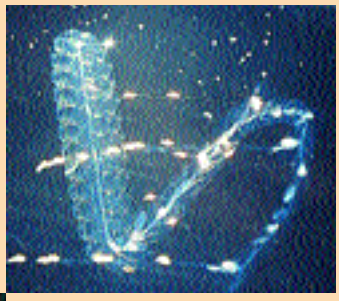
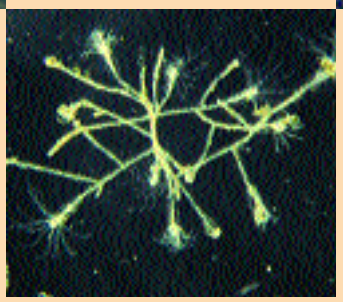
Ocean Detectives

Solving the Mysteries of the Sea

Mary Cerullo





For Jeff Rotman, my partner
in underwater endeavors

Steck-Vaughn Company

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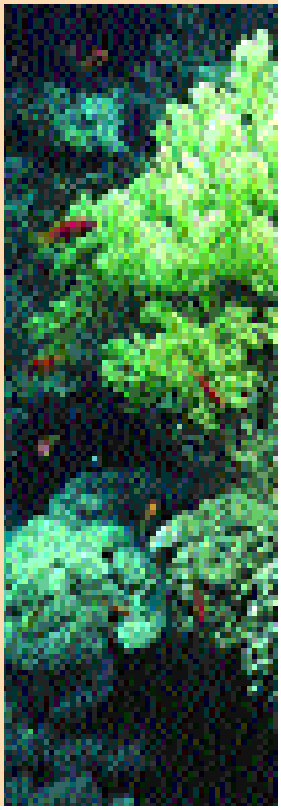

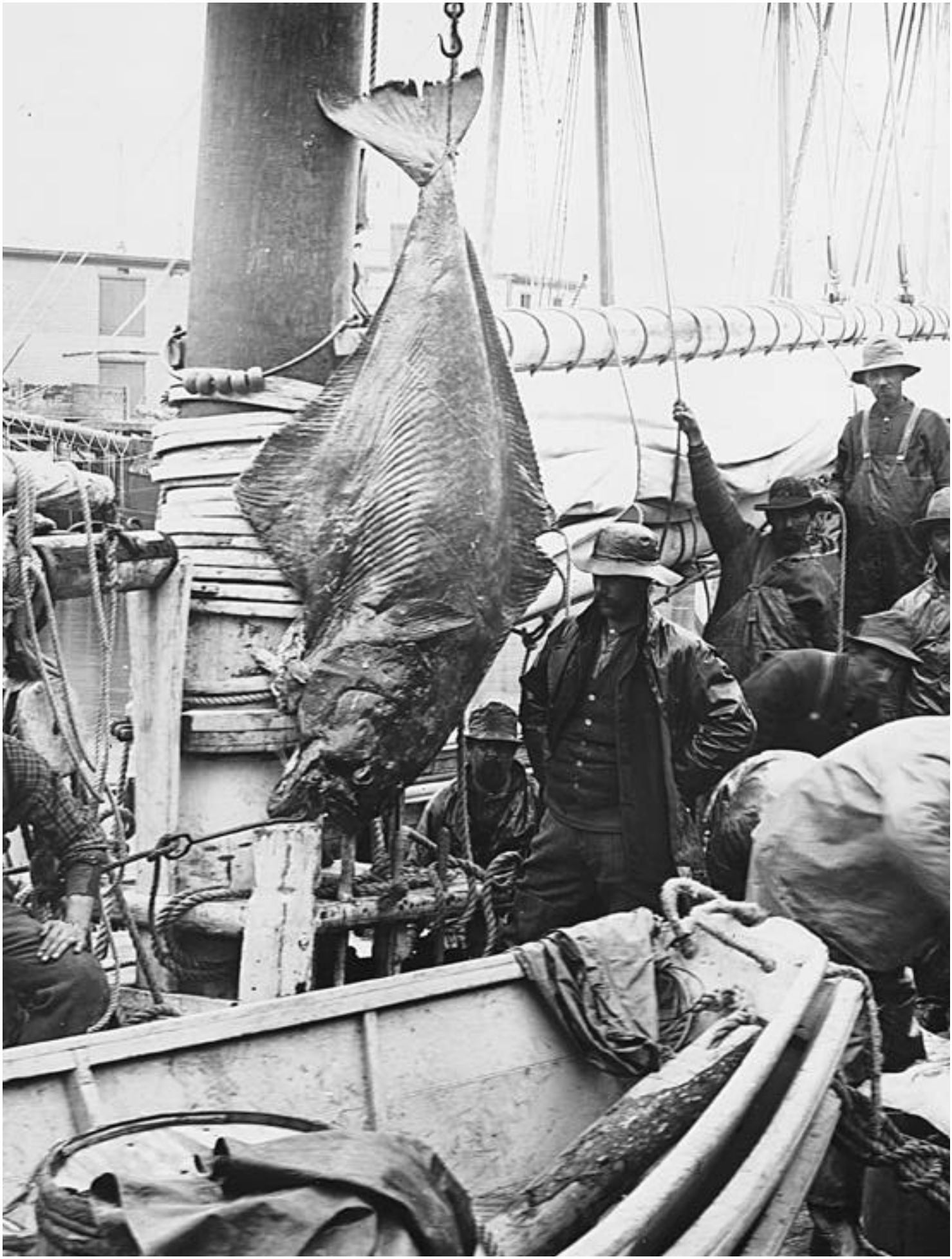

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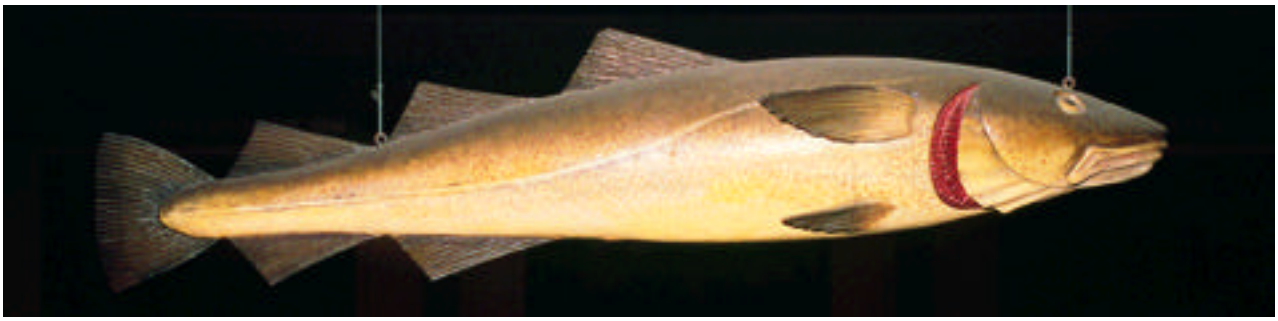
MYSTERY OF THE VANISHING FISHES

Georges Bank, Northwest Atlantic

Georges Bank was once one of the richest fishing areas in the world. But now overfishing has caused the huge schools of fishes to vanish. Scientists studying the fishes have found that usually 99 percent of baby fishes don't make it to their first birthday. What things kill the baby fishes of Georges Bank?

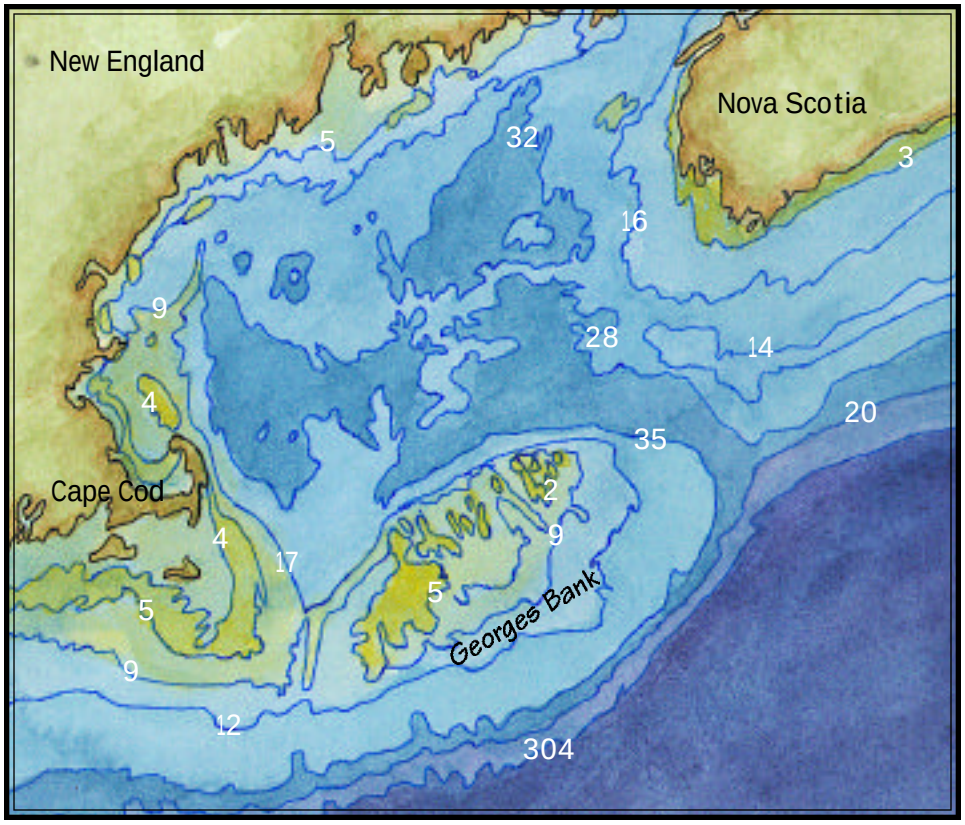


In 1497, English explorer John Cabot was mapping the North Atlantic coast of the New World and came upon Georges Bank, a shallow undersea shelf of land extending almost 321 kilometers (about 200 miles) into the Atlantic Ocean. There, he was amazed to see that "the sea is covered with fishes." In the 1500s and 1600s, many other Europeans came to harvest cod. In the 1620s, the Plymouth Pilgrims set up a profitable fishing industry on the coast of Massachusetts that quickly attracted other settlers seeking "to serve their God and to fish." Over the next century, many colonists came to pursue religious freedom and the sea's riches.

For hundreds of years, fishers worked their nets, scooping up huge quantities of the fishes of Georges Bank—cod, haddock, and yellowtail flounder—with

(above)
A wooden carving of the Sacred Cod hangs in the State House of Massachusetts as a tribute to the colonists' fishing success. Those who made their fortunes from fishing became known as the "Codfish Aristocracy."

(left)
In addition to halibut like this huge catch, 100 other species of fishes, as well as 32 species of whales, dolphins, and marine birds, were once abundant on Georges Bank.



Georges Bank is part of the North American continental shelf, a shallow rim of submerged land that runs around the edge of the continent. The chart above shows the depth of the seafloor in the Gulf of Maine. The darkest blue represents the ocean seafloor. The other shades are part of the continental shelf, and the numbers show the average depth in meters. Parts of Georges Bank are so high that sunlight can reach all the way to the bank's floor. Most food production in the ocean depends on sunlight. Phytoplankton, small ocean plants that rely on sunlight to live and grow, are abundant here. They are important food for copepods, which in turn are important food for young fishes.

each pass. But the heavy nets scoured the ocean floor where fishes spawn, or lay eggs, and so destroyed many of the eggs of the next generation of fishes. Some of the fishes the nets caught were too small to keep. Even though they were thrown back, the young fishes were usually already dead, killed by the crushing weight of the other fishes in the net. Yet the sea continued to yield rich harvests of cod for hundreds of years.

By the 1970s, sophisticated new sonars—"fish finders"—showed exactly where the fishes were. Using the new techniques along with larger boats, record numbers of fishes were caught. But soon the size of the catches fell to record low levels as people took all the fishes they could find.

Despite regulations, the cod, flounder, and haddock of Georges Bank all but disappeared. In December 1994

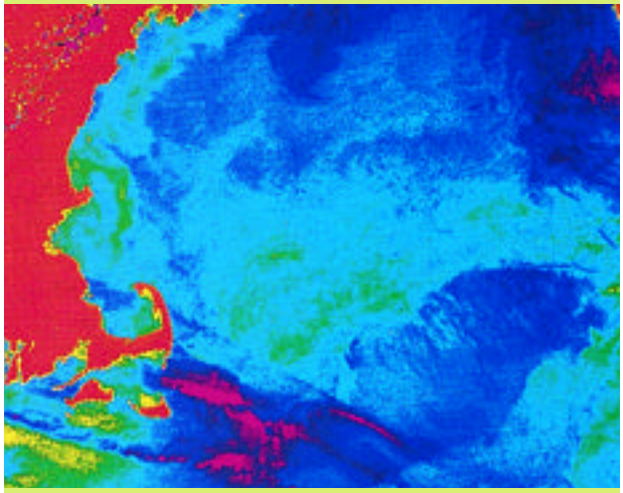
the National Marine Fisheries Service closed about a third of Georges Bank to fishing.

This could be the end of the story of overfishing on Georges Bank. But it is just the beginning of a mystery that a team of seventy investigators is working to solve. Overfishing is the main reason for the disappearance of adult fishes on the bank, but most of the cod and haddock on Georges Bank die long before they grow large enough to be caught in a fishing net. In most years, more than 99 percent of all fishes die before they are six months old. Scientists want to know under what conditions baby fishes of Georges Bank survive or die. If they die, scientists want to know why. By determining the natural forces that kill baby fishes, scientists can make a model to determine how changes in the environment will affect fish survival. Then, they can adjust human fishing activity accordingly.

On the other hand, every year a number of young cod and haddock manage to live long enough to reach adulthood. If scientists could find out what helps these fishes survive, it could be the key to making the fishes abundant on the bank again.

Peter Wiebe, an ocean scientist at Woods Hole Oceanographic Institution (or WHOI, pronounced "HOO-ee") in Woods Hole, Massachusetts, is the project leader for the Georges Bank GLOBEC (Global Ocean Ecosystems Dynamics) program. GLOBEC was formed to study how climate change might affect life in the world's oceans. On Georges Bank changing temperatures in the water may be part of the reason baby fishes don't survive.

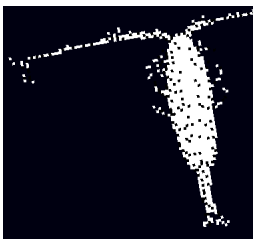
The GLOBEC Mystery: How Is Global Warming Affecting Life in the Sea?



The goal of GLOBEC is to predict the future of ocean animals in the face of global climate change. The Georges Bank project is the first of several GLOBEC ocean studies that will take place around the world. These projects will examine how changes in the world's climate may affect life in the ocean.

As air warms, so does water. Scientists are noticing changes in the ocean food chains in places as far apart as Antarctica and coral reefs off Florida. The changes may be due to global warming.

Satellites can provide information for scientists on what's happening globally. Images like the one above of Georges Bank show the patterns of heat released from the earth and the ocean. Images taken over time can help scientists track changes in the climate. In this image the warmest water appears red. Cooler waters appear in this order from cool to cold: yellow, green, blue.

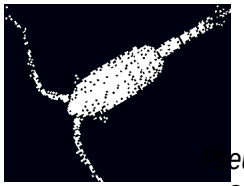


This *Calanus* is a shrimplike copepod. It grows to only 2.5 mm (about 1/8 inch) long.

H actual length

Copepods are tiny cousins of lobsters and crabs. They are the most abundant animals in the ocean, possibly the most abundant on Earth, with an estimated population of one quintillion (the number 1,000 followed by 15 zeroes). If people shared all the copepods in the world equally, everyone could have one billion copepods.

What would we do with them all? We could feed most of the ocean's animals. Copepods are such an important food for baby fishes, crabs, and the other animals we eat that their number affects the amount of food humans can take from the sea. If there aren't enough copepods, there won't be enough seafood for us to eat.



Pseudocalanus, a copepod, is just 1 mm (about 1/32 inch) long.

H actual length

To find out, a multiyear project is under way to study the climate, water movement, and zooplankton, small swimming animals that are important food for young fishes on Georges Bank. Peter explains, "Fundamentally what we're trying to do is figure out how nature works by taking apart an ecosystem bolt by bolt."

Scientists involved in the Georges Bank GLOBEC project suspect that global warming, the heating of the earth's atmosphere, may affect the survival of young fish. To find out, they are gathering evidence on the things that influence the fishes' survival, such as predators, or animals that eat them. Prey, or animals they eat, and competitors for food and space are also factors. Scientists are also studying Georges Bank's plants, water, currents, atmosphere, and ocean floor. All this information will be entered into a computer to make a model of Georges Bank. The model will show how everything works together. It will also help predict how changes such as less fishing or global warming might affect how many fishes survive. This information will help others make decisions about how to protect the larval, or baby, fishes on Georges Bank.

To make the model, the GLOBEC scientists chose four indicator species to study: baby cod, baby haddock, and two types of copepods, shrimplike creatures that are food for the growing cod and haddock. All of these animals are zooplankton, and each of them starts out smaller than the *o* in *cod.*

Zooplankton are very important, explains oceanographer Cabell Davis, "because they're near the bottom of the food chain, feeding all other animals directly or indirectly. Most animal species in the ocean are zooplankton for at least part of their lives."

GLOBEC scientists are trying to find out all they can about these zooplankton. What they find out will help them understand the food chain of the whole ecosystem.

Every month between January and July, research ships, like the one from Woods Hole, Massachusetts, set out to investigate Georges Bank. From WHOI, Peter Wiebe, GLOBEC scientists, and crew members collect tiny, floating plants called phytoplankton along with zooplankton and water samples from forty places around Georges Bank. They also record the speed and direction of water currents, water temperature, and other information to help build a picture of Georges Bank through the seasons.

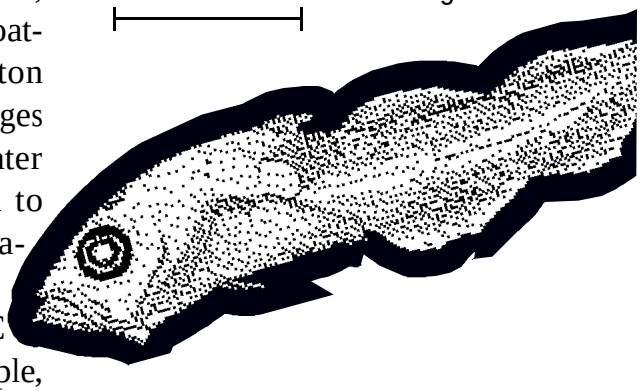
In addition to collecting general data, GLOBEC scientists also investigate specific mysteries. For example, zooplankton specialist Scott Gallager wants to find out where baby fishes live at different seasons of the year. He thinks that may have something to do with their survival. Scott also wants to find out at what depth they live and how well they survive there. "For example, we know that cod and haddock spawn between January and March on the northern tip of Georges Bank, so we have a cruise to study eggs and early larvae then." Despite the worst weather of the year in an area famous for shipwrecks, Scott and the crew work around the clock collecting samples of baby cod and haddock.

From samples taken so far, they have learned that baby fishes are very sensitive to the amount of light in the water. Without enough light, the fishes can't see their prey. If there's too much light, they're blinded, like when you look at the sun. Either way, they starve. Baby fishes need just the right amount of sunlight to survive.

While Scott Gallager chases baby cod and haddock around Georges Bank, Cabell Davis pursues copepods, the first food of newborn cod and haddock. Cabell is interested in finding out what affects the survival of copepods. He explains his work as taking "a series of snapshots" of where the copepods live and how many there are in each place. That will help the scientists make

Baby cod measure about 2.5 cm (almost 1 inch) long.

actual length

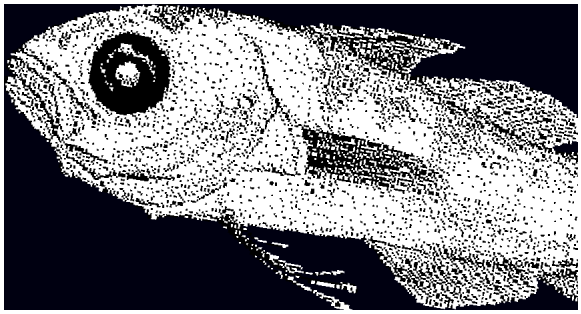


Under Study

GLOBEC scientists are studying different species—baby cod and baby haddock, along with two of the copepods they eat, Calanus and Pseudocalanus.

A baby haddock at 2.5 cm (almost 1 inch) long is at the bottom of the food chain, at least until it grows bigger.

actual length



The Video Plankton Recorder, shown here with scientist Cabell Davis, is usually towed behind a ship. But it can also be mounted on a remote-controlled submersible. Like a regular microscope, the Video Plankton Recorder has both high and low settings, for seeing close up and *very* close up. The low setting takes pictures of an area about four to six centimeters square (about two inches square).

a computer model of copepod and fish populations on Georges Bank. "We're focusing on a few species and looking at what affects them," says Cabell.

To uncover the secrets of Georges Bank, Cabell, Scott, and WHOI engineers designed and built an underwater microscope, which they named the Video Plankton Recorder. It was designed to videotape all kinds of plankton, or tiny drifting plants and animals.

While the recorder's cameras take pictures, other instruments the recorder carries note the time, water depth, temperature, and salinity, or saltiness, of the water, and the location. So not only can Scott and Cabell see their subjects in action, they can also analyze the physical characteristics of the places where the animals are found.

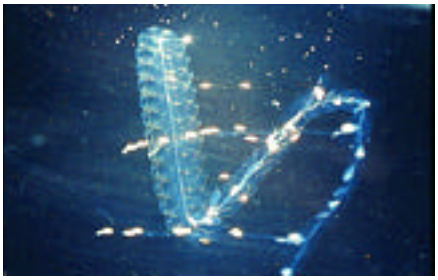
At least, that's how it's supposed to work. When the ship is tossing in twenty-foot waves, it's easy for equipment to break or fall to the bottom of the ocean. When experiments go wrong or instruments fail, scientists have to be prepared to change their plans. Cabell takes it all in stride. Turning obstacles into opportunities is all part of ocean science. "It's detective work at its best. It requires you to investigate things you wouldn't even think of until you get out there."

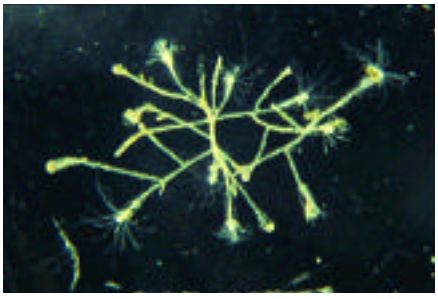
When the system works, the Video Plankton Recorder takes sixty pictures a second. That means that at the end of a cruise, there are thousands of images to review. To help with the job, scientists created a computer program that analyzes the images, catalogs the animals by species, and selects the best pictures for scientists to examine.

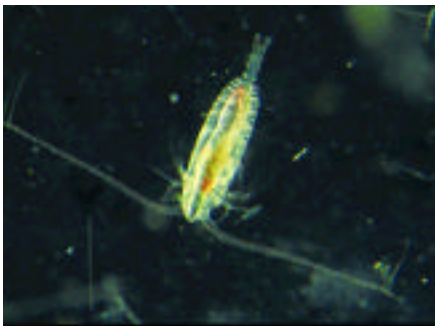
Another way that scientists find out about ocean life is by using echo sounders. An echo sounder works by sending sound waves out into the water. The waves bounce back as echoes from objects, such as plankton, through the water. This can help scientists find out where different animals live around the bank. All the information collected is entered into the computer to add to the computer model.

The GLOBEC cruises have provided many new clues about where the indicator species live on Georges Bank, what times they are most plentiful, and where they go in different seasons. The scientists have learned, for example, that young copepods swim into deeper, colder waters before June when the surface waters become too warm for them. There they lie until they wake up in early winter and molt, or shed their shells, and turn into adults.

Knowing where copepods live at different times of the year may help scientists predict where and when this important food supply can be found by the other creatures also living on the bank. However, Scott has discov-

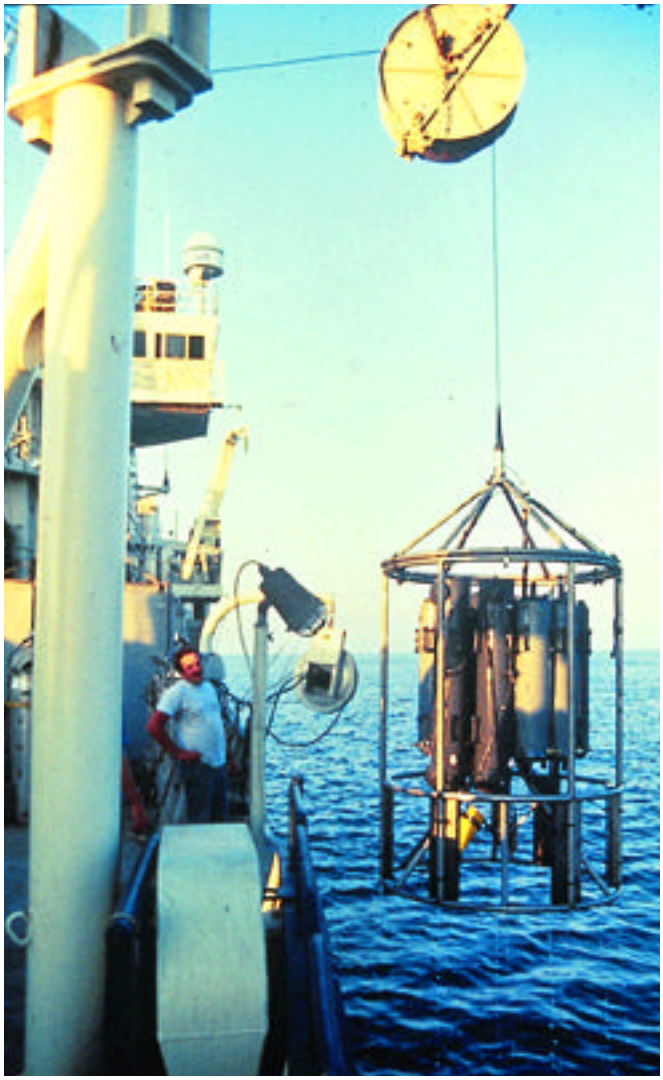






The Video Plankton Recorder's high setting covers an area about 2.5 centimeters (about 1 inch) square. One copepod or baby fish just about fills the screen.

The Video Plankton Recorder is used to study phytoplankton and zooplankton like these (top and middle) jellyfish colonies *Nanomia* and *Clytia*, and also *Calanus*, a copepod (bottom).



Seawater's temperature and saltiness vary from place to place and at different times of the year. The device shown above is called a CTD. This is short for Conductivity, Temperature, and Depth. It measures the conductivity (saltiness) and temperature of seawater at different depths.

ered that even if baby cod and haddock end up in the same place as the copepods, the larval fishes may not necessarily be able to find them.

He learned that many things affect a baby fish's ability to see and find its prey. Cloudy water, weather conditions, waves, and even the angle of the sun, which changes with the seasons, can prevent hungry young fishes from finding copepods. Global warming may also play a part. Warmer temperatures may drive young fishes or their food to a cooler place, separating the baby fishes from their prey.

Too many predators can also spell disaster for larval fishes. Scientists have found many more predators feeding on baby fishes than they had expected.

The GLOBEC investigators may never be able to completely solve the mystery of why so many cod and haddock die before their first birthdays. But they hope to use the information that they are collecting to understand the best conditions for the fishes to survive. Understanding all the things that affect young fishes—from predators and prey to weather conditions and water temperature—may help scientists discover ways to help more baby fishes grow to adulthood.

The scientists' work gives information that forms the beginnings of a computer model for Georges Bank. Part of that model is a food web that shows how creatures in an ecosystem are connected by what they eat. The web is made of several food chains, or lines that show how energy moves as animals eat plants or other animals.

This net is one of the tools GLOBEC scientists use. It opens and closes underwater to collect samples of plants and animals at different depths.

The model will allow scientists to monitor how things in Georges Bank change over time and help predict the bank's future. Cabell declares, "You can't really understand how global warming is going to affect fisheries and other marine populations until you understand how the whole system works."

Who's Eating Whom? Georges Bank Food Web

This food web of Georges Bank shows the food relationships involving young cod and haddock. In this web, phytoplankton are at the bottom. They are eaten by microzooplankton, which are extremely small zooplankton. Copepods eat both phytoplankton and microzooplankton. Everything then branches out from the copepods. The copepods are eaten by tiny invertebrate predators and baby cod and haddock. They are prey, or food, for even some of the largest animals in the ocean, right whales and humpback whales. The baby cod and haddock are eaten by larger fish, which are then eaten by even larger animals such as dolphins and seals. Using computers, scientists ask a question such as, "What if all the baby cod disappeared?" and determine how the model would change.

Copepods

Copepods are key animals in the ocean food web. They are the main food for many larger animals, such as invertebrate predators, right and humpback whales, and baby fishes. If they disappeared, the food web might collapse.

Phytoplankton

Called "the grass of the sea," these microscopic plants are food for both copepods and other zooplankton.

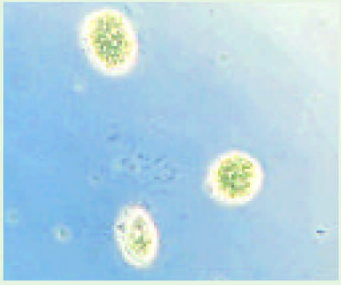
eaten by

eaten by

eaten by

Microzooplankton

These are microscopic animals that feed on phytoplankton and are, in turn, eaten by copepods.



Right Whales and Humpback Whales

Whales are only at Georges Bank during the summer, so they are part of the food web for only a few months of each year.

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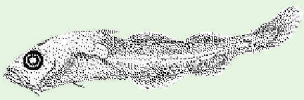
Larval Cod and Haddock

Scientists are looking for ways to bring these fishes back to Georges Bank.



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Herring and Mackerel

Herring and mackerel eat the smaller baby cod and haddock, and they eat more of them than investigators had expected.

eaten by

Dolphins and Seals

Dolphins and seals come to Georges Bank for herring and mackerel. If those fishes disappeared, the dolphins and seals would probably hunt for food somewhere else.

eaten by

Invertebrate Predators

These tiny creatures feed on the even tinier copepods.