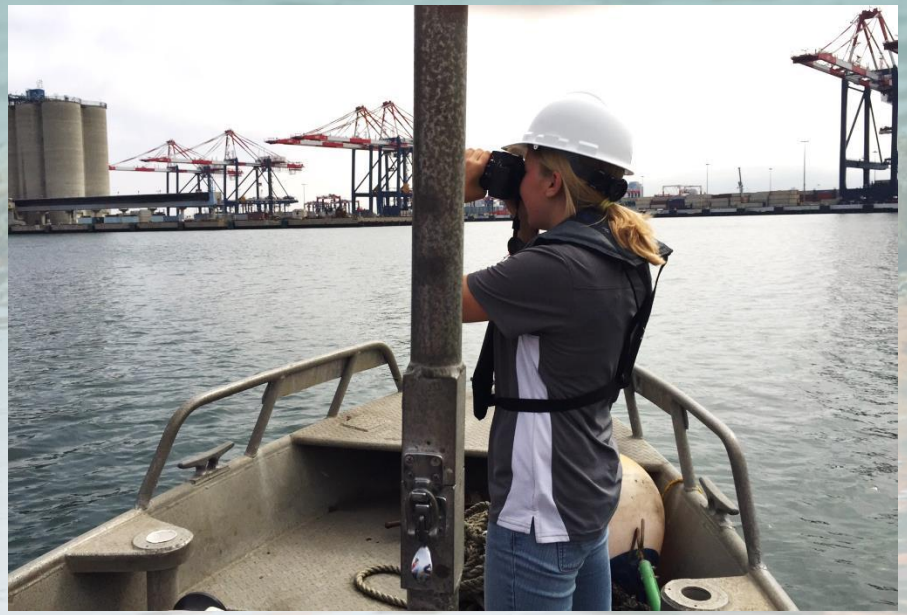


2015 COAST Summer Internship: State Lands Commission's Marine Invasive Species Program **Vessel Biofouling Management**

Chrissy Edmiston
California Maritime Academy

About me (as briefly as possible)

Chrissy Edmiston

- Senior at California Maritime Academy
  - Major: Global Studies and Maritime Affairs
  - Minor: Marine Science
- COAST 2015 Summer Intern
  - COAST is the Council on Ocean Affairs, Science and Technology for CSU Students

Internship Projects Outline

Outline of Projects

Project 1: Database Improvement

GOALS

1. Verify Anti-Fouling Coating Biocides
2. Separate Clusters of Coatings
3. Find and populate the database, researching
    A. Biocide delivery method
    B. Expected coating lifespan
    C. Speed intended for use
    D. Biocide contents

Project 2: Waterline Evaluation

GOAL

To determine which maintenance and operational practices are associated with the extent of fouling on waterlines of commercial vessels.

Outline of Projects

“The attachment or association of marine organisms to the wetted portions of a vessel”

➔ Leads to

Invasive species, $ impact, Regulatory Agency impact..

Definition of Biofouling

Background: Biofouling

- Are there key elements and indicators that could be used to **identify** a greater level of increased levels of biofouling on commercial vessels?
- Why do we look at FOULING in marine environments? What **IMPACT** does it have?

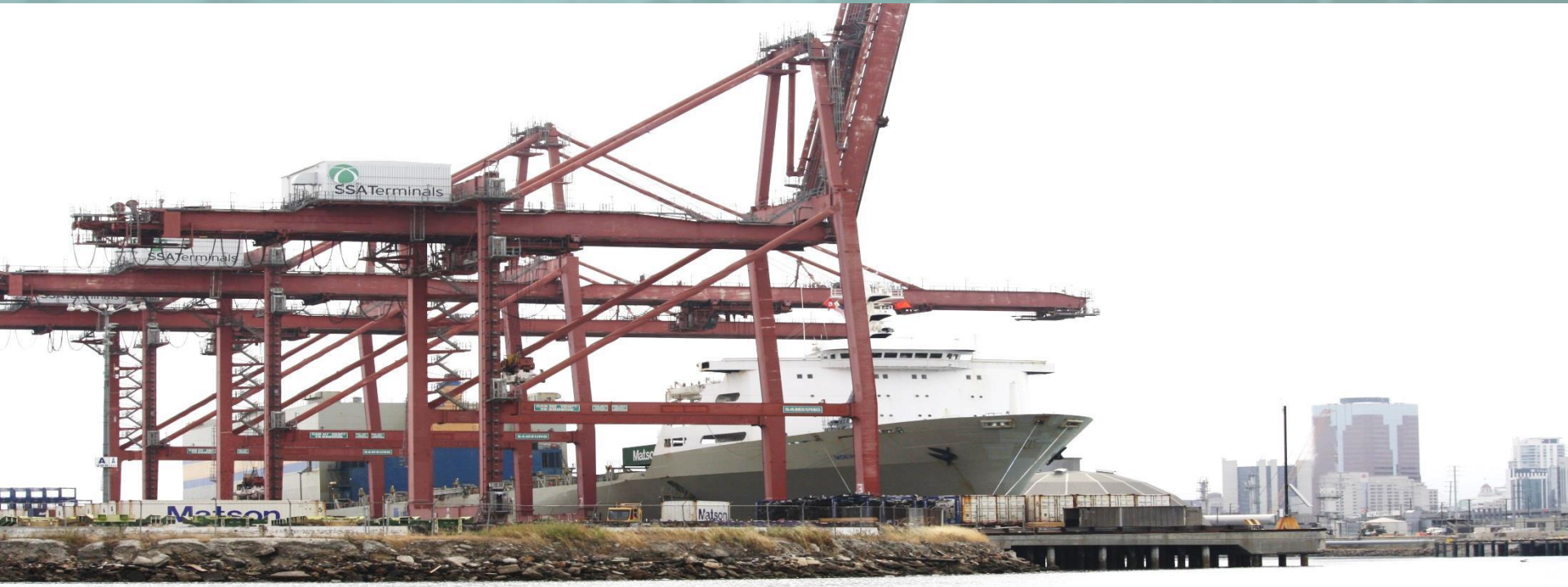
Panamax Container annual fuel consumption= **$10 million.**

Estimates of increases in fuel consumption from biofilm ALONE range from 8-12%.

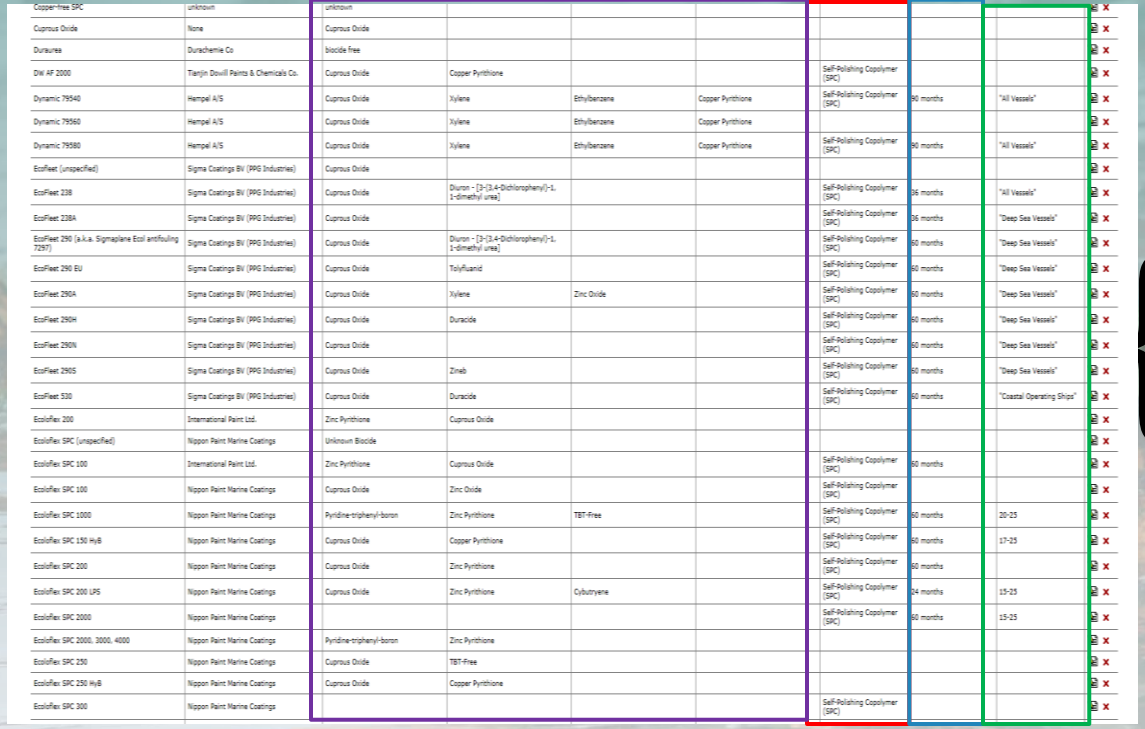
Additional minimal $800,000 addition to fuel costs/year for ships with minimal consumption..

A company with a fleet of 18 Panamax container ships would lose $14,400,000 a year (not to mention, environmental impacts from drag on the ship, invasive species introduced..)

Example of Economic Impact of Biofilm [algae and bacteria] Alone



Project 1 Database Improvement



Copper-free SPC	unknown	unknown							
Cuprous Oxide	None	Cuprous Oxide							
Duraures	Durachemie Co	biocide free							
DW AF 2000	Tianjin Dowill Paints & Chemicals Co.	Cuprous Oxide	Copper Pyrithione			Self-Polishing Copolymer (SPC)			
Dynamic 79540	Hempel A/S	Cuprous Oxide	Xylene	Ethylbenzene	Copper Pyrithione	Self-Polishing Copolymer (SPC)	90 months	"All Vessels"	
Dynamic 79560	Hempel A/S	Cuprous Oxide	Xylene	Ethylbenzene	Copper Pyrithione				
Dynamic 79580	Hempel A/S	Cuprous Oxide	Xylene	Ethylbenzene	Copper Pyrithione	Self-Polishing Copolymer (SPC)	90 months	"All Vessels"	
EcoFleet (unspecified)	Sigma Coatings BV (PPG Industries)	Cuprous Oxide							
EcoFleet 238	Sigma Coatings BV (PPG Industries)	Cuprous Oxide	Diuron - [3-[3,4-Dichlorophenyl)-1, 1-dimethyl urea]			Self-Polishing Copolymer (SPC)	36 months	"All Vessels"	
EcoFleet 238A	Sigma Coatings BV (PPG Industries)	Cuprous Oxide				Self-Polishing Copolymer (SPC)	36 months	"Deep Sea Vessels"	
EcoFleet 290 (a.k.a. Sigmaplane Ecol antifouling 7297)	Sigma Coatings BV (PPG Industries)	Cuprous Oxide	Diuron - [3-[3,4-Dichlorophenyl)-1, 1-dimethyl urea]			Self-Polishing Copolymer (SPC)	60 months	"Deep Sea Vessels"	
EcoFleet 290 EU	Sigma Coatings BV (PPG Industries)	Cuprous Oxide	Tolylfluanid			Self-Polishing Copolymer (SPC)	60 months	"Deep Sea Vessels"	
EcoFleet 290A	Sigma Coatings BV (PPG Industries)	Cuprous Oxide	Xylene	Zinc Oxide		Self-Polishing Copolymer (SPC)	60 months	"Deep Sea Vessels"	
EcoFleet 290H	Sigma Coatings BV (PPG Industries)	Cuprous Oxide	Duracide			Self-Polishing Copolymer (SPC)	60 months	"Deep Sea Vessels"	
EcoFleet 290N	Sigma Coatings BV (PPG Industries)	Cuprous Oxide				Self-Polishing Copolymer (SPC)	60 months	"Deep Sea Vessels"	
EcoFleet 290S	Sigma Coatings BV (PPG Industries)	Cuprous Oxide	Zineb			Self-Polishing Copolymer (SPC)	60 months	"Deep Sea Vessels"	
EcoFleet 530	Sigma Coatings BV (PPG Industries)	Cuprous Oxide	Duracide			Self-Polishing Copolymer (SPC)	60 months	"Coastal Operating Ships"	
Ecoloflex 200	International Paint Ltd.	Zinc Pyrithione	Cuprous Oxide						
Ecoloflex SPC (unspecified)	Nippon Paint Marine Coatings	Unknown Biocide							
Ecoloflex SPC 100	International Paint Ltd.	Zinc Pyrithione	Cuprous Oxide			Self-Polishing Copolymer (SPC)	60 months		
Ecoloflex SPC 100	Nippon Paint Marine Coatings	Cuprous Oxide	Zinc Oxide			Self-Polishing Copolymer (SPC)			
Ecoloflex SPC 1000	Nippon Paint Marine Coatings	Pyridine-triphenyl-boron	Zinc Pyrithione	TBT-Free		Self-Polishing Copolymer (SPC)	60 months	20-25	
Ecoloflex SPC 150 HyB	Nippon Paint Marine Coatings	Cuprous Oxide	Copper Pyrithione			Self-Polishing Copolymer (SPC)	60 months	17-25	
Ecoloflex SPC 200	Nippon Paint Marine Coatings	Cuprous Oxide	Zinc Pyrithione			Self-Polishing Copolymer (SPC)	60 months		
Ecoloflex SPC 200 LPS	Nippon Paint Marine Coatings	Cuprous Oxide	Zinc Pyrithione	Cybutryene		Self-Polishing Copolymer (SPC)	24 months	15-25	
Ecoloflex SPC 2000	Nippon Paint Marine Coatings					Self-Polishing Copolymer (SPC)	60 months	15-25	
Ecoloflex SPC 2000, 3000, 4000	Nippon Paint Marine Coatings	Pyridine-triphenyl-boron	Zinc Pyrithione						
Ecoloflex SPC 250	Nippon Paint Marine Coatings	Cuprous Oxide	TBT-Free						
Ecoloflex SPC 250 HyB	Nippon Paint Marine Coatings	Cuprous Oxide	Copper Pyrithione						
Ecoloflex SPC 300	Nippon Paint Marine Coatings					Self-Polishing Copolymer (SPC)			

Methodology

1. **Identify and begin research on all 420+ coatings, looking for 4 main factors**
   - A. Biocide delivery mechanism
   - B. Expected coating lifespan
   - C. Speed intended for use
   - D. Biocide contents
2. **Identify and separate unusable coatings and clusters**
3. **If Unable to find on website, conduct outreach**
   1. Email Companies
   2. Call Companies, if email reply unsuccessful or unavailable
4. **Manually input all data into coatings database**

+ Observations

- Larger companies were fairly easy to contact and were happy to assist in our project
- Help from Raya, Chris, and Chris' contacts helped facilitate direct communication with company representatives

- Observations

- Smaller companies were hesitant to be open about coating information
- Time change/ language barriers created communication issues
- Companies often remove all/any information about outdated/expired coatings

- What SLC's MISP Gains
  - Updated coating data, allowing for more thorough analysis
  - Cohesive and accurate biocide information inputted by a single source, rather than multiple over a span of time.
- What I Gain
  - Experience communicating with domestic and international companies
  - Connections and knowledge for obtaining coating data for future research
  - Basic knowledge of biocides, appropriate coatings for commercial vessels

Final Results from Database Improvement

# Found out of 343			
Delivery	Months	Speed (qualitative and quantitative)	Biocides
292	242	215	331
# Found out of 343 (as a %)			
Delivery	Months	Speed (qualitative and quantitative)	Biocides
85%	71%	63%	97%

Total Data Collected

1080

78.72% of total

Project 2 Waterline Evaluation

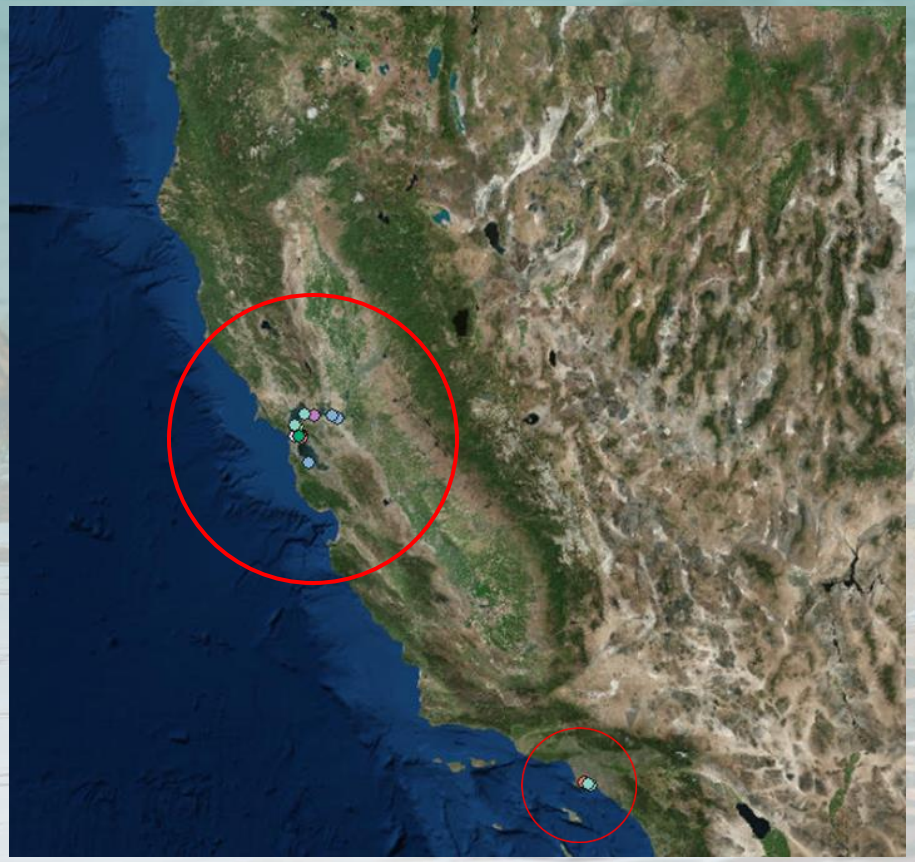
Methodology

1. **Opportunistic Stratified Sampling**
   A. **Available ships**
   B. **Targeted matrix of variables**
      A. **Vessel type**
      B. **Coating age**
      C. **Vessel speed**
      D. **# transits through tropical waters**
      E. **# transits through fresh water**
2. **Obtain Hull Husbandry Reporting Form**
   A. If unavailable, contact Jackie in Long Beach for assistance
   B. OR request form when aboard vessel
3. **Go out with inspectors to vessels- document level of fouling* and at least 5 pictures of**
   A. Bow
   B. Mid-ship
   C. Stern

*level of fouling: categorical ranking based on percent cover of the waterline covered in macrofouling

Methodology

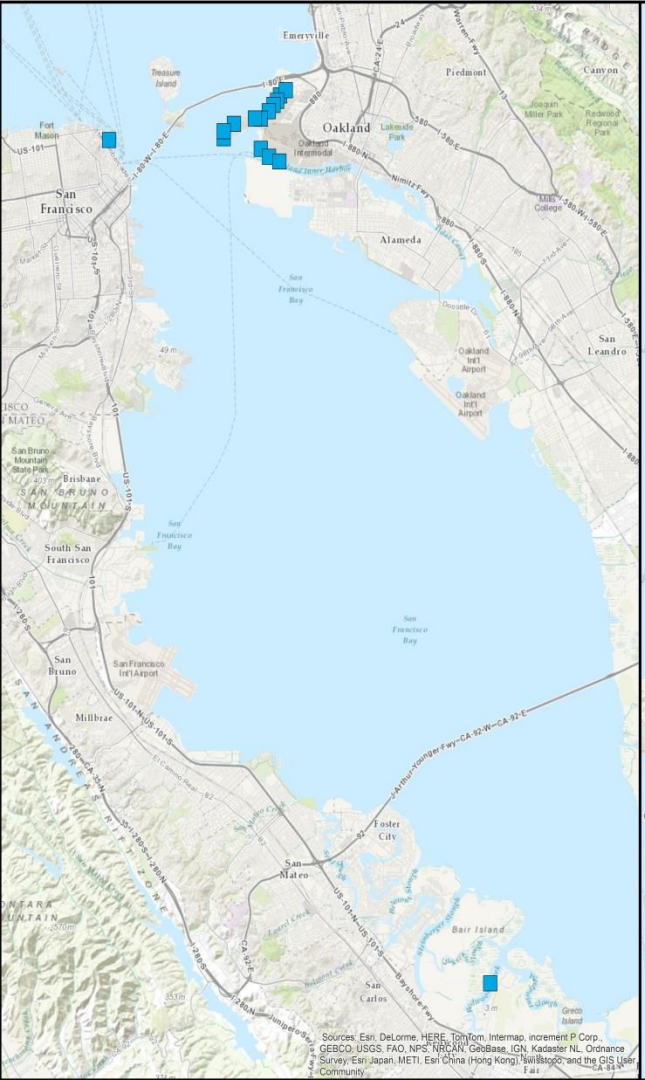
4. **Use iPad app (Collector) to input GPS location, HHRF data, and record level of fouling.**
5. **Input data into computer**
   A. Verify and submit data to ARCGIS
   B. Upload photos
   C. Use photoQuad software to determine accuracy of LOF's.
   D. Analyze data for association- Are there relationships between the variables and the levels of fouling?

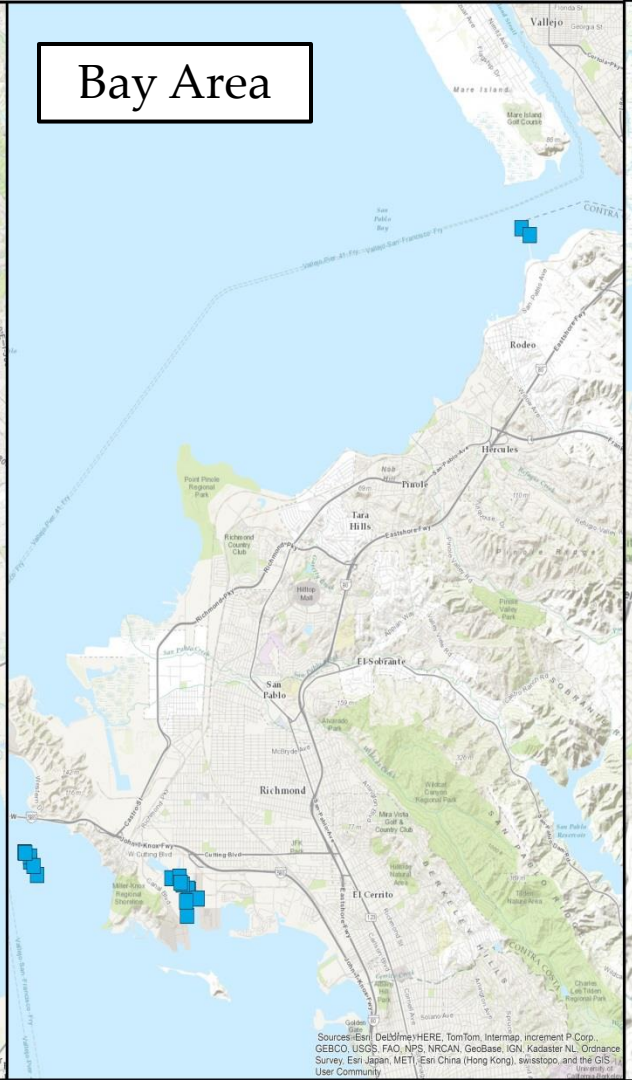


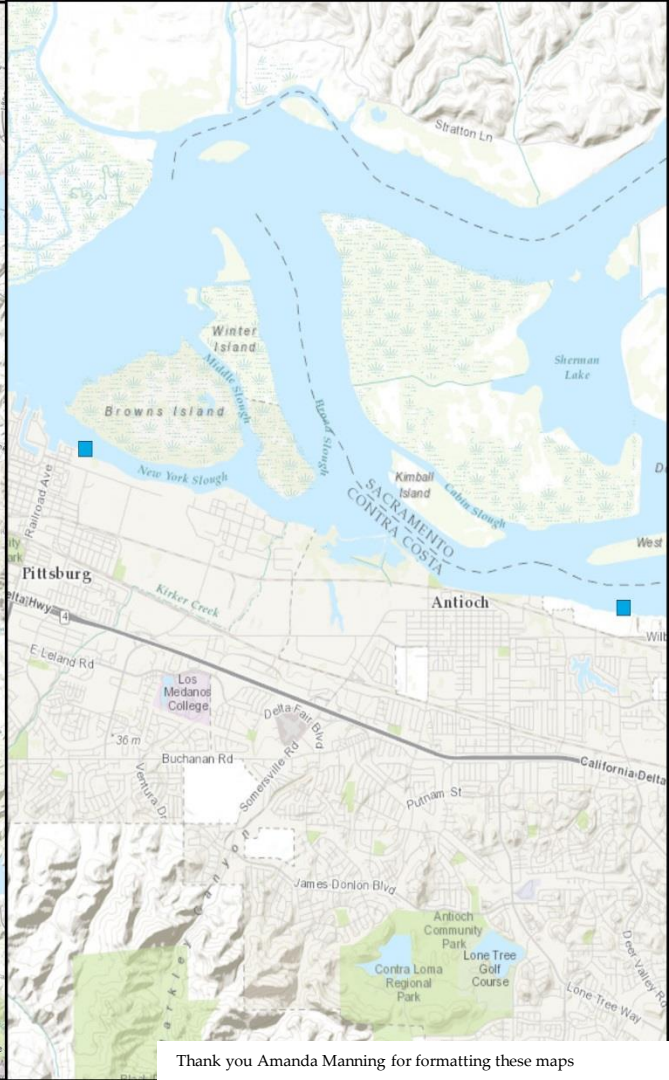
- **Northern California**
  - Carquinez
  - Conoco-Phillips/Rodeo
  - Oakland
  - Redwood City
  - Richmond
  - San Francisco
- **Southern California**
  - Port of LA/ Long Beach

Where We Sampled

Bay Area

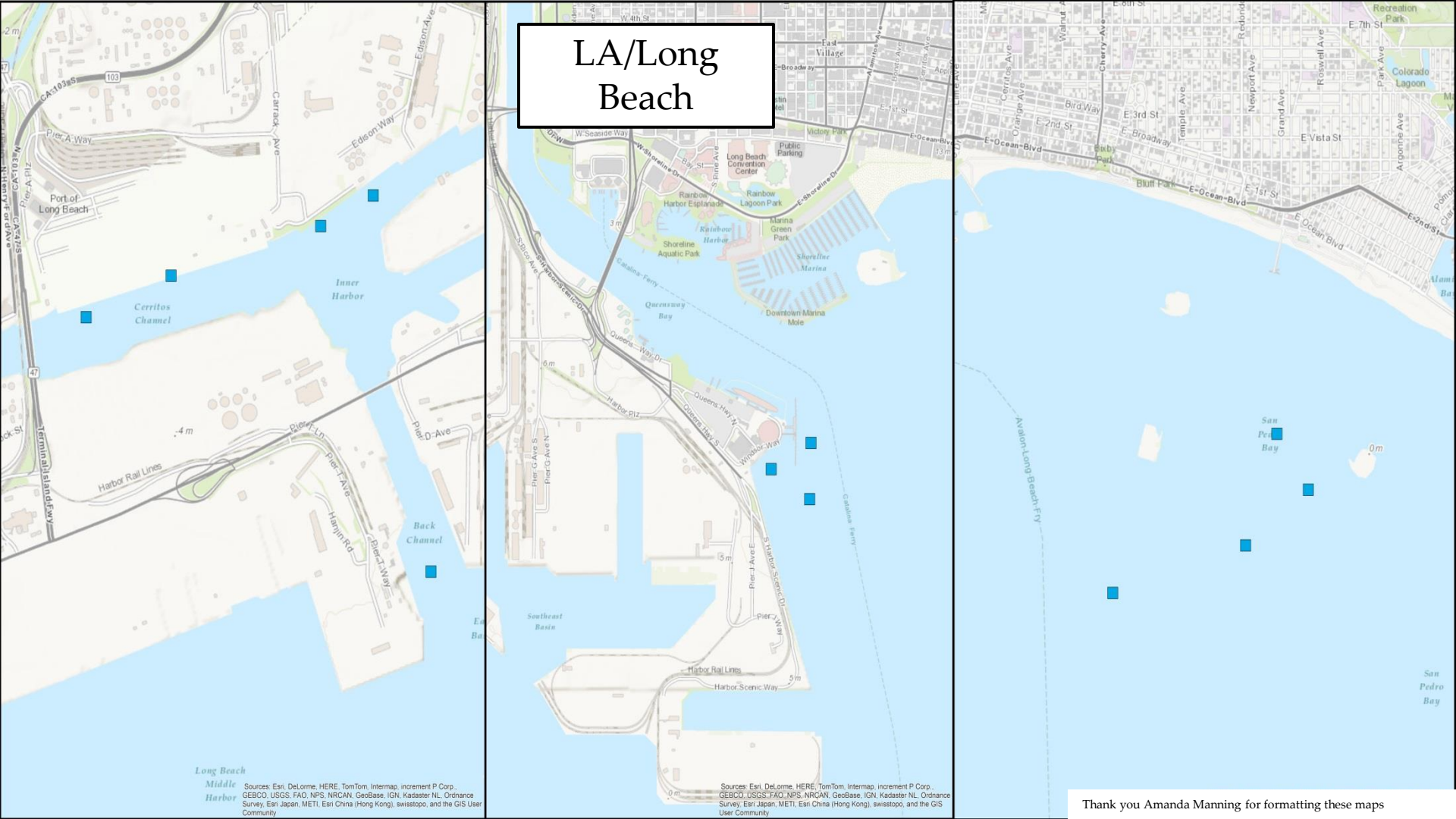






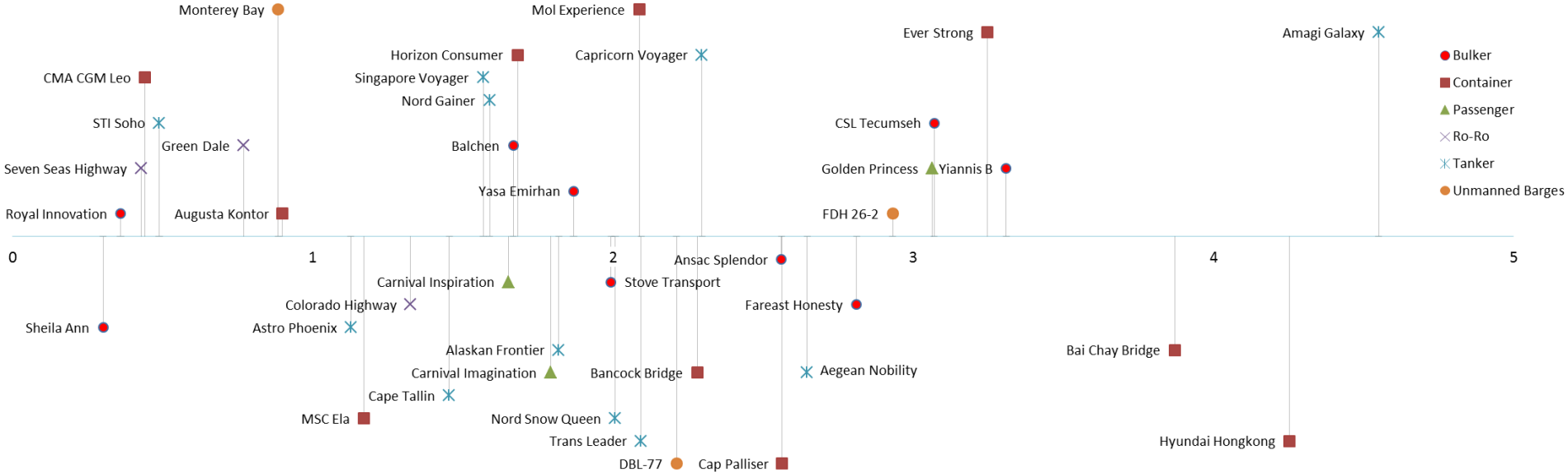
Thank you Amanda Manning for formatting these maps

LA/Long Beach



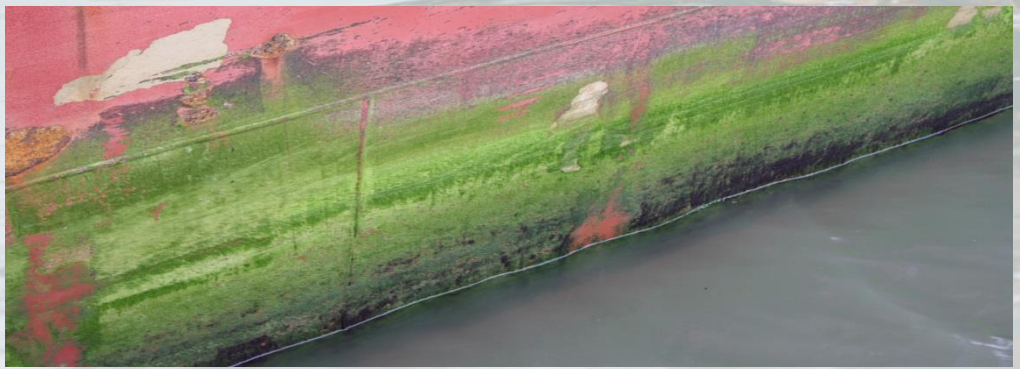
Thank you Amanda Manning for formatting these maps

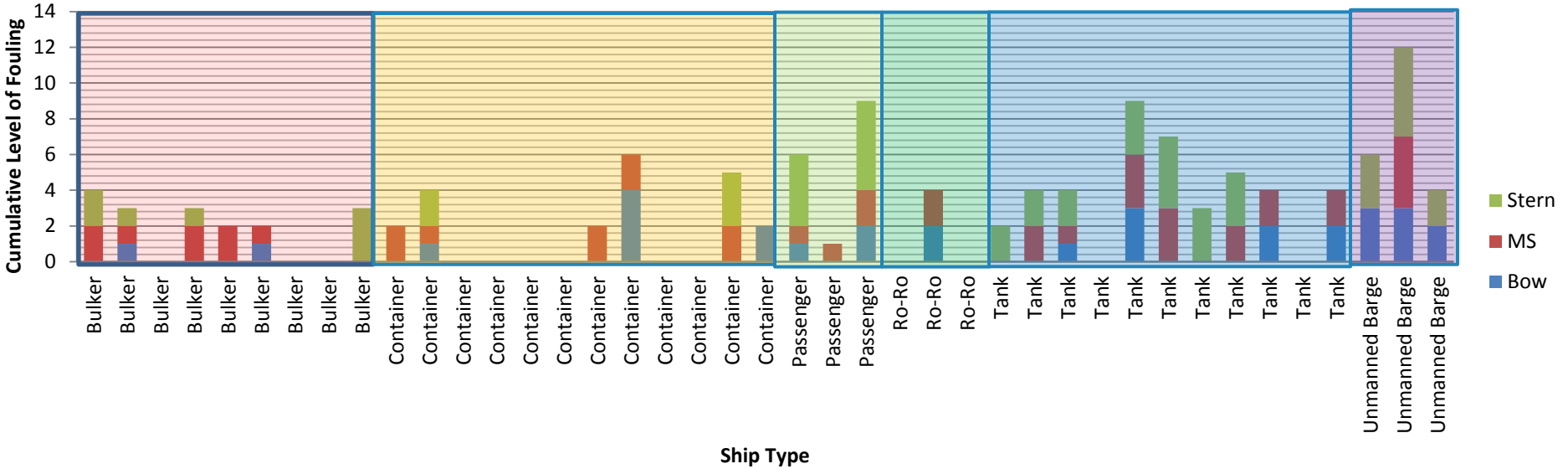
Timeline: Distribution of ships by years since new coating applied



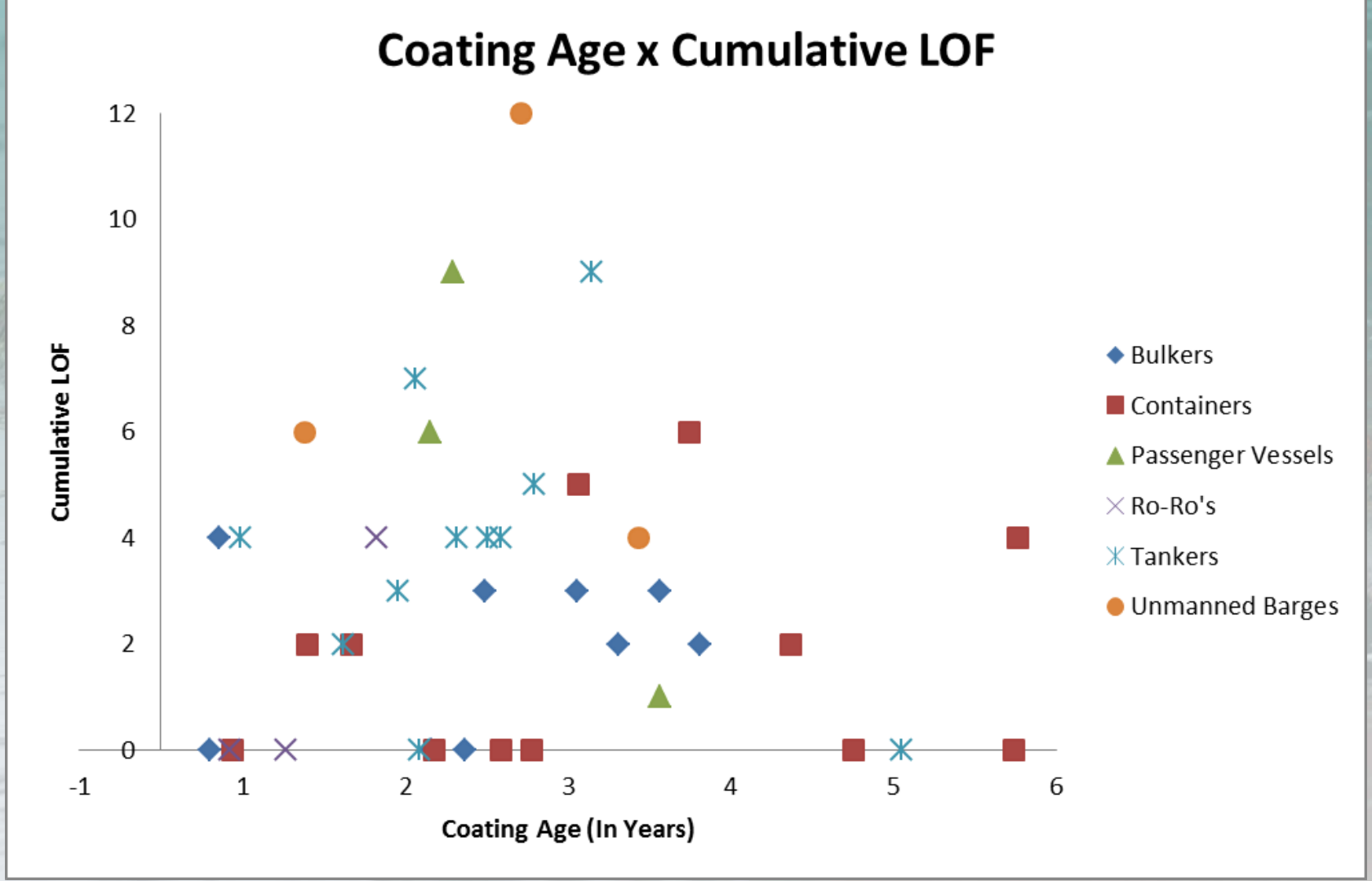
Results

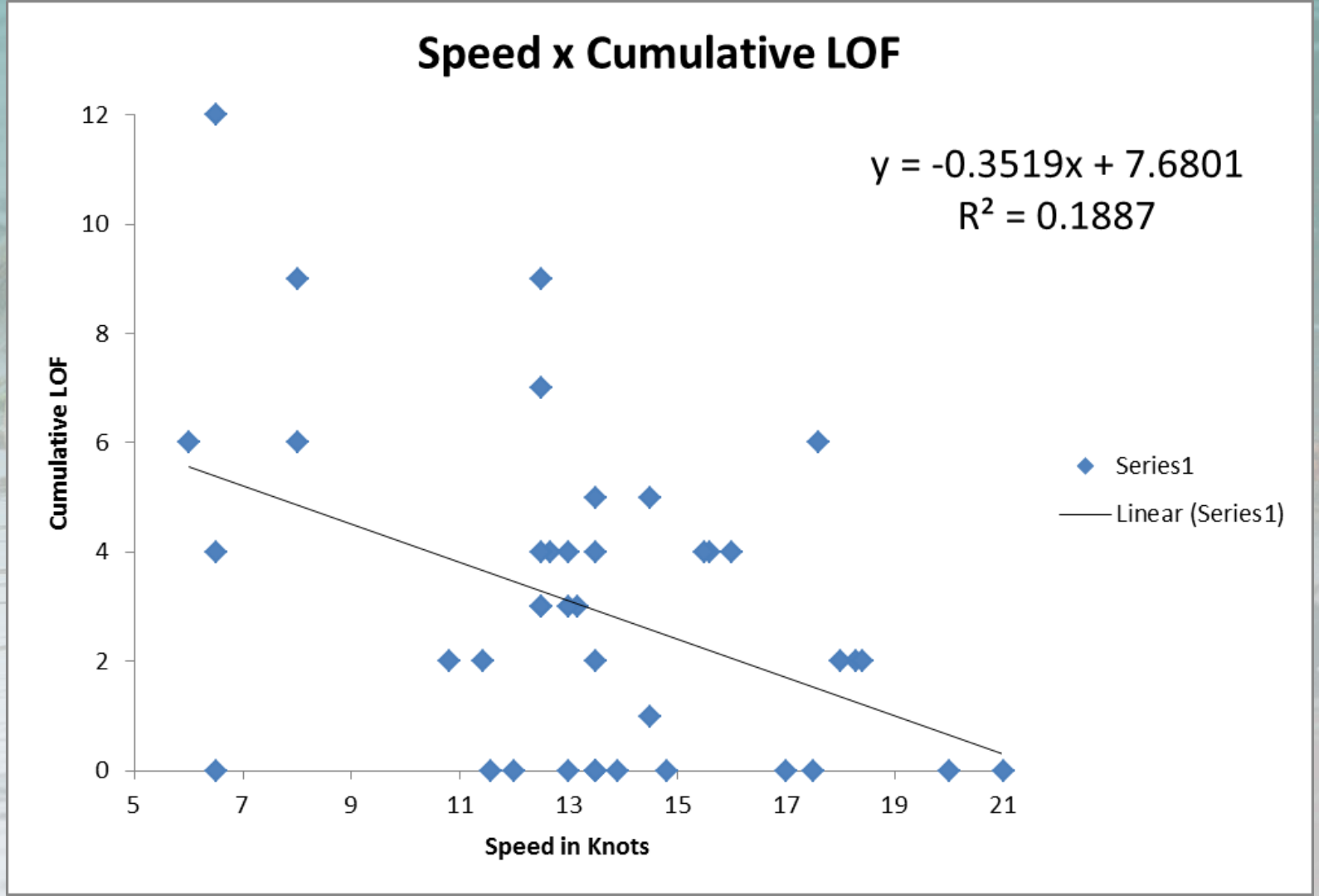
- Data Trends



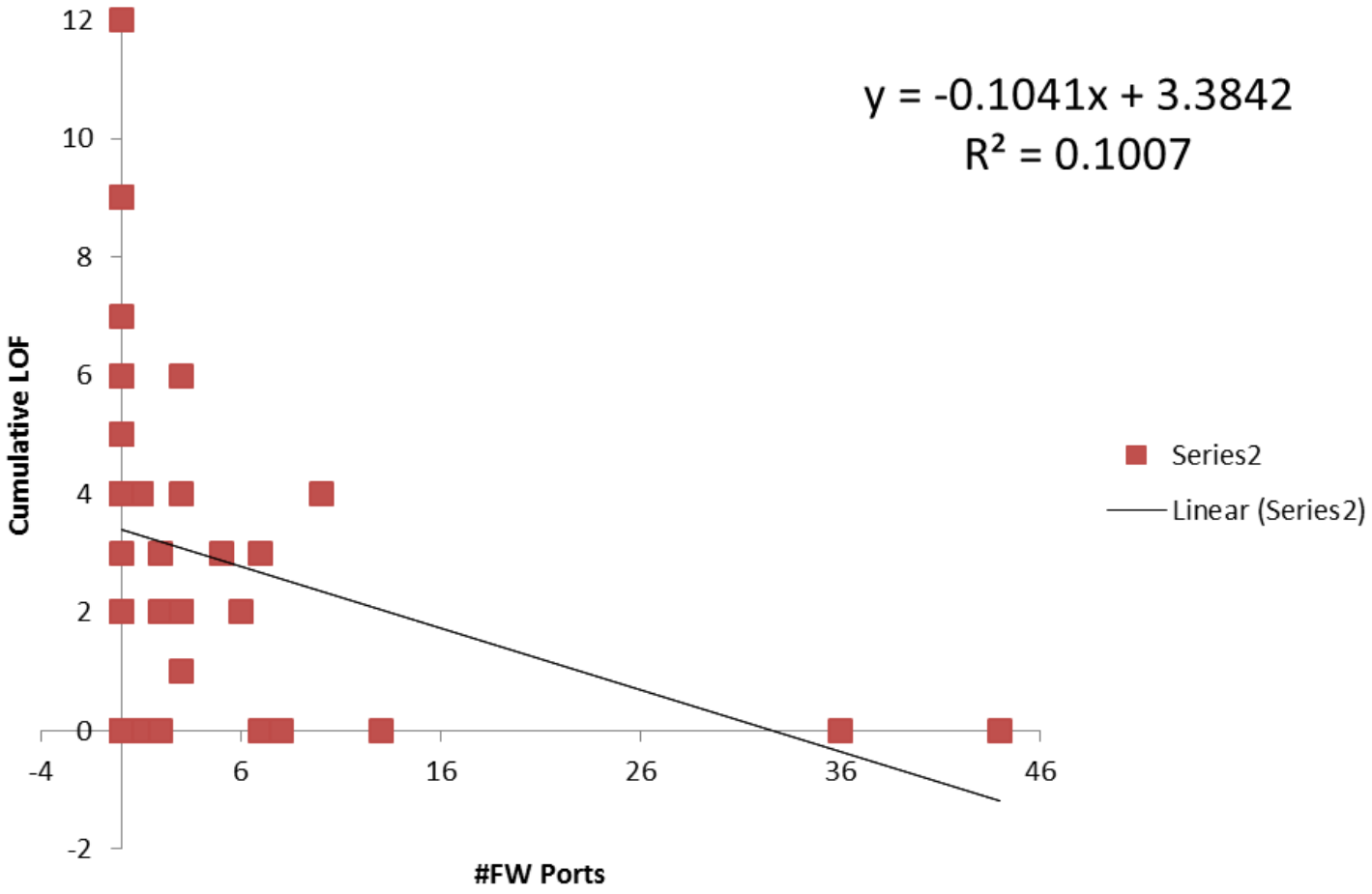


LOF Distribution for Ships


Coating Age x Cumulative LOF
Cumulative LOF
12
10
8
6
4
2
0
-1
1
2
3
4
5
6
Coating Age (In Years)
Bulkers
Containers
Passenger Vessels
Ro-Ro's
Tankers
Unmanned Barges


Speed x Cumulative LOF
y = -0.3519x + 7.6801
R² = 0.1887
Cumulative LOF
Speed in Knots
Series1
Linear (Series1)
0
2
4
6
8
10
12
5
7
9
11
13
15
17
19
21

FW Ports x Cumulative LOF



+ Observations

- There are data trends and association between several factors and levels of fouling
- Use of technology (iPad app, better camera lenses) created efficiency for data collection
- All offices were more than happy to help with the project, including advice, trips out to ports, and valuable learning opportunities, which is the only way this project was possible

- Observations

- There are so many factors attributing to fouling, it would be difficult to develop an accurate, precise method to predict it;
  - however, anything that gives a hint can be useful
- Sampling was often opportunistic, making it difficult to hit targets
  - BUT we still exceeded # of original targets
- Future improvements:
  - More ships = more powerful data

- What SLC's MISP Gains
  - Hints that can determine which maintenance and operational practices are associated with the extent of fouling on vessel waterlines
  - Basis for improving/developing upon data and methods that I used
- What I Gained
  - Hands-on experience navigating and working in a port environment, working with port and ship personnel, and port safety and operational practices that I would not otherwise have opportunity to experience
  - Opportunity to work with professionals in the maritime industry and State Lands Commission
  - Broadened understanding of ballast water and biofouling, as well as in the Marine Science field in general
  - Legislative and public policy experience
  - Confidence in Excel, data collection, and presentation of results in PowerPoint and research paper format
  - Public speaking experience
  - Photography experience
  - Opportunity to express creativity through initiative in an applied project

Final Results from Waterline Research

Thank you for your time!

Any questions?

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