Travelling to the North

When we encounter the word ‘travelling’, we think of discovery, novelty and exploration. When we travel, we think the same way scientists do: staying alert and watchful, looking out for the unusual, and remaining open to risks and surprises. In this exhibition, we aim to meet your inner need to explore by following a sailboat on the waters of the North Atlantic, making you wonder what we might meet on the journey.

So, climb aboard, cast off and let the wind of curiosity fill your sails!

Our itinerary

In this exhibition, we follow the route taken by Barbara and Thierry Courvoisier on board their sailboat *Gaia* between the spring of 2020 and the autumn of 2021.

We set out from La Rochelle, France, where we'll think about what to take on board for a long journey to the North.

We'll then head for Scotland and the Faroe Islands. Along the way, we'll discover how sailboats move and why they stay afloat.

On our journey, we'll meet birds, sea mammals and other strange creatures. In our ports of call, we'll meet local inhabitants who speak languages very different from ours.

We'll soon be heading for Iceland, a volcanic island just below the Arctic Circle. Beyond, the midnight sun can be seen…

Leaving *Gaia* in Iceland, we continue our journey towards icy Greenland.

3 Facing the Sun

Why does the length of the day change depending on our latitude?

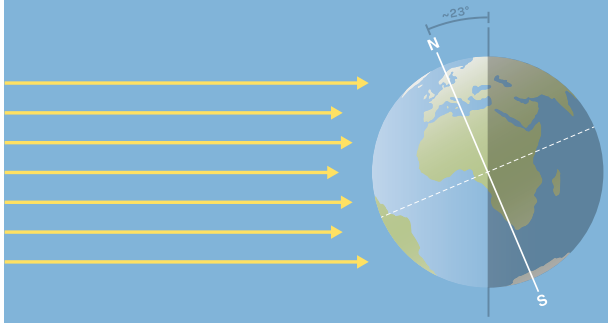
Spin the globe for a full 24 hours and see how:

- **the blue dot (France)** changes from day to night and back again.
- **the red dot (Norway)** stays lit the whole time.

But why?

It's because the Earth's axis of rotation is tilted by about 23°.

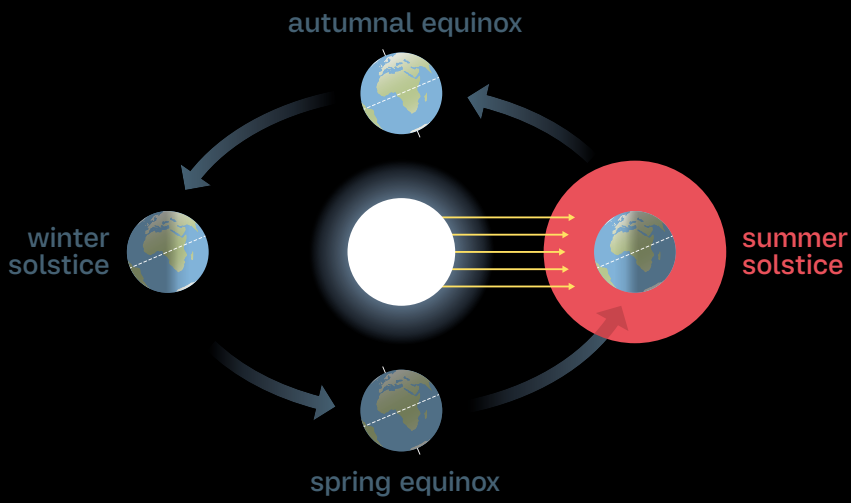
Due to this tilt, the sun/shade boundary is not aligned with the north-south axis (except at the equinoxes). It's this tilting that causes different lengths of daylight depending on the latitude of any location.



Midnight sun vs. polar night

The Earth revolves around the Sun in 365 days, and its axis always remains oriented in the same way. This means the following can be observed:

- On 21st June (summer solstice), the sun does not set for latitudes within the Arctic Circle; this is known as 'midnight sun'.
- On 21st December (winter solstice), the opposite is observed: the Sun does not rise there at all; this is 'polar night'.
- At the South Pole, the opposite is true.



4 Facing the Sun...

Here we are close to the longest day of the year, the summer solstice (21st June). Use the screens to compare the path of the Sun at the same time in two different locations at very different latitudes. Impressive, isn't it?

The two dots indicate the locations used to film the Sun's path shown on the screens. There is more than 20° difference in latitude between the two locations.

in France

Shots from: Storkenkopf, Vosges Mountains

What's going on? In summer, at our latitudes, the Sun appears on the horizon every morning. It then rises to its highest point in the sky and then falls back down and disappears below the horizon. Night falls. The sky is covered with stars. Then dawn arrives and everything starts afresh.

in Norway

Shots from: Røren, Lofoten Islands

What's going on? Within the Arctic Circle, the Sun is always visible on the horizon in summer. It rises and falls slightly, but never sets. This is the midnight sun.

5 Flat as a globe

When a sailboat leaves port, an observer stood in the harbour watches as the hull and then the mast disappear below the horizon. As the ancient Greek scientist Aristotle observed, this is because the Earth is round!

So how do we describe a given point on this globe called Earth? Most often, we use geographic coordinates, expressed in terms of longitude and latitude. Because we are describing angles, we measure them in degrees (°degrees, ′minutes, ″seconds).

Any location can be identified using a latitude and a longitude. For example, Lausanne is at 46°31′10″N, 6°36′14″E.

Latitude

Just imagine if you could slice the Earth up horizontally. The imaginary lines you'd create are called **'parallels'.** The equator is the middle slice. It lies exactly halfway between the North and South Poles.

Latitude is used to describe the distance of a location from the Equator. At the Equator the latitude is 0°, at the North Pole it is 90° N.

Longitude

Now imagine slicing up the Earth into orange-like segments. The imaginary lines we create in this process, which all pass through the poles, are called **'meridians'.**

Longitude is used to describe the distance from the Greenwich meridian. This prime meridian is an arbitrary choice corresponding to the observatory in Greenwich, London.

From globe to map

To make life easy, the Earth is often shown flattened. On a two-dimensional map, the geographic coordinate system creates a grid of parallels (horizontal) and meridians (vertical).

However, this leads to a distorted view of reality! For example, on some maps the parallels are all the same length, which is not the case in reality.

6 Points of view

Answer these questions using the world map and/or the globe and, if you want, the tape measure:

1. Which European city is at a similar latitude to Washington DC (USA): Paris (France), Berlin (Germany) or Lisbon (Portugal)?

2. Which city in the Northern Hemisphere is at the same distance from the Equator as Santiago (Chile): Copenhagen (Denmark), Beirut (Lebanon) or Bern (Switzerland)?

3. Which country has the largest surface area: Greenland or Australia?

4. Which is the shortest route from Ottawa to Beijing: via Paris, via the Pacific Ocean or via the North Pole?

5. Measure the distance between Reykjavik (Iceland) and Wellington (New Zealand) both on the globe and on the map. Do you get the same result?

Answers

1. Lisbon (38.5° N) is at a similar latitude to Washington DC (39° N). Paris is at 49° N, Berlin is at 52.5° N.
2. It's Beirut! 33° N for Beirut and 33° S for Santiago. Copenhagen is at 56° N and Bern at 47° N. The Equator is lower than we often imagine, isn't it?
3. It's Australia (7,690,000 km²) which is more than three times larger than Greenland (2,166,000 km²)! For this kind of question, you should use the globe, not the map. There are also different types of map, this one does not accurately reflect surface area. Regions near the poles appear larger than they really are.
4. The shortest route from Ottawa to Beijing is via the North Pole! For this you need to use the globe; it's simply impossible to find the right answer using the map.
5. There's no way you identified the shortest distance between these two cities using the map. A map is a projection of the surface of a sphere onto a flat sheet; it is a very useful format, but there are limits to what information can be correctly captured.

7 Nose to the wind!

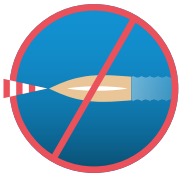
The energy used by sailboats is wind energy.

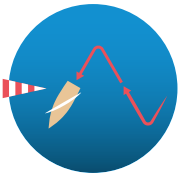
It's easy to understand how sailboats move when the wind is behind them, but it's less simple to understand how they can sail into the wind.

Here the fan blows onto the boat, **exerting a force at a right angle to the sail.** This powers the boat, which is fixed to a rail, meaning it can only travel backwards and forwards.

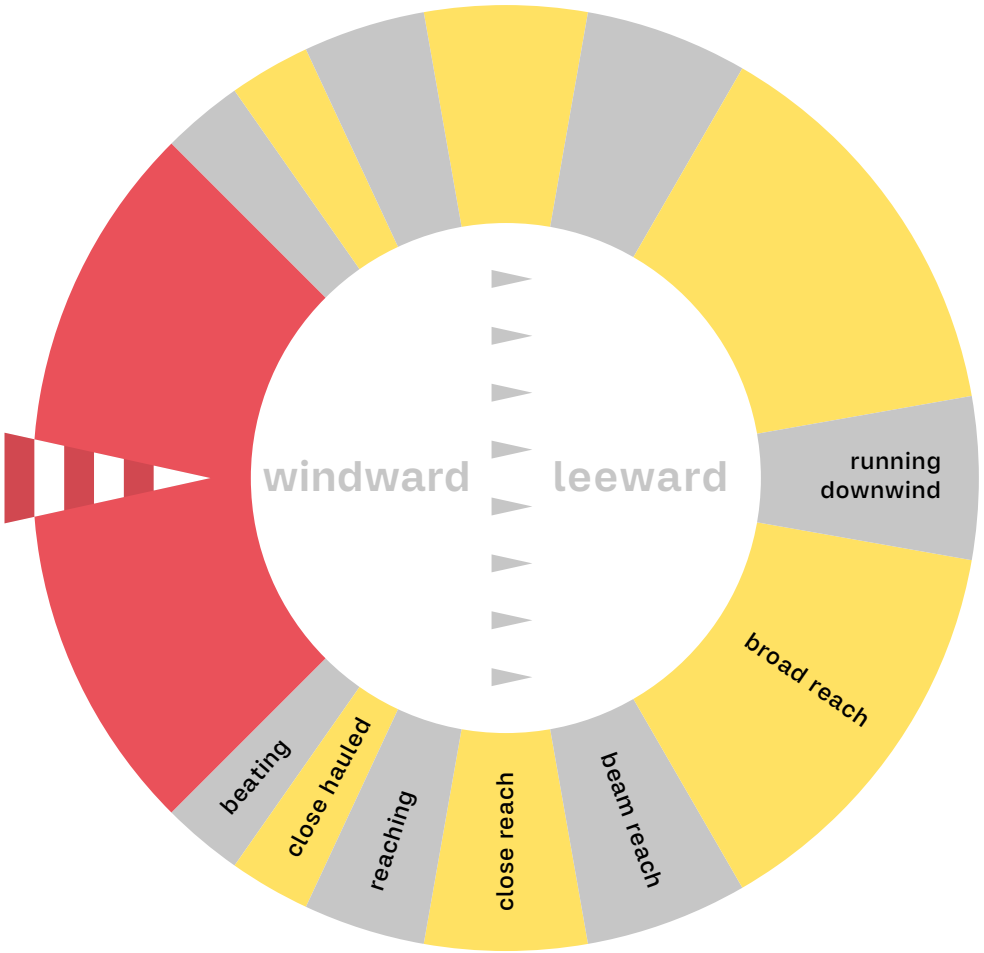
By orienting the rail to close hauled, the combination of wind strength and the effect of the rail allows our boat to move upwind.

Of course, there are no rails at sea! Instead, sailboats have special keels that cause the same effect. Sailboat keels are vertical fins below the boat that reduce sideways movement. Perhaps they should be called 'anti-keels'.





Of course, there's just no way to sail directly into the wind. Instead, you have to follow a zigzag pattern, called 'tacking'.



To describe the direction of travel in relation to the wind, we speak of 'points of sail': **beating, close hauled, reaching, close reach, beam reach, broad reach, and running downwind.**

1. Place the boat at the start of the rail.
2. Align it using the crank handle.
3. Press the button to 'turn on the wind'.

8 Keeling

The keel is the lowest part of a boat, but what does it do?

Without a keel, you capsize! This is due to **the wind exerting a force on the sails** that causes the boat to lean. If the boat leans too much, it can overturn. The keel adds weight and acts as a counterbalance preventing the boat from capsizing. At the same time, it also acts as a fin and keeps the boat on course. A keel really does multitask!

On a sailing dinghy without a keel, it's the sailors on board who act as the counterweight by leaning out of the boat.

Press the button to blow.

Point the windsock
at each boat and observe.

Total weight of *Gaia:* 18 tonnes

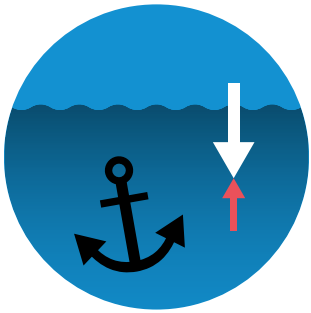
Keel alone: 5.4 tonnes,
almost a third of the total weight.

9 Eurikool!

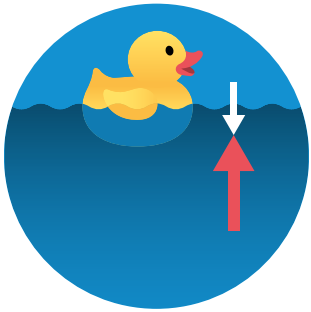
A good boat stays afloat! But why do some things float and others not?

All objects are subject to a force pulling them towards the centre of the Earth. This is **the force of gravity.**

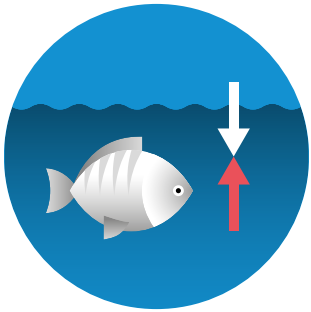
When we place an object in liquid, it is also subject to a force pushing it upwards. This force exerted by the liquid pushing the object back to the surface is described by the **Archimedes' principle.** It's this force that means we feel lighter in water than in air!



When the force of gravity is greater than the upward force, **an object sinks!** This happens when the object's weight is greater than the weight of its equivalent volume of water.



Conversely, when the upward force is greater than the force of gravity, **an object floats.**

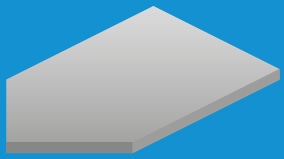


When the two forces are equal, the object is said to be **'neutrally buoyant'.** This is the case when the weight of the object is equal to the weight of the same volume of water.

Sink or float?

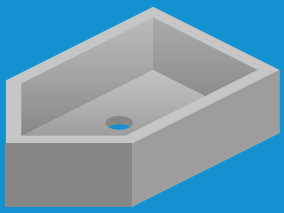
Do you think the aluminium boat/raft will float or sink?

Pump the tube full of water to see if you're right...



This raft sinks.

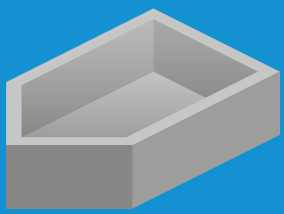
Its weight is greater than the weight of its equal volume of water.



This boat sinks.

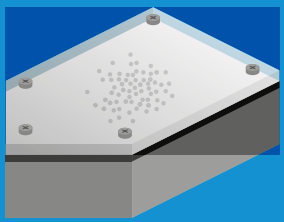
There are holes in it, allowing water to seep in and replace the air.

The total weight of the boat (aluminium + water in the hull) is therefore greater than the weight of the same volume of water.



This boat floats.

Its total weight (aluminium + air) is less than the weight of the volume of water it displaces.



This boat is neutrally buoyant.

Its total weight is equal to the weight of its equal volume of water.

10 Lost your bearings?

You are at sea, the coast is in sight but your GPS is broken... To continue on your route, you need to know your precise position. What can you do?

Fortunately, there is a nautical chart and a compass on board. We can use them along with **the principle of triangulation,** as used by land surveyors.

1. On the coast there are two points that are easy to see (A and B), aim at them using the sight of this compass.
2. For each point, remember the angle indicated by the red mark on the compass.
3. Use the sliders to set the angles on the dials. Your position is where the rubber bands cross.

Press this button to check your answer.

11 Navigational tools

When travelling, you often need to know where you are and where you are going, in other words, to be able to find your bearings. This is especially important when travelling by boat, where you have few landmarks to rely upon.

Discover the variety of instruments that navigators use to find their way around and to navigate safely.

Beware, there is an intruder, it's up to you to spot it!

→ *Translations in the exhibit*

14 Land of ice? Land of fire!

Iceland is a region of high volcanic activity.

It's an island located on the boundary between two tectonic plates (North American/Eurasian), known as the Atlantic Ridge. The two plates are moving away from each other, and this movement leads to the production of new crust in between them. In some places, this movement also allows for the upwelling of magma through volcanoes or fissures.

Discover four rather special Icelandic volcanoes by pressing the corresponding button.

"In the 1960s, my eruption gave birth to a new island."

"In 1973, I almost clogged a small harbour with my abundant lava but humans went out of their way to divert it."

"I erupted for more than six months in 2021."

"In 2010, I caused air traffic to stop for several days."

I am Fagradalsfjall.

After 800 years of sleep, I woke up in March 2021. Lava escaped from several of my cracks.

These eruptions offered a magnificent spectacle that lasted for more than six months.

The accumulation of lava flows first formed several small cones, and finally gave rise to a new volcano.

I am Eldfell.

I suddenly appeared on 23rd January 1973 in the Vestmann Islands, right next to the houses.

Fountains of lava threatened to block the entrance to the port. It would have been a disaster for this fishing region!

To deflect the lava, the authorities set up an impressive watering system.

The operation was a success despite one death and significant damage.

I am Eyjafjöll.

In April 2010, my eruption caused a huge plume of volcanic ash.

It was such a danger to aircraft that several countries closed their airspace out of caution, causing a major disruption to global air traffic.

I am the island of Surtsey.

I appeared between November 1963 and June 1967 due to a volcanic eruption.

The eruption started at 130 metres below sea level and peaked at 173 metres.

Although I'm barely more than a square kilometre in size, many scientists are interested in me and particularly in how life colonises me.

15 The Great North

There are about twenty different mammals and countless birds, fish and insects living in the polar regions. They all have to be well adapted to this particularly hostile environment (extreme winters, scarce food).

To protect themselves from the cold – and temperatures can drop to -40° Celsius – they have thick layers of fat and/or very generous coats and feathers. Their body shapes are also adapted, for example, small ears and short legs are common.

We can also see how their behaviours have been adapted to this harsh location, for example, the lemming sleeps under the snow where the temperature does not fall below 0° Celsius. Another essential strategy for many species is migration. The Arctic tern, which is the world's largest migratory bird, follows the summer from the Arctic to the Antarctic. Then there's the musk ox, which migrates south in winter where food is more abundant. Hibernation, on the other hand, is rare here, because the temperatures drop too low and waking back up is not a guarantee.

→ *Translations in the exhibit*

18 Northern cold?

The average temperature on the Earth's surface is 15° Celsius.

However, there are huge differences among the regions of the planet. But why is it colder at the poles than at the Equator? Well, there are actually three contributory factors.

Here there are three small experiments to show you how the individual factors, when combined, make it colder at the North Pole than in Switzerland...

19 Albedo

As you probably felt during the experiment, a white surface in the sun is less hot than a black surface.

This is because white absorbs less light, and therefore heat, than black. A light surface, for example, snow or ice, absorbs less energy than earth, sand or vegetation.

Place your hand on one plate, then the other.

Can you feel the difference in temperature?

20 The angle of incidence

You can see here how the illuminated area is larger at the poles than at the equator.

The sun’s rays reach the equator almost vertically. At the poles, however, the sun’s rays reach the Earth’s surface at a sharp angle. This means that the light energy is less concentrated, because it is spread over a larger area.

Move this lamp up and down and observe the size of the illuminated area on the globe.

21 The thickness of the atmosphere

This experiment shows that light rays have to pass through a thicker portion of atmosphere to reach the poles than to reach the equator.

Part of the light energy of the Sun's rays is absorbed by the atmosphere. The greater the distance travelled through the atmosphere, the greater the loss of energy. The light energy reaching the polar regions is therefore less than that reaching the equatorial region.

Move the sunbeam with this lever and observe the distance it travels through the atmosphere.

A Barbara and Thierry Courvoisier

Barbara and Thierry Courvoisier are a youthful and adventurous retired couple living on Vaud's La Côte.

With several decades of sailing experience behind them, they set out in 2020 to travel the seas of the world for a few years on board their new boat *Gaia.* They were soon eager to share the encounters and discoveries from their trip, and so they created the project *Science & Sailing with Gaia,* which brings together many scientific institutions and people, including *Espace des inventions.*

This exhibition was conceived and produced as part of the project *Science & Sailing with Gaia.* Travelling to the North invites you to follow the course taken by Barbara and Thierry on board *Gaia* starting in the spring of 2020.

For more information on this project: *www.sy-gaia.ch*

B The sailboat *Gaia*

Gaia is a beautiful sailing boat built by the shipyard Amel. She is 15 metres long and over four metres wide. *Gaia* is a 'cutter', a sailing boat with a mast and two headsails. She has a sail area of just over 120 square metres.

Gaia is a well thought-out boat for two people. Barbara and Thierry live comfortably on board and can easily accommodate guests.

Why the name? *Gaia* is a primordial goddess known for nurturing earth but not being blissfully benevolent. 'Gaia' is associated with the sun and happiness and also happens to be close to *'gioia'*, the Italian word for 'joy'. Finally, and quite practically, 'Gaia' is a short word making it very easy to spell out on the radio: *Golf, Alpha, India, Alpha.*

C Scotland and its legends

Besides Nessie, Scotland has a great many other historical and modern legends, as Barbara and Thierry found out...

"In Castelbay, we visited a spooky castle in the middle of the bay. It's said to have been the setting for the Tintin film 'Black Island'. The castle is dark, square and massive, making it the perfect setting for a story about forgers and a gorilla. There's a lot about it that closely resembles Hergé's drawings, but it's not really on an island and most probably there's no gorilla, although we're not sure, because there's a huge gate blocking access...". Perhaps it was wise of them not to climb up...

Sometime later, during a walk around Oban, they came across some rock formations dating from an ancient period of active volcanism in the region. *"One of these formations is a column about 30 metres high, about 10 metres in diameter, and narrower at its base. Apparently this formation was created by the rubbing chain of a particularly massive and powerful dog tied up there by a giant Viking. I'm glad I didn't pass by at that time".* Understandably so...

D Shipwreck Islands

Thierry's description of the Isles of Scilly doesn't make you want to go and spend your holidays there, just judge for yourself: *"The Isles of Scilly lie in the Atlantic Ocean just beyond Cornwall. They are wild islands that are difficult to approach due to the winds, currents and swells off the tip of Great Britain. The area is dotted with reefs and is a real graveyard for boats. On one of the islands, there is a museum exhibiting the figureheads of ships wrecked in the area. It is also said that the islanders used to light fires in misleading places to trick sailors into wrecking their ships, which they then plundered. 'If there must be shipwrecks', says a local prayer, 'may God grant that they occur in the archipelago'. We had sailed this way many years earlier in high winds and thick fog and we can readily confirm that it's tough going, so much so, I'm told, that tax collectors only managed to start going there in the 1950s".*

E The courtesy ensign

On a boat, we can talk about 'flags' but the term 'ensign' is more accurate! Out of respect for the coastal state, the ensign of that country is flown on the starboard* side. This ensign, also known as a 'courtesy flag', is compulsory and must be flown as soon as you enter the territorial waters of the country in question.

When the above picture was taken, it was clear that *Gaia* was sailing in Faroese waters. In the picture below, *Gaia* is leaving Faroese waters to enter Icelandic ones, and we see Thierry busy changing the courtesy flag. The yellow flag indicates a request for the right to enter and dock in the waters of the destination country. It is removed once the official formalities have been completed. It is called the flag of request for *free pratique.*

* Port and starboard refer to the left and right sides of a boat, respectively, when looking forward.

F Comfort on board

Gaia is not a racing boat, so life can be relatively comfortable for her crew. In the central part, there is a decent kitchen and a living area called 'the mess'. In addition, there are two double bedrooms, a small single bedroom and two bathrooms with shower. Space is nevertheless limited, so everything is optimised and every little corner is cleverly employed. Everything has to be closed and/or secured properly so that it does not open and/or fall out when the boat is sailing and heeling (leaning into the wind).

G In the bowels of *Gaia*

Gaia is a large sailboat (15 metres, 18 tonnes) that looks good and has more than just ballast below deck...

Indeed, pretty much everything can be found in *Gaia*'s hull. In addition to the engine and fuel tank, there's also wine, beer, water and food, a fresh water tank, pumps and pipes, batteries, lots of electrical wiring, an echo sounder, a small propeller to measure the speed of the boat and the distance travelled, tools and various spare parts, sailcloth for repairs, fins, a diving mask and oxygen tank for accessing the boat's base, a dinghy, two anchors, fire extinguishers, mooring lines, gas bottles and even two bicycles!

H Thieves in sight

The crew of *Gaia* had several opportunities to observe a rather cheeky thief, the great skua.

The great skua has a habit of chasing other birds in flight and harassing them until they drop their lunch from their beaks. The skua then swoops in after the catch before eating it unabashed. No wonder it's known as a pirate!

Off the coast of Iceland, another strange bird – this time a picture thief – flew over *Gaia,* as Thierry tells us: *"A drone flew over us and we were unable to identify where it came from or who was flying it. It just goes to show the potential that drones have for snooping. In the evening, in Dalvík, a man came up to us and handed us a USB drive with the images captured by the drone. It turned out to be the local emergency services on exercise rather than someone with prying curiosity!".*

I The fisher's paradox

Industrialisation produces paradoxical situations. Thierry tells us of an Icelandic anecdote illustrating this reality: *"Fishing is important in Seyðis-fjörður – as it is everywhere Iceland – but the entire catch is sent out for industrial processing, making it impossible to find any fresh fish in the ports. Anyone who doesn't fish for themselves therefore has to buy frozen fish from the supermarket. It's also impossible – in principle – to buy directly from the fisherman, as quotas are strictly applied. But Barbara did skilfully circumvent these rules by trading beer and chocolate for a superb cod".* Bartering is good!

J Not so crazy

On several occasions, Barbara and Thierry have had the opportunity to admire northern gannets.

These large, majestic birds (Europe's largest seabirds) have a spectacular fishing technique: with their keen eyesight, they hover high above the water and when they spot their prey, they retract their wings and dive downwards. They enter the water at over 100 kilometres per hour and can catch prey that might be far below the surface. When they fish in a group, it's an onslaught for any unfortunate shoal of fish that happens to be passing by.

K A big meeting...

During their journey, Barbara and Thierry came across several sea animals.

They often had dolphins accompany them as they sailed, but one encounter with another creature – as big as *Gaia* – could have ended badly. Thierry tells us about this remarkable episode: *"We were heading towards Reykjavík and crossing a large gulf towards Ólafsvík. The sea was calm, so we were motoring, and I was down in the mess reading a book on a bench. All of a sudden I heard Barbara calling me urgently. I threw down my book and jumped into the cockpit to see the huge back of a sperm whale a few metres from our bow*. I slammed us into reverse and slowed* Gaia *down enough to avoid a collision. Just earlier, Barbara had been recording this long period of motoring on a windless sea in the logbook, writing: "Everyone's a bit bored!..."*

* The bow is the frontmost part of a boat.