The Influence of Boat Hull Coatings on Fouling Growth

Recreational boat owners need to control hull fouling organisms to maintain speed and manage fuel consumption. For example, studies on ships found that biofilm (earliest fouling stage) can reduce speed by 3% and increase required shaft power by 10%. Heavy growth can reduce speed by 11% and increase required shaft power by 59%.[1]

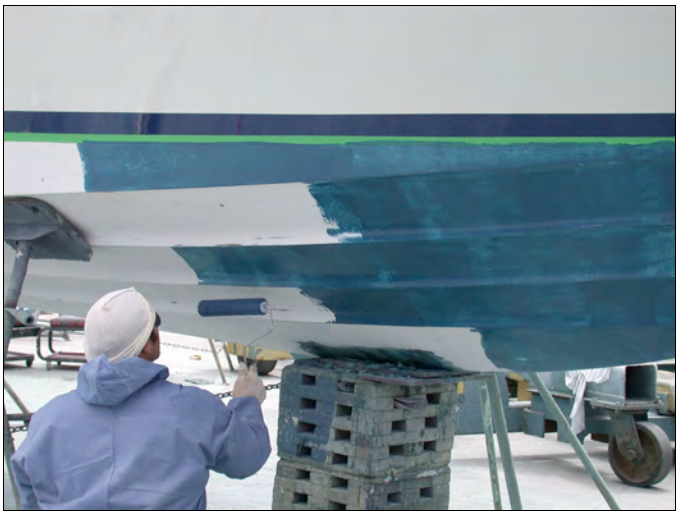
Hull coatings are applied to boat bottoms to deter fouling or protect the hull. Boaters can choose from a wide variety of toxic and nontoxic coatings. Toxic, copper-based antifouling paints ("copper") are widely used to deter fouling growth. They are regulated as pesticides in California. In contrast, nontoxic coatings are not considered pesticides[2] and so are less likely to have impacts on water quality than toxic coatings. Nontoxic epoxy coatings are durable and can withstand vigorous cleaning by powered brushes.[3] Surface characteristics of nontoxic slick (silicone, siliconized epoxy) coatings cause fouling organisms to attach loosely.[4] They are often called "foul release" coatings because fouling may be removed more easily or, if the boat regularly exceeds 12 knots, they may slough off.[5]

Most hull fouling organisms are considered to be native or non-native to the local area. Others are called "cryptogenic" because their origin is unknown. Scientists have not yet identified some fouling bacteria, algae and invertebrate animals to the level of species; thus we call them "unresolved" and we cannot be sure of their origins. Non-native fouling organisms are of particular concern because they may be carried to new areas where they can have negative impacts on harbor infrastructure and local ecosystems.[6,7,8,9]

Fouling organisms have preferences for certain surface characteristics (e.g., smooth, rough, chemical cues or deterrents).[10,11] Therefore, characteristics of hull coatings may influence the type and amount of fouling organisms that settle and begin to grow on them. Some hull fouling species, particularly non-natives, are more tolerant of copper toxins used in antifouling paints.[12,13,14] Copper paints may thus give copper tolerant species a competitive advantage over non-tolerant species.

Balanced Approach Needed

Commonly applied copper paints are known to be effective at reducing fouling on boat hulls. However, evidence about the impact of these paints on water quality in harbors has raised concerns about their use.[15,16] As a result, copper paints are now being restricted in Washington[17] and part of California.[18] These restrictions, along with the desire for improved water quality, are leading to increased interest in less toxic and nontoxic hull coatings.



Applying nontoxic coating to boat hull

Switching from copper paints to less toxic and nontoxic coatings may help improve water quality, but it also may have implications for boat maintenance and the potential transport of non-native invasive species. To investigate potential impacts of using nontoxic coatings and paints, we conducted research to 1) evaluate how the type of hull coating affects the type and amount of fouling organisms, particularly non-natives, that attach to it, and 2) assess whether non-native species settle sooner and occupy more space than native species on copper paints over time. Results of this work will help inform the development of best management practices that balance boating operations with ecosystem health (water quality, invasive species).

Fouling on Different Hull Coatings

Our study to evaluate fouling on different types of hull coatings was conducted at four locations in Santa Barbara Harbor (SBH) and three locations in Shelter Island Yacht Basin (SIYB) of San Diego Bay. The study ran for one year, from April 2008 through March 2009.

Sets of four 15 cm x 15 cm (6 in x 6 in) panels were attached to frames and placed in the water at local boat docks. Panels were placed 1 meter (about 1 yard) below the surface of the water. Of the four

panels in each set, one had only a base, gel-coating. The other three had an additional toxic or nontoxic coating over the gel coat:[A]

1) Interlux Epoxy Modified Antifouling™ toxic copper antifouling paint ('copper' coating),
2) CeRamKote Marine™ nontoxic ceramic epoxy ('epoxy' coating),
3) Eco-5 Marine™ nontoxic siliconized epoxy ('slick' coating), and
4) Cook Composites™ nontoxic polyester base coat ('gel' only coating).

Attaching experimental frame to side of dock

Panels were replaced on the frame each month. The removed panels were taken to the laboratory where the type and amount of fouling that had accumulated during that month was assessed for each panel. Results were then compared among the four types of coatings.

Highlights of results include:

- All surfaces fouled, but fouling was extremely low on copper panels compared to nontoxics over each 1-month interval.
- Only 13 of 672 copper panels fouled during the 1-month intervals.
- The *Hydroides* spp. tube worms fouled nontoxic epoxy more heavily than nontoxic slick.
- See photos at right for examples of the above three results.

[A] Product names are provided for educational purposes and do NOT imply endorsement.

Fouling accumulation on four coating types after 1 month in the water:

Copper coated panel

Gel coated panel

Nontoxic epoxy coated panel

Nontoxic slick coated panel

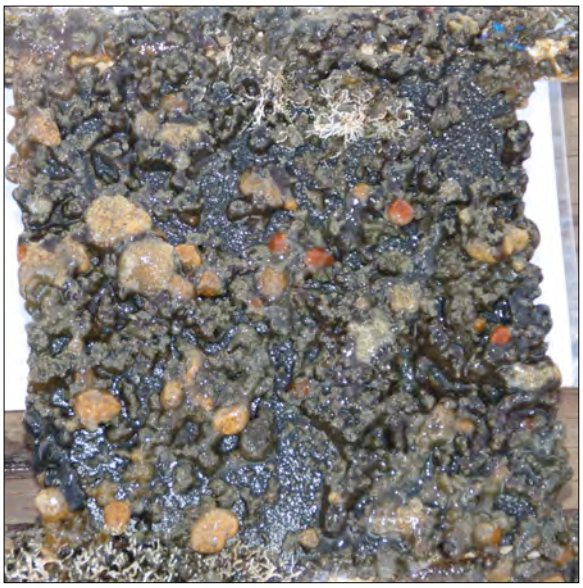
Fouling on Toxic Copper Paint over Time
We conducted another study to determine how longer submersion times affected fouling on copper paint. This study was conducted only at Kona Kai Marina and Half Moon Anchorage in Shelter Island Yacht Basin of San Diego Bay. It ran for one year, from July 2008 through June 2009.

Sets of three experimental panels were attached to frames and placed in the water (as before) at local boat docks. All panels received copper coating over gel base coat. A single panel was removed from each frame after 3 months, another after 6 months, and the final panel was removed after 12 months in the water. The removed panels were taken to the laboratory where the type and amount of fouling on the panels was assessed for the three submersion times.

Highlights of results include:

- Copper paint was effective at deterring settlement of most, but not all, fouling organisms for up to 6 months. Fouling was much heavier after 12 months.
- Non-native species settled on the copper paint panels sooner than native, but some native species did eventually settle on the panels.
- Non-native species were more abundant than native species on the copper panels at the end of the experiment.
- Some non-native (but no native) species settled on copper panels in under 6 months. This suggests non-natives could tolerate copper, increasing the likelihood that they could be carried on hulls with copper coating of this age.
- After 6 months, a native red alga *Rhodymenia californica* was found on top of the non-native bryozoan *Watersipora subtorquata,* suggesting the non-native and not the coating was a suitable surface to which the native could attach. After 12 months, the alga had attached directly to the copper panels, suggesting that the coating's toxicity had dropped.
- This result (on direct versus indirect attachment) is in line with reports by other scientists that some non-native and cryptogenic species may provide a surface to which less copper-tolerant species can attach.[19]

Conclusions
The hull coating's type and age can influence the need for additional fouling control measures, risks to water quality, and risk of spreading non-native invasive species. Although boats with copper paints require little or no hull cleaning initially, they will eventually become fouled. They may impair water quality in poorly flushed boat basins by continually leaching copper toxin. Copper paints also represent a risk for spreading non-native invasive species because some non-native invasive species more readily foul and occupy more space on them over time than native species. Further, copper tolerant species can provide a foundation for non-tolerant and less tolerant, non-native (and native) species to attach. Comparatively, nontoxic coatings likely are less harmful to harbor water quality but require more frequent hull cleaning, as they do not deter fouling. Further, the undeterred fouling means there is a high risk for transporting non-native invasive species. Results are most pertinent for boats that rarely move (about half of California's coastal boats).[20]



Fouling accumulation on copper panel after 12 months in San Diego Bay

Recommendations
Based on our comprehensive research results (highlights presented here and additional results in the report mentioned below), we support using a balanced approach for managing hull fouling that considers boat operations, water quality and invasive species. Regardless of the hull coating, companion strategies, such as hull cleaning,[21] are essential for maintaining boat performance and for reducing the spread of non-native invasive species. In choosing a fouling control strategy we recommend using an Integrated Pest Management approach that considers, for example boating activities, harbor location, environmental conditions and regulations.

For more information see our report, **IPM for Boats: Integrated Pest Management for Hull Fouling in Southern California Coastal Marinas**, available at http://ucanr.org/sites/coast/publications/.

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