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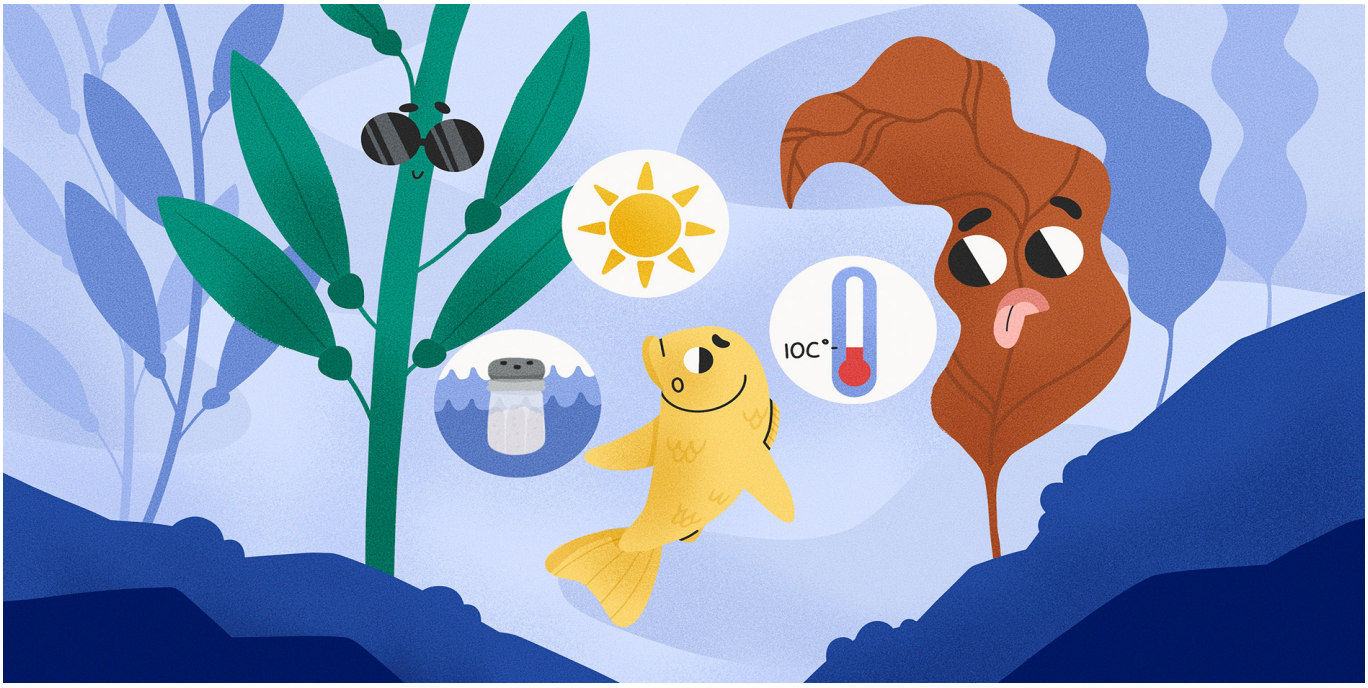

KELP IN A CHANGING ARCTIC OCEAN

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YOUNG REVIEWERS:

ARIA
AGE: 10

LEAF
AGE: 9

In the northernmost part of our planet, in the icy cold coastal waters of the Arctic Ocean, you will find underwater forests filled with fish, crabs, and sea urchins. Unlike forests found on land, these underwater forests are made up of large brown marine algae called kelp. The various kelp species that make up the underwater forests are important in the Arctic Ocean. As temperatures continue to rise because of climate change, the future of Arctic kelp is unknown. In this article, we will discuss how changes in the Arctic climate, from melting ice to changes in ocean saltiness, may affect these underwater worlds.

UNDERWATER FORESTS

Imagine walking through a forest full of trees, and seeing all the plants and animals that call the forest home. What you are imagining is an **ecosystem** created by the trees. Now, hold your breath and imagine a similar forest under the ocean. Not just any ocean—the icy-cold Arctic Ocean. You can stop imagining because these underwater forests

ECOSYSTEM

A set of organisms that interact with each other and with their environment.

exist. They are commonly found along the coasts of oceans all over the world, including the Arctic!

Underwater forests are similar to forests on land but, instead of trees, there are large, brown **marine algae** that can be several meters tall. They are called **kelp** (Figure 1). Like trees, kelp make their own food using sunlight, carbon dioxide, water, and nutrients found in the water. This is called photosynthesis.

Figure 1

Kelp create an environment like trees do on land: they generate shade and soften not the wind, but the waves. Kelp forests provide a safe, protected place for animals to hide and reproduce. These forests are a perfect home for fish, crabs, and sea urchins.

The same way you can find many kinds of trees in a forest, you can find many kinds of kelp in kelp forests. Lots of kelp species have been described in the Arctic Ocean. Understanding these species is important, because it tells scientists how healthy the forest ecosystem is [1].

A CHANGING ARCTIC OCEAN

Before we discuss the kelp that are found in the Arctic Ocean, it is important to understand the environment and conditions that they live in. Kelp forests have adapted to the temperatures and light found in the areas of the world where they live. In the Arctic Ocean, kelp forests have adapted to live in freezing temperatures and long periods of darkness in the winter. They can even grow underneath the sea ice! Today, all the northern conditions that Arctic kelp have adapted to are changing.

MARINE ALGAE

Plants that grow in saltwater environments like oceans, seas, and estuaries. The plants come in different shapes, sizes and colors.

KELP

A type of large seaweed that belongs to the brown **marine algae** family.

Figure 1

The Arctic kelp communities located in Kongsfjorden, an inlet on the west coast of Spitsbergen, which is an island that is part of the Svalbard archipelago in the Arctic Ocean. You can see the forest-like habitat created by several kelp species in this coastal region of the Arctic.

What is changing in the Arctic? As a result of climate change, temperatures are getting warmer. The air temperature in the Arctic rose by 3°C over the last 50 years. This is three times higher than the rise in temperatures seen in the rest of the world! Ocean temperatures have also risen. The sea-surface temperature of the Arctic Ocean has warmed twice as fast as the sea surfaces in the rest of the world [2]. This warming has a dramatic impact on the sea ice. In the summer, Arctic sea ice is melting more quickly than we have ever seen before. The ice is also freezing more slowly in the winter. Taken together, these changes mean that there is less sea ice in the Arctic than there used to be—up to 40% of the sea-ice cover has been lost. The **glaciers** and **permafrost** in the Arctic are melting, too. This makes the coastline more fragile.

GLACIER

A large mass of ice, snow, rock, sediment, and often liquid water that starts on land.

PERMAFROST

A thick layer of soil underneath the ground surface that remains frozen throughout the year in polar regions.

These changes in the Arctic kelp's environment affect how they grow and even whether they survive. The warmer temperatures cause other environmental factors to change too—which you will soon see, if you keep reading.

HOW CLIMATE CHANGE AFFECTS ARCTIC KELP SPECIES

So far, you know that underwater kelp forests are real and that they are important for Arctic life. You also know that climate change is changing the Arctic Ocean. Now we will tell you what we know about how kelp species are affected by the changes in the Arctic.

Let us start with temperature. Like temperatures on land, the ocean temperature is very important for underwater life. It also changes with seasons. In the winter, water temperatures in the Arctic Ocean average 0°C. In summer, water temperatures average 5°C, but can reach 10°C in the southern parts of the Arctic Ocean where it is warmer. Scientists that study Arctic kelp found that many species grow best between 10–15°C. So, the increasing temperatures in the Arctic Ocean are good for some kelp, helping them to grow well [3]. Other kelp species grow better in lower temperatures and might not survive as well as the waters warm. The kelp species that prefer colder temperatures and are only found in the southern region of the Arctic Ocean today may even start growing in the northern regions of the Arctic Ocean where the water temperature is slightly colder. Even kelp species that are usually found in the Atlantic Ocean are being found more frequently in the Arctic Ocean. This is because the Arctic waters are warming enough to be suitable for them, and this may result in a lot of changes to the kelp species found in the Arctic kelp forests. Warming waters might also change which animals live in in those forests.

SALINITY

A measure of how salty water is, so the amount of salt that is dissolved in water. The higher the salinity, the more salt there is in the water.

The amount of salt in seawater, called its **salinity**, is important as well. When ice melts on land, freshwater flows into the Arctic Ocean and dilutes the salt, therefore decreasing the salinity. The opposite happens

when water freezes and salinity increases again. In the Arctic Ocean, salinity changes naturally due to the freezing and melting of ice with the seasons. But as more ice melts due to climate change, the salinity of the Arctic Ocean is decreasing. Just like with temperature, kelp species have ranges of salinity that are best for their growth. Studies have found that the growth of some kelp species can decrease if there is a strong decrease in salinity.

Use your imagination again: pretend that the sea ice is a lid that covers the water below. When there is less ice, or when the lid is no longer there, more light can reach into the water. Because kelp need light, a loss of sea ice could be good news for kelp forests. Scientists believe that the loss of ice in the Arctic will open up new areas for kelp to grow.

TURBIDITY

A measure of how murky water appears to be because of small particles that are suspended in the water. The higher the turbidity, the more particles there are in the water.

Turbidity is the last factor to consider. Turbidity describes the clarity of the water, or how see-through it is. The turbidity of water is determined by the number of particles present. The more particles, the higher the turbidity, and the more light is blocked from traveling through the water. This is not a good thing because, as you know, kelp need light to grow. The melting of glaciers and permafrost in the Arctic region is increasing the turbidity of the water in coastal regions, by bringing more soil particles, called sediment, into the ocean. Sediments block light from reaching kelp forests [4]. Therefore, as temperatures continue to increase and melting continues, increasing turbidity could make survival tough for Arctic kelp species.

KELP FORESTS OF THE FUTURE?

As you can see, when it comes to kelp forests, there are positive and negative outcomes of climate change in the Arctic Ocean. The impact that climate change will have also depends on the species, the specific region of the Artic, and the elements of the environment that are affected. Many ideas have been proposed to describe what the kelp forests of the Arctic might look like in the future. One idea is that kelp species that can handle the higher temperatures and lower salinities will dominate in the region, and the other kelp species will disappear from the forests. The animals that depend on the kelp species will likely follow the same trend (Figure 2).

CUMULATIVE EFFECT

Changes to the environment that are caused by more than one effect, like the effects of changes in temperature, salinity, and turbidity on the kelp forests.

It is important to understand that all the environmental elements are connected, so kelp may face many changes at the same time—like changes in temperature *and* salinity. We call this the **cumulative effect** of climate change, and it is difficult to predict. For example, scientists did an experiment on one kelp species that does not like high temperatures or low salinities, and when the two negative conditions were combined, the kelp grew even slower and struggled to photosynthesize [5]. Understanding the cumulative effect

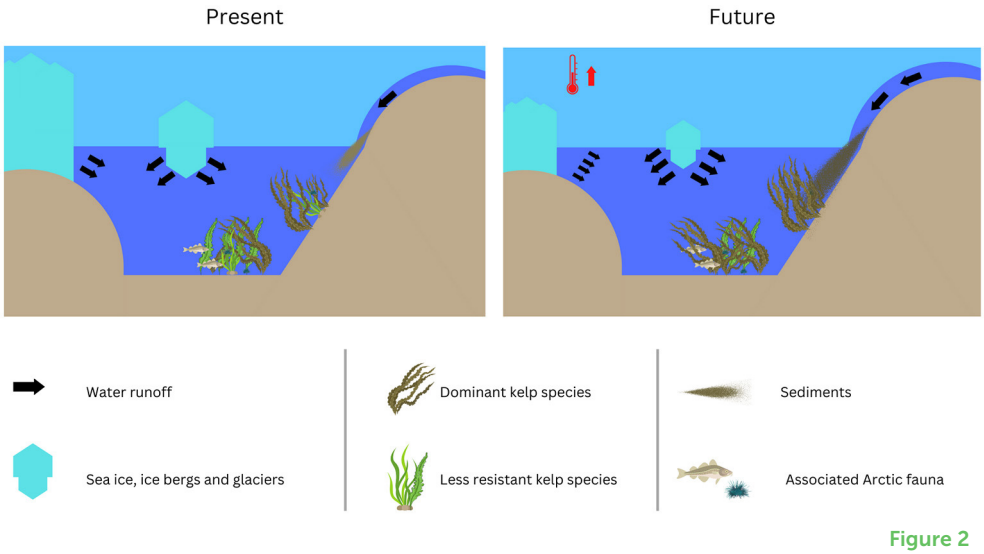

Figure 2

Present and predicted future conditions of coastal Arctic kelp communities. In the future, there will probably be increased water runoff from glaciers, icebergs, sea ice, and land resulting from increased temperatures in the Arctic. Waters are more turbid in the future, as more water runoff from land brings sediments into the water. The dominant kelp species will persist into the future, while the species that are less resistant to new conditions will probably disappear. The animals that live in Artic kelp forests, like sea urchins, may also change as conditions change in the future.

of climate change on kelp is a big challenge for scientists studying kelp today.

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YOUNG REVIEWERS

ARIA, AGE: 10

Aria loves playing with her two guinea pigs and feeding birds and squirrels in her backyard. She gave each squirrel a unique name and lots of peanuts. Aria is always curious about science and she has a lot of questions about nature, animals, and the universe. She also likes singing and drawing in her spare time.

LEAF, AGE: 9

I am in third grade, and my favorite subject is Art and Science. I love observing changes in the world. I like to work as a Young Reviewer as I can observe many more changes using scientist's equipment. In my spare time, I like hiking, swimming, and riding bikes with my friends.

AUTHORS

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Megan is an M.Sc. student studying science, innovation, and valorization of marine resources student at the Universite Cote d'Azur in France. For her internship, she was involved in the ORCA (Benthic Organisms and Communities in a Changing Arctic) project that studies the response of Arctic kelp to changes in light, temperature, and salinity. In her research career, she hopes to pursue her strong interest in kelp species. *megan.shipton@etu.univ-cotedazur.fr

ANAÏS LEBRUN

Anaïs is a Ph.D. student from Sorbonne University, working on how the arctic communities living on the seafloor—including kelp—are responding to global change. She is part of a project called "Horizon 2020 Future of Arctic Coastal Ecosystems—Identifying Transitions in Fjord Systems and Adjacent Coastal Areas",

which aims to help manage arctic fjord systems better, considering the quick changes happening in the ice-covered and biodiversity. Anais looks at how these changes are affecting the body functioning and its potential impacts on the entire community.

STEEVE COMEAU

Steeve is a research scientist from the Centre National de la Recherche Scientifique, working in the Laboratoire d'Océanographie de Villefranche. He studies the effects of global change on a large range of marine ecosystems, from tropical corals to Arctic kelp communities. He is the leader of the project "Benthic Organisms and Communities in a Changing Arctic" funded by the Fondation Prince Albert II de Monaco. This project aims to study the response of Arctic kelp to changes in light, temperature, and salinity.