Arctic attack A journey through melting sea ice

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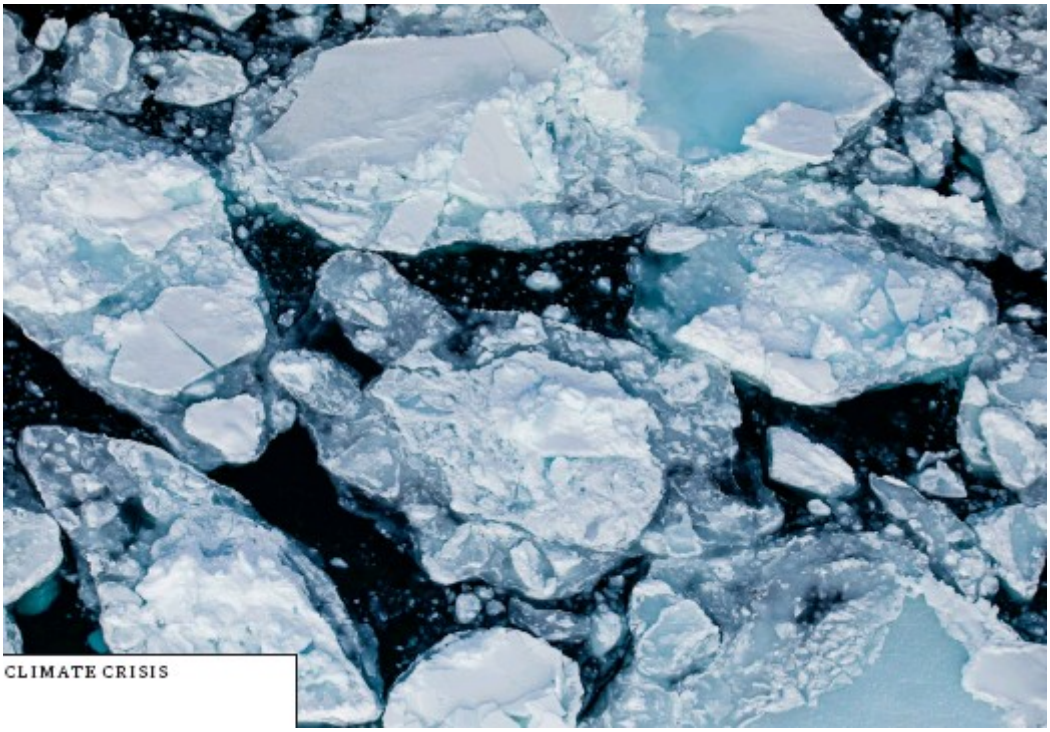
The demise of an entire ocean is almost too enormous to grasp, but as you sail deeper into the Arctic, the colossal processes of change are increasingly evident. The first fragment of ice appears off the starboard bow a few kilometres before the 79th parallel in the Fram Strait.



CLIMATE CRISIS

The solitary floe is followed by another, then another, then swarms, then entire fields of white crazy paving that stretch to the horizon.

From deck level it is a stunning sight. But from high above, drones and helicopters capture the bigger, more

alarming picture: a slow-motion blast pattern of frozen shrapnel radiating from the high Arctic southwards through this strait, which is the interchange of 80% of the water between the ice cap and the world's oceans.

This is where ice floes come to die, and the cemetery is filling faster each year, according to the leader of this scientific expedition, Till Wagner, of the University of North Carolina Wilmington (UNCW).

One of the objectives of this expedition is to investigate why the collapse of Arctic ice is happening faster than climate computer models predict and

to understand what this augurs for the rest of the planet.

The melt is not simply a seasonal process. The natural thaw that starts in spring is being amplified by humanmade global heating. The Arctic has heated up by 2C above pre-industrial levels, twice the global average. Some hotspots, including parts of the Fram Strait, have heated up by 4C. There are variations from year to year, but the trend is clear and ac-

celerating. Sea ice is melting earlier in the spring and freezing later in the autumn. Each summer it thins more and recedes further, leaving greater expanses of the ocean exposed to 24-hour sunlight. This is driving back the frontiers of ice and fragmenting one of the planet's most important climate regulators. It is also creating a series of feedbacks that are accelerating the Arctic melt. Several are only partially understood.

The team and crew set out on the Greenpeace ships Arctic Sunrise and Esperanza from the port at Longyearbyen in May, less than a month after the sea ice reached yet another record low. At the start of the melt season, this is a fast-changing body of water. The Greenpeace crew say high winds and strong currents have pushed the ice front southwards by 80km in the last four days. The floes appear on the radar screen as a thickening swarm of yellow flies. When the bands of ice cannot be evaded, they are nosed aside by the prow, scraping the hull as we pass. Occasionally, they are smashed through with a clanging jolt. All the floes have one thing in common: they are diminishing as they head south. On the surface you can see the outliers, tiny chunks that are destined to shrink to the size of an ice cube before they melt into the Atlantic.

Since the start of the satellite era in 1979, the summer Arctic sea ice has lost 40% of its extent and up to 70% of its volume, says Wagner. Other scientists calculate the rate of decline at 10,000 tonnes a second. Much of the multiyear ice is now gone. Most of what is left is the younger, thinner layer from the previous winter, which is easier for the sun to melt and the wind to push around. Wagner expects ice-free summers in 20 to 40 years, which would allow ships to cruise all the way to the north pole.

Ice-free summers are 10 times more likely if the world heats up by 2C rather than 1.5C, according to the United

Nations Intergovernmental Panel on Climate Change (IPCC). The body of top international scientists said last year that the Arctic and coral reefs were the ecosystems at greatest risk.

The Fram Strait is one of the few places in the Arctic where the ice extent has not declined, but that is probably not good news. One of the theories being tested is whether this is because more ice is being flushed through this channel. The pace of change is mindblowing, Wagner said. "What we are looking at is whether this exit is accelerating."

The team is also examining other processes to help gauge the health of the ocean. To get a baseline, they conduct tests at intervals along the 79th parallel. First, they identify a suitably sized floe, then an armed polar bear guard ensures there are no predators and checks the solidity of the ice. After the all-clear, a dozen or so scientists and volunteers pull up on motor dinghies to drill, measure, take water samples and extract cores. On the ship, crew members test the water at different depths for acidity, temperature, turbidity, dissolved oxygen and acidification.

In the past, the data would have been related only to physics and chemistry, but there is a growing awareness of the crucial climate role played by marine organisms, so biologists are also part of this team. They scan the horizon for whales, seals and walruses and use tightly meshed zooplankton nets to capture teeming masses of minute shrimp- and wormlike creatures.

These and the algae on which they graze play an essential role in the global climate and food chain, according to a growing body of research. The largest synchronised movement

of biomass on the planet is the daily vertical migration of zooplankton, as they move from the depths to surface feeding waters.

Researchers are discovering that the floes are home to an extraordinary variety and abundance of life even in winter. The ice can be permeable and elastic, with space inside that can be colonised by bacteria, fungal spores and the tiny creatures that feed on them such as the transparent jellyfish Sympagohydra tuuli. The green and yellow shades at the base of floes indicate phytoplankton – algae that use sunlight to convert carbon dioxide and water into oxygen and energy. These are the pastures on which the zooplankton graze. Most important are copepods, a fat-filled staple in the diet of whales and fish. Together, millions of these species form an oceanic pump, said Mattias Cape, a biological oceanographer with the University of Washington.

Phytoplankton help the oceans produce more oxygen than all the world's forests. They also sequester CO2 more effectively because copepods and the bigger creatures that eat them take the gas down to depths where it can be stored for hundreds of years. Nowhere is this pump more effective than near the poles – the zooplankton here are bigger, so they sink deeper.

But this is changing. When Cape observes the zooplankton through a microscope, he can see that the chubby Arctic copepods have competition from their smaller Atlantic counterparts. This invasion has been recorded in other parts of the ocean. "We see a shift from big to small, which is a concern, because it will make this pump action weaker," he said. The study may help to explain why the Arctic is losing oxygen faster than almost anywhere on Earth. Another factor is that cold water absorbs more CO2, which gives it high levels of acidity. "We talk about the ocean being hot, sour and out of breath," Cape said.

If the Arctic were a patient, doctors would be alarmed. As well as hot flushes, asthma and contamination, the ocean has also been diagnosed with a weakening immune system. For centuries, the Arctic's distinctive character has been shaped by a layer of cold, relatively fresh water just below the surface. This has insulated the sea ice from the warmer, denser, saltier waters of the Atlantic currents that flow in the depths. But this stratification is collapsing.

The shift was outlined in a landmark study published last year in Science, which found that the water density and temperature of the Fram Strait and Barents Sea were increasingly like those of the Atlantic. The study's lead author, Dr Sigrid Lind of the Institute of Marine Research and the University of Bergen, said this year: "The polar front is shifting. The Arctic as we know it is about to become history. It will go when stratification breaks down completely and the Atlantic takes over the whole region."

First to succumb, according to Lind, will be the Barents Sea, which will have no fresh water by 2040, then the Karel Sea. The consequences will be far-reaching. The food chain is already affected. Atlantic species of cod, herring and mackerel are moving northwards. For the next 20 to 30 years this could boost fishing catches, but forecasts by Norway suggest boom will turn to bust later as the waters grow too warm for fish larvae.

There are signs elsewhere in the Arctic that the arrival of smaller

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Atlantic copepods may be associated with a decline in whale populations. Heather Koopman, a marine physiological ecologist at UNCW, said she is concerned that the speed of change is outstripping species' ability to evolve.

"The bowhead whale, for example, can live for 200 years and rarely reproduces, so some are having to adapt to a modern climate with faculties developed in the Georgian age," Koopman said. "Things are moving far too rapidly for them to keep up. Perhaps small invertebrates can adapt from year to year because their breeding cycles come round more quickly. But for a 200-year-old whale, how can they change that fast?"

For humanity, the biggest impact is on the weather. The area between the cold pole and the warm equator is a ramp that propels weather fronts across continents. Lind speculated that ocean destratification is the most important driver for ice loss, which in turn affects the jet stream, weakens the polar vortex and can lead to heatwaves in the southern US and cold weather extremes in Asia. "We seem to be seeing large-scale weather pattern changes connected to the shrinking Arctic. As the Arctic becomes history, we need to understand how it affects the globe."

Such concerns are part of the motive for a new wave of international research. From September a German research vessel, Polarstern, will drift across the north pole and be frozen into the ice over the winter so that 600 scientists can conduct tests billed as the biggest ever study of the Arctic. Norway has just launched a new icebreaker, the Nansen Legacy, which will embark on a series of trips over six years in conjunction with Birmingham University to examine ocean acidification and food chain contamination.

"Emotionally, I detach myself," Wagner said. "The Arctic is an object of study. It's like a doctor observing a patient to see how sick they are." He says the physics make a recovery extremely unlikely.

"I have to hurry up or my science will become archaeology," the 34-yearold joked. "There will still be sea ice during the winter, but in the summer it will probably disappear. It won't be the death of the Arctic, but will be the end of the Arctic as we know it."