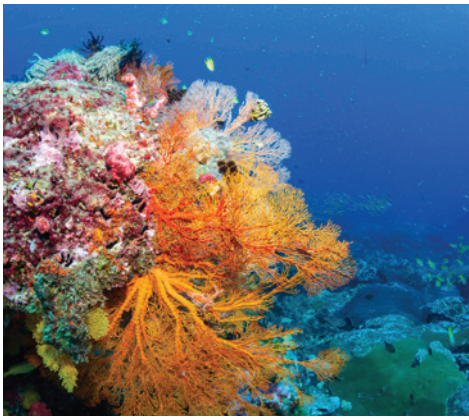
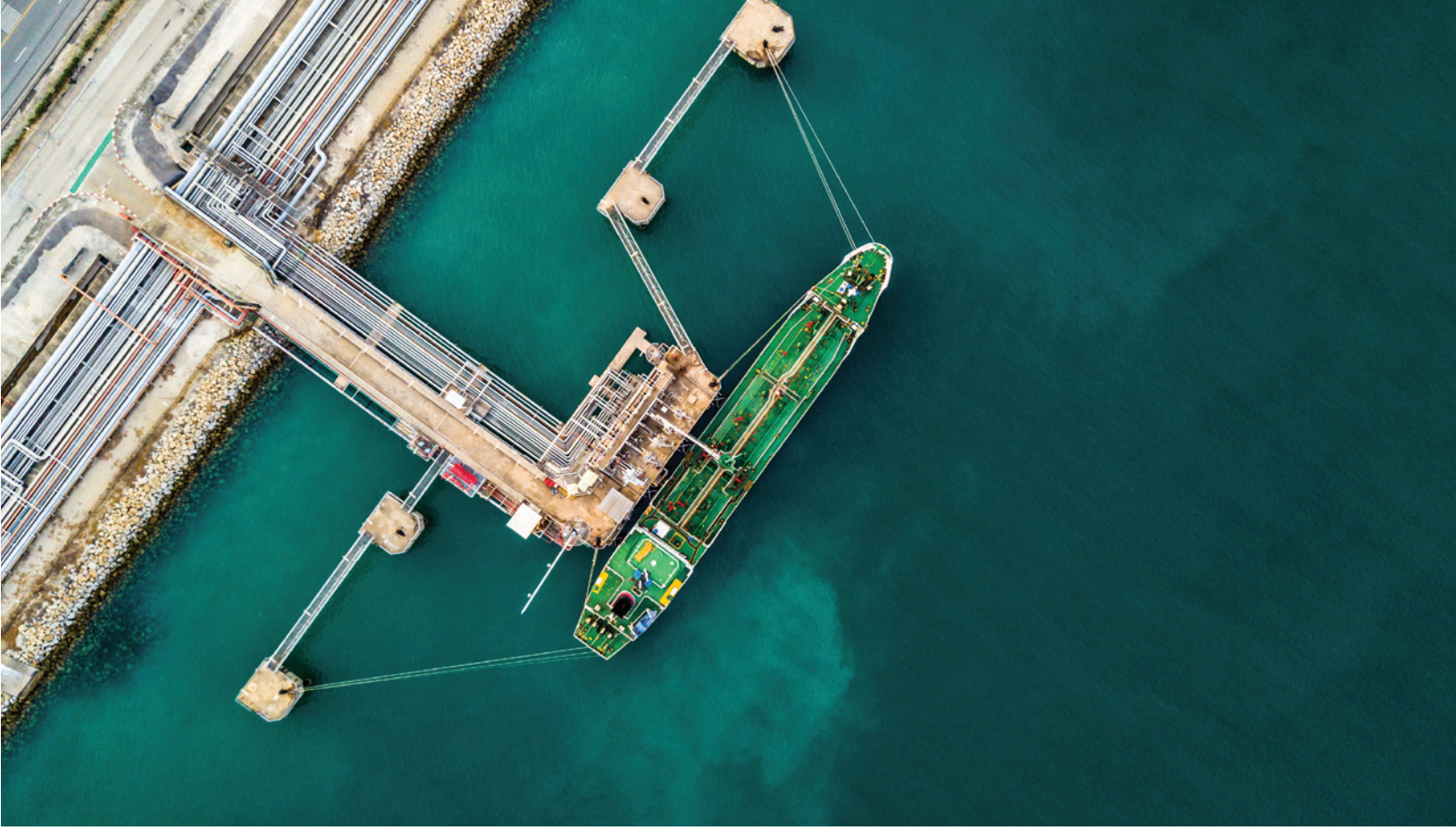
Ammonia at sea:

Studying the potential impact of ammonia as a shipping fuel on marine ecosystems





As the shipping industry faces increased pressure to decarbonize and considers ammonia generated from renewable energy as an alternative to fossil fuels, a report by Environmental Defense Fund (EDF), Ricardo PLC, and Lloyd's Register examined the potential environmental impacts of ammonia spills on marine ecosystems during its use as a shipping fuel.

Our Methodology:

This study's aim is to understand the impacts of large ammonia fuel spill from container, bulker and tanker ships on marine habitats. We used modeling due to lack of real-world data, and our scenarios focused specifically on spills that occur during bunkering and collisions.

The outputs were tested across eight habitats (rivers, estuaries, wetlands, coastal waters, coral reefs, mangroves, polar regions and the deep sea) using seven ecological receptors (bacteria, plankton, macrophytes, invertebrates, fish, birds, reptiles, and marine mammals). Potential impacts of elevated ammonia concentrations were derived from case studies in available literature.

This modelling was also conducted for marine gas oil spills, under the same parameters, for a bunkering spill comparison.

KEY FINDING #1

Negative environmental impacts of ammonia as a shipping fuel are possible.

A negative impact of ammonia as a shipping fuel on aquatic environments and associated ecological receptors could be possible if a spill were to occur during bunkering or in the case of a ship's collision and sinking, without mitigation measures and solid spill management practices.

Why ammonia?

Depending upon its safety, ammonia produced with renewable energy could be a cleaner option for a future shipping fuel, replacing oil-based fuels.

Maritime shipping emits approximately **1,056 million tons of carbon dioxide (CO_2) per year**

That's **nearly 3%** of **global greenhouse gas emissions**

If it were a country, the shipping industry would be one of the **top ten climate polluters in the world.**

To align with the 1.5 degrees Celsius temperature goal of the Paris Agreement, the shipping industry has to start reducing its emissions during this decade and fully decarbonize by 2050. There's an increasing pressure on the industry and the International Maritime Organization (IMO) to do so.

Why do we need to study ammonia's environmental impacts?

The maritime industry has prior experience with ammonia transported in gas carriers and used as refrigerant.

However, the introduction of ammonia as a shipping fuel creates new challenges related to safe fuel bunkering, storage, supply and consumption for different ship types, as ammonia is toxic if released into the environment.

> **The shipping industry must make a rapid energy transition to address the climate emergency. But it is also clear that we must proceed with caution. We owe it to future generations to ensure we are championing true climate solutions that don't damage our rivers, our oceans or our health. Like cutting off your nose to spite your face, we can't sacrifice our oceans for the sake of our climate.**
>
> **Marie Hubatova**
> Director of Global Shipping,
> Environmental Defense Fund

KEY FINDING #2

Certain habitats and species may be more vulnerable to ammonia spills than others.

Estuaries, mangroves and wetlands are particularly sensitive to ammonia, while the polar regions and the deep sea are less so. Within these habitats, it is typically fish which are the most sensitive to an ammonia spill, with birds and mammals to a lesser degree.

Table A - High level summary of potential impacts of an ammonia spill on aquatic habitats.

AQUATIC HABITATS	KEY IMPACTS OF AMMONIA
Rivers Estuaries Wetlands	Increase in algal growth and biochemical oxygen demand could lead to eutrophication. Toxicit to fauna could have implications on food chain dynamics.
Coastal Waters Coral Reefs	Increase in algal growth and biochemical oxygen demand could lead to eutrophication and smothering of intertidal habitats. Toxicity to fauna could have implications on food chain dynamics.
Polar Regions	Changes in phytoplankton and ammonia oxidising organism population abundance. Toxicity to fauna could have implications on food chain dynamics.
Mangroves	Potential beneficial effects on mangrove growth and ecosystem health as nutrient limited systems. However, could result in stunted growth, increased sensitivity to drought and hypersalinity. Toxicity to fauna could have implications on food chain dynamics.
Deep Sea	Unknown impacts.

Table B - High level summary of potential impacts of an ammonia spill on ecological receptors.

ECOLOGICAL RECEPTORS	KEY IMPACTS OF AMMONIA
Bacteria Plankton Macrophytes	Elevated growth until tolerance threshold exceeded, causing a reduction in reproductive success via slower cell growth and mortality at toxic levels.
Invertebrates	Reduction in growth and reproductive rate and mortality at toxic levels.
Reptiles Fish Birds Marine mammals	Physiological damage and mortality at toxic levels, impacts on habitat quality and prey availability.

KEY FINDING #3

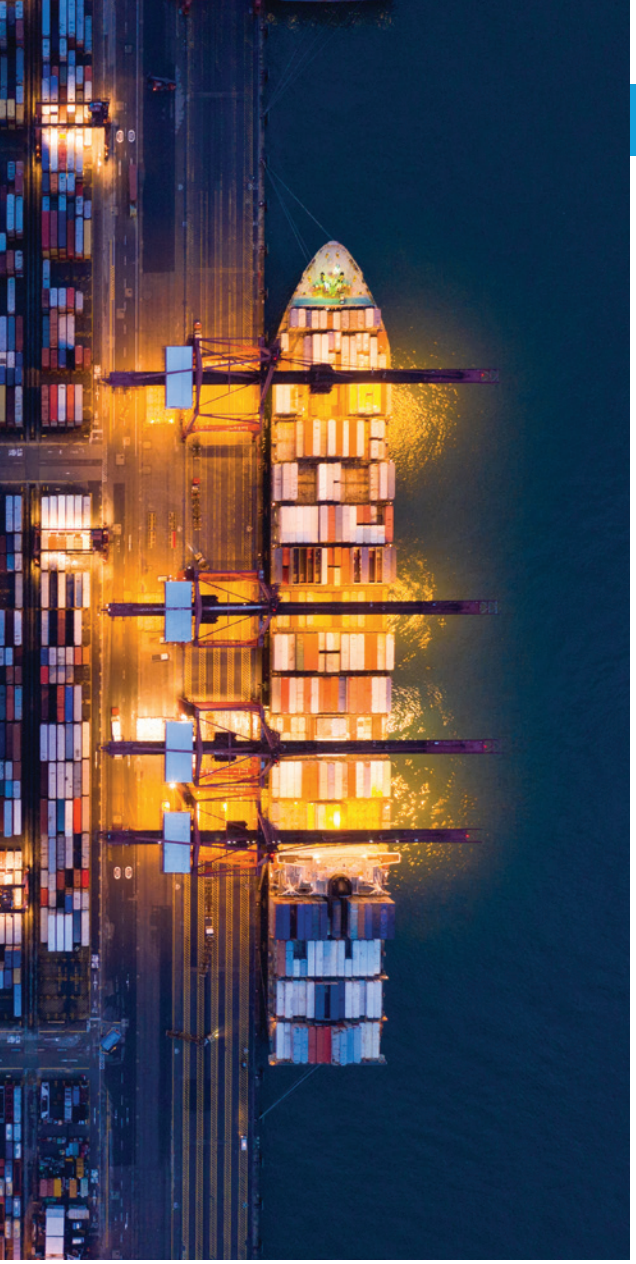
When compared to conventional oil spills, ammonia spills are less likely to disperse as widely, and do not persist as long in the environment.

Reports of the environmental impacts of oil-based fuels show that conventional fuels have high impacts on invertebrates and birds, compared to ammonia having a high impact on fish. Ammonia has a medium impact on all other ecological receptors, except bacteria, whereas oil-based fuels have medium impacts on plankton, fish, macrophytes, reptiles and marine mammals.

ENVIRONMENTAL IMPACT LEVEL

Low–Med–High

OIL SPILL IMPACTS	RECEPTOR	AMMONIA IMPACTS
● ○ ○	Bacteria	● ○ ○
● ● ○	Plankton	● ● ○
● ● ○	Macrophytes	● ● ○
● ● ●	Invertebrates	● ● ○
● ● ○	Reptiles	● ● ○
● ● ○	Fish	● ● ●
● ● ●	Birds	● ● ○
● ● ○	Marine Mammals	● ● ○



KEY FINDING #4

The likelihood and impact of an ammonia spill depends on various variables including ship type, hole size, temperature or even time of the day.

The most likely and most damaging ammonia spill scenario would be a spill from a 200mm hole in containership's bunker line when bunkering at night, in low wind and stable conditions. Although a scenario looking at a larger hole in a container ship's fuel storage tank caused by a collision showed worse and more damaging impacts overall, it also showed to be extremely unlikely and so could only be considered an outlier event. In any case, ammonia spilled at night would remain on the water surface for a longer time compared to a spill during the day due to lower temperatures and less solar radiation.

KEY FINDING #5

This is a first look at ammonia's potential impacts as a fuel. Further research is needed.

We recommend further studies to evaluate the full range of ecological and health implications of ammonia, including:

The health impacts of ammonia (especially to a ship's crew)

The increased nitrogen deposition from chronic ammonia leakage and combustion by-products to determine its safety

The potential impacts of ammonia spills in the deep sea

The potential impacts of ammonia spills on birds, marine mammals and aquatic reptiles

Conclusion/ Recommendations

To set the shipping industry on a clear path to decarbonize, it will be critical to ensure that any future fuels provide the greatest possible climate benefits—while also ensuring they do not harm our communities, oceans, rivers or other waterways. Environmental Defense Fund urges the shipping industry and policymakers to support efforts to:

- Improve our understanding of the future fuels and wider environmental consequences of their use.
- Implement a robust policy framework providing clear guidance and rules on how to use these fuels in a way that is safe for human health and the environment.

For more information about ammonia as a maritime fuel or the maritime shipping industry's pathway to decarbonization:

PLEASE VISIT
https://www.edfeurope.org/shipping

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