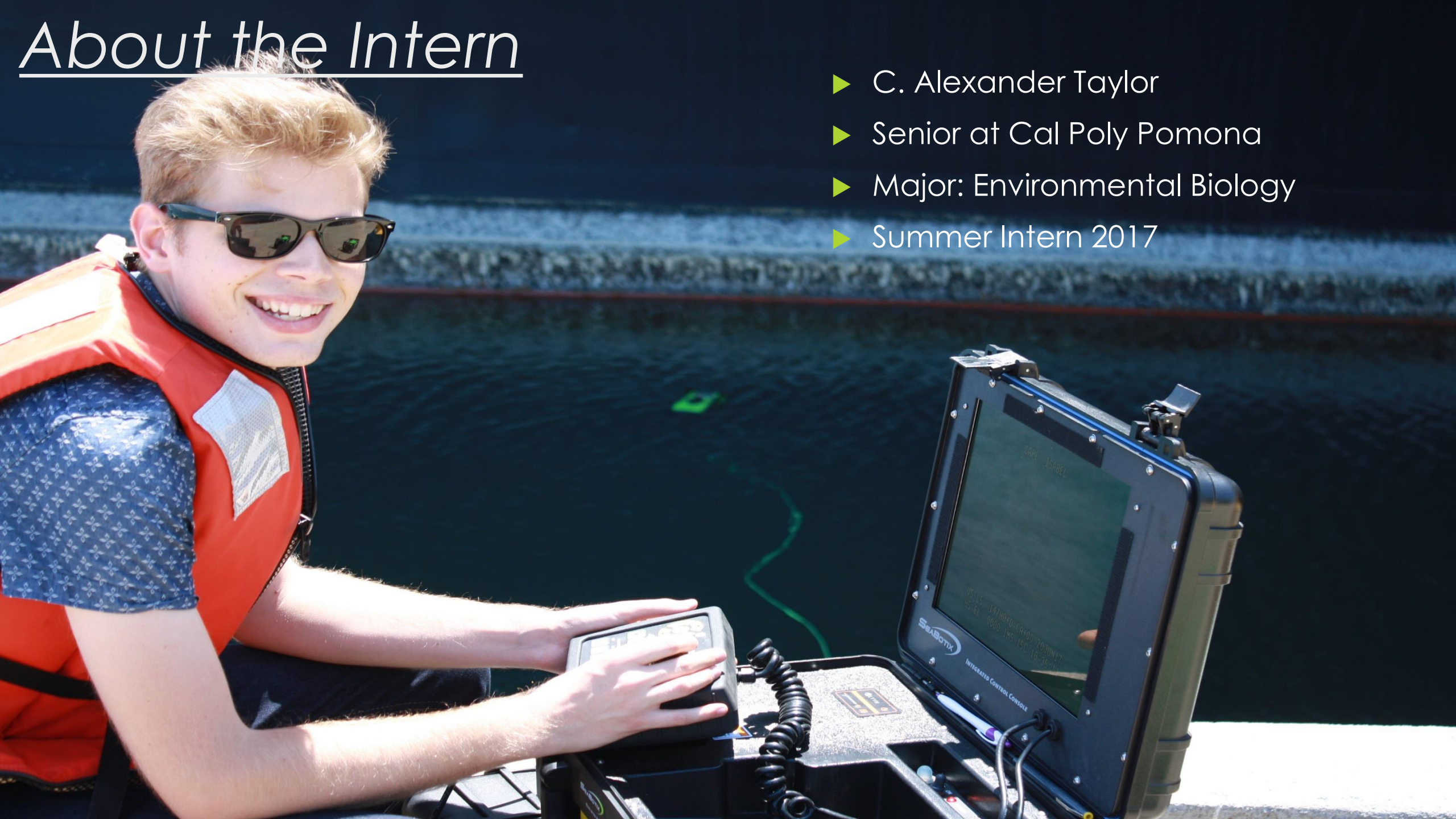
CSU COAST INTERNSHIP: Biofouling Research Summer 2017

STATE LANDS COMMISSION, LONG BEACH, CALIFORNIA

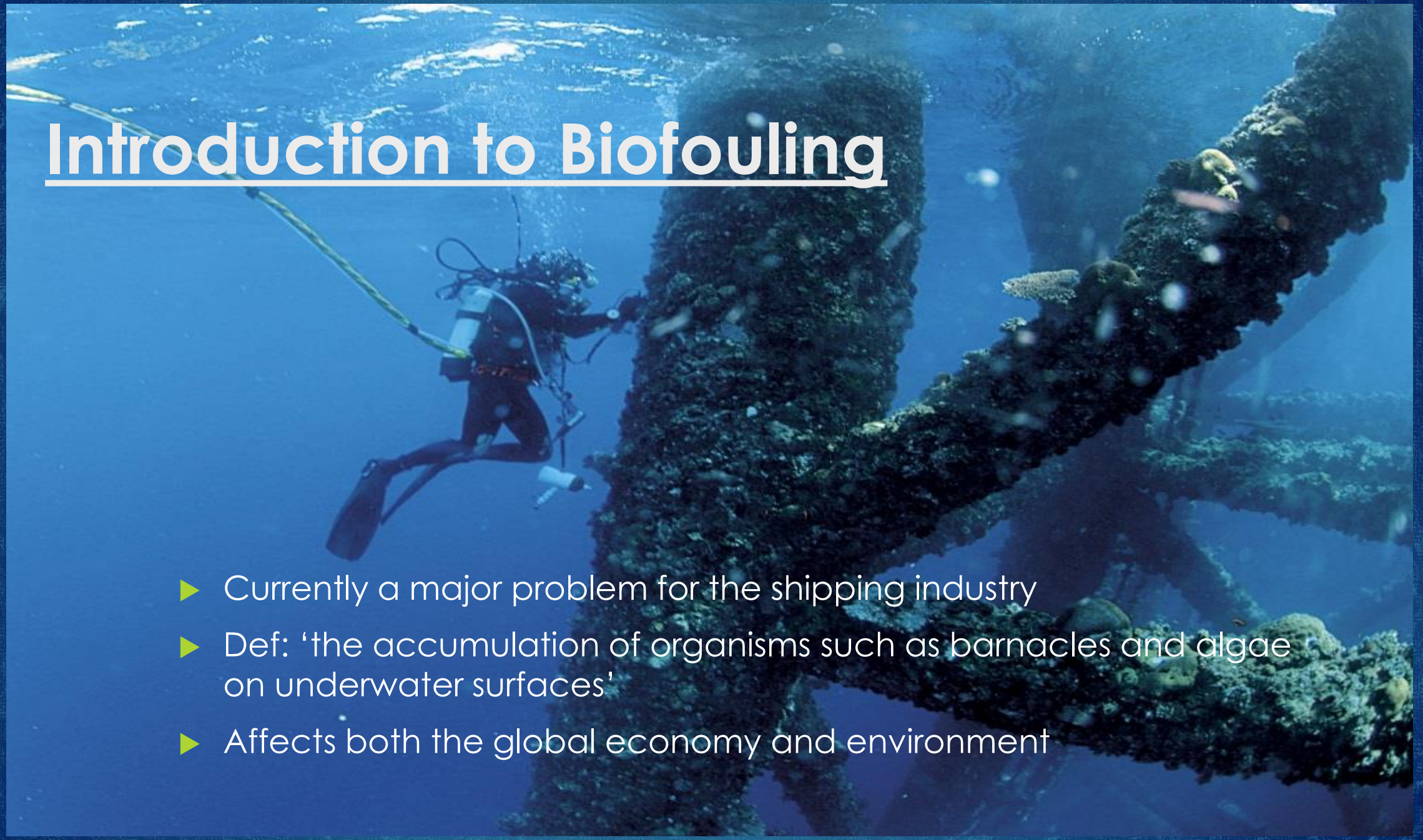
C. ALEXANDER TAYLOR

About the Intern



- C. Alexander Taylor
- Senior at Cal Poly Pomona
- Major: Environmental Biology
- Summer Intern 2017

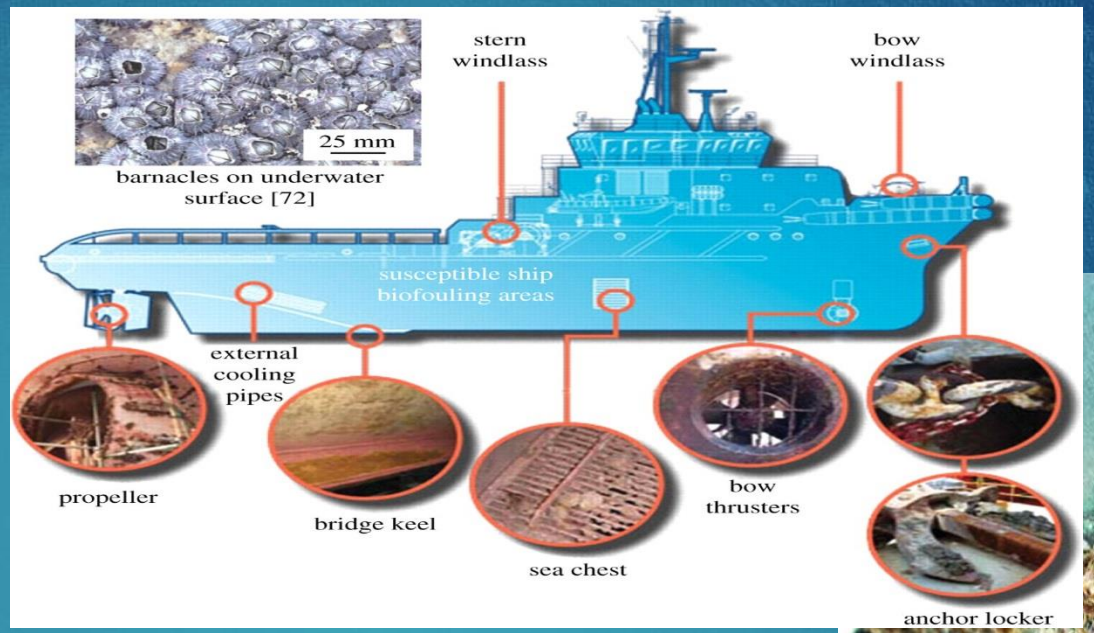
Introduction to Biofouling



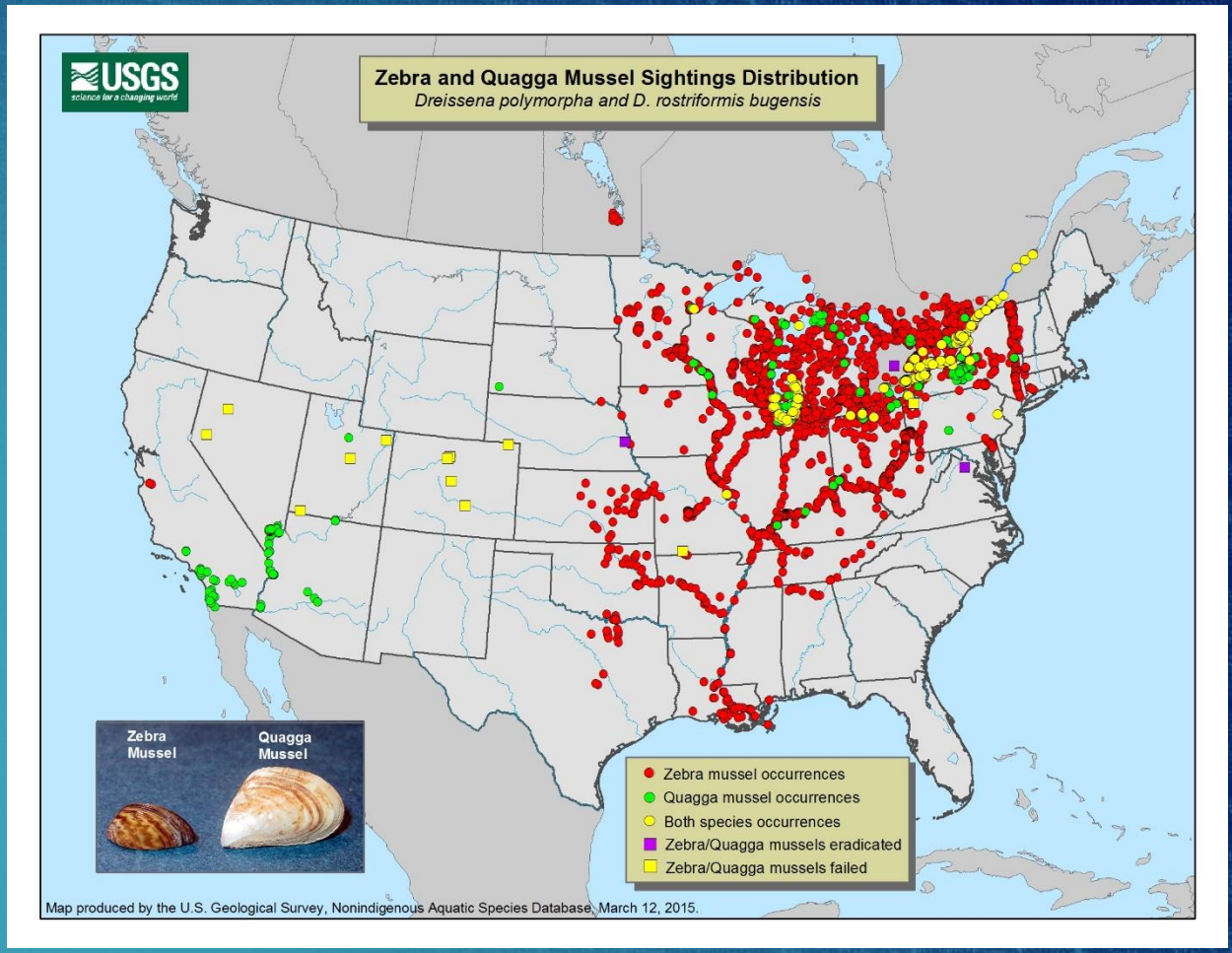
- Currently a major problem for the shipping industry
- Def: ‘the accumulation of organisms such as barnacles and algae on underwater surfaces’
- Affects both the global economy and environment

The Shipping Industry and Biofouling

- Damages sensitive equipment
- A film can slow ships by 30-50%
- Costly to remove
- Large Investment in Removal and Prevention
- Unprotected hulls can accumulate 150kg in 6 months
- Current anti-biofouling coatings leach copper and heavy metals



Aquatic Invasive Species



- Often introduced into new environments via ballast water or biofouled hulls
- Invasive species outcompete native flora and fauna and in turn decimate native populations
- Routine cleanings and dryings most effective at eliminating risk

The Two Projects:

In-Water-Cleaning Report

- In-depth research into the current status of in-water-cleaning in regards to biofouling
- Status report on capabilities and limitations of current cleaning tech
- Analysis of Hull Cleaning regulations

IMO
INTERNATIONAL MARITIME ORGANIZATION

ROV Survey

- Collect and process digital images from and ROV submersible camera
- Estimate percent coverage of hard biofouling
- Discover most accurate measuring method
- Tracking the development of a biofouling community over time

The Status of In-Water-Cleaning in 2017:

CURRENT AND NEW TECHNOLOGIES

INTERNATIONAL REGULATIONS AND PRACTICES

In-Water Cleaning

- In order to avoid the cost and time limitations of dry-dock cleaning, most shipping companies invest in In-Water-cleaning
- Traditional practice used trained diving teams
- More companies utilize some form of Remote Operation
- Some practices can conflict with water or environmental regulations

IMO: Rules and Regulations

- The IMO **(International Maritime organization)** is the largest internationally recognized organization dedicated to the management and security of ships and subsequent marine pollution.
  - **February the 13th, 2004** the International marine organization formally adopted the International Convention for the **Control and Management of Ships Ballast Water and Sediments.**
  - **July 15th, 2011**, the 2011 **Guidelines for the Control and Management of Ships' Biofouling** to Minimize the Transfer of Invasive Aquatic Species are adopted.
  - The 2004 agreement will come into force on **September 8th, 2019** instead of 2017.
  - Most guidelines are **voluntary**, however most countries agree upon these guidelines and implement then in one form or another in their respective governments.

Methods of Cleaning

Diver Operated

- Large Organized teams
- Effective at covering whole hull area
- Capture of Debris
- Able to more effectively clean niche areas
- Standard method

Remotely Operated

- More cost effective than diver teams (long term)
- Zero risk of human endangerment
- Capture of Debris
- Can not always reach niche areas, more effective on large flat surfaces

Types of Technology (Traditional)

Brushes/Blades

- Used by both ROV and Divers
- Most traditional
- Ineffective at preserving hull coatings if not used properly

Water Pressure

- Used in ROV and by Divers
- Maybe more effective than brushes
- More widely used
- Can also damage hull coating

Cavitation

- Used by divers
- More effective at removal than water jets
- May preserve hull coating more effectively
- Less stress on diver

Types of Technology (New)

Sonic Transduces

- Attaches directly to inside of hull
- Prevents hard biofouling from forming
- Only periodic light cleaning needed

Thermal Shock

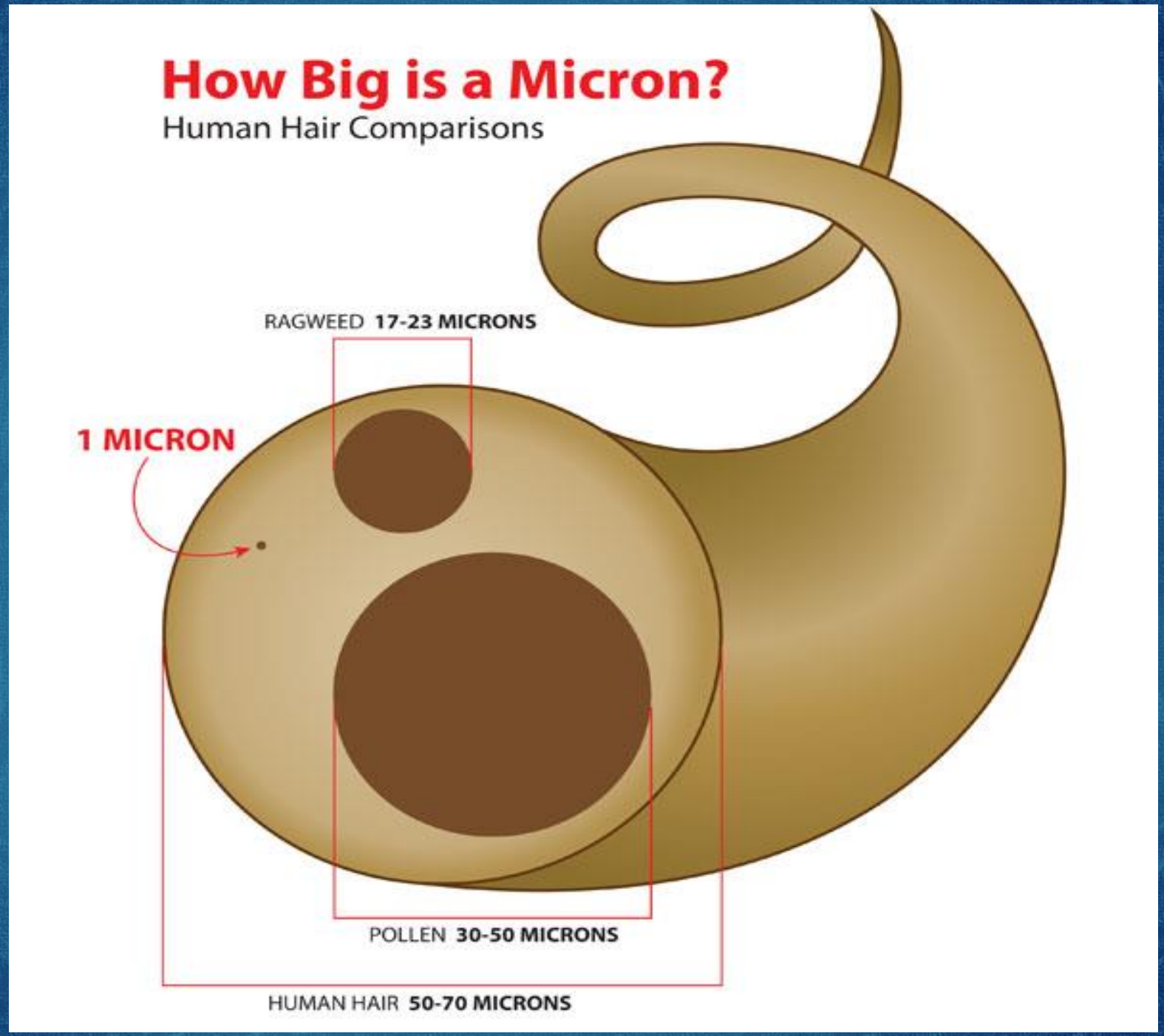
- Not commonly used in the USA
- Concentrated heat kills off biofouling
- Kills but does not remove said biofouling

UV Radiation

- Still in development
- Has prevented hard biofouling from growing
- Effective at protecting sensitive equipment

Technologies and Supplier Companies

	Mode of Cleaning	Mode of Operation	How is Debris Managed	Particle Capture Size	Website Link
Underwater Services International	Brushes	Diver operated	Captured, water is filtered and treated	25 um	http://www.hullcleaning.com
Cavidine	Cavitation bubble jets, manual tools	Diver driven operations	Not Captured	NA	http://cavidyne.com/
Corydoras Hull-Washer	Brushes, Water jets, assorted manual tools	Can be automated or manned	Complete capture and filtration	20 um	http://www.hullwasher.net/copia-di-home
Ned Marine	Ultrasonic Transduces	Installed (on ship) system	No need for capture as biofouling is not present	NA	http://www.nedmarine.com/
FranMarine Envirocart	Contactless Blades	ROV is used in junction with large out-of-water filtration system	Captured; water is filtered and treated	First stage 50 µm, Second stage 25 µm,	http://www.gageroadsdiving.com.au/


How Big is a Micron?
Human Hair Comparisons
RAGWEED 17-23 MICRONS
1 MICRON
POLLEN 30-50 MICRONS
HUMAN HAIR 50-70 MICRONS

Technology and Regulations Summary

- Biofouling remains a common and potentially disastrous problem on a global scale
- The two main ways we are able to prevent biofouling is through developments in technology and regulatory enforcement
- In order to have the most beneficial impact ,cleaning systems need to be able to clean the hull and prevent organic and inorganic debris from leeching into the surrounding water.
- In general small scale organizations (local ports and state governments) have been the most proactive in protecting environments from Invasive species introduction and enforcing ships to follow regulations

ROV Survey Report 2017

ANALYZING COMPLETE TRANSECT VS RANDOM SAMPLING

ANALYSIS OF SPECIES COMPOSITION AND GROWTH

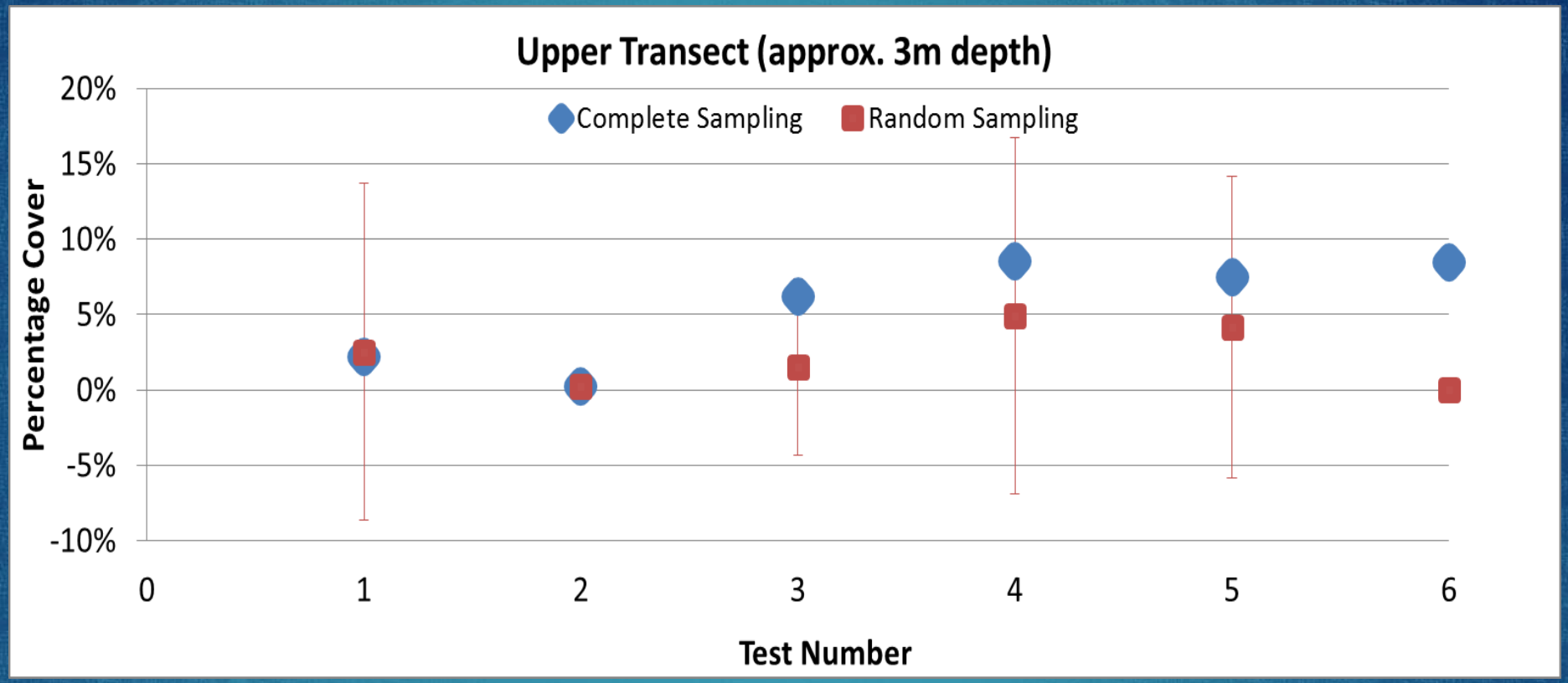
The Process

- Each day of data recording proceeded as follows:
  1) Drive to the Cape Isabel
  2) Unpack ROV and Equipment
  3) Connect ROV to Controls and Controls to the Laptop
  4) Hook-up and activate Generator
  5) Locate and film portside thruster
  6) Record and film 3 m depth transect (going towards the stern) then once 46 m mark is reached on cord, film 4 m depth transect heading back towards setup
  7) Move set up to Rudder and film rudder
  8) Once done, rinse of equipment and head back
  9) Convert Video into Mpeg-2 files
  10) Use Pinnacle Studio to select frames and photoQuad to obtain area coverage

Goals

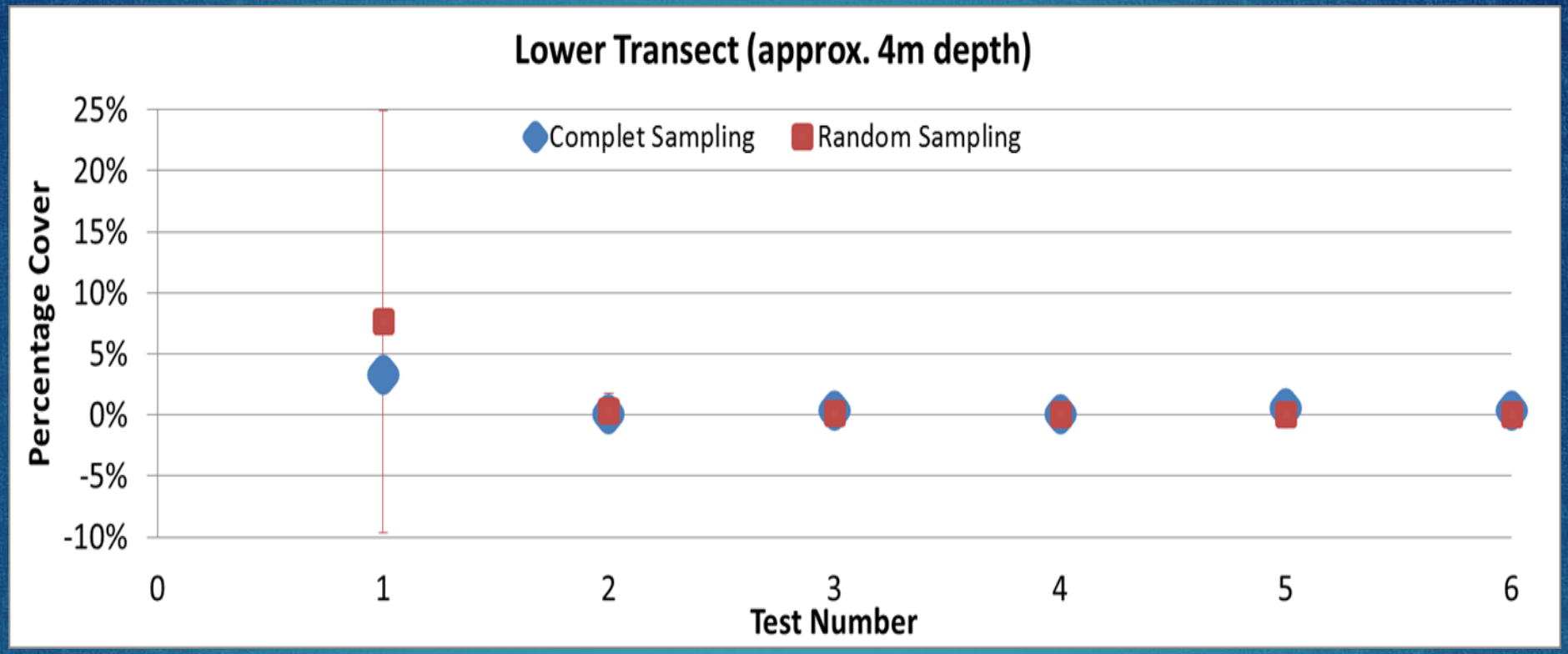
- 1) to conduct complete and random sampling of biofouling present on a section of the ship hull and determine if random sampling is effective enough to be used in a situation like this.
- 2) To analyze patterns of growth on niche areas on the ship (the rudder) and determine relationships of growth and species for tube-worms, Bryozoans, and Mussels

Results of Complete vs Random Sampling



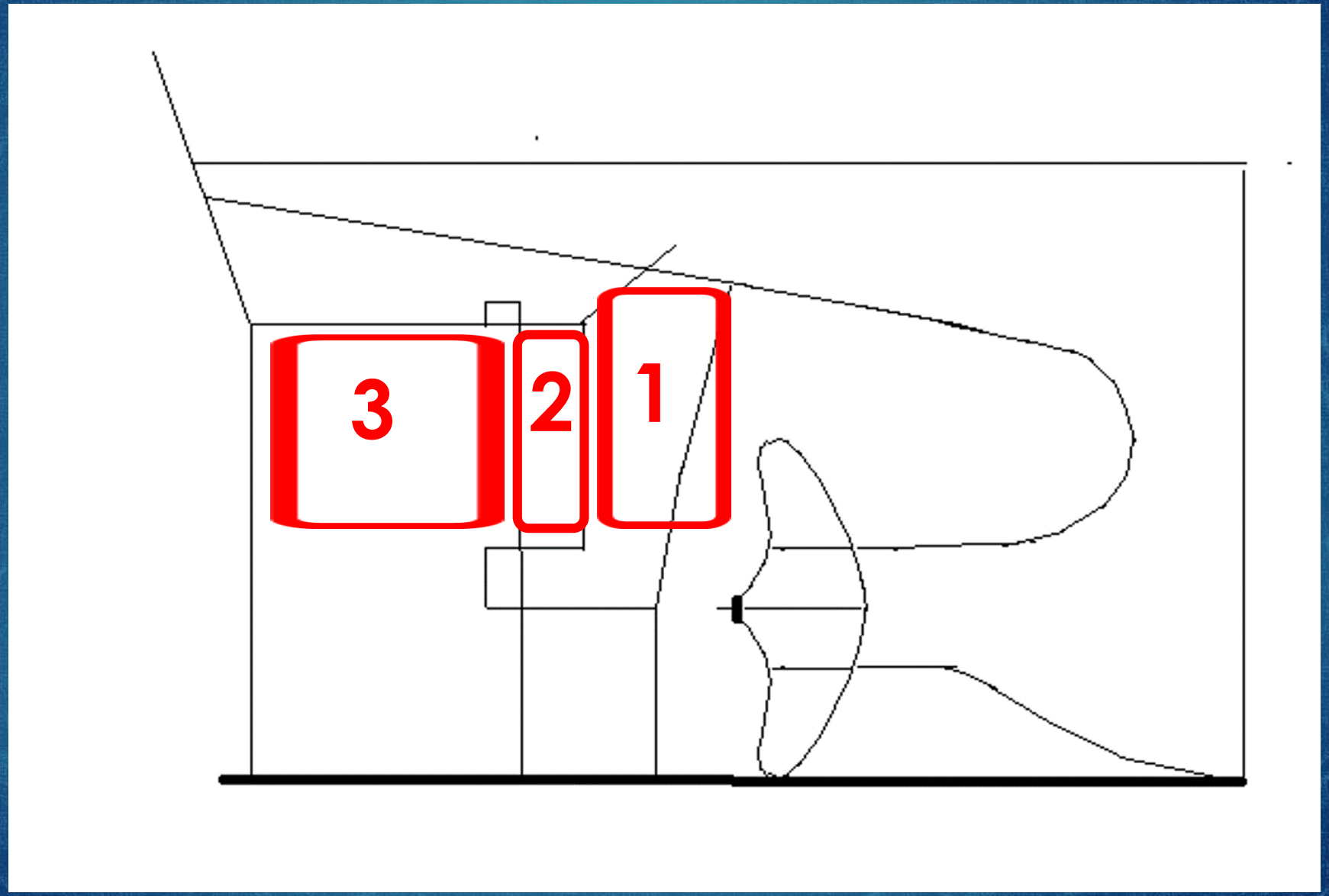
- On some occasions the random sampling matched the true percent cover very closely, most of the time it did not, and many times it provides results with very high variability.

Results of Complete vs Random Sampling



- The random and true values match closely most often in regards to the lower transect. This was most likely due to the actual lack of hard fouling.

Areas of the Rudder Studied



Focal Organisms

Bugula neritina

- Common brown Bryozoan

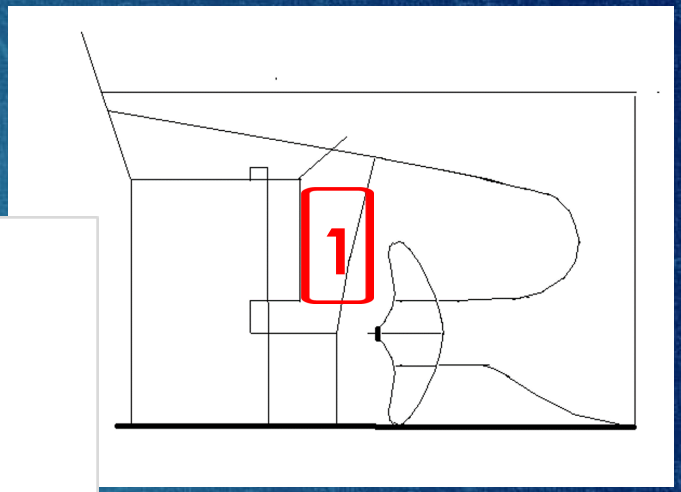
Hydroides sp.

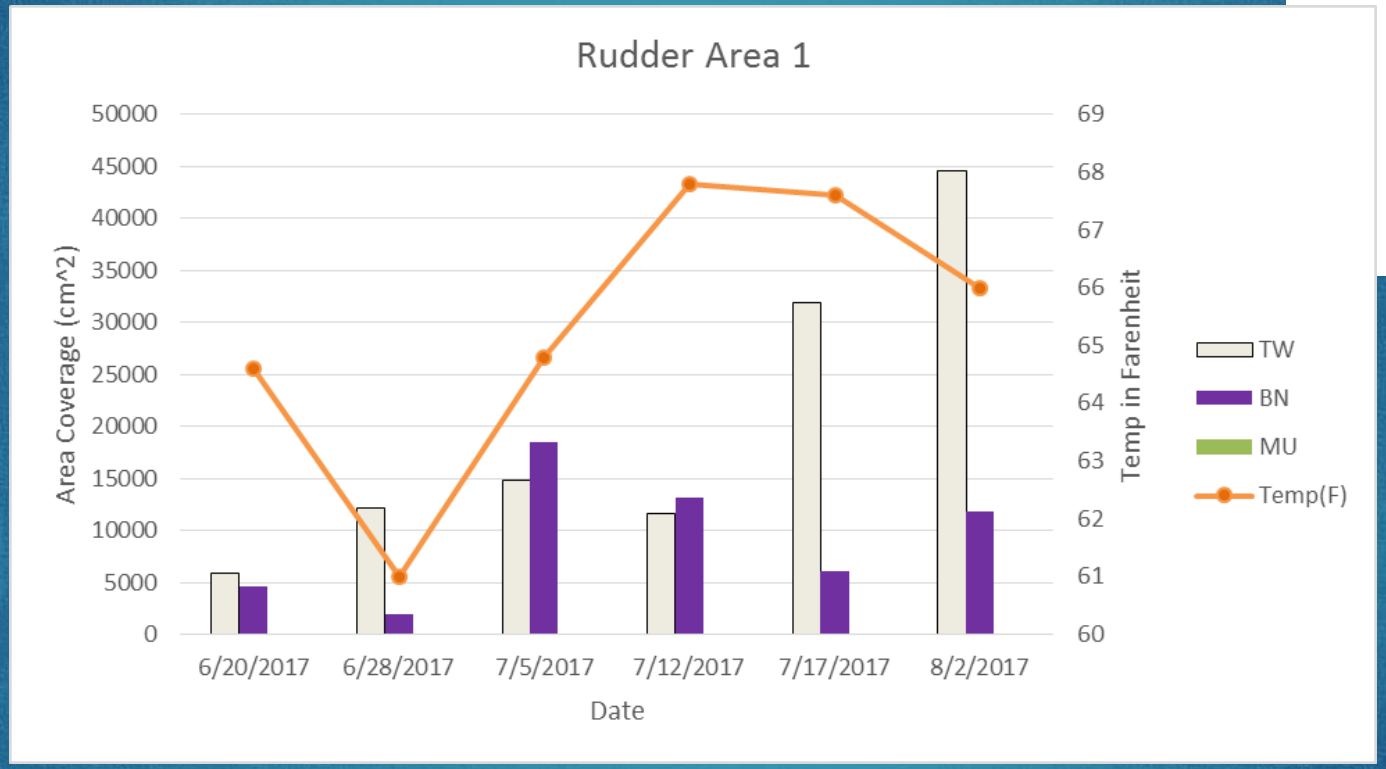
- Common tube worm

Mytilus sp.

- California and Mediterranean mussels possibly present

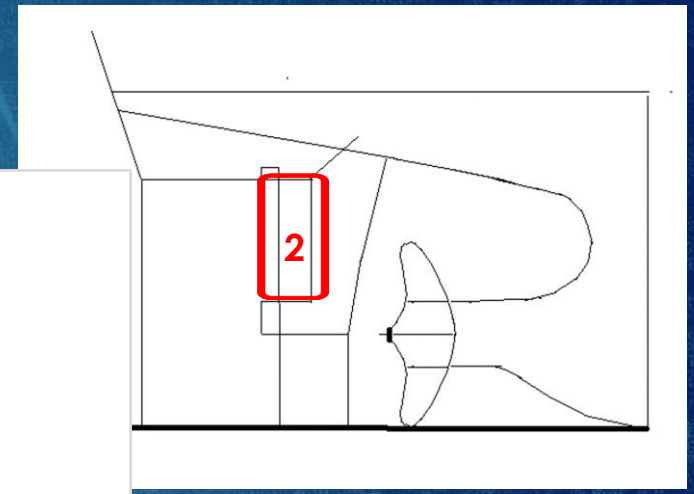
Rudder Species Composition

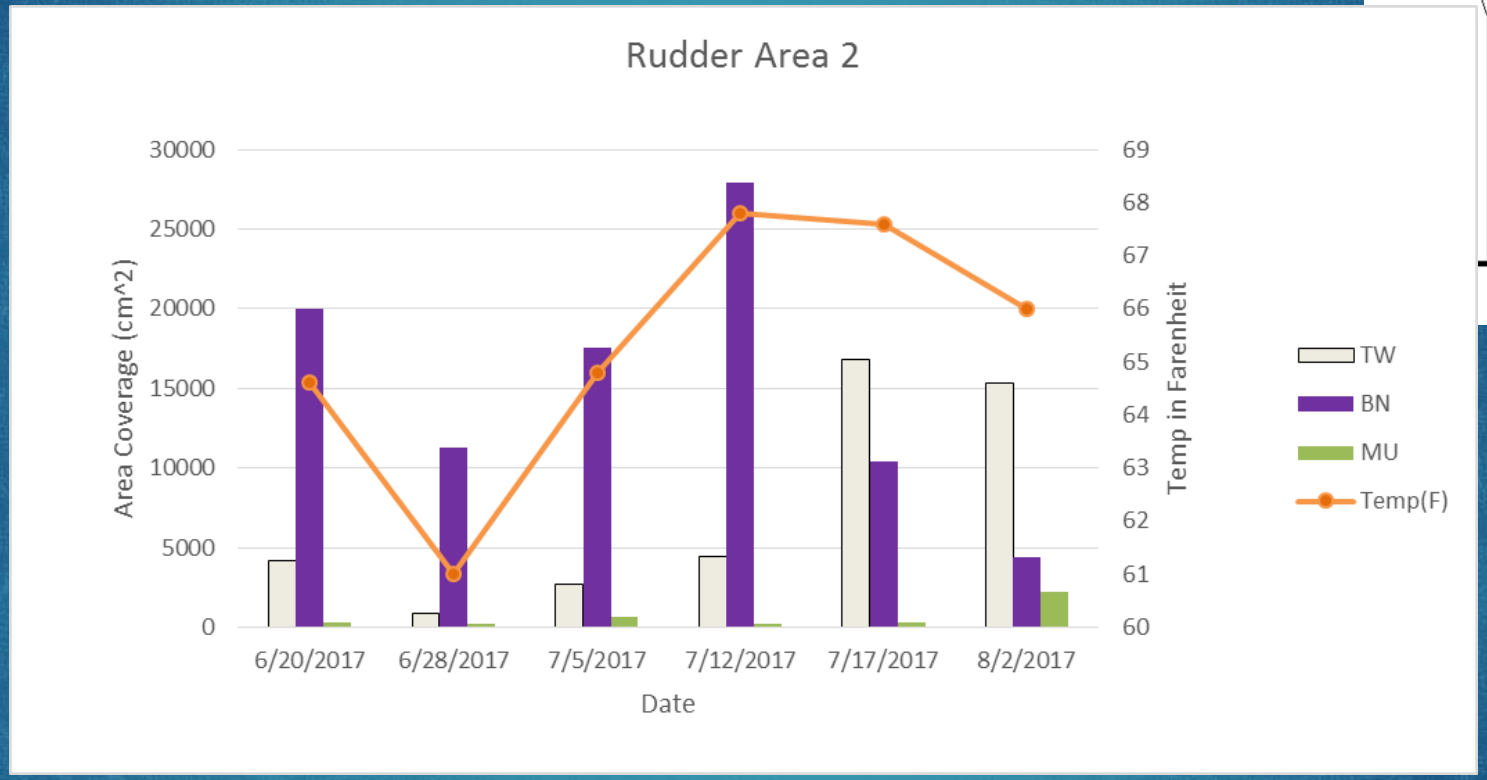




There is definite competition between the bryozoans and the tube worms.
In area 1, the tube worms dominated for most of the observed days.

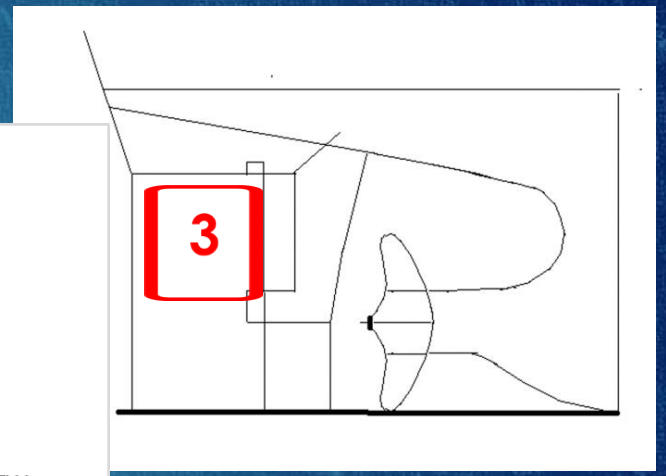
Rudder Species Composition

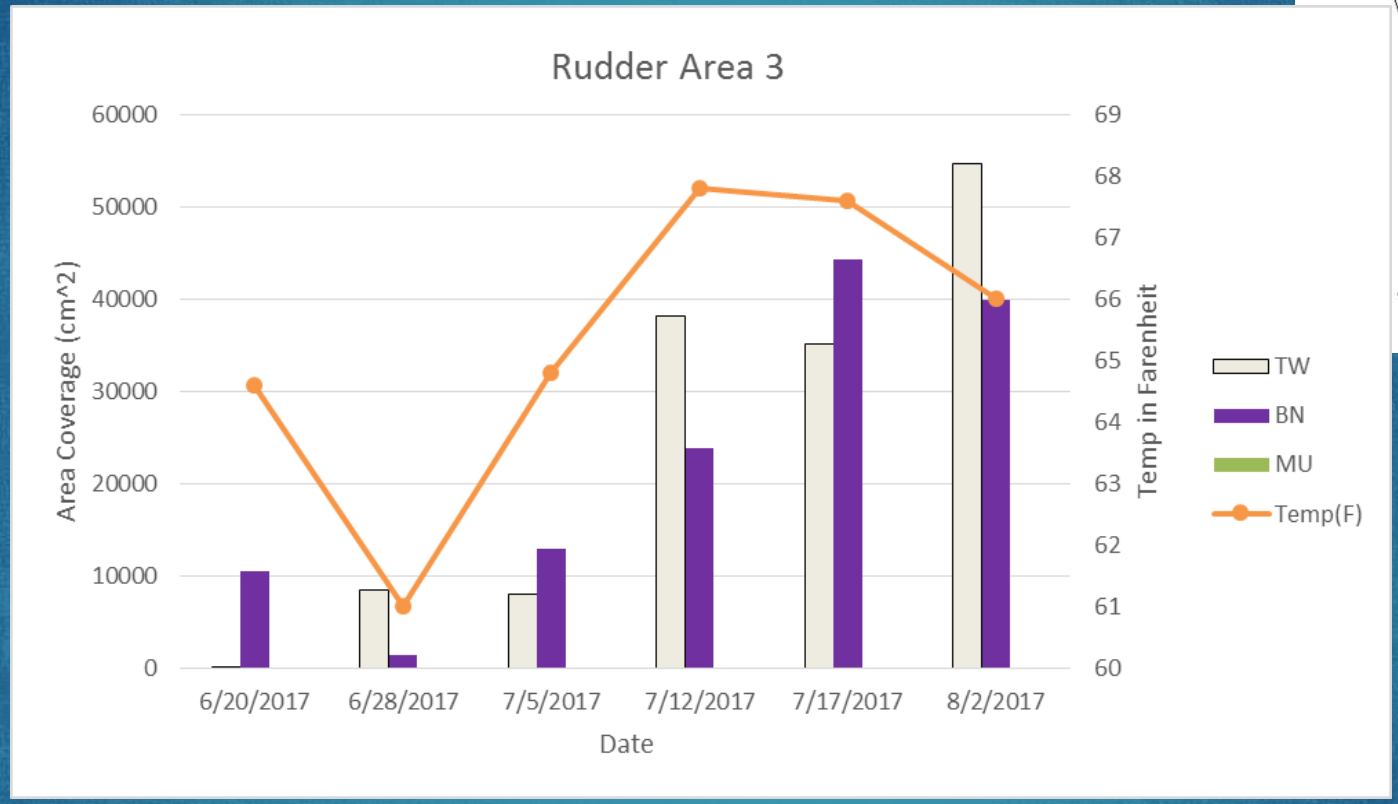




Throughout the entirety of the project, the only recorded mussels appear in area 2. Up until the 5th week of study the bryozoans dominated area 2.

Rudder Species Composition





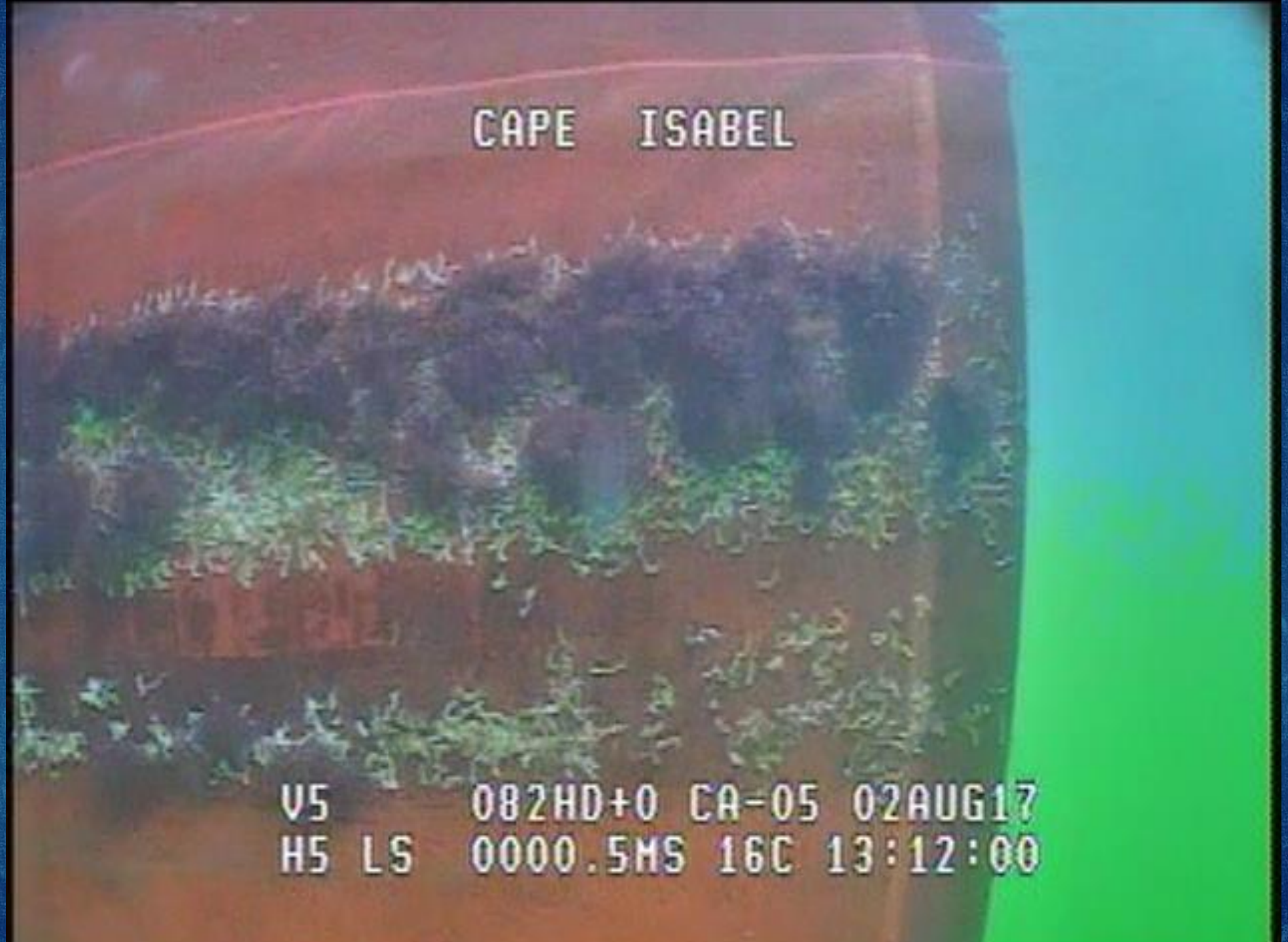
In area 3, there is more definite competition between the bryozoans and the tube worms. Despite the interspecies competition, both species have increase in area coverage over time.


CAPE ISABEL
V5 L5 018HD+1 CA-15 28JUN17
H5 L5 0000.2MS 13C 13:21:50


CAPE ISABEL
V5 L5 066HD+0 CA-15 05JUL17
H5 L5 0000.1MS 16C 12:53:41


CAPE ISABEL
V5 058HD+0 CA-05 12JUL17
H5 L5 0000.2MS 17C 12:14:39


CAPE ISABEL
V5 078HD+0 CA-30 17JUL17
H5 L5 0000.2MS 16C 11:26:07


CAPE ISABEL
V5 082HD+0 CA-05 02AUG17
H5 LS 0000.5MS 16C 13:12:00

What I Got Out of This Internship:

The past eleven weeks have given me **experience** and **insight** into the working at a government management agency. Being able to apply myself to this program has given me:

- New abilities/techniques to preform scientific research with professional tools
- Options for new carriers in similar areas of study
- Empowered passions for ecological study and natural resource management
- Experience working with a dedicated network of professionals
- New-found Confidence!

Thank you for your time…

C. Alexander Taylor

xandertaylor@gtmail.com

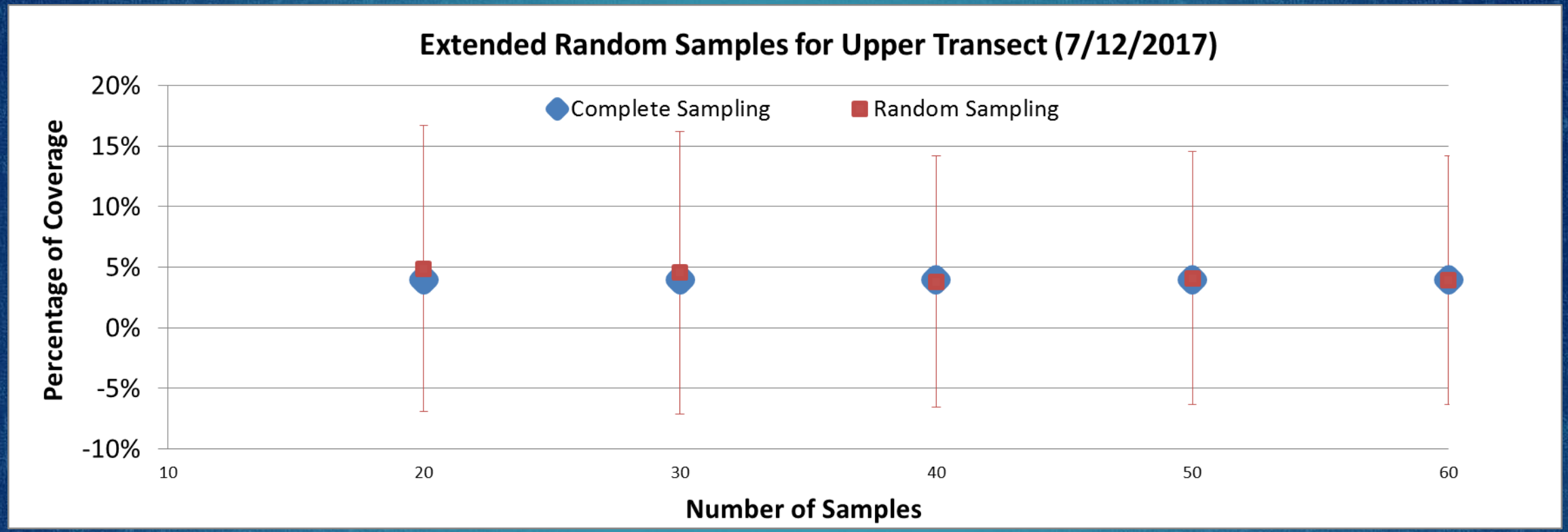
562-423-1688

Citations:

- 1. Jolly, Christopher J., Richard Shine, and Matthew J. Greenless. "The impact of invasive cane toads on native wildlife in southern Australia." Ecology and Evolution 5.18 (2015): 3879-3894. Web.
- 2. Pimentel, David, Rodolfo Zuniga, and Doug Morrison. "Update on the environmental and economic costs associated with alien-invasive species in the United States." Ecological Economics. College of Agriculture and Life Sciences, Cornell University, Ithaca, NY, 29 Dec. 2004. Web. 9 Aug. 2017.
- 3. Connelly, Nancy A., Charles R. O'Nell, Barbara A. Knunth, and Tommy L. Brown. "Economic Impacts of Zebra Mussels on Drinking Water Treatment and Electric Power Generation Facilities." Environmental Management 40, no. 1 (May 24, 2007): 105-12
- 4. Drake, John. "Hull fouling is a risk factor for intercontinental species exchange in aquatic ecosystems." Aquatic Invasions 2, no. 2 (March 13, 2007): 121-31. doi:10.3391/ai.2007.2.2.7.
- 5. Jackson, Lynn. Marine Biofouling and Invasive Species: Guidelines for Prevention and Management. 2008.
- 6. Bohlander, Jerry. 2009. Review of options for in-water cleaning of ships. Ministry of Agriculture and Fisheries Biosecurity New Zealand Technical Paper No. 2009/42.
- 7. Floerl, Oliver, Lisa Peacock, Kimberley Seaward and Graeme Inglis. 2010. Review of biosecurity and contaminant risks associated with in-water cleaning: Keeping marine pests out of Australian waters. Commissioned by the Department of Agriculture, Fisheries and Forestry.

Port	Country of Origin	Water Management Agency	Ecology Management Agency
Los Angeles	USA	Los Angeles Regional Water Quality Control Board	California State Lands Commission
Long Beach	USA	Los Angeles Regional Water Quality Control Board	California State Lands Commission
San Diego	USA	San Diego Regional Water Quality Control Board	California State Lands Commission
San Francisco	USA	San Francisco Regional Water Quality Control Board	California State Lands Commission
Portland	USA	Oregon Department of Environmental Quality	Oregon Department of Environmental Quality
Houston	USA	The Port Authority of Houston	The Texas Parks Wildlife Dept.
New York	USA	The Port Authority of NY and NJ	NY State Dept. of Environmental Conservation
Seattle	USA	State Dept. of Ecology	Washington Dept. of Fish and Wildlife

Results of Complete vs Random Sampling



- While the addition of more samples did bring the predicted coverage closer to the true coverage of the transect. However, even with 60 random samples the variation was still very large.