Internship Project: Design and Prototype of STREON Aquatic Organism Exclosure

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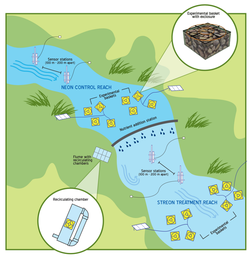
National Ecological Observatory Network

What is STREON?

The STReam Experimental Observatory Network (STREON) is an ecological experiment supported by the National Ecological Observatory Network (NEON) to simulate and observe changes in aquatic ecosystems. One primary STREON treatment involves a patch-scale elimination of top consumers (i.e. fish) from food webs. The treatment will be accomplished by creating an underwater electrical field around patches of stream bottom. The field is generated by passing electric current through two concentric metal rings. This presented the following engineering challenges:

1. Creating a watertight connection between the rings and the power source cables
2. Anchoring the rings to the STREON underwater apparatus (a basket filled with sediment)
3. Ensuring rigidity and strength of the apparatus

There are sites located throughout the United States, therefore all materials used in the final product were chosen to withstand variable temperatures, water conductivities, depths, and flow rates characteristic of STREON locations.



Example of STREON test site

Requirements and Assumptions for Electric Rings

- The assembly will have an outer ring diameter of 11.7” and inner ring diameter of 3.94”
- Rings will be manufactured out of .125” diameter 316L stainless steel with a .5” long portion of tin plating
- Coverage of sediment basket shall be less than 10%
- Electrical houses cover entire area of tin plating
- Electrical houses will be potted to prevent moisture ingress and corrosion of tin plating
- No protrusions from top of basket more than .5”
- Streamlined components
- Easy to clean and store
- Assembly shall facilitate quick and easy field construction and maintenance
- All sub-assemblies shall be tested prior to deployment
- Used during growing (warm) seasons
- Used for no more than 6 weeks annually
- Used in freshwater streams
- Will not be used at extreme depths (i.e., >1 meter)

Engineering an Underwater Electric Fence

Define Problems

1 Electrolysis Induced Corrosion

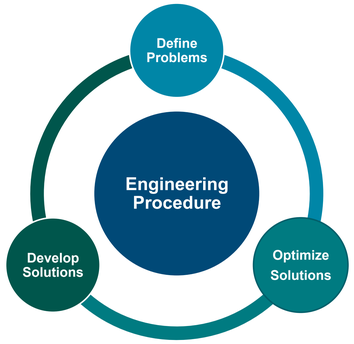
- Electricity pulls water molecules apart
- Mobile ions in water rips electrons from metal
- Metal then reacts with ions and corrodes

2 Environmental Factors

- Minimum impact to ecosystem
- Cannot introduce certain metals
- Harsh stream environments
- Strength and rigidity required

3 Field Use

- Must be simple to use in the field
- Assembled and disassembled multiple times
- Used for extended period of time



Develop Solutions

Use of 316L stainless steel for rings provided superior resistance to corrosion.

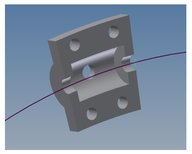
Use of Nylon 6/6 for ring components provided a non-conductive material with high strength and rigidity.

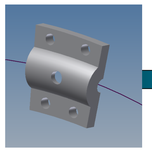
Optimize Solutions

Iteratively testing and refining a design, prioritizing design criteria, and considering environmental, social, and economic impacts of a design are all part of optimizing solutions.

STREON ring designs underwent multiple tests which led to more refined and better performing parts.

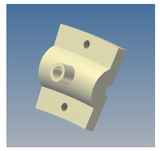
Designed a barrier to protect solder interface between rings and power source cables from corrosion





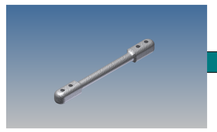
Problems with sealing the potting epoxy (for encapsulating electrical circuits) inside the electrical houses plagued the design.

Solution

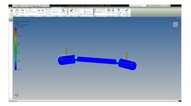


Addition of a small lip kept the epoxy from leaking out

Designed spokes to hold rings together

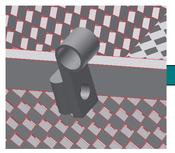


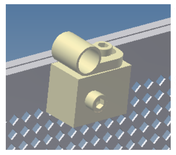
- Nylon 6/6 UTS: 12.5 KSI
  - 12500 lbs/in^2
- Moment of Inertia, I
  - I = .25*pi*r^4
  - .001917 in^4
- Sigma_max= max allowable stress
  - = (Moment*r)/I
  - 25000 lbs/in^2 = (.635*F_max)*(.125)/.001917
  - F_max = 30 lbs
- In terms of a sedimentary rock (density of app. 160 lbs/ft^3) underwater
  - Weight_rock – Force_boyant = 30 lbs
  - 160lbs/ft^3*Volume_rock – 62.4 lbs/ft^3*Volume_rock = 30 lbs
  - Volume_rock = .2567 ft^3 = 4/3*pi*r^3
  - Radius_rock= .394ft = 9.5 in diameter



Performed strength analyses to ensure the components can withstand pre-determined parameters.

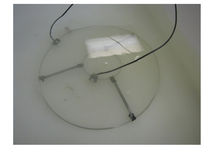
Designed mount to connect rings to basket





These tabs were moved to the inside of the sediment basket to meet dimensional requirements.

Test of STREON Ring Watertight Electrical Houses



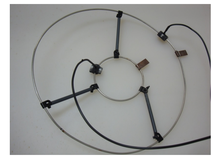
A few minutes into the test

15 hours into the test. Exposed steel + electricity + water = lots of rust

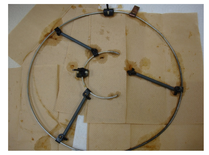
The most difficult design aspect of the STREON apparatus was the connection between the current carrying wires and the STREON rings themselves.

The test to the left is an “accelerated life test”. It is meant to increase the rate at which the parts being tested fails (or else it would take decades for parts made out of stainless steel!).

The point of this trial was to see if the portion of the steel ring inside the electrical houses would be free of any corrosion and still be transmitting current by the end of the test.



Stainless steel STREON rings prior to testing

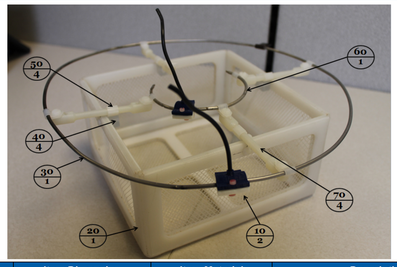


Rings after our test

Even with a large portion of stainless steel gone, current was still being transmitted. The watertight electrical housings and potting epoxy created a barrier between the stainless steel rings and the surrounding environment, proving a successful design.

Locations of the electrical houses during test

Final Assembly and Future Plans



#	Item	Item Dimension	Item Material	Description
10	Electrical housing	.91”L X .91”W X .35”H	Nylon 6/6	Prevents water ingress/corrosion from ring-current carrying wire interface
20	Test Basket	7.9”L X 7.9”W X 3.9”H	Various thermoplastic polymers	Holds stream sediment to be tested
30	Ring, large	11.7” inner diameter	316L Stainless Steel	Provides conduit for current passage
40	Tabs	.41”L X .67”W X .5”H	Nylon 6/6	Anchors STREON rings to test basket while maintaining low profile
50	Multi-use clips	.85”L X .40”W X .37”H	Nylon 6/6	Quick connect fasteners to aid in field assembly/disassembly
60	Ring, small	3.7” inner diameter	316L Stainless Steel	Provides conduit for current passage
70	Ring spokes	3.94”L X .25”W X .25”H	Nylon 6/6	Low profile, rounded specimens connecting concentric rings

The STREON exclosure assembly (seen above) is planned to begin real-world trials in the next few years and achieve full-scale operation by 2017.

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