



COD'S JOURNEY BACK HOME—FROM BIRTH TO NURSERY

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YOUNG REVIEWER:



GIGI
AGE: 9

Adult cod swim hundreds of kilometers away from home to release their eggs into the ocean water. After some days, tiny larvae hatch from the eggs. At first, the larvae have a small food reserve to sustain them during their first days of life. Soon after emptying the yolk-sac, the larvae must find food on their own. Both eggs and larvae are carried by the ocean currents and they experience large changes in conditions as they drift back to the nursery areas where their parents came from, where the larvae grow up to become adult fish. Our research on cod indicates that the number and location of cod larvae are associated with the size of the spawning adults; and that the number of larvae influences how many cod will grow to be recruits. So, it is important to also know the living conditions of the parents *before* they spawn, which will be important for the survival of their offspring.

Figure 1

(A) The life cycle of cod. (B) The location of the Barents Sea, where cod feed and grow to be adults, and the Norwegian Sea, where adult cod release their eggs (image credits: Adult cod photo: modified from Dr. Bernd Ueberschär/fishbase.se; egg and larvae photo: modified from Terje van der Meeren/Institute of Marine Research, Norway).

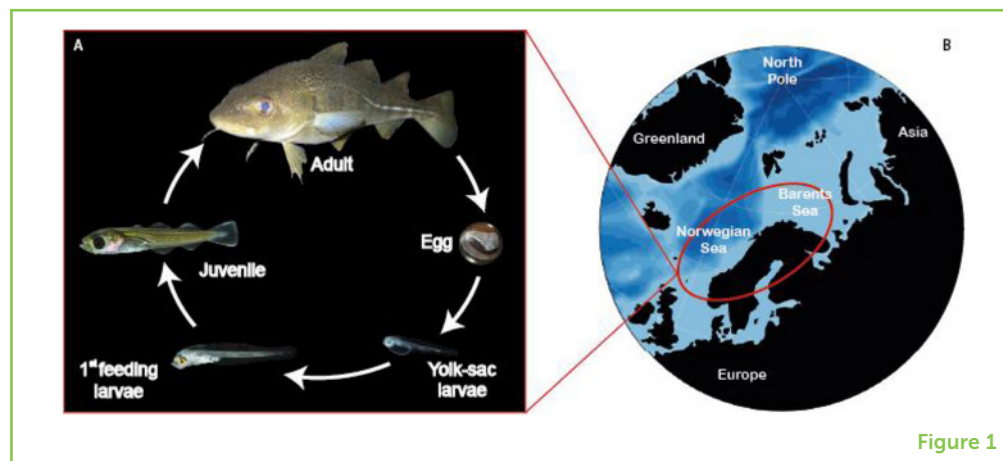


Figure 1

WHAT ARE COD?

Cod is a familiar fish species and a food that many of us have tried at least once. Since cod is a very popular food around the globe, it is a heavily fished species. If cod populations are not well-studied and managed, there is a risk of overfishing and depleting the population. Good management of the cod population relies on research, which helps us gain knowledge about cod and their environment.

During their lifecycle, cod start out as eggs, and after about 15 days, tiny **larvae** hatch from the eggs [1]. The larvae grow to be juveniles in about 6 months and eventually adults after 3 years (Figure 1A). Adult cod can grow to be 2 m in length and can live to be 25 years old. There are many different cod populations, and they reside in various areas of the North Atlantic and Arctic Oceans. Adult cod usually prefer deep, cold waters, while young cod prefer shallower waters. Cod usually swim long distances—200 km on average—to find a suitable place to release their eggs, but the cod that live in the Barents Sea (Figure 1B) can travel up to ten times that distance!

THE CHALLENGES OF BEING A SMALL COD LARVA IN A BIG OCEAN

In late winter, after leaving the cold, dark Barents Sea, the adult cod arrive in a warmer, brighter area along the Norwegian coast. This is a good place to release their eggs and for their offspring to start their development in the early spring. But the babies, called larvae, will have to make their way back to their **nursery** area in the Barents Sea, this journey may take 6 months. The nursery area is where the juvenile fish feed and grow up to become adults. Returning to the nursery is not an easy task for the small larvae!

During **spawning**, adult fish release their eggs into the water. The released eggs are each about the size of a grain of coarse sand. The total number of eggs spawned varies from year to year, depending on

LARVAE

The babies that hatch from the fish eggs.

NURSERY

The area where fish grow up to become adults.

SPAWNING

The part of the fish reproduction process in which the fish release the eggs, which are then fertilized in the water.

Figure 2

Copepod (*Calanus finmarchicus*) in the adult and young stages. First-feeding cod larvae eat the young-stage copepods (image credit: Terje van der Meeren/Institute of Marine Research, Norway).

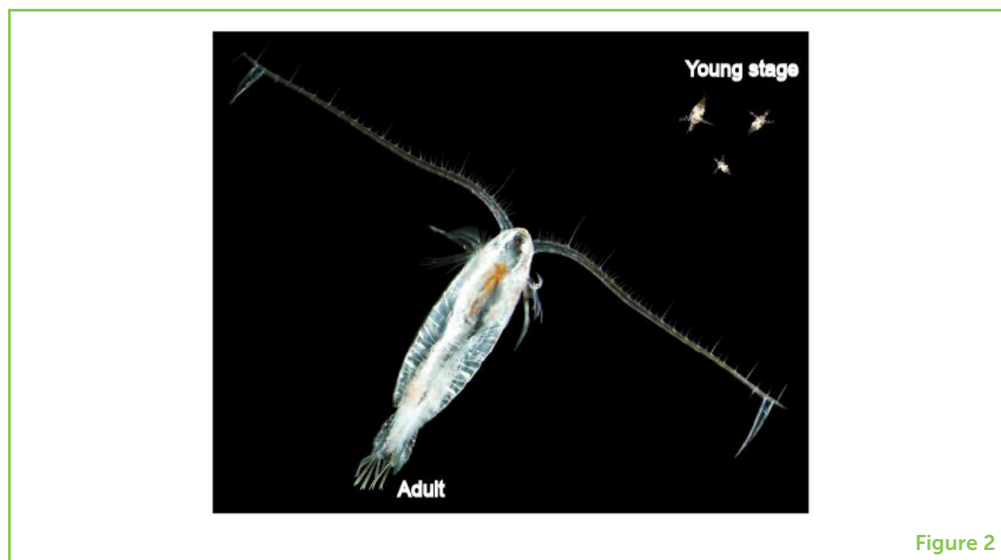


Figure 2

the number of adult cod and their sizes. Big fish can produce more eggs than smaller fish, and a big adult cod can produce millions of eggs! The eggs float in the water and begin to develop into larvae, while being carried around by the ocean currents. The speed at which the eggs develop depends on water temperature and can range from 2 to 5 weeks. Eggs in warmer waters will develop faster than eggs in colder waters. When the eggs hatch, small larvae, about the size of your little-finger nail, emerge. The small larvae are called yolk-sac larvae, since they each have a small food reserve, something like the yolk of a chicken egg. While they have their yolk-sacs, the larvae do not need to search for food, which is good because they are not very good swimmers yet and only drifts with the currents.

Once the food reserves in their yolk sacs are consumed, the small larvae (now called first-feeding larvae) will need to find food that fits into their tiny mouths. But what can a first-feeding larva eat that is smaller than its mouth? Cod larvae mainly eat the young stages of a tiny animal called a copepod (*Calanus finmarchicus*), distantly related to shrimps, lobsters, and crabs (Figure 2). Young copepods are even smaller than cod larvae. The copepod's life cycle is adapted to the **spring bloom**, which is a period in spring when billions of microscopic algae grow (bloom) in the northern seas. These algae are the food for the copepods. When there are many algae, the copepods thrive, grow, and reproduce. Copepods are numerous along the Norwegian coast, but they are not evenly distributed. So, the cod larvae, drifting with the ocean currents, need to be in the same place as their copepod prey at the right time, so that they can find food.

Besides finding enough tiny food to eat, the cod larvae must be in an ocean current that will help them drift back toward the Barents Sea (Figure 3). Otherwise, they might end up in an area that is unsuitable for them to live in. The larvae also need waters with the appropriate

SPRING BLOOM

An increase in the number of microalgae in the sea, similar to the blossoming of flowers on land in spring.

Figure 3

Adult cod migrate hundreds of kilometers from the cold, deep Barents Sea to the warmer coastal waters of the Norwegian Sea, where they release their eggs. The eggs develop into larvae, which must drift through changing ocean conditions back to their nursery area in the Barents Sea. The variations in water temperature are indicated by the color of the drift line.

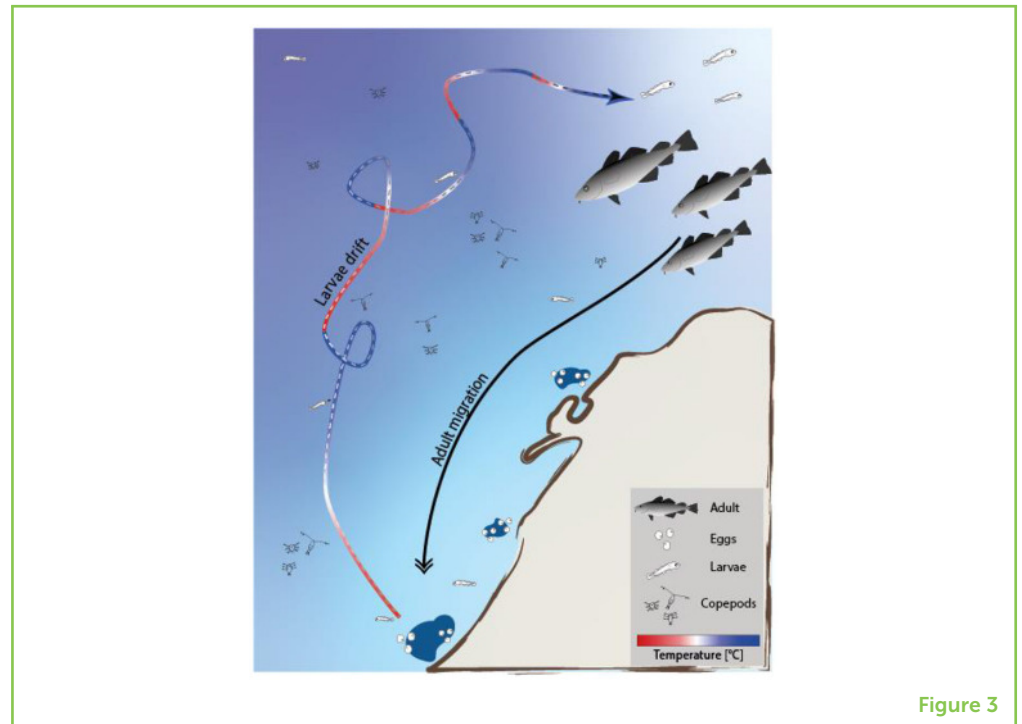


Figure 3

temperatures for their growth. Cod larvae in warmer waters (with enough food) will grow faster and have a better chance of survival than the larvae in cold waters. Not all spawned eggs will become larvae and not all larvae will find enough food to survive or safely drift back to the Barents Sea. Many will die, and some will be eaten by other marine animals, such as jellyfish. Only a very small portion of the larvae will make it back to the Barents Sea. The ones that return successfully will feed and grow until they become adult cod, big enough to swim back to the Norwegian coast and release their own eggs, restarting the cycle.

OUR STUDIES OF COD

Many fishers go to the Barents Sea to fish and some of them are specifically interested in cod. Scientists also go to the Barents Sea onboard research ships and some scientists are also specifically interested in cod. The scientists want to know how many cod there are in the sea, and they want to determine how many cod fishers can catch without damaging the population. These scientists use several different kinds of equipment and techniques to determine how many fish or fish larvae there are and where they are. For example, scientists use nets with a very thin mesh to collect fish eggs, larvae, and other tiny animals in the water. To count these tiny creatures, scientists use a stereomicroscope, which works like the magnifying lenses you might use to observe insects in your garden. Scientists are also interested in the environmental conditions that the fish are living in, so they

measure water temperature and how many animals there are for the fish to eat.

We wanted to learn about the processes that affect the number of cod larvae that grow up to be adults. From the fish larvae data from cruises in the years 1959–1993, we found that some years there were many cod larvae, while other years there were fewer. In some years, the larvae were distributed more to the south and east, while in others they were found more to the north and west. There were years when the larvae were concentrated in one location and years when they were widespread throughout the Barents Sea. We investigated whether the number and size of adult cod and the living conditions of the larvae affect their **abundance** (how many there are) and **distribution** (where they are found) from year to year. We also investigated how the abundance and distribution of the larvae affect the number that survive to become new adults, called **recruits**, in the population.

ABUNDANCE

The number of individuals of a certain species.

DISTRIBUTION

The location of the individuals of a certain species.

RECRUITS

Fish that are big and old enough to belong to the adult population that can be fished.

WHAT DID WE LEARN AND WHY IS THIS IMPORTANT?

We found that the abundance and distribution of cod larvae were associated with the size of the spawning adults. In other words, high abundance and wide distribution of larvae result from the presence of large and healthy adult cod. We also found that the abundance of larvae influences the number of cod that grow to be recruits, meaning the more larvae there were, the more recruits there would be the next season. But, contrary to our expectations, the abundance and distribution of the cod larvae were not so much affected by the living conditions the larvae experienced while they were drifting!

What do these results mean? Importantly, the results tell us that the living conditions of the parents *before* they spawn are important for the survival of their offspring. The size and health of the parents are important because bigger and healthier adult cod produce more, bigger and healthier eggs and, consequently larvae, which can favor them in their journey back to the Barents Sea and to survive. It also indicates that it is important to manage fisheries so that the big fish are not all taken from the population. This tells us that, to help cod larvae survive, we must manage the number and size of adult cod that fishers can catch. We need to maintain a healthy adult population. Since the parents need enough food to build up their energy reserves, it is also important to maintain and manage cod's prey populations. We can help adult cod to get enough to eat by reducing or eliminating human activities that negatively affect the cod and cod's prey, including overfishing, destruction of the sea floor, and pollution of the ocean with toxic chemicals and plastics. If we can maintain a healthy adult cod population, these fish may also be better able to survive climate change. Future research and conservation efforts will help us to protect this interesting and important species.

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REFERENCES

1. Ottersen, G., Bogstad, B., Yaragina, N. A., Stige, L. C., Vikebø, F. B., and Dalpadado, P. 2014. A review of early life history dynamics of Barents Sea cod (*Gadus morhua*). *ICES J. Mar. Sci.* 71:2064–87. doi: 10.1038/278097a0

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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YOUNG REVIEWER

GIGI, AGE: 9

My name is Gigi. I play piano and like art. My favorite thing to do is art and crafts. I have a tuxedo cat named Athena. And my favorite color is yellow!



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Frode B. Vikebø is a senior scientist and program director at the Institute of Marine Research, Norway, with a background in physical and biological oceanography. His research activities mainly address development and use of numerical models and observations for investigating natural and human-induced impacts on eggs and larvae of fish and the interaction with their prey and predators.



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Natalia A. Yaragina has worked as lead scientist at the Polar Branch of the Russian Federal Research Institute of Fisheries and Oceanography for about 40 years. She investigates marine fish population structure, reproduction, growth, condition, maturation, feeding, and environmental effects on fish. Data collected and analyzed by the Institute are used for Northeast cod stock assessment and for producing recommendations for fisherman.



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Solfrid Sætre Hjøllo is a senior research scientist at the Institute of Marine Research, Norway, and her research is focused on changes in the food web in cold environments of the Norwegian and Barents Seas. Her specialty is in ecosystem modeling, using computer simulations to study food web changes due to environmental pressures as fishing and the climate change. Her favorite animal is the copepod *Calanus finmarchicus*; the world's strongest animal.



LEIF CHRISTIAN STIGE

Leif Christian Stige has worked as researcher at the University of Oslo in Norway for more than 10 years. He investigates how changes in climate and human activities such as fishing influence marine species. To do so, he analyses data collected over many years, to search for associations between changes in the fish populations and factors such as climate conditions, other species, and fishing. He is also interested in how oil spills may affect the species in the ocean. Most of his research has been on the Barents Sea ecosystem.

Photo: Magne Velle/MET/The Nansen Legacy.