

Transcript:

Claas Wollna: That's perch, flounder, pike, zander and whitefish. That's fine, I had worse catch.

It's a good morning for fisherman Claas Wollna. He has just come back from the gillnets and now heaves four boxes of catch onto the jetty. Some of the fish are still wriggling.

Wollna is the last permanent fisherman in the region of Stralsund, a harbor town on the German coast of the Baltic Sea. Most of his colleagues have given up. Fishing no longer earned them a sufficient income. And that's because their most important fish, the herring, is almost gone. It doesn't reproduce sufficiently.

To save the herring from extinction, Wollna is only allowed to catch a meagre 1.3 tons a year. Eight years ago that fishing limit was still at 36 tons. Back then his nets were still packed with herring, and he could sell it for such a low price, that customers would come to him from as far as Berlin – that's almost 3 hours of car drive away – and buy 200 kilogramm of fresh fish at once. Today, Claas Wollna has just two local restaurants and a loyal community of locals left as buyers for the bit of herring he is allowed to catch.

Claas Wollna: I am not against protection of herring at all. I understand that if the stock is poor, it needs to be saved. But that needs to be done in a way that people can survive.

The first customer of the day walks by as he puts the catch into the cold store.

Claas Wollna: I feel sorry when I hear that another fisherman has given up. They've been fishing for four or five generations. That's what they always did. And fishing is just part of life at the coast, after all. I just hope that the fish herring will stay.

Claas Wollna's struggle runs way deeper than mere fishing regulations. And the missing herring is just a symptom of a much a bigger problem. Something's fundamentally wrong with the water ... no, with the sea itself, all

along the coast. Not just in the Baltic Sea, but at many coasts around the world. Something has changed.

Dag Aksnes: And then we saw that the water down there was very dark.

Florian Hoffmann: We could see about an arm's length. It wasn't even a meter.

You're listening to Living Planet, I'm Neil King. And this deep dive is a literal one. We're about to explore the phenomenon of coastal ocean darkening, also known as coastal browning or brownification. Although "known" seems to be a bit of an overstatement. A fairly small community of researchers around the world has only just begun to understand where this darkening comes from and how it messes up pretty much everything from seaweed to fishery and even the oceans' ability to help us protect the climate.

To get started, we head to another harbor town on the German Baltic Sea coast, Warnemünde, to meet Oliver Zielinski a renowned expert on Coastal Ocean Darkening.

Oliver Zielinski: Ocean darkening and specifically coastal ocean darkening refers to how much light gets into the depths of the ocean to a plant or a fish sitting at the bottom of the ocean. It refers to the light within the ocean itself, not as seen from above. From a bird's eye view, an ocean surface can shine brightly and yet be very dark under water.

Oliver Zielinski is the director of the Leibnitz Institute for Baltic Sea Research. He has studied the darkening in the Baltic Sea and North Sea for years. However, the problem is a global one. Researchers found the darkening happening in the waters around New Zealand, the US, Singapore, China, Japan and in the Mediterranean Sea.

Oliver Zielinski: ...that's where we measured darkening of coastal waters. This is where we have long series of measurements and where human interaction with the ocean has been strong.

"Human interaction with the ocean" - we'll save this little bit of what Zielinski just said for later when we talk about what – or who – causes the darkening.

Before that, we're taking a little walk with Zielinski to the harbor quay. He wants to show us something. A tool.

Oliver Zielinski: I now lower the disk into the water and watch it slowly drift down from the surface.

The disk that Zielinski puts in the water, is a Secchi disk, named after its inventor, Pietro Angelo Secchi, a 19th century priest and scientist in Italy. It is white and 30 cm in diameter. A bit like a large pizza plate on a cord. Zielinski is holding the cord with both hands, letting the disk sink down centimeter by centimeter into the water just off the quay.

Oliver Zielinski: It is getting harder to see the disk now as the murky water covers it. The important thing is that I now figure out the exact depth at which I can hardly see the disk. If I lift it up a little now, I can see the disk again. That's it. And that is the depth I'll write down.

The disk is roughly 2.5 meters under the sea surface. And according to Zielinski, light, as a rule of thumb, reaches down into the water three times as deep. That's ... 7.5 meters then. That sounds pretty deep actually, but it used to be much more. Since 1900, the depth of visibility, or Secchi depth, on the coasts of the Baltic Sea and North Sea has decreased by 3 to 4 centimeters per year. The question is: why did this happen?

Oliver Zielinski: The water itself obviously didn't change over the past 100 years. So it's the substances that got into the water, three of them: algae, dissolved matter and sediments.

Okay, so here is what we've got so far. Coastal waters around the globe have been getting darker for decades. Meaning that the depth to which light can reach into the water has decreased. And that's because of algae, dissolved matter and sediments. Let's explore what that exactly means – and what harm it does.

We're in a speedboat, heading out to a lagoon in the Baltic Sea, east of Stralsund.

We're not here on our own of course.

Florian Hoffmann: I am Florian Hoffmann, I am a biologist and have been working with the World Wildlife Fund in Stralsund for 10 years.

Florian has kindly agreed to take us out for a diving trip. We arrive at the lagoon. But if you're thinking of crystal-clear, turquoise water now, you won't find that here. Quite the opposite. But that's why we're here after all.

We drop anchor near a small island, where many plants are supposed to grow on the seabed, like seaweed or crested pondweed, green and lush. The water is not that deep, only 2.5 meters, as the echo sounder on board indicates. You don't need big diving gear for this depth. So, we're already dressed with a wetsuit, now it's time for the flippers and the belt with heavy weights.

Florian Hoffmann: I'll start with two weights. I'll go down and then tell you how much you take with you. Because the wetsuit leads to a little buoyancy.

Time to spit on the diving goggles, rub the spittle so that the goggles don't fog up, adjust the mouthpiece of the snorkel - and we're ready to go.

Hoffmann jumps first.

Florian Hoffmann: Visibility is terrible.

Let's go take a look for ourselves.

The seabed is just a few strong pulls away. Gliding above it, we can only see about an arm's length, beyond that it gets dark. Not dark in the sense of black of course, we are in shallow water after all, more like a fog, a dense and murky mixture of brown and green.

What we can see directly in front of us are patches of sand and then again patches of seaweed and other plants. Their stalks seem to pop up out of nowhere and sweep across our arms and face.

To be honest, it's a bit of a confusing and uncomfortable environment at first, but after gaining some orientation, much of the murkiness seems to come

from masses of small green particles. They float around in the water weightlessly, like artificial snow in one of those kitschy snow globes.

Back on the boat, Florian Hoffmann explains what we just saw. The green particles, he says, that's phytoplankton, the basis of all life in the seas and producer of half the oxygen we breathe. So having phytoplankton in the seas is essential. But when there's too much of it, it makes the water foggy as it dies and slowly sinks to the ground.

Florian Hoffmann: This means that the light zone decreases. ... We know from older literature that the depths to which you could look down into the water here used to be up to 8 meters. It now has decreased to three or two meters. And that of course makes it a lot harder for sea plants to grow on the seabed here.

Hoffmann pulled out a handful of seaweed and brought it back on board. Some of the stalks are covered with small brown stains. The remains of phytoplankton shield the living plants from light even in death.

The reason for this mess in the water lies on land, Hoffmann says.

When farmers spread too much fertilizer on their fields, it doesn't only make their crops grow.

Florian Hoffmann: That overuse of fertilizer leads to increased supply of water bodies with nutrients. That's nitrogen, which is important for photosynthesis, and phosphorus, a component of the DNA, which is also an important building block for life.

Florian Hoffmann has brought a clipboard with him, with sheets of paper, showing charts and numbers.

Florian Hoffmann: So, these are figures from the Federal Ministry of Environment from 2021. Agriculture accounted for 78% of nitrogen inputs in the Baltic Sea and 51% of phosphorus inputs, while point sources such as sewage treatment plants accounted for another 10% of nitrogen inputs and 20% of phosphorus inputs.

Apart from these nutrients and water of course, it's light that makes photosynthesis possible and lets plants grow. Imagine if someone switched off the sun. How long would life on earth survive? The trees, the bushes, insects, birds, mammals, all life.

This is a dark thought experiment. But looking at the foggy water underneath our boat out there on the lagoon, the threat seems real enough. If the seaweed doesn't get enough light, it dies. Like here in the lagoon. Spanning more than 500 km² big there used to be giant underwater seaweed lawn here just 70 years ago. Today, the plants have retreated to the shallow edges of the lagoon.

This has effects on the whole food chain in the water and beyond. Small fish that are at the start of the chain use seaweed to hide and to spawn. In this part of the Baltic Sea, it's the herring that essentially depends on it as it lays its spawn in the seaweed. The herring population has massively collapsed over the last 10 years. In an unfavorable combination, the fish migrated to the lagoon earlier due to warmer waters – but then failed to find sufficient seaweed there.

The problem with that is that the herring is at the beginning of the local marine food web. Less herring means less food for bigger fish, ducks, and less catch for fisherman Claas Wollna, whom we heard at the beginning of this episode.

Healthy seaweed is also a real climate superhero. One square kilometer of seaweed captures twice as much CO₂ as terrestrial forest and it does this 35 times faster as well. The same goes for other plants in coastal waters. Researchers in New Zealand looked at the health of kelp in a lagoon that had strong inflow of nutrients from agriculture and the city of Auckland. They found that the darkening in that lagoon caused local kelp forests to degrade and fix up to 4.7 times less carbon than they usually would.

To mention it a bit in advance: we're not doomed because of Coastal Ocean Darkening. That being said though, our take-away from the diving trip with Florian Hoffmann is that Coastal Ocean Darkening does both harm biodiversity and the climate.

Except for one life form that seems to handle the dark waters quite well. As Hoffmann speaks, a handful of common jellyfish floats past the boat, just a little below the sea surface. Jellyfish who consist of 95% water are particularly transparent and small, about the size of a saucer. They have a distinct advantage in the murky water.

Dag Aksnes: Jellyfish don't need light to feed. It's a so-called tactile predator.

That's Dag Aksnes.

Dag Aksnes: I'm a marine ecologist at the University of Bergen. And I have studied mostly fjords but also the ocean.

You've likely seen pictures of Norway's majestic fjords. Long and narrow, placed between steep cliffs and several hundred meters deep. At first glance the fjords appear to be lakes, but they are in fact saltwater inlets from the North Sea, mixed with some freshwater from land that gets into the fjords via mighty waterfalls. But we're moving away from the topic...

After decades of research, Dag Aksnes has come to know the fjords around Bergen like the back of his hand, both above and below the water's, in the living and non-living world. Until he and his colleagues from the University of Bergen went to a fjord called Lurefjord to check up on the fish population there. They let the trawl net down into the water, started the boat's engine and set off.

Dag Aksnes: We would expect, like, at maximum in half an hour to get like 100 kilograms of this fish, which is very abundant also. But, when we trawled in this field, then we actually had to cut the trawl in the water and destroy it because we couldn't have it all up on deck.

Instead of a bit of fish – and after just a few minutes – the trawl net was bursting with thousands of big, orange, fluorescent jellyfish.

Dag Aksnes: You can trawl them and, actually, in five minutes you can have five tons. So it's a ton per minute.

The helmet jellyfish is found all over the world and that's perfectly normal. But not in such large numbers. For the whole fjord, Aksnes estimated the population of jellyfish at 50,000 tons. Or in individuals...

Dag Aksnes: Ohhh (laughs). Well if it's 500 grams each, in a ton you will have 2000 and then you have 50,000 tons multiplied by 2,000.

Which translates into 100 million jellyfish. But almost no other life.

Dag Aksnes: And then we started wondering, why is this jellyfish here and not the fishes?

Dag Aksnes: And then we saw that the water down there was very dark.

Too dark for visual-hunting fish to see its prey. Meanwhile jellyfish don't need light but use their tentacles to sense prey. Less competition and warmer seas due to climate change help them to spread. Not only in the Lurefjord, which is now also known as the "jellyfish fjord", but to a smaller extent also in many other fjords along the Norwegian coast.

But the reason for the dark water in the fjords is different from the nutrient overflow in the Baltic Sea.

Dag Aksnes: So actually, we got a very extended water column with coastal water containing lots of dissolved organic matter which originates from land. And then this question, of course, which we still investigate, is why has this amount of dissolved organic matter which absorbs lights increased.

Dissolved organic matter. Small particles of rotten leaves or wood. It gets into the Norwegian fjords via the rivers from all over Northern Europe. And stays in there for decades before it eventually degrades. In the case of Lurefjord, it accumulates more and more due to an exceptionally narrow exit to the sea.

The irony here is that the source of all this organic matter is something that we'd usually desire: more nature.

Dag Aksnes: The evidence now is that this is because of increased greening in Northern Europe. [...] There are more trees now than a hundred years ago. Much more. This is partly because of change in land use. [...] The other reason is, I believe, warming and also increased precipitation over Northern Europe, which also stimulates greening. [...] More green coverage in Scandinavia and Northern Europe which produces more dissolved organic matter that enters the sea sooner or later.

Think of it as a cup of tea. You pour in the water, add a tea bag and watch as the water slowly turns brown.

And now think of that cup of tea as a big barrel standing in a garage building, named like a character from a Transformers movie: planktotron.

We're at the Institute for Chemistry and Biology of the Marine Environment in Wilhelmshaven. That's another German harbor town – the last one, that's a promise – but this one is situated at the North Sea coast. The planktotrons are 12 large cylindrical tanks made from stainless steel and wrapped with hemp and black foil for insulation. The numbers 1 to 12 are taped on the foil with pink duct tape.

Maren Striebel: We can simulate the marine environment on a smaller scale here. We can put 600 liters of seawater or lake water in each Planktotron and then either recreate the same conditions as outside [in the seas] or manipulate the conditions. [...] For example we can increase water temperature. We can manipulate nutrients or what we did in the Coastal Ocean Darkening project was to manipulate the light.

Maren Striebel is a biologist at the institute. She does research on plankton and was part of the research group of Oliver Zielinski, whom we heard earlier. Striebel used the planktotrons to cross-check and add to the research results from the analysis of the long record of secchi disk measurements and new measurements with satellites and deep-diving autonomous sensors.

Maren Striebel: We could do this with lights at the top of the planktotron. But mostly we were interested in the organic material, i.e. the colored

material that can be washed from the land into the seas. So we added a peat extract to the water which caused a brown coloration and also brought some nutrients into the water.

Nutrients and organic matter, the two drivers of coastal ocean darkening that we have already looked at in this episode.

Striebel moves a small ladder up to one of the planktotrons. She has filled it with tap water and switched on the power to show how it works. Through a thick pane of glass, we can see a paddle slowly rotating around an axis in the middle. It keeps the water moving and uses a silicone lip to wipe the inside wall of the barrel to prevent vegetation growth. Valves are built into the wall to be able to take water samples and measure values such as oxygen concentration or temperature. On top of all that, strong LED lights simulate daylight with different intensities.

In her five-week experiment on coastal ocean darkening in 2017, biologist Striebel filled the planktotrons with water from the North Sea. Which means that she also had to simulate the tides. She used pumps and hoses to create a cycle with rain barrels of the same size.

Maren Striebel: We had three different levels of intensity of input of dissolved organic matter. There was definitely shading at the beginning and an impact on the primary producers, the phytoplankton. We observed a reduction in its biomass, which had an impact on the next trophical stage, i.e. the food web in the water. But then the organic matter degraded over time and the nutrients were used up, so the system returned to its orginial state at some point.

The dissolved organic matter waseaten up, so to say, by organisms in the water, which subsequently cleared and brightend up. That's good news. But in another experiment Striebel and her colleagues also added sediment to the water in the planktotrons, or sand, taken from the local beach. And sand doesn't get used up by organism because, well, it's just sand, there are no useful nutrients in it like the organic matter. So the sand stays in the water.

Again, think of it as a cup or glass. This time you add a teaspoon of sand and give it a good stir. The water turns murky for some time, before the sand slowly settles at the bottom of the glass. But the seas are no glass of water and the sediment in it is more than a teaspoon.

Here's Oliver Zielinski again.

Oliver Zielinski: Storms carry more sediment into the water and make the water murky. We will have more storms as a result of climate change. But we also have more sediment in the water because we have coastal erosion due to coastlines and construction work [in the water]. Trawlers stir up the sea ground with their heavy nets. All these things mobilize sediments and make the water cloudy. So the effect of sediment for visibility in the water is very strong.

TRAILER for The Place that Thaws

Nature's trick to keep sediment on the seabed is vegetation, like seaweed. It stabilizes the ground with its roots. If the seaweed retreats because of too little light, the seabed becomes even more unstable and the water even murkier. It's a vicious cycle, if you like.

Oliver Zielinski: I rather like to tell science in positive narratives. If we manage to grow seaweed again, this will also bind sediment. The water will become clearer and we may be able to go deeper to establish even more seaweed.

Speaking of positive narratives, Oliver Zielinski hardly complains as we talk. He has every reason to do so, doesn't he? I mean, people are worried about plastic in the seas or coral bleaching. But darkening water isn't getting that kind of attention.

His optimism comes from the fact that darkening is already stagnating in the Baltic Sea in particular, but also in the Mediterranean and North America. In

the North Sea, the water has even been brightening again since the 1980ies thanks to regulations around fertilizer use and the ban of phosphate in washing detergents, less nutrients have been entering the North Sea.

But with global warming, rainfall and storms will become more extreme, which will lead to more organic matter and sediment being washed into coastal waters, Zielinski says. The best way to stop coastal ocean darkening would therefore be to limit global warming.

Oliver Zielinski: Measures are being taken. But the efforts need to be increased, they actually need to be doubled, because climate change is working against us. We have to make an even greater effort to get back to the situation we had [in the coastal waters] before.

That's the big picture. Back in the harbor, marine biologist Florian Hoffmanns thinks that very specific, local action is needed too.

Florian Hoffmann: Well, trying to use less fertilizer and specifically for what you need. And possibly trying to keep water in the landscape, not pumping it directly into the sea, but letting it flow through a reedbed area where the washed-away nutrients can separate.

Today's episode of Living Planet was researched and written by Jonas Mayer. It was narrated and edited by me, Neil King. Our sound engineer was Thomas Schmidt.

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