SeaKeepers Digital Lesson Plans

Lesson 17: Pip Hare - Ocean Currents and Marine Weather

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: Ocean Currents and Marine Weather

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 introduces students to the different types of marine weather and ocean currents that often affect boats travelling across the globe. The lesson investigates two forms of ocean currents (surface and deep water), exploring how these currents travel around the globe and the ways that both ocean currents and marine weather influenced Pip Hare's 2024 Vendee Globe Race. Stories and footage from Pip Hare's endeavours bring this lesson to life, inspiring students to use their personal resilience to achieve success in the face of adversity.

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

- Investigate the different forms of marine weather that can influence sailboat voyages across the global oceans, including strong winds, waves, storms and hurricanes.
- Learn how different currents move around the global oceans in both the surface and deep waters.
- Using Pip Hare's story as inspiration, understand the importance of personal resilience when aiming to succeed in challenging scenarios.

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 ocean currents and marine weather to take part in this lesson, however, an understanding of density would be valuable. Teaching resources are included for this lesson, but feel free to use other materials you may have to explain these concepts. To present the main activity, educators will need:

- A large, transparent bowl
- Food dyes of various colours
- Tap water
- Boiling water
- Ice (coloured in advance using food dyes)
- Salt water
- Watering can/bottle/other object for pouring small amounts of water
- Fan (optional)

To complete the activity worksheet, students will need:

- Pens or pencils
- Erasers (optional)

Lesson Breakdown:

1. Introduction to marine weather (atmospheric and wave conditions at sea), ocean currents and Pip Hare's Vendee Globe 2024 race (20 minutes)
2. Main Activity: Simulate ocean currents and marine weather using classroom resources, visualising the impacts of adverse conditions on global ocean-exploring vessels. Students complete an activity worksheet to support engagement in and understanding of the topic (30+ minutes)
3. Wrap up Discussion (15 minutes)
4. Clean up (5 minutes)

Lesson Vocabulary:

- **Circumference** – the outside edge of an area or object that is round or curved.
- **Convergence** – the coming together of two or more things.
- **Coriolis Effect** – the deflection of circulating air as a result of the Earth's rotation.
- **Density** – the relationship between the mass of a substance and how much space it takes up.
- **Downwelling** – the sinking of surface water into the deep ocean layers.
- **Fetch** – the distance travelled by wind or waves across open water.
- **Friction** – the resistance that one surface or object encounters when moving over another.
- **Global Ocean Conveyor Belt** – a system of ocean currents that circulate water around the world, driven by variations in temperature and salinity.
- **Hurricane** – a tropical storm with winds that have reached a constant speed of 74 miles per hour or more.
- **Latitude** – the angular distance, in degrees, north or south of the Earth's equator.
- **Marine weather** – the atmospheric and oceanic conditions at sea, including wind, waves, visibility, and other elements that affect maritime activities.
- **Peak (waves)** – the wave with the highest energy in a wave spectrum, namely the highest point above the wave's rest position.
- **Resistance** – a force opposing the motion of an object, or a force preventing a stationary object from moving.
- **Trough (waves)** – the wave with the lowest energy in a wave spectrum, namely the lowest point below the wave's rest position.
- **Upwelling** – the rising of deep, cold, nutrient-rich water to the surface.
- **Water column** – a vertical section of water from the surface to the seafloor, characterised by different physical and chemical properties.
- **Wave** – a disturbance in the water's surface that transmits energy across the ocean.

Lesson Introduction/Overview:

Global ocean explorers

The concept of mapping and traveling the world's oceans in a single, grand voyage is an idea that has captivated the minds and dreams of explorers for centuries. To become one of a select few that have circumnavigated the world and glimpsed every ocean is a once-in-a-lifetime achievement that many strive for. Some further challenge themselves by competing for this in races such as the Vendee Globe - a single-handed, unassisted yacht race that spans 24,000 nautical miles around the globe. However, the requirements and planned travel paths differ greatly depending on the nature of the circumnavigation: global racers can use much lighter, faster yachts built to handle intense waves while also maintaining the highest speeds possible, whereas leisure explorers with less focus on speed can travel using more comfortable vessels, such as motor yachts or catamarans. Conversely, 15th century global ocean explorers that undertook trips with the purpose of discovery, aiming to find new waters and trade routes, required larger vessels built to withstand their longer periods at-sea. However, all boats that travel the world are built with one consistent focus - safety. Many boats are simply not built to handle an ocean voyage of such intensity and magnitude as a global circumnavigation. To this day, 32 different types of boats have made the global trek, and survey responses from their captains have yielded surprising results - boats that are often considered ideal are not regularly chosen or preferred by prospective global explorers. Each captain generally has their own specifications with little agreement on intricacies and specifications. However, all emphasised the importance of safety, speed, and plenty of space for watchkeeping and storage - necessities for all voyages.

What is marine weather?

Ocean explorers require their boats to be built to last due to the highly variable weather conditions experienced across the global oceans. Marine weather acts and behaves very differently to terrestrial conditions - its patterns are much less forgiving and out in the open ocean, can sometimes be life-threatening. Understanding the potential fluctuations in marine weather is paramount for global ocean explorers and travellers alike. Fundamentally, preparation is key - keeping up-to-date with marine weather forecasts and planning the expedition accordingly is critical to ensure safe travel. There are many types of marine weather that will affect global travellers - marine winds, waves, and storms ranging from minor precipitation events to intense hurricanes.

Like terrestrial winds, marine winds form as a result of atmospheric pressure changes. When air is near the Earth's surface, it warms up and expands, becoming less dense. As this air pocket has a lower density than the air around it, it rises upwards in the atmosphere, leaving behind an area of low pressure. Colder, more dense air is drawn into this surface region to replace the rising air. This air movement aims to re-establish atmospheric pressure balance, creating what we experience as wind. The ocean surface is smoother than land as there are fewer obstacles, such as mountains, buildings and trees, pointing upwards into the atmosphere that interfere with air movement. As such, there is lower friction and associated resistance between the ocean and atmosphere, allowing air to move more easily. Marine winds are therefore often stronger than those on land, which can affect a boat's handling, durability and stability. Intense, high-speed winds can be unpredictable with their movements, thus boaters must monitor these in order to stay on course and prevent disasters, such as capsizing.

When marine winds blow across the ocean, friction forms between the winds and sea, pushing and pulling the surface water in different directions to form small ripples. As these wind speeds increase, more energy is provided to the surface waters, causing them to move faster than those waters below, forming a circular system. This wind-induced disturbance makes the sea surface rise and fall, forming a wave. Winds with a larger fetch are able to create larger waves in the open ocean, which can travel great distances before reaching a coastline. When the ocean becomes shallower, such as near the coastline or over a reef, the bottoms of these circular systems are dragged along the seafloor, causing the waves to break and crash like those that you see at the beach. Huge waves in the open ocean can have very high peaks and very low troughs. These large up and down movements are very dangerous for captains, crew and guests as there is a high risk of falling overboard. Many boaters often try to stay far away from areas with high winds and waves to reduce their risk of harm. Pre-trip research and adequate preparations are essential to ensure vessels avoid these highly unpredictable regions during their ocean voyages.

The most extreme types of marine weather are large tropical storms, named either a hurricane, typhoon or cyclone. These titles all describe the same phenomenon; however, the different terms indicate where the system formed - hurricanes form in the Atlantic and Northeast Pacific Oceans, typhoons form in the Northwest Pacific Ocean, and cyclones form in the South Pacific and Indian Oceans. For this lesson plan, we use the term hurricane to minimise confusion. Hurricanes form in the tropical latitudes when specific conditions are met - the ocean must be over 27^{O}C for at least 45 metres depth with converging surface and slower, diverging, high-altitude winds. The converging surface winds gain heat and moisture from the ocean, causing the air to become less dense and rise. The high-altitude winds slow the movement of the rising air, preventing it from leaving the weather system as quickly. The warmer rising air releases heat energy as it moves upwards into the cooler atmosphere. Warm, moist air is continually added from the ocean's surface into the base of the storm to replace the rising air, adding more and more energy into the system. The converging winds at the sea surface therefore become faster and faster as more air rises upwards, increasing the speed of the high-altitude winds that move apart in the upper atmosphere, making the system more unstable. Tropical storms are only termed hurricanes, cyclones or typhoons if the surface wind speeds are greater than 74 miles per hour (119 kilometres per hour) – they can grow up to approximately 300 miles (485 kilometres) wide!

As the Earth spins, different locations move at different speeds as its circumference varies in size across the latitudes. For example, the equator spins faster than the poles as a point here has to travel a larger distance to return to its original position in the same period of time. Because of this, something not attached to the Earth's surface that's travelling directly north or south from the equator will appear to move at an angle using a curved path rather than in a straight line. It's similar to throwing a ball from the middle of a rotating merry-go-round to a friend standing near the edge - the ball doesn't travel in a straight line either! This deflection is known as the Coriolis Effect. Once formed near the equator, hurricanes are pushed by strong winds, such as the westerlies or trade winds, either slightly northwards in the Northern Hemisphere or southwards in the Southern Hemisphere. Because of the Coriolis Effect, these winds begin to spin either anticlockwise in the Northern Hemisphere or clockwise in the Southern Hemisphere. Hurricanes continue to grow as they move until they reach either colder water or land masses, where their specific conditions are no longer met. Here, they begin to dissipate while causing damage and destruction to coastal towns and villages in their path. Hurricanes are powerful weather systems which must be avoided by any ocean explorer as they are a huge threat to human life. Boaters often plan their routes to explore tropical regions outside of "hurricane season", when ocean temperatures are less favourable for hurricane formation. This minimises their risk of harm and enables them to enjoy beautiful tropical waters without the threat of destruction.

What are ocean currents?

Ocean currents are continuous movements of seawater that flow throughout the global oceans. They are split into two types depending on how they form and are powered - surface and deep water. Surface currents are driven by wind movement, whereas deep water currents are driven by density and temperature changes throughout the water column. Although they are not directly in contact with the atmosphere, deep water currents are still greatly affected by the climate as this alters the temperature and salinity of the surface waters.

As discussed previously, surface waters move whenever the wind interacts with the ocean. The Earth experiences unequal heating from the equator to the poles, which when combined with the Coriolis effect, creates areas where air regularly rises from the surface and others where air regularly falls from the upper atmosphere. This rising and falling creates the global wind circulation system, which comprises strong, prevailing equatorial trade winds, mid-latitude westerlies, and polar easterlies. The friction between the ocean and these large-scale winds causes constant water movement, forming surface currents and setting the global ocean circulation system in motion. The equatorial trade winds create a pair of currents that move from east to west in the low latitudes of both the Northern and Southern hemispheres. Whereas the westerlies generate east to west currents in the mid-latitudes, and the polar easterlies form the converse in the Arctic and Antarctic regions. However, as the Earth isn't entirely made-up of ocean, these currents are sometimes deflected by continental land masses. This causes their routes to change and the currents to flow into each other to create one circular current, called a gyre. For example, the Atlantic trade winds and westerlies combine to form the North and South Atlantic gyres that almost entirely cover these ocean basins. Stand parallel but diagonally opposite a friend with a bowl of water between you, and blow on the water's surface - can you see the water begin to move in a circular motion? You've created your own gyre!

Further down the water column, the ocean is not in contact with the atmosphere, thus is not directly affected by wind movement. Motion in the subsurface and deep waters therefore relies on density changes to maintain the flow of water from one region to another - a process called thermohaline circulation. Like when air rises and falls in the atmosphere depending on its density, water in the ocean moves in a similar way. Warmer waters are less dense than colder waters, while more saline waters are more dense than those with a lower dissolved salt content. Colder, more saline waters therefore should be found at the bottom of the ocean, while warmer, less saline waters should stay at the ocean's surface. However, in reality, warm surface waters experience high levels of evaporation, releasing water molecules into the atmosphere and increasing the ratio of water to salt in the remaining water, raising the salinity. Similarly, as surface currents move water from one location to another, the water changes temperature. For example, equatorial surface waters are warm, soaking up heat from the sun. However, as they travel to higher latitudes, they become cooler and subsequently more dense. As their density increases, they sink below the surface, entering the deep ocean. Here, water chemistry remains almost stable, with negligible temperature and salinity changes. These values only vary if mixed with other water masses, such as downwelling water like that previously mentioned or near the coastlines. Where this mixing occurs, the water temperature and salinity is slowly altered until it becomes warmer and less dense than the surrounding water masses and rises to the surface. Once at the surface, it warms up, gains salinity, moves to cooler regions, and sinks, repeating the cycle. This cycle is known as the Global Ocean Conveyor Belt. Understanding and following this global movement of water not only allows boaters to travel more quickly and effectively around the world, but also makes charting a path significantly easier as weather patterns are more predictable. By better understanding global oceanography, ocean explorers can better predict where they will encounter challenging conditions, allowing them to prepare themselves for the trials and tribulations that lay ahead on their journey.

How did Pip Hare use her personal resilience to counter challenging conditions during the Vendee Globe 2024?

Pip Hare has faced some of the most extreme marine weather conditions in the world while competing in solo ocean races, like the Vendee Globe. She has sailed through violent storms with hurricane force winds and massive waves, including dangerous regions such as the Southern Ocean. These conditions test every part of her: physically, mentally and emotionally.

To cope with such weather, Pip relies on a combination of careful preparation, skill and determination. She constantly monitors weather forecasts, trims her sails to suit the changing conditions, and follows strict daily maintenance routines to keep her boat in the best shape. During storms, she works hard to stay calm and make practical decisions under pressure.

Once of her most dramatic experiences came during the 2024 Vendee Glove, when her boat was dismasted and the main mast broke, leaving her unable to sail properly. Rather than giving up, Pip built a temporary sail system herself called a “jury rig”, using parts from the damaged rig. This showed incredible problem-solving skills and perseverance.

Pip understands the challenges of solo sailing, especially during prolonged exposure to extreme conditions. Being alone at sea for weeks can lead to exhaustion and isolation. She combats these feelings by focusing on her passion for sailing, setting personal goals, and staying connected to her sense of purpose. It is this mix of mental toughness, physical endurance, practical skills, respect for nature, and emotional resilience that allows Pip to deal so effectively with the extreme weather conditions she faces at sea.

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 race, 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:

This activity allows educators to simulate ocean currents using a large, transparent bowl of tap water. This will allow the students to visualise how ocean currents form and move around the ocean, using a simple classroom setup. This activity involves the use of various solutions that could be hazardous for participants – please take care when conducting the experiments and ensure no children conduct the experiments without supervision**. All participants partake in the educational activity at their own risk**. Educators should create different forms of ocean currents by adding the below items to a bowl of tap water:

1. Deep water currents:
    - Adding colour-dyed boiling water.
    - Adding colour-dyed salt water.
    - Adding colour-dyed ice-cold water.
2. Surface water currents:
    - Blowing/fanning the water surface

Please note – these solutions should be added to the bowl of tap water alone. The experiment will not clearly show each intended type of current if the bowl of tap water contains multiple different solutions at once.

After conducting the ocean currents experiments, educators should add a small vessel to the surface of the water to discuss how marine weather impacts vessels. Educators should simulate different forms of marine weather by adding the below item to the bowl of tap water, or interacting with the bowl of tap water in the way described below:

1. Repeatedly breaking the water's surface at different speeds (simulating weak and strong waves)
2. Pouring small and large amounts of water into the bowl (simulating light and heavy rainfall during storms)
3. Strongly blowing/fanning the surface of the water (simulating strong winds)
4. Performing the above methods at the same time (simulating hurricanes)

Following both experiments, students should complete the below activity worksheet to investigate the conditions visualised in the main activity through the eyes of Pip Hare's Vendee Globe experience.

Wrap up Discussion:

To maximise engagement and understanding, educators should gather the students to discuss their activity worksheet answers and their key learnings from Pip Hare's Vendee Globe experience. Compare and contrast the students' responses, questioning why they answered as they did.

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

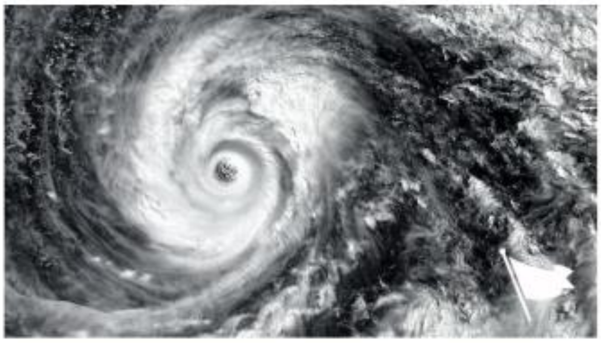
Ocean Currents:

- Ocean Currents – National Oceanic and Atmospheric Administration (NOAA)
- Ocean Current - Britannica

Marine Weather:

- The importance of buoy observations to marine weather forecasts – SOFAR Ocean
- Understanding marine forecasts – MetOcean Solutions

Media:



Images of different forms of marine weather (waves, hurricanes and storms) alongside Pip Hare aboard her vessel, Medallia.

Activity Worksheet

Lesson 17: Ocean Currents and Marine Weather

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Question 1: Why did extreme weather often make it more challenging for Pip Hare to perform basic tasks aboard her vessel?

Question 2: Which personal traits and professional skills does Pip Hare rely on to ensure her boat functions effectively in challenging conditions?

Question 3: Why is it important for Pip Hare to be resilient when undertaking global ocean races

Question 4: What do you think drives Pip Hare to keep pushing forward in spite of the tough weather conditions?

Question 5: How important was Pip Hare's mindset when she was faced with obstacles in her Vendee Globe 2024 race, and why?

Question 6: Why was it important for Pip Hare to be aware of ocean currents and environmental conditions during the Vendee Globe race?

Question 7: Which form of marine weather discussed in the session would have had the biggest impact on Pip Hare's Vendee Globe race, and why?

Question 8: How do ocean currents affect marine life across the global oceans?