



Back to Blue

An initiative of
Economist Impact and The Nippon Foundation

THE INVISIBLE WAVE

Getting to zero chemical
pollution in the ocean

EXECUTIVE SUMMARY

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An initiative of
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Back To Blue marries Economist Impact's global audience and its reputation for objective, independent analysis with The Nippon Foundation's global reputation for supporting ocean science, data and evidence. This unique initiative aims to have a measurable impact on ocean health.

The Nippon Foundation has played a key role in transforming our scientific knowledge of the ocean, in addressing sustainability and plastics pollution, and in engaging young people and educational institutes in building awareness of the ocean and the need for better management and protection. Economist Impact through the World Ocean Summit & Initiative has succeeded in bringing the ocean to a wider global audience and stakeholders, encouraging the public and private sectors and civil society to collaborate, and helping catalyse the transition to sustainable practices and governance among businesses and governments.

Foreword

At the UN Ocean Conference in Lisbon, co-hosted by the governments of Kenya and Portugal, there will no doubt be much discussion on the upcoming negotiation of a global treaty on plastic pollution. That plastic is at the top of the UN ocean agenda is extraordinarily good news, and a testament to the global community of policymakers, activists, businesses and scientists who together have worked tirelessly for the past decade and more to raise awareness about the issue, and catalyse coordinated action.

Solving plastic pollution is critical for a healthy ocean. But plastic is not alone as a marine pollutant. *The Invisible Wave*, published in March 2022, sets out the case for chemical pollution in the ocean to be treated with the same gravity—and the same urgency—as plastic pollution. In many ways, they are two sides of the same coin.

The objective of *The Invisible Wave* is to raise the status of chemical pollution as a priority for ocean health. We see this report as only the beginning of the conversation. Our (unashamedly ambitious) aim is to have a transformational impact on knowledge and awareness of marine chemical pollution. In so doing, we hope to catalyse—and contribute to shaping—a coordinated global response to marine chemical pollution.

At Back to Blue, we conducted more than one hundred interviews with industry leaders, investors, scientists, activists and policy experts over the course of 2021.

The scientists we spoke with, all of whom generously shared their time and expertise, told us broadly the same story: chemical pollution in the ocean is an urgent and underappreciated crisis that if left unaddressed will lead to considerable—and possibly irreversible—damage to the marine environment. Patchy data makes it difficult to quantify the risk, but there is enough information to conclude that we need to act—now.

In contrast, the business leaders, investors and policymakers we interviewed, many of whom also generously shared their time and expertise, told a broadly different story. Few mentioned chemical pollution as a priority. None cited marine chemical pollution as a priority. The gulf between what the science is telling us must happen to reduce and prevent marine chemical pollution, and what is actually happening is worryingly wide.

The Invisible Wave is not intended simply as a critique of industry, investors or policymakers, although there is no shortage of critical analysis. Many of those we spoke with in business, finance and policy said that they haven't considered marine chemical pollution because they are otherwise absorbed by decarbonisation and circularity: this has some resonance, even if it can also be a smokescreen. Instead, we hope to spark a discussion across governments, industry and civil society about how to begin grappling with this important issue and the actions we need to take to achieve ocean health.

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Charles Goddard
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Yohei Sasakawa
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Praise for The Invisible Wave

Scientists have understood the impacts of chemical pollution on the marine environment for decades, but global action to address it has not kept up with the science. Recent research indicates that we are hitting “planetary boundaries” for chemical pollution. As the case is for climate change, if we don’t act quickly, we may leave an irreversibly damaged marine environment for future generations. *The Invisible Wave* makes a compelling science-based case for global action to prevent chemical pollution by fundamentally reshaping the chemical industry and the downstream sectors that rely on it. More research to understand these threats is needed. However, rather than simply paint a picture of doom, the report asks the fundamental question, “What if the world wakes up to the threat of marine chemical pollution?” and outlines a set of solutions for industry, investors, governments, and civil society, providing hope that with the right leadership, incentives, and investments we can tackle this global challenge the way we are beginning to address other global environmental crises.

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Chemical pollution in our ocean is a daunting challenge to humanity. It is a symbol of our crisis in the Anthropocene, where human might has started to disturb the stability of the earth systems of which our oceans are an integral part. With *The Invisible Wave*, The Nippon Foundation and Economist Impact have a real opportunity to make an important difference to this serious matter.

Naoko Ishii
Executive Vice President and Professor at the
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Director at the Center for Global Commons
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The risks to marine ecosystems and thus to people from marine chemical pollution are significant and cumulative. This important research helps not only to raise awareness of the issues and decipher their complexity but also encourages industry and the finance sectors to start identifying pathways as to how to begin to develop and implement solutions.

The chemical sector not only faces challenges in physically transition before critical tipping points are reached, but they are also exposed to regulatory risk and the implications of new sustainable taxonomies and other financial assessment tools that can raise funding hurdles and disrupt business models.

The information contained in *The Invisible Wave* will, for instance, have direct consequences on asset allocation decisions by investors applying "ocean ESG" criteria. I would encourage everyone, whether asset owner, industry executive or finance provider and regulator, to fully absorb the stark conclusion that chemical pollution is a first-order global threat, alongside climate change and biodiversity loss, and often compounding the impacts of these other issues, and needs to be proactively addressed.

Torsten Thiele
Founder
Global Ocean Trust

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Marine Chemical Pollution: A call for action

The overall aim of this report—written by Economist Impact for Back to Blue, an initiative of Economist Impact and The Nippon Foundation—is to bring the issue of marine chemical pollution to a wider audience. And with that, bringing it to policymakers, governments, the chemicals industry itself, the broader business community, the finance sector, civil society and consumers.

Chemical pollution—of land, air, rivers, watersheds—has been a festering issue for decades, occasionally prompting resolute action. But only recently has the scale of chemical pollution become more apparent. Chemicals in the form of nutrients, heavy metals, persistent organic pollutants, sewage and many others are being uncovered almost everywhere—in soils, aquifers, food chains, remote ecosystems such as the Antarctic, in the highest and lowest places on Earth, and in humans. As evidence accumulates of its impact on nature and human health, there is a gathering consensus that chemical pollution is a first-order global threat, alongside climate change and biodiversity loss, and often compounding the impacts of these other issues.

This awakening to the systemic nature of chemical pollution understandably focuses on where humans live, on land. This report seeks to raise awareness of marine chemical pollution,

as its scale and potential impact—and thus urgency—are not widely appreciated, and to focus minds on delivering solutions that prevent, reduce and minimise chemical pollution in the marine environment. An aspiration towards zero pollution is gaining currency. The hope is not so much that the ocean can be free of pollution, which may be impossible, but rather that more will be accomplished if the goal is seen to be ambitious. Back to Blue shares this aspiration.

The Back to Blue initiative grew out of the findings of our 2021 global survey, which showed that plastic and chemical pollution are the two greatest concerns that people have about ocean health, with climate change ranked third. As this report will show, the three are profoundly connected.

The ocean is fundamentally important to all life on Earth. It covers 70% of the planet's surface and comprises 99% of its habitable space.¹ It is therefore remarkable that there has not yet been a serious scientific assessment at scale of marine chemical pollution and its impact on life in the ocean, marine biodiversity and how ocean ecosystems function, and ultimately on the ocean's overall health. This report seeks to set out clearly what is known about its impact and where our knowledge gaps sit, prompting the urgent need for more research.

This urgency is underscored by a further point that this report seeks to demonstrate: that despite lacking a complete picture of the dangers posed by marine chemical pollution, failing to act now is a risk too far. The report therefore suggests solutions for various groups of stakeholders that, if taken, would ameliorate chemical pollution in the marine environment. It is a starting point: mapping out the paths to those solutions is the function and aim of a research and engagement programme that the Back to Blue initiative will undertake following the launch of the report.

Despite lacking a complete picture of the dangers posed by marine chemical pollution, failing to act now is a risk too far

The marine environment

This report concerns itself with the impact of chemicals on the marine environment. In other words, we are looking at the saltwater part of the hydrosphere: from the deep ocean to coastal seas, bays and estuaries, and including the array of ecosystems found there, including coral reefs, seagrass beds, mangroves, mudflats, sediments and water columns. The freshwater part of the hydrosphere—rivers, land run-off and groundwater—is a key transport mechanism for chemical pollution reaching the ocean and coastal areas, but otherwise is not a focus of this report.

The importance of the saltwater hydrosphere to life on Earth is greatly underestimated. Not only is the ocean a crucial food source for billions of people, but it also provides more than half the planet's atmospheric oxygen, acts as a massive carbon sink (without which global warming would be far worse), regulates the weather and climate, and provides countless formal and informal jobs in economically crucial activities that include fishing, shipping, tourism, recreation and offshore hydrocarbon exploration. The ocean provides services estimated to be worth trillions of dollars—services that are at risk from marine chemical pollution.

Despite the ocean's centrality to all life on Earth, humanity's view has been that the seas have an infinite capacity to absorb waste. That is wrong. While there is patently a need for more research on the harm that chemicals inflict on the marine environment, the existing evidence is clear: chemical pollution has damaged marine biota, from polar bears to plankton to large-scale ecosystems such as the seas and beyond. As the production and use of chemicals rises, so inevitably will their impact escalate too.

There are many reasons why this matters. Science has already shown that climate change is in large part due to human activities, and this anthropogenic cause is true too for marine chemical pollution. Importantly, the two are linked: science is learning that synthetic chemicals in the seas can increase climate change's negative effects, while the effects of climate change (including warming water temperatures, increased acidification due to higher carbon levels, and greater salinity) can heighten the negative effects that chemicals have in the marine environment. In other words, climate change and marine chemical pollution are deeply interlinked. Consequently, it is crucial to tackle both.

Failing to do so will lead to accelerated damage to marine life and biodiversity—"the variety of life ... and the natural patterns it forms"²—and would come even as the number of species on Earth is declining at perhaps its most rapid rate due to factors like climate change, pollution and activities like overfishing. And while biodiversity loss is common to the terrestrial environment and ocean, one key difference is that we know very little about countless marine creatures. Consequently, when it comes to the ocean, we often do not even know what we are losing.³

This damage to marine biodiversity, and the complex interactions that underpin it, has important knock-on effects on the functioning and resilience of ocean ecosystems. Exactly how such ecosystems are affected by complex and multiple stresses such as warming waters,

acidification, chemical pollution and the growing industrialisation of the seas, including overfishing, is still not well understood. The science is in its infancy. Yet rising levels of marine chemical pollution are an important factor in undermining, even potentially imperilling, the capacity of marine ecosystems to provide the services on which all of humanity relies, and that are crucial to the stability of wider systems, including climate and the carbon cycle.

Why marine chemical pollution?

Marine pollution as a broad topic has deservedly gained greater attention in recent years, with plastic taking centre stage. As many of our interviewees pointed out, this is because plastic pollution is highly visible and emotive: who can forget the video of a turtle with a plastic straw in its nostril, or media coverage of whales and seabirds found dead with plastic waste in their stomachs?

Plastic is a challenge of epic proportions and complexity, and is also important to the chemicals story. Marine chemical pollution, however, is of a different order:

- For a start, it is invisible and, in a world where awareness-raising is often most effective when it is visual, as the turtle video shows, this hinders understanding its scope and significance.
- Second, synthetic chemicals production is increasing rapidly and set to grow fastest in the coming years and decades, with many new chemicals being created and circulated. The green transition is an important driver of these trends.
- Third, production is shifting to middle- and lower-income countries where regulations to manage chemicals and combat chemical pollution are typically limited and less effective. At the same time, higher-income

countries that have addressed conventional chemical contaminants to some degree face new challenges with the relentless pace of chemicals' innovation and associated pollution risks.

- Fourth, scientists are open about the need for more research to better determine how marine chemical pollution will damage the ocean, which is not surprising given that there are tens of thousands of chemicals with, in most cases, completely unknown effects on human health and the environment.
- And fifth, while marine chemical pollution continues to be a threat in wealthier countries, much of the new and incremental damage taking place globally is in poorer countries where people and ecosystems are at a great remove from the markets ultimately driving the increased use of chemicals. This further decreases its visibility.

For these reasons and more, as we explore in detail in this report, marine chemical pollution is an under-appreciated and underestimated danger. It must not be.

Key chemicals and their sources

A recent study found that there are at least 350,000 synthetic chemicals and mixtures of chemicals, with thousands being added each year.⁴ Yet, worryingly, we know almost nothing about most of their health and environmental consequences. Additionally, even when chemicals are deemed so harmful that they must be replaced, their replacements are also often found to be toxic (known as regrettable substitution).

In recent years, hundreds of chemicals have been placed on lists for banning, restriction or substitution. Of particular concern are persistent organic pollutants (POPs), which, as the name indicates, linger in the environment, can travel long distances, and have serious effects on the environment and

biota. Although hundreds of chemicals have been recognised as POPs, some researchers believe thousands of other unrestricted chemicals meet the requirements to be classified that way.

The sheer volume of chemicals makes drafting a list of the worst of them a significant challenge, and inevitably this report does not provide a comprehensive list of all chemicals of concern. For that reason, our expert panelists have suggested a list of classes or groups of chemicals that they feel are the most severe or that could have the greatest impact in terms of:

- Environmental health, particularly the health of the ocean.
- Human health.
- Economics (quantifying this is a long-term goal of the Back to Blue initiative).

Given their effects, POPs are an obvious category for inclusion, and feature heavily in this report. The others include heavy metals, nutrients, pesticides, plastics, pharmaceuticals, radioactive materials, oil products, household chemicals and pseudo-persistent chemicals. While some of these chemicals are banned or restricted, most are not.

By default, these are the chemicals or chemical groups that we know most about. However, future research will surely identify others that constitute a greater threat or that inflict increased harm to marine ecosystems. It is entirely possible, then, that the potential impact of marine chemical pollution will prove to be wider and more serious than currently estimated.

That raises two important questions:

- What effects do these chemicals have in the marine environment?
- How do they enter the marine environment?

Answering the first with accuracy requires more research, particularly when it comes to determining how chemicals react individually and collectively in the real world. The answer to the second question begins by identifying the various parties involved in the chemicals value chain: the chemicals industry (which to date has externalised its costs), its clients (more than 95% of manufactured goods contain chemicals) and financiers. It also includes regulators and governments (with public sector sources of pollution including dredging and defence), end-of-life operators and civil society.

Consumers are also of note. Sources of marine chemical pollution here include pesticides, fertilisers and plastics, with pharmaceuticals and personal care products—sometimes referred to as chemicals of emerging concern—becoming increasingly important due in part to the growth in the number and size of coastal cities and towns in recent decades, and with the background rise in population numbers and incomes globally.

Our efforts to map accountability across the value chain of the chemicals' lifecycle also includes the pre-production phase: extracting and processing the fossil fuels, minerals and metals used to manufacture chemicals, with oil and gas majors like ExxonMobil, Shell and BP involved in both extraction and chemicals manufacturing. Given the projected growth of the chemicals industry and its role at the heart of marine chemical pollution, as well as often-lax industry oversight, accountability will become more important going forward.

The end-of-life phase of the chemicals value chain is another important source of marine chemical pollution, with municipal waste, e-waste and untreated sewage growing in importance. Plastics, for instance, are laced not only with chemicals from the manufacturing process, but they also break down into micro- and nano-sized particles that can adsorb chemicals in the water and transport them vast distances.

Overseeing, in theory at least, this vast value chain from extraction to disposal are regulators. The success of any strategy to combat marine chemical pollution hinges on regulators enacting and enforcing stricter rules on pollution, and working in concert with peers elsewhere to combat regulatory arbitrage, where firms move to jurisdictions with less oversight. Encouragingly, research by the European Commission shows that regulations bring numerous benefits, cutting the costs of marine chemical pollution on the environment and human health, and lowering water pollution levels.

The success of any strategy to combat marine chemical pollution hinges on regulators enacting and enforcing stricter rules

Regulations, properly enforced, also require that producers adhere to common standards, and should be employed to ensure that product designers factor in end-of-life aspects, particularly impacts on the marine environment.

The dangers of inaction

Most marine chemical pollution is caused by humans, and most of that has taken place in the past 100 years. Given that the pace of chemical production and innovation is predicted to rise rapidly in the coming years and decades, and that much of the production growth will happen in countries with less regulation, it is likely that marine chemical pollution will get significantly worse unless action is taken.

Assessing the scope, extent and impact of marine chemical pollution, now and in the future, is a pressing task for scientists and environmentalists, as is evaluating the cost of such pollution. Armed with a clearer picture, action is more likely to succeed. And while inaction remains a possible response, it is no longer necessarily the likely response. The past few years have seen a broad awakening to the problem of pollution. The UN

Environment Programme (UNEP) has elevated pollution (chemicals, plastics and waste) alongside climate change and biodiversity loss as one of three interconnected anthropogenic crises. Pollution is one of the key stresses that led the UN to state that ocean sustainability is “under severe threat”, and that addressing pollution was vital to achieve the UN Sustainable Development Goals (SDGs). Meanwhile, *New Scientist* rang the alarm in mid-2021 with the headline: “Why chemical pollution is turning into a third great planetary crisis”.⁵ The Stockholm Resilience Center has, for the past decade, included pollution as one of several planetary boundaries within which humans need to operate to ensure stable Earth systems.

The language of crisis and emergency is nothing if not a call to action. While more research (and funding) is needed to close some significant knowledge gaps, it makes no sense to refrain from acting until every gap is filled. After all, it will be decades before we understand the effects that the tens of thousands of synthetic chemicals might have on health and the environment, whether individually or collectively, and the world does not have that much time. Additionally, intervening is in line with the precautionary principle, which demands that we act now on the grounds that we know enough about the effects of marine chemical pollution to be concerned about its potential effects.

A large part of this burden to act must fall on the chemicals industry and on its clients in the broader business world. In part, this will require that the business community factor in its impact on marine chemical pollution in the way that it has started to do on climate change.

If the world does not act, it is reasonable to assume that the problem of marine chemical pollution will worsen. Rising production volumes is one reason, but there are others like weak regulation and enforcement, poor product design, the lack of domestic and industrial wastewater treatment in much of the world, and insufficient waste management.

Yet perhaps the biggest problem, our experts said, is assuming that we can keep dumping waste into the ocean because it is vast enough to absorb and dilute the array of toxic substances that we produce. As this report shows, we cannot.

A global problem that lacks local research

The transboundary nature of marine chemical pollution means it affects everyone, no matter how far they are from its production. Toxins have been found in islanders in the Pacific and the Faroes, as well as in people living in the Arctic Circle—and, notably, in women and children in poorer countries who rely on seafood.

Marine chemical pollution, in other words, is a global problem. That said, much of our understanding of its economic costs is derived from a few high-income countries, which means that research is lacking that would be most relevant to billions of people for whom the seas are crucial to lives and livelihoods. This needs to be remedied. Funding should be targeted at the chemicals with the greatest potential to harm ocean biota and, in turn, human health and local economies.

It is also clear that much more research is needed on chemicals and their impact—particularly in conjunction with other chemicals in the marine environment. This needs to factor in climate change variables like temperature, acidity and salinity, as each can affect how chemicals react.

One result of the research bias favouring wealthier nations is that the studies cited often examine marine chemical pollution in the rich world. While this is an unavoidable consequence, we have kept this imbalance in our minds and endeavoured where possible to incorporate research that covers poorer nations. Clearly, a key task for the future is tipping the scales back.

A final point on research is that what is known needs to be brought to the wider community.

As UNEP notes, this includes improving the flow of communication between researchers and policymakers. This could help to motivate change by quantifying the costs of inaction and the rewards of intervention. Our bespoke case study on marine chemical pollution in the US Gulf of Mexico, for instance, found that dead zones worsening—where the sea has been starved of oxygen owing to pollution—would cost the US about US\$838m a year in fisheries revenue. Taking measures to reduce dead zones, on the other hand, would boost marine biodiversity and therefore increase revenue by more than US\$117m.

Roadmaps for key stakeholders

While intervening makes sense on every level—including in terms of human health and wellbeing, and on the environment, economy and culture—it requires co-ordinated action from all stakeholders: government, industry, finance and civil society. It also requires a sense of urgency. This is a concern because previous crises like mercury, which saw the adoption of the Minamata Convention, require consensus-building, which can take decades.

International and national legislation

The extent of marine chemical pollution, and the fact that it is getting worse, shows that the existing (and complex) legal and regulatory landscape does not work as it needs to. An international treaty could serve to oversee action yet would require that countries overcome the risks of excessive caution, mis-framing and time lags that characterise co-ordinated global efforts.

Improving regulation would also require overcoming vested interests, increasing awareness of marine chemical pollution, and implementing monitoring and assessment programmes, with the resulting evidence driving further policy actions. Countries should also improve their treatment of wastewater and solid

waste (and enforce existing regulations, where those exist), with wealthier countries helping poorer nations to improve or build such systems.

This report would like to see a range of interventions, including: raising awareness of the causes and remedies for marine chemical pollution (particularly better communication between scientists and policymakers, and also to the public); using the precautionary principle to prevent further damage to the marine environment; improving the regulation of harmful chemicals (and enforcing rules globally); establishing a global science-policy body with a remit that covers chemicals and waste; creating a comprehensive chemicals database at the global and national levels; and mandating disclosure of all chemicals in products and their potential effects.

Industry

As the ultimate source of chemical pollution, the chemicals industry has the primary responsibility to act. It could hugely influence resolving the issue. However, if it fails to act, it could face an existential crisis for two reasons. First, this industry is dependent on fossil fuels to manufacture feedstocks, with the likely regulatory and financial pressures this carbon-heavy operational base will bring. Second, owing to the growing understanding of the impacts of chemical pollution on environmental and human health, there is increasing consumer and investor pressure on this issue, which could ultimately prove as critical as climate change.

Additional pressure on laggards in the sector will come as more innovative firms step up in areas like green chemistry, which could hold the key to sustainable change for the sector, even as clients come under pressure from customers to better manage the chemicals in their product portfolios, and as public awareness compels governments to enforce stricter regulations.

Surprisingly, though, industry efforts have been piecemeal at best, even though the momentum for a circular economy is growing—as with plastics. Accelerating change will require a shift at the corporate culture and systems levels.

Among the interventions this report would like to see are more innovative approaches from the chemicals industry, where it seeks to develop new and more sustainable products and processes, and in that way shift from a risk-based approach to one avoiding hazard. This will also create a commercial incentive to change, creating a “coalition of the willing” that would help to offset first-mover disadvantage. Increased transparency and collaboration across the supply chain will also be key.

Finance

Banks and other financial players like asset managers remain largely unaware of marine chemical pollution and its associated risks. This mirrors the situation in the mid-2000s on climate change and, as with climate change, our view is that the finance sector will one day be compelled to factor marine chemical pollution into its environmental, social and governance (ESG) considerations.

Better information can help the finance sector to see this picture more clearly and would help to clarify the risks and rewards of transitioning to a more sustainable future for chemicals. Equally, failing to transition to net zero will bring risks for the chemicals sector, and therefore finance, as seen in other sectors. These include litigation, reputational risk and changed downstream market conditions.

On the other hand, progressive players should reap rewards in a more ESG-focused world, with firms more likely to require access to funds to finance such transitions. To that end, eliminating marine chemical pollution needs to be an investable proposition, with room for novel

solutions like blue bonds and impact investing—and with opportunities for deep-pocketed investors like private equity to fund the necessary long-term, capital-intensive projects.

Improved ESG-related guidance, more and better published data on companies' impacts on marine chemical pollution and their exposure to transition risks, and improved sources of and access to transition financing solutions are other actions that should be implemented.

Civil society and consumers

The final group could be classed as motivators of change with a track record of putting pressure on policymakers, governments and companies on important issues. Popular awareness of the dangers of marine chemical pollution is low compared with other urgent environmental problems, and rectifying this would require emotive and visual storytelling that is grounded in science.

The next step would be to ensure that people can take achievable actions by exerting their power as voters and consumers. Solutions include better labelling, citizen science projects and efforts to promote behavioural change such as replacing or cutting down on using products with toxic chemical ingredients like sunscreens that kill coral.

For their part, civil society groups can co-ordinate action and focus it on the other key stakeholders, and can also convene these disparate groups in an effort to find solutions to marine chemical pollution.

Among the interventions this report would like to see are awareness-raising to make the invisible visible, developing campaigns that are grounded in science yet emotionally appealing, and offering individuals solutions that are realistic and achievable—in part by providing them with the tools and information needed to be proactive.

Conclusion

Although marine chemical pollution remains a largely invisible problem, this is starting to change. There is now enough evidence to show that the problem is extensive and worsening. Moreover, given the crucial role that the ocean plays in regulating climate and weather, generating oxygen, absorbing carbon, and providing food for billions of people, we also know that inflicting further harm risks too much.

Action, then, is vital. It requires that all stakeholders play their part. Although marine chemical pollution is a huge challenge to solve, it is not impossible. In mapping the sources of marine chemical pollution, the consequences (as we know them) and a series of paths that can resolve one of the defining issues of our times, this report and the Back to Blue initiative aim to raise awareness and galvanise action from all of those involved.

CHEMICAL POLLUTION AND THE OCEAN: PATHWAYS AND POLLUTANTS

Over 350,000 chemicals have been registered for production and use, and they play a fundamental role in many of the technologies and products of our everyday life, from smartphones to food preservation. Most marine chemical pollution, then, begins on land—about 80%, according to a commonly cited statistic, versus 20% that is thought to originate in the seas. Here, we illustrate some chemicals of key concern to ocean health.



HEAVY METALS



Mercury
Enters the environment through channels including artisanal gold mining, burning coal, and non-ferrous metal and cement production



Cadmium
A grade 1 human carcinogen used in products such as batteries, solar panels and plastics, with major effluent sources including marble, steel and metal-plating industries



Lead
Produced by industries including mining, oil and gas exploration, construction and dredging, and electronics. Lead accumulation is linked to heart disease, strokes and cancer



MANUFACTURED CHEMICALS



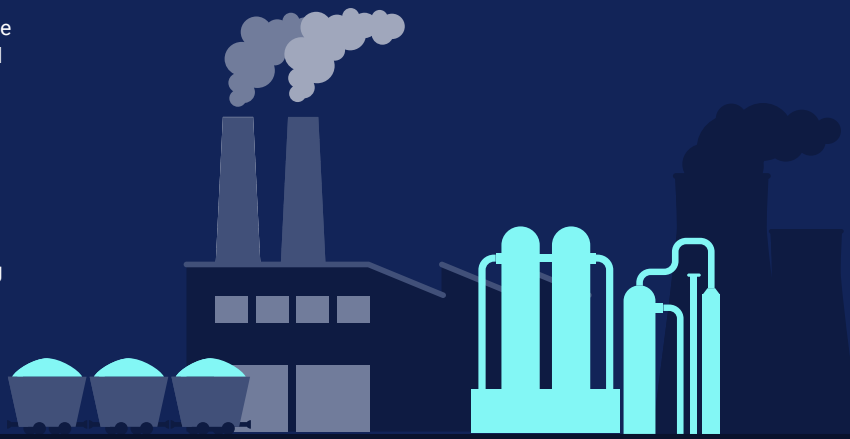
POPs
Carbon-based chemicals found in everyday products like furniture and electronics that can harm human health



Hydrocarbons
Oil includes around 10,000 components, some of which are linked to cancers, mutations and birth defects



Pesticides
More than 1,000 pesticides—insecticides, herbicides and fungicides—are used globally. They are causing coral die-offs and bleaching events and damaging aquatic vegetation



Principal findings and recommendations

Detailed summaries of principal findings and recommendations are included at the start of each chapter. What follows is a simplified and condensed summary of the research's most important findings.

- **Marine chemical pollution is a profound and growing global problem that requires urgent and co-ordinated action.**

Synthetic chemicals are present in the deepest parts of the ocean and in all manner of marine biota, and concentrations of many of the most dangerous chemicals in the marine environment continue to rise. Worryingly, a 2022 study concluded that the world has already crossed the planetary boundary where chemicals threaten the very ecosystems—including the marine environment, which provides services worth trillions of dollars every year—upon which humans and most other species depend. Ocean services range from economic benefits like fishing and tourism to Earth-critical functions like generating oxygen, storing carbon and regulating the climate.

- **Marine chemical pollution is a human-made problem that will get worse.**

Since humans are producing far more chemicals and in ever-greater volumes, and will continue doing so for decades, the impact on the marine environment will get more severe. Exacerbating factors include the so-called greening of economies (not least the push for deep-sea mining to meet resource needs); the expansion of production by the

chemicals industry, particularly in Asia and to countries with limited oversight; and growing populations—predominantly in poorer countries with a limited capacity to deal with chemical pollution. Among the urgent solutions suggested by the 2022 planetary boundaries study is to cap chemicals' emissions, as with greenhouse gases, to ensure they do not exceed the planet's ability to cope.

- **Marine chemical pollution is linked to tackling both climate change and plastic waste.**

The way chemicals interact with environmental factors like temperature, acidity and salinity—all of which are affected by climate change—and the way they react to other chemicals has a big influence on their effects in the marine environment. Modelling projections show climate change could cause chemical concentrations in marine environments to rise as much as three-fold, with that increase driven largely by higher water temperatures. At the same time, plastics constitute a central challenge to marine chemical pollution: not only do they contain numerous toxic chemicals, but they also absorb chemicals and transport them in the marine environment. Microplastics have known negative effects on marine life, including weight loss, lower growth and reduced fecundity, while nanoplastics have been shown to affect reproduction, and can be bioaccumulated and biomagnified in the marine food chain. Sunlight can chemically alter certain plastics as they break down, producing a range of thousands of new, water-soluble products that do not resemble the original material.

- **More research is needed, but this must not hamper taking steps to combat marine chemical pollution.**

There are tens of thousands of synthetic chemicals, yet in most cases we know nothing about their potential impact on the ocean environment—or on humans. Much more research is needed to determine the damage that many chemicals inflict on the marine environment, including how their interactions increase or lessen that harm. This will require far greater levels of funding, which should be targeted towards the chemicals of greatest concern in terms of their harm to ocean ecosystems and biota and, via those, to human health and local economies. Yet the fact that we cannot fully quantify the damage done by chemicals to the marine environment must not preclude action: we do know enough to be concerned about the *potential* impact. It is already clear that certain chemicals inflict significant harm. Additionally, a large number of chemicals still need to be assessed and managed. For these reasons and more, the need to act is urgent.

- **Regulators need to enact and enforce stricter rules on pollution; producers need to adhere to common standards.**

Central to marine chemical pollution is the fact that industry has been able to externalise its costs—passing these on to society, and often to the poorest and most vulnerable. Given that most future chemicals production growth will originate in Asia-Pacific, the Middle East and Africa, countries in these regions should take regulatory steps to protect their citizens and environments—underpinned by stronger global action as some countries in these regions lack sufficient national capacity. Industry players need to ensure their facilities in Asia and other regions operate

at a minimum to the standards required in their home countries. In addition, too few manufacturers take end-of-life factors into account when designing and making products. Given that more than 95% of manufactured products rely on chemicals to some degree, manufacturers must factor in end-of-life considerations.

- **The chemicals industry and companies along the chemicals value chain can have a massive impact on resolving marine chemical pollution.**

Actions by the chemicals sector, encompassing fossil fuel-based commodity chemicals, specialty chemicals, pharmaceuticals and agricultural chemicals, present perhaps the most compelling opportunity to address marine chemical pollution. Yet the industry is sprawling, diverse, intertwined in long and complex global supply chains, and dependent on capital-intensive infrastructure and processes that operate at low margins and demand huge scale. Change will be a complex, expensive and fraught process. Failure to change may lead to an existential crisis for chemicals companies.

- **Momentum is growing for a circular economy; innovation in green chemistry may be a route to reducing pollution.**

There are viable pathways for change. Growing segments of the industry have pledged to tackle plastic pollution. While some companies and industry groups still insist that recycling while producing ever-larger quantities is a solution, others have begun to acknowledge that a genuinely circular economy will require radical product redesign and may result in reduced sales. Green chemistry offers an opportunity to design high-performance products that are less toxic and less polluting.

- Investors are not sufficiently aware of the problem of marine chemical pollution: better information is needed.**

A lack of awareness among the finance community about the profoundly damaging effects of marine chemical pollution is a barrier to change: the current level of awareness mirrors the sector's understanding of climate change in the mid-2000s. While demand for sustainability-linked investments is strong, data about marine chemical pollution, the role that industry plays and the possible impact of regulation are patchy. Better information about the material risks that the chemical sector will face transitioning to a zero-pollution ocean will be an important first step for any finance sector-led solution—in tandem with an appreciation of the potential rewards for early movers.
- Quantifying the costs of inaction and the rewards of intervention may help motivate change.**

Although putting a dollar value on everything at risk is impossible, combating marine chemical pollution has been shown to bring sizeable economic benefits in areas it has been measured. In a case study in this paper on the costs of hypoxic “dead zones” in the Gulf of Mexico, The Economist Intelligence Unit found that should the issue worsen and contribute to a greatly reduced landing weight of fish catch, the US stands to lose nearly US\$838m in annual fisheries revenue. Conversely, if measures were taken to reduce the dead zone, contributing to increased marine biodiversity and fisheries landing weight, the best-case scenario (a 15% increase in landing weight) could see an increase in revenue of over US\$117m.
- Popular awareness of the danger of marine chemical pollution is low: consumers need better information.**

Community awareness about marine chemical pollution is low relative to other environmental issues such as plastic pollution or climate change. Knowledge-building is a critical first step. The most effective way to do this is by using emotive and visual storytelling. And while industry and government are the stakeholders that can have the most direct impact on marine chemical pollution, civil society groups have had some notable success in influencing decision-makers to act on marine chemical pollution. Ultimately, the most potent way for individuals to influence marine chemical pollution is through purchasing decisions. Unfortunately, consumers do not always have access to the necessary information to make these decisions. A key goal is to establish consumers' right-to-know about hazardous chemicals in the products they buy.
- Non-government organisations (NGOs) can act as focuses of citizen power and convenors of stakeholder groups with divergent interests.**

NGOs play a crucial role in focusing and co-ordinating popular action: there are some illustrative examples of multinational businesses and governments responding directly to NGO campaigns or community pressure to address marine pollution. NGOs can also act as convenors, bringing together disparate stakeholder groups that might not otherwise act in concert.

As this report makes clear, marine chemical pollution is a global and systemic problem for which we are all responsible. To that end, tackling marine chemical pollution requires the co-ordinated action of everyone in the chemicals value chain—from the chemicals industry itself through to the broader business community, governments, regulators, investors and financiers, as well as civil society and consumers. Failure to address marine chemical pollution in a systematic manner risks inflicting irreparable harm on the ocean, its biota and functions, risks exacerbating a threat that humanity simply cannot afford to ignore.

About the report

The Invisible Wave: Getting to zero chemical pollution in the ocean is a report from Back to Blue, an initiative of Economist Impact and The Nippon Foundation. The full report is available to download at the [Back to Blue website](#).

The report was written by Economist Impact. The overall aim of *The Invisible Wave* is to bring the issue of marine chemical pollution to a wider audience, one that includes policymakers, governments, the chemicals industry itself, the broader business community, the finance sector, civil society and consumers.

The authors of the report were Robert Carmichael and Jessica Brown. The lead editor was David Line, while editorial management was provided by Naka Kondo. The case study of the economic impact of dead zones was conducted by Pratima Singh, Shreya Mukarji, Divya Sharma Nag and Aayushi Idda Sharma. The initiative lead for Economist Impact is Charles Goddard.

In preparing for this report, and to inform the wider Back to Blue initiative, we have spoken with many people from businesses, financial institutions, governments, NGOs and scientific research institutes. We would like to thank them for their time and insights. A list of people who are either quoted in the report or joined our expert panel is included in the full version of this report.

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