Tricky Trawling Game
Education Resource Manual

https://campaign.zsl.org/trickytrawling/

Initial publication date: March 2019

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The "Tricky Trawling" game was created by developers Octophin Digital for the Zoological Society London (ZSL) in partnership with the Greenland Institute of Natural Resources.

Funding was provided by the European Union via the BEST 2.0 Programme and Sustainable Fisheries Greenland.

Special thanks: Lars Poort, Martin Blicher, and to all the teachers and students at Nuuk Internationale Friskole, Nalunnguarfiup Atuarfia, and Atuarfik Hans Lynge for participating in the game launch.

Image Acknowledgements: NOAA Photo library
https://www.flickr.com/photos/noaaphotolib/

Video Acknowledgements: Zoological Society London (ZSL)

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Introduction

This manual was created to help guide you and your students through the main scientific messages of the Tricky Trawling sustainable fishing video game.

The main purpose of this resource is not to tell you *how* to teach your students, but rather to provide you with the scientific basis behind benthic ecosystems. **Our aim is to help inspire curiosity** and awe in your students for deep-sea conservation in and around Greenland!

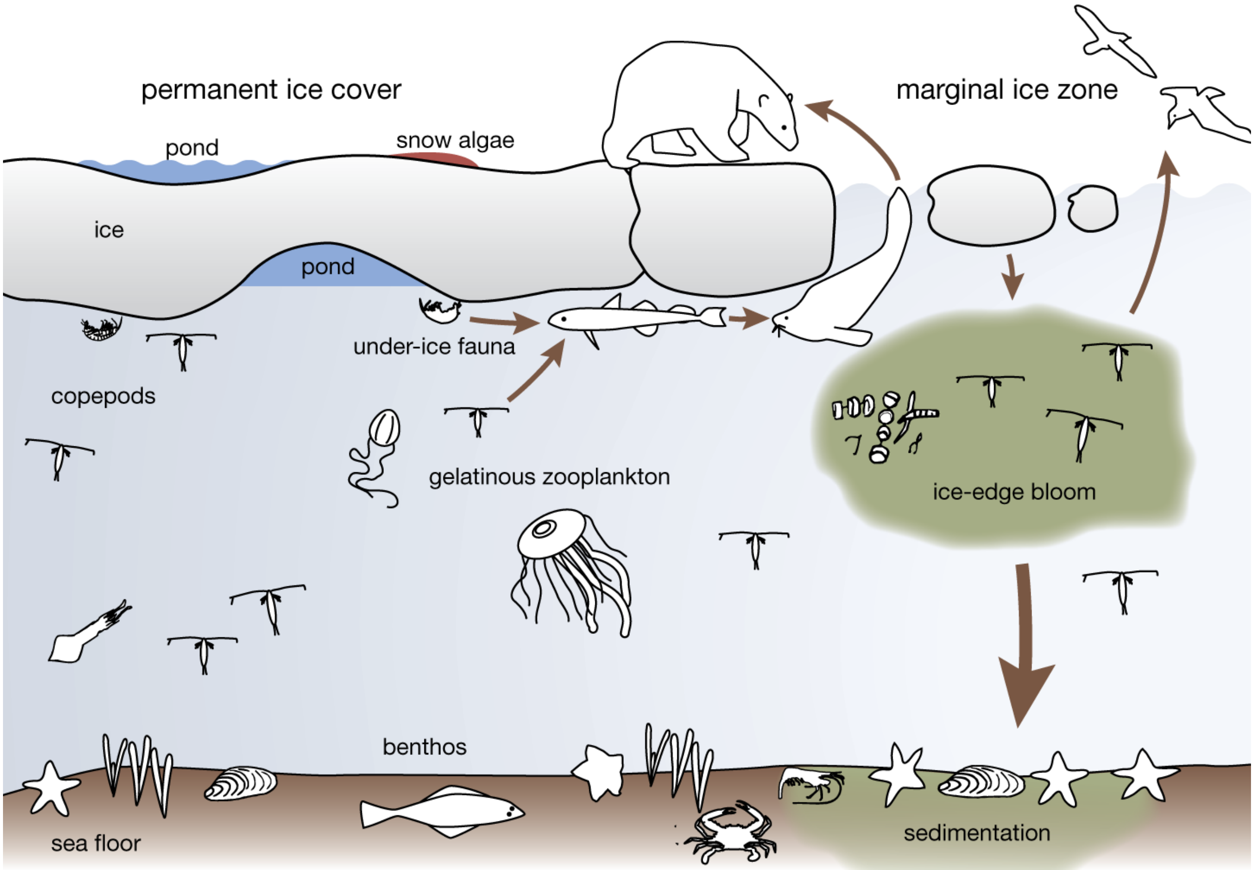
The resource is designed with no chronological order, so feel free to pick and choose which areas are most applicable to your classroom and teaching style.

At the end of the manual you will find a **glossary** for key scientific terms, as well as **ten in-class activities** to help bring benthic conservation alive in class.

We hope this packet enriches your experience of the Tricky Trawling video game and that your students have fun… while learning a thing or two along the way!

Food Webs

So how is the benthos on the sea-floor connected to the rest of the ocean?



Gradinger, R., Hopcroft, R.R. & Bluhm, B. 2004. Arctic Census of Marine Life (Arc-CoML) Program Proposal. University of Fairbanks. Fairbanks, Alaska. 35 pp.)

Sea ice algae and phytoplankton grow in the upper surface of the ocean under the influence of sunlight (part of primary production). Zooplankton eat the algae which are then eaten by, for example, Arctic cod and sea birds, which in turn act as the major link to other fish and birds, seals, and whales. A large part of the production form the surface (such as dead algae, excrement by zooplankton) sink to the ocean floor, where it serves as food for the benthic animals. Many fish prey on benthic animals such as sea stars and shrimps, and even walrus forage on benthic clams. So benthic animals are very important as food themselves!

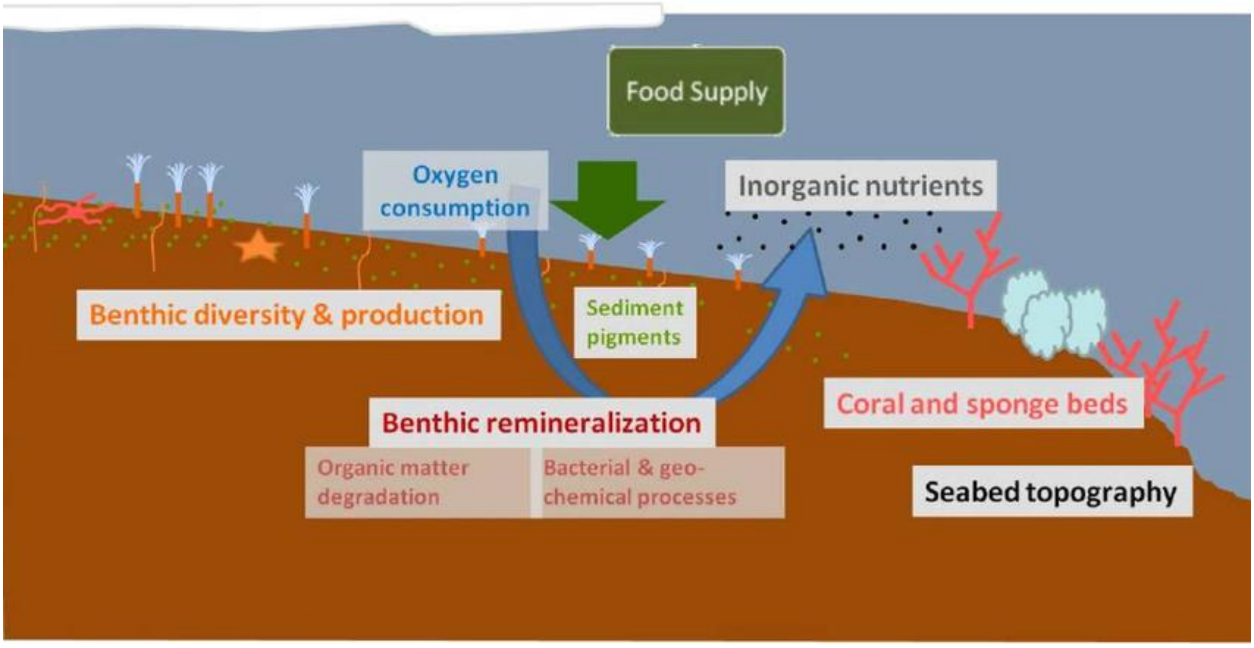


Image Credit: Ellen L. Kenchington

Benthic animals also play a role in nutrient recycling, providing new nutrients that are important for algal growth in the surface waters. They further break down the sediment organic matter by consumption, so that bacteria can then re-mineralize it. They also keep the seafloor "healthy" by bioturbation, which is constantly mixing and oxygenizing it with their digging activity.

As shown above, **interplay within the benthos is quite complex**. We are all familiar with food webs on land, and marine environments have their own. Yet it's all connected. **Any change in one part of the process has an effect on the others**, as seen by the example of the food web. Disturbance in any one of the components of a web can throw the system off balance. **Sometimes environmental harm can be reversed and ecological health restored, but in the case of vulnerable species there is no coming back from extinction.**

One way of presenting this concept to your students is to help them imagine arriving late to class. Any lesson they miss will set them back and they will continue to fall behind. Of course, it's always possible to play catch up, and any ramifications of being late can be reversed. But if the student doesn't put the effort in to learn what they missed then this will affect their education as a whole system.

See **Activities 5 through 7** for some interactive food web activities to highlight this concept in class!

Benthic Habitats of Greenland

In this section we review the **biodiversity, distribution, function and vulnerability** of **benthic habitats** in Greenland.

Before we begin, let's have a quick review of what the benthos is. This will help us better understand the ecological role the seabed plays within the entire marine ecosystem.

In Western Greenland the continental shelf extends over 1,000 km inside the Arctic Circle. The vast major of its seafloor remains unexplored. Even though it is home to a wide diversity of marine life that humans have yet to lay eyes on, benthic ecosystems are strongly impacted by our actions on the surface. In Greenland in particular, the main source of stress places on these fragile environments is from non-sustainable fishing practices.

The ***Benthic zone*** is defined as the lowest ecological area of the ocean. This includes bottom sediment such as sand, as well as any living organisms and their habitats. In the Tricky Trawling game some examples of benthic dwelling species in Greenlandic waters are sponges, bubble-gum coral, and skate fish. But also species we eat, such as Greenland halibut and cold-water prawns can be seen as part of the benthic ecosystem. In depths below ca. 200 meters, there will not be any sunlight left, so there are no algae there.

Above Left: A healthy bubble gum coral (c) NOAA Photo Library (2002), Monterey Bay Aquarium Research Institute.

Right: A skate searches sediment for bottom-dwelling invertebrates to eat.

A key component of Tricky Trawling is its focus on the vast **biodiversity** found within the benthic zone. Play Tricky Trawling (**Activity 1** in In-class Activities and Print-outs) for getting a first impression of the game.

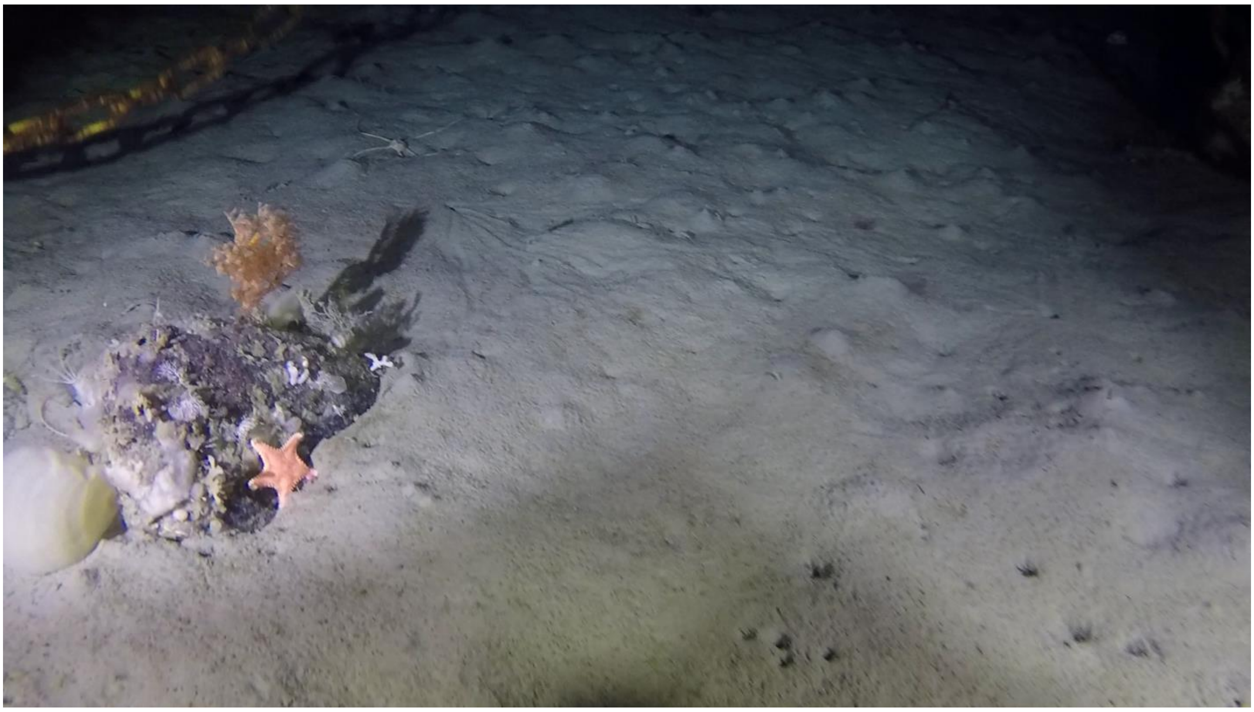
You may have to review the concept of biodiversity with your class before going on with this section. In this section we'll cover some species on the Greenlandic seafloor and some of the habitats they occur in.

See the Activity 2 for a fun way to introduce the amazing benthic biodiversity found on Greenland's seafloor to your students.

A **habitat** is defined as a place where an organism makes its home. There are different seafloor habitats, with different environmental conditions and different animals present.

The **biodiversity** and **distribution** of organisms on the seafloor depends on the surrounding **habitat factors** which can vary with location.

- Examples of **habitat factors** are depth, temperature, currents, production of food on the surface, iceberg density, and of course substrate type.
- We therefore find different animals in different areas, and different depths of the ocean.
- Researchers have mapped and modelled different substrate types along the West coast of Greenland, also in order to get a better idea of what animals may be living there (see the scientific article Gougeon et al. 2017).



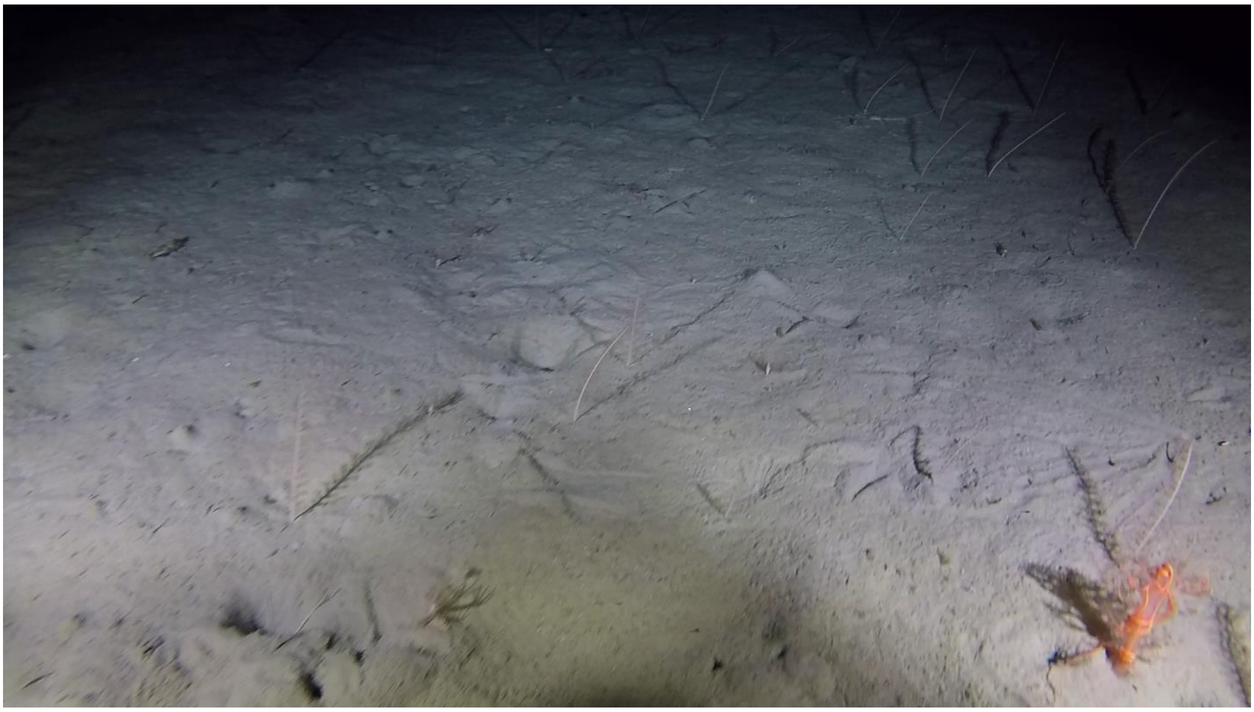
Stone with sponges, moss animals, bamboo corals and a sea star. In the mud, many holes from worms living inside the sediment can be seen.

- Different organisms take over different **functions** (e.g. some provide habitat, different feeding modes etc). If there is a high biodiversity, we often also have a "functional" diversity.
- This has implications for resilience. This means, usually if more different species are present in a habitat and one is harmed or removed, another animal can take over their function. An analogy that can be used to explain this concept to students is that of a sports match; i.e. if one defense player is injured another member of the team can take his or her place. If one has more diverse players to choose from, the trainer can make the best choice and take a player that is good in defense.

In 2012 researchers discovered a coral reef with the stony coral *Lophelia* not too far from Nuuk. This coral is quite rare, and one of the few cold water corals that can construct entire reefs, not unlike tropical reefs. They usually occur in waters between 4-12 degrees, from depths between 200-1000 meters. These coral reefs are often biodiversity hotspots, meaning they give shelter and provide nursery and feeding grounds for fish, crabs and many other small and large invertebrates. The Greenlandic government protected the area around the reef as a 'no fishing zone'. However, more research is needed to define the exact borders of this pristine habitat and whether the current protected zone includes all of the area. (See for further information: Click for further information. See page 14.

Sea pen field habitats

Sea pens are one of the unique species currently under threat from deep sea trawling around Greenland. Sea pens are actually a colony of polyps, where each individual works to support overall survival. Using a bulb located at the base, the sea pen can then anchor itself in the loose seafloor sediment. Polyps located on the sea pen's "arms" are used to catch drifting plankton. The sea pen habitat is characterized by plains of this loose sand and mud, making them exposed to the drag of trawling nets. The distinctive lines that deep sea trawling leaves on the ocean floor are easily spotted in these environments.



Sea pens at ca. 900m depth on muddy soft seafloor. Other animals, such as basket stars are often associated with sea pens (to the right).

See Activities 3 and 4 for ideas on how to incorporate these ideas into a lesson!

How is the seafloor explored?

The key for conserving species is to know where they are. Mapping by ZSL and the Greenland Institute of Natural Resources (GINR) with underwater cameras is a crucial part of this. And the images from the benthos seen in Tricky Trawling are from our research cruises!

A great summary and way of showing your students about the Greenlandic deep-sea research underpinning Tricky Trawling is to screen this movie (Danish) made by us, the scientists at ZSL! It gives a great overview of our survey techniques and the habitats we monitor. It is available in both Danish and English.

The **key educational messages** in Tricky Trawling cover the diversity of life found in the benthic zone and the awe surrounding new discoveries that are being made. Precisely because we know so little about the deep-sea it is important to conserve these areas before causing unknown harm. Some species and habitats are more vulnerable than others, and for example need more protection from deep-sea trawling.

See Activity 2 for a fun way students can identify species in some deep-sea images from our research cruises!

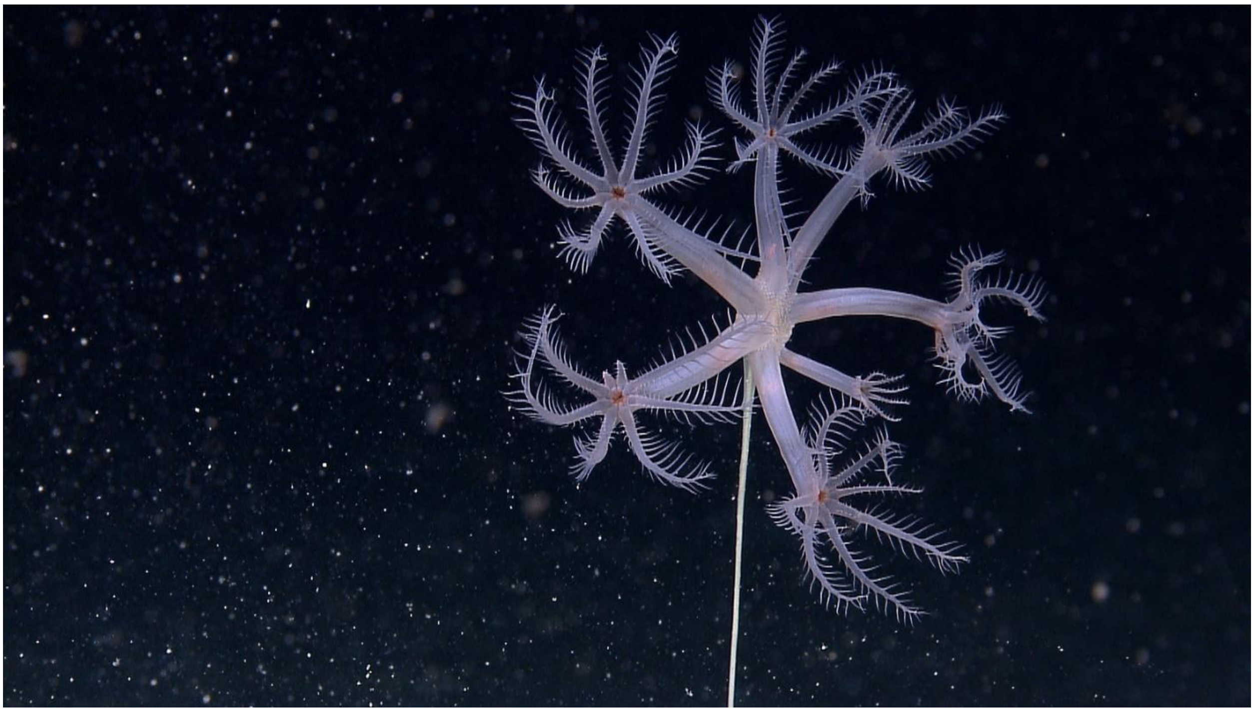
What are VME indicator species and why are they important?

A **VME indicator species** is an organism that helps researchers know if a habitat may be a **Vulnerable Marine Ecosystem (VME)** because it holds potentially high biodiversity, rare species or species that are vulnerable to human impact. For example, the *Lophelia* coral is a typical VME indicator species.

By assessing the distribution and abundance of these species, scientists can then judge whether a marine habitat is under threat. While VME species are not the only signal for benthic vulnerability, they do often play an important role when protecting these habitats. They serve as benchmarks for stakeholders of sustainable fisheries in Greenland, and throughout the world.

A case example: Researchers from GINR and ZSL conducted a survey in the area of Melville Bay, using drop cameras and nets. They found a high abundance of large Umbelulla sea pens, which are listed under the ICES VME Indicator Species Database (see link for more information). They concluded that these would be vulnerable to trawling if fishing continued in the area. So the fishery, together with the government of Greenland decided to close some (if not all) of these areas for fishing (see this article here).

VME indicator species can be a variety of species, but are often large and long-lived corals and sponges. One destroyed, their recovery can take decades. Some of the VME indicator species we encounter in the Tricky Trawling game are the stony, reef forming coral *Lophelia*, the *Umbellula* which helps create sea pen field habitats, and the soft coral Duva which make up a crucial species for cauliflower coral gardens.

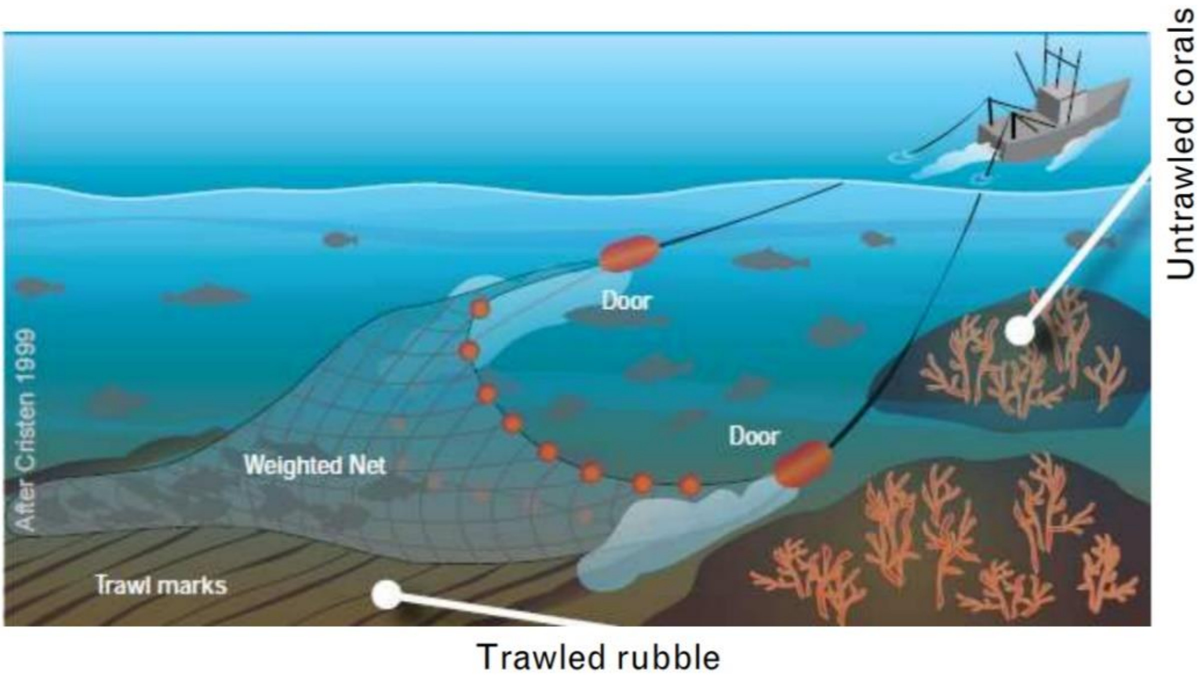

Above: An Umbellula reaching out its flowering arms to catch sources of food.

Deep Sea Trawling: Types and Effects

There are two types of trawling used to catch fish, the midwater (or pelagic) trawling and the deep-sea bottom trawling, commonly used in Greenland. **The Tricky Trawling game emphasizes impacts by bottom trawling**, mainly used in the coldwater prawn (*Pandalus borealis*) and offshore halibut (*Reinhardtius hippoglossoides)* fisheries.

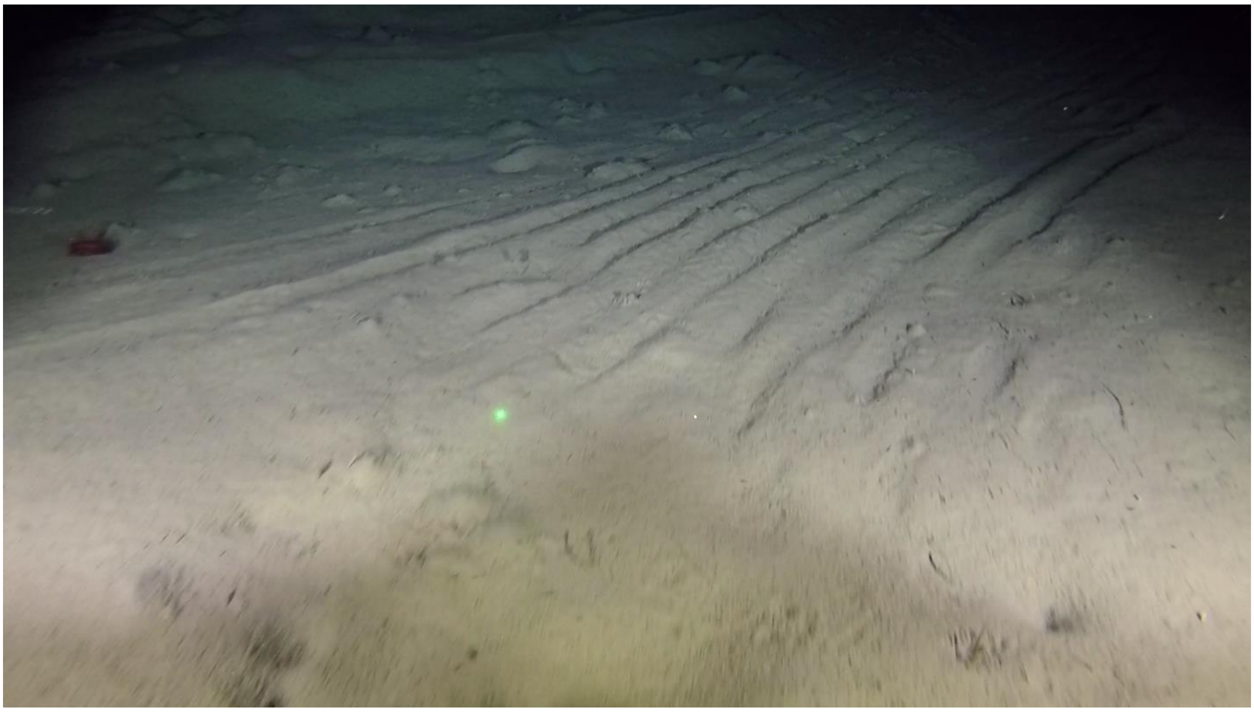
So how does deep sea trawling work and what does it do to the sea-floor?

As seen in the game play, **bottom trawling** is a type of fishing where a net is used to catch fish by dragging it along the ocean floor behind a boat, often called a trawler. The trawl, or net, catches anything everything in its path, meaning that the net can catch certain species of fish that may be unintended by the fisherman, and also destroy any organisms and habitats near the sediment surface through dragging. Deeper going disruption to the seabed occurs mainly by the long metal beam doors that holds open the mouth of the net.



(Cristen, 1999)

As shown in the image above, the trawl net leaves distinctive marks in the sediment. **Researchers often use these marks as a primary indication that specific marine areas have been subjected to deep sea trawling** (see below).



Trawl fishery has a long history in West Greenland. Today a large part of the continental shelf has been subject to trawling within the past 30 years (see included maps). Finding pristine untouched habitats and knowing how they looked like before the impact is difficult. However, researchers can map areas of high trawling intensity and compare them to less intensely trawled areas in order to estimate the impact. What do you think they find? Yes, species vulnerable to trawling, less likely to recover quickly from a damage are more rare in trawled areas.

Just like any other fishery, trawl fisheries may have the problem of bycatch. Bycatch species are often other fish (such as skates for example, which are similar to size to halibut), but can also be benthic invertebrates (such as sea pens and corals). The shrimp fishery in west Greenland usually has little bycatch, primarily because nets use sorting grids that select out larger fish. In the halibut fishery, the net mesh size will select out small young fish, but anything that is similar in size to the halibut will be caught (e.g. skates). Greenland sharks may also be caught by trawlers, and because we know very little about abundance and distribution of these long-lived sharks, we do not know the impact on the population.

Sustainable Fisheries

What makes a sustainable fishery different from a regular fishery?

A sustainable fishery will make sure there will be populations of seafood for the future and the bycatch and environmental damage is low. May small scale fisheries, using a normal fishing rod are sustainable. But also larger fisheries can engage and try to become more sustainable.

What can a fishery do to become more sustainable?

Example: Shrimp fisheries in West Greenland. The trawl fishery in West Greenland is MSC certified. This means they are enrolled into a sustainability scheme, and have to oblige certain rules which try to prevent overfishing and environmental impact. They can therefor place the MSC label on their product and gain a higher market price. Despite a lot of criticism, the MSC is the widest applied sustainability scheme in the world.

Under the MSC, the fishery has to prove that they have looked into the environmental impacts their specific fishery gear causes, or if they fish in any VME habitats. They also have to documental all bycatch (e.g. sharks) and that they keep the stock of their target fish healthy and do not catch too many, i.e. stick to quota. If they do not meet the criteria they have to change their practices in order to gain certification.

Marine protected areas (MPAs), or no-fishing zones, can help to protect some areas which have high biodiversity or vulnerable species, or where fish are known to have their spawning grounds.

The fishery can also make changes to their gear, for example, by using semi-pelagic (floating) doors.

Tricky Trawling highlights the importance of gear upgrades precisely because of its integral role in sustainable fishing management.

While gear upgrades may initially cost the fisherman more than basic trawl nets, government and non-profit subsidies in Greenland can help with this. The savings from fuel costs over time also contribute to gear upgrades being an economically viable approach to sustainable fishing.

So who benefits? **Sustainable fisheries are a win-win situation.** They help protect the future of fishing stocks, and thus the livelihood of fisherman. At the same time, they also **protect vulnerable habitats and species from extinction.** A future without benthic biodiversity and ecological vitality creates unhealthy marine ecosystems to the detriment of the fishing economy. Aside from preserving these species for their intrinsic value and beauty, it's important to encourage fisheries to adopt sustainable practices in order to maintain abundance of fish stocks for the industry.

See Appendix for in-class games **Activity 9 and 10** related to sustainable fisheries.

Key Terms and Definitions

Term glossary

Some key scientific words that may be useful to define for your students playing the game:

Benthic

The benthic zone is the bottom zone of a lake or an ocean including the surface of rocks, boulders, sand or mud. Benthic basically equals the word "seafloor". The organisms that live in this zone (on, in, or close to the seafloor) are called **benthos.** The opposite of the Benthic zone is the so-called **Pelagic** zone, the free water mass.

Biodiversity

The variability among living organisms (including microorganisms, fungi, plants and animals) and the ecosystems of which they are part. Scientists use the term 'biodiversity' to refer to the concepts of variation, ecosystems and interconnectedness (how things are connected or interact) within nature. High biodiversity basically means there are a lot of different species in one area. These areas are worth protecting because they help maintain ecosystem function.

Bycatch

The unwanted fish (e.g. Greenland sharks) and other marine creatures (e.g. corals or sponges) trapped by commercial fishing nets during fishing for a certain species (e.g. halibut).

Conservation

Conservation is the protection of animals, plants and natural areas (or entire ecosystems), especially from the damaging effects of human activity such as climate change.

Deep sea

Scientists usually refer to the deep sea as the parts of the ocean located beyond the continental shelf. Some use the term for the marine world below 200 meters of depth, where there is no light left to penetrate the water column.

Demersal/Bottom trawls

These are the types of nets used in bottom fishery. They consist of a net, rockhopper gear (to stop the net being caught on stones), and two trawl doors (which hold the net open). Demersal (bottom) trawls used in fishing halibut are very heavy. They are dragged along the seabed and can damage animals living there.

Ecosystem

An ecosystem includes all of the living organisms (such as bacteria, plants and animals) in a given area that interact with each other, and also with their non-living chemical and physical environment (soil, water etc.).

Filter feeding

Many marine animals are filter feeding, meaning they have tentacles, feathery arms or other projections which can capture tiny plants or animals (plankton) or particles out of the water. In the sea this is possible because the water current continuously supplies the animal with food, though in the deep sea there is less food available/flowing by. Seapens are an example of typical filter feeders.

Habitat

The type of natural home or environment that the animal, plant, or other organism lives in.

Juvenile

A juvenile is a young person who is not yet old enough to be considered an adult. When we talk about juvenile fish we mean they have not yet reproduced, as opposed to mature fish, which can produce offspring.

Marine protected area (MPA)

A marine protected area (MPA) can be established to protect animals and ecosystems or sustain fisheries production. Usually these are areas that have high biodiversity, have very rare species or are important breeding areas for some animals. They can vary in size and regulations (e.g. if fisheries are restricted or forbidden), and can differ between countries.

Floating trawl doors

Also called “semipelagic” trawl doors. These differ from normal trawl doors in the way that they float slightly above the seafloor. Floating trawl doors are better for wildlife as they don’t damage the sea bed as much as traditional trawl doors do.

Quota

Are a means by which many governments regulate fishing. The regulator (e.g. the government) sets a total allowable catch (TAC) for the commercial species, typically by weight and for a given time period. Then individual quota (or percentages) are distributed to each of the participating fishers. This is done to prevent overfishing and give the fish time to replenish their stock. This also helps keep a fishery sustainable for the future.

Sorting mesh

Fishing nets can have selective mesh sizes so that juvenile fish can escape and grow up to adults.

Spawning ground

This is considered as the area where fish or other animals migrate to spawn, which means releasing their eggs for reproduction.

Sustainability

Sustainable fishing means leaving enough fish in the ocean, respecting habitats and ensuring people who depend on fishing can maintain their livelihoods. A sustainable fishery will for example limit the number of fish that can be caught, leaving enough individuals which can reproduce, and try to minimize the negative impacts on other species such as sharks and corals.

Stock

The term fish stock usually refers to a particular fish population that is more or less isolated from other stocks of the same species. They can be, but are not always, genetically different from other stocks.

Habitat Factors

Several factors impact the characteristics of marine benthic ecosystems and the distribution of species:

Temperature: A key defining factor of the deep sea is that there are less temperature fluctuations than the upper parts of the water column. The average temperature change is only around 0-4 degrees Celsius throughout the year. Surface waters are much more exposed, thus warming up by sunlight or cooling down in the winter.

Light: Little light reaches below 200m in the water. This one of the main reasons why there is no algae in the deep sea. Plankton production occurs only in the upper part of the water column, above 200m.

Oxygen: Is limited in soft bottom habitats, which can be a problem for animals that burrow, like clams and worms. A lot of organic material (rotting algae or phytoplankton that sinks to this depth can produce anoxic conditions).

Salinity: There is very little variation in salinity in the deep sea. Only around 34 ppm. Fluctuations can occur in shallower water, where ice melt (of sea ice or glaciers) brings in freshwater. Many benthic dwelling animals are sensitive towards fluctuations however.

Depth: With increasing depth, most other habitat factors change. For example: in the summer, the shallower waters are warm because they heat up from the sunlight. The temperature in the deep is colder, and very stable throughout the year, around 1-2 degrees. Another example is the substrate type. At shallow benthic habitats there are often more hard rocks and stones, prevailing currents wash away any accumulating sediments. With really deep habitats, we often find muddy, really soft bottoms.

Overall the deep sea is a more stable habitat than tidal zones, for example, where strong wave impacts, tides and daily fluctuations in temperature, salinity, and oxygen supply occur.

Substrate: We distinguish substrate between hard bottoms (with stones) and soft bottoms (mud or sand). Most deep sea habitats are soft habitats, with occasional stones that get deposited down from glaciers. This is very important for benthic animals, as some of them need stones for attachment (they attach as babies, in their planktonic larvae stage). But there are also many animals that can burrow in the sediment, like clams and worms.

Overall the deep sea is a more stable habitat than tidal zones for example, where strong wave impacts, tides and daily fluctuations in temperature, salinity and oxygen supply occur.

Species glossary

A key component of Tricky Trawling is its focus on the vast **diversity** found within the benthic zone.

The **biodiversity** found on the Greenlandic seafloor can take surprising shapes and forms. **Tricky Trawling highlights several species**, including the following:

Sponges

Sponges (Porifera) belong to the animal kingdom and are colonial animals, consisting of many small cell-like individuals. Some of these colonies can grow large and provide shelter for juvenile fish.

Skates

Skates are often caught in bottom trawls. They are related to sharks, meaning they have no bones like real fish, only cartilage. They love eating prawns and brittle stars.

Octopus

Octopus are invertebrates but are very intelligent and clever little animals. They can change their color for camouflage, and often hide underneath stones for protection or dig small holes in the sediment.

Lophelia

Lophelia is a reef forming stony coral that lives in the cold waters of the north Atlantic. The first Lophelia reef in West Greenland was discovered by accident in 2012. Lophelia reef is a vulnerable habitat that is protected by law.

Greenland Sharks

Greenland sharks are ancient animals. They have been estimated to live more than 400 years. But they are hiding in the deep ocean and we don't know how many there actually are. Because of their old age and our lack of knowledge about their abundance, they may be vulnerable to bycatch.

Greenland halibut

Greenland halibut (*Reinhardtius hippoglossoides*) is a flatfish common in the Arctic. In the offshore sea they are caught by bottom trawls. Nets have sorting grids, so juvenile fish are protected and can grow to adults who reproduce.

Cup Corals

Cup corals (Flabellidae) have a "calcium skeleton" that looks like a cup. The animal sits inside and catches prey with its long tentacles.

Cauliflower corals

The family of cauliflower corals (Nephtheidae) are colonial animals, with each little flower (polyp) representing one individual. Like all jelly animals, they have numerous stingy cells in their skin used for defense and catching prey.

Umbellula

Umbellula seapens are commonly known as sea flowers due to their resemblance to flowers. They can grow more than a meter in height and live over 70 years. They easily get tangled in fishing nets.

Seapens

Seapens are in the same group as all corals and jellyfish. They may look like a feather quill pen, but they are actually often much bigger. They sit anchored in the sea mud, filter feeding on plankton and small particles. Unfortunately, they often get tangled in fishing nets.

Redfish

Deepsea redfish (*Sebastes* sp.) taste fantastic. But they are frequently overfished because of late maturity. They like to hide in corals and it is important to maintain their habitats so they can find places to hide and spawn.

Moss animals

Moss animals (Bryozoa) are really strange creatures. Most people think they are corals, but they are actually much smaller. They also form a calcareous skeleton and will break easily if touched by a fishing net.

Deep-sea prawns

Deep-sea prawns (*Pandalus borealis*) are common in Greenlandic waters. Prawns are small crustaceans, swimming close to the seafloor and eating worms, small mussels, detritus and plankton. To catch them, vessels use bottom trawls, which can capture many shrimps at once.

Crinoids

Feather stars and sea lilies (Crinoidea) are delicate creatures that attach themselves to stones and use their ten arms to filter small food particles from the surrounding water column.

Bubblegum coral

The bubblegum coral (*Paragorgia arborea*) is a deep-sea species found in all oceans including the Arctic. It can grow to heights of six meters. Ocean currents carry the corals' larvae and the young polyps the larvae become.

Sea squirts

Humans belong to the phylum Chordata, and so do all mammals, birds, reptiles and fish – as well as sea squirts. When they are larvae, they swim around in the water until they settle on stones and sand and grow to adults.

Brittle stars

All brittle stars (Ophiuroidea) have five arms, and while they look a lot like other starfish, they are a little more... brittle! Halibut love a good meal of brittle stars. This makes them part of the benthic food chain and an important player in the deep-sea ecosystem.

In-Class Activities and Print-outs

Activity 1 Tricky Trawling:

Play the Tricky Trawling game! As this manual is designed to accompany the Tricky Trawling video game, we of course suggest you allow your students full reign to play! **The game can be introduced prior to any benthic lessons, during, or after. Or all three!** Questions about the deep sea and conservation methods will likely arise once they play, and we hope our manual as provided a good base for you to launch your teaching from!

As an activity, the game can be played in-class on laptops or ipads... and it's also an excellent take-home activity to be played anywhere, anytime!

An offline version of the game is also available. Contact us for access at greenlandgame@zsl.org

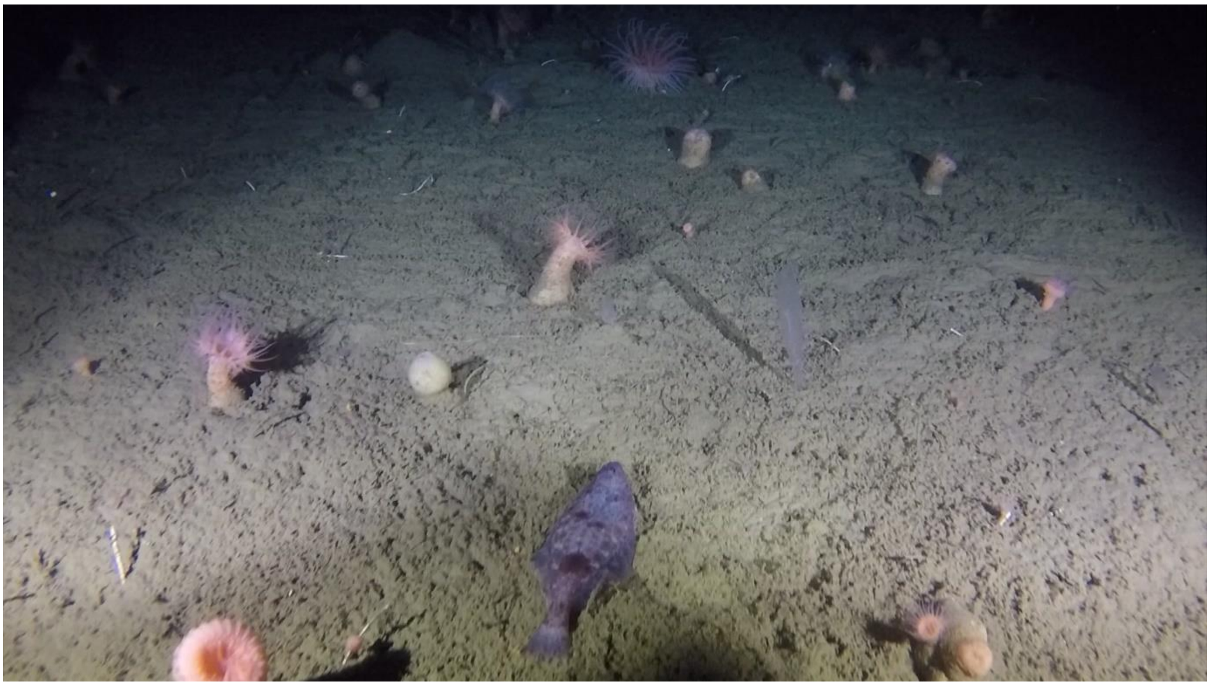
https://campaign.zsl.org/trickytrawling/

Activity 2 Species identification:

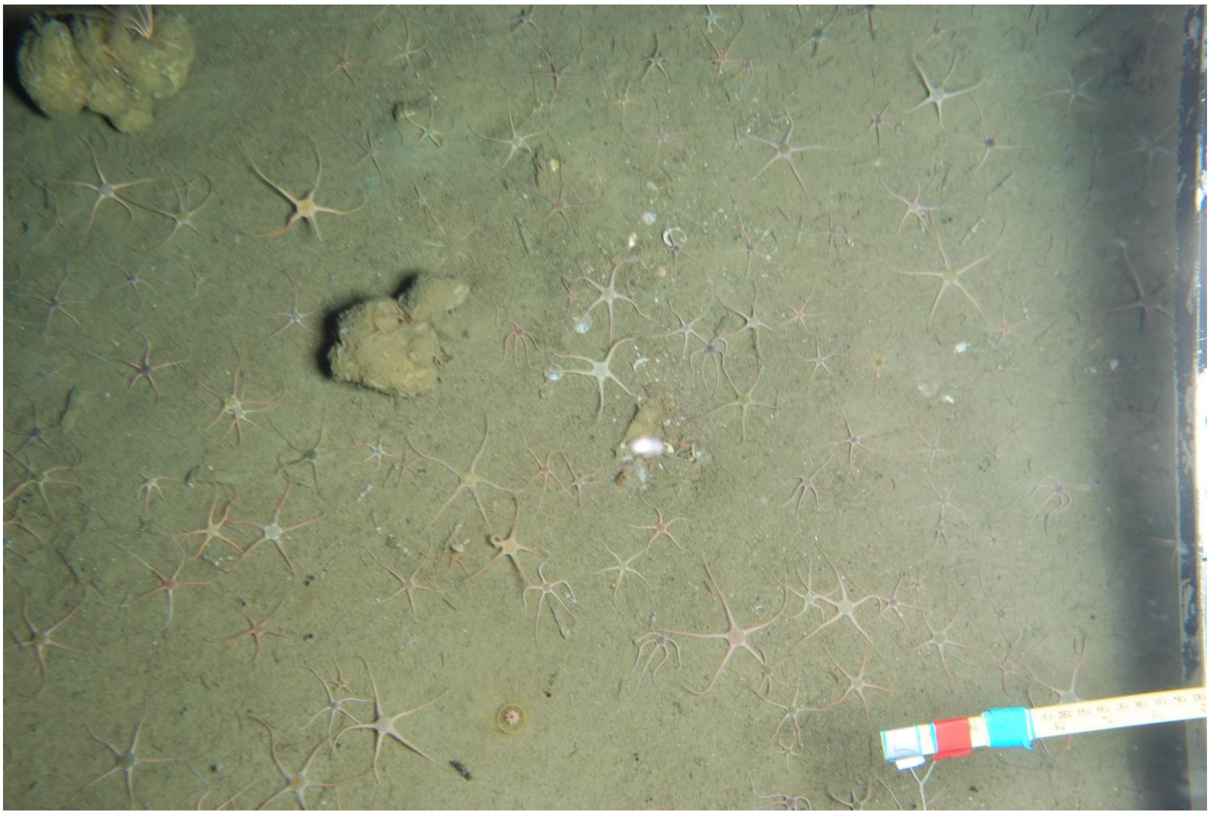
Print out these images from the seafloor of Greenland in the pictures taken by the scientists and get the students in your class to mark all animals they can see.

Did you know that biologists classify animals according to their similarity in body-plan and evolutionary history (for example, octopus and snails both belong to the phylum called “Bløddyr”). Also, every species is given a scientific name in Latin which is unique to them. E.g. Kongsnegl = *Buccinum undatum.*

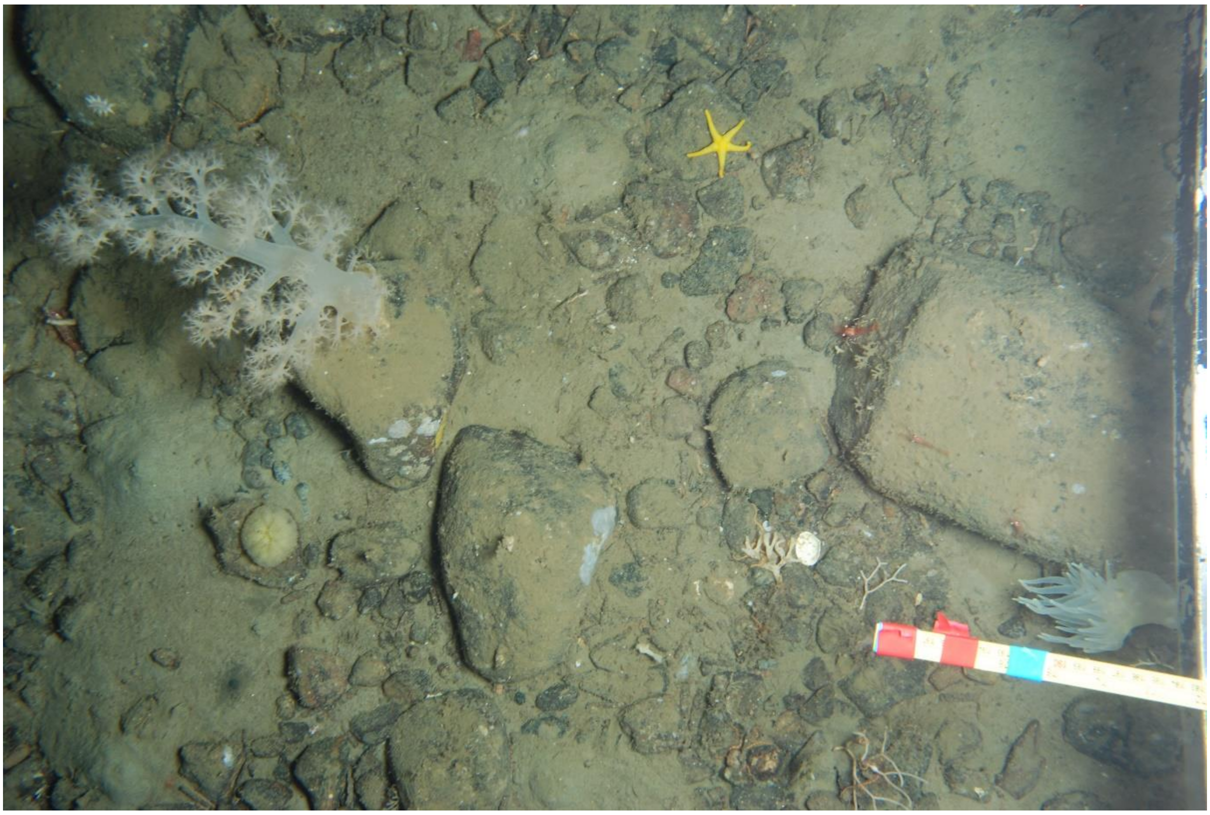
Picture 1. Depth = 381m



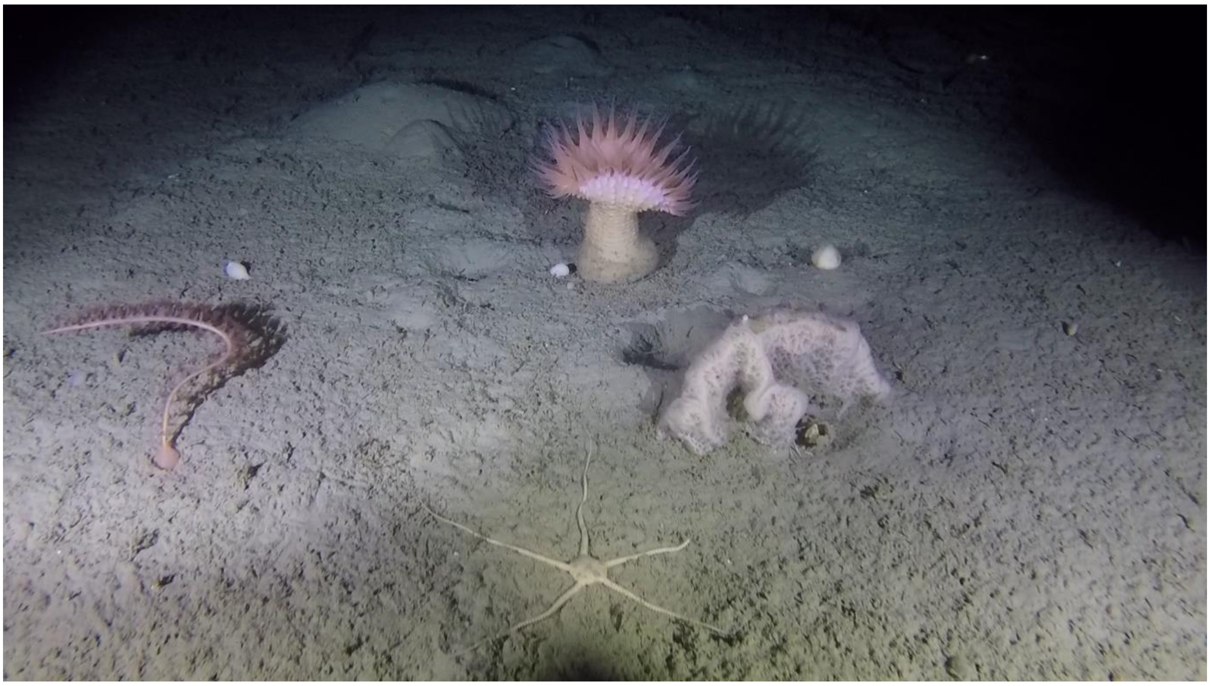
Picture 2. Depth = 674m



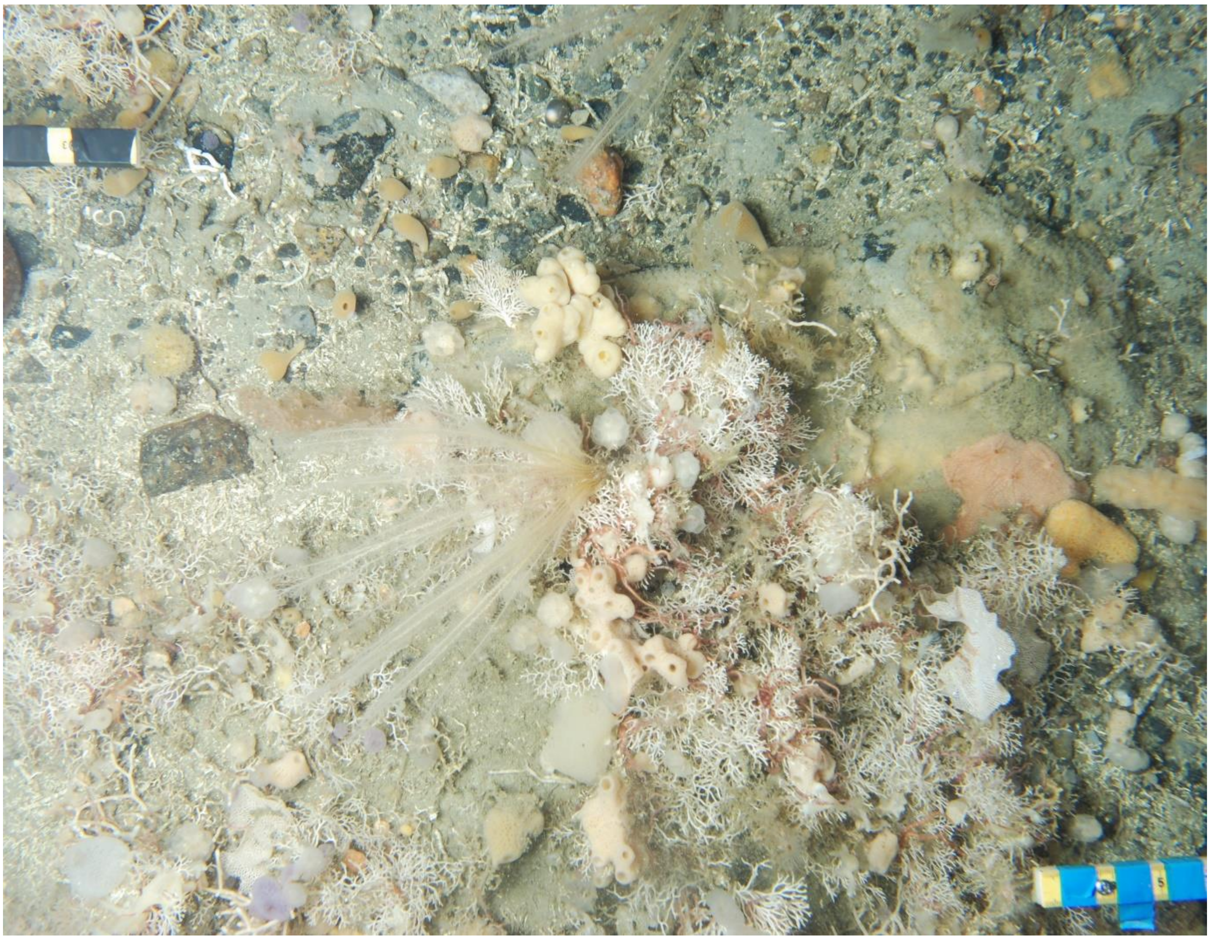
Picture 3. Depth = 183m



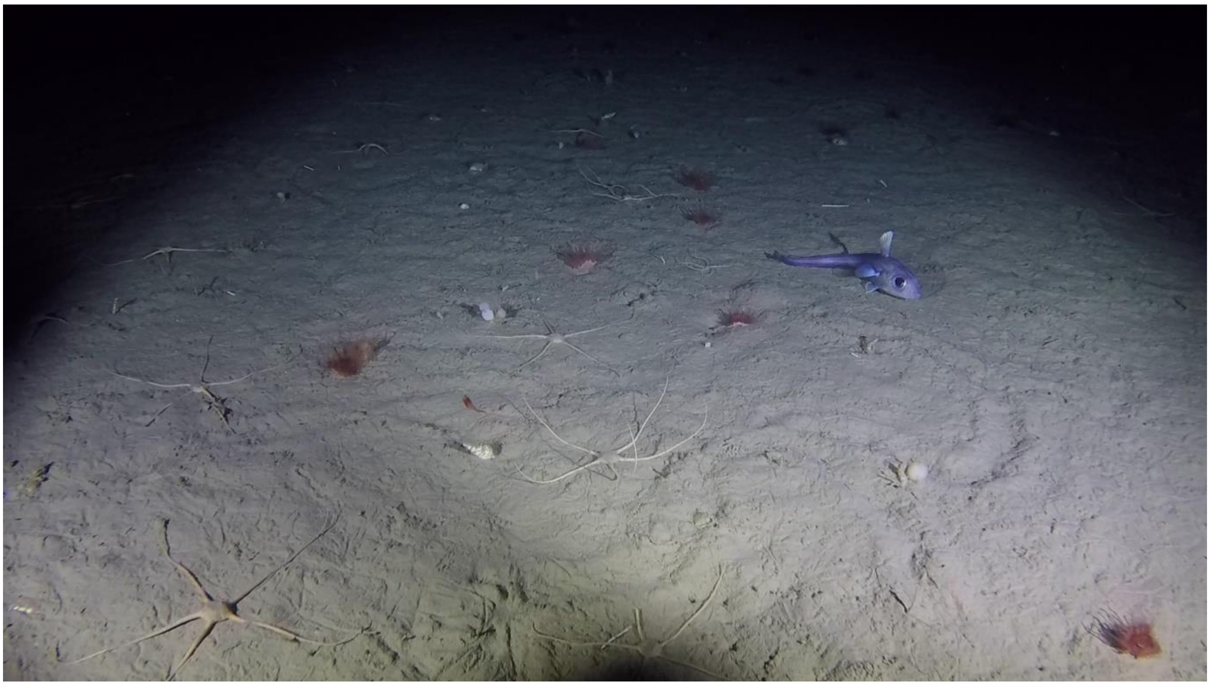
Picture 4. Depth = 297m



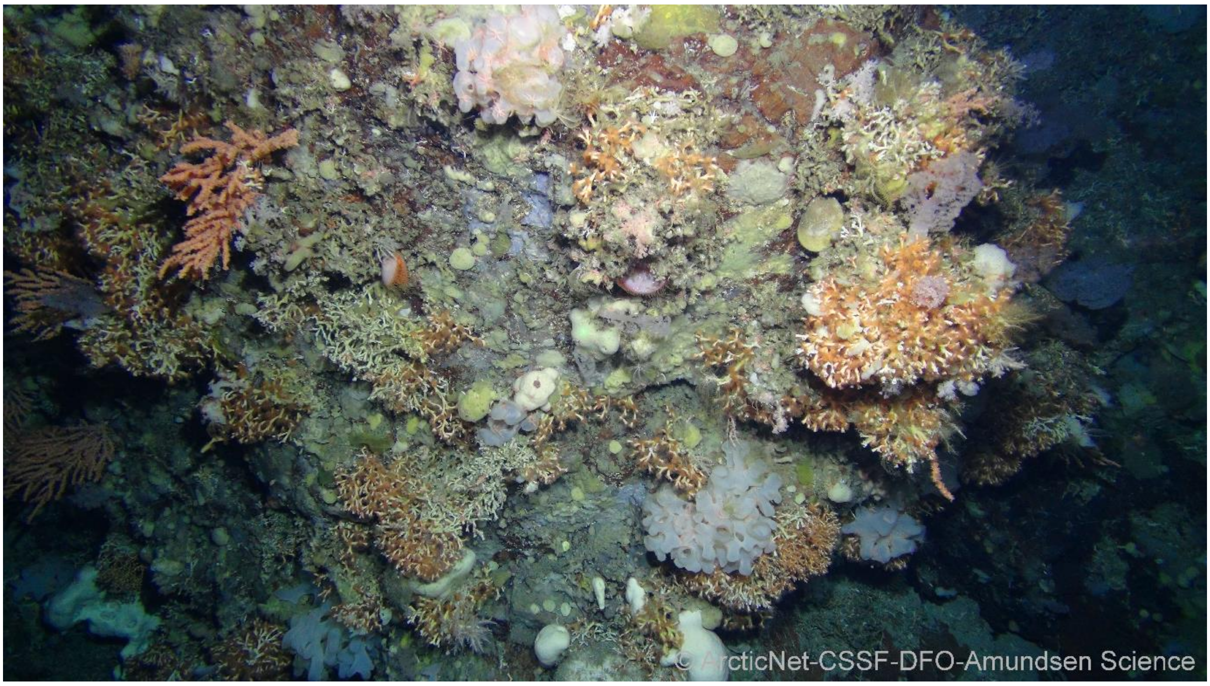
Picture 5. Depth = 650m



Picture 6. 210m



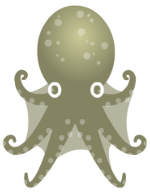
Picture 7. Depth = 828m



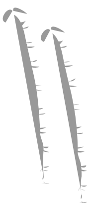
Picture 8. Depth = 250m

Can you find some of these animals?

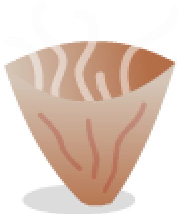
Bløddyr

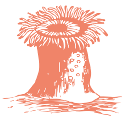
Octopus  Musling 

Børstemark



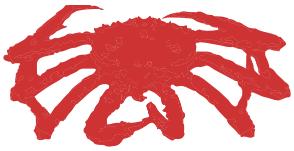
Koralldyr

Korall  Bægerkorall  Blomkålskoral 

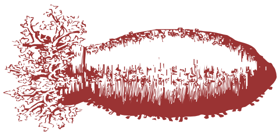
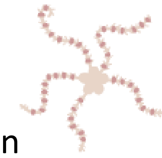
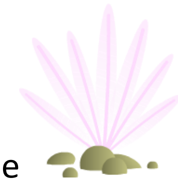
Lophelia  Søanemone  Søfjær 

Mossdyr

Krebsdyr

Dybhavsreje  Troldkrabbe 

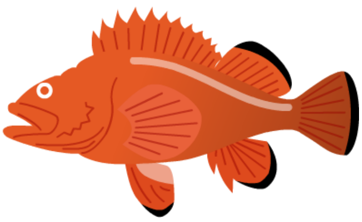
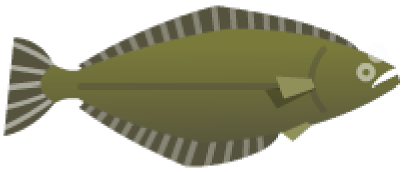
Pigghuder

Sjøpølse  Slangestern  Sølilje  Søsterne

Svampdyr

Søpunger

Fisk

Redfish  Hellefisk 

Get the students to answer these questions:

How many different animals do you count in each picture?

ZSL has a portal where it stores all seafloor images and where scientists count all the animals seen in the pictures. You can access and explore it here: https://www.biigle.de/login?

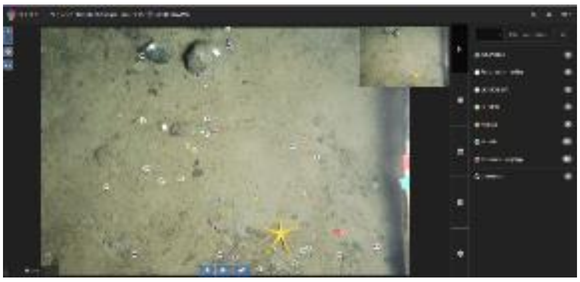
User: greenlandhabitats@gmail.com

Password: deep_sea

Each of the volumes is a collection of images from a cruise. Click on the picture to explore the collection and show all images.

Map: Click on the globe button to explore the map and see where pictures were taken (sampling location).

Image: Click on each picture to see the full image and the labels of animals on the pictures.



Go back for overview.

Click on the top right corner info button to view more image information, depth, and area of image.

Are some pictures more "diverse" than others?

Example answer: This is very variable, for example, Picture 6 has many animals, some of the mare colonies and difficult to count.

Do you think you can see all animals actually living in the area where the picture was taken?

Example answer: No, some are hidden under stones or inside the mud/sand. The pictures only show a small snapshot of sea bottom habitat – they don't account for variation over space.

Activity 3 Seafloor habitats:

A habitat is the type of natural home or environment that the animal, plant, or other organism lives in.

1. Create a word cloud at the front of the classroom of words describing what it’s like in a benthic habitat, at the bottom of the ocean.

   Example answer: (Words: dark, high pressure, cold, stable, current, limited food, sand, rocks,…)

2. Using the images from Activity 2, get the students to think about why there are different animals living in different habitats.

   Example answer: Because animals need different habitat factors, some prefer soft ground, some need hard stones to attach to. Also, animals do distribute via planktonic larvae (babies, or offspring), carried by currents. They might end up in different places because of this. Also, disturbances like trawling can play a role in distribution of animals on the seafloor.

How do the images differ in the habitat factors of: light, temperature, salinity, currents, and substrate type?

a. Is it light or dark?
b. What is the temperature like?
c. Is there a lot of current?
d. What’s the substrate like? (i.e. rocky/sandy/muddy)
e. Are the conditions very variable, like a beach, or nearly always the same?

Example answers:

a. Light: penetrates down to ca. 200m. It is fairly dark below that, so no algae are found in deeper habitats.
b. Temperature: in deeper habitats the temperature is fairly stable, around 2 degrees. Closer to the surface there is more variability, cold in the winter, warmer in the summer.

c. Currents: there is usually higher currently on rocky bottom, it carries sand away and exposes rocks. High currents bring a lot of food particles, this is why we often find animals that are attached to rocks in high current environments: they simple don't need to move to find food, the currents bring it to them!
d. Substrate type: we distinguish between hard bottom (rocks and stones) vs soft bottoms (mud and sand). Often we find a mixture of both substrate types. Did you notice that a lot of animals such as corals like to attach to stones? Stones provide a solid anchoring substrate for many animals, and often we find high diversity in these habitats. However, there are many animals we don't see on the pictures, they burrow in the mud!
e. The deeper you go, the more stable usually the conditions are. They are less influences by air temperatures, sun exposure, and melt water on the surface.

Activity 4 How benthic animals live:

1. Get students to select one of their favourite species from the Tricky Trawling game, using the Internet or the species facts above (or on the main landing page for the game) to get ideas.
   Try and make sure all 15 species are chosen by at least one student.
2. Ask them to research the animal and answer the following questions:
   a. What does the animal spend its time doing (sitting in one spot on the sea floor, swimming around, hiding etc.)
   b. How big does the animal get?
   c. How old can the animal live?
3. Get each student to quickly tell the class about their animal.

Activity 5 Interactive food web:

One major interaction between animals are eating each other, i.e. forming food webs

1. Get each student to choose one animal from the game (for example the one they researched in **Activity 4**)
2. Get students to stand in a circle and give one a ball of string. Get them to pass the ball to the animals they interact with (eat or get eaten by) using more than one ball if interact with more than one, whilst still keeping hold of one end. Then get that student to pass it on to who they interact with etc. until all animals are connected, in a web, to the animals they interact with.
3. Go round the circle and get each student to discuss what the impact on the other animals would be if they were removed from the web (if they pull on the strings they hold, any animals that feel the pull would be impacted).
4. Remove the any species to show how the web falls apart.
5. Discuss how even affecting once species in an ecosystem has a knock on impact on everything else.

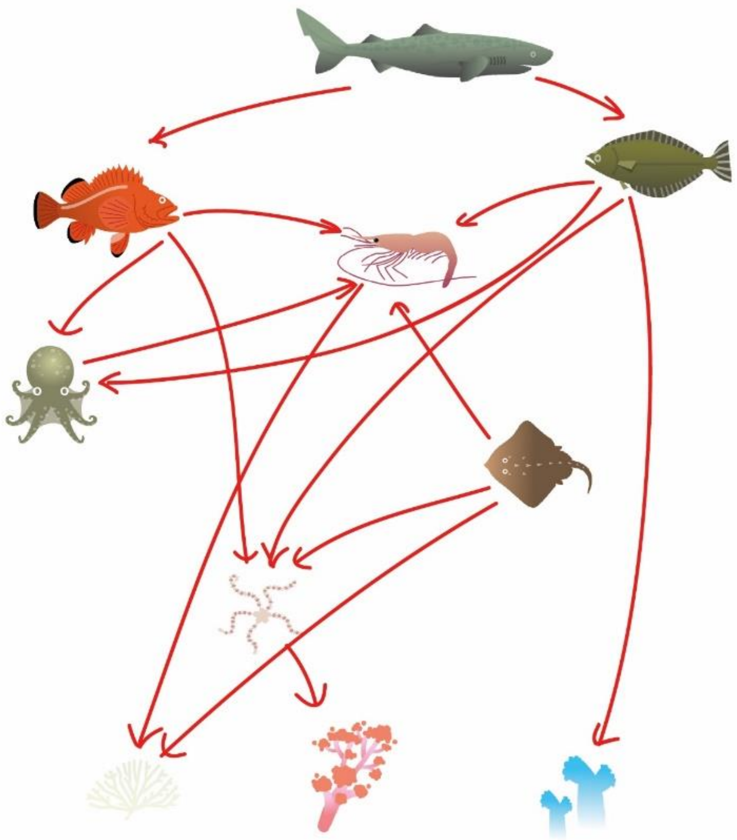
Activity 6 Biodiversity in food webs:

1. Define 'Biodiversity' for the students (The variety of plant and animal life in a given area)

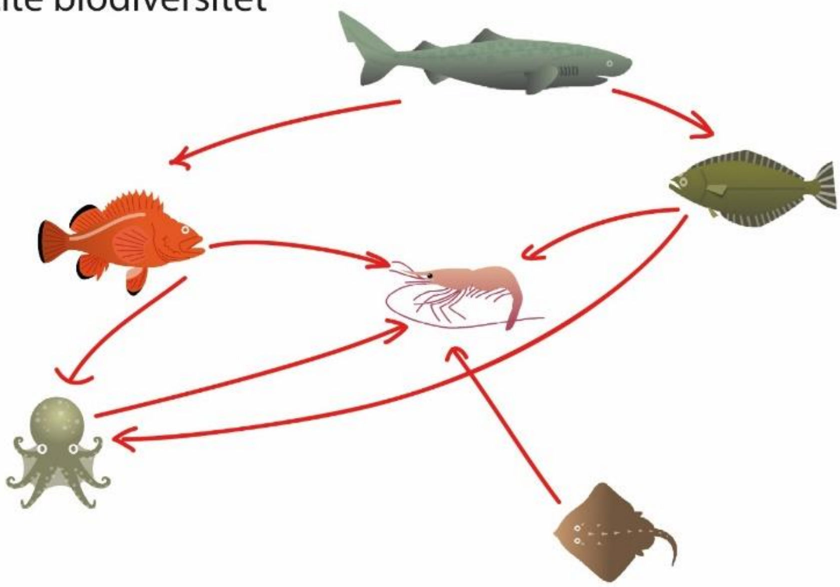
2. Look at the two webs provided below. Ask the students to make the following two food webs (connecting each other with strings similar to **Activity 5,** or simply give them the following print out). Then remove **shrimp** from both of the food webs. What happens?

3. Example answer: The second food web will collapse, because it has lower biodiversity and some species rely exclusively on the shrimp for food. In real life, this means if one species would be removed (due to disease or overfishing etc), in a highly diverse food web there will be others present that those higher up the food chain can eat instead, so the impact will be less. The higher the biodiversity the more stable the ecosystem is – the more resistant to change.

Stor biodiversitet

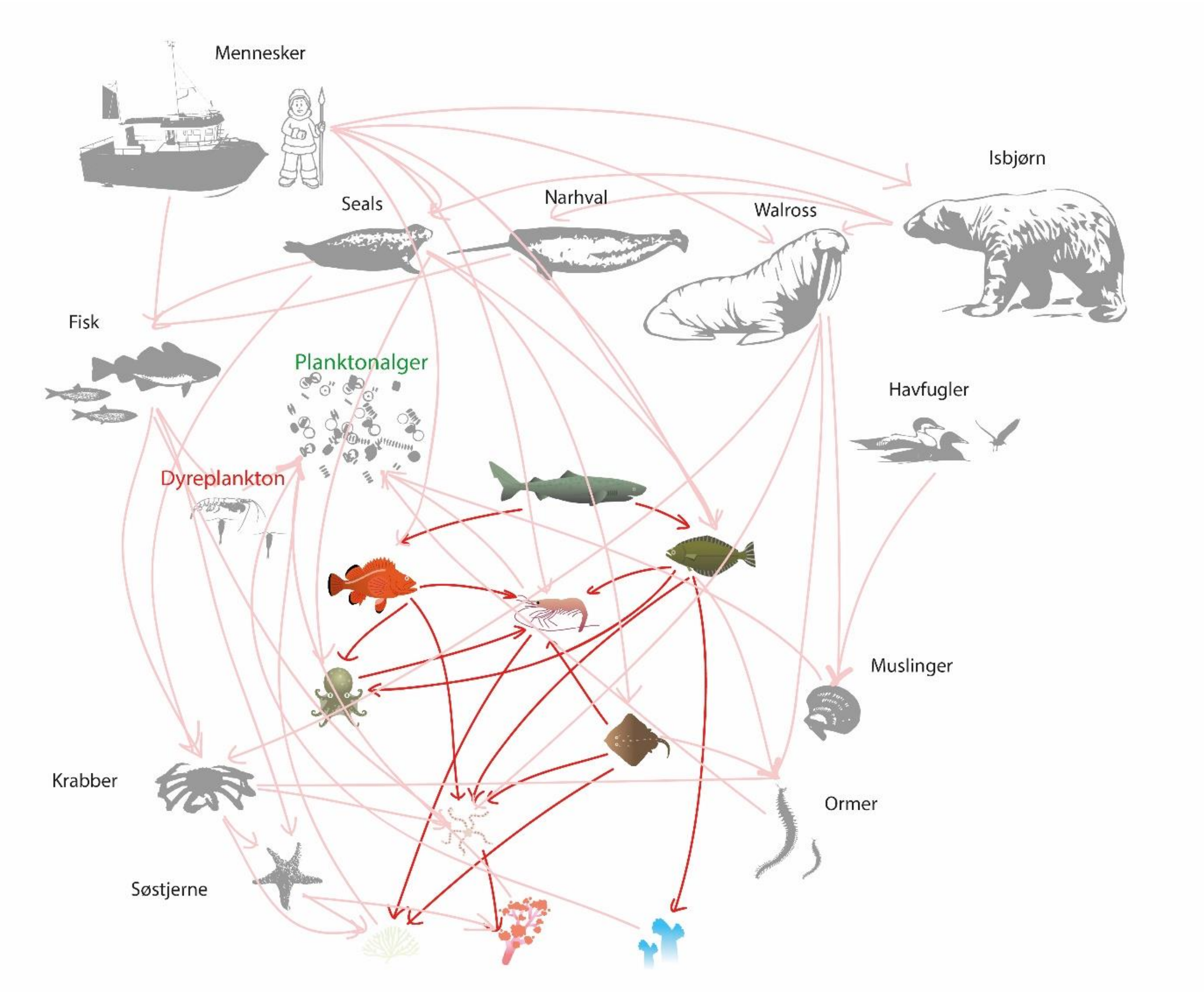


Lite biodiversitet



Activity 7 Food webs and other interactions in the ecosystem:

1. Revise the concept of ecosystems with your students.
2. Discuss that an ecosystem is made up of both living and non-living things (organisms and habitat factors), and the complex interactions between them.
3. One major interaction in the ecosystem are food webs. Similar to **Activity 5**, make a "**food web**" representing the following members. You can also let students draw or handicraft food webs and put them up on your classroom wall.
4. Discuss how also benthic animals are connected to the ecosystem and even humans.



Benthic animals don't only serve as food for fish and other animals in the ecosytem, they also provide hiding grounds and attachment. This is an important ecosystem function. Redfish for example are often found associated to coral reefs. Brittle stars live on seapens, sponges, in corals.

5. Use the following illustration to add other interactions (non-feeding) to the food web, focusing on the role of benthic species as habitat for others. How would the web look now?

Activity 8 Interactive exploration of life around the beach or school:

1. Send students outside to explore an area nearby – such as the school grounds and a beach.
2. Ask them to write a tally of all the different living things they see (likely to mostly be invertebrates).
3. Discuss which habitat is the most biodiverse: The benthos or the one near the school? Which had the most different species in it?
4. Was this what they expected?
5. If your class has beach access: How does a beach habitat differ from a deep sea one? Would they expect the beach habitat or the deep sea benthic habitat to be more biodiverse?

Activity 9 What is sustainable fishing? Interactive classroom game:

Use the following activity to introduce how fishing effects marine life populations, as well as why fish populations are declining in some places and how they can be managed more sustainably to prevent this.

<u>Materials required:</u>

- Four bags of small sweets (to represent shrimp)
- Four bags of large sweets (to represent benthic species)
- One bag of popped popcorn (to represent other marine life)
- Medium sized dishes or bowls, one per group (to represent different fishing areas)
- Small cups (to represent their boat)
- Spatulas, on per student
- Spoons, one per student
- Tongs or chop sticks, one set per student
- Stop watch/timer

<u>Prep:</u>

- Create one ‘ocean’ per group of 5 students – put a layer of the large sweets at the bottom of the medium sized dishes (the benthic species), then cover this with 40 smaller sweets (shrimp) mixed with popcorn (other marine species)

<u>Game rules:</u>

- Each student is a ‘fisher’ whose livelihood depends on them catching a certain amount of fish.
- Their target species is ‘shrimp’ (small sweets), and they must catch at least five of these per ‘fishing season’.
- ‘Fishing seasons’ will last 30 seconds, during which time students should use their ‘fishing equipment’ (spatula) to fish out as many of the target species as possible and place them in their ‘boat’ (plastic cup)
- If any ‘non-target species’ (popcorn or large sweets) end up in their ‘boat’, they cannot put them back in the ocean.
- The animals left in the ‘ocean’ reproduce between fishing seasons, therefore after each ‘fishing season’ one new small sweet/large sweet/popcorn will be added for every ocean animal left in the ‘ocean’.

The Game:

1. Explain the rules of the game to the class.
2. Divide the class into groups of five and give them each an ‘ocean’.
3. Give each student a spatula to represent trawl fishing – they are only allowed to use this for catching fish, not their fingers!
4. Tell students to ‘start fishing!’ and give them 30 seconds for the first fishing season.
5. If they haven’t caught five of their target species, they haven’t survived until the next fishing season and must sit out.
6. Between fishing seasons add an extra small sweet/large sweet/popcorn for every one left in the ‘ocean’, to represent reproduction.
7. For the second ‘fishing season’ allow one student per group to use a spoon instead, representing net fishing.
8. For the third ‘fishing season’, allow one student per group to use the tongs/chop stick to represent line fishing.
9. If their ocean runs out of the target species, allow students to ‘invade’ other oceans.
10. Repeat until all or most of the target species are gone. (if fish are decreasing quickly enough, increase the length of the fishing season.)

Discussion:
- Which fishing methods caught the most fish?
- Which fishing methods caught the most unintended animals (especially benthic species)
- Share with them that sadly, over 85% of the worlds fish populations that people depend upon are no longer able to produce as much fish as they once were due to overfishing. This is a big problem because without healthy fish populations over 1-billion people around the world won’t have enough food to survive.
- Ask students to suggest how they could make their fisheries more successful to allow both fishers to catch enough fish to survive as well as allowing enough fish to stay in the oceans to maintain healthy populations that will continue for many years to come. Be sure to include:
    - Using the fishing method that catches enough of the target species whilst also allowing fishers to be selective and not catch too many other species.
    - Decrease the number of target fish they need to catch each season.

  - Leaving one ocean/area free from fishing for a season or two to let the number of fish recover.
- If students want to, they can try out their ideas in another round of the game.

Activity 10 Discussion:

- Ask students to write a theoretical letter to either:
    - A local politician
    - A shrimp trawl fishery
- Explaining
    - What is special about the benthic ecosystem?
    - How is fishing effecting it?
    - Why should people care?
    - What can the politician/fishery do to help protect it?

Ideally, do not send this letter!