

Appendix B: Calculation of Recreational Boat Discharges of Dissolved Copper to the Harbors Back Basins

Passive Leaching

Based on the information provided by the Los Angeles County Department of Beaches and Harbor, there are 2,000 slips of vessels in the back basins D, E and F. Based on the studies conducted for Shelter Island Yacht Basin TMDL (San Diego Regional Water Quality Control Board), the average size recreational vessel is 40 feet in length, with a beam width of 11 feet. Average wetted hull surface area is calculated based on this average size vessel, which is then used to calculate the amount of passive leaching over time per vessel. Wetted hull surface area is calculated using the following equation: Wetted hull surface area = (Overall length) * (Beam height) * (0.85)

$$\text{Annual copper load (kg/year)} = P * S * N, \text{ and } S = L * B * 0.85$$

Where:

P = Passive leaching rate = 6.5 ug/cm²/day

N = Number of boats = 2,000

S = Wetted hull surface area = Overall length * Beam * 0.85

L = Average length = 40 feet = 12.2 m

B = Average beam height = 11 feet = 3.4m

Wetted hull surface area = (12.2m)*(3.4m)*(0.85)=35.3m²

$$\begin{aligned} \text{Annual load (dissolved copper)} &= (6.5 \text{ ug/cm}^2/\text{day}) * (35.3\text{m}^2) * (2,000 \text{ vessels}) * (10,000 \text{ cm}^2/ \\ &\text{m}^2) * (\text{kg}/10^9 \text{ ug}) * (365 \text{ day}/\text{yr}) \\ &= \mathbf{1,675 \text{ kg/year} = 3,693 \text{ lb/year}} \end{aligned}$$

Hull Cleaning

Underwater hull cleaning is a common maintenance practice designed to prevent buildup of marine organisms on a ship's hull. The growth of marine organisms may be removed from recreational vessel hulls either through haul-out at boatyard, or manually while the boat is in-water using underwater hull cleaning techniques. It has been estimated that almost all of the pleasure crafts in the Marina del Rey undergo periodic underwater hull cleaning.

The physical process of removing marine growth on the ship's hull underwater results in a release of dissolved copper from the paints. The amount of copper released from hull cleaning is dependent on cleaning frequency, method of cleaning, type of paint, and frequency of painting. Estimated underwater hull cleaning frequency is 2 times per month in the summer months (May through October) and 1 per month in the winter months for a regularly maintained recreational boats. 80% of the boats in the Marina del Rey do not move and are hauled out for cleaning (e-mail communication with Mr. Joel Hanson, Santa Monica Bay Restoration Project Boaters Education Program, August 8, 2002).

The calculation is based on the information utilized for the for Shelter Island Yacht Basin TMDL. In order to determine the load from underwater hull cleaning, it was assumed that approximately half of the vessels are painted with epoxy paints and half with vinyl paints, and that MPs are used to clean hulls on approximately half of the vessels. For epoxy paints, cleaning without MPs doubled the dissolved copper flux, from 8.6 µg /cm²/event to 17.4 µg /cm²/event (Schiff *et al.*, 2003). The response from hard vinyl paints remained similar whether or not BMP/MPs were used (3.8 versus 4.2 µg /cm²/event) (Schiff *et al.*, 2003). Using these assumptions, the rates for the epoxy and vinyl paints were averaged to arrive at an emissions rate for underwater hull cleaning in Marina del Rey's back basins

Determination of Hull Cleaning Rate

Average dissolved copper emissions rate from epoxy paints
= $(8.6 \mu\text{g}/\text{cm}^2/\text{event} + 17.4 \mu\text{g}/\text{cm}^2/\text{event})/2$
= $13 \mu\text{g}/\text{cm}^2/\text{event}$

Average dissolved copper emissions rate from vinyl paints
= $(3.8 \mu\text{g}/\text{cm}^2/\text{event} + 4.2 \mu\text{g}/\text{cm}^2/\text{event})/2$
= $4 \mu\text{g}/\text{cm}^2/\text{event}$

Average dissolved copper emissions rate (both paint types)
= $(13 \mu\text{g}/\text{cm}^2/\text{event} + 4 \mu\text{g}/\text{cm}^2/\text{event})/2$
= $8.5 \mu\text{g}/\text{cm}^2/\text{event}$

Determination of Source Loading Using Hull Cleaning Rate

Annual copper load (kg/year) = P*S* N_v, and S = L*B*0.85

Where:

P = Underwater hull cleaning rate

N_v = Number of vessels

S = Wetted hull surface area = Overall length*Beam*0.85

L = Average boat length

B = Average beam width

Cu = Copper

Given:

P = $8.5 \mu\text{g}/\text{cm}^2/\text{event}$

N_v = $2,000 * (20\%) = 400$

L = 12.2 m

B = 3.4 m

N_h = 18 events/year

Wetted hull surface area = $L*B*(0.85)$

Wetted hull surface area = $(12.2 \text{ m})*(3.4 \text{ m})*(0.85) = 35.3 \text{ m}^2$

Annual load = $(8.5 \mu\text{g}/\text{cm}^2/\text{day})*(35.3 \text{ m}^2)*(400 \text{ vessels})*(10,000 \text{ cm}^2/\text{m}^2)*(1 \text{ kg Cu}/10^9 \mu\text{g})*(18 \text{ events/year})$

= 21.6 kg/year = 47.6 lbs/year