Nancy (00:09):

On June 24th, 1893, the Norwegian polar explorer and scientist Fridtjof Nansen set off with 12 men in especially built boat named the Fram. His mission was to explore the uncharted mysterious land at the very top of the world. The Fram was built with a reinforced round bottom to protect it from the ice. It made for really uncomfortable sailing, but it was perfect for Nansen's crazy plan, which was to freeze the boat into the polar ice, to see where the currents would take it. The Fram spent three years on its frigid journey. It was the first ever scientific expedition into the great unknown that was the Arctic ocean. Nansen and his crew brought back piles of information about everything from the depth of the Arctic ocean — more than 3,900 meters deep — to data on ocean temperatures, salinity, and currents. These early measurements seem simple to us now, but at the time they were revolutionary. They opened the door for future scientific exploration because before Nansen, no one really knew what lay at the top of the world. And it turns out that in some important ways, we still don't.

Nancy (01:30):

In the winter of 2010, an international team headed off into the polar darkness of the Arctic. Their quest was nearly as surprising as Nansen's was in his day. The scientists sailed aboard the Norwegian research vessel, the Helmer Hanssen into the Arctic. They were just off the Norwegian archipelago of Svalbard, at roughly 79 degrees, North latitude, along a coastline fringed with jagged ice covered peaks. And then — they turned off all their lights.

Jørgen Berge (02:04):

We were in the small open boat behind the big research vessel and what we saw when we looked down, we saw this cosmos of blue, green light that was shining and blinking in a three-dimensional space. A bit like looking up and you see the cosmos with all the stars. And it was the same thing you saw down below us. These two moments were moments of realizing that there is something very special going on in the Arctic polar night that no one has ever examined before.

Nancy (02:46):

I'm Nancy Bazilchuk. And this is 63 Degrees North, an original podcast from NTNU, the Norwegian University of Science and Technology. Today, I'm going to tell you the story of how researchers figured out that the ocean is teaming with critters in the complete darkness of the Arctic night, and why, in a time when the Arctic is warming at a record pace that matters.

Nancy (03:17):

Ten years ago, researchers thought most Arctic marine life lay dormant in the winter's dark. Now they're scrambling to figure out how the rapidly changing climate and melting ice cover will affect this sensitive ecosystem, especially as melting ice brings the possibility of more ships and more activity into the Arctic, even during the winter.

Nancy (03:36):

It's a story that's got creatures slowly waltzing up and down in the ocean controlled by the faint light of the moon and the Aurora Borealis, glowing zooplankton floating in the water, lighting up like Christmas trees. Researchers sitting in little rubber boats like kids turning their headlights on and off in the name of science to see what happens. Oh, and — krill eyeballs. That's krill, the centimeter-long critters that look like baby shrimp, that whales and other sea life eat. One researcher figured out how to get krill to swim in place so he could measure how much light — or actually how little — the krill eyeballs could detect. And like many things in science, it started with an accident.

Nancy (04:39):

First, a little backstory.

Nancy (04:42):

The fourth International Polar Year started in 2007. This was an effort where lots of nations pledged to do a ton of research in the Arctic and the Antarctic. It was a big deal for a lot of countries, but especially for Norway, which has its polar territory of Svalbard. One of the places Norwegian researchers wanted to study was a fjord called Rijpfjorden, which is one of the most northerly fjords in Svalbard. This is about as close as you can get to Santa's workshop at the North Pole without eight tiny reindeer.

Jørgen Berge (05:12):

The start of this was that that we deployed an observatory in first of all, Rijpfjorden, that was through a project part of the International Polar Year, where we wanted to study the impact of sun and a declining ice cover.

Nancy (05:30):

That's Jørgen Berge, a polar marine biologist with a dual appointment at UiT — the Arctic University of Norway and NTNU. He and NTNU Marine biologist Geir Johnson have been studying marine life during the polar night together for more than a decade.

Jørgen Berge (05:44):

So it was intended for the spring period, but in doing so this is ice covered fjord, we had to deploy the observatory in the autumn. So by almost as an accident or a by-product, it was recording also during the winter and the polar night. When we then went back in the autumn of 2007 and brought back the observatory and downloaded all the data, we almost immediately saw that during the darkest months, December, January, there was much, much more activity on the echo sounder than what we had dreamt of. This for the first time that we realized that something's going on during the polar night. Until then everyone, including us had just assumed and accepted as a fact that during the polar night, nothing is happening

Nancy (06:48):

After the researchers figured out that all this activity they had recorded was real. They decided they had to go back and check it out.

Geir Johnsen (06:56):

Just when we started this around 2009, people were almost laughing, like, "You're going there during winter time? It's dark. It's nothing there!"

Nancy (07:07):

That's Geir Johnsen. But of course, there were things going on there. That sea of blinking lights that Jørgen described at the beginning of the podcast? That's something called ...

Jørgen Berge (07:19):

Bioluminescence. That's the ability of organisms to produce light. So in the darkness, especially in the deep sea, we know that the large majority of organisms, they are able to produce light because in total darkness, light is a very effective way of communicating. And it turns out that in the Arctic polar night, organisms that live quite shallow, the majority of them are also able to produce light.

Nancy (07:47):

And not only do these creatures make light....

Laura Hobbs (07:49):

So we're interested in a range of behaviors. The one that I'm mostly interested in is called diel vertical migration. I'm Dr. Laura Hobbs I'm a zooplankton ecologist working at the Scottish Association for Marine Science and the University of Strathclyde.

Nancy (08:02):

Laura has worked with Geir and Jørgen on the polar night research, and the discovery of diel vertical migration was one of the big moments for the researchers. Laura, again.

Laura Hobbs (08:12):

So this is zooplankton or a range of species do this behavior. They go up to the surface at night and they feed on phytoplankton, so small plants that sit on the surface. And then as the sun rises, not during the polar night, of course, they sink down to depth to hide from visual predators, so things like fish or bigger, the bigger zooplankton that will be able to see them. And then the sun sets and they'll go back up to the surface again. And this happens every single day, all latitudes. So it's diel vertical migration, this sort of daily vertical movement. Obviously, in the polar night, we didn't expect this to happen. There's no solar cycle. And so it was kind of expected that everything was asleep or in hibernation during this period. But we do see really strong signals of DVM occurring right throughout the winter. And so even at these really low light levels, these light mediated behaviors are still happening.

Geir Johnsen (09:02):

Actually, when it's for us humans, it's pitch dark during the polar night, then the diffuse light of the sun that is far below the horizon, for us it's totally dark, but it's enough photons for these organisms to react to it.

Nancy (09:18):

By now, you may be saying, why are these scientists so excited about seeing little plankton waltz up and down in the water, in the dark and the polar night? Well....

Geir Johnsen (09:28):

The marine phytoplankton produce about 50% of the oxygen that we breathe on earth.

Nancy (09:34):

That's Geir Johnsen again. Oxygen. That's pretty important. We don't want to mess with that too much.

Geir Johnsen (09:41):

So without the phytoplankton, that's the driving force. It's, it's the major food source for other organisms. So we have like phytoplankton are getting eaten by zooplankton and larvae. And the zooplankton larvae get eaten by smaller fish, which are then being eaten by larger fish again. And then we have the seal and the polar bears and humans. So there is close connection here between the different, what we call trophic levels, of organisms. But they're all like.... The basis, here, it's all light driven.

Nancy (10:19):

Okay. Quick recap. Climate change is melting Arctic sea ice. The sea ice normally blocks light, and these little critters are far more sensitive to light than we ever knew. That means they're much more at risk of being affected by light pollution. And even though light pollution, isn't currently a problem, it could be as the climate warms and there's more human activity in the polar regions. What does that mean for the whole food chain that Geir just described, over the long run? The problem is researchers really don't know yet, but there is one last big thing that they do know is a problem. Here's where the researchers sitting in little boats with flashlights come in. Geir again.

Geir Johnsen (11:05):

So we're sitting just in a rubber boat, a Zodiac in the polar night, pitch dark. And then we started to measure the zooplankton and larvae in the water column. So that was like ambient natural light conditions. To do things in the boat, it's pitch dark. So for us as humans, we then need to use artificial lamp, like a torch, to see. And then we started like, wouldn't it be cool just to play with the light down into the water and see what happens. And then from the acoustic sensor, we can see that the zooplankton started to react to this. And it was like in seconds that they moved away if we applied light. So they move away because they want to avoid predators that can see them. And like, "No, this cannot really happen!I mean, is this just, did we do something wrong?" But then we started to systematize artificial light on and off. And then we saw the same pattern. So when they put the light on, then we saw on the echo sounders that we could see that the zooplankton disappeared when we put light on.

Nancy (12:13):

That's when researchers started to realize that everything they thought they knew about the basic marine biology of the Arctic in the winter was wrong, because all the measurements they had made in the past had been done from lighted research boats. They realized if they really wanted to know what was going on in the polar night, they'd have to turn off the light.

Jonathan Cohen (12:34):

The first time we asked the ship to turn off the lights on the research vessel, it literally, it took them 30 minutes just to figure out where the light switches were, because they've never turned the lights off. It's just not something that you normally do on a research vessel.

Nancy (12:46):

That's Jonathan Cohen from the University of Delaware, and another member of the polar night gang. He's the guy who figured out how to measure how much light krill eyeballs can detect. We'll hear more about that later. It's often said that we know more about the surface of the moon than we know about the ocean. So knowing that lights as dim as flashlights, or as bright as from a research boat, have an effect — that's a pretty big thing. It really matters when it comes to something practical like estimating fish stocks, or how many fish there are for people to catch and eat. Geir again.

Geir Johnsen (13:21):

For instance, herring, I mean, everyone knows the fish herring and herring get attracted by light. You can actually, at night time you can attract herring by using artificial light to catch them. And that's now basically forbidden so we can lure organisms towards the light source or away from it.

Jørgen Berge (13:41):

So by going into these environments with a research vessel that is fully lit, it's quite obvious that it will affect the organisms.

Nancy (13:51):

Jørgen Berge.

Jørgen Berge (13:52):

But the real surprise here is, how much they are affected and that they can be affected. So far, we have documented a clear effect down to at least 200 meters depth, which is quite significant. We have also been able to run experiments with a research vessel where we have moved and done sort of simulated stock estimations. Using echo sounders with lights on and off. And we clearly show that the results are different when the lights are turned off.

Nancy (14:35):

That's when researchers realized they would have to send their own kind of spaceships into the dark of the polar night. Vessels that can move away from the ships' lights and measure what was going on for real, in the water, because they didn't need light to do their job.

Jørgen Berge (14:49):

There's only so much that we can do on a research ship that is in absolute darkness. There are certain safety issues that cannot be overlooked and that are quite obvious. So for much of the work that we're going to do, I think we will have to rely on data collected from autonomous robotic platforms that we send out.

Nancy (15:13):

These can be all kinds of wild-looking vessels, like boxes the size of little refrigerators with impeller motors on them, or a kayak that has been outfitted with different sensors that can work in the dark. My favorite is one that is shaped like a torpedo, maybe two meters long.

Laura Hobbs (15:29):

I think all these different technologies kind of pieced together, form a great picture.

Nancy (15:33):

Laura Hobbs again.

Laura Hobbs (15:35):

So the data that I use is usually for moorings. So these are in one place that, like I said, sit there for years at a time, but that gives us no understanding of spatial variation. So then you get things like an AUV, which we'll deploy off the ship and we'll get some idea about spatial variation in the area, and you can take it away from the ship and closer to the ship and look at these sort of things, but that's over a shorter time period, relatively. And obviously the moorings give us an idea about depth variation and so we're trying to sort of use all these different technologies to piece together, the puzzle.

Nancy (16:07):

These different instruments also allowed researchers to discover something they called,

Geir Johnsen (16:12):

Ahooooooo, it's the werewolf effect.

Nancy (16:14):

Geir Johnsen.

Geir Johnsen (16:14):

The big light source during the polar night is the moon. And during the full moon, the zooplankton, they really dive down into the deep because they want not to be illuminated by the full moon. So that's what we called the werewolf effect. The moon is then a major trigger for behavior.

Laura Hobbs (16:35):

Five years ago, being up in Svalbard at a meeting with one of my PhD supervisors, also from Scotland, and we were sitting in a small meeting room. Although we worked together, this happens quite a lot that you never get any time to sit down and look at data. And so while we're in Svalbard at this meeting, we took a quiet evening, just to hide out and print off some plots and have a look through them.

Nancy (16:53):

Laura Hobbs again.

Laura Hobbs (16:55):

And that's when our moonlight work started. So we were looking at these figures and we started seeing these odd observations and this is in the acoustic data. And we saw it in one place and I have acoustic data for across the Arctic. So we plotted out another figure and we looked at that and we saw it there as well. And then we saw it somewhere else in the Arctic. And we were sort of putting together all these pieces. And then we were trying to work out what was going on with these zooplankton behaviors that just weren't what we expected. And we found out that it was this lunar migration. So the full moon was causing this movement in the zooplankton that we hadn't really expected before. And it was just this complete... It was just a really exciting moment of science. It's kind of, I don't know, the Eureka moment that everyone thinks that scientists have on like a weekly basis.

Nancy (17:43):

So that's cool, but it also really matters because it tells us just how sensitive marine creatures in the Arctic are to light. But exactly how sensitive? Jon Cohen from the University of Delaware found a way to figure this out.

Jonathan Cohen (17:58):

One of the things that we've been interested in is how much light does it take for an organism's eye to respond to it, or what colors of light can the eye see. And so we needed to do some experiments that said, okay, this is how much light the organism can see, and this is the colors of light that they can see. And so the organism of choice is a krill, Thysanoessa inermis because it's very abundant and it's basically fish food and bird food.

Nancy (18:27):

In case you're wondering, this krill looks like a tiny shrimp with giant eyes, but it's pretty small, about 25 millimeters long, which is a little bigger than a bumblebee. And it's not like a dog. You can't give it treats to sit in one place while you measure how much light is being detected by its eye. Enter.... super glue!

Jonathan Cohen (18:48):

If you were to take a small piece of plastic and you were to stick a pin like a little map pin or sewing pin into this plastic, you make a little hole and you attach it with some glue. And then you can touch a little bit of super glue to the end of the head of the pin, and then touch that to the back of the organism that you're trying to work with. And it needs to be done without water involved, so you have to take the animal out and put it on a little piece of paper and then you touch them and then you just hold it there for about 10 seconds. And then you put them under seawater. The animal will stay just fine and it swims, but it can't swim away. So it stays put. And so when the animal stays put, then you can take a small needle. And again, it's about the size of a sewing needle. So it's an insulated wire and you'll just place that just ever so gently into just the outer edge of the eye. And what that does is because the eye and the nerve cells that are within the eye work by passing electrical currents. And that's how they, how they send signals. We're able with that little needle to measure those currents. And so those experiments showed us that these krill and other marine organisms like them can see generally down to 50 or more meters during the polar night. So even though there doesn't seem like there's a lot of light available, there's still enough light available for them to have normal visual function down well within to the water column. And so it reinforces the idea, which I had mentioned earlier that there is light available for organisms throughout the year, including during the polar night.

Nancy (20:27):

And the researchers also found out that light levels are 100 million times lower during the polar night than they are during the Arctic summer. Now those are some eyeballs! And that brings us back to the biggest take home message here. Climate change is altering the Arctic in a lot of ways, but one way is by melting sea ice. Some researchers now think the Arctic could be completely ice-free in the summer in 15 years. There will still be ice during the winter, but the area that it covers will be much less.

Geir Johnsen (21:02):

So we know now in the Arctic we get less and less sea ice and we get more and more human activity. So we have a higher degree of fisheries, we have higher activity regarding oil and gas activity, mineral extraction, new transport routes, ice-free conditions, more vessels more transport. We have more tourism. Simply, it's just more and more human activity. All of this activity actually influences the biology.

Nancy (21:38):

The good news is that the Research Council of Norway just granted the polar night researchers 10 million kroner, or about 1.2 million US dollars to continue their work.

Jørgen Berge (21:48):

Ultimately we hope to quantify to which degree the current stock estimations are valid or not.

Nancy (22:00):

Jørgen Berge.

Jørgen Berge (22:00):

At the moment, we know that many cruises where they do stock estimations, they are carried out in the dark. We want to quantify to which degree these estimations are realistic or not.

Nancy (22:17):

And what of Fridtjof Nansen the explorer, whose story opened the episode? He actually left the Fram with a crew member, Hjalmar Johansen, when they realized that the Fram wouldn't get carried over the North Pole as they had hoped. And what has to be one of the most amazing survival stories ever, the two explorers spent more than a year on their own, overwintering in a stone hut. I can't tell you the whole story here, but you can read Nansen's own description of it translated into English in a book he wrote called Farthest North. In November, 1893, well into his journey and in the deep dark of the winter, he wrote: "Here I sit in the still winter night on the drifting ice flow and see only stars above me. Far off, I see the threads of life twisting themselves into an intricate web, which stretches unbroken from life's sweet morning dawn to the eternal death stillness of ice." I wonder what he would have thought if he knew that a riot of life was there in the cold open ocean, right around his little patch of ice.

Nancy (23:39):

I'm Nancy Bazilchuk, and you've been listening to 63 Degrees North, an original podcast from the Norwegian University of Science and Technology. Sound design, and editorial help from Historiebruket. Thanks for listening.