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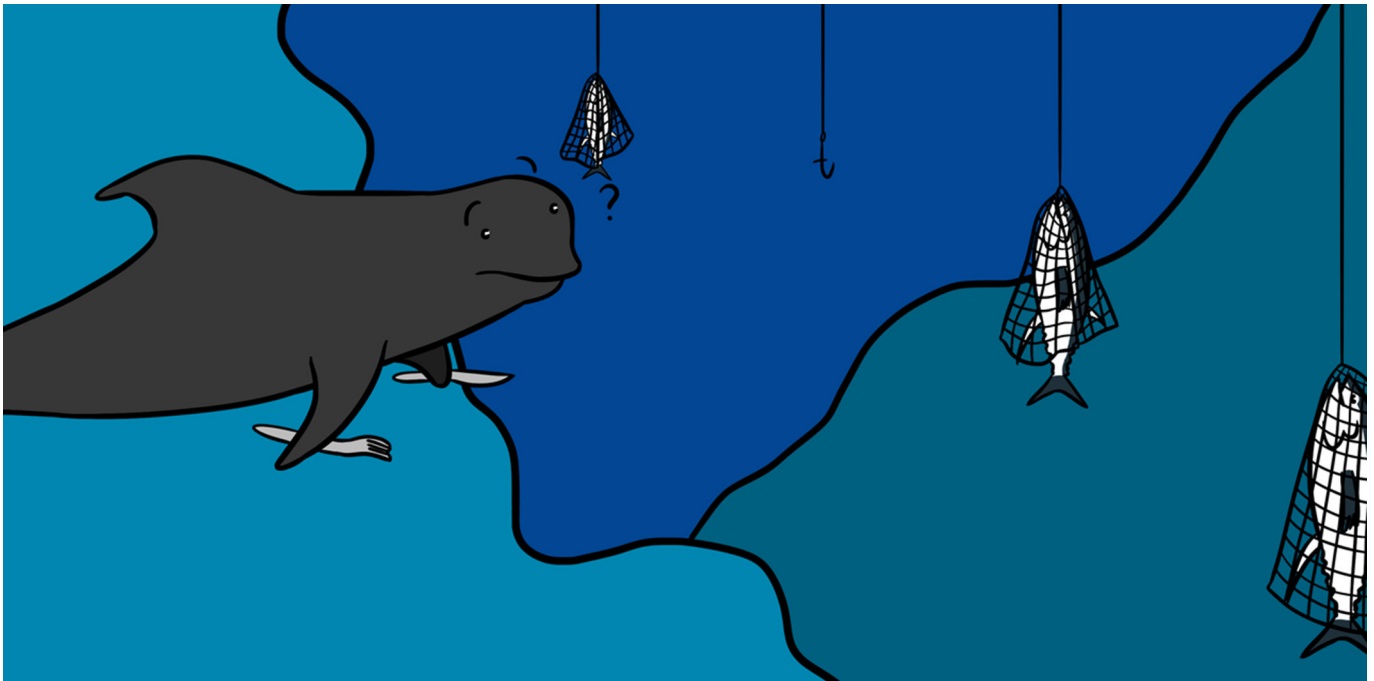
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SHIELDING FISH TO PROTECT WHALES AND FISHERS INCOME

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**INTER-
NATIONAL
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OF BERGEN**

AGE: 8



MATÍAS

AGE: 16



SEBASTIAN

AGE: 12

Some toothed whale species have gotten used to stealing or damaging fish that have been captured by the fishing equipment of fishers. This stealing is called depredation, and it is a problem for both fishers and toothed whales in all the oceans of the world. Fishers lose their catch and must work harder, and the whales can get injured and forget how to hunt. It is important to develop a solution to prevent toothed whales from stealing fish captured by fishers. Our group of scientists is developing a system that can protect captured fish from being stolen. Basically, our innovation is like Spider-man[®] throwing a spiderweb over the fish, to hide them from toothed whales! In the near future, we are hopeful that this system will both help the fishers by protecting their catch and help to protect toothed whales.

TOOTHED WHALES

A group of marine mammals, including killer whales or dolphins, that have pointy teeth and feed on fish or squids.

DEPREDATION

The act of damaging or stealing plants or animals grown or bred by humans. For instance, coyotes or foxes sneaking into a farm to eat chickens is depredation.

Figure 1

Depredation affects toothed whales, fishers, and captured fish. Depredation changes the hunting strategies of toothed whales and these animals can also get injured when they try to steal the hooked fish. Fishers lose money and have to work harder to compensate for their damaged catch. Finally, depredation impacts fish species because, since depredated fish are not counted in fisheries statistics, the number of fish left to catch in the ocean is calculated incorrectly.

WHAT IS DEPREDATION AND WHY IS IT A PROBLEM?

You probably already know that fish are an important part of the human food supply. But did you know that **toothed whales** have learned to steal fish from fishers in all the oceans of the world? When fish are captured in fishing gear, some species of toothed whales have gotten used to eating them before the fish are hauled onto the fishing boat. This is called **depredation**. Depredation by toothed whales happens frequently, and it is bad for both the toothed whales and the fishers [1, 2].

Why is depredation bad for toothed whales? Well, instead of hunting wild fish as they should naturally do, these whales would rather eat fish that have already been caught. By doing so, they save energy and easily get a large amount of nutritious food. Depredation can lead whales to forget their own natural hunting strategies, and they might lose the ability to obtain food by themselves. Toothed whales can also be injured by fishing gear—they can get entangled or hooked as they try to remove the fish. All marine mammal species are classified as endangered, and several laws exist to protect these species from human threats, including threats posed by the fishing industry. This is one reason depredation should be prevented.

In terms of the fishers, they cannot sell damaged fish, so to replace the fish lost to depredation, they must do more fishing! This is a waste of time and money because the fishers must use more fuel, deploy more hooks, invest more hours, and fix the equipment damaged by toothed whales. Depredation also has consequences for the total number of fish available to be harvested as human food. Fish are a limited resource. Depredated fish are not counted by the fishers and therefore are not reported in fishery statistics. Consequently, fishery scientists might incorrectly calculate how many fish are left to catch in the ocean (Figure 1).



DRIFTING LONGLINE FISHING

A technique involving a floating mainline set in the ocean, with hundreds of vertical baited branchlines attached to it. This longline drifts for hours to catch fish.

MAINLINE

A horizontal fishing line set in the water and suspended at the surface thanks to large buoys attached at regular intervals. It can be as long as 150 km.

Figure 2

(A) A longliner sets a drifting longline to catch large fish. The mainline is suspended by buoys and the branchlines hang off of it, each one ending in a hook. A short-finned pilot whale is depredating a captured fish and leaves its head on the hook. (B) Drifting longlines target large fish, such as tuna and swordfish, which are mainly depredated by two toothed whale species: the false killer whale and the short-finned pilot whale.

BRANCHLINE

A vertical secondary line attached at regular intervals to the mainline, with a baited hook at its end. Fishers can set up to 3,000 branchlines on the same mainline to capture fish.

ECHOLOCATION

A hunting technique used by bats or marine mammals. They emit calls and they listen to their echoes. They use this technique to locate, identify, and hunt their prey.

WHAT KIND OF FISHING DO WE STUDY?

For our work, we focus on a fishing technique called **drifting longline fishing**. Fishers use this method to catch large fish such as tuna or swordfish in the ocean. They sail a type of boat called longliner and set a fishing line called a **mainline** in the water. This mainline is suspended at the surface thanks to large buoys attached at regular intervals. The mainline, which can be as long as 150 km, is attached to vertical secondary lines called **branchlines**, each one with a hook at its end. Each hook is baited with a squid or a mackerel. The branchlines are left to hang down in the water to attract and catch fish (Figure 2A). This entire fishing apparatus is called a longline. Fishers can set up to 3,000 hooks on the same longline. The longline is left to drift for about 6–7 h before being hauled onboard to harvest the captured fish.

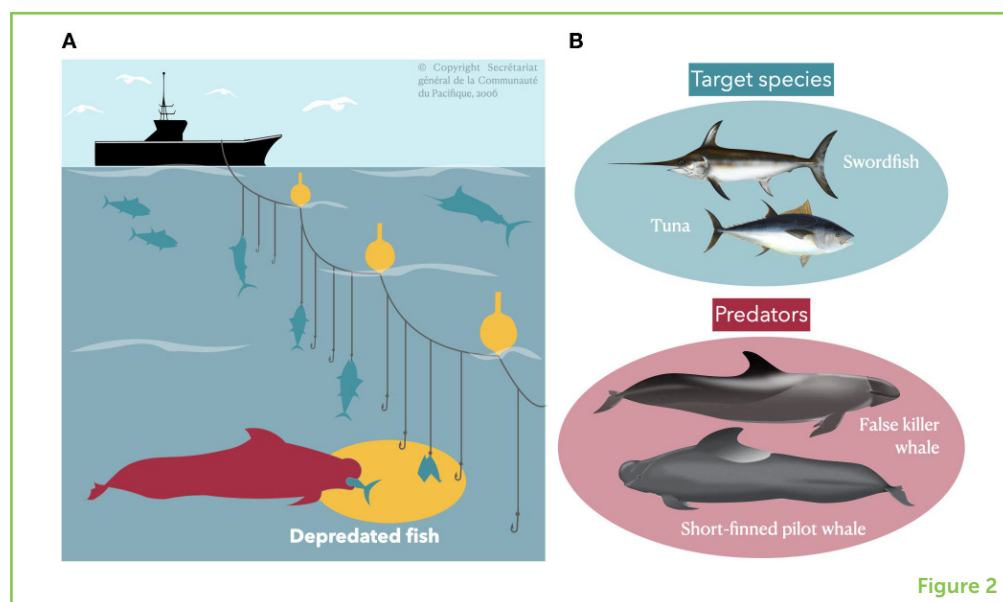


Figure 2

WHICH TOOTHED WHALES ENGAGE IN DEPREDAATION?

In tropical waters, two species of toothed whales—the false killer whale and the short-finned pilot whale—are commonly involved in depredation of fish caught on longlines (Figure 2B). Can you guess how big tuna and swordfish captured by longliners are? Tuna can exceed one meter in length, and swordfish can measure 2–3 m in length. However, false killer whales and short-finned pilot whales can be up to 6 m long. When depredating a fish, they tear the flesh off, leaving only the fish's head on the hook (Figure 2A).

To locate and hunt their prey, toothed whales emit calls. Then, they listen to the echoes of those calls that bounce off the objects surrounding them. This technique is called **echolocation**. Toothed whales and other animals, like bats, use this hunting technique to locate and identify their prey, based on the specific echoes that return to them. Toothed whales use echolocation to spot the hooked fish,

and the noises of the boat in the distance also attract the whales. Since hooked fish cannot swim away, it is very easy for the whales to feed on them: it is like a ready-to-eat meal in an all-you-can-eat restaurant! It is so easy that toothed whales sometimes swim along the mainline and steal every single captured fish, making the fishers to feel desperate.

PARADEP: A POTENTIAL SOLUTION

So far, several techniques have been tested worldwide to decrease depredation, but none of them work very well [3–5]. We run a project called PARADEP¹, to find an innovative way to reduce depredation by toothed whales. The aim of the project is to design a shield that can hide and protect the captured fish. How does it work? First, picture Spider-man[®]: his super power allows him to shoot an adhesive spiderweb through a small barrel located on his wrist, right? Our device is similar to this barrel. Two protection nets (which look like Superman's[®] cape) are stored inside a small case. These cases are attached to the tops of every branchline. When the fish bites the bait and pulls on the hook, the case opens. Then, the protection nets are ejected, slide down the branchline, and wrap the fish up. Then the fish is protected by a shield, as if it were wearing an invisibility cloak. The net shield makes it harder for toothed whales to see and eat the fish, so the net avoids whales from depredating the fish until the line is hauled back onboard. This way, the fisher can harvest undamaged fish, even if toothed whales are swimming near the boat (Figure 3).

¹ <https://paradep.com/en>

Figure 3

Our PARADEP system could decrease depredation. **(A)** The case (containing the nets) is set on top of the baited branchlines. **(B)** The case opens when the fish bites the bait and pulls on the branchline. **(C)** The nets exit the case, **(D)** slide down the branchline, and **(E)** wrap up the fish to protect it. Toothed whales are unable to depredate the protected fish and will swim away.

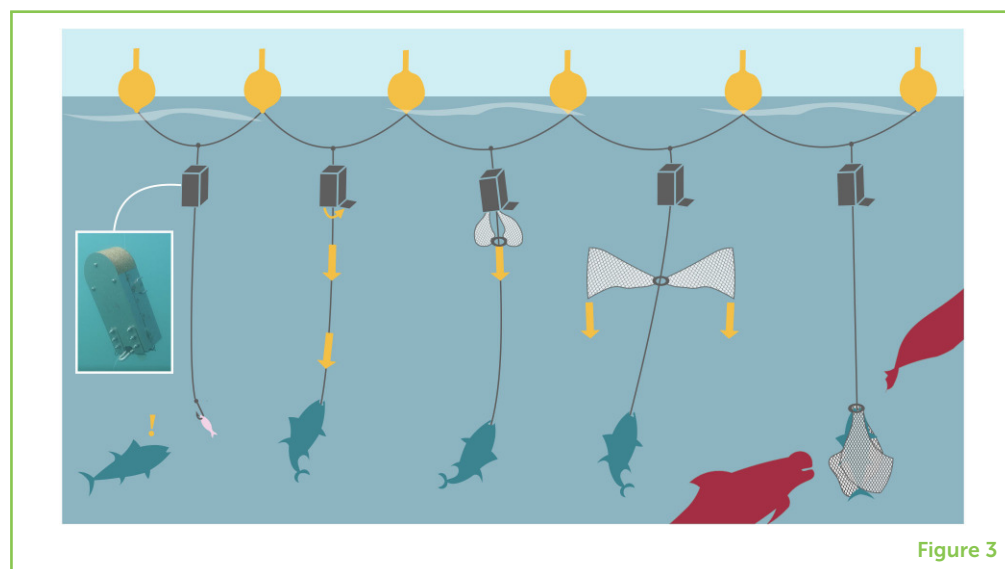


Figure 3

Our device will keep fishers from both losing income and working overtime to compensate for the loss of fish. The device is reusable, so it is environmentally friendly and economically attractive for fishers. It will also help protect the toothed whales, because it will reduce their risk of injury and they will have to use their natural hunting skills again.

TAKE-HOME MESSAGE

Depredation of fish caught by drifting longliners causes conflicts between fishers and toothed whales. This interaction needs to change, so that fishers and toothed whales can share the same feeding/fishing grounds without harming each other. By creating a shield around a hooked fish until it is hauled onboard, the PARADEP device may be the solution we are looking for, both for protecting toothed whales and preventing fish from being stolen. We are working with fishers because they want something to help them decrease depredation. They are playing an important role in testing the PARADEP device. After several months of PARADEP testing and collection of feedback from the fishers who are using it, we will know whether PARADEP works well-enough to help reduce depredation by toothed whales throughout the world's oceans.

ACKNOWLEDGMENTS

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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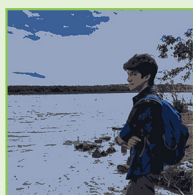
INTERNATIONAL SCHOOL OF BERGEN, AGE: 8

The 8 graders at the International School of Bergen form a dynamic group with highly diverse international backgrounds. They are interested in learning the scientific method and sustainability, but also have a great artistic talent.



MATÍAS, AGE: 16

I love playing music and doing magic tricks, I like science and my favorite subject is physics.



SEBASTIAN, AGE: 12

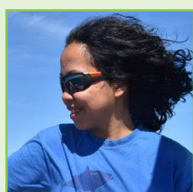
I like sports, reading, math, animals, and the great outdoors!



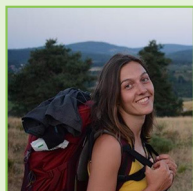
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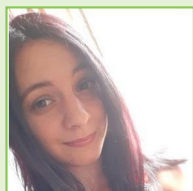


species and fisheries. She tries to understand when, where, and why negative interactions occur and how to prevent them. She likes traveling, photography, and diving. Since she was a kid, her favorite movies have been *The Big Blue* and *Free Willy*. She also grew up reading *The Old Man and the Sea*, by Ernest Hemingway. *njaratiana.rabearisoa@ird.fr



ALICE ARNAU

Alice Arnau is a master's student at the science faculty of the University of Montpellier. After graduation, she will work in the complex field of environmental management. She will especially dedicate herself to answering questions related to human coexistence with other living organisms (depredation being one of many examples).



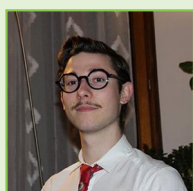
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Pascal Bach is currently a researcher at the French Institute of Research for Sustainable Development. He has been working for 30 years as a fishery ecologist involved in research projects with scientific partners mainly based in the south west Indian Ocean. The theme of his research is ecosystem-based fishery management, and he is developing ways to decrease the negative impacts of fisheries on non-targeted species. He enjoys meeting the other people involved in fisheries management over a glass of wine, to make the discussions more pleasant.