SeaKeepers Digital Lesson Plans

Lesson 18: Pip Hare – Marine Pollution

This activity was created in partnership with Pip Hare Ocean Racing as part of SeaKeepers' Inspirational Figures lesson plan series for educational engagement on virtual platforms.

Activity: Marine Pollution

Preface:

Our oceans face many threats today, including climate change and pollution. In order to protect and preserve our oceans, we need to understand these threats and how the oceans respond to them. The International SeaKeepers Society supports marine research and education by connecting scientists with yacht owners, creating research opportunities for scientists to better understand our oceans – and to create plans to protect them.

Taking inspiration from the real-world experiences of Pip Hare and created in partnership with Pip Hare Ocean Racing, this lesson discusses the different forms of marine pollution and the ways that they affect ocean life. Contaminants can disrupt the normal behaviours and life processes of various plants and animals living in the global oceans, requiring organisms to be resilient if they are to survive. By taking inspiration from the experiences and encounters of Pip Hare during her 2024 Vendee Globe Race, students will learn how they can become better ocean stewards and protect vulnerable habitats by making small lifestyle changes to become more resilient individuals.

Objectives: Students participating in this lesson should see improvement in the following areas:

- Understand the term marine pollution, including the sources and distributions of various types, namely chemical, fertiliser, noise, oil, pathogen, plastic and sediment.
- Investigate how each form of marine pollution can adversely harm marine life, such as individual animals and vulnerable habitats.
- Discuss the ways that students can become better ocean stewards and use their personal resilience to make small lifestyle changes to protect the marine environment from unnecessary harm, taking inspiration from the positive actions of Pip Hare.

Age Group: Key Stage 3.

While this lesson plan was produced by SeaKeepers UK Chapter, our lessons are available and applicable to students globally. For further information on which education curriculum standards this lesson meets for your region, please reach out to programming@seakeepers.org

Estimated time: 70+ minutes

Required Materials:

Students do not need any background knowledge of marine pollution to take part in this lesson. Teaching resources are included for this lesson, but feel free to use other materials you may have to explain these concepts. To create their posters, students will need:

- Paper
- Pens/pencils
- Erasers
- Rulers (optional)
- Glue/Sellotape/Blu tack
- Clean household recycling OR Recyclable crafting materials, such as cardboard, ice lolly sticks and newspaper

Lesson Breakdown:

- Introduction to marine pollution, impacts on the marine environment and Pip Hare's Vendee Globe 2024 race experiences/encounters (20 minutes)
- Main Activity: Create a collage-style picture showing the impact of marine pollution using clean household waste (30+ minutes)
- Wrap up Discussion (15 minutes)
- Clean up (5 minutes)

Lesson Vocabulary:

- **Aerobic** – relating to, involving, or requiring free oxygen.
- **Anoxia** – an absence of oxygen.
- **Dredging** – the process of removing sediments, debris and other materials from the bottom of a body of water, such as a river, lake, or harbour, to deepen or maintain its channel.
- **Echolocation** – the use of sound waves to determine the location of objects.
- **Ecosystem collapse** – a potentially irreversible shift in an ecosystem's structure, composition and function.
- **Great Pacific Garbage Patch** – a collection of marine debris in the North Pacific Ocean, which has formed due to the convergent ocean currents in the North Pacific Subtropical Gyre.
- **Marine debris** – any human-created persistent, manufactured or processed solid material that has been discarded, disposed of or abandoned in the marine and coastal environment.
- **Marine pollution** – the introduction of substances (whether directly or indirectly) or energy into the marine environment by humans, resulting in harmful effects to living resources, human health and seawater quality.
- **Oil slick** – a film or layer of oil floating on an expanse of water.
- **Porpoise (verb)** – moving through the water using rising and submerging movement above and below the surface, respectively.
- **Resilience** – the capacity to withstand or to recover quickly from difficulties.
- **Surface run-off** – the movement of water over the land surface when it cannot infiltrate into the soil or evaporate.
- **Trophic cascades** – ecological phenomenon where the population size of a species at one trophic level significantly impacts the population sizes of other species, especially those at a lower trophic level within a food web.
- **Wastewater** – any water that has been used and contaminated, making it no longer suitable for its original purpose without treatment.

Lesson Introduction/Overview:

What is marine pollution?

Marine pollution refers to the various waste products and chemicals that enter the global oceans as a result of human activities. These pollutants can cause considerable harm to the marine environment, threatening the survival of ocean life and damaging valuable marine resources that we rely on to sustain civilisations, for

example, through fishing and tourism. There are two broad classifications for marine pollutants depending on where they originate from - point source and non-point source. Point source pollutants come from a single, identifiable source, such as a particular factory or sewage plant, whereas non-point source pollutants arise from multiple sources, such as surface run-off containing fertilisers, chemicals, oil pollutants, and more! Marine pollution is a highly prevalent issue worldwide and has become a key focus of many international initiatives. For example, the International Convention for the Prevention of Pollution from Ships is an international treaty that aims to limit marine pollution from vessels through the MARPOL framework and is enforced by the International Maritime Organisation. Over the last few decades, plastic pollution specifically has become a particular concern, as plastic takes hundreds to thousands of years to fully degrade in the ocean. In 2018, the United Nations reported that more than 60 countries have enacted regulations to limit or ban people from purchasing and using single-use plastics - since then, this number has increased to over 100 countries! Marine pollution is an ever-pressing issue for conservationists and industry professionals that are striving to raise awareness for the challenges faced by marine life as a result of anthropogenic pollution. Without major change, global ocean environments and the life living within will become increasingly threatened to a point of no return.

How does marine pollution affect marine environments and ecosystems?

Marine pollution enters the ocean from various sources, ranging from rainwater washing land-based pollutants into the sea to overboard waste disposal. Below are examples of different types of marine pollution, the ways in which they enter the marine environment, and how they affect life within:

Chemical - Some chemicals are naturally found in the ocean, such as sodium chloride in the form of salt. However, when either those that are not normally found in the marine environment or excessive amounts of naturally-occurring chemicals enter the ocean, they can cause significant harm. Chemical pollutants often enter the marine environment from various land-based sources, such as industrial and agricultural development, through surface run-off and ineffective wastewater disposal. For example, introducing salt to the ocean raises its salinity, which can affect the circulation of global ocean currents. Surface and deep water currents control global ocean temperatures and atmospheric climate, thus any change in ocean circulation can have worldwide impacts on both human and natural populations.

Fertiliser - Farmers regularly spray fertilisers onto their fields to improve crop growth, enabling them to earn more money from their land. Fertilisers often contain high quantities of elements such as nitrogen and phosphorus, which are required for photosynthesis. However, when rain falls and washes these fertilisers into the ocean, they can cause excessive and harmful plant growth. For example, phytoplankton are very small algae that naturally occur in our waterways. When fertilisers are washed into the surface waters, algae take in the excess nutrients and rapidly grow at an unnatural rate, forming large populations called harmful algal blooms (HAB). HABs are highly damaging in the marine environment. While alive, the algae physically block sunlight from reaching the seafloor, preventing healthy plant growth. However, when they die, large amounts of oxygen are required to safely decompose the plant matter, causing the surrounding waters to become increasingly oxygen-deficient. Where ocean circulation is limited, oxygen concentrations can significantly decrease to form entirely anoxic waters. Here, aerobic ocean life is unable to survive, turning once biodiverse regions into entirely barren landscapes.

Noise - Along the coastline and at sea, human activities create lots of different sounds that can be heard by marine life, for example through shipping, recreational boating, naval sonar and industrial action. These noises can distract and disorientate animals, causing them to become lost and confused, increasing their risk of harm. Underwater noise particularly impacts cetaceans (whales, dolphins and porpoises), as many rely on sound to communicate, locate prey, avoid predators and navigate in the ocean - a biological process called echolocation. External sounds mask their

underwater clicks, disrupt their hearing and can even cause direct harm if they are too loud! Noise pollution can therefore significantly disrupt marine populations, causing long-term harm to species that are common features in global ocean ecosystems.

Oil - Defined as the introduction of petroleum products into the ocean, oil pollution is highly detrimental to marine life as oil and water do not physically mix. Because of this, when oil enters the marine environment, it rises to the surface and forms a thin layer on top of the ocean called a slick. Whenever animals move into or out of oil-covered water, like when dolphins porpoise at the surface or birds dive in to hunt fish, their bodies become covered in oil. Dolphins breathe through blowholes which can fill with oil as they pass through the slick, increasing their chances of suffocation. Seabird feathers normally trap air to maintain their water repellence, however, these gaps become filled with oil when they encounter a slick. Because of this, their feathers lose the ability to repel water, increasing the seabird's risk of hypothermia. As oil is also heavier than both air and water, oil-polluted seabirds lose their ability to float on the ocean's surface, increasing their risk of drowning. Oil usually enters the ocean through accidental spills, offshore drilling operations and as a result of terrestrial run-off from industrial activities. By implementing more effective oil pollution preparation and remediation protocols, we can better protect the marine environment from the harmful impacts of oil pollution.

Pathogen - When pollution enters the sea from either land or a boat in the form of sewage, surface run-off or wastewater discharge, it can introduce harmful microorganisms into the marine environment. These bacteria and viruses are often not naturally found in the ocean; thus, they can easily spread throughout the ecosystem as native wildlife have not had the opportunity to become immune. Whenever one animal eats another, they consume all the pathogens that were present within the prey. As predators need to eat a lot of food to provide themselves with sufficient energy, they can ingest large quantities of pathogens, increasing their likelihood of harmful infection and subsequent risk of decline. A loss of apex predators can lead to severe trophic cascades, where mid-level populations grow exponentially as there is no top-down, predatory control, causing lower-level consumers and producers to become limited and the entire ecosystem to collapse.

Plastic - In recent years, plastic pollution has remained at the forefront of the media. Fishing lines, single-use plastics, shopping bags, plastic straws, packaging materials, coffee cups, and more, are regularly discarded both on land and at sea. Plastics can severely harm all types of marine life. For instance, larger animals may become entangled in lines and ropes, inhibiting their movements and increasing their risk of predation. Degrading plastics can leach toxic chemicals into the ocean, reducing the water quality and causing biodiversity declines. When broken down into small fragments known as microplastics, fish and filter-feeders unintentionally ingest plastics as they take in water through their gills and mouths, respectively, leading to reproductive and growth defects. Every year, approximately 100,000 marine animals die from plastic entanglement and ingestion alone - no one knows how many are killed as a result of all plastic pollution! We therefore need to reduce the volume of plastic entering our oceans, if we are to safeguard marine biodiversity for future generations.

Sediment - As the global human population grows, the demand for additional space to build facilities and provide resources intensifies. On land, people make this space by deforestation, removing trees to clear vast areas for housing and agricultural development. Whereas at-sea, industries are lowering the seafloor near active ports to allow larger ships to enter and provide additional goods, and offshore drilling operations have expanded to increase access to valuable oil reserves. Collectively, these activities are increasing the amount of sediment that enters the oceans, whether through an influx of soil near deforested areas, or by directly digging into the seafloor. By increasing sediment pollution, the water column becomes more turbid, limiting light penetration to the seafloor. Plants rely on light for photosynthesis, thus they cannot survive where solar influx is low. As such, sediment

pollution can inhibit the growth of keystone producers at the base of the food web, causing habitats to become barren that were once biodiverse.

Why do species need to be resilient to withstand marine pollution?

Marine pollution impacts all forms of ocean life, from the smallest plants to the largest animals. Once a pollutant enters the ocean, it takes time for it to either decompose, degrade or be removed. The impact of marine pollution on one species or individual can have knock-on effects on the entire ecosystem. Even when a pollutant is no longer present, these long-lasting repercussions can still cause significant harm. Species and individuals therefore need to be resilient in order to maximise their chances of survival in an increasingly threatened underwater world. However, this is not always possible.

For instance, many fish gills are unable to filter non-natural toxins and anthropogenic particles, such as those found in microplastics, synthetic oils and sewage. Consequently, these pollutants passively enter their bodies, causing severe harm. Ingested microplastics cannot be processed by natural bodily functions. Fish stomachs therefore become filled with indigestible material, causing the individual to feel full and cease feeding, even though they have no nutritionally valuable material within their system. Similarly, ingested oils can cause sensory blockages and inhibit key metabolic processes, such as respiration, growth and reproduction. Whereas sewage contains harmful substances and various bacteria and viruses that, when ingested, can lead to physiological changes or disease transmission. Pollutants therefore cause significant changes to species viability, threatening individual survival and subsequently decreasing population sizes. For species higher up the food chain, prey becomes more sparse, whereas for those at a lower level, predation decreases. A single change as a result of marine pollution can therefore cause the entire food web to become unbalanced, reducing local biodiversity and increasing the likelihood of ecosystem collapse.

As our human population grows, climate change enables vessels to traverse previously inaccessible regions and we begin to regularly explore the deep ocean, more marine life will encounter pollution than ever before. Ocean currents also transport pollutants from one place to another, acting as a conveyor belt to distribute these harmful substances to remote environments. This movement is clearly evidenced by the Great Pacific Garbage Patch (GPGP) - a large aggregation of marine debris in the North Pacific ocean between Hawaii and California, where ocean currents converge and trap discarded waste. Pollutants have travelled across the global oceans to reach the GPGP, as recreational and commercial vessels do not often travel to this region unless for research or clean-up purposes. Plastics account for 99.9% of the GPGP, ranging from fishing nets to bottles to packaging items, including debris from the 2011 Japanese tsunami. Did you know the GPGP is 1.6 million square kilometres in size - that's three times the size of France! Marine life therefore needs to be resilient in order to survive in less hospitable conditions, as the global oceans are becoming increasingly polluted, and ocean currents ensure that no habitat remains unaffected. However, fundamentally it is our responsibility to be proactive and make significant changes to limit marine pollution, in order to better protect ocean health and ensure the survival of marine life.

How did Pip Hare limit marine pollution during her Vendee Globe 2024 race?

Pip Hare took several important steps to reduce marine pollution and support sustainability during her Vendee Globe 2024 race. During the race she relied on renewable energy to power her vessel in order to eliminate the use of fossil fuels. Pip also used reusable food containers and water bottles, and collected her waste onboard as she travelled, allowing her to responsibly dispose of or recycle everything that she used when she returned to land. These efforts helped her to prevent any pollution from entering the sea while she was solo-racing around the world.

Since completing the Vendee Globe, her sails (which were damaged during the race) have been recycled to prevent them going to landfill. They have been used to create various bags and pens, giving them a new

purpose while limiting her impact on the oceans. Pip is deeply committed to protecting the marine environment.

In order to physically limit the racers' direct impact on the marine environment, the Vendee Globe organisers established Protection Zones along the route. These areas were identified as regions of high conservation importance, such as the waters surrounding the Azores and Cape Verde, where marine megafauna are known to feed and breed. As such, the boaters were instructed to steer clear of these regions while they competed in this global ocean challenge. This minor route restriction has huge value for protecting marine life. By limiting access to areas of high ecological value, the competitors had no direct impact on the survival of vulnerable individuals or endangered populations. For marine megafauna in particular, boats are a common source of significant, harmful noise pollution, and can severely injure individuals if they physically collide. Avoiding these areas therefore allowed the competitors to actively safeguard enigmatic animals without inhibiting their race success.

Pip Hare

Pip Hare is a global ocean racing yachtswoman who in 2021, became the 8th woman ever to finish the Vendee Globe; a non-stop solo race spanning approximately 24,000 nautical miles across the world. In 2024, Pip returned to the race, showcasing her resilience and determination. Unfortunately, during the Vendee Globe 2024, her yacht, Medallia, dismasted approximately 800 miles from Australia, although a challenging setback in her journey, Pip demonstrated remarkable self-rescue skills and managed to stabilise her boat to ensure her safety and make her way slowly to Australia.

During the race, many boaters participated in environmental conservation research projects to provide valuable data to various scientific initiatives. Pip used a Calitoo photometer to measure atmospheric particles as she raced to provide researchers with crucial information about the atmosphere from previously understudied regions. Her participation in the project allowed researchers to investigate environmental health without the costs associated with collecting the data themselves. By becoming a citizen scientist, Pip, and the other Vendee Globe competitors that participated in conservation research projects, proved that boaters can play a vital role in scientific data collection and increase global understanding of key environmental issues, proactively conserving the natural world for future generations.

With a professional career of over 25 years, Pip has made sailing her life. Her passion, determination and hard work have enabled her to succeed where others might struggle. After racing through the world's toughest environments and overcoming many challenges along the way, Pip uses her experiences and accomplishments to inspire others to aim high and strive to achieve their goals. Her story shows one of grit, determination and resilience beyond what some may say is humanly possible. Having achieved her life-time goal of completing the Vendee Globe at 46, and in a male dominated environment, Pip proves what is possible when you are determined, ambitious and resilient in the face of adversity. When faced with unforeseen obstacles, Pip's ability to adapt under pressure has allowed her to think clearly, find a solution and continue to achieve success. Her ability to cope in any scenario enables her to do things differently and hit targets that others wouldn't even consider. This resilience provides her with the capacity to both withstand changeable weather conditions in the open ocean when aboard her vessel Medallia, and disregard the status quo to become an inspirational changemaker. Pip shows why it is important to think beyond the norm and be resilient in all walks of life, navigating the challenge of achieving your goals in order to become the best version of yourself.

Activity Instructions:

Setup

1. Lay out the clean household recycling or recyclable crafting materials in an accessible location for the students to use.
2. Give each student a piece of paper, or lay a large piece of paper on a table/the classroom floor, which the students can use as a background for their collage.

Main Activity

3. Students should either collectively (one large piece of paper) or individually (individual pieces of paper) choose which type of marine pollution they are going to create with their collage.
4. Each design should focus on the type of marine pollution and the impact it would have on an animal, plant or habitat found within the global oceans.
5. Once the collages are complete, students should share which form of pollution they have created on their collage with the remaining student cohort.
6. Students should identify:
    - Why this form of pollution harms the marine environment or ocean life.
    - One way that their form of pollution could be limited or stopped entirely by actions of either a country, industry or individual person.
7. After the activity, the students' collages can be displayed and used as an educational, or disposed of sustainably using sustainable facilities.

Wrap up Discussion:

Educators should begin a discussion into the ways that the students could reduce the amount of pollutants that they release, limiting their individual harm to the marine environment. Examples include:

- Choosing more sustainable product alternatives
- Using fewer of single-use plastics
- Car-sharing, cycling or using public transport
- Buy local produce
- Recycle waste where possible

Educators should follow-up this discussion by asking these questions about resilience:

- Why is it important for creatures to be resilient when their environment becomes polluted?
- Do we need to be resilient when our environment changes or we are challenged?
- Can you think of any examples where you needed to be resilient to withstand a challenge?

For more information, here are some useful websites:

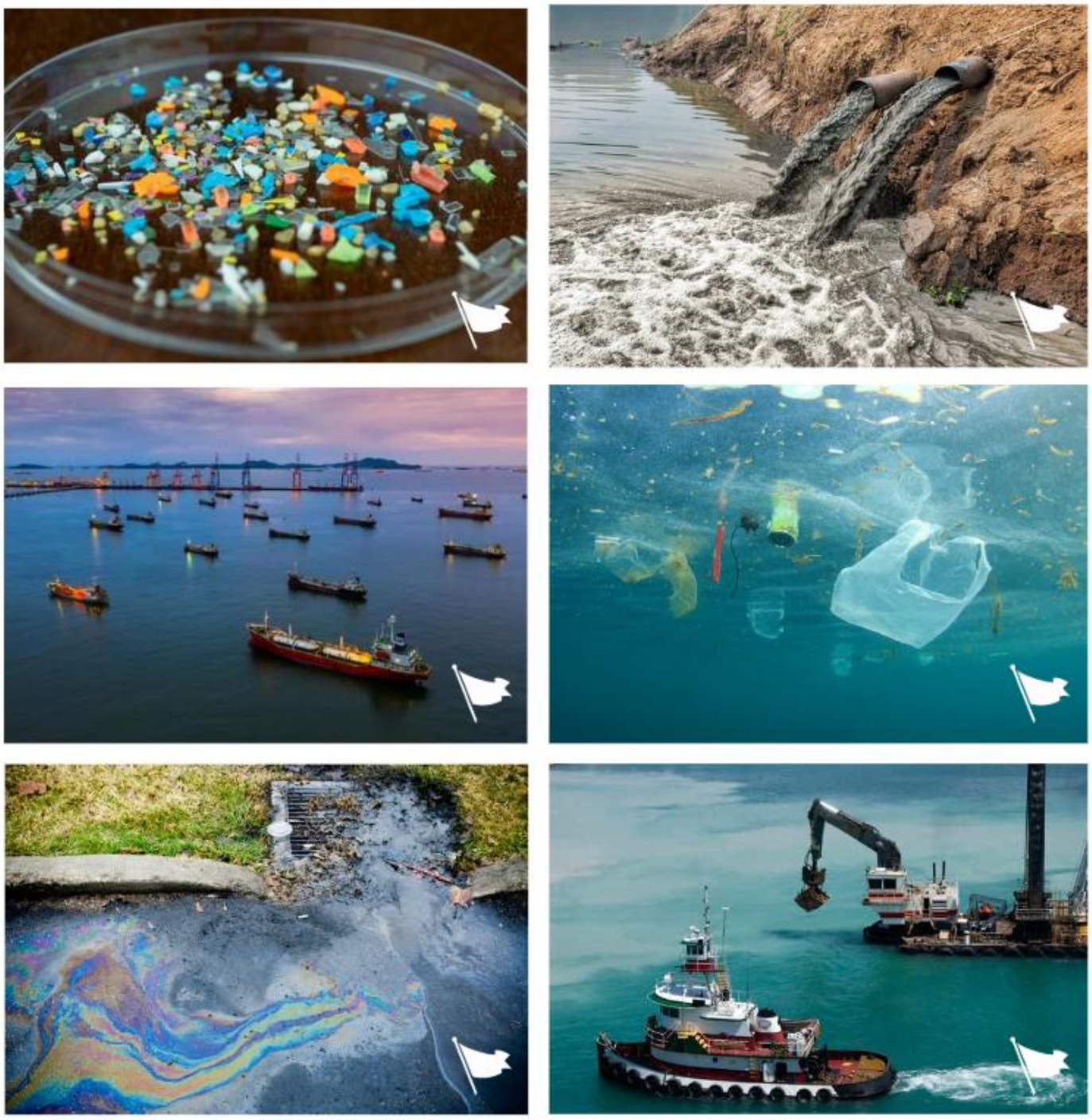
Pip Hare Ocean Racing and the Vendee Globe:

- https://www.piphare.com/
- https://www.vendeeglobe.org/en

Marine Pollution:

- Ocean pollution and marine debris – National Oceanic and Atmospheric Administration (NOAA)
- Ocean pollution | Marine debris – Marine Conservation Society
- Plastic pollution: Facts and figures – Surfers Against Sewage
- Marine pollution and ecosystems – European Environment Agency

Media:



Images depicting different forms of marine pollution, including microplastic, chemical, noise, plastic, oil and sediment pollution.