Pollution Impacts from Large Commercial Vessels:

Protecting Virginia's Health, Climate, and Coastlines.

A visual diagnostic of the shipping industry's air and water pollution crisis, crisis, and the policy mandate required to secure Virginia's future.

Protect Virginia

Virginia's Coastal Identity and Economy Depend on Healthy Waters

$1.27 Billion

Total Output of the Virginia Seafood Industry in 2023.

10,000+ Jobs

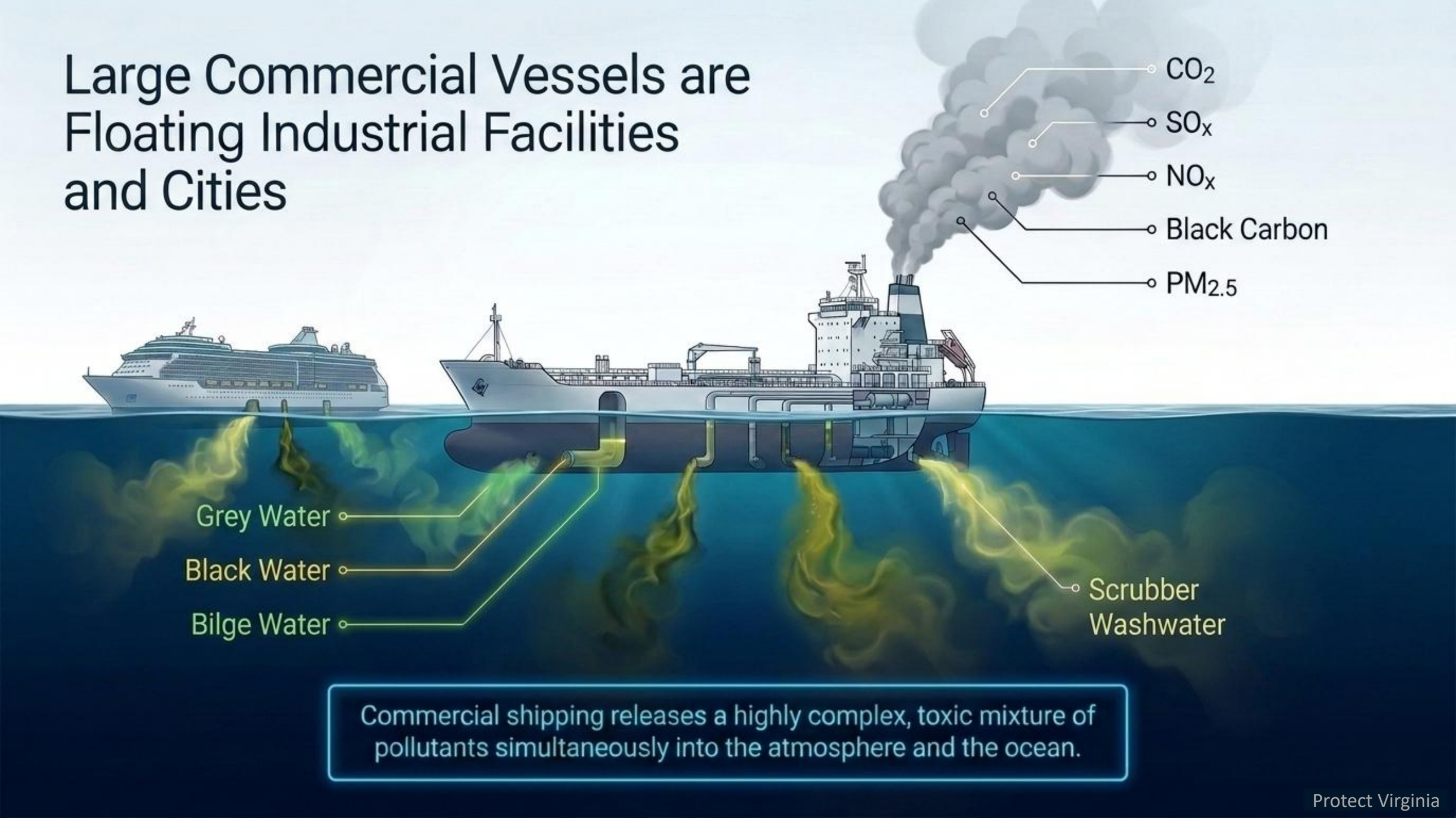
Supporting watermen, aquaculture farmers, processors, and distributors.

#3 in the Nation

Virginia's rank as a U.S. marine products producer.

Virginia's marine resources are not just ecologically vital—they are the economic engine of our coastal communities, generating over $390 million in tax revenues.

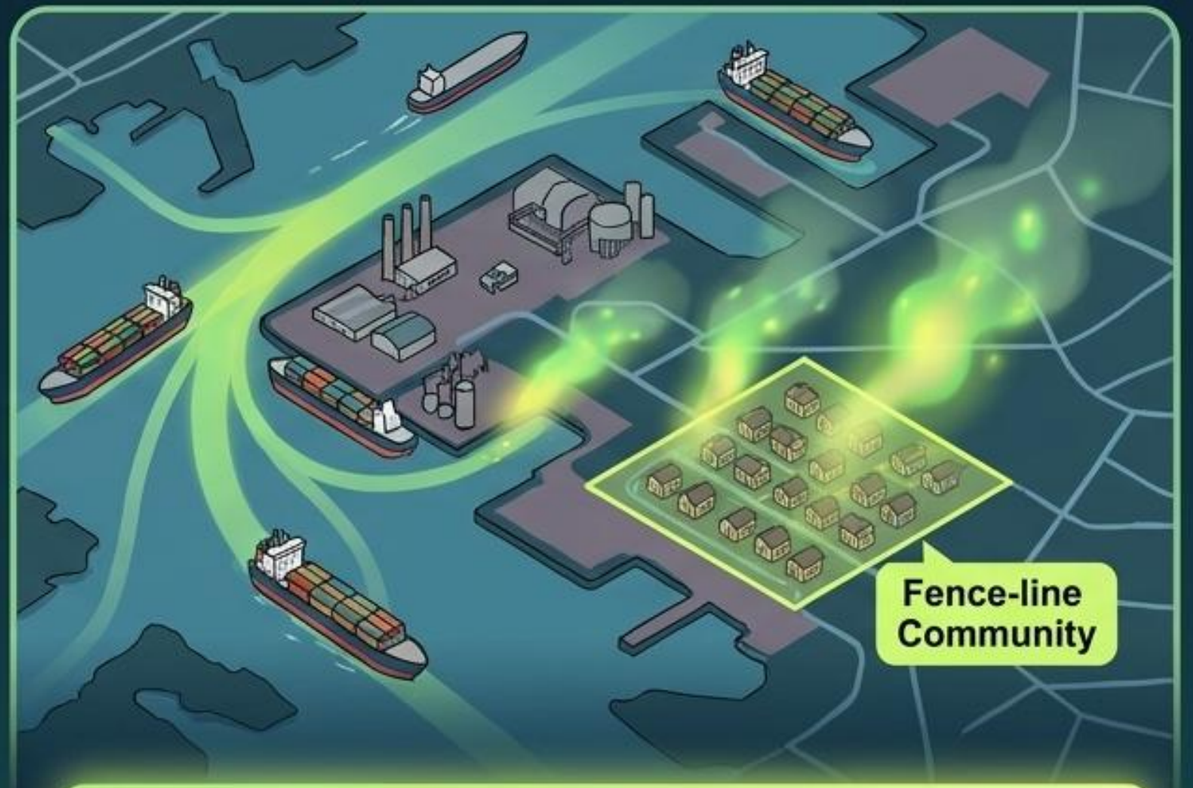
Large Commercial Vessels are Floating Industrial Facilities and Cities



Commercial shipping releases a highly complex, toxic mixture of pollutants simultaneously into the atmosphere and the ocean.

Environmental Justice: Disproportionate Impact of Ship Air Pollution on Port Communities

Marginalized communities near ports face significantly higher exposure to these pollutants, leading to elevated rates of asthma, respiratory illness, and cancer.



Fence-line Communities Bear the Brunt

Higher asthma rates and health risks are concentrated in these neighborhoods, often predominantly low-income and people of color, not distributed equally.

PM2.5 Knows No Boundaries: The Inland Reach and Environmental Injustice

The Reach

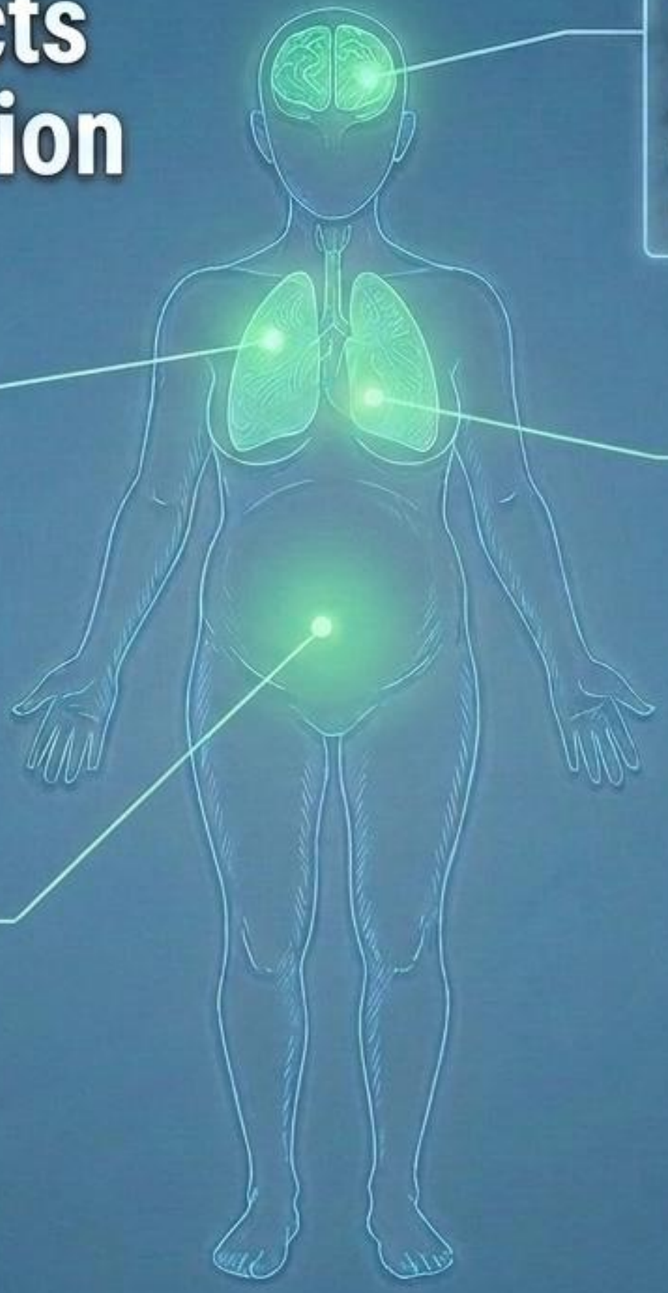
700% of ship emissions occur within 250 miles of the shore, but toxic PM2.5 is routinely carried up to 560 miles inland, affecting millions of Virginians.

Environmental Justice

Port-adjacent communities bear a highly disproportionate burden. In some coastal states, ships account for up to 80% of local NO_2 concentrations, directly driving EPA non-attainment.

IT IS NOT ONLY PORT COMMUNITIES AFFECTED

Public Health Impacts from Ship Air Pollution



Brain

Accelerates cognitive decline and increases the risk of Alzheimer's and all-cause dementia (up to 92% increased risk).

Lungs

Drives severe respiratory diseases, COPD, lung cancer, and millions of childhood asthma cases globally.

Heart

SO_2, NO_2, and $PM_{2.5}$ trigger cardiovascular disease and stroke. Globally, shipping emissions are projected to cause over 265,000 premature deaths annually.

Womb

Fine particles infiltrate biological systems from the earliest stages of life, detected in placental tissue and linked to preterm birth, low birth weight, and increased risk of stillbirth.

The Dual Threat to Climate and Coastlines

CO_2

Massive CO_2 absorption from ship exhaust rapidly lowers ocean pH

The Albedo Effect

Black Carbon settling on global ice accelerates melting, driving the sea-level rise.

Ocean Acidification

fundamentally threatening the ability of oysters, clams, and other calcifying marine life to form their shells.

Acid Rain

mix with atmospheric moisture to form acid rain, devastating coastal soils and waterways.

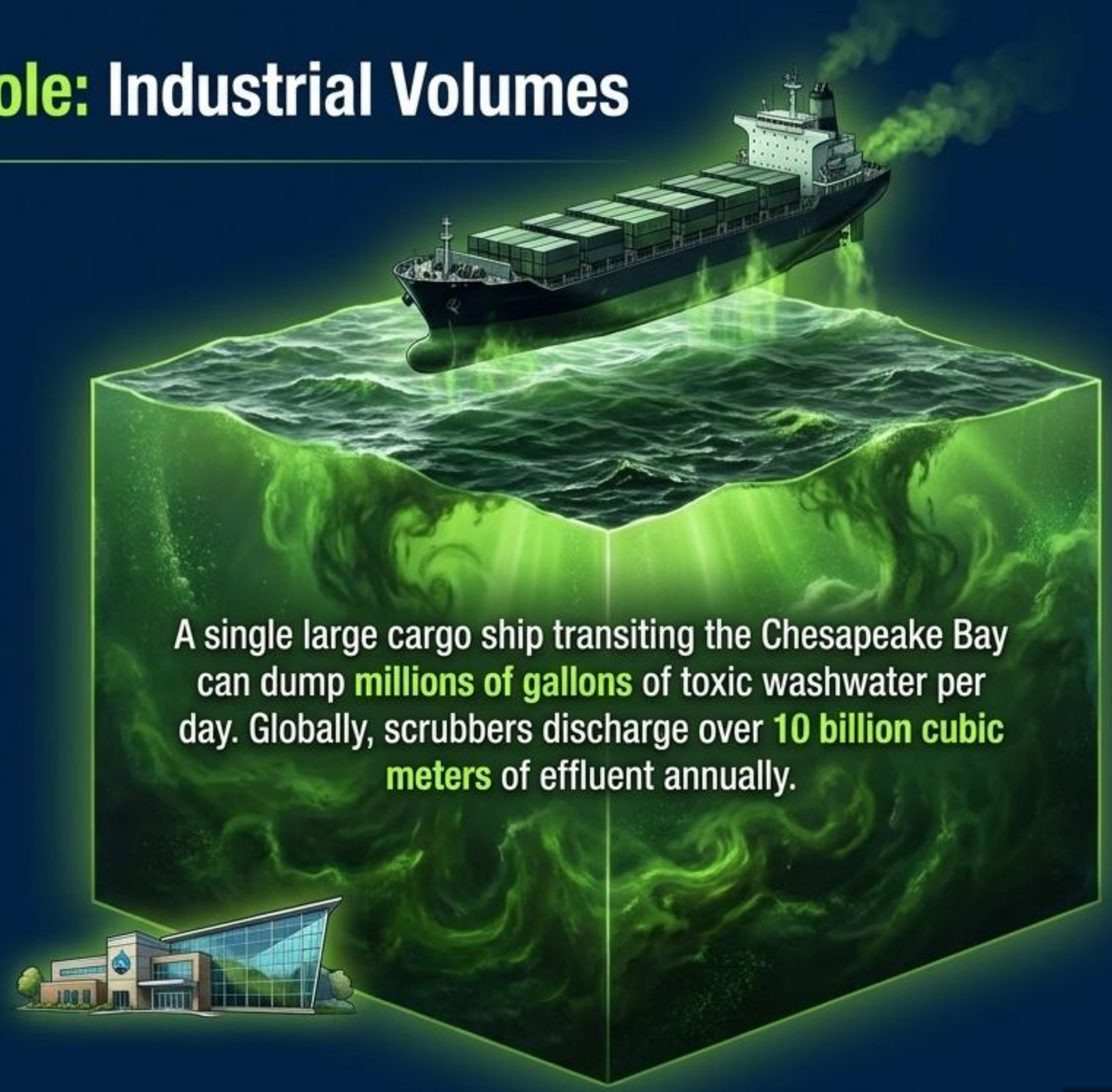
The Scale of the Loophole: Industrial Volumes

The Fleet Data

The Fleet: Over 5,000 commercial ships are now equipped with scrubbers.

The Dominance: 86% are “Open-Loop” systems—meaning they discharge continuous, untreated waste directly into the sea.

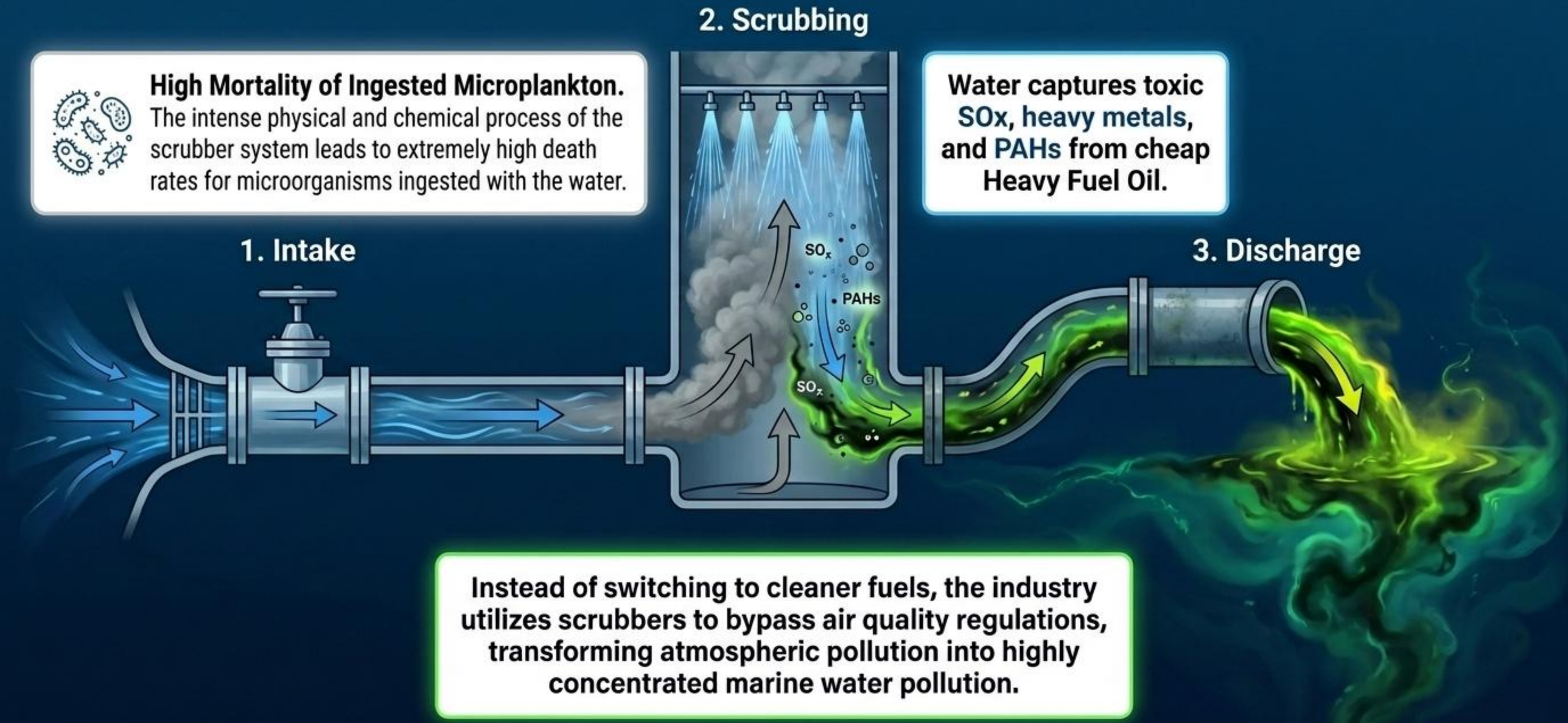
The Volume: An open-loop scrubber generates roughly 90 cubic meters of washwater per Megawatt-hour.



A single large cargo ship transiting the Chesapeake Bay can dump **millions of gallons** of toxic washwater per day. Globally, scrubbers discharge over **10 billion cubic meters** of effluent annually.

The Scrubber "Loophole": Washing Air Pollution into the Ocean

High Mortality of Ingested Microplankton.
The intense physical and chemical process of the scrubber system leads to extremely high death rates for microorganisms ingested with the water.



Water captures toxic SOx, heavy metals, and PAHs from cheap Heavy Fuel Oil.

Instead of switching to cleaner fuels, the industry utilizes scrubbers to bypass air quality regulations, transforming atmospheric pollution into highly concentrated marine water pollution.

The Witch's Cauldron: Washwater Chemistry

Extreme Acidity
(Ocean Acidification)

The Data: Discharge pH sits violently low at 3.0 to 4.0 (up to 100,000 times more acidic than surrounding seawater).

The Source: SO_x reacting with water to form sulfuric acid.

Heavy Metals
(Persistent Toxins)

The Data: Massive spikes in Vanadium (V), Nickel (Ni), Lead (Pb), Copper (Cu), and Zinc (Zn).

The Source: Heavy Fuel Oil combustion, system corrosion, and anti-fouling paint.

PAHs
(Carcinogens)

The Data: 71 measured Polycyclic Aromatic Hydrocarbons, far exceeding the EPA's priority 16.

The Source: Unburnt petrogenic fuel residues from incomplete engine combustion.

PROJECT: COMMERCIAL VESSEL EMISSIONS ANALYSIS
DRAWING NO: ENV-3084-002
SCALE: N.T.S.

Effects of Acidity

Hampton Roads and the Chesapeake Bay rely heavily on the economic and ecological output of Eastern Oysters and Blue Crabs.

The Mechanism of Harm:

- **Shell Dissolution:** The extreme acidity (pH 3-4) of scrubber washwater rapidly dissolves calcium carbonate.
- **Larval Failure:** Early life stages (spat and larvae) cannot expend the energy required to harden their shells in an acidified, metal-heavy environment.
- **The Outcome:** Stunted growth, developmental abnormalities, and high mortality rates in Virginia's most vital fisheries.

Systemic Biological Breakdown

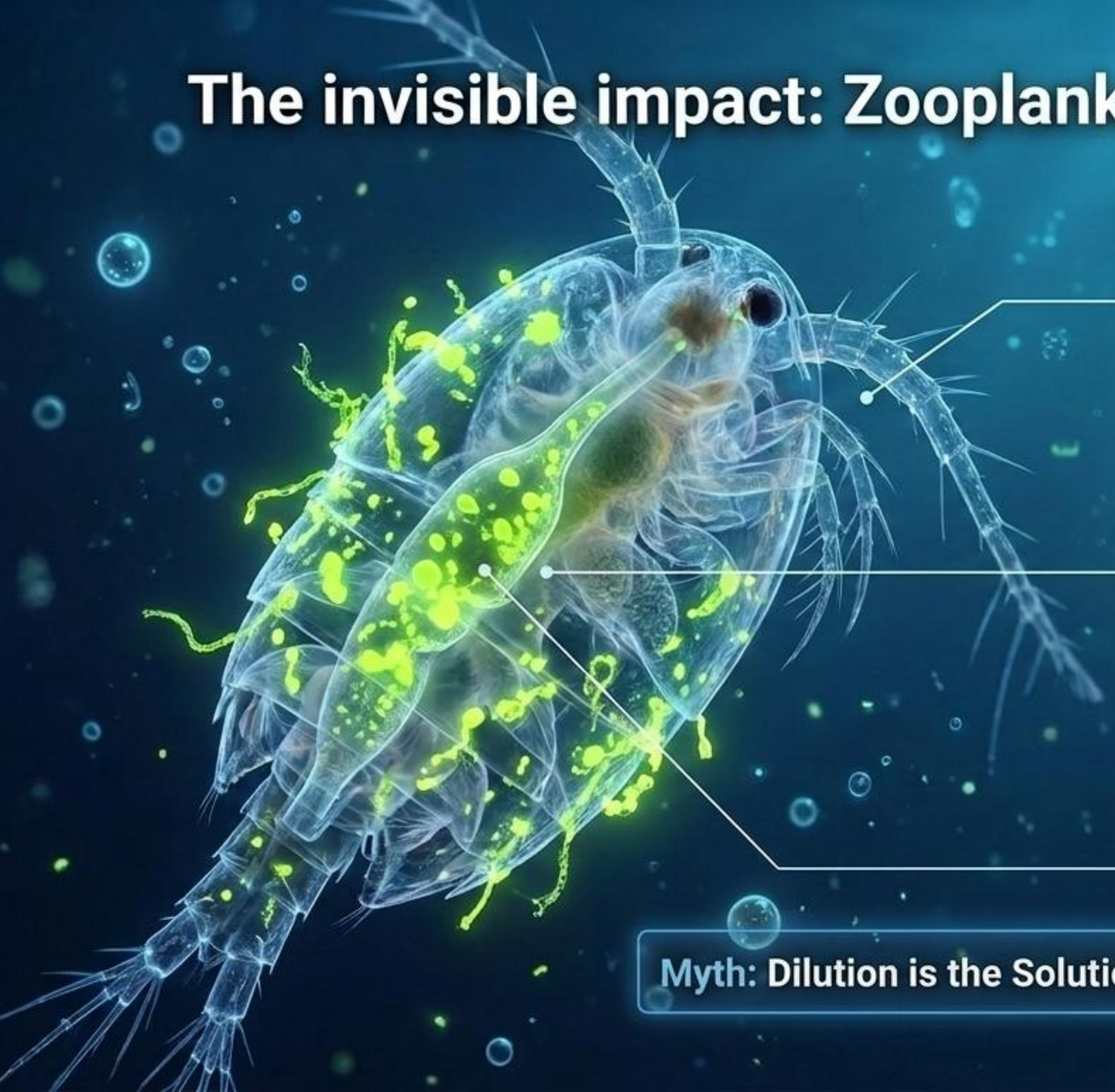
Tissue damage and severe respiratory distress caused by direct exposure to heavy metals.

Overload, toxicity, and lesion formation from attempting to process concentrated PAHs.

Endocrine disruption leading to reduced egg viability and population collapse.

Neurological impairment resulting in erratic swimming behavior and critically slowed predator-avoidance responses.

The invisible impact: Zooplankton bioaccumulation



The Foundation:
Zooplankton are the foundational base of the marine food web.

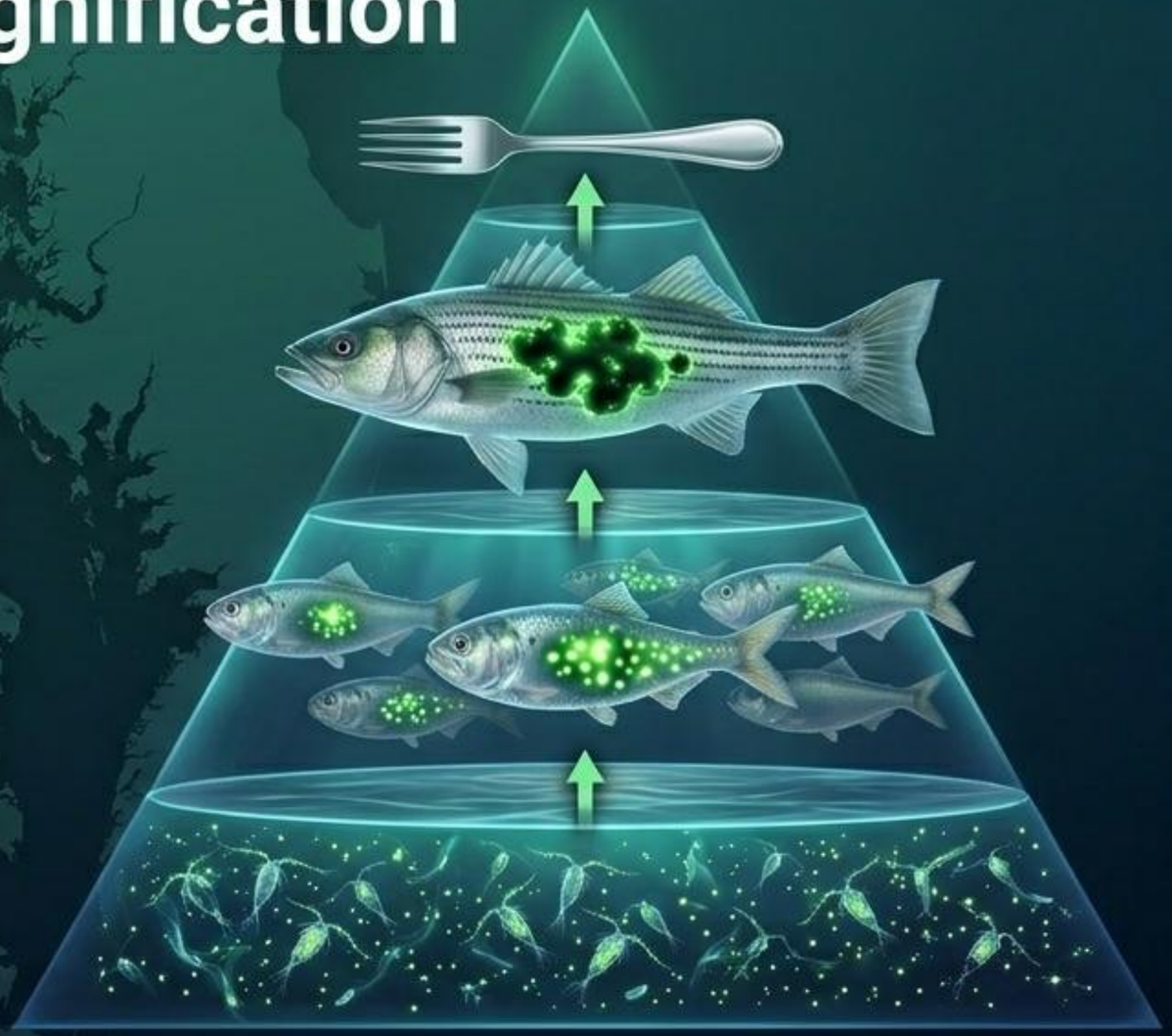
The Sponge Effect:
Due to their small size and feeding mechanisms, they rapidly bioaccumulate toxic washwater contaminants directly from the water column and ingestion.

Lethal Outcomes:
Exposure to scrubber washwater severely reduces survival rates and feeding capabilities in vital species like *Acartia tonsa*.

Myth: Dilution is the Solution

Up the Food Web: Biomagnification

- **The Multiplier Effect:** As organisms are consumed by larger predators, toxins transfer and concentrate.
- **The Virginia Chain:** Contaminated Zooplankton -> Eaten by Menhaden -> Eaten by Striped Bass and Blue Crabs.
- **The Human Risk:** PAHs and heavy metals magnify at each ascending tier, eventually threatening human health via the consumption of contaminated local seafood, risking DNA damage, endocrine disruption, and developmental abnormalities.



Myth: Dilution is the Solution

PROJECT: COMMERCIAL VESSEL EMISSIONS ANALYSIS
DRAWING NO: ENV-3034-003
SCALE: N.T.S.

A Global Regulatory Shift: Worldwide Scrubber Bans and Restrictions

Global Momentum

45 Countries and have implemented 93 measures to regulate commercial ship pollution to protect marine ecosystems and public health.

The US Vulnerability

Only California and Connecticut have stopped scrubber discharge through regulation. The US lags the rest of the world.

The Virginia Imperative

Without stopping the influx of toxins in the air Virginian's beath and the waters supporting the seafood economy, public health and our ecosystem are at risk.

The Solution: Low Sulfur Fuels

Conclusion: We do not have to choose between clean air and clean water. Mandating low sulfur fuels (like marine gas oil) eliminates the need for scrubbers entirely. It is fair to ask foreign shipping providers to use clean fuel to limit the cost impacts to Virginia.

	Heavy Fuel Oil + Scrubber (The Loophole)	Low-Sulfur Fuels (The Solution)
Air Quality	✓ Reduces SOx	✓ Reduces SOx, Black Carbon, and Particulates
Water Quality	✗ Dumps millions of gallons of acidic toxins	✓ Zero scrubber discharge
Heavy Metals/PAHs	✗ High environmental release	✓ Eliminated at the source
Fairness to VA	✗ Virginians pay the health/economic cost	✓ Shippers pay for clean fuel

The Evidence:
Built on Global Scientific Consensus

Emissions Data & Global Scale

International Council on Clean Transportation (ICCT) reporting on global scrubber washwater discharges, fleet mapping, and true emissions costs of heavy fuel oils.

Epidemiology & Human Health

World Health Organization (WHO) and Global Burden of Disease epidemiological studies mapping $PM_{2.5}$, NO_2, and SO_2 to cardiovascular mortality, asthma, and cognitive decline.

Economic Impact & Local Stakes

Virginia Institute of Marine Science (VIMS) and Virginia Tech economic contribution reports detailing the billion-dollar output and jobs dependent on the Virginia Seafood Industry.

Marine Biology & Toxicology

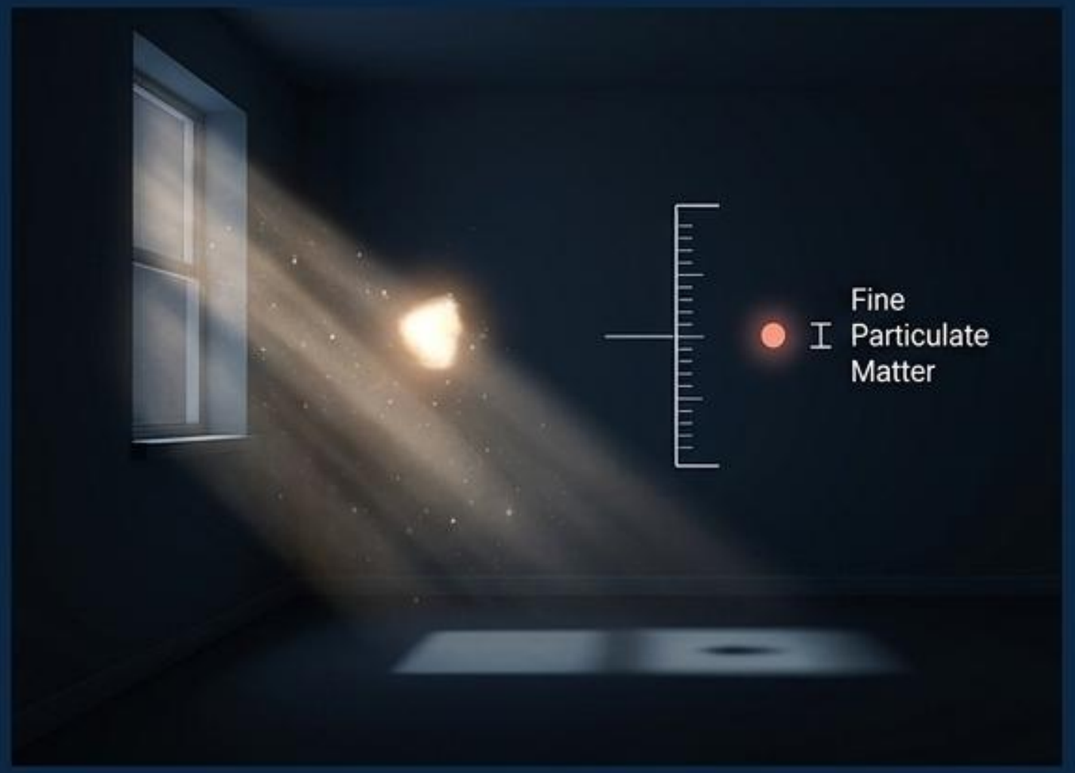
Peer-reviewed literature quantifying heavy metal toxicity, co-toxicity multipliers, APOE ε4 interactions with $PM_{2.5}$, and scrubber effluent impacts on marine trophic cascades.


Get involved helping to pass Commonwealth legislation for clean shipping!
info@protect-virginia.org
Protect Virginia's Waters. Require Low-Sulfur Fuels.
We can sustain a thriving port economy and a healthy, profitable Chesapeake Bay—but only if we stop treating our coastal waters as an industrial dumping ground. The solution is simple. The time is now.
Scan to learn more to protect our marine ecosystems, public health, and our maritime heritage.
StopShipPollutionVA.org
Protect Virginia

This presentation was produced by Protect Virginia using NotebookLM™ and over 70 publicly available sources, including peer reviewed research, government reports, journalistic articles, and select web resources.

Backup

The Invisible Air Threat & Human Health



Scale: Fine particulates are smaller than a dust mote dancing in the air in a sunbeam.

Bypasses lung defenses and enters the bloodstream

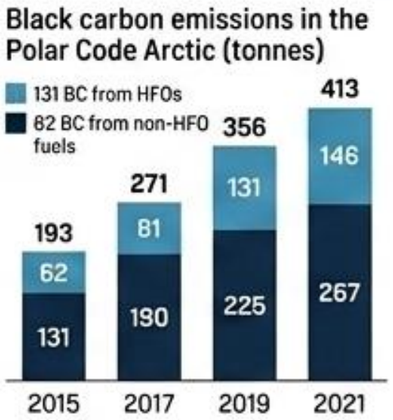
Impacts on the unborn, increased risk of Alzheimer's, and severe respiratory diseases

Environmental Justice: Disproportionate impacts on fence-line communities and port regions (e.g., Hampton Roads, Newport News) where toxic air emissions are concentrated.

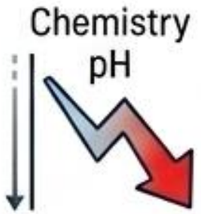
The Climate Threat: Atmospheric Warming and Ocean Acidification

Black Carbon & CO_2

Black carbon settles on ice, destroying the albedo (reflectivity) effect, absorbing heat, and driving rapid regional and global climate change.



Ocean Acidification



The ocean absorbs a significant amount of atmospheric CO2. This dissolves in the water to form carbonic acid, lowering the pH and causing **ocean acidification**, which threatens marine ecosystems.

KEY SHIP WATER POLLUTION SOURCE MATERIAL

1) **Brown, K., Ptáček, S., & Gamble, J. (2025).** *Poison in the water: The call to ban scrubber discharge*. Pacific Environment.
2) **Clean Shipping International (2025).** *STUDY DISPROVES SCRUBBER WASHWATER ENVIRONMENTAL CONCERNS*.
3) **Comer, B. (2020).** *Scrubbers on ships: Time to close the open loop(hole)*. International Council on Clean Transportation (ICCT).
4) **Folbert, M. E. F., Corbin, C., & Löhr, A. J. (2022).** Sources and Leakages of Microplastics in Cruise Ship Wastewater. *Frontiers in Marine Science*, 9:900047.
5) **Lunde Hermansson, A., Hassellöv, I.-M., Grönholm, T., Jalkanen, J.-P., Fridell, E., Parsmo, R., Hassellöv, J., & Ytreberg, E. (2024).** Strong economic incentives of ship scrubbers promoting pollution. *Nature Sustainability*, 7(6), 812–822.
6) **Magnusson, K., & Granberg, M. (2022).** *Evaluation, control and Mitigation of the EnviRonmental impacts of shippinG Emissions (EMERGE): D2.3. Report on scrubber water whole effluent toxicity testing, at different geographical regions*. IVL Swedish Environmental Research Institute.
7) **Marin-Enriquez, O., Krutwa, A., Behrends, B., Fenske, M., Spira, D., Reifferscheid, G., Lukas, M., Achten, C., & Holz, I. (2023/2024).** *Environmental Impacts of Discharge Water from Exhaust Gas Cleaning Systems on Ships: Final report of the project ImpEx*. Umweltbundesamt (UBA), Report No. FB001089/ENG.
8) **Osipova, L., Georgeff, E., & Comer, B. (2021).** *Global scrubber washwater discharges under IMO's 2020 fuel sulfur limit*. International Council on Clean Transportation (ICCT).
9) **Osipova, L., Georgeff, E., & Comer, B. (2023).** *Global update on scrubber bans and restrictions*. International Council on Clean Transportation (ICCT).
10) **Saraji-Bozorgzad, M. R., Bendl, J., Jeong, S., Padoan, S., Mudan, A., Etzien, U., Giocastro, B., Schade, J., Kaefer, U., Streibel, T., Buchholz, B., Zimmermann, R., & Adam, T. (2025).** Influence of low and high sulphur marine engine fuels and wet scrubbing on heavy metal emissions from ships. *Science of the Total Environment*, 999, 180254.
11) **Thor, P., Granberg, M. E., Winnes, H., & Magnusson, K. (2021).** Severe Toxic Effects on Pelagic Copepods from Maritime Exhaust Gas Scrubber Effluents. *Environmental Science & Technology*, 55, 5826–5835.

The Systemic Loophole:
Flags of Convenience

Regulatory Shell Game

The Practice

Shipping companies exploit "Flags of Convenience," registering vessels in countries with lax environmental and labor oversight to bypass strict international regulations.

The Offenders

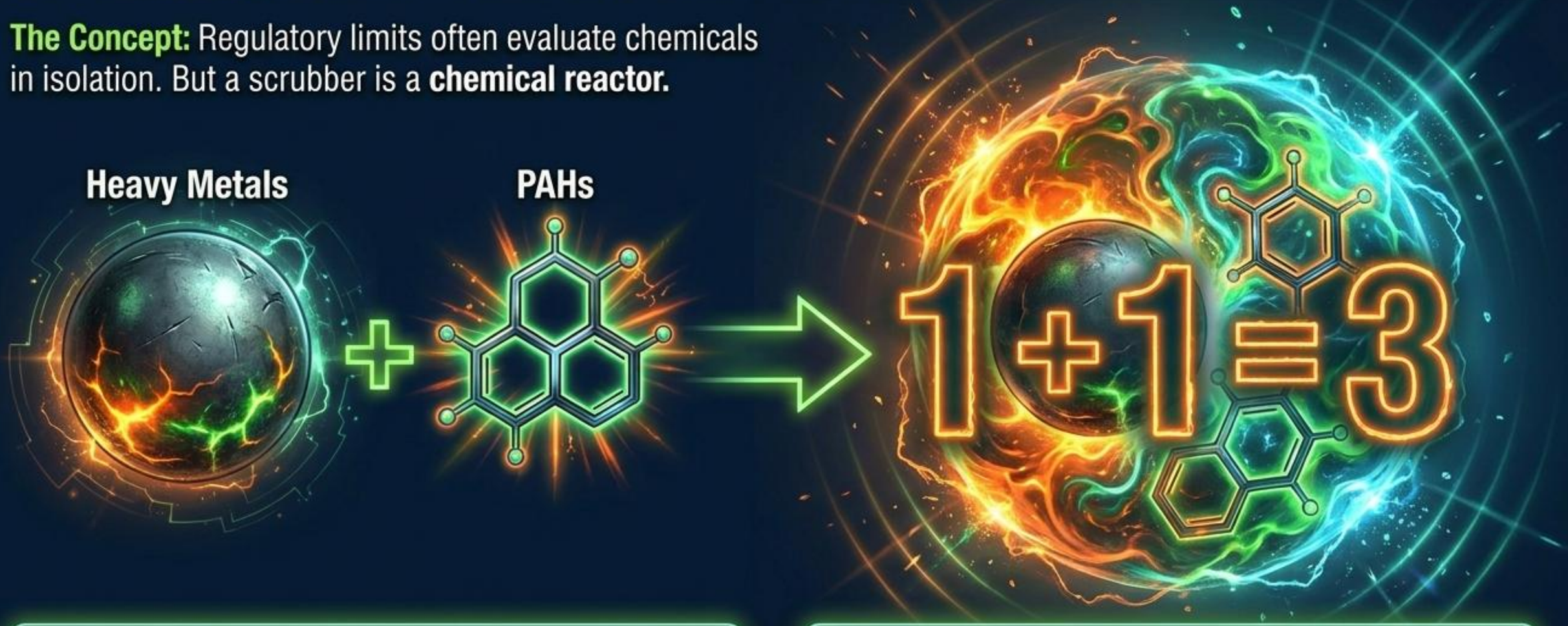
Ships flying the flags of just three nations—Panama, the Marshall Islands, and Liberia—account for 40% of all global scrubber washwater discharges.

The Irony

In a stark admission of the danger, Panama has banned open-loop scrubber discharges in its own Panama Canal, yet continues to register vessels that dump millions of tons of toxic washwater into the waters of other nations.

Co-Toxicity: More Than the Sum of Its Parts

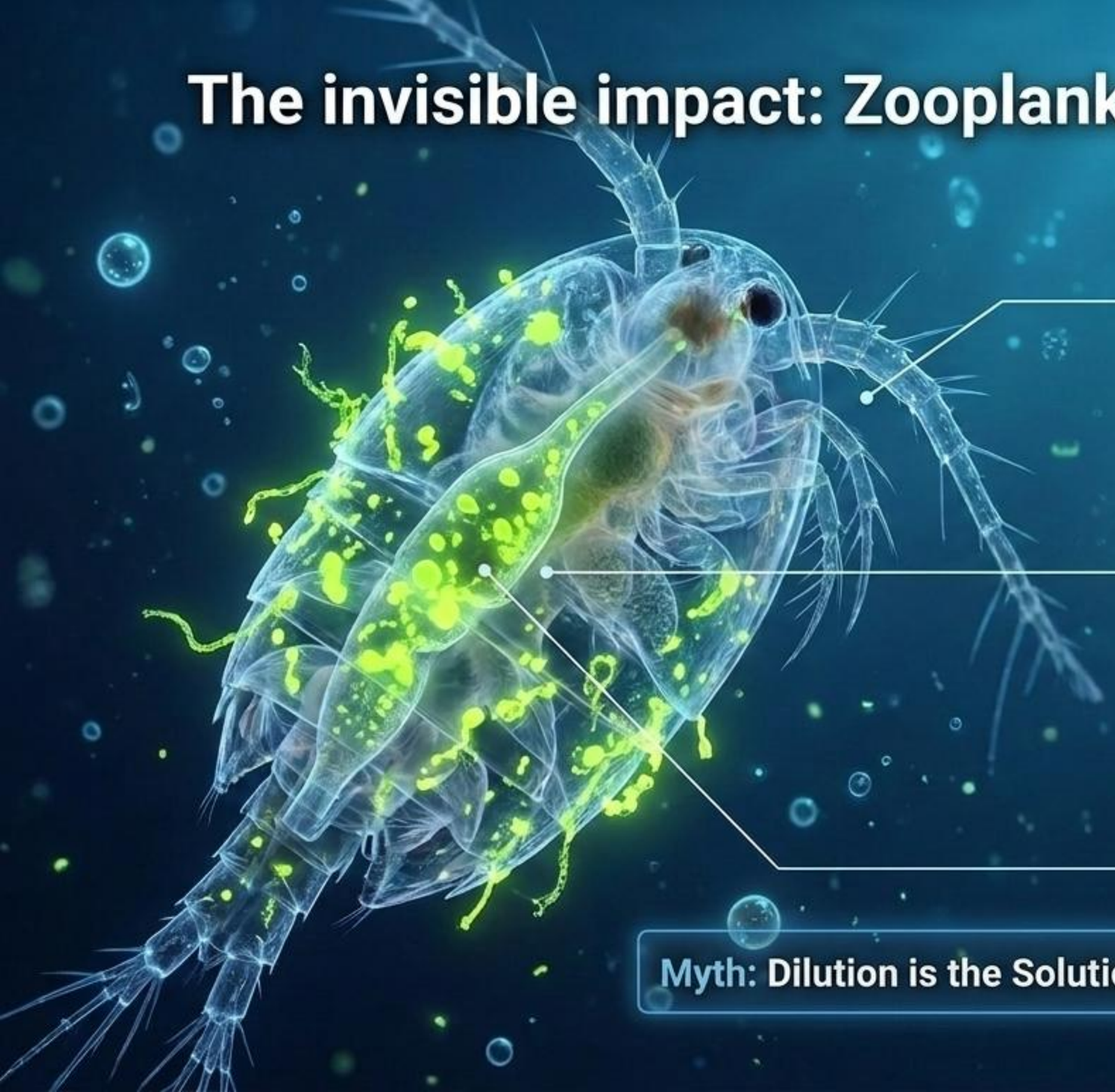
The Concept: Regulatory limits often evaluate chemicals in isolation. But a scrubber is a **chemical reactor.**



The Reality: When heavy metals and PAHs mix in the high-temperature, low-pH environment of a scrubber, they they create “more-than-additive” toxic effects.

The Result: Yeast Dioxin Screening (YDS) confirms these mixtures trigger severe dioxin-like effects, rendering the discharge exponentially more hazardous to aquatic life than its individual components suggest.

The invisible impact: Zooplankton bioaccumulation



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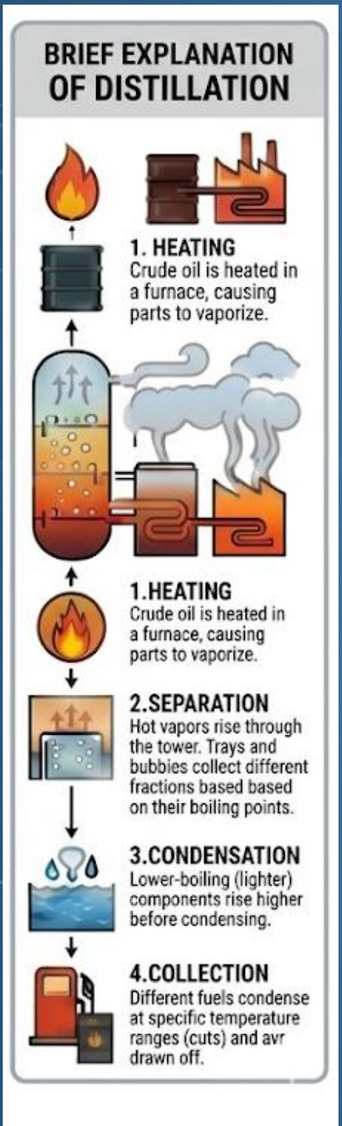
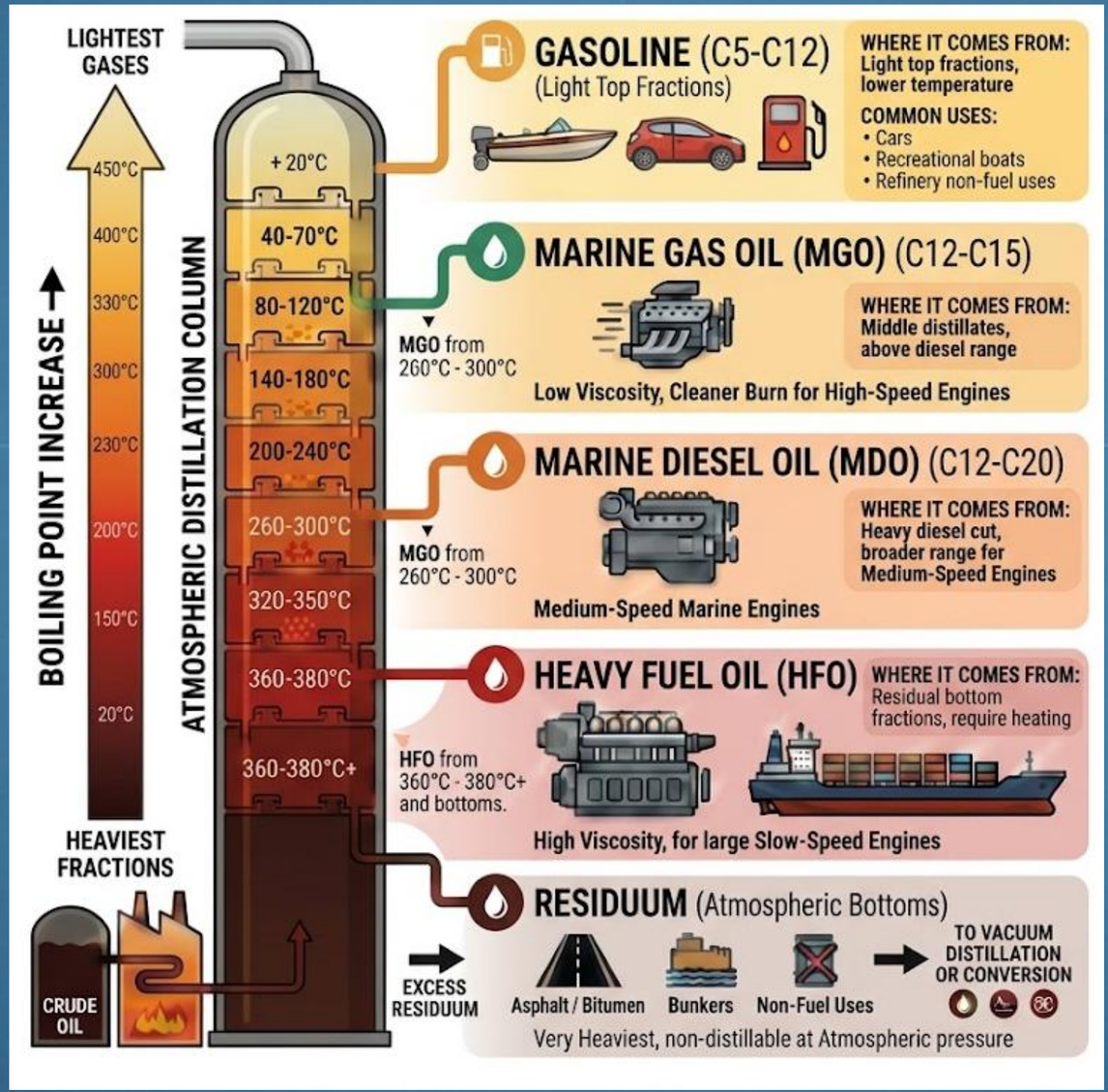
Fuel Distillation





CLEANEST

A responsible standard for commercial shipping

DIRTY SHIPPNG FUEL

Fine Particulate Matter (PM2.5) in Hampton Roads, Virgina

Video

Source:
https://climatetrace.org/air-pollution/ghs-fua_7050