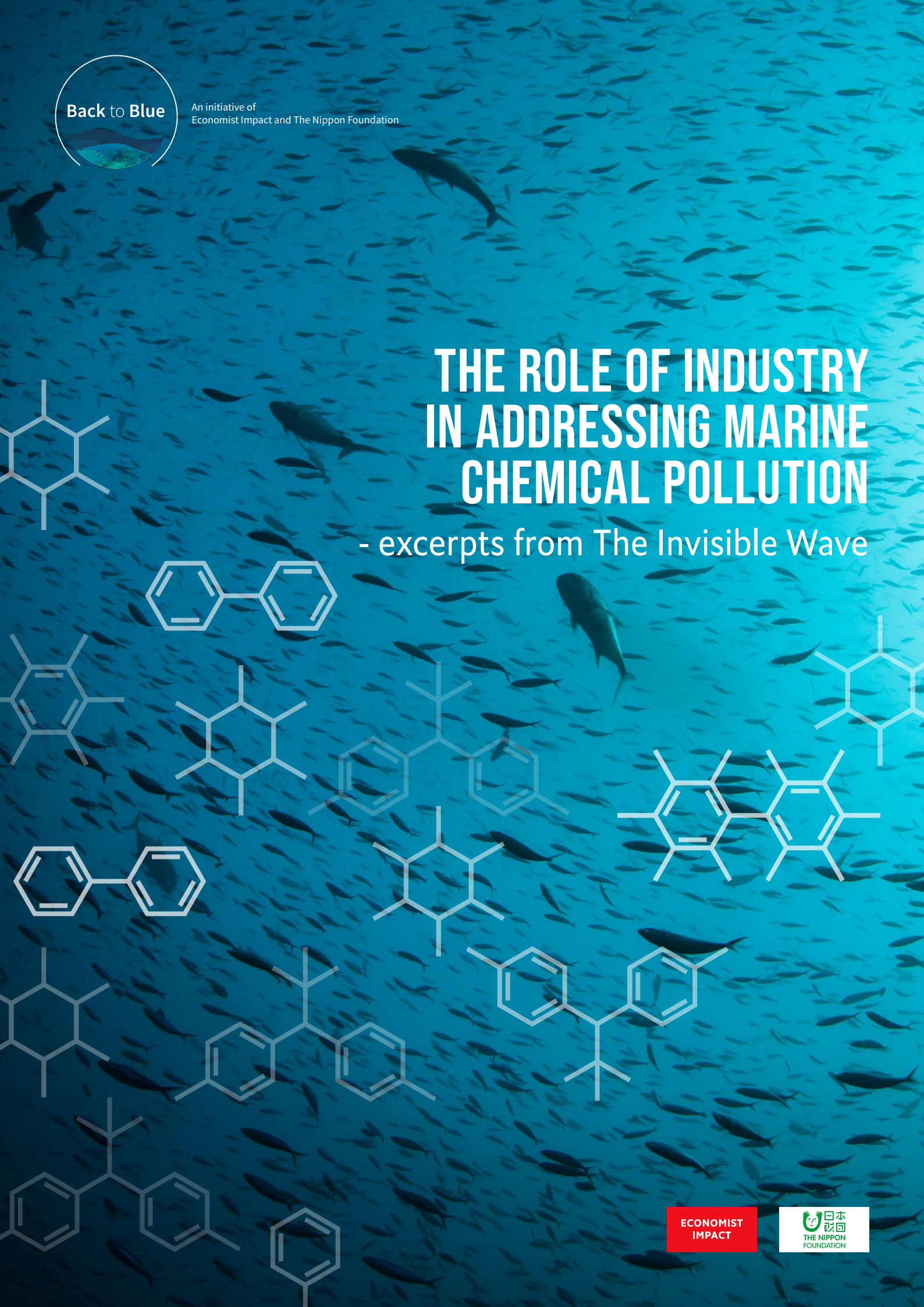
Back to Blue

An initiative of
Economist Impact and The Nippon Foundation

THE ROLE OF INDUSTRY IN ADDRESSING MARINE CHEMICAL POLLUTION

- excerpts from The Invisible Wave



ECONOMIST IMPACT

THE NIPPON FOUNDATION

About The Invisible Wave

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. The Invisible Wave 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.

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.

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.

The role of industry in addressing marine pollution: Principal findings and recommendations

- **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.**
  The chemicals sector is enormously dependent on fossil fuels, both as feedstock and to power its energy-intensive processes. If the industry does not begin to face up to looming climate-related regulatory and financial pressures, it will face an existential crisis. This necessary but painful transition can, and should, address the industry's impact on the marine environment as well as on climate.

- **Efforts to date have been piecemeal; real impact will require cultural and systems-level change.**
  Positive signs are beginning to emerge that parts of the industry take sustainability seriously, although there is little sign yet that activity by companies and sectoral consortiums has translated to widespread impact. There are numerous drivers of change. European chemicals giants, subject to relatively strict EU rules, are leading the way. Around the world, consumers and financiers are beginning to demand greater transparency about the industry's impact. Shareholders will need to recognise the long-term risk to the chemicals sector of not adopting greener business models, and be prepared to bear some of the shorter-term costs of transition. Importantly, efforts to transform must include smaller producers in the value chain—and organisations in regions like Asia and the Middle East, which will become increasingly important centres of chemicals production.

- **Momentum is growing for a circular economy; the bid to address plastic waste may help drive change.**
  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. That such momentum has developed in the industry around plastic waste in the past five years or so suggests that an industry-led approach to tackling *liquid* pollution in the ocean is also possible.

The most exciting path to change rests on a quality inherent to the modern chemicals industry: scientific innovation. Green chemistry offers an opportunity to design high-performance products that are less toxic and less polluting

- **Green chemistry innovation may hold the key to sustainable change.** The most exciting path to change rests on a quality inherent to the modern chemicals industry: scientific innovation. Green chemistry offers an opportunity to design high-performance products that are less toxic and less polluting. In many cases the technology already exists, and there is a vibrant green chemistry startup scene. The usual roadblocks are there: the transition is slow, costly and difficult. Currently fewer than 2 percent of patent applications for chemicals are green, although green chemistry's share of the market is growing fast. Acquisitions of green chemistry startups may offer a cost-effective way for incumbent chemicals companies to introduce new, more sustainable products at scale.

- **Change is required along the value chain.** It is not just the chemical industry itself that will have to transform. Downstream users are often hesitant to change the way they use chemicals in their products and manufacturing processes due to cost. Chemicals companies and their customers will need to innovate collaboratively. The question is one of where chemicals producers' responsibilities begin and end: the chemicals industry favours a risk-based approach to assessing product safety and sustainability that fails to consider "leakage" through the lifecycle. Regulations typically do not consider production or end-of-life impacts, while consumers do not always understand that products can contain potentially toxic compounds that lead to pollution. The burden of proof in demonstrating which chemicals damage the marine environment currently lies with the government and civil society—not with the producer.

- **An industry wish list: six steps on the path to combating marine chemical pollution.**

  1. **Innovation**: develop new, more-sustainable products and processes, and shift from a risk-based approach to a hazard-avoidance one.

  2. Create **commercial incentives** to change: if the private sector is to play a critical role in addressing marine chemical pollution, market conditions must allow it to profit from doing so.

  3. Create an industry **coalition of the willing** to help mitigate "first mover disadvantage" and that brings together industry players with other stakeholders from finance, governments and civil society.

  4. Increase **transparency and collaboration across the supply chain**: chemicals users can demand greater openness about polluting and hazardous inputs into their products.

The only real solution is a systems-level change: it is unrealistic to expect the chemicals sector to shift voluntarily at the scale and speed required. In practice, this means a multitude of overlapping push and pull approaches

5. **Improve processes and practices for chemicals users**: best practices are also emerging in the agriculture, aquaculture and waste management sectors that demonstrate a pathway for using and managing chemicals more responsibly.

6. Conduct a conversation on **extended producer responsibility**: to tackle marine chemical pollution effectively, chemicals producers will need to accept more responsibility for what happens to their products after sale.

Innovation and transformation: business and marine chemical pollution

Actions by the private sector present perhaps the most significant opportunity to address marine chemical pollution. Promising developments in green chemicals, which can be profitable for industry and less polluting to the marine environment, offer a tantalising glimpse of a future ocean-friendly chemicals sector. World-leading consumer brands from footwear to furniture, responding to increasingly eco-conscious customers, are beginning to demand transparency and a more significant say over the chemicals that go into their products. Innovative technology and practices promise to transform how farmers think about using chemicals on land and at sea.

Yet while encouraging changes are happening, they are small in scale. Legacy business models still constrain the majority of the chemicals sector. Improved industry and agricultural practices can help reduce the amount of chemical waste reaching the ocean, but this will not be enough on its own. Products from building materials to shampoo bottles will need to be redesigned. Transforming systems, processes and supply chains is hugely complex and capital-intensive. The commercial payoff is uncertain and distant.

The only real solution is a systems-level change: it is unrealistic to expect the chemicals sector to shift voluntarily at the scale and speed required. In practice, this means a multitude of overlapping push and pull approaches. On the pull side: there must be demand for more sustainable products as well as supply. Increasing consumer and retailer awareness (including, crucially, among small and medium-sized enterprises) about marine chemical pollution will be critical to ensure this demand increases. On the push side: shareholders must recognise the risk to the chemical sector of not transitioning to greener business models.

"The chemicals sector stands at an inflection point," says Guy Bailey, head of intermediates and applications at Wood Mackenzie, a consultancy that specialises in energy and chemicals. "It needs to address the environmental impact of its waste footprint and drastically reduce the greenhouse gas emissions associated with the production and consumption of its products."

Economic megatrends such as digitisation and carbon net-zero alignment present commercial opportunities for companies willing to be bold.[6] Currently, "the outlook is challenged by the environmental footprint of the sector," Mr Bailey notes. "If the industry cannot address the issue of mismanaged waste, its large and growing carbon footprint, air pollution or water consumption, some combination of regulatory intervention, investor exit or consumer revolt will clip the sector's wings."

6.2 Current approaches: Promising noises, little effective action

Marine pollution is "not on the industry's radar," says Anne-Sofie Bäckar, executive director of ChemSec, an NGO that works with businesses to reduce their use of hazardous chemicals. Most chemicals companies fulfil their regulatory obligations to manage wastewater in developed economies, says Ms Bäckar. Beyond that, "I don't think they consider how chemicals impact the ocean".

There are glimmers of hope: driven by consumer demand, tighter regulation and increased investor scrutiny, some parts of the chemicals sector are beginning to consider their environmental footprint more holistically. Still, even among the most forward-thinking companies, marine chemical pollution is not a high priority (although some have policies to address plastic pollution).

ChemSec has analysed the world's 50 largest chemical companies and ranked them according to their use of chemicals of concern and green chemistry investments. The most recent results, released in late 2021, are sobering. The top scorer in the ChemScore index, Thai company Indorama Ventures, received a B grade. Dutch company DSM and US company Air Products received a B-. The remainder scored between C+ and D.

Encouragingly, several chemical producers have used the rankings as an opportunity to improve their score, says Ms Bäckar. Yet others have not. ChemScore found that while 76 percent of the 50 companies assessed actively market sustainable products, only 8 percent show evidence of a public strategy to phase out existing hazardous chemicals.[7]

"Our experience engaging with chemicals manufacturers regarding ChemScore rankings showed a surprising unwillingness to be transparent," says Eugenie Mathieu, a senior ESG analyst at Aviva Investors. Ms Mathieu uses the rankings to work directly with companies to improve their exposure to environmental, social and governance risks.

"Other sectors like food manufacturers are more advanced in their cooperation and dialogue with stakeholders, including key NGOs," she says. "Currently, it feels like the chemicals industry is taking a fairly passive attitude to engaging on sustainability. Like the tobacco industry did, there are many instances where companies in the industry deny a problem exists."

ChemScore ranks the world's 50 largest chemicals companies on their use of chemicals of concern[8]

Company	Country	Score	Grade
Indorama	THA	28.8	B
DSM	NLD	27.9	B-
Air Products	USA	24.8	B-
Avery Dennison	USA	22.6	C+
Johnson Matthey	GBR	20.2	C
Toray Industries	JAP	18.2	C
Air Liquide	FRA	18.0	C
Linde	DEU	17.5	C
Mitsubishi PLC	JPN	17.4	C
Lyondell Basell	NLD	17.2	C
Akzo Nobel	NLD	16.6	C
Sherwin-Williams	USA	16.6	C
Yara Intl.	NOR	16.1	C-
Covestro	DEU	16.0	C-
Mitsui Chemicals	JPN	15.9	C-
Sumitomo Chem	JPN	15.7	C-
Nan Ya Plastics	TWN	15.1	C-
BASF	DEU	15.0	C-
Nutrien	CAN	14.6	C-
Evonik Industries	DEU	14.0	C-
Nitto Denko	JPN	13.8	C-
SABIC	SAU	13.2	C-
Westlake Chem	USA	12.7	D+
Braskem	BRA	12.5	D+
LG Chem	KOR	12.4	D+

Company	Country	Score	Grade
Ecolab	USA	12.3	D+
Lanxess AG	DEU	12.0	D+
Asahi Kasei Corp	JPN	11.6	D+
Lotte Chemical	KOR	11.4	D+
Mosaic USA	11.4	D+	
Sasol	ZAF	11.2	D+
PPG Industries USA	11.0	D+	
Eastman Chemical	USA	11.0	D+
Shin-Etsu Chem	JPN	11.0	D+
Bayer	DEU	10.6	D+
Dow	USA	10.5	D+
Corteva	USA	10.4	D+
Dupont Nemours	USA	10.4	D+
Showa Denko	JPN	10.1	D+
Tosoh Corp	JPN	9.7	D+
Umicore	BEL	9.2	D+
3M	USA	9.2	D+
Arkema	FRA	9.0	D+
Solvay	BEL	8.0	D
DIC Corp	JPN	8.0	D
PTT Global Chem	THA	7.1	D
Hanwha Solutions	KOR	5.1	D
Wanhua Chem	CHN	4.5	D-
Formosa Chem	TWN	3.6	D-
Sinopec Shang-A	CHN	3.6	D-

Source: ChemSec (2021)

Producers: recognising commercial opportunity

Nevertheless, as corporate sustainability becomes mainstream, encouraging examples of chemicals companies embracing new business models and transitioning to greener products are emerging. In Europe, where the strict REACH legislation is driving widespread change, this trend is particularly evident. Several chemicals companies report that environmentally sustainable products and solutions account for a growing share of revenue.

As corporate sustainability becomes mainstream, encouraging examples of chemicals companies embracing new business models and transitioning to greener products are emerging

BASF, a German chemicals conglomerate, publishes a Sustainable Solution Steering Methodology to enable its customers to assess the sustainability of each of its BASF products. The company has identified more than 16,000 accelerator solutions to help customers reduce their environmental impact. BASF plans to sell €22bn worth of these products—about one-third of the company's revenue—by 2025. In 2020, BASF generated sales of €16.7bn with accelerator products.[9]

Sumitomo Chemical, a Japanese company, has launched an initiative called Sumika Sustainable Solutions (SSS) to identify products and technologies within its portfolio that contribute to climate change, reduce environmental burdens and improve natural resource efficiency. As of 2021, Sumitomo Chemical had designated 57 of its products or technologies as SSS products, accounting for 20 percent of revenues.[10]

Clariant is a Swiss manufacturer of specialty chemicals. In 2020, around 8 percent of its sales were generated by what the company calls "sustainability leading products", says Richard Haldimann, Clariant's head of sustainability. Yet while this number seems small, "sales of these products are growing at one and a half times as fast as the average of the portfolio," Mr Haldimann says.

Leading companies are also beginning to consider more carefully the health and sustainability impacts of their products. Dutch multinational DSM, for example, assessed its entire product portfolio in 2020 to determine which products contain substances of very high concern (SVHC). SVHCs include "CMR (Carcinogenic, Mutagenic or Reprotoxic), PBT (Persistent, Bio-accumulative and Toxic) and vPvB (very Persistent very Bio-accumulative), respiratory sensitisers, endocrine-disrupting chemicals, and suspected CMRs". DSM has developed an action plan for each product found to contain more than 0.1 percent SVHC, which includes risk-reduction and considers possibilities for replacement.[11] Other chemical companies, such as Dow Chemical, are undertaking similar initiatives.

Clariant now assesses its products against 36 sustainability-related criteria, but "this has been a journey over the past ten years," says Mr Haldimann. "It's not been super-fast, but it has been thorough. We now have businesses that won't consider an innovation project if it doesn't have a certain specific sustainability benefit."

Sector-led initiatives

For those companies thinking about how to transition, there are several industry-led initiatives and frameworks to guide them. Responsible Care is a voluntary initiative led by the International Council of Chemical Associations (ICCA) in which signatories commit to governance and sustainability principles (see box). Some 580 CEOs representing 96 percent of the world's largest chemicals companies have signed up to the charter, according to the ICCA.[12] Yet, as with

The Responsible Care Charter

Signatories of the Responsible Care Charter agree to adhere to six principles:

- Enable a corporate leadership culture that proactively supports safe chemicals management.
- Safeguard people and the environment by continuously improving our environmental, health and safety performance, facility security, and the safety of our products.
- Strengthen chemicals management systems around the globe.
- Work with business partners to promote safe chemicals management within their operations.
- Engage with stakeholders, respond to their concerns and communicate openly on our performance and products.
- Contribute to sustainability through the development of innovative technologies and other solutions to societal challenges.[13]

other industry-led initiatives, Responsible Care is voluntary. Several regional industry bodies have proposed more ambitious frameworks.

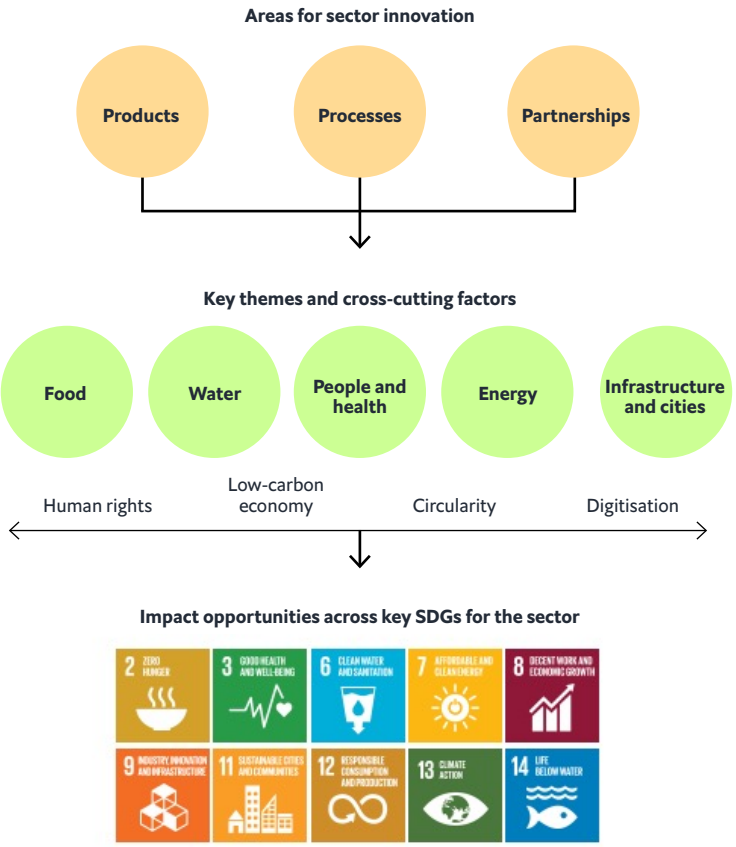
Cefic, the regional body representing European chemicals companies, has developed several sustainability-focused initiatives alongside Responsible Care. As well as a sustainability charter,[14] it is developing a set of Sustainable Development Indicators (SDIs) to align the industry with the European Green Deal.[15] Circularity, climate, environment and the Sustainable Development Goals (SDGs) account for four of the eight pillars of Cefic's long-term industry vision.[16] In October 2021, Cefic published a report, *Sustainable by Design*, which proposes a pathway for the European chemical industry to "bring chemicals, materials, products and technologies to the market that are safe, bring environmental, economic and/or social value through their applications, are accelerating the transition towards a circular economy and climate-neutral society and prevent harm to human health and the environment."[17]

Together for Sustainability (TfS), a global network of 31 chemicals companies, claims to be the de facto international standard for chemical supply chains' environmental, social and governance performance, aligned with the UN Global Compact and ICCA's Responsible Care principles. Member companies commit to conducting a minimum number of assessments and audits of their suppliers each year.[18]

Broader sustainability initiatives such as the UN Global Compact and the Sustainable Ocean Principles, produced in consultation with over 300 stakeholders, provide a framework for responsible business practices across sectors and geographies to achieve SDG 14.

The chemicals sector working group of the World Business Council for Sustainable Development (WBCSD), which includes a global group of 11 large chemicals companies as well as Cefic and the American Chemistry Council (ACC), has adopted an SDG Roadmap. The roadmap, it says, will enable the industry to "explore, articulate and help realise the potential of the chemicals sector to leverage its influence and innovation to contribute to the SDG agenda".[19]

How the chemicals sector can contribute to the UN Sustainable Development Goals



Source: World Business Council on Sustainable Development Chemicals Sector SDG Roadmap (2018)

These early examples are encouraging, yet more widespread adoption of these principles will be necessary to achieve a zero-pollution ocean. "The manufacturing sector needs to take into account what the lifecycle cost of the current product portfolio will be ten years in the future, when increased true value-costing, new regulation and changing customer demand may add considerably to the total cost," says Marcel van den Noort, senior director, chemical industry at the WBCSD.

Chemicals companies that want to improve their environmental performance should, as a first step, undertake a portfolio sustainability assessment (PSA), says Mr van den Noort. The WBCSD has developed a PSA methodology for the chemicals industry, which it says enables them to "proactively steer their overall product portfolios towards improved sustainability outcomes".[20] This type of assessment is becoming more commonplace but is still not ubiquitous across the industry.

"Many front-running companies are doing a great job applying this and report improved decision-making, a higher growth rate of their sustainable solutions and much stronger, positive stakeholder relationships. Not thoroughly assessing one's portfolio today and taking subsequent appropriate decisions will put companies adhering to a wait-and-see strategy

at a disadvantage," says Mr van den Noort. "Some will be caught by surprise."

"Rapid improvements in technology mean we can measure pollutants in the ocean at ever lower concentrations now than just ten years ago, and this will continue to improve," says Mr van den Noort. "This means that we are developing a much better picture of the true extent of pollution."

Assessing the total lifecycle impacts and cost of products is essential in improving the industry's environmental footprint, but ultimately, many products will need to be redesigned.

"Industry can put controls on chemicals in place at different points of the lifecycle, but if they don't go back and redesign products to eliminate the toxic chemical in the first place, the problem will remain unsolved," says Joel Tickner, professor at the Lowell Center for Sustainable Production at the University of Massachusetts Lowell and executive director of the Green Chemistry & Commerce Council. "Chemical pollution is increasingly not simply a manufacturing emissions problem, it's a product problem."

As Mr Tickner and his colleagues write in a 2021 article in the journal *Environment: Science and Policy for Sustainable Development* (see box), the industry has not yet begun to grapple with the more fundamental changes that will be required if it is to transition to a low-pollution future. Current initiatives are steps in the right direction, but "they focus on minimizing the impacts of the same chemistries and materials made in the same facilities with the same processes".[21]

A transition plan for an existential crisis

The chemicals industry must adopt a credible transition strategy to meet a series of "existential" sustainability and commercial challenges, according to a paper published in late 2021 by Joel Tickner, Ken Geiser and Stephanie Baima in the journal *Environment: Science and Policy for Sustainable Development*.

The paper describes an industry "mired in the status quo" that has "lost its once-lauded innovation leadership". Because the chemicals sector is tied to hugely capital-intensive and fossil-fuel-dependent infrastructure, with low margins that have eaten into R&D budgets, the authors argue that it must adopt a transition strategy that would address:

- Its dependence on fossil-fuel feedstocks, which—while also environmentally damaging—present an enormous financial risk to the industry.
- Capital investments in fossil-fuel-based infrastructure which make a genuine sustainability transition financially unviable.
- Vulnerability to supply chain disruptions.
- Falling research and development budgets that impede innovation.
- Carbon emissions.
- The impact of chemicals on health and ecosystems.

Without an urgent and complete reinvention, the authors argue, the chemicals sector will not be able to meet the environmental and financial demands it will face in the coming decades.[22]

Can the industry innovate itself to sustainability?

Perhaps the most exciting pathway to addressing marine chemical pollution, then, lies in the very essence of the chemicals industry itself: science.

Green chemistry (sometimes known as sustainable chemistry) is "the utilisation of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products."[23] There are several industry-led efforts to accelerate the adoption of greener chemicals. The Green Chemistry & Commerce Council (GC3) is key among these. This multi-stakeholder collaboration "drives the commercial adoption of green chemistry by catalysing and guiding action across all industries, sectors and supply chains".[24]

As well as several working groups which bring together industry sub-sectors, GC3 runs a Startup Network to connect green chemistry entrepreneurs with incumbent chemicals suppliers and users to accelerate investment in and markets for these companies.[25] Partnerships between large chemicals companies and startups provide a critical pathway for innovation in green chemicals, says Mr Tickner. And as the following section discusses in more detail, acquisitions of green chemistry startups offer a cost-effective way for incumbent chemicals companies to introduce new, more sustainable products at scale.

The chemicals industry itself also clearly sees value in these types of collaborations. Cefic, the European chemicals industry body, also runs its own Future Chemistry Network, which it says is a "global innovation hub and a hotspot for investments into breakthrough climate-neutral and circular technologies".[26]

The green chemistry start-up scene is vibrant, with several emerging companies valued at hundreds of millions or even billions of dollars.[27] Examples include:

- P2 Science, founded by one of the fathers of green chemistry, Paul Anastas, which uses "patented green chemistry processes to convert bio-based feedstocks into high impact specialty chemicals used by consumer-facing and industrial companies around the world."[28]
- Germany DexLeChem, which uses water-based chemical manufacturing to replace crude-oil-based solvents in pharmaceuticals.[29]
- US-based Lygos, which produces "sustainable organic-acid specialty chemicals and bio-monomers" for use in industrial and consumer products.[30]
- Japan's Green Earth Institute, which produces biofuels and green chemicals including resins, carbon fibres and feed additives.[31]
- Solugen, which opened the world's first carbon-negative molecule factory.[32]

The road to innovation is not always a smooth one, even for existing and well-resourced companies. The example of Omnia, a high-performance solvent produced by Eastman, an American chemicals company, is illustrative. After identifying cleaning products as an area with high demand for a more sustainable and less hazardous alternative, Eastman's chemists narrowed down a list of 2,400 solvents to a possible list of 70 molecules based on a series of toxicity tests. They then determined that 20 could be manufactured cost-effectively and subjected the final list to an additional battery of tests. They decided that the final candidate molecule was safer than traditional solvents: biodegradable and non-toxic to humans and

aquatic life. A final round of tests showed that the candidate molecule was equally as effective as conventional solvents at cleaning surfaces.

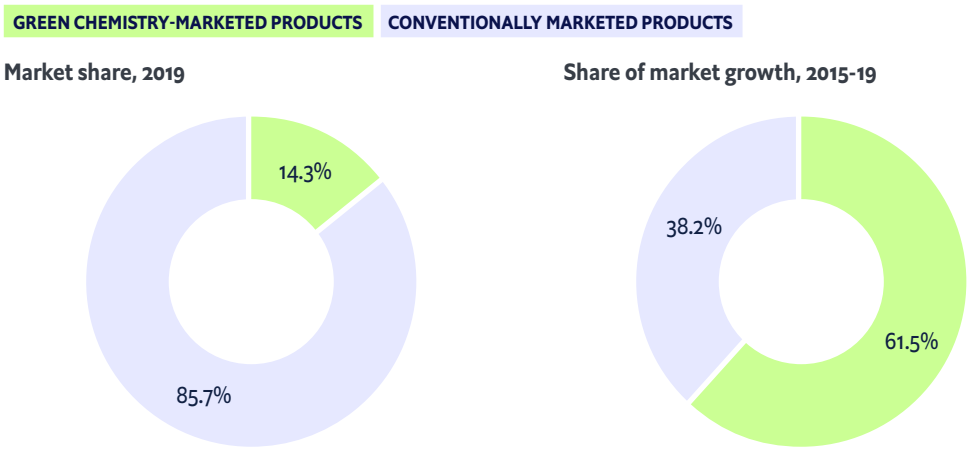
Yet the market was slow to adopt Omnia. Producers of cleaning products did not see a compelling reason to change their product formulations, which they saw as "safe enough". After Eastman's chemists visited 200 cleaning-product manufacturers across the United States and Canada, demand for Omnia began to increase.[33]

"Omnia failed at first because customers are so used to the incumbent," says Mr Tickner. "They didn't want to pay for the cost of reformulating their products."

The thinking of many cleaning-product manufacturers was, "incumbents work well and aren't restricted, so why would we change?" he says. The lesson is cautionary: chemicals companies have little incentive to produce less-polluting products unless customers demand it and are willing to pay for it, or regulations require it.

Green chemistry is not yet widespread. A previous study suggests that fewer than 2 percent of chemical products are from green chemistry, says Zhanyun Wang of the Technology & Society Laboratory, Swiss Federal Laboratories for Materials Science and Technology (EMPA).[34] Yet it does account for a growing segment of the market. Research published in 2021 by the University of Massachusetts Lowell and the GC3 found that while green chemistry-marketed products account for a relatively small share of the overall chemicals market, that share is growing—driven by both customer demand and increasingly stringent regulation.[35]

The growth of green chemistry



Source: Green Chemistry & Commerce Council[36]

Reduce, reuse, recycle?

One emerging and often-touted solution to pollution is chemical recycling, which promises to help close the material and value chain by converting used chemicals into commercially viable products before they become waste. The UK Research and Innovation (UKRI) Interdisciplinary Centre for the Circular Chemical Economy, for example, is currently working with 20 multinational companies and small and mid-sized enterprises to develop commercially viable solutions to recycle widely used chemicals such as ethylene and propylene.[37] Plastic recycling is attracting significant commercial and investor interest. Saudi Arabian chemical company SABIC has developed a portfolio of circular products and services it calls "Trucircle". Examples of products already in commercial production include recycled ice-cream containers and pet food packaging.[38]

There are downsides. Chemical recycling is more resource-intensive than mechanical recycling, releasing carbon emissions during the process which could reduce its utility in efforts to decarbonise the chemicals sector.[39] The technology has a lot of benefits, but there are still questions about its viability, says Mr Tickner. "At this point, it's not economically viable at large scale because fossil fuels are so cheap—and we still have very little knowledge about the emissions produced during the chemical recycling process."

Dilution is no solution: Treating liquid waste

Perhaps the most effective way to address marine chemical pollution is to stop liquid waste entering the ocean in the first place. This means capturing and treating industrial, agricultural or municipal waste before it reaches the sea.

The technology to capture and treat liquid waste—cost-effectively and at scale—exists, says Frédéric Madelin, head of the Liquid and Hazardous Waste segment of the French multinational Veolia. The main obstacle, he believes, is the enforcement of regulation. Often, there are rules that prohibit industry from releasing liquid pollutants. In practice, they are difficult to enforce, and liquid industrial waste often ends up in the sewerage system or in waterways.

Veolia has three "golden rules" when it comes to treating liquid waste, says Mr Madelin. The first is traceability. Information technology enables the company to work with ports, shipping lines, offshore oil rigs, factories and municipalities to track and sample each stage of a process to identify where hazardous waste exists and needs to be disposed of.

The second is no dilution. In many jurisdictions regulatory loopholes allow liquid waste to be released into the environment if it falls under a set toxicity threshold. Simply diluting the waste with water means it can be released without being treated. But, says Mr Madelin, "if we allow dilution, well, we might as well throw everything in the sea". Veolia declines to tender for projects which call for treatment via dilution, he says.

The third is treatment. Mr Madelin points to an experimental waste treatment facility that Veolia has developed in Huizhou, China, which uses incineration, chemical treatment and safe burial to manage hazardous waste generated by the energy, manufacturing and chemical industries. The critical feature of any treatment plant, says Mr Madelin, is that it allows no liquid waste to escape so there is no risk of marine contamination.

"Industries should treat waste in a proper way to avoid it being released in rivers, underground water or the ocean," Mr Madelin says. And while the technology exists to capture and treat waste at source, our ability to clean up pollution once it reaches the ocean is very limited. "Once it's in the sea, you cannot do anything. You are not going to decontaminate the whole ocean."

Down the supply chain: Addressing risk and responsibility

Innovation in products is certainly one potential solution, but solutions that do not recognise the downstream and lifecycle risks of chemicals in general are unlikely to stop chemicals ending up in the ocean.

The most effective way to address marine chemical pollution is to stop liquid waste entering the ocean in the first place. This means capturing and treating industrial, agricultural or municipal waste before it reaches the sea

One challenge is that, overwhelmingly, the chemicals industry favours a risk-based approach to assessing product safety and sustainability, says ChemSec's Ms Bäckar. In practice, chemicals producers often deem potentially hazardous chemicals low-risk if they are designed to be used in low concentrations or in settings where the risk of human or environmental exposure is low.[40] Yet a risk-based approach fails to consider "leakage" through the lifecycle, says Mr Tickner. As an example, a flame retardant in an electronic product casing may be low-risk, but when burned in an open landfill it creates exposures which the company doesn't consider."

The question is one of where chemicals producers' responsibilities begin and end. Most regulatory regimes allow chemicals producers to market certain hazardous or polluting chemicals if they are correctly labelled and used in a way that limits human or environmental exposure. Most households, for instance, own cleaning products that are toxic to humans if consumed. These products typically come with warning labels, and the responsibility lies with the consumer—not the producer—to ensure the products are used and disposed of correctly. Regulations typically do not consider production or end-of-life impacts.

In practice, consumers do not always understand that products can contain potentially toxic compounds that lead to pollution (such as oxybenzone in sunscreen). Yet the burden of proof in demonstrating which chemicals damage the marine environment currently lies with the government and civil society—not with the producer, says Alex Rogers, director of science at REV Ocean, a privately funded ocean research and expedition vessel. "This is a major problem," he says, and one which the chemicals industry seems mainly unwilling to address.

Use less, pollute less

There are encouraging examples of innovative practices along the chemicals supply chain helping to reduce marine chemical pollution, which—if deployed at scale—could have a profound positive impact.

Aquaculture is a significant contributor to marine chemical pollution, yet promising industry-led solutions are beginning to emerge. Integrated aquaculture pairs different species and organisms together to create an integrated "food web" like a biodynamic farm on land. Shellfish such as mussels and oysters feed on the excess food and faecal matter that escapes from fish farms. Macroalgae reduce the need for pesticides and become a feed-source for fish. Artificial lagoons or wetlands can purify water from land-based aquaculture sustainably.[41]

Co-culturing, or growing different fish species together, can reduce pathogens and therefore the need for antibiotics—as can vaccines. Cargill, a global food corporation, is one of the world's largest feed suppliers for the aquaculture industry. It has reduced antibiotics sold in medicated salmon feeds by 80 percent since 2015.[42]

As Chapter 2 explained, agriculture is one of the most crucial sectors for marine chemical pollution, with farm runoff one of the leading causes of marine pollution. One straightforward way to reduce fertiliser runoff is to use less of it. If China, Brazil, Mexico, Colombia and Thailand—some of the world's most significant users of fertiliser—adopted more-efficient processes, they could reduce nitrogen pollution by around 35 percent—without a substantial loss of crop yield.[43]

Other, more high-tech solutions can help reduce fertiliser use too. Precision agriculture, which involves satellite data and remote-sensing technology, allows farmers to pinpoint precisely how much fertiliser is needed in specific areas, increasing yields while reducing both cost and pollution.[44]

Farmers are also beginning to implement both high- and low-tech solutions to reduce the amount of pollution that leaves their land. High-efficiency irrigation equipment can reduce water use (less water means less runoff), while on-farm water treatment facilities manage waste at the source. Nature-based solutions such as wetland buffer zones soak up pollutants before they reach waterways.[45]

Industry coalitions can provide businesses with the impetus to adopt these new practices in lockstep. Project Catalyst, a multi-stakeholder partnership between sugarcane growers and environmental NGOs in Queensland, Australia, is a leading example of the positive impact that improved farming practices can have on marine chemical pollution. By supporting farmers to enhance soil quality, implement chemical and nutrient management plans and improve water management, the project has significantly improved water quality in the adjacent Great Barrier Reef.[46]

Water credits: Policy innovations to reduce chemical runoff

Untreated urban wastewater, industrial and agricultural runoff are significant sources of marine pollution. Still, many countries have created a market for recovering, treating and reusing wastewater before it reaches the marine environment by increasing the value of clean, unpolluted water.

Water quality trading schemes operate like carbon credits, allowing industrial and agricultural water users to buy and sell water rights at a variable price based on pollution levels, creating a financial incentive to lower pollution or treat polluted wastewater. Farmers and landowners in the Ohio River Basin in the US can earn Water Quality Credits—which have a monetary value of between US$12-14 per credit—by reducing nitrogen or phosphorus discharge into the water system. One pound of nutrient reduction earns one credit.[47] In Queensland, Australia, the Reef Credit Scheme pays farmers to reduce pollution reaching the Great Barrier Reef.[48]

Water quality schemes can also provide knock-on commercial opportunities, leading to a boom in farmers and landowners building, upgrading or "greening" water infrastructure. Novel financial instruments, such as blended finance, help too. In Belize, Guyana and Jamaica, governments offer discounted loans to businesses to build and maintain wastewater treatment projects. Thailand's Kasikorn Bank offers discounted interest rates to waterfront hotels to finance wastewater and solid-waste treatment facilities.[49]

The drawback to this type of scheme is that they tend to be local, so achieving scale is a challenge. But the principle—that businesses along the coastal fringe have a financial interest in reducing marine pollution—could be applied to larger schemes encompassing a more diverse range of industries.

Consumer-facing sectors such as cosmetics, healthcare, FMCG, furniture, technology and household goods can also play a critical role in forging solutions to marine chemical pollution and improving the overall sustainability of the chemicals industry

Consumer pressure further down the supply chain

Consumer-facing sectors such as cosmetics, healthcare, fast-moving consumer goods (FMCG), furniture, technology and household goods can also play a critical role in forging solutions to marine chemical pollution and improving the overall sustainability of the chemicals industry. One major challenge is that producers of these products, which can have long and complex supply chains, are often unaware of the chemicals that go into them. With few regulatory requirements to disclose the chemical make-up of products, and seemingly little interest from consumers in knowing, producers of finished goods have until now typically adopted a "don't ask, don't tell" approach—if they have thought about chemicals at all.

Growing consumer awareness of sustainability and product safety is driving change in some sectors.

"Companies that have a direct-to-consumer business model are getting serious about this problem because they risk a reputational hit," says Alix Grabowski, director for Plastic & Material Science at WWF. Several multinational consumer brands have taken an industry-leading approach to chemical management. These examples provide a road map for how other businesses and sectors can work to address marine chemical pollution.

Consumer goods companies' supply-chain policies on chemicals

Sportswear brand **Nike** publishes a "Chemistry PlayBook and Restricted Substances List", which it says is a "critical tool for helping suppliers understand how Nike defines chemistry and what they must do to demonstrate they're meeting our expectations".[50]

Sephora, a global chain of cosmetics stores, publishes a chemicals policy for its private-label products and third-party brands it carries. Sephora has an internal restricted-substances list, which goes beyond the requirements of EU legislation, and uses independent auditing to ensure its products comply with the list. It has published a list of high-priority chemicals which it asks third-party suppliers to reduce or eliminate.[51] Almost 30 percent fewer products carried by the chain contained high-priority chemicals in 2021 than in 2019.[52]

Furniture retailer **IKEA** requires that all suppliers adhere to strict requirements around chemicals in its products. IKEA carries out random site visits and conducts third-party tests of products in its supply chain.[53] Its chemical standards are often far stricter than legislation requires.

Technology giant **Apple** lists "smarter chemistry" as one of its three environmental priorities. Apple maps and catalogues all chemicals used along its supply chain and maintains a restricted-chemicals list.[54]

Clothing manufacturer **H&M**'s chemical roadmap sets out a path to "toxic-free fashion" by 2030.[55]

Diversified consumer goods company **Unilever** maintains a dedicated Safety and Environmental Assurance Centre (SEAC), which conducts safety and sustainability assessments across its product range.[56] Unilever has committed to eliminating fossil-fuel-derived chemicals in its cleaning products by 2030.[57] In 2021, it joined an industry task-force convened by the Royal Society of Chemistry to explore scalable greener alternatives to polymers in liquid formations (PLFs) used in products such as shampoos, paints and adhesives.[58] Yet Unilever has also faced criticism for its ongoing use of disposable plastic packaging and microplastics,[59] demonstrating how challenging and complex the path to eliminating pollution can be even for those companies considered to be industry leaders.

Cosmetics multinational **Estée Lauder** published a peer-reviewed article in the journal *Green Chemistry* in 2021 which details the company's methodology for integrating green chemistry and sustainability considerations into raw-materials selection and product development.[60]

"Sustainability is becoming a business decision," says Clariant's Mr Haldimann. "It's no longer a qualifier but it is becoming a driver for companies to select products." This doesn't mean, however, that sustainability trumps all other considerations. "A small portion of the population is willing to give up on certain performance aspects of certain products because it is more sustainable. But it's a small portion." Sustainability and performance must not be seen as a trade-off, Mr Haldimann believes. "We have to tie these two elements together."

There are also encouraging examples of companies along the supply chain coming together to address pollution. Roadmap to Zero is a multi-stakeholder initiative in the textile and footwear sectors whose contributors aim to reduce the chemical footprint of the industry. "Consumers can play a vital role in driving companies to act on pollution", says Frank Michel, Executive Director of the ZDHC Foundation, which oversees the implementation of the Roadmap to Zero programme. However, he says, "consumers often don't have transparency on which brand is engaging in this field. Our Roadmap to Zero Programme is engaging the entire supply chain to transform the industry to create this transparency."

Clariant partnered with Unilever and TOMRA, a manufacturer of sorting equipment for the recycling industry, to design black plastic bottles that can be easily sorted by recyclers. The black colour typically used is not detectable by the sorting machines, which results in lower-quality, discoloured recycled plastic. This was a complex process, explains Clariant's Mr Haldimann. First, they had to design a black plastic colour that could be detected and sorted by industrial sorting machines. Then, they worked with Unilever to ensure the product would be acceptable to designers and consumers. Finally, they worked with TOMRA to ensure the product could be practically sorted using existing processes.

"A lot of the technical solutions already exist," says Mr Haldimann. "It's about bringing supply chain partners together and making them work in a new setup."

The International Association for Soaps, Detergents and Maintenance Products (AISE), which represents these industries in Europe, offers another example of how various parts of the value chain can work together. Along with the European Committee of Organic Surfactants and their Intermediates (CESIO), AISE funds a joint research platform called ERASM (which stands for Environmental Risk Assessment and Management), which undertakes scientific research aimed at improving the health and environmental impacts of detergent-based surfactants.[61]

AISE has also introduced an industry-wide Charter for Sustainable Cleaning to reduce the sector's carbon and environmental footprint. More than 170 European companies have adopted it so far.[62] Another example, the Health Product Declaration Collaborative, brings together businesses along the building industry value chain to assess and consistently report on the health impacts of products used in the built environment.[63] The charter is just one example of a sub-sector of the chemical industry working proactively to improve sustainability, suggesting that more widespread change is feasible.

6.3 Barriers to change: Cultural transformation required

Cost, scale and technology

There are three practical obstacles to the adoption of more sustainable products and practices, as Wood Mackenzie's Guy Bailey explains:

> "**Technology readiness**: to move from a concept in a lab to a deployed commercial material can take decades, as companies work through the size of the market and the

challenge of moving to commercial-scale production. Even when we know how to provide more sustainable alternatives, it takes time to roll out."

The chemicals sector is also highly competitive, with a ruthless focus on efficiency. Sustainable or less hazardous alternatives to existing products tend to be overlooked if they represent a squeeze on margins

"**Cost**: typically, new technologies have higher costs, which come down over time. These higher costs can deter buyers but have also historically been challenging for the investment community."

"**Scalability**: in plenty of chemicals markets, end-consumers need scale. For example, PLA is a bioplastic that can be considered a competitor with PET and PE. It costs about twice what the commodity polymers do, but it has some superior properties, and clearly, some in the market are willing to pay for it. But if Coca-Cola decided to switch PET for PLA in its material portfolio, it would find enough PLA globally to meet just 7 percent of its needs. It takes time and partnerships for sustainable materials to incrementally build out scale before they can compete at the commodity level."

The chemicals sector is also highly competitive, with a ruthless focus on efficiency. Sustainable or less hazardous alternatives to existing products tend to be overlooked if they represent a squeeze on margins. Efficiency drives are common, but the dividends are routinely pumped back into the same—often polluting—parts of the business rather than being invested in developing less harmful alternatives, says Kakuko Nagatani-Yoshida, global coordinator for chemicals and pollution at the United Nations Environment Programme (UNEP).

Mr Tickner of the Lowell Center explains how these commercial barriers play out in practice. "We've had conversations with a group of chief technology officers of mid-size chemicals companies who say they are ready to produce more-sustainable products," he says. Often, this means a long and expensive process developing new chemicals and manufacturing processes. "The problem is if a competitor is selling a cheaper, more-polluting incumbent product and customers are not willing to absorb higher costs, that company is going to lose market share."

"I have heard of internal battles in companies where they have better alternatives ready to scale, but they're not going to stop selling the incumbent as long as it means losing that market," Mr Tickner says. In a for-profit entity that reports quarterly, short-term commercial considerations often trump environmental concerns—even if there is the potential for a longer-term payoff.

The need to build new infrastructure is also a significant barrier to adopting green chemistry at scale, says Mr Tickner. "We've heard a lot from chemicals companies that, unless they can drop more-sustainable products into existing manufacturing processes, it is difficult to adopt them. The costs of building new manufacturing infrastructure are so high."

Marcel van den Noort of the WBCSD agrees: "Largely, the industry has the technology to solve the problem of direct pollution. The barrier is cost."

Yet the flipside of cost is opportunity. Companies that produce hazardous chemicals face extremely high safety-compliance costs. Sumitomo Chemical, for example, spends more than US$370m on environmental protection costs each year.[64] Transitioning to safer chemicals can also mean lower compliance costs. Pharmaceutical company Pfizer saw a reduction in costs, for example, by employing green chemistry principles to reduce the amount of waste produced during its manufacturing process.[65]

Decarbonisation tops the sustainability agenda

The chemicals sector's efforts to transition to net-zero carbon emissions provide both a template and a cautionary tale for any future efforts to achieve a zero-pollution ocean. It is difficult to estimate the projected cost of transitioning to net-zero emissions versus net-zero pollution. Still, it is easy to imagine that both transitions would involve similar challenges: redesigning products, rebuilding supply chains, and re-engineering legacy processes. In short, both will be expensive and complicated, decades-long efforts.

The necessary drive to decarbonise the chemicals sector cannot become a missed opportunity to address ocean pollution

ShareAction is an NGO that aims to encourage investors to improve their portfolios' environmental and social impacts. They say that despite the chemicals sector's high emissions, few companies have credible transition plans in place to achieve net zero. One particularly thorny issue for the industry is its Scope 3 emissions, which measure indirect emissions up and down the value chain. For many sectors, switching to renewable energy and fuel sources will eliminate most emissions. Yet chemicals face a double whammy: not only are they energy-intensive to produce, but most are created using fossil-fuel feedstocks. Even if the process used to make chemicals becomes substantially greener, the products themselves still account for about 50 percent of the sector's emissions.[66] The road ahead will be a rocky one.

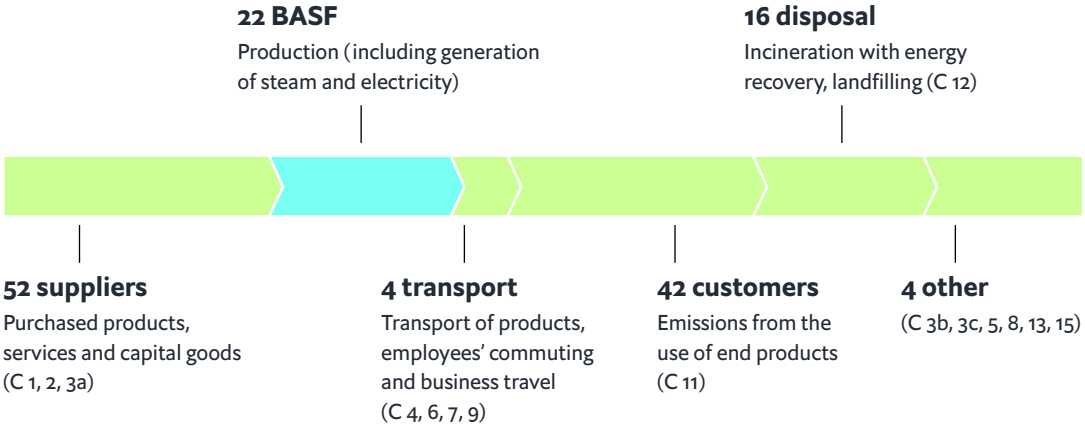
Some efforts to decarbonise the sector, such as reducing fertiliser use, will positively affect marine pollution. Yet, the causes of carbon emissions and pollution do not always neatly overlap. "We need to go back to the basic chemistry causing toxicity in the ocean," says Mr Tickner. Unfortunately, "replacing carbon sources doesn't solve that".

The reality, then, is that pollution may remain a second-order environmental problem for some time for an industry that faces an enormous and expensive decarbonisation transition. That means the industry must look for win-win solutions that simultaneously address carbon emissions and pollution. The necessary drive to decarbonise the chemicals sector cannot become a missed opportunity to address ocean pollution.

The bulk of BASF's greenhouse gas emissions are Scope 3

BASF's greenhouse gas emissions along its value chain
BASF Annual Report 2018

Greenhouse gas emissions along the BASF value chain in 2018*
Million metric tonnes of CO_2 equivalents



Source: World Business Council for Sustainable Development, TCFD Chemical Sector Preparer Forum Guide to Climate-related Financial Disclosure (2019). * BASF operations including the discontinued oil and gas business; according to Greenhouse Gas Protocol, Scope 1, 2 and 3; categories within Scope 3 are shown in parentheses

A change in corporate culture

To overcome these significant commercial barriers, large parts of the sector will need to undergo a substantial shift in corporate culture. One interviewee, who wished to remain anonymous, highlighted the "cognitive dissonance" of many executives in the chemicals industry, who see themselves as drivers of innovation and prosperity. They simply cannot accept that they may be part of the problem. Or, as another interviewee said, "they are dinosaurs".

This is, of course, not a universal characterisation. In large, complex organisations, there can be a multitude of norms. Some parts of the business may embrace the opportunity to reduce pollution, while others dismiss it or have not considered it at all. Even in organisations with well-resourced and active sustainability departments, there can be patchy adoption of new norms. Nothing short of a revolution is required. "It is about an organisational change," says Eric Usher, head of the UNEP Finance Initiative.

There is cause for optimism, says Craig Halgreen, an independent consultant whose career has been in sustainability at large chemicals companies, including Austria's Borealis. "Many more executives in the chemicals sector recognise the need for change than they did even five years ago," he says. "It's now quite common to hear discussions in boardrooms about the

need to act responsibly on behalf of their children and grandchildren. That was unheard of a decade ago."

Still, one major challenge for the industry is that the transition will not always be profitable. In some cases, companies can swap a polluting product for a less polluting one that will generate a profit—in time, at least. In other cases, the solution is to reduce or eliminate chemical products altogether. These are more difficult shifts for the industry to make.

To overcome these significant commercial barriers, large parts of the sector will need to undergo a substantial shift in corporate culture

"For the longest time, the chemicals industry focused on finding markets and not functionalities," says Mr Tickner. Instead of chemicals companies creating a product and then looking for places to sell it, in the future new product growth will need to be driven by customers asking chemicals producers for products that meet product and toxicity needs, he says. Some companies see value in becoming service providers and not just product manufacturers. For example, P&G Tide is now setting up commercial laundries as a model for the future. Many companies offer chemical leasing services. "Not every product redesign needs a chemical solution," he says.

This challenge is already becoming apparent in the transition to circular economy models, which will inevitably mean reduced demand for chemicals. Yet despite this commercial reality, says Mr Halgreen, many companies in the chemicals sector are now embracing circularity. They have begun to rethink how to redesign their plastic production processes to enable reuse and recycling. With the right commercial and regulatory incentives in place, such a radical shift in industry culture and practice might be entirely possible.

Cultural change comes from the bottom as well as the top. One barrier to change is the lack of accredited tertiary degrees in safe and sustainable green chemistry. "We need to train a generation of chemists and engineers that you don't design something without thinking about toxicity and sustainability," says Mr Tickner. A growing number of universities have begun to embed green chemistry and sustainability into their curricula, but green and sustainable chemistry education (GSCE) needs to expand before it can be considered mainstream, according to a paper prepared for the UNEP's Global Chemicals Outlook.[67]

Changing corporate culture to support biodiversity

The Proteus Partnership, a collaboration between the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) and a group of leading companies, helps member companies to assess and manage their impacts and dependencies on biodiversity, and shows the challenges—and opportunities—of working to instil a culture of sustainability in large companies.

Proteus's member companies, including oil supermajors such as BP and ExxonMobil and miners such as BHP and Rio Tinto, look a lot like the world's largest chemical companies: huge, diversified conglomerates with sprawling global operations.

The challenge of engaging these companies is similar, says Stacey Baggaley, senior programme officer for Nature Economy at UNEP-WCMC. Some parts of the business will be highly engaged, while other parts of the organisation are typically not. To overcome this, the Proteus Partnership encourages both a top-down and bottom-up approach, she says.

This means working with the C-suite and leadership teams to highlight both the business risks and opportunities from biodiversity whilst equipping sustainability champions throughout the business with the data, tools and skills they need to manage biodiversity and communicate horizontally across the organisation.

It is crucial, Ms Baggaley says, to embed knowledge and capacity not just in the environment function but across the broader business.

Engaging the "missing middle" of the sector

Cultural inertia is a powerful barrier in even the most progressive parts of the chemicals industry. Still, perhaps an even more significant challenge is engaging the parts of the industry for which sustainability is not yet even a consideration. Large multinationals tend to be demonised for their environmental records, but they often operate under greater scrutiny and in markets with strict regulatory standards. Usually, the multitude of smaller businesses and those working under the radar in jurisdictions with laxer rules are the most polluting. Reaching the middle tier of companies which perhaps have the resources and incentives to solve the pollution problem but have not yet thought about doing so will be a necessary—if challenging—part of any solution.

Indeed, efforts to improve the industry's environmental footprint tend to include the usual suspects: prominent, often Western, multinationals that use sustainability as a point of market differentiation, or consumer-facing brands fearing a reputational backlash. For those trying to champion sustainability in the industry, this is a pragmatic approach. "You can do an awful lot by working with big companies when the door is already open," says Stacey Baggaley, senior programme officer for Nature Economy at UNEP-WCMC.

These businesses play a vital role in setting the tone and direction of travel for the wider industry. "The value chain is incredibly convoluted, but there are a much smaller number of big companies at the top of the value chain—producing and processing base chemicals—and in the consuming sectors," says Mr Bailey of Wood Mackenzie. "If companies in these 'bottlenecks' can move in a more sustainable direction, the wider industry has little choice but to follow."

And yet, unless the "missing middle" sees the value in adopting new norms, large-scale impact will remain elusive. Geographical shifts in the chemicals sector threaten to compound this problem further: much of the progress on sustainability is happening among European and, to a lesser extent, North American companies, while the sector's geographic centre of gravity is inexorably moving towards Asia and the Middle East (see box).

Unless the "missing middle" sees the value in adopting new norms, large-scale impact will remain elusive

Interviewees for this report continually cited European examples of sustainability-related transformations in the chemicals industry. Driven by the EU's relatively strict REACH legislation, the region's companies do appear to be, on average, further ahead on sustainability. ChemScore, which awards an average score of 15.1 for European companies, 13.6 for US and Canadian companies and 11.6 for Asian companies[68], confirms this widely held observation. But without an effort to engage a geographically wider group of companies, any plan to achieve a zero-pollution ocean will founder.[69]

Megatrends shaping the chemicals industry of the future

Chemicals production is forecast to grow by almost 60 percent by 2050. Yet this headline figure obscures a more complex picture. Fossil-fuel-based commodity chemicals make up the bulk of global sales, yet shrinking margins and fierce competition—compounded by pandemic-related disruptions—have eaten into profits. There are bright spots. Specialty chemicals, pharmaceuticals and agriculture are growing segments. Perhaps unsurprisingly, most R&D spending is also happening in these (higher-margin) categories, suggesting they will be a key driver of future industry growth.[70]

Megatrend #1—Geography

The modern chemicals sector was born in Europe and North America, and throughout the 20th century big Western conglomerates such as Germany's BASF and the United States' Dow Chemicals dominated the industry.

This picture has been quietly but rapidly changing. Since the turn of the century, much of the growth in the global industry has happened in Asia. The region now accounts for half of all global chemicals sales; by 2030 this figure will be closer to two-thirds.

Big, diversified conglomerates will still rule. But it will be Sinopec, ChemChina and SABIC that dominate in volume, sales and profits. China is currently a net importer of chemicals, but on current trends this will soon reverse.[71]

Megatrend #2—Sustainability

The chemicals sector's fortunes are inextricably tied to fossil fuels. Action to address climate change will have an outsized impact on the sector, which is the third-largest industry source of CO_2.[72]

Around half of the sector's emissions come from energy use; the other half are embedded in the chemical products themselves.[73] There will be no cheap or easy way for the sector to transition. The good news? The chemicals sector is so intertwined with other sectors that if it does manage to successfully decarbonise, its efforts will have an outsized positive impact on global emissions.[74]

The industry's shifting centre of geographic gravity also has important implications for its climate impact. China's chemicals sector produces more of its emissions from coal than from relatively cleaner feedstocks such as oil or natural gas compared with its international counterparts. And much of the industry's growth is forecast to happen in emerging economies with relatively weaker regulatory frameworks to manage the environmental impact.[75]

Megatrend #3—Volatility

The chemical sector's heavy dependence on fossil fuel feedstocks and China's growing importance also exposes it to other risks. Any slowdown in China's economy or decoupling of Chinese and Western supply chains would upend the industry. Volatility in commodity prices is an ongoing threat: profit margins of fossil-fuel-based chemicals are so thin that even minor swings can have a deleterious impact on the bottom line.[76]

Megatrend #4—Technology

It is not all doom and gloom, however. The chemicals industry today, locked into legacy production processes, looks—from a technological perspective at least—remarkably like it did in the 1960s.[77]

Technology offers a chance to change that. While the market for commodity chemicals is ever less profitable, demand for specialty chemicals and niches such as biotechnology and fuel cells is growing.[78] These segments are small relative to the industry's overall size, but suggest a viable future for the industry to survive—and even prosper through—decarbonisation.

Technology will underpin this shift. Smart manufacturing, artificial intelligence, the Internet of Things, better data availability and processing, engineering innovations such as digital twins and breakthroughs in materials science offer a tantalising glimpse at what a leaner, greener chemicals industry might look like in the future.

6.4 Pathways to progress: Why the sector needs system-level change

Another disincentive for the industry to act on marine chemical pollution (or, in fact, on any other environmental or social issue) is that individual businesses often face a first-mover disadvantage. Before new revenue streams are well-established, those that stick out their necks risk scrutiny or face high transition costs. Industry alliances, which reduce the risk to individual companies of moving too far ahead of their peers—or being left too far behind—will be critical to persuade businesses to contribute to achieving a zero-pollution ocean.

This "first-mover disadvantage" has driven the creation of many industry coalitions to address other environmental and social issues. Several initiatives already exist that contribute in some way to addressing marine chemical pollution, although none focuses specifically on it. Nevertheless, these alliances may provide a template for a broad-based chemicals industry alliance (see box).

A central feature of these collaborations is bringing together industry players with other stakeholders from finance, government and civil society. This multi-stakeholder approach is crucial: different norms and expectations between these groups can be a significant roadblock to progress, which several interviewees highlighted as a major challenge.

Even within the private sector, industries such as chemicals, agriculture and waste management tend to be siloed, says Erik Giercksky, head of the Ocean Stewardship Coalition at the UN Global Compact. The most powerful coalitions tend to be multisectoral.

"We need to have the conversation between policymakers, scientists and business. And it's not only about the chemicals industry, but also the finance industry and consumer goods," agrees EMPA's Zhangun Wang.

Strength in numbers: Industry alliances as potential templates for action

- The **Getting to Zero Coalition** is an alliance of 150 companies within the maritime, energy, infrastructure and finance sectors that aims to decarbonise the shipping sector by developing commercially viable deep-sea zero-emission vessels by 2030. Coalition members commit to a "race to the top" to adopt carbon-neutral vessels ahead of regulatory requirements.[79]
- Members of **ReSource Plastic**, a consortium of eight multinational packaging companies under the leadership of environmental NGO WWF, have committed to track, disclose and reduce the plastic waste they produce.[75]
- **The Alliance to End Plastic Waste** comprises 80 member companies and invests in downstream solutions to manage plastic waste.[81]
- Members of **Operation Clean Sweep**, including chemicals, manufacturing and packaging companies, pledge to prevent pollution from plastic resin and pellets.[82]
- The **Ship Recycling Transparency Initiative**, "a market-based approach to improving ship recycling practices in the current absence of global standards," allows shipowners to disclose information about their ship-recycling efforts to inform cargo owners' and investors' purchasing and lending decisions.[83]
- **The Ocean Stewardship Coalition**, previously the UN Global Compact Action Platform for Sustainable Ocean Business, brings together industry players across key "blue" sectors: aquaculture, energy production, fisheries and shipping. The platform provides a framework for responsible practices in these sectors, aiming to unlock opportunities for profitable and sustainable solutions.[84]

Standards bodies such as the International Organization for Standardization (ISO) and ASTM International provide well-established, voluntary systems to drive greater sustainability. Standards give confidence to consumers (for example, that the products they buy do not contain certain hazardous chemicals). Standards bodies also present an opportunity for the industry to agree on best practices voluntarily.

That said, it is worth noting that these for-profit organisations serve their customers, i.e. the industries that use their standards. This means there can be a tendency to favour standards that are inexpensive, fast and convenient to administer instead of those that are time-consuming but potentially more rigorous, says Linda Amaral-Zettler, chair of the ASTM D20.96 Subcommittee subsection on Natural Environment Degradation/Biodegradation (Anaerobic/Aerobic). Standards bodies are not regulators: they primarily respond to industry needs rather than forward a policy agenda, limiting their capacity to move ahead of the industry at large.

Other types of standards are emerging too. The Chemical Footprint project is a survey that "evaluates responders' chemicals management systems against best practice to measure and reduce chemical footprints."[85] Safer Choice is a certification programme run by the United States' Environmental Protection Agency that allows consumers to find products that don't contain harmful chemicals.[86]

It is unrealistic to expect the chemicals sector to act alone. Regulatory change, public pressure and demand from retailers for more sustainable chemicals, and investment from the finance sector, will all be required if there is to be a shift to less polluting business models

A roadmap for corporate change

Despite some encouraging noises, the reality is that the incentive to change is simply not strong enough for many businesses along the chemicals supply chain. One barrier is financial. Polluting, hazardous products are often the most profitable, and corporate leaders must still consider the bottom line first. Executives have to weigh the (often substantial) upfront cost of refitting plants and redesigning processes to produce less harmful products against an uncertain and trailing revenue stream.

Shareholders might have an increasing focus on environmental, social and governance risks (discussed in more detail in the next chapter). However, they still expect a financial return on their investment. For the private sector to play a critical role in addressing marine chemical pollution, market conditions need to be sufficiently attractive, says Torsten Thiele, founder of the Global Ocean Trust.

Ultimately, it is unrealistic to expect the chemicals sector to act alone. Regulatory change, public pressure and demand for more sustainable chemical inputs from retailers, and substantial capital investment from the finance sector, will all be required if the industry shifts to less-polluting business models. "There are chemicals companies ready to make better,

A road map for industry-led action on marine chemical pollution

- **Innovation**: develop new, more-sustainable products and processes, and shift from a risk-based approach to a hazard-avoidance one.
- Create **commercial incentives to change**: if the private sector is to play a critical role in addressing marine chemical pollution, market conditions must allow it to profit from doing so.
- Create industry-wide or sector-specific **coalitions of the willing** to help mitigate "first-mover disadvantage" and bring together industry players with other stakeholders from finance, governments and civil society.
- Increase **transparency and collaboration across the supply chain**: chemicals users can demand greater openness about polluting and hazardous inputs in their products.
- **Improve processes and practices for chemicals users**: best practices are also emerging in the agriculture, aquaculture and waste management sectors that demonstrate a pathway for using and managing chemicals more responsibly.
- Conduct a conversation on **extended producer responsibility**: to tackle marine chemical pollution effectively, chemicals producers will need to accept more responsibility for what happens to their products after sale.

safer and more sustainable chemistries," says Mr Tickner. "But no one wants to pay for it. We are slowly getting there, but there is a lot more to change."

The only feasible way to reduce pollution while still providing the products the world needs is to innovate. The chemicals industry is the only stakeholder with the resources and know-how to do this at scale

In some ways, it is difficult to imagine how the chemicals sector, which is so sprawling, so diverse, and so reliant on revenue from polluting products, can be a proactive driver of change. But there are encouraging examples that—if replicated and scaled—could dramatically reduce chemical pollution in the ocean.

For many, the chemicals sector itself is the problem. But given the crucial role they play in modern life, there is no choice but to co-operate and engage with the industry. The only feasible way to reduce pollution while still providing the products the world needs is to innovate. The chemicals industry is the only stakeholder with the resources and scientific know-how to do this at scale.

Underpinning this effort must be a conversation about risk and responsibility. To tackle marine chemical pollution effectively, chemicals producers will need to accept more responsibility for what happens to their products after sale. Consumers increasingly expect and demand this, and their voices may yet be the key to persuading chemicals producers to be more accountable.

Some retailers now require not just transparency about chemicals along their supply chain but demand safer chemicals, too. These examples provide a clear pathway for how other chemicals users can demand greater openness about polluting and hazardous inputs in their products.

Processes are as important as products, and best practices are also emerging in the agriculture, aquaculture and waste management sectors that demonstrate a pathway for using and managing chemicals more responsibly.

Most businesses will be unwilling to act alone in both the chemicals sector and along the chemicals supply chain. An industry coalition focused squarely on reducing marine chemical pollution could agree on best practices and give commercial cover to first-movers. The challenge will be filtering changes throughout the industry. Preaching to the choir is one thing, but it will be crucial, too, to engage the congregation.

Nothing short of a green chemical revolution is needed. The key to unlocking it is the creation of commercial incentives for the industry to profit from the transition. Encouragingly, a few chemicals companies have started to embed sustainability in their business model—and to profit from it.

Please see Notes for references

Notes

1 Living Ocean, NASA Science. See: https://science.nasa.gov/earth-science/oceanography/living-ocean/

2 UNEP and Biodiversity, UNEP (2020). See: https://www.unep.org/unep-and-biodiversity

3 Ibid.

4 Toward a Global Understanding of Chemical Pollution: A First Comprehensive Analysis of National and Regional Chemical Inventories, Wang Z et al, Environmental Science & Technology (January 2020). See: https://pubs.acs.org/doi/10.1021/acs.est.9b06379

5 Why chemical pollution is turning into a third great planetary crisis, Graham Lawton, New Scientist (July 2021). See: https://www.newscientist.com/article/mg25133440-700-why-chemical-pollution-is-turning-into-a-third-great-planetary-crisis/

6 Chemical Companies Need a Bold New Approach to Value Levers, Andreas Gocke, Marcus Morawietz, and Udo Jung, BCG (March 2021). See: https://www.bcg.com/en-au/publications/2021/a-new-approach-to-value-levers-in-the-chemical-industry

7 Chemical companies tout green credentials whilst developing hazardous chemicals behind closed doors, ChemSec (December 2021). See: https://chemsec.org/chemical-companies-tout-green-credentials-whilst-developing-hazardous-chemicals-behind-closed-doors/

8 ChemSec ChemScore. See: https://chemscore.chemsec.org/

9 Sustainable Solution Steering, BASF: See: https://www.basf.com/au/en/who-we-are/sustainability/we-drive-sustainable-solutions/sustainable-solution-steering.html

10 Solutions: Contributing through Business –Sumika Sustainable Solutions (SSS), Sumitomo Chemical. See: https://www.sumitomo-chem.co.jp/english/sustainability/management/promotion/sss/

11 DSM, Integrated Annual Report 2020. See: https://annualreport.dsm.com/ar2020/report-by-the-managing-board/planet/product-stewardship.html

12 Responsible Care® Global Charter: Company Signatories, International Council of Chemical Associations. See: https://icca-chem.org/wp-content/uploads/2020/09/Signatories-of-RC-Global-Charter.pdf

13 Ibid.

14 Teaming up for a sustainable future: Cefic Sustainability Charter, Cefic. See: https://cefic.org/app/uploads/2019/01/Cefic-Sustainability-Charter-TeamingUp-For-A-SustainableEurope.pdf

15 Cefic Sustainable Development Indicators, Cefic. See: https://cefic.org/a-solution-provider-for-sustainability/cefic-sustainable-development-indicators/

16 Molecule Managers: A journey into the Future of Europe with the European Chemicals industry, Cefic. See: https://cefic.org/app/uploads/2019/06/Cefic_Mid-Century-Vision-Molecule-Managers-Brochure.pdf

17 Sustainable by Design: Boosting Innovation and Growth within the European Chemical Industry, Cefic. See: https://cefic.org/app/uploads/2021/09/Safe-and-Sustainable-by-Design-Report-Boosting-innovation-and-growth-within-the-European-chemical-industry.pdf

18 Together for Sustainability (TfS). See: https://tfs-initiative.com/

19 Chemicals sector SDG Roadmap, World Business Council on Sustainable Development. See: https://docs.wbcsd.org/2018/07/Chemical_Sector_SDG_Roadmap.pdf

20 Chemical Industry Methodology for Portfolio Sustainability Assessments (PSA), World Business Council for Sustainable Development (October 2018). See: https://www.wbcsd.org/Programs/Circular-Economy/Resources/Chemical-Industry-Methodology-for-Portfolio-Sustainability-Assessments

21 Transitioning the Chemical Industry: The Case for Addressing the Climate, Toxics, and Plastics Crises, Joel Tickner, Ken Geiser & Stephanie Baima, Environment: Science and Policy for Sustainable Development (2021). See: https://doi.org/10.1080/00139157.2021.1979857

22 Tickner et al, Environment: Science and Policy for Sustainable Development (2021)

23 Green Chemistry: Theory and Practice, P T Anastas and J C Warner, Oxford University Press, Oxford (1998)

24 The Green Chemistry & Commerce Council (GC3). See: https://greenchemistryandcommerce.org/

25 GC3 Startup Network. See: https://greenchemistryandcommerce.org/startup-network/

26 Cefic Future Chemistry Network. See: https://cefic.org/thought-leadership/future-chemistry-network/

27 "Forsaking funding at a 1 billion valuation, Solugen preps a new gen chemical product and a big 2021", Jonathan Shieber, Tech Crunch (January 2021). See: https://techcrunch.com/2021/01/21/forsaking-funding-at-a-1-billion-valuation-solugen-preps-a-new-green-chemical-product-and-a-big-2021

28 P2 Science. See: https://p2science.com/about-us/

29 DexLeChem. See: http://www.dexlechem.com/home_en

30 Lygos. See: https://lygos.com/

31 Green Earth Institute. See: http://www.gei.co.jp/en/

32 Solugen. See: https://solugen.com/about

33 "Eastman Chemical Company's quest to develop a safer solvent", Carol Perkins, GreenBiz (September 2016). See: https://www.greenbiz.com/article/eastman-chemical-companys-quest-develop-safer-solvent

34 Barriers to the Implementation of Green Chemistry in the United States, Matus et al, Environmental Science & Technology (2012). See: https://pubs.acs.org/doi/10.1021/es3021777

35 Green Chemistry a Strong Driver of Innovation, Growth, and Business Opportunity, Golden et al, Green Chemistry & Commerce Council and University of Massachusetts Lowell (October 2021). https://greenchemistryandcommerce.org/resources/publications

36 Ibid.

37 UK Research and Innovation (UKRI) Interdisciplinary Centre for the Circular Chemical Economy, Loughborough University. See: https://www.lboro.ac.uk/departments/chemical/research/centre-for-circular-chemical-economy/

38 Chemical Recycling Poised to Take Off, Sreeparna Das, Plastics Technology (January 2021). See: https://www.ptonline.com/articles/chemical-recycling-ready-to-take-off

39 Slow Reactions: Chemical companies must transform in a low-carbon world, Jana Maria Hock, ShareAction (September 2021). See: https://api.shareaction.org/resources/reports/Slow-Reactions-Chemicals-and-Climate.pdf

40 Hazard vs. Risk; Who's the winner from a chemicals legislation perspective? ChemSec. See: https://chemsec.org/publication/risk-and-hazard/hazard-vs-risk/

41 Towards Environmental Sustainability in Marine Finfish Aquaculture, Carballeira Braña et al, Frontiers in Marine Science (April 2021). SeeL https://www.frontiersin.org/articles/10.3389/fmars.2021.666662/full

42 Aqua Nutrition Sustainability Report 2020, Cargill. See: https://www.cargill.com/doc/1432196768685/cargill-aqua-nutrition-sustainability-report-2020.pdf

43 Can we reduce fertilizer use without sacrificing food production? Hannah Ritchie, Our World In Data (September 2021). See: https://ourworldindata.org/reducing-fertilizer-use

44 "Here's how precision agriculture could help farmers reduce fertilizer use", Emma Bryce, Anthropocene (April 2019). See: https://www.anthropocenemagazine.org/2019/04/heres-how-precision-agriculture-could-help-farmers-reduce-fertilizer-use/

45 Solving Marine Pollution, Olha Krushelnytska, World Bank Group (September 2018). See: https://documents1.worldbank.org/curated/en/651521537901259717/pdf/130154-WP-PUBLIC-SolvingMarinePollution.pdf

46 Project Catalyst. See: https://www.projectcatalyst.net.au/

47 First Climate. https://www.firstclimate.com/en/water-quality-credits/

48 Reef Credit Scheme. https://greencollar.com.au/reef-credits/

49 Krushelnytska (2018)

50 Nike Chemistry. See: https://about.nike.com/pages/chemistry-restricted-substances-list

51 Sephora Public Chemicals Policy (July 2019). See: https://www.sephorastands.com/wp-content/uploads/Sephora-Public-Chemicals-Policy-July-2019.pdf

52 Sephora Public Chemicals Policy 2nd Progress Update (2021). See: https://www.sephorastands.com/wp-content/uploads/Sephora-Public-Chemicals-Policy-2nd-Progress-Update-2021-.pdf

53 How we work with chemicals, IKEA. See: https://about.ikea.com/en/sustainability/healthy-and-sustainable-living/how-we-work-with-chemicals

54 Environmental Progress Report, Apple (2020). See: https://www.apple.com/environment/pdf/Apple_Environmental_Progress_Report_2020.pdf

55 Chemicals, H&M Group.See: https://hmgroup.com/sustainability/circular-and-climate-positive/chemicals/

56 Our approach to the safety of products and ingredients, Unilever. See: https://www.unilever.com/brands/Our-products-and-ingredients/Our-approach-to-the-safety-of-products-and-ingredients/

57 Unilever to eliminate fossil fuels in cleaning products by 2030, Unilever. See: https://www.unilever.com/news/press-releases/2020/unilever-to-invest-1-billion-to-eliminate-fossil-fuels-in-cleaning-products-by-2030.html

58 Consumer goods giants team up for greener chemicals drive, Sarah George, Edia (May 2021). See: https://www.edie.net/news/8/Consumer-goods-giants-team-up-for-greener-chemicals-drive/

59 ASN bank talks with Unilever about microplastics in cosmetics, Plastic Soup Foundation (July 2020). See: https://www.plasticsoupfoundation.org/en/2020/07/asn-bank-talks-with-unilever-about-microplastics-in-cosmetics/

60 The Estée Lauder Companies Publishes Methodology to Drive Sustainable Cosmetics Innovation & Strengthen Environmental, Social & Governance Commitments, Market Screener (December 2021). See: https://www.marketscreener.com/quote/stock/THE-ESTEE-LAUDER-COMPANIE-12437/news/Estee-Lauder-The-Estee-Lauder-Companies-Publishes-Methodology-to-Drive-Sustainable-Cosmetics-Innov-37249658/

61 ERASM. https://www.erasm.org/

62 Charter for Sustainable Cleaning, International Association for Soaps, Detergents and Maintenance Products. https://www.aise.eu/our-activities/sustainable-cleaning-78/charter-kpi-reporting.aspx

63 Health Product Declaration® (HPD) Collaborative. https://www.hpd-collaborative.org/

64 Sumitomo Chemical, "Sustainability Data Book 2020". See: https://www.sumitomo-chem.co.jp/english/sustainability/files/docs/environmental_protection.pdf

65 Pfizer's Green Chemistry Program, Juan Colberg et al, ACS (November 2021). See: https://communities.acs.org/t5/GCI-Nexus-Blog/Pfizer-s-Green-Chemistry-Program/ba-p/86557

66 Slow Reactions: Chemical companies must transform in a low-carbon world, Jana Maria Hock, ShareAction (September 2021). See: https://api.shareaction.org/resources/reports/Slow-Reactions-Chemicals-and-Climate.pdf

67 Green and sustainable chemistry education: Nurturing a new generation of chemists: Foundation paper for United Nations Environment Programme Global Chemical Outlook II, Vania Zuin and Ingo Eilks, UNEP (January 2019). See: https://wedocs.unep.org/bitstream/handle/20.500.11822/32621/GSE.pdf?sequence=1&isAllowed=y

68 Chemical companies tout green credentials whilst developing hazardous chemicals behind closed doors, ChemSec (December 2021). See: https://chemsec.org/chemical-companies-tout-green-credentials-whilst-developing-hazardous-chemicals-behind-closed-doors/

69 The state of the chemical industry—it is getting more complex, McKinsey & Company (November 2020). See: https://www.mckinsey.com/industries/chemicals/our-insights/the-state-of-the-chemical-industry-it-is-getting-more-complex

70 Tickner et al, Environment: Science and Policy for Sustainable Development (2021)

71 Chemical industry vision 2030: A European perspective, Kearney. See: https://www.kearney.com/chemicals/article?/a/chemical-industry-vision-2030-a-european-perspective

72 Tickner et al, Environment: Science and Policy for Sustainable Development (2021)

73 Slow Reactions: Chemical companies must transform in a low-carbon world, ShareAction (September 2021). See: https://api.shareaction.org/resources/reports/Slow-Reactions-Chemicals-and-Climate.pdf

74 2022 chemical industry outlook, Deloitte (2021). See: https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/chemical-industry-outlook.html

75 Tickner et al, Environment: Science and Policy for Sustainable Development (2021)

76 Ibid.

77 Ibid.

78 Chemical industry vision 2030, Kearney

79 Getting to Zero Coalition. See: https://www.globalmaritimeforum.org/getting-to-zero-coalition/ambition-statement

80 ReSource Plastic. See: https://resource-plastic.com/footprint-tracker

81 The Alliance to End Plastic Waste. See: https://endplasticwaste.org/About

82 Operation Clean Sweep. See: https://www.opcleansweep.org/

83 Global Goals, Ocean Opportunities, United Nations Global Compact (2019). See: https://d306pr3pise04h.cloudfront.net/docs/publications%2FGlobal-Goals-Ocean-Opportunities.pdf

84 Sustainable Ocean Business Action Platform, United Nations Global Compact. See: https://www.unglobalcompact.org/take-action/ocean

85 The Chemical Footprint Project. See:https://www.chemicalfootprint.org/

86 Safer Choice, EPA. See: https://www.epa.gov/saferchoice

ECONOMIST IMPACT

LONDON

20 Cabot Square
London, E14 4QW
United Kingdom
Tel: (44.20) 7576 8000
Fax: (44.20) 7576 8500
Email: london@eiu.com

GENEVA

Rue de l'Athénée 32
1206 Geneva
Switzerland
Tel: (41) 22 566 2470
Fax: (41) 22 346 93 47
Email: geneva@eiu.com

NEW YORK

750 Third Avenue
5th Floor
New York, NY 10017
United States
Tel: (1.212) 554 0600
Fax: (1.212) 586 1181/2
Email: americas@eiu.com

DUBAI

Office 1301a
Aurora Tower
Dubai Media City
Dubai
Tel: (971) 4 433 4202
Fax: (971) 4 438 0224
Email: dubai@eiu.com

HONG KONG

1301
12 Taikoo Wan Road
Taikoo Shing
Hong Kong
Tel: (852) 2585 3888
Fax: (852) 2802 7638
Email: asia@eiu.com

SINGAPORE

8 Cross Street
#23-01 Manulife Tower
Singapore
048424
Tel: (65) 6534 5177
Fax: (65) 6534 5077
Email: asia@eiu.com