Blue Planet Prize 2023

Professor Richard Thompson OBE FRS
Professor Tamara Galloway OBE
Professor Penelope Lindeque

Interview Summary

THE ASAHI GLASS FOUNDATION

Professor Richard Thompson OBE FRS / Middle

Born: 15 July 1963 / UK
Professor of Marine Biology and
Director of the Marine Institute, Plymouth University

Professor Tamara Galloway OBE / Right

Born: 6 February 1963 / UK
Professor of Ecotoxicology, School of Biosciences,
University of Exeter

Professor Penelope Lindeque / Left

Born: 7 September 1971 / UK
Head of Science, Marine Ecology and Biodiversity,
Plymouth Marine Laboratory

—Research and Achievements by the Three Laureate Professors—

<Impact of ingestion of microplastics by plankton>

A team of researchers comprising of three professors has conducted research on the effects of pollutant microplastics on marine life and outlined the adverse effects of microplastics on zooplankton after ingestion as follows:

- ◇ Microplastics can be mistaken for food and when ingested by zooplanktons it would cause them to feel less hunger, which results in reduced intake of real food, leaving them undernourished and leading to reduced reproductive rates and increased production of unhatched eggs, which ultimately decreases their viability.
- ◇ Certain microplastic chemicals inhibit molting and can impede the growth of zooplankton.
- ◇ Plastics contain a range of additives, and their microscopic particles can pass through the digestive system and enter the bloodstream of zooplankton. This can interfere with the immune and hormonal systems, leading to health problems for genetic material.
- ◇ Zooplankton forms the basis of the food web and decline in zooplankton populations caused by nutritional deficiencies and health damage reduces the food available for animals that

depend on them.

◇ Zooplankton absorb carbon from the water surface and settle on the seabed after their death. This absorption of carbon helps hinder the progress of global warming, however, the uptake of microplastics enhances the buoyancy of dead zooplankton, which hinders the transfer of carbon to the seabed, leaving a negative impact on the biological pump as a whole.

Zooplankton ingesting microplastics

In addition, the following influences can be expected on the food web

◇ Zooplankton ingest microplastics

◇ Small fish ingest the zooplankton that ingested microplastics

◇ The small fish would normally also ingest microplastics through seawater in addition to the intake through zooplankton, resulting in multiplied contamination

◇ Larger fish and marine mammals that prey on these small fish also ingest multiple layers of plastic through various sources

As shown above, plastic pollution is widespread in all layers of the marine food web.

Plastic pollution is prevalent not only in marine life but also in wildlife and human tissue. However, the extent and location of ingestion, as well as the adverse effects, are subjects of ongoing research. Professor Galloway, who specialises in biotoxicology, explains;

"In toxicology, we have a saying that all substances are a poison. There is no substance that is no poison. It's the dose that makes the poison. So generally, the more of something that you take, the more its effects are going to be. With plastics, we don't yet understand, at what level they start to have a negative effect."

＜Working Towards Solutions＞

While the professors are researching the effects of microplastics on marine life, they are also exploring solutions to the issue.

One potential solution is the utilization of mussels and other bivalves for microplastic removal. Professor Lindeque's team is conducting tests on such natural filtration methods.

Bivalves such as mussels ingest seawater and extract nutrients from the enclosed plankton and other

substances. They have a voracious appetite and filter vast quantities of water up to 150,000 litres per day. Moreover, shellfish display superior resistance to plastic pollution compared to zooplankton. Professor Lindeque and her team have constructed a unique tank to mimic coastal conditions and placed mussels inside, to measure their ability to eliminate microplastics from running water in a naturalistic setting. The results indicated that a kilogram of mussels was capable of filtering out 250,000 pieces of microplastic per hour. Naturally, most of the microplastic would be ingested by the mussels and then discharged again, so they put the mussels in a custom-made cage-like container in a natural setting and fix a funnel-like setup at the container's base to gather all the mussels' excreta which contains microplastic. Professor Lindeque highlights that this technique can be executed with any bivalve mussel worldwide.

Professor Galloway collaborates with various companies to study methods of utilizing organic waste to produce easily degradable plastic substitutes, which break down into water and carbon dioxide after use. One such method currently under consideration is deriving polymers from the carbon in banana peels. They try designing prototype products that provide the advantages of plastic yet could easily decompose with no harm to the environment after use. The research collaborated with Professor Lindeque is currently underway in the Galapagos Islands, where plastic waste poses a significant challenge to the environment. Their experiment aims to reduce plastic waste through the development of new plastic materials from waste that biodegrades back into the local environment.

Another collaborative project involving Professor Thompson and Professor Lindeque is the Bioplastic Risk Project. Bioplastics are renewable plastics created from carbon sources like plant materials. Biodegradable bioplastics are now widely used as a superior alternative to traditional

plastics and a vast amount is already entering marine environments. Regrettably, sufficient research has not yet been done in this field. Even if bioplastics are made from biologically derived raw materials, the resulting material may not be highly degradable, depending on environmental conditions. The team led by the professors placed various so-called biodegradable materials in natural, terrestrial, and marine environments to research their biodegradation process in each ecosystem. They investigate how biodegradable substances move through the environment, how they are processed in ecosystems and geobiochemistry, whether they also move and settle in sediments, and whether they have any negative effects, etc. They aim to provide evidence for the development of new plastic alternatives that have less impact on the environment.
In this way, the three professors are not only collaborating in their efforts to solve the existing plastics problems, but also addressing new issues surrounding microplastics.

＜New challenges with microplastics＞

Plastic issues are expanding beyond microplastics. Over a decade ago, an article studying plastics in cosmetics revealed that a lone cosmetics container held three million plastic particles. This evidence was presented to the UK Parliament and eventually led to the creation of legislation to forbid the production of such cosmetics. Nonetheless, there are now another type of plastic concern. One example is microfibres, i.e., plastic fibres originating from clothing and fabric. These fibres are lengthy, slim plastic strands that emerge from textile waste and the manufacturing and washing of garments. With hundreds of millions of garments produced globally each year, and a third of them discarded without even being worn, the vast discharge of plastic fibres into the environment poses a serious issue. In the effort to reduce the level of fibres discharged into the environment, extensive research conducted by Dr. Imogen Napper, who collaborates with Professor Thompson, revealed that altering the types of materials and the way they are used in the clothing could reduce the amount of fibre release by 80%. This result highlighted the importance of choosing the right materials in the clothing from the production stage, to significantly decrease harmful plastic discharge into the environment. It also turned out that the plastic particles generated from car tyres are posing a serious issue to the environment. As tyres wear down, they release thousands of particles onto the road surface every time a car is driven. These particles are scattered far and wide by the atmosphere and penetrate into the natural environment. In the event of heavy rainfall, they are washed into drainage channels and eventually carried into rivers and the sea. The problem with tyre particles is that they are more toxic than other types of plastics and that they are extremely small and black in colour, making them extremely difficult to collect. It is also impossible to stop the usage or production of tyres in today's world, as they would be required even with all-electric vehicles. Professors are currently working to find out how tyre particles move and where they accumulate, as well as to identify highly toxic chemicals. The aim is thereby to provide evidence of safety at the planning and design stages and to encourage the production of safer tyres.

＜The Ubiquity of Microplastic on Earth＞

Professor Thompson is a renowned pioneer and leading authority on the issue of microplastics and receives valuable input from numerous scientists. Researchers examining the deep sea have sought his advice concerning plastics discovered in thousands of metres of water. In close collaboration with Dr Lucy Woodall of the Natural History Museum, he has identified significant amounts of plastic present in deep-sea sediment. Scientists working in the Arctic have discovered plastic in the ice cores they've retrieved and analysed. They have also received queries from an indigenous individual living in the Arctic Circle of North America, who questioned whether a change in the taste of their drinking water could possibly due to plastic contamination. There is also a report from some project analyzing the snow near the peak of Mount Everest, which revealed the presence of plastic.
Small fragments of plastic which became microparticles, nanoparticles as well as microbeads, are now ubiquitous across the globe. They travel invisibly through both human and natural pathways, spreading via the ocean and atmospheric circulation.

＜International Contribution＞

The warning about the dangers of microplastic pollution by three scientists, Professors Thompson, Galloway and Lindeque, and the researchers who collaborated with them on the problem of plastics, resulted in the passing of the Microbead-Free Waters Act in the US in 2015. In 2017, the United Nations Environment Assembly (UNEA) resolved to a global objective to tackle plastic pollution in marine environments. In 2018, legislation was enacted in the UK, Sweden, Canada, New Zealand and South Korea that prohibits products containing plastic microbeads in an effort to tackle the issue. Furthermore, the REACH regulation, which regulates chemicals in the EU, has resulted in global limitations on intentionally adding microplastics to products. The study findings of the professors are affecting decision makers, instigating modifications and carrying notable consequences for the international society.

—Personal, Educational and Professional Background of the Laureates Professors—

Professor Richard Thompson;

<Early Childhood to University>

Professor Richard Thompson was born in July 1963 in Nottingham, UK., where he resided until he commenced his university studies. He was an only child, raised by parents who came from families deeply rooted in Nottingham for over a century. Many of his relatives also lived nearby. The family house, on the city's outskirts, had a charming garden. During his childhood, he dug a sizable hole in the garden to create a pond, fostering a habitat for wildlife.

Childhood photo of Prof. Thompson at primary school in Arnold, Nottingham.

Frequent family trips to the seaside and expeditions to nearby rivers to look at the creatures living there became cherished memories, fostering his deep connection to the natural world, especially waterside environments. One enduring childhood memory centers around his fascination with a TV documentary series titled "The Undersea World of Jacques Cousteau," presented by the renowned oceanographer Jacques-Yves Cousteau.

Professor Thompson's passion for biology was ignited by a dedicated teacher who nurtured his innate curiosity for scientific exploration. Though uncertain of his academic path after high school, he ventured into the business world for seven years, running his own shop selling everything from birthday cards to Christmas decorations. Despite its success, the business lacked personal fulfillment, pushing him towards higher education. His love for the sea deepened during this period, as he actively pursued snorkeling and acquired diving skills in his leisure time. This fueled his natural progression towards Marine Biology.

Professor Thompson aimed for a career Marine Biology and enrolled at Newcastle University. Though other universities caught his attention, Newcastle's proximity to the River Tyne and the nearby coastline, ensuring a constant connection to the sea, was a decisive factor.

Graduation from Newcastle University

He recalls those university days with fondness, marked by academic success that fueled his determination to push further. After his bachelor's degree, Professor Thompson spent a year on construction sites, working part-time while refining his academic focus, before pursuing a PhD at the University of Liverpool.

During his time at the University of Liverpool, Professor Thompson delved into the intricate relationship between grazing molluscs and their food, revealing its profound impact on coastal ecosystems. Mollusc populations devour algae, which can trigger a domino effect with the abundance of larger seaweed declining, impacting its dependent organisms and causing biodiversity shifts. Conversely, an algae boom may lead to a shellfish decline, reshaping the entire ecosystem. "Understanding this delicate equilibrium was paramount," Professor Thompson emphasizes, highlighting the importance of this work.

Larger algae tend to be scarce in wave-battered coasts, where filter-feeders like barnacles and mussels flourish due to constant water flow. Sheltered areas, conversely, favor lush algal growth. Yet, even moderate-wave beaches experience dramatic fluctuations, boasting abundant algae one year and complete barrenness a few years later. What environmental forces disrupt this delicate balance? Professor Thompson's exhaustive research revealed the significant role of meteorological factors.

The effects become particularly pronounced during summer when the sun's altitude increases, leading to rising temperatures, enhanced UV radiation, and desiccation stress, impacting both algae and shellfish. Professor Thompson underscores the importance of understanding these natural interactions. Distinguishing these natural variations from human-induced changes is essential for a comprehensive understanding of environmental changes. This prevents misattributing natural fluctuations to human actions, ensuring informed conservation and management practices.

Following his PhD at the University of Liverpool in 1996, Professor Thompson held lecturing positions at the Universities of Newcastle and Southampton. He eventually settled in Plymouth, taking up a vacant post in Marine Ecology at the University of Plymouth.

＜Interest in plastics, related papers and people’s reactions＞

During his PhD research, Professor Thompson helped organise beach cleanups, diligently collecting all the rubbish along the coast. However, despite his unwavering efforts, the tide of litter seemed endless, prompting him to investigate its source. Seeking a deeper understanding, Professor Thompson enlisted the collaboration of local volunteers. Together, they organized extensive beach cleanups, meticulously sorting and recording data on the gathered litter. But a concerning reality emerged: the most prevalent culprits, tiny plastic fragments, were often overlooked, their insidious presence unrecorded. Recognizing this, Professor Thompson asked his students to find the smallest items po of plastic on the beach. Microscopic examination of their sand samples confirmed the presence of these insidious microplastics, revealing the extent of the invisible threat.

He collaborated with chemists to analyze the particles and identified common polymers, particularly polyethylene. This marked the inception of Professor Thompson's exploration into microplastics. Nearly a decade later, in 2004, his paper titled "Lost at Sea: Where Is All the Plastic?" was published in the journal Science. The paper unveiled the accumulation of minuscule plastic particles as imperceptible waste in the oceans, a previously overlooked reality. He was surprised when the paper sparked an overwhelming and substantial response, inundating the university with emails, phone calls, and inquiries. Consequently, Professor Thompson shifted his primary research focus from marine ecology to the pressing issue of plastic pollution, consuming a significant portion of his research time. This groundbreaking paper initiated a new field of scientific inquiry into plastics.

Professor Thompson considers himself extremely fortunate that his paper was published in Science. At the time, his research on plastics was unfunded and conducted during his spare time, driven by personal interest—essentially, a hobby pursuit. He expresses gratitude for the invaluable assistance of numerous student volunteers who contributed to the research without requiring substantial funding. The absence of time constraints allowed him to delve deeply into the subject, and several fortunate circumstances also contributed to the paper's production. He coined the term 'microplastics' to describe these small plastic fragments, defining them as particles smaller than 5mm.

The publication of his paper in Science significantly raised global awareness about the issue of microplastics and profoundly impacted Professor Thompson's research trajectory. Subsequently, it spurred collaborations with Professor Galloway, Professor Lindeque, and numerous scientists from diverse fields, all centered around this critical issue.

＜Encounter with Professor Galloway and Professor Lindeque＞

A research paper by Professor Hideshige Takada from Tokyo University of Agriculture and Technology prompted Professor Thompson's interest in the link between plastics and chemicals. Takada's study revealed a startling fact: plastics have a strong affinity for hazardous chemicals in the environment. Imagine washing dishes with vibrant food coloring like curry in a plastic bowl; the pigments, due to their hydrophobic nature, stick stubbornly to the plastic, preferring it over water. This raised concerns about plastics serving as a conduit for toxic chemicals, potentially releasing them into the environment and impacting marine life. Intrigued by these implications, and prompted by his Head of School, Professor Thompson sought the expertise of Professor Galloway,

a renowned ecotoxicologist.

He was subsequently introduced to Professor Lindeque through Galloway, who she already shared collaborations with. Lindeque, with a keen interest in the reciprocal relationship between plastics and plankton, joined forces with them from the Plymouth Marine Laboratory. Plankton, being the foundation of the food chain, plays a pivotal role in any study concerning the impacts of contaminated plastics on marine organisms. Through the combined expertise of Professor Lindeque, specializing in plankton, Professor Galloway in ecotoxicology, and Professor Thompson in environmental science and marine biology, this small region in the southwest of the UK has become a global leader in plastics research.

Professor Tamara Galloway:

<Early Childhood to University>

Childhood photo of
Prof. Galloway with her brother

Professor Tamara Galloway was born in February 1963 in Sussex, England, moving to Glasgow, Scotland when she was a year old. Raised in a family of four, she lived with her father - a Russian linguist at the University of Glasgow - her mother, a teacher, and her brother. Their residence on the outskirts of the city offered Tamara easy access to the stunning Scottish countryside, which she frequently explored on nature walks. In addition, she enjoyed playing with dolls at home. From a young age, Professor Galloway exhibited a keen curiosity about the world around her, particularly in understanding how things worked. She holds deep gratitude for her parents, who consistently supported and encouraged her exploration of various interests. It was, however, during her time at the university that her passion for science and biology truly blossomed.

Scottish university education differs from that in England in several ways. Tuition fees are not imposed, and it operates under a distinctive academic system known as the "broad general" program. In their first year, students take a wider range of subjects before specializing in a chosen field during a three-year undergraduate bachelor's program. Professor Galloway embarked on her academic journey at the University of Glasgow, selecting biochemistry as her major. Her choice was influenced by an inspiring visit to the laboratory of Dr. Duncan Stewart-Tull, a microbiologist and a close friend of her father, who lived in their neighborhood. It was during her time at the university that Professor Galloway became captivated by biology. The intricate explanations of the mechanics of life, the complexities of our existence, and the evolution of life forms held a deep fascination for her. She marveled at how this discipline explores the unique characteristics defining various living species, from the depths of the ocean to the vastness of the skies, and unravels the fundamental basis for

their diverse adaptations. Recognizing the depth of understanding entailed in the science of biology, she found these phenomena utterly captivating.

Following her undergraduate studies in biochemistry at the University of Glasgow, Professor Galloway delved deeper into the biochemistry that enables living processes by pursuing a Ph.D in Biochemistry at the esteemed University of Edinburgh Medical School, where she focused on the intricate toxins produced by cholera bacteria. It was during this phase that her passion for the environment began to blossom. The seed of curiosity was planted when she attended a captivating lecture by an ecologist. The lecture vividly painted a picture of the environmental impact of human activity - the mountains of waste we generate, the vast quantities of oil we burn, the rivers we drain. Professor Galloway was surprised, then immediately intrigued, by the sheer scale and complexity of this impact. It dawned on her that human awareness of our environmental footprint was woefully inadequate.

The cholera toxin she researched was significantly influenced by environmental factors, rather than being solely attributed to the structure of the bacterium. Simply encountering the bacteria may not cause significant harm. However, when the bacteria thrive in unsanitary conditions, like contaminated water or poor sanitation, it can lead to severe illness in humans. Therefore, addressing these concerns could involve focusing on improving environmental hygiene and sanitation practices, rather than solely targeting the bacteria itself. Fueled by her deep passion for the field and unwavering support from friends and mentors, Professor Galloway completed her Ph.D. in Biochemistry at the University of Edinburgh. Following graduation, she pursued a career in clinical diagnostics at a pharmaceutical firm in London, where she lived with her partner. However, after the birth of her first child in 1988, she took a seven-year career break to focus on raising her family.

＜Returning to science and starting a career in biotoxicology＞

While raising her children, Professor Galloway and her family relocated from London to Cornwall in southwest England. During this time, she worked as a part-time lecturer at several further education colleges. A chance encounter at a party on the outskirts of a small town led to a pivotal moment in her career: she met Dr. Peter Mitchell, the 1978 Nobel Prize winner in Chemistry. Engaging in a conversation about her career aspirations, Professor Galloway was offered a research assistant position at Dr. Mitchell's private research institute. This unexpected opportunity reignited her passion for science. Dr. Mitchell imparted two fundamental principles of scientific methodology that left an indelible mark on her. The first principle emphasized dedicating ten times more time to pondering an experiment than to its execution. The second principle stressed the futility of conducting an experiment if it couldn’t be succinctly explained in a single sentence. These insights

profoundly influenced her approach to experimental work. To this day, she regularly asks herself, "What precisely is my objective, and am I conducting this experiment after thorough contemplation?" Moreover, she endeavors to instill these concepts in her students, aiming to pass on Dr. Mitchell's valuable teachings.

Professor Galloway began her academic journey by taking on a part-time teaching role at Plymouth University, instructing biology to nurses. Following this, she transitioned into a research group at the same institution, devoting herself to exploring ecotoxicology. Her pivotal moment arrived in 1998 when she supervised a Ph.D. student focusing on the impact of insecticides, igniting her career in ecotoxicology. Ecotoxicology delves into the ecological consequences of hazardous contaminants, meticulously assessing their effects not only on individual organisms but also on communities, populations, habitat functions, and even minute alterations at the molecular level. This field extensively studies and investigates the repercussions of these changes on cells and organisms, ultimately aiming to understand and mitigate their environmental impact.

Leveraging her expertise in human health, Professor Galloway embarked on a new path, investigating the impact of contaminants on marine and underwater organisms. To delve deeper into this research domain, she initiated a collaboration with Professor Richard Thompson, who was then pursuing separate research at the University of Plymouth. This collaboration proved pivotal, prompting Professor Galloway to apply for an available position at the University of Exeter. In 2007, she secured her professorship in ecotoxicology, marking a significant milestone in her career. In the subsequent years, she co-supervised a student with Professor Lindeque, solidifying a long-lasting and productive collaboration between them.

＜Plastic and Biotoxicology＞

Professor Galloway's primary research focuses on endocrine disruptors, synthetic chemicals released into the environment that pose significant ecotoxicological risks. Their strong link to plastic production led her to collaborate with Professor Thompson on a comprehensive investigation into the plastic lifecycle, uncovering its final destinations and ecological impacts. For Professor Galloway, this exploration marked a significant departure from her previous expertise in human health science and diagnostic research, opening up a whole new research avenue.

The collaboration between Professor Thompson, a renowned expert on the impact of microplastics on marine life, and Professor Galloway, an ecotoxicologist with a background in human health science, was further enhanced by the involvement of Professor Lindeque, an expert in microscopic plankton ecology integral to the marine food web. Leveraging the collective knowledge and expertise of all contributors has significantly advanced the understanding of how plastics affect marine life and their ecosystems.

Professor Penelope Lindeque:

<Early Childhood to University>

Childhood photo of Professor Lindeque

Professor Penelope Lindeque was born in September 1971 in a village near Totnes, South-west England, where she spent her childhood with her family. Her father worked as a postman, her mother as a teacher, and she had an older brother. An active child, she devoted most of her time to playing outdoors in the woods and fields around her home. Her curiosity was evident as early as two years old when she dismantled a talking doll with a screwdriver to explore how it produced sound.

As a child, she harbored a deep love for nature and animals, which gradually evolved into a fervent interest in mathematics, chemistry, physics, biology, and art during her secondary school years. It was in sixth form, however, that her fascination with biology blossomed. This field, encompassing the functions and survival mechanisms of all living organisms across molecular and ecosystem levels, captivated her.

Guided by her passionate secondary school biology teacher, Penelope chose to pursue Applied Biology at the University of Bath. There, her university years provided her with a comprehensive education in biology, focusing on molecular biology, biochemistry, pharmacology, and ecology. This education extended beyond traditional classroom learning, encompassing diverse field and laboratory work. She worked on developing the animal model for multiple sclerosis, scrutinized fungi, and delved into marine ecology on the Lizard peninsula in Cornwall.

As her university tenure progressed, her passion gravitated toward biochemical science, specifically the intricate workings of organisms at the molecular level.

＜Plymouth Marine Laboratory＞

Fresh out of the University of Bath, Professor Lindeque landed a role at the Plymouth Marine Laboratory, helping to host the International Zooplankton Production Symposium and edit the resulting special issue. This work ignited her passion for zooplankton, and so before heading off to travel through New Zealand, Australia, and Southeast Asia with her now husband, she worked with potential supervisors to write a PhD proposal specializing in zooplankton and utilizing her undergraduate biomolecular skills. Her PhD proposal was successful, and she returned from travelling to start a PhD at Plymouth Marine Laboratory. While her undergraduate studies hadn't primarily focused on marine science, she was immediately captivated by the vital role the tiny zooplankton creatures played in ecosystems worldwide. Peering through a microscope, she marveled at their intricate forms and captivating beauty.

Her early research at the institute delved into the molecular identification and adaptations of zooplankton to changing environments. However, the course of her career took a sharp turn after Professor Richard Thompson's groundbreaking 2004 paper defining microplastics. The discovery ignited her passion to investigate the impact of these imperceptible plastic fragments on zooplankton, the essential contributors to the ecological web.

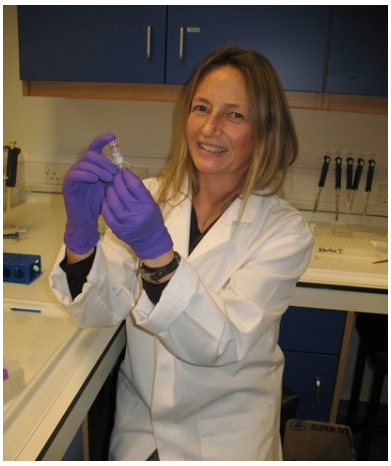
＜Microplastics and Zooplanktons＞

Professor Lindeque and Professor Tamara Galloway first crossed paths at a meeting on nanoplastics and microplastics. Both shared a deep concern about the potential adverse effects of plastics on the marine environment, and marine animals, but from different perspectives. Professor Galloway focused on the ecotoxicology aspect, while Professor Lindeque's expertise lay in zooplankton biology. This shared concern, along with their co-supervision of students, laid the foundation for a fruitful collaboration. Their joint research into the source, distribution and impacts of plastics expanded significantly over the years. When joining forces with Professor Richard Thompson this interdisciplinary partnership, based in the southwest of the UK, became a powerhouse of plastic research, involving colleagues from a wide range of disciplines. This bringing together of minds across disciplines allowed the team to look at the wider picture, to assess the problem, develop novel analysis techniques, challenge the status quo and look towards solutions.

In 2013, Professor Lindeque and her colleagues achieved a groundbreaking milestone. They published the world's first research paper demonstrating that zooplankton ingest microplastics as pollutants. More importantly, their work included capturing stunning images of microplastics, labeled with fluorescent dyes, being ingested by zooplankton and moving through their digestive tracts. These vivid images, depicting real-time exposure to microplastics, resonated strongly with the public. They served as a powerful visual reminder of the gravity of the issue, sparking widespread concern and prompting calls for action.

＜Research Beyond Marine Ecology＞

To achieve their groundbreaking discoveries, Professor Lindeque's team has pioneered several ingenious research techniques. One such method involves isolating microplastics from biological material using an enzymatic digestion technique, an adaptation of a technique Lindeque developed for obtaining DNA from zooplankton.



They have also devised a clever method for extracting microplastics from sediment. This process utilizes a highly concentrated salt solution, which allows inorganic material to sink and microplastics to float, the two then being mechanically separated.

Building upon their organic matter removal method, the team devised a new methodological pipeline for a crucial study looking at the ingestion of microplastic by a marine top predator – the seal. They collected seal excreta, aiming to assess microplastics within it, and using molecular techniques, to determine the diet of the seal. This pipeline allows insights to be gained into the plastic content of fish consumed by seals and therefore trophic transfer of microplastics. These methods were rigorously optimized for minimal environmental impact.

In 2019 Professor Lindeque and colleagues demonstrated that the density of ingested microplastics affects the sinking rate of copepod fecal pellets, a key route by which organic matter and carbon are transported from the surface to the deep ocean. This finding has important implications for deep ocean ecosystems, the carbon and climate.

Professor Lindeque has expanded her reach beyond biology, collaborating with chemists, remote sensers and mathematical modelers. One such collaboration has been with environmental economists on a paper that unveils the alarming economic consequences of marine plastic pollution. This groundbreaking research sheds light on how plastic contamination erodes the immense value of ecosystem services provided by marine habitats. Their estimates paint a stark picture, revealing an annual economic damage ranging from $500 billion to a staggering $2.5 trillion.

Numerous studies have underscored the multifaceted impact of marine plastic pollution, highlighting its detrimental effects on all dimensions of ecosystem services. These encompass tangible resources like food and materials (supply services), crucial regulatory functions such as the ocean's role in climate regulation and storm protection (regulatory services), and even the cultural benefits we derive from its beauty and recreational opportunities (cultural services).

This diverse collaboration of researchers underscores the power of pooling expertise and exchanging ideas to spark innovative research methodologies. Professor Lindeque considers this collaborative spirit a cornerstone of the Plymouth Marine Laboratory, attracting and fostering a vibrant spectrum of scientific talent.

—Relaxation and Work Motto of the Three Laureate professors—

＜Professor Richard Thompson＞

Professor Thompson, a dedicated researcher, emphasizes the importance of vacations and quality family time to unwind. During his spare moments, he indulges in various hobbies, including boating, canoeing, and collecting coins and stamps. Appreciating good food, wine, and short nature walks are also essential ways for him to recharge. In his professional endeavors, Professor Thompson prioritizes the precision and validity of his scientific research.

Professor Thompson with his daughters on the occasion of him being elected as a Fellow of the Royal Society

＜Professor Tamara Galloway＞

Despite her bustling research commitments, Professor Galloway finds solace in the sea. Whether it's swimming or paddleboarding with friends, regardless of the season, the ocean offers a sanctuary. Living in Cornwall with her partner Simon, a renowned sculptor, surrounded by the sea, rivers, moors, and woodlands, she considers it one of the world's most stunning locales. Walking her dog serves as another cherished way to unwind, alongside her passion for integrating yoga into her daily routine. Her work philosophy is centered on identifying and pursuing what truly ignites her enthusiasm. She firmly believes that if one lacks clarity on the purpose behind their actions, it might be time for a reevaluation. Fortunately, Professor Galloway harbors a genuine fondness for her work. She feels exceptionally fortunate to engage in what she regards almost as a hobby, all while being compensated for it.

Professor Galloway surfing with her friend

＜Professor Penelope Lindeque＞

Professor Lindeque's passions extend far beyond the lab. For relaxation, she enjoys rowing and racing Cornish pilot gigs, a traditional wooden rowing boat that slices through the ocean waves. She

also finds serenity in the simple pleasure of walking beside the sea and swimming in the open water. Her love for nature extends to her garden, where she cultivates fruits and vegetables, transforming them into homemade juices and jams—a delightful pursuit that aligns with her commitment to reducing plastic waste. During colder months, she crafts stunning jewelry from beach-combed sea glass and loses herself in the rhythmic art of crochet and other creative endeavors. Having grown up amidst the verdant beauty of nature, Professor Lindeque cherishes moments spent outdoors with her family and her loyal canine companion.

Professor Lindeque on SUP with her daughters

Professor Lindeque's leadership style centers on trust and respect, treating every colleague with unwavering integrity. As a team leader, she cultivates a nurturing environment that unlocks the potential within each member, fostering innovation, creativity, and perseverance. Ultimately, her aim is to guide her team towards generating impactful research that demonstrably fosters greater biodiversity, health, and productivity of our seas for future generations.

—Messages from the Three Laureate Professors—

Below you will find the concerns for climate change and each Professor's message to policy makers, industry stakeholders and to us all.

＜Professor Richard Thompson＞

“I foresee a looming threat posed by the escalating pressure of the expanding human population concerning the livable landmass and sustainable environmental conditions, including appropriate temperatures and accessible water and food sources. Human-driven climatic changes will significantly challenge our species, potentially sparking conflicts over increasingly scarce resources in the future.

My urgent message to both industry and policymakers is centered on the responsible usage of plastic. While durable and affordable plastics introduced in the 1950s were groundbreaking, our adoption of a disposable culture, primarily for convenience, has led to adverse consequences. In the 1950s, global plastic production stood at 5 million tons, with around 40% dedicated to single-use applications—an amount relatively small on a global scale. Contrastingly, today, we manufacture 400 million tons of plastic, 40% of which is single-use. Our planet cannot sustain such excessive waste generation rates.

When we're done with a plastic product, whether it's a soft drink bottle, a packet of crisps, or any similar item, it's crucial to consider its subsequent fate. Therefore, a fundamental shift must occur from the product's design phase. By incorporating environmental considerations into the design process, we can substantially minimize the release of microfibers, tire particles, or microbeads into our surroundings. Governments need to ensure that companies adopting responsible practices are not undermined by those neglecting their environmental responsibilities.

We need legislation that can drive us toward more responsible practices, while at the same time ensuring a fair marketplace. Subsequently, we need actively engaged consumers to embrace the necessary changes in production. Educating consumers on the responsible utilization of the planet's limited resources is crucial. Furthermore, reviewing and modifying our own behaviors, questioning the necessity of throwaway bags, and embracing reusable alternatives are crucial. Changing habits so deeply ingrained over 50 to 60 years is extremely challenging. However, gradual progress is achievable. For instance, bringing our own reusable bags while shopping is a small step. In our daily lives, we can adopt numerous practices, such as avoiding unnecessary plastic items and reusing products whenever possible, to address this issue.

The future of our blue planet rests heavily in our hands. Considering the example of plastic, I don't believe the solution lies in eliminating it from our lives, despite its undeniable harm to marine life and potential health impacts. Rather, it's about using plastics more responsibly. I strongly believe, we can extend this approach to tackle climate change and other environmental crises. However, reaching these goals demands commitment and depends on the collective dedication of governments, businesses, and each individual to embrace change and take action.“

＜Professor Tamara Galloway＞

“Our insatiable consumption and reckless disposal habits are the root of the problem. We extract,

drive, and produce excessively, tossing things aside without a thought. It's time to pause, reflect—what do we consume, what do we discard, and how can we shift towards a more sustainable future?

To policymakers, I urge a resolute commitment to making the Global Plastics Treaty a powerful force for good. We have successful precedents like the Stockholm Convention, the Minamata Convention, and the fight against acid rain—proof that collective action can dramatically improve our environment. By acting collectively, we can make a substantial difference.

To witness the devastating reach of plastic pollution firsthand, I invite businesses to visit the Galapagos Islands. Far from any coastline, these pristine ecosystems are tragically marred by plastic debris. Would your brands truly want to contribute to such environmental harm? Let's join forces to protect these delicate landscapes from encroaching waste and build a more sustainable future, together.

My message to the public is to reconsider their consumption habits. Before making a purchase, take a mindful pause. Ask yourself: Do you truly need that item? Will it be used more than once? Where will it end up after use? Can we collectively reduce our reliance on plastic? Small changes, multiplied by billions, hold the power to transform our world.

Despite the immense challenges, I remain optimistic. The passion of countless individuals and the tireless efforts of scientists fill me with hope and faith in the possibilities ahead."

<Professor Penelope Lindeque>

"My primary concern lies in the synergistic escalation of climate events our planet faces. If these occurrences continue at amplified frequencies and intensities, we risk reaching a tipping point, where the damage becomes irreversible. This compounding effect of multiple stresses on our planet is my greatest fear. As a scientist, I believe it's our duty to emphasize that every individual choice carries the potential for a negative (or positive) impact, no matter how small. I urge industries and policymakers to heed the stark warnings of scientific evidence. Let's prioritize actions backed by robust data, not just short-term profit for a few, but long-term well-being and protection for our planet.

As consumers and citizens, we hold immense power in shaping our planet's future. Every choice we make, from the travel we choose to the food we eat, carries an environmental footprint. By reducing our travel footprint, reconsidering holiday destinations and flight frequency, and embracing plant-based options in our diets, we can collectively weave a tapestry of change. Even seemingly small steps, when stitched together, can create a powerful impact. When it comes to plastics, adopting responsible practices like reusable alternatives can curb their devastating impact. My greatest hope lies in humanity awakening to the delicate balance of our planet. By learning to live within its means, fostering respect for its resources, and curbing the insatiable hunger for excess, we can strive for a future filled with biological abundance and sustainable prosperity for generations to come."