

A photograph of a marina at sunset. The sky is a warm orange and yellow. In the foreground, several sailboats are docked, their masts and rigging silhouetted against the bright sky. The water reflects the light from the sky. In the background, a city skyline is visible, including a prominent mountain peak. The overall scene is peaceful and scenic.

# “Safer Alternatives to Copper Antifouling Paints” Project

## Stakeholder Workgroup Meeting

December 10, 2008

A photograph of a marina at sunset. The sky is a warm orange and yellow. In the foreground, several sailboats are docked, their masts and rigging silhouetted against the bright sky. The water reflects the light. In the background, a city skyline is visible, including a prominent mountain peak.

# Agenda

1. Introductions

2. Overview of Panel Testing

3. Results

4. Next Steps

# Mission Statement

“Assist the Port of San Diego and the Institute for Research and Technical Assistance with identifying viable alternatives to copper-based antifoulant paint and encouraging the transition away from copper paints toward safer alternatives”.

# EPA Grant Tasks Timeline

|  | Start Date | End Date |
|--|------------|----------|
| Assemble Work Group                    | 01/01/08   | 03/31/10 |
| Examine Current Coatings/Methods       | 01/01/08   | 04/01/08 |
| Examine Alternative Coatings/Methods   | 01/01/08   | 05/01/08 |
| Develop Panel Test Protocol            | 04/01/08   | 06/01/08 |
| Conduct Panel Tests                    | 06/01/08   | 10/01/08 |
| Analyze Results / Select Best Coatings | 10/01/08   | 01/01/09 |
| Develop Boat Test Protocols            | 01/01/09   | 03/01/09 |
| Conduct Boat Tests                     | 03/01/09   | 10/01/09 |
| Analyze Results                        | 10/01/09   | 02/01/10 |
| Prepare Report                         | 12/01/09   | 03/31/10 |

Agenda Item 2:

# Overview of Panel Testing



# Test Coating Categories

## ❖ 46 Alternative Coatings

- 18 ZINC COATINGS
- 4 NON-ZINC ORGANIC BIOCIDES COATINGS
- 24 NON-BIOCIDES COATINGS

## ❖ Commonly used high and low copper content coatings

- AF-33 (33% Cu)
- Super KL (51-75% Cu)

# QA/QC

## ❖ Negative Controls

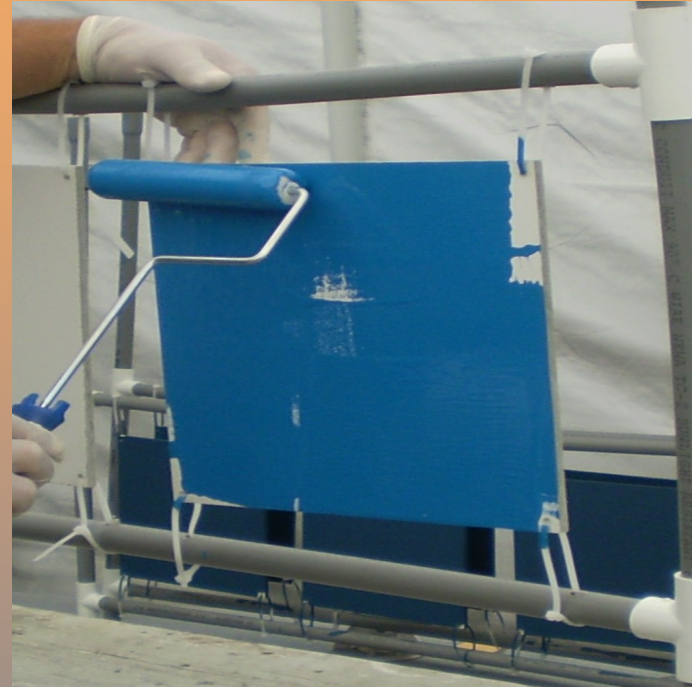
- 4 frames with blank panels with no gel or test coating
  - ✓ Characterize fouling community in SIYB
- 3 frames of blank panels with gel coat only
  - ✓ Isolate effectiveness of cleaning methods

## ❖ Cleaning Controls

- 1 no-clean panel for each test coating
  - ✓ Evaluate effectiveness of each paint when not cleaned

# Application of Paints

- ❖ Applied at boatyards per instructions from coating suppliers
  - Application mechanisms
  - Undercoats, thinners, number of coats, etc.



- ❖ Coating suppliers encouraged to be present
- ❖ Coatings applied to both sides of panels

# Participating Boatyards

- ❖ Nielsen Beaumont
- ❖ Koehler Kraft
- ❖ Knight and Carver
- ❖ Marine Group

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Coatings applied last  
2 weeks of May 2008



# Study Site Location

- ❖ Installed in slips at yacht clubs on La Playa Cove in SIYB:
  - San Diego Yacht Club
  - Southwestern Yacht Club
- ❖ June - October 2008



- ❖ Frames arranged by coating category on docks
- ❖ South facing at constant depth exposure

# Focus of Panel Phase

- ❖ Evaluate coating performance by assessing:
  - Fouling Growth
  - Level of effort required to clean
  - Coating condition
  
- ❖ Identify coatings that are:
  - Effective in repelling or preventing growth
  - Relatively easy to clean

# Inspection Schedule

|           | 2 Wk | 3 Wk | 4 Wk | 5 Wk | 6 Wk | 8 Wk | 12 Wk |
|-----------|------|------|------|------|------|------|-------|
| 6/17      | ✓    |      |      |      |      |      |       |
| 6/24-6/25 |      | ✓    |      |      |      |      |       |
| 7/2       | ✓    |      | ✓    |      |      |      |       |
| 7/8       |      |      |      | ✓    |      |      |       |
| 7/15-7/16 | ✓    | ✓    |      |      | ✓    |      |       |
| 7/29      | ✓    |      | ✓    |      |      | ✓    |       |
| 8/6-8/7   |      | ✓    |      |      |      |      |       |
| 8/12      | ✓    |      |      | ✓    |      |      |       |
| 8/25-8/26 | ✓    | ✓    | ✓    |      | ✓    |      | ✓     |
| 9/9       | ✓    |      |      |      |      |      |       |
| 9/16-9/17 |      | ✓    |      | ✓    |      |      |       |
| 9/25      | ✓    |      | ✓    |      |      | ✓    |       |
| 10/7-10/8 | ✓    | ✓    |      |      | ✓    |      |       |

# Routine Panel Inspection

- ❖ Step 1 – Photograph panels
- ❖ Step 2 – Fouling assessment
  - ❖ Designated Team Member – Stephanie
- ❖ Step 3 – Cleaning of panels
  - ❖ Designated Team Members - Katy and Heather
- ❖ Step 4 – After cleaning fouling and coating condition assessment
- ❖ Step 5 – Photograph panels

# Fouling Assessment

- ❖ ASTM D3623-78a standard method for static immersion panel testing
- ❖ Evaluate percent cover of categories of fouling, such as:
  - Algae
  - Tubeworms
  - Bryozoans
  - Tunicates
  - Barnacles
  - Sponges



# Fouling Assessment Ratings

| Rating | Fouling Performance   |
|--------|---|
| 1      | <b>No to low levels of fouling growth; FR is 90-100; incipient fouling may be present; if macrofouling forms present, are few in number or spread out across panel; paint surface still visible beneath fouling</b>   |
| 2      | <b>Low levels of fouling; FR is 70-90; macrofoulers present; painted surface may be obscured by fouling</b>   |
| 3      | <b>Medium levels of fouling; FR is 50-70; primary foulers may be densely grouped and may include large individuals; secondary fouling may be present</b>  |
| 4      | <b>Medium to high levels of fouling; FR is 30-50; macrofoulers include mature forms that may be densely grouped; secondary fouling attached (i.e. barnacles on barnacles or tunicates attached to barnacle) but still able to distinguish primary and secondary fouling</b> |
| 5      | <b>High levels of fouling; FR is &lt;30; macrofoulers densely grouped and may completely cover panel surface; secondary fouling present; may be hard to distinguish primary from secondary fouling; paint surface no longer visible beneath fouling</b>                     |

# Fouling Assessment

June 17



October 8

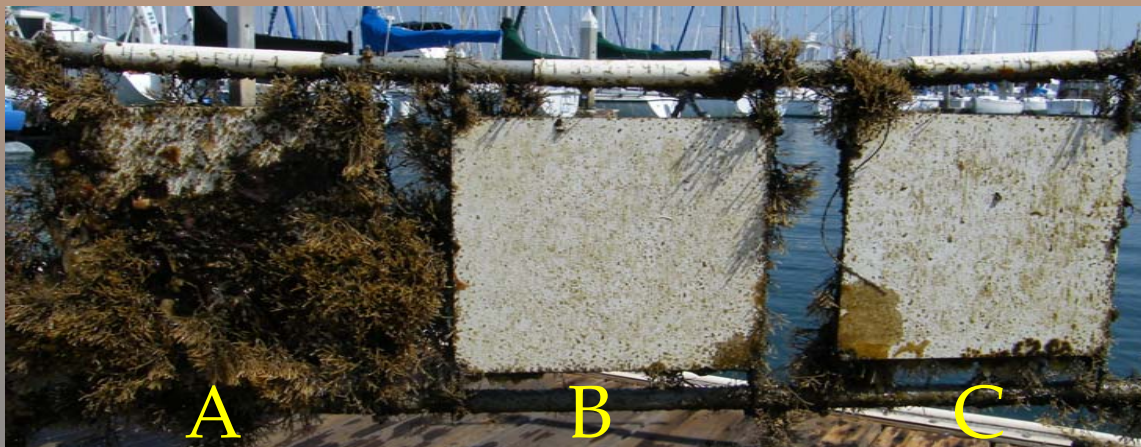


# Cleaning Assessment



# Cleaning Protocol

- ❖ Panel A - “No Clean” Panel
- ❖ Panel B - Cleaned by standardized method and frequency (Carpet every three weeks)
- ❖ Panel C - Panel cleaned to supplier recommendations (method and frequency)
  - ❖ Tools – Carpet, T-shirt, Microfiber Cloth, Purple Pad, Brushes, Spatula, Seawater



# Cleaning Protocol

- ❖ Limited panel exposure time to prevent drying
- ❖ Rinsed with bay water using peristaltic pump



# Cleaning Assessment Rating

| Cleaning Rating | Cleaning Effort   |
|-----------------|---|
| <b>1</b>        | <b>Light effort: very easy to remove growth with one wipe</b>   |
| <b>2</b>        | <b>Light to medium effort: still easy to remove growth but may require two or more passes in some areas to remove growth</b>                        |
| <b>3</b>        | <b>Firm effort: firm scrubbing and continuous passes required to remove fouling growth</b>  |
| <b>4</b>        | <b>Hard effort: With very hard physical effort, growth presented a challenge to remove but could be removed using specified cleaning mechanism.</b> |
| <b>5</b>        | <b>Using specified cleaning mechanism and hard effort, growth was unable to be removed.</b>   |

# Examples of Cleaning Tools Used



# Post-Cleaning Condition Rating

| Rating | Coating Condition   |
|--------|---|
| 1      | <b>New, slick finish, still shiny if appropriate to type of coating</b>                           |
| 2      | <b>Shine is gone or surface is lightly etched on all of coating, no physical failure detected</b> |
| 3      | <b>Physical failure detected in coating less than 20% of panel</b>                                |
| 4      | <b>Some defects. Physical failure detected in coating on 20%-50% of panel</b>                     |
| 5      | <b>Physical failure detected on over 50% of panel</b>   |

# Examples of Coating Condition



Agenda Item 3:

Panel Test Results

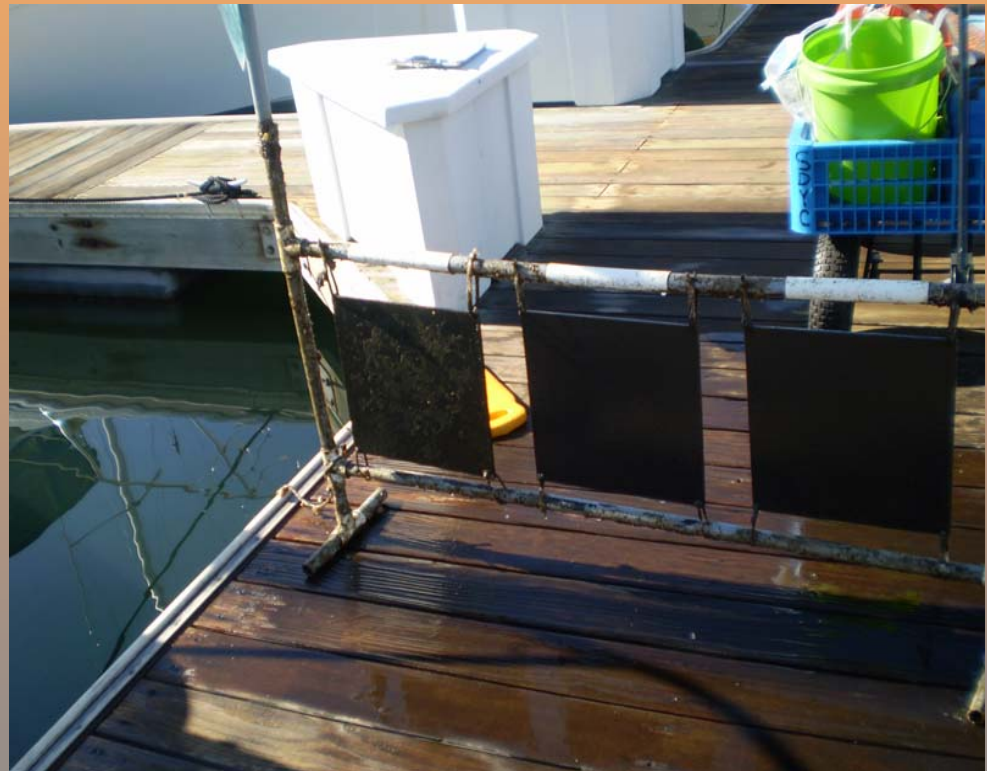


# Test Paint Categories

- ❖ Copper baseline paints
  - AF-33 (33% Copper)
  - Super KL (51%-75% Copper)
- ❖ Zinc paints
  - Contain zinc biocide, zinc oxide, organic biocide in some combination
  - Contain only zinc metal or only zinc oxide
- ❖ Organic biocide paints
  - Contain organic biocides only
- ❖ Non-biocide paints
  - Do not contain biocides of any kind or zinc in any form

# General Panel Fouling Results

1. Copper baseline, zinc biocide, organic biocide paints had low fouling
  - ❖ Almost always had no hard fouling
  - ❖ Often had soft fouling (algae)



## Fouling Results Cont'd

2. Zinc oxide paints had low fouling like biocide paints



## Fouling Results Cont'd

3. Zinc metal coatings had hard fouling
4. Some non-biocide paints had substantial hard fouling



# Panel Shading Effects

- ❖ Front and back of three panels were painted
- ❖ Panels placed so front faced the sun
- ❖ Back of panels shaded
- ❖ Observed significantly more fouling on back of panel than front
- ❖ Shading effect apparently known phenomenon

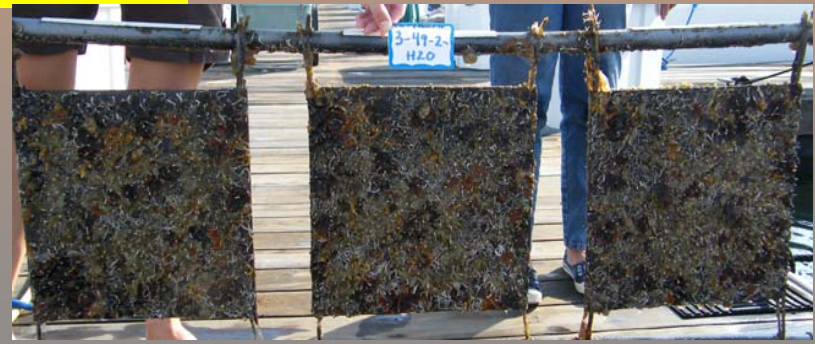
# Frame Front

# Frame Back

Example One



Example Two



# General Panel Cleaning Results

❖ Zinc biocide, organic biocide and zinc oxide paints easy to clean on three-week standard and supplier schedules

- Carpet often contained paint after cleaning
- In some cases, standard and supplier schedules removed paint, causing a physical failure
- Physical failure occurred because of cleaning frequency and/or cleaning tool



❖ Zinc metal paints very hard to clean

# Cleaning Results Cont'd

- ❖ Zinc oxide-only paints behaved like biocide paints
  - Zinc oxide not classified as a biocide
  - Called an adjuvant
- ❖ Zinc oxide-only paints included in project are formulated with catalysts
  - Photoactive release coatings repel fouling and are easy to clean
  - Carpet often contained paint after cleaning

# Cleaning Results Cont'd

- ❖ Some non-biocide paints hard to clean and some easy to clean
  - Hard paints (ceramic, epoxy) harder to clean
    - ❖ Hard fouling grows into matrix of paint
  - Some softer, more flexible paints (silicon compounds) easy to clean
    - ❖ Hard fouling stays on surface of paint

# Non-Biocide Panels

Hard to Clean



Easy to Clean



# Issues for Paint Types

## ❖ Cleaning

- Zinc biocide, organic biocide and zinc oxide paints require very infrequent and gentle cleaning
  - ❖ Coating may fail
  - ❖ Biocide ends up in water
- Some suppliers selected inappropriate cleaning tools
  - ❖ Some non-biocide paint methods not aggressive enough

## Issues Cont'd

- ❖ Biocide and zinc oxide only paints  
repel fouling well
  - ❖ Lower active ingredient
  - ❖ Metals build up from zinc coatings
  - ❖ Organic biocides are halogenated and little is known about their effects
  - ❖ May be trading one problem for another

# Analyzing the Results

## Project Goal

- ❖ Identify viable alternatives to copper-based antifoulant paint

## Project Objectives

- ❖ Encourage transition away from copper paints toward safer alternatives
- ❖ Use project to assist in TMDL compliance
  - Find paints that boaters are willing to use
  - Consider Environmental Impacts
  - Consider Cost Impacts

## Panel Testing - Identify coatings that are:

1. Effective in repelling or preventing growth
2. Relatively easy to clean

# Assessment Process

1. Use protocol requirements
2. Compared “like” panels
  - Determined if panel met study criteria for minimal fouling and ease of cleaning
  - Assigned each panel a “+” or “-” based on above criteria
  - For test panels near the +/- criteria, a recheck was performed in the field.
  - Evaluated panel series as a whole to move the coating through to the hull testing phase.

# Assessment Process (cont')

## 3. Incorporated stakeholder input

- Use only the best
- Limit to a reasonable number (20 max)
- Considered the probability/possibility of needing repainting during hull testing.

# Zinc Paint Performance

| ID Number | Ingredients       | Performance w/<br>No cleaning | Performance w/<br>standard cleaning | Performance w/<br>manufacturer cleaning |
|-----------|-------------------|-------------------------------|-------------------------------------|---|
| 01011D29  | ZnP, ZnO          | +                             | +                                   | +                                       |
| 01022E80  | ZnP, ZnO, E       | * / +                         | * / +                               | +                                       |
| 01032E86  | ZnP, ZnO          | +                             | +                                   | +                                       |
| 01041D27  | ZnP, ZnO, E       | +                             | +                                   | +                                       |
| 01052E86  | ZnO, E, T         | +                             | +                                   | +                                       |
| 01062E80  | Zn                | -                             | -                                   | -                                       |
| 01081D25  | ZnP, ZnO          | +                             | * / -                               | * / -                                   |
| 01091D52  | ZnP, ZnO, E       | +                             | -                                   | +                                       |
| 01101D29  | Zn                | -                             | -                                   | -                                       |
| 01111D25  | ZnP, ZnO,<br>Nano | +                             | +                                   | +                                       |

\* Field recheck required / Final Rating

E - Econeal; Nano - Zinc Oxide Nanoparticles; S - Sea Nine; T - Tolyfluanid; Zn - Zinc Metal; ZnO - Zinc Oxide; ZnP - Zinc Pyrrithione;

# Zinc Paint Performance cont'

| ID Number | Ingredients | Performance w/ No cleaning | Performance w/ standard cleaning | Performance w/ manufacturer cleaning |
|-----------|-------------|----------------------------|----------------------------------|--------------------------------------|
| 01121D19  | ZnP, ZnO    | +                          | +                                | +                                    |
| 01131D48  | ZnP, ZnO, E | +                          | -                                | -                                    |
| 01141D50  | ZnP, E      | +                          | * / -                            | +                                    |
| 02202G05  | ZnP, ZnO    | +                          | +                                | +                                    |
| 03471E48  | ZnO         | +                          | +                                | +                                    |
| 02212G05  | ZnO, S      | +                          | +                                | +                                    |
| 03271B06  | ZnO         | +                          | +                                | +                                    |
| 01171D48  | ZnP, ZnO, E | +                          | +                                | +                                    |

\* Field recheck required / Final Rating

E - Econeal; Nano - Zinc Oxide Nanoparticles; S - Sea Nine; T - Tolyfluanid; Zn - Zinc Metal; ZnO - Zinc Oxide; ZnP - Zinc Pyrithione;

# Organic Biocide Performance

| ID Number | Ingredients | Performance w/<br>No cleaning | Performance w/<br>standard cleaning | Performance w/<br>manufacturer cleaning |
|-----------|-------------|-------------------------------|-------------------------------------|---|
| 02182G03  | E, T        | +                             | +                                   | +                                       |
| 02192G03  | E, T        | +                             | +                                   | +                                       |
| 02222G07  | E           | -                             | -                                   | -                                       |
| 02232G07  | E           | +                             | -                                   | -                                       |

E - Econea; T - Tolyfluanid;

# Non-Biocide Performance

| ID Number | Performance w/<br>No cleaning | Performance w/<br>standard cleaning | Performance w/<br>manufacturer cleaning |
|-----------|-------------------------------|-------------------------------------|---|
| 03242H06  | +                             | -                                   | -                                       |
| 03251B08  | -                             | -                                   | -                                       |
| 03292G28  | +                             | +                                   | +                                       |
| 03302F26  | +                             | +                                   | +                                       |
| 03312H12  | -                             | * / -                               | +                                       |
| 03322F44  | -                             | -                                   | -                                       |
| 03331E50  | -                             | -                                   | -                                       |
| 03342H14  | -                             | -                                   | -                                       |
| 03352F08  | +                             | * / +                               | -                                       |
| 03362H06  | -                             | -                                   | -                                       |
| 03372F26  | -                             | +                                   | +                                       |
| 03382G28  | -                             | -                                   | +                                       |

\* Field recheck required / Final Rating

# Non-Biocide Performance cont'

| ID Number | Performance w/ No cleaning | Performance w/ standard cleaning | Performance w/ manufacturer cleaning |
|-----------|----------------------------|----------------------------------|--------------------------------------|
| 03391E08  | -                          | -                                | -                                    |
| 03401E46  | -                          | * / -                            | -                                    |
| 03412H04  | +                          | -                                | -                                    |
| 03422F08  | -                          | -                                | -                                    |
| 03432H14  | -                          | * / -                            | +                                    |
| 03451B08  | -                          | -                                | -                                    |
| 03462G26  | -                          | -                                | -                                    |
| 03482G26  | +                          | -                                | -                                    |
| 03492H20  | -                          | -                                | -                                    |
| 03502H04  | -                          | -                                | -                                    |
| 03511B06  | -                          | -                                | -                                    |
| 01161D19  | +                          | +                                | +                                    |

\* Field recheck required / Final Rating

# Top Performers

## ❖ Zinc-based

- 03271B06
- 03471E48
- 01011D29
- 01022E80
- 01032E86
- 01041D27
- 01052E86
- 01111D25
- 01171D48
- 02212G05
- 02202G05
- 01121D19
- 01091D52
- 01141D50

## ❖ Organic Biocides

- 02182G03
- 02192G03

## ❖ Non-Biocides

- 03292G28
- 03302F26
- 01161D19
- 03372F26
- 03352F08

# Boat Hull Testing



# Hull Testing Objectives

- ❖ Evaluate different coating application methods
- ❖ Evaluate performance
  - Maintenance
  - Longevity
- ❖ Consider environmental impacts
- ❖ Evaluate costs of alternative coatings

# Draft Conceptual Approach

- ❖ Consider coatings for inclusion in tiers
  - Study questions/design may be different for each tier.
  - Provides an inherent safety margin for environmental impacts.
  - Cleaning requirements may be different for each tier.
  - The number of boats participating has not been identified, to date.
  
- ❖ Tier 1 = Non-biocides (5)
- ❖ Tier 2 = ZnO only or Organic only (4)
- ❖ Tier 3 = Remaining active ingredient combinations (10)

# Tiered Coating Categories

## Tier 1: Non-biocides

- 03292G28
- 03302F26
- 01161D19
- 03372F26
- 03352F08

## Tier 2: ZnO /Organic

- 03271B06
- 03471E48
- 02182G03
- 02192G03

## Tier 3: Active Ingredient Combinations

- 01011D29
- 01022E80
- 01032E86
- 01041D27
- 01052E86
- 01111D25
- 01171D48
- 02212G05
- 02202G05
- 01121D19
- 01091D52
- 01141D50

# Draft Study Design Questions

## ❖ Tier 1 Questions

### 1. Application Strategies

- How can costs be controlled when applying non-biocide paints?
- Do different application methods impact non-biocide coating performance?

### 2. Performance

- How frequently do non-biocides need to be cleaned to remain effective?
- What is the longevity of non-biocide coatings?

## ❖ Tiers 2 and 3 Questions

### 1. Environmental Considerations

- What are the environmental impacts from Zn products or Organic biocides?

### 2. Performance

- What is the optimum cleaning frequency needed to remain effective?
- What is the longevity of Zn or organic-biocide coatings?

# Draft Study Design

## ❖ Tier 1

### 1. Application Strategies

- Use 3 different coating application approaches

### 2. Performance

- Evaluate all boats at the same frequency
- Identify the number of times cleaning is required and the effort needed
- Identify any physical failures in coating condition

## ❖ Tier 2 and 3

### 1. Environmental Considerations

- Evaluate leach rates of Zn products and organic biocides
- Evaluate toxicity of Zn products and organic biocides

### 2. Performance

- Evaluate all boats at the same frequency
- Identify the number of times cleaning is required and the effort needed
- Identify any physical failures in coating condition

# Hull Testing – Evaluating Performance

- ❖ Conduct performance evaluation on Tiers 1, 2, & 3
  - Visit all boats on set schedule – 3wks
  - Conduct assessment and perform cleaning only when needed
  - Identify number of times boats require cleaning
  - Identify level of effort needed to clean hull
  - Assess for physical failure of coating

# Hull Testing – Evaluating Application

- ❖ Evaluate different application methods to determine which are most cost effective
  - Roll on
  - Spray on
  - Apply over copper
- ❖ Each non-biocide coating (5) would be applied using all three methods
- ❖ Compare to standard - copper
  - Can non-biocides be applied the same way as copper paints
  - Consider performance
  - Consider cost of application method and whether additional processes (Stripping, tie coats, primers, etc) are required

# Hull Testing – Evaluating Environmental Issues

- ❖ Evaluate registration data
- ❖ Conduct leach rate testing
  - Evaluate leach rate
  - Evaluate potential loading
  - Assess passive leaching only
- ❖ Perform toxicity tests
  - Consider TIEs to determine toxic agent(s)

# Questions

1. Does the conceptual study design work?
2. How can we keep the number of boats to a reasonable number?
  - Limit to only Tier 1 study (5 paints, 15 boats)?
  - Limit to only Tier 1 and Tier 2 (19 boats)?
  - Limit the number of Zn coatings?
  - Exclude Zn coatings from hull testing – only test on panels for leaching/toxicity?
  - Choose representatives (subset) from zinc and organic biocides?
3. Can any portion of study be completed using existing resources (data/boats)?
4. Do the selected coatings meet the APCD VOC limit?

# Tiered Coating Categories

## Tier 1: Non-biocides

- 03292G28
- 03302F26
- 01161D19
- 03372F26
- 03352F08

## Tier 2: ZnO /Organic

- 03271B06
- 03471E48
- 02182G03
- 02192G03

## Tier 3: Active Ingredient Combinations

- 01011D29
- 01022E80
- 01032E86
- 01041D27
- 01052E86
- 01111D25
- 01171D48
- 02212G05
- 02202G05
- 01121D19
- 01091D52
- 01141D50

# Next Steps

1. Refine Study Design
2. Identify costs of study design
3. Discuss cost options with parties
4. Continue efforts to find boaters willing to participate

# Timeline & Schedule



# Meetings / Deadlines

## January 21, 2009

- ❖ Stakeholder Workgroup Meeting (study design, cost options)

## February - March

- ❖ Apply coatings to boat hulls

## March 11, 2009

- ❖ Stakeholder Workgroup Meeting (finalize hull testing protocol)

## April 1 – October 31

- ❖ Begin testing phase
- ❖ Summer hull test evaluation

# Project Contact Information

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A photograph of a marina filled with numerous sailboats at sunset. The sky is a warm, orange glow, and the water reflects the light. In the background, a city skyline and mountains are visible under the twilight sky. The text "THANK YOU FOR BEING A PART OF OUR PROJECT!" is overlaid in white, serif font in the center of the image.

THANK YOU  
FOR BEING A PART  
OF OUR PROJECT!

# Role of Workgroup Members

To achieve the mission of the work group, participants are being asked to:

- ❖ Provide input on viable paints.
- ❖ Provide input on panel and boat testing protocols.
- ❖ Review and provide input on analysis of panel and boat testing.
- ❖ Provide input on informational materials about the application and maintenance of the selected alternative paints.