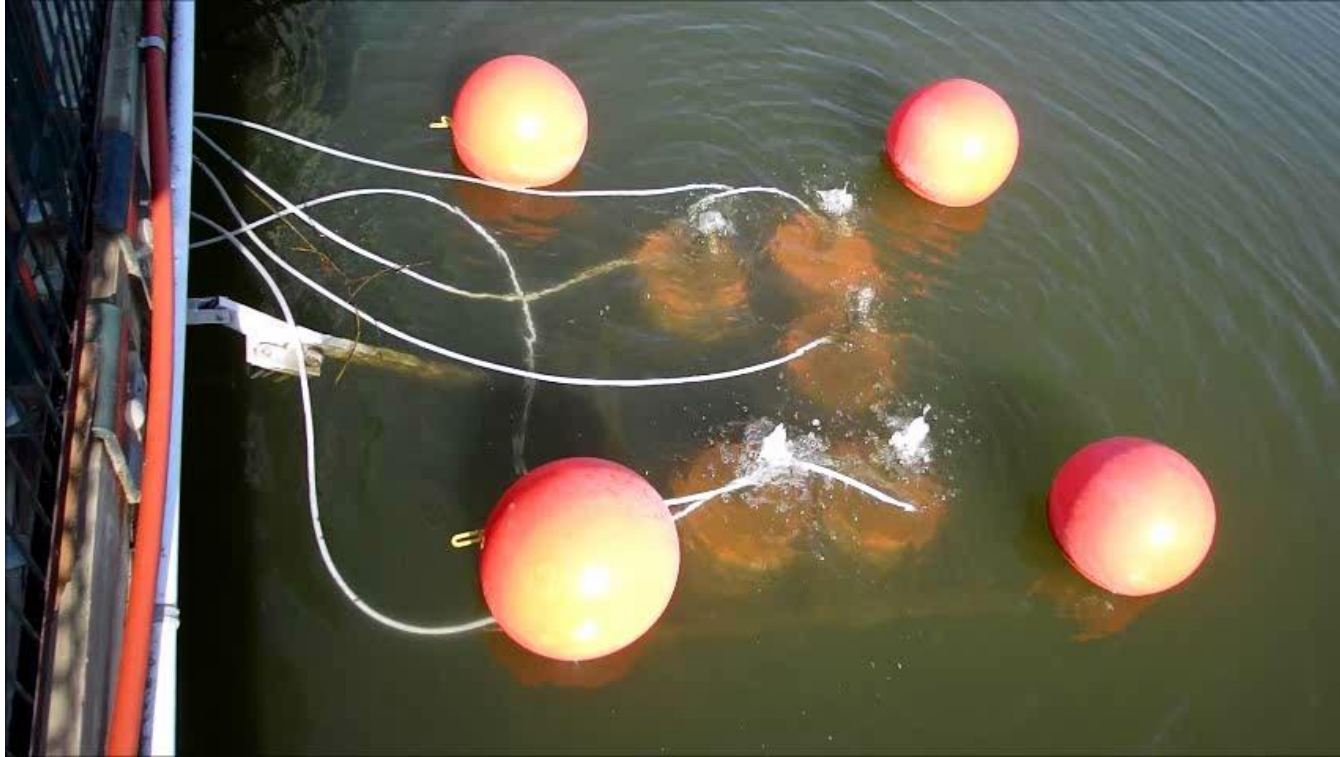




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ZOOMS!

Installation and Operation, Prop. Buckets



Installation and Operation, Challenges





Created by: Shelli G. Stedman P. Gentry, A. and Kaitlyn N.



Show Us Your Mussels Challenge

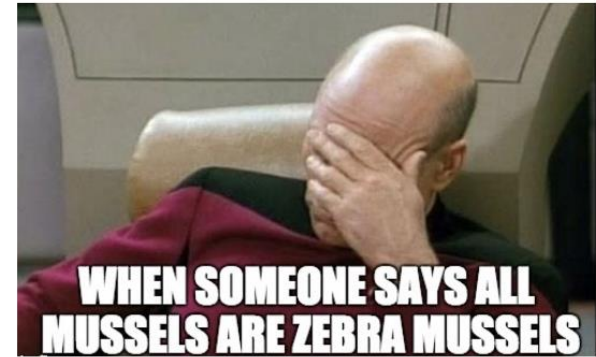
Conservation Education Program



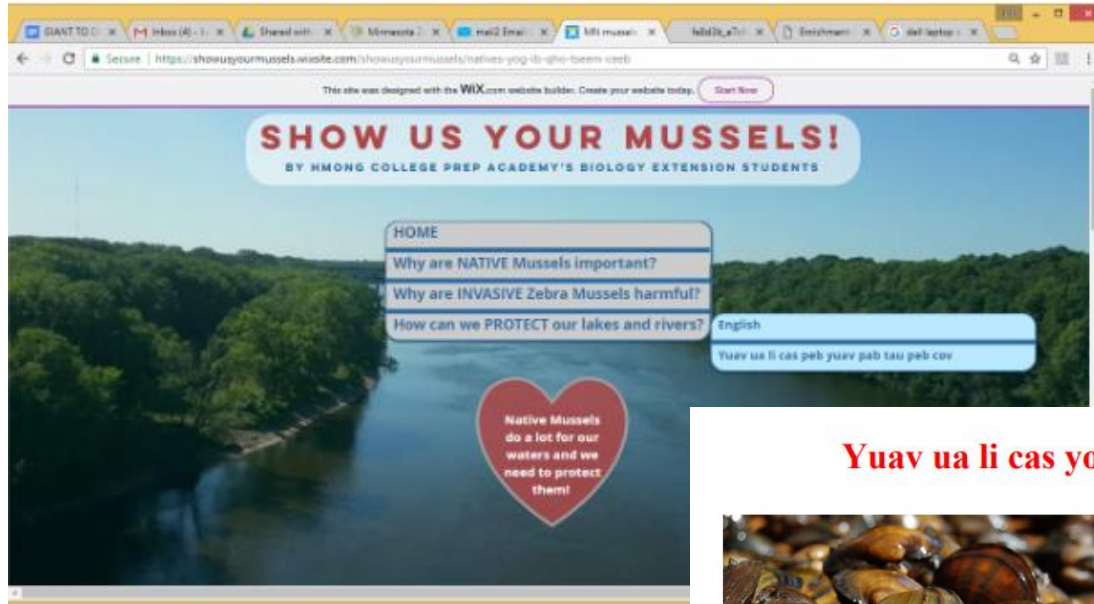
Show Us Your Mussels

- Who?
 - High School students around the state
- What?
 - Created digital campaigns to promote mussel conservation and water quality.
- When?
 - Voting from February 1-28th, winners announced on March 12, 2019

Apollo High School— Home of the Memes



Hmong College Prep Academy



Yuav ua li cas yog haiv neeg qwj nplais?



Neeg qwj nplais hauv Minnesota yog thawj tsiaj nyob rau hauv peb cov pas dej thiab cov niam dej, muaj nyob ntawm no txij li thaum ua ntej tib neeg pib sib txuas lus nrog cov dej. Lawv yuav tsum tau muaj kev tiv thaiv vim hais tias lawv coob tau heev raug mob los ntawm kev ua pej xeeb.

25 ntawm peb 48 haiv neeg mussel tsiaj nyob rau hauv Minnesota no xws li "imperiled," uas txhais tau tias lawv cov pejxeem yog nyob rau hauv kev txaus ntshai.

Lawv yog cov nyob rau hauv kev txaus ntshai, raug thawb tawm ntawm lawv txhais ntshai.



Teacher Support Show Us Your Mussels



- Free Curriculum (10 state standard aligned lesson plans)
- Free Professional Development on Native Freshwater Mussels
 - Fri., Sept 21st 10am-2pm OR
 - Sat., Sept 22nd, 10am to 2 PM
- Technical assistance (we come to your school)



Created by: Shelbi K, Maddie P, Sidney A, and Katelyn N

Mnzoo.org/digitalmussels

Education

Minnesota Zoo > Education > Schools & Teachers

"Show Us Your Mussels" Challenge



Take the Challenge! Register now to have your students compete in the "Show Us Your Mussels" Campaign!

What is the "Show Us Your Mussels" Challenge?

High School students create original digital media campaigns to inform the public about the impact of water quality on native mussels.

The school group that gets the message out to the most people will receive a FREE field trip to the Minnesota Zoo including bussing, admission, parking and interactive sessions with our Mussel Conservation staff.



Thank You!



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Donaldson



PENTAIR

BNSF
RAILWAY



Medtronic



H.B. Fuller

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