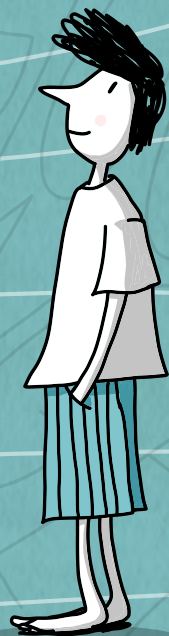


by Chiara Fontanot & Lisa Peratoner

Drawings by Chiara Sepin

SILENCE, THE SEA IS SPEAKING!



with QR codes
to listen
to the sounds
of the sea!



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SILENCE, THE SEA IS SPEAKING!

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This is the most incredible story that has ever happened to me.

Summer again – like every other year, I spent at the seaside with my sister and my parents, always in the same place, always in the same two hellish weeks of August.

Like in an anthill, every morning we made our way through a labyrinth of umbrellas, deckchairs, beach games, cackling children, crying babies, babbling adults on their mobile phones, just to make it to our own little patch of beach. And then? Then nothing: for me it was two weeks of boredom, endless boredom. My only consolation were my headphones:

I would estrange myself from the world for hours and hours, immersing myself in my music and resisting every attempt by my mother to force me into ‘normal’ beach activities.



“Ernesto, why don’t you go for a swim?” “Ernesto, help your sister make a sandcastle!” “Ernesto, you have to move around a bit: go for a walk on the promenade!”

Between soaking in the water and playing with my sister, the walk was by far the least bad, if only because I could do it without having to take off my headphones.

And so, I set off that morning.

I didn’t think about anything, I just listened to the soundtrack I had chosen to ease the burden of those endless days while I walked, walked, walked.

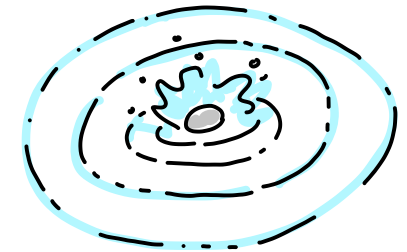
I don’t know how far I walked. All I know is that at a certain point I found myself alone: no umbrellas, no coconut sellers and no screaming kids.

A sign indicated the end of the bathing area and the beginning of a marine protected area.

What’s in a sound?

Sound originates from a **vibration** that propagates in the form of a sound wave in all directions.

Let’s think of a stone that is thrown into a pond: from the point where it enters the water, concentric ripples are created on the surface of the pond, which propagate in all directions. Sound propagates similarly: the sound wave travels in all directions thanks to successive compressions and decompressions of the medium it passes through, which may be gaseous (air), liquid (water) or solid (the ground).
A sound cannot propagate in the vacuum!



At the end of the jetty that bordered the reserve, I glimpsed a lone figure. A girl. She was lowering a strange object (a fishing line?) into the water and was wearing a pair of strange headphones. Curiosity won out over my shyness, and I approached.

“What are you fishing for?”

“Sounds. But be quiet, please.”

OK. She fishes sounds. Nuts, I thought.

I was considering my options - running away or asking her for an explanation. I chose to keep a low profile.

“I’ll be quiet as a fish, I promise.”

She turns sharply, takes a good look at me and bursts into laughter. “Quiet as a fish? That’s a good one! Whatever, dude, work’s over for today. Come, I’ll let you in on a secret.

Ah, by the way, I’m Alice. I’m a marine biologist and... -winking - ...an inventor. And you?”

“Ernesto, nice to meet you.”

“Well Ernesto, sorry to disappoint you but actually fish are not silent at all. The sea talks. And I listen to it.”

“I’ve never heard any fish speaking. And I’ve snorkelled a lot!”

“Eh, if only it were so easy to hear them! But that’s where the hydrophone, my beloved research companion, comes in...”

And as she speaks to me, Alice lifts the cable out of the water, bringing out a giant microphone-like instrument attached to the headphones she is wearing.



Sound characteristics

Frequency is the number of oscillations per second made by the sound wave and is measured in Hertz (Hz). The human ear is 'equipped' to hear sounds between 20 and 20,000 Hz. Sounds with a frequency below 20 Hz are called **infrasound**, and are perceived by elephants, for example.

Above 20,000 Hz we have **ultrasounds**, emitted and perceived by bats and dolphins.

Intensity, on the other hand, is measured in decibels (dB) and depends on the amplitude of the sound wave.

The **threshold of audibility** for humans is 0 dB; above 50 dB a sound becomes **annoying** and above 120 it becomes **painful** (aircraft taking off or ambulance siren).



Hydrophone

This is an instrument designed to capture sounds and noises propagating in the sea and to detect the direction they are coming from. We can consider it as a **large microphone** that is able to transform the mechanical energy of sound waves into electrical energy, and thus into electrical signals that can be processed.

In reality, however, **there is no** instrument capable of automatically **translating** the sounds emitted by marine animals into a language we can understand.

Bioacoustics scientists, however, are able to **interpret** sounds and gather information about the analyzed environment.



Before I get a chance to ask her for an explanation, I glimpse two unmistakable shapes out at sea behind Alice's head: two fins intermittently sticking out of the water a short distance from us.

"Dolphins!" I exclaim in excitement.

"Two bottlenose dolphins to be precise: real chatterboxes!" comments Alice, lowering the hydrophone into the water. Then she hands me her headphones: "Put them on and listen."

"You're right! I hear whistles and clicks: is that really them?"

"Of course! And they're not just communicating: the clicks they emit are for seeing..."

"For seeing? Don't they already have eyes?"



"Sure, they use their eyes, but they also benefit from echolocation: the sounds they produce 'bounce' off objects around them and allow them to spot fish to eat or obstacles to avoid."

"Cool!" I comment. I am thrilled.

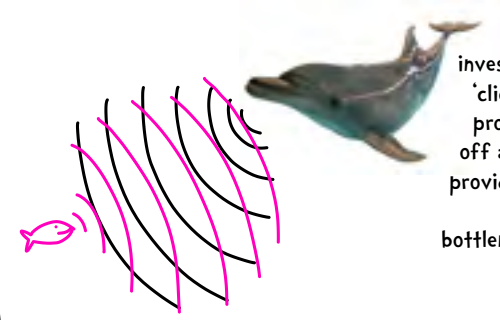
"You think this is cool? The best is yet to come!"

Alice walks over to the headphones I'm wearing and turns a lever I hadn't noticed.

In an instant it's pure magic: I can't believe my ears but I can understand what they are saying to each other!

"Bank of fish at ten o'clock: mullet I would say."

"Thank you, I'm so hungry I can't tell you! Watch out for the boat moored at nine o'clock!"



Echolocation

Dolphins also produce sounds to acoustically investigate the world in which they move. By emitting 'clicks' in the direction their heads are facing, they produce a high-frequency sound pulse that bounces off any present objects and returns as a kind of echo, providing valuable information about their surroundings.

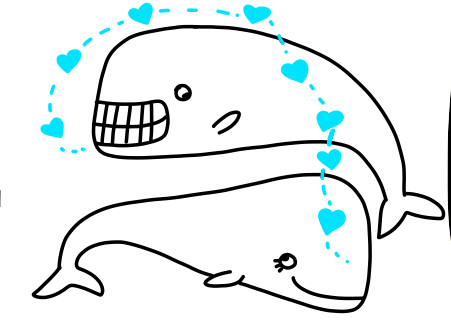
In captivity, it has been possible to verify that a bottlenose dolphin can detect a sphere of 2.5 centimetres in diameter at a distance of 72 metres.

How dolphins communicate

Cetaceans are known to have a pronounced ability to communicate, and this is especially evident in odontocetes (dolphins, orcas and sperm whales).

By producing whistles or continuous sound series called BPS (Burst Pulsed Sounds), they are able to communicate and produce emotional responses to external stimuli when courting or when they are afraid or angry.

Each dolphin has its own characteristic whistle, like a sort of 'signature' that makes it instantly identifiable from other individuals of its species.



Incredulous, I pull off my headphones in a rush, trying to unravel the mystery. “What the hell?”

Alice bursts into thunderous laughter, “What’s the matter, Ernesto? Did you think you were the only one chatting with friends?”

I told you: dolphins, fish and many other marine organisms are far from silent. In fact, some can be very noisy: it’s a real concert down there! Let’s dive near that reef and I’ll introduce you to some of them”.

“Here, take mine, I don’t need them,” she says, handing me a pair of fins and a snorkel mask. And, just like that, we are out at sea.

The sea, in that place far from the crowds of swimmers, is densely populated by many different inhabitants: shoals of fish speed around me, and the seabed, partly sandy and partly rocky, is populated by many different organisms.

But I am here to listen, so I switch on the special headphones I am wearing.

I’ve done a lot of snorkelling over the years, but this is really something different: it’s like being in a small underwater metropolis at rush hour. Only instead of horns, braking, sirens and roaring engines, it’s all a succession and overlapping of ticking, screeching, thumping and snapping.

Alice points out to me a small shrimp with one claw larger than the other: it resembles a fierce little boxer.

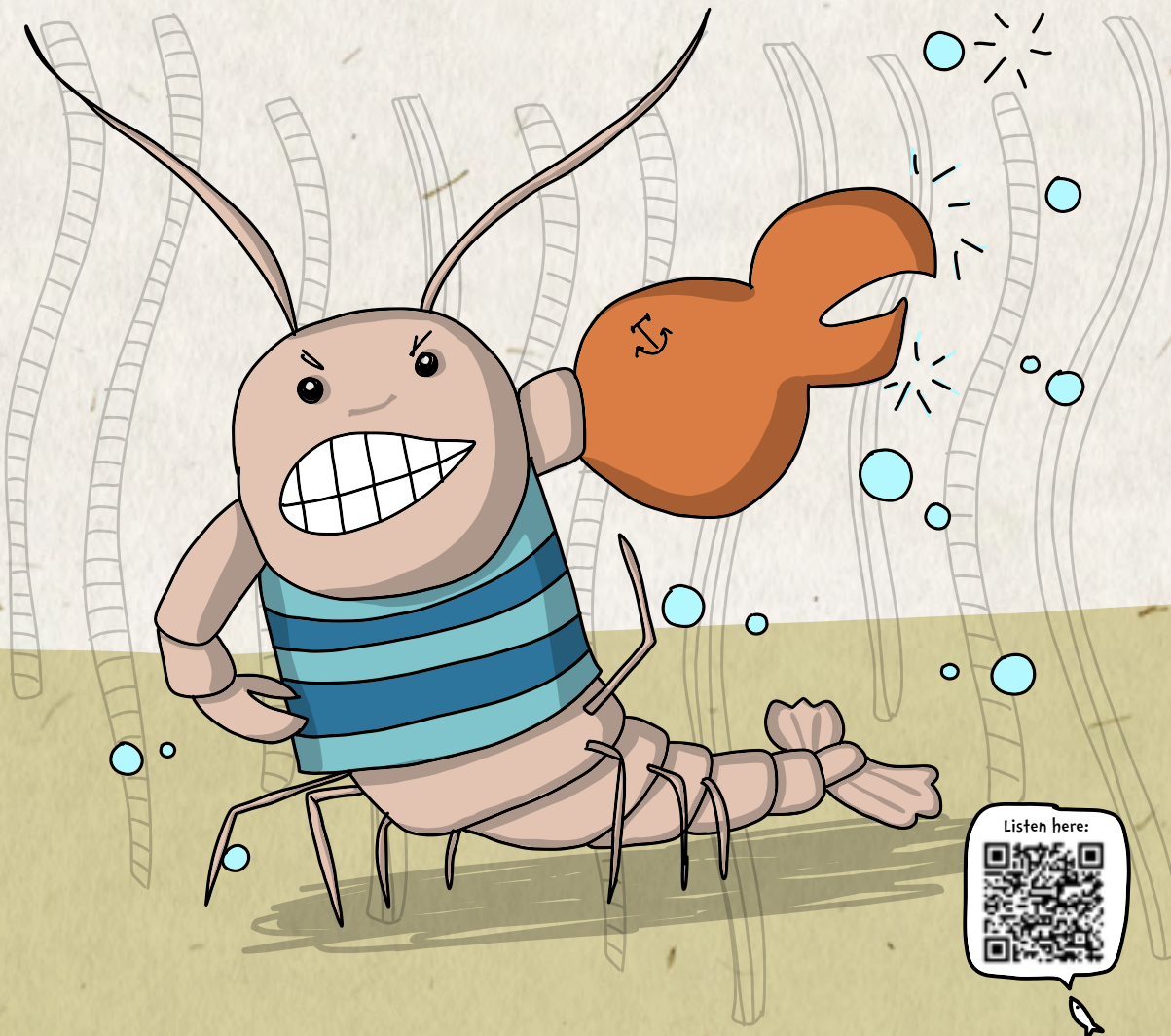
It is menacingly confronting another crustacean of the same species, and moving its claw, it forms air bubbles, which then burst, producing a snapping sound.

It is time to put Alice’s special headphones into action: I lift the lever and listen....

“Don’t come any closer! Shoo away!”

“Give me room, come on... I just want to get through!”

“One more step and I’ll stun you with a pop!”



The snapping shrimp

This small crustacean is one of the noisiest animals in the world. It is equipped with one claw that is much larger than the other.

By opening and closing this claw, it is able to produce a **sound** comparable to a **gunshot** (in fact, it is also called pistol shrimp), with which it is able to **stun** possible preys or opponents. It has recently been discovered that this sound is due to a phenomenon called cavitation: the movement of the claw **forms a bubble** that implodes due to water pressure, producing a sound wave that can reach 210 decibels.



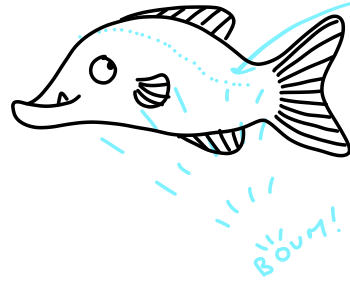
Listen here:



A bit further down, I glimpse a submerged reef.
 As I get closer, I see some fish with conspicuous yellow fins moving elegantly in circles. The males are courting a female and follow her, making drum-like sounds in chorus. Intrigued, I approach to catch their speech:
"Baby, I am here: choose me!" "No, me!"
"I'm the best"
"No way, look at my fins!"

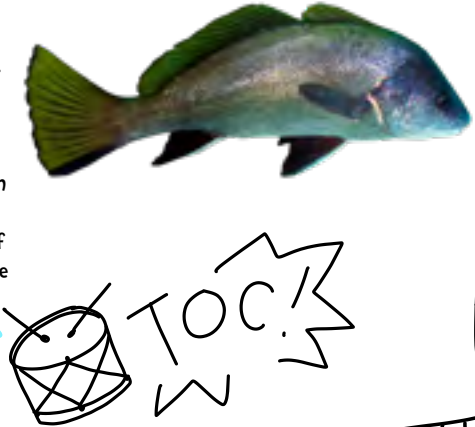
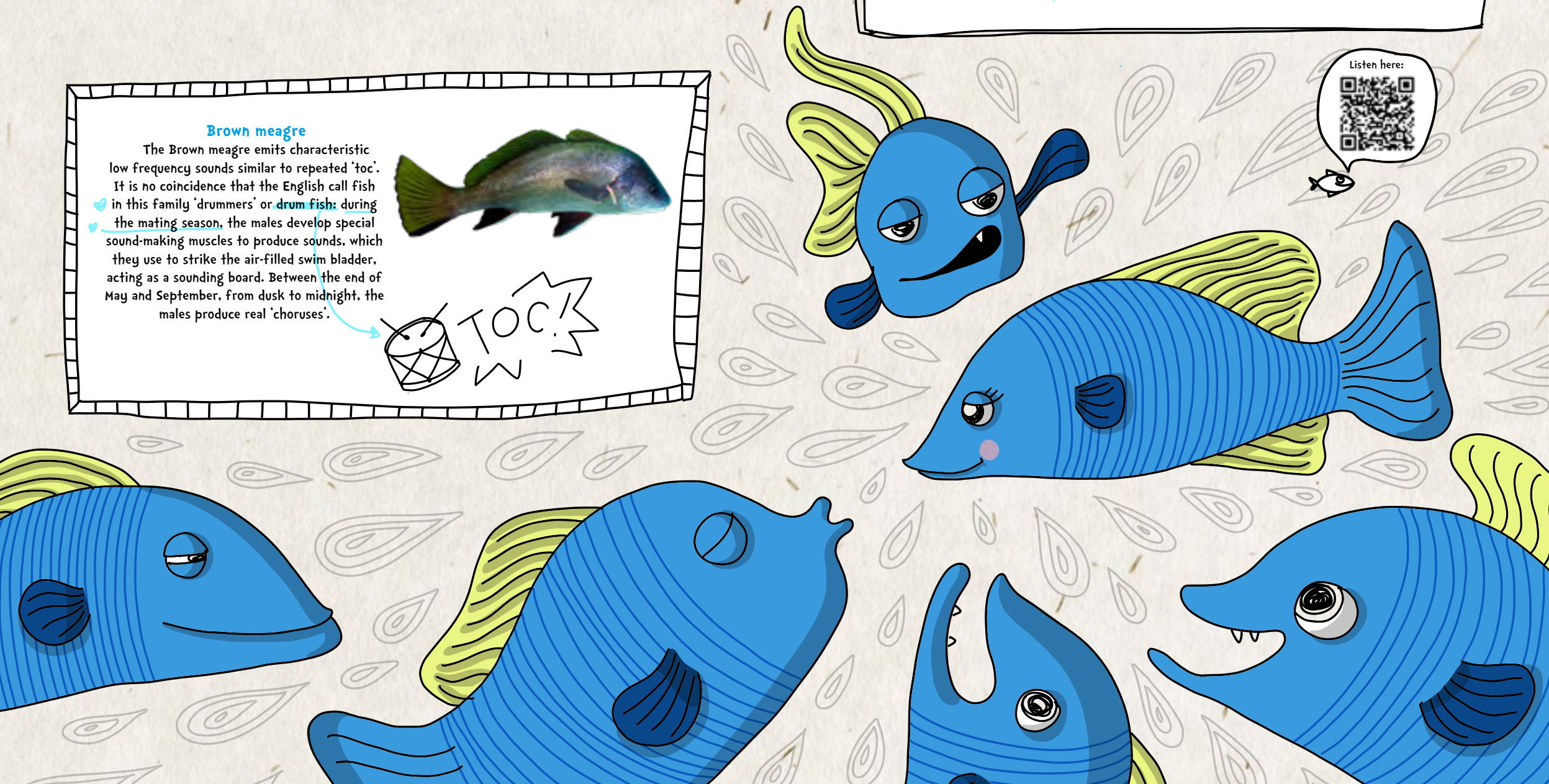
How fish hear

If sounds are produced, they must also be perceived. But how? Fish do not possess an outer ear but have a well-developed inner ear that also receives information from the lateral line system. This system allows the fish to perceive the movement of water particles, caused for example by a sound impulse, thanks to a series of receptors called neuroblasts, distributed along a line running on the side of the fish.



Brown meagre

The Brown meagre emits characteristic low frequency sounds similar to repeated 'toc'. It is no coincidence that the English call fish in this family 'drummers' or **drum fish**: during the mating season, the males develop special sound-making muscles to produce sounds, which they use to strike the air-filled swim bladder, acting as a sounding board. Between the end of May and September, from dusk to midnight, the males produce real 'choruses'.

Other smaller fork-tailed fish seem very busy. After clearing a small portion of the rock of algae and encrustations, one of them starts moving in circles, flapping its tail, and emitting 'pop' sounds. So much excitement: but what is it saying?

"Clean here, clean there. Look what a nice nest I've made! Hey pretty damsel, how about laying your eggs here?"

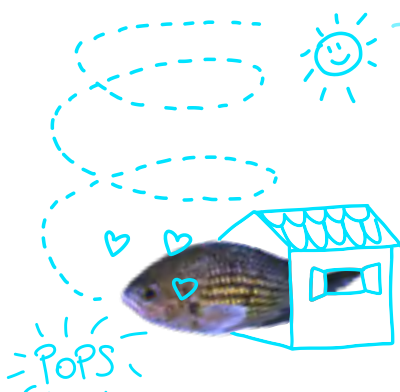
But my attention is drawn by another curious scene that I see a little further on, and by the strange noises that reach my ears.

"Don't come closer, unknown goby, this is my territory!"

The warning comes from a small yet fierce fish as it emerges from its burrow, its red mouth wide open and fins spread to look more threatening. Another fish of the same kind tries to take its place.

The house owner is not intimidated and launches himself into a duel of fin strokes, bites and tail blows, until he gets the better of him and the intruder now turned pale, walks away sheepishly.

'Don't let me see you around here again,' adds the winner, slipping back into the den.



Damselfish

Generally, these small fish live in the water column, but during the summer season the males descend close to the rocky seabed to prepare their nest, a portion of rock cleared of algae and encrustations.

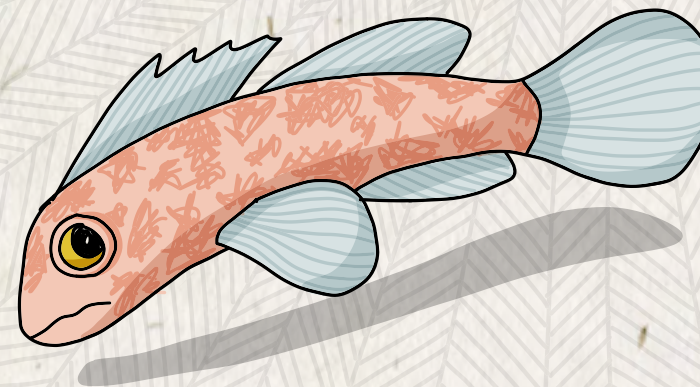
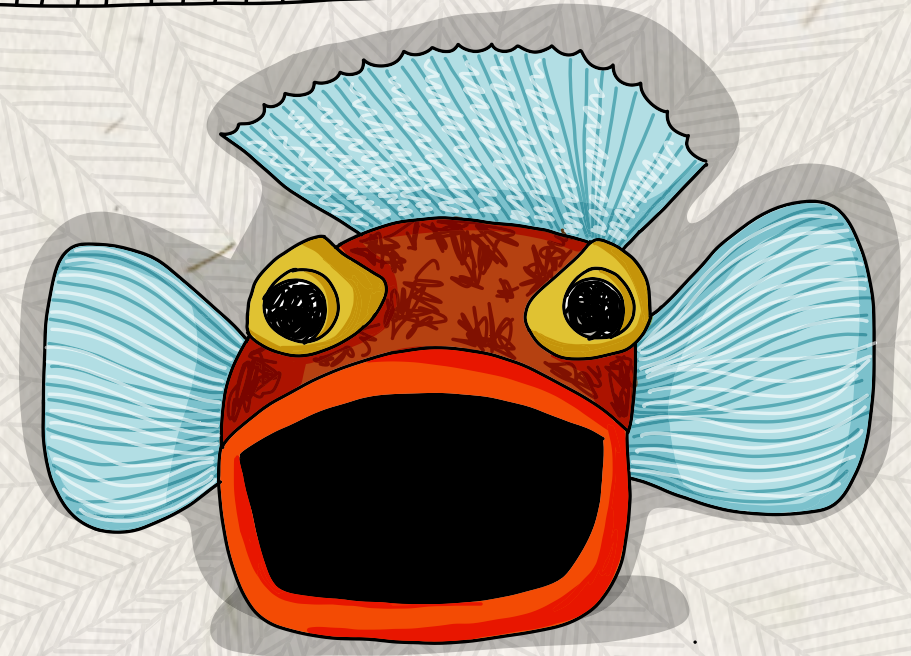
At this point they begin to perform a kind of ritual made up of signalling jumps, which draw circular trajectories from the nest along the water column. This dance is accompanied by characteristic sounds called 'pops', which serve to attract females and to drive other males away from the nest.



The redmouth goby

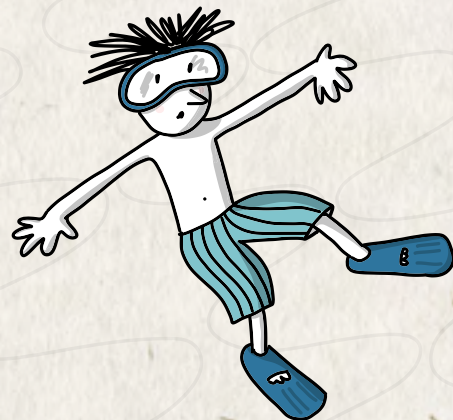
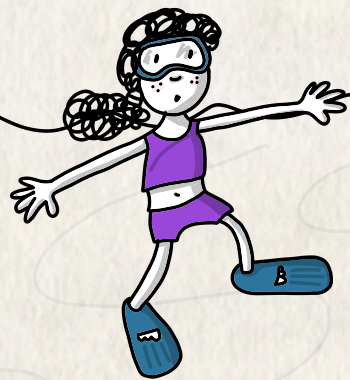
This is a common fish in the Mediterranean, recognisable by its bright red cheeks and lips, living on rocky or sandy seabed up to a depth of 50 metres.

Like other species of the same family, it is **solitary** and **territorial** and, when an intruder approaches its burrow, it emits characteristic 'groar-like' sounds, opening its mouth and fins wide to appear more threatening. If the acoustic threats are not enough to drive the intruder away, the invasion results in a fight with blows and bites, at the end of which the **loser** assumes a **pale white colour** and walks away.



Listen here:





Alice signals me to come up to the surface, but I don't want to go. It is just as she said: the sea speaks. And I want to listen to it again.

The sound of the wind and the waves provide the background for singing and chattering sounds. In some cases, I can discover who is responsible for the sounds I pick up, in others the source remains hidden between rocks or under the seabed.

Noise from boats
 It has been shown that the **main source** of noise pollution in the Mediterranean is the **noise generated by vessels** of all sizes. Factors affecting the nature and loudness of a sound include hull length, engine power and type, and cruising speed.

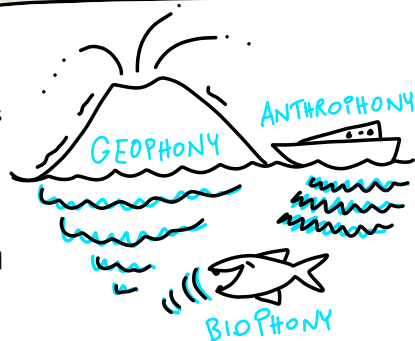
Suddenly, I jolt. I notice a disturbing noise, getting louder and closer.

The reef dwellers have also felt it and suddenly there is a rush: although the source of the noise is not visible and remains at a distance, the damselfish head out to sea, the brown meagres hide among the rocks of the reef, shrimps and gobies return to their burrows.

Alice and I, without saying a word, immediately return to the surface and see the culprit: it is a speedboat whizzing by, a few hundred metres away from us. It is far away and yet we all heard it very well, especially the inhabitants of the small underwater metropolis. After its passage, all that is left of them are a few disoriented fish coming out of their makeshift shelter.

The soundscape

In water, sounds travel faster and further than in air and contribute to the Sea Ambient Noise. This is a collection of sounds from essentially three elements of the soundscape: **geophony**, which includes sounds produced by non-living natural elements such as wind, waves, earthquakes and volcanoes; **biophony**, which includes those produced by marine organisms; and **anthropophony**, the set of sounds produced by humans.



Man-made sounds

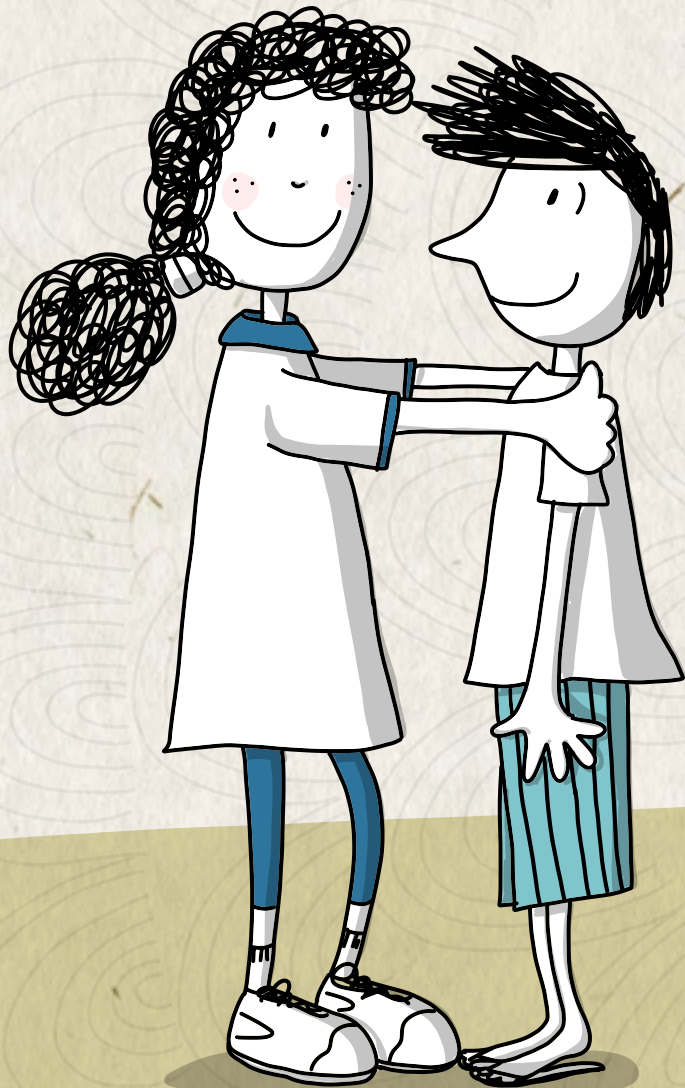
There is a **wide range of man-made sounds**: explosions, sonar, drilling, laying of underwater pipes for gas and oil pipelines, ocean and geological research all produce noises that contribute to raising the background noise of the sea.

Maximum noise peaks are generated by seismic surveys and military sonars and can reach 259 dB, with sounds repeated every 10 seconds for weeks or even months.

The magic is now over and all we must do is return to the shore.

“I didn’t think a speedboat could create such a fuss,” I comment bitterly, removing my fins, mask and headphones.

“Imagine how many boats pass by every day in the seas around the world, of different sizes, and multiply this number by the noise you heard: you will realise how much we can interfere, albeit unintentionally, with the life and well-being of marine organisms,” Alice replies.



Time has flown by and I have to hurry back to the beach umbrella before Mum and Dad call the police, the fire brigade and the hospitals all over the city.

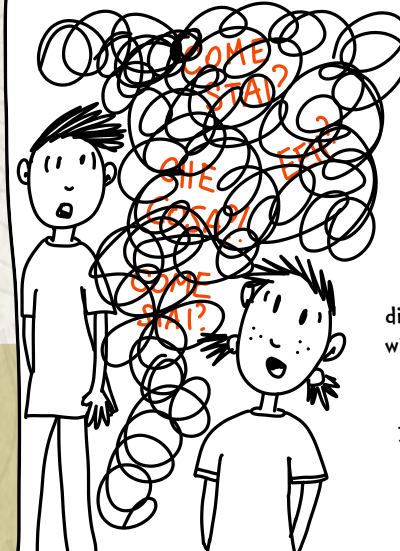
I hand the headphones back to Alice and give her a big smile.

“Thank you, really: it was an incredible experience. I won’t forget it.”

She smiles and pats me on the shoulder: “Keep your ears always open, mind you!”.

At the beach umbrella, Mum greets me with a look of disapproval: “Where have you been? Come on, Dad is renting a speedboat to take us for a little ride and explore the surroundings!”

“No way,” I retort firmly. ‘If you want to go for a ride in the sea, there are SUPs: there’s a rental just over there’.



Effects of noise pollution on marine organisms

Think about how difficult it can be to talk to a friend in a very noisy environment.

The same applies to marine organisms, as man-made noises overlap with biological sounds, masking them and making them unintelligible.

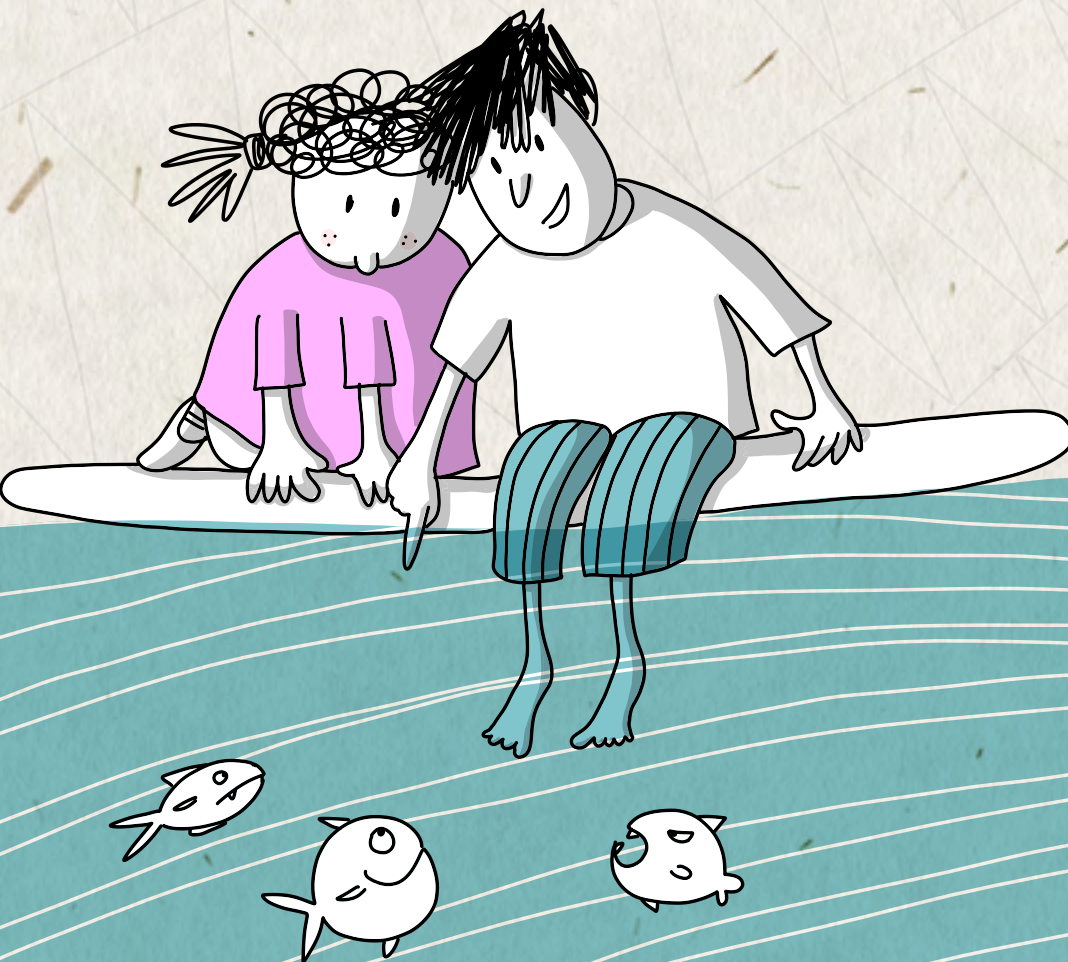
There are several species of aquatic organisms that depend on their auditory system to detect prey and predators, to orient themselves in the sea and to communicate with other individuals of the same or different species. Underwater noise can negatively interfere with the communication of individuals, alter their behaviour, raise stress hormones or even impair hearing ability, in the case of very intense noises.

In turn, all this can compromise their ability to reproduce and the survival of the species.

After some fifteen minutes, in between paddling, we arrive near the reef I explored with Alice. Throughout the whole trip, my sister never stopped humming, cackling and shrieking with joy. At one point I blurted out annoyed, "Can you please be silent?"

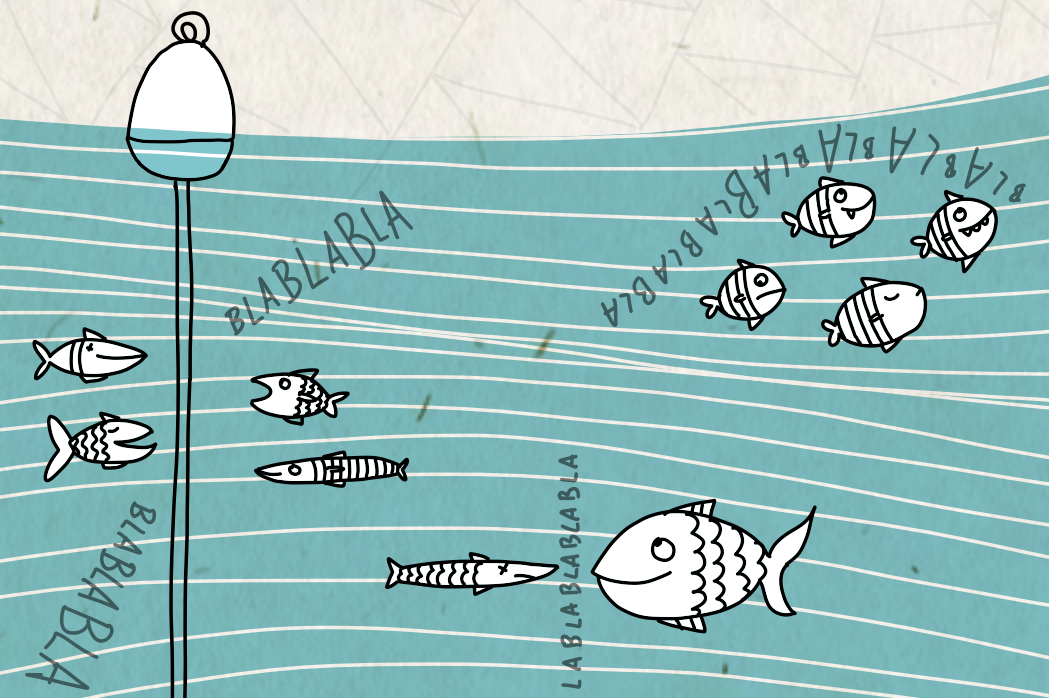
"OK, I'll be quiet as a fish," she replies mortified. I look at her and burst out laughing:

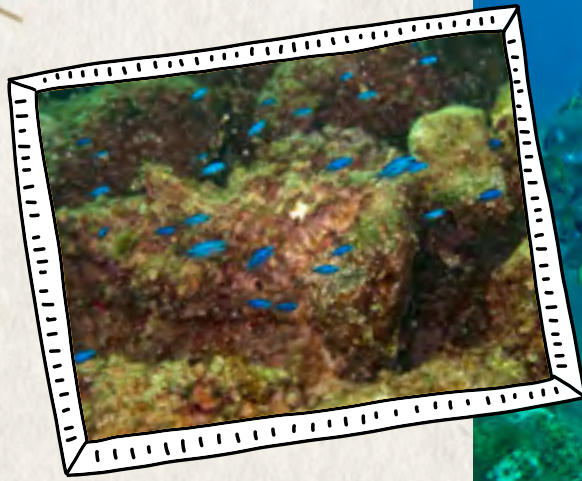
"Quiet as a fish? That's a good one! Let me tell you a secret."



What can we do?

Today, there is much research into monitoring underwater noise with the aim of reducing its impact. At the same time, in many areas, scientific and regulatory efforts are being made to provide the tools to protect more effectively the marine environment throughout Europe. Many solutions to noise pollution already exist and are also quite simple: reducing the speed of boats, modifying certain shipping lanes to limit the access of boats to densely populated areas, especially during mating or migration periods. From a technological point of view, efforts are being made to build reduced-noise boats, for example by replacing the noisiest propellers with others designed to reduce cavitation (the creation of tiny bubbles that burst when they explode), using electric motors or applying insulation systems.





FLABELLINA

Like the nudibranch whose name it bears, and which decorates its sides, it moves **slowly** and **silently** through the protected waters of Miramare: Flabellina is the Protected Marine Area's fully electric-powered boat, an **8-metre** pontoon boat that can accommodate up to **16** people.

Thanks to its silent sailing and the use of a **hydrophone**, visitors have the opportunity to listen to **the underwater soundscape** and to be told by WWF guides how the noise produced by offshore boats, and any other human activity at sea or on the coast, can disturb and compromise the vital functions of organisms, from reproduction to communication, from defence against predators to orientation.



MIRAMARE MARINE PROTECTED AREA

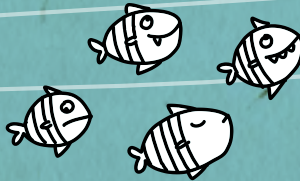
Established in **1986**, the first among Italian marine reserves, the Marine Protected Area of Miramare, managed by WWF Italy, is a local and national reference point for **education** and **dissemination** on marine and coastal environment. In the early 2000s, the first pioneering studies at national level were conducted in Miramare about **the impact of boat noise** on the physiology, communication and behaviour of some of the reserve's species. Monitoring of the background noise that characterises this important protected area was launched. From 2022, these topics will again be offered to the public through an **outreach programme**, of which this publication is an integral part, aimed at purchasing a new, environmentally friendly and silent electric boat.



Ernesto, a bored boy annoyed by the hustle and bustle of the beach, seeks some peace and quiet.

Instead, he meets Alice, a marine biologist who will accompany him on a real underwater adventure listening to the sounds and noises that organisms make to communicate, orient themselves and reproduce.

In the end, Ernesto will discover how false is the saying 'quiet as a fish' is false and how much the noise produced by our activities can disturb and compromise the fragile marine ecosystem.



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