(Music)

(Narrator)
Join Quest for a never-before seen view under the waves of the Gulf of Maine.

(*Music and narration for open as in all shows)*

(Linda Greenlaw)
From my perspective, when you look out at the Gulf of Maine, I assume it doesn't look any different than it did when the first people came to fish these waters, but scientists tell us that if you're a fish, you've seen a lot of changes.

Hi, I'm Linda Greenlaw. This quest is about the Gulf of Maine, something I happen to know a little bit about. I've been a commercial fisherman for 23 years now and I have spent more time then I care to admit on the Gulf of Maine.

(Ransom Myers)
Many people think of the open oceans as this vast virgin territory that has been virtually untouched by humans. Well, that is totally false. What we've done is put together data worldwide from Antarctic islands to tropical reefs to the open ocean to the Continental Shelf around Newfoundland. And you've got the same story everywhere. Worldwide, there are 10 percent of the fish left.

(Narrator)
What does it mean to have only 10 percent of fish left? Can anything be done? As they scramble to understand the crisis in this largely unknown world, ocean scientists find themselves on a new scientific frontier in the Gulf of Maine; they're trying to understand the relationships between organisms -- before they disappear. Whether examining the smallest microscopic plant or the largest whale, marine biologists are now integrating their knowledge with chemists, geologists, archeologists, historians and fishermen. Together, they hope to better understand the delicately balanced ecosystem that is the Gulf of Maine.

(Music)

(Robert Steneck (VO)
An ecosystem includes all of the plants and animals that live together, interact together and are connected through the energy and food that they share or rely upon…

(Robert Steneck)
As you find appropriate substrates, start suction sampling.

(Nat. sound diving)

(Narrator)
Bob Steneck is an oceanographer in the University of Maine's School of Marine Sciences. Based at the Darling Marine Center, he dives all over the world, studying ecosystem interactions. In the waters off York Harbor, Maine, Dr. Steneck's looking for signs of the shifting balance between several organisms in the food web.

(Robert Steneck)
If you start thinking about the Gulf of Maine as an ecosystem, you start realizing that hey, these species and these organisms are actually interacting with one another. We're talking about a theater that has a cast of characters and you start to get to know how the cast interacts. If you have a predator and you were to remove

the predator, its prey may become more abundant, or if you remove all the prey the predator could starve. Those kind of interactions are related to how energy flows within an ecosystem. We call those food webs.

(Narrator)
Dr. Steneck is finding some surprising results in his work on one food web. He started by looking at sea urchins, sometimes called the cows of the ocean because they graze on kelp and sea grasses.

(Robert Steneck)
Most of Maine from the New Hampshire border up through Casco Bay have had almost all the sea urchins removed. And in their place sprung up these forests of kelp, and where kelp hasn't been present for decades. This is a remarkable change but again it shows you that we are fishing down the food webs and you're taking out one consumer and the prey springs up and in this case the prey happens to be kelp.

So we asked the question, why don't we just bring the sea urchins in, let them graze this down and then that will let more sea urchins come in and we'll actually have restored the system to the way it was just a decade ago. When we brought in over 30-thousand sea urchins, we brought them early in April, they stayed for a couple of months and then in August a wave of large, big Jonah crabs moved through. These were crabs with an attitude, they were big, they were hungry, they moved in huge numbers and they ate all of the sea urchins. Over thirty-thousand of them were gone in just a couple of weeks. So…we're talking about a cast of characters that have changed entirely.

(Peter Auster)
Amazingly we're still finding out very fundamental things about how animals live in underwater landscapes. Some of the types of things we've been looking at are bits of information that terrestrial biologists have known about animals that live on land for over a century, but we're just being able to make those observations in the ocean because of the technologies that are available to be able to work there...

(Narrator)
Rather than simply dissecting a fish in a lab to understand its nature, ecosystem scientists need to examine organisms in their natural habitat, interacting with other species and their environment. University of Connecticut scientist Peter Auster specializes in how underwater landscapes affect deep water fish – often going thousands of feet under the sea to study them.

(Peter Auster)
My terrestrial counterparts can walk out into the field with a notebook and a pair of binoculars and go to work. In order for me to do that I need to drape myself in some sort of technology like a research submersible, or use a remotely operated vehicle like the one behind me to be able to look at those animals in the environment in which they live.

(Narrator)
Many people don't realize the Gulf of Maine is more than the Maine coast. It actually stretches from Cape Cod in Massachusetts to Nova Scotia in Canada -- and all the way out to the Atlantic Shelf, known as George's Bank.

The way the Gulf was formed has a lot to do with understanding how it functions as an ecosystem today.

(Music)

(Bruce Bourque)
The Gulf of Maine is an evolving body of water. When the Ice Age ended, the Gulf of Maine looked virtually

nothing like is does today. The banks that are now submerged in the hugely important fisheries were out of water. The sea entered and left through what's called the Northwest Channel. It was really an enclosed sea, a semi-enclosed sea, but as the land sank and the sea level rose, more and more tidal water began to enter the Gulf, tides increased, and it's biological productivity increased sharply to the point where it was probably one of the more productive bodies of water in the world.

(Narrator)
Geologists and historians who study the results of our glacial history combine their knowledge with that of oceanographers. Along with technological advances that aid geographers to create better maps are advances in submersible technology that let scientists better explore the ocean floor.

However, with only about 13% of the gulf mapped these scientists are dealing with more unknowns than Lewis and Clark when they set out on their expedition.

(Les Watling)
In the Gulf of Maine we're using R.O.V.'s which are remotely operated vehicles and they're connected to the ship by a tether that supplies power to the vehicle when it's in the water and brings the TV picture back to the ship. So you sit in a room and you watch television and you sit next to a pilot who actually drives the machine and you use the TV cameras on the R.O.V.'s as your eyes.

(Peter Auster)
One of the benefits of using R.O.V.'s is that all the scientists and students can participate in every dive. Using the remote video technology we can all view the underwater scene at the same time and ask questions about we are doing and modify what we are doing on the dive in order to collect the greatest amount of data in any particular area.

(Narrator)
Sometimes the underwater view can be disappointing for scientists in search of marine life. This area has been trawled, meaning a large ship has dragged or trawled a fishing net over the ocean floor, probably many times judging from the many track marks.

Will plants and animals return here? And even if we had the power to return the Gulf to a more pristine state, how would we know what to return it to?

(Robert Steneck)
We're starting to ask the question well, what is natural? And as we started thinking about it and started researching it, we had to start asking a question what was natural? What was the Gulf of Maine like before there were any humans here at all…and that takes some sleuthing. And that sleuthing includes going into Indian middens, garbage heaps where we find they are loaded with the bones of fish species that are actually rare today, but they obviously weren't rare in the past

(Bruce Bourque)
This is called the Glidden Point Midden. A man named Glidden owned the property and it's over 20 feet high. It's as if people lived on the high back, maybe to stay up in the breeze and away from the insects and processed oysters and tossed the shells over the bank...but some of these oysters were over a foot long. Yeah, it was unbelievable.

But this is not a typical shell midden, this is an industrial site. This is a place where we're pretty sure people came and just hauled oysters off the reefs out here which are now dead and brought them ashore, opened them up and smoked the meat for later consumption.

(Narrator)
One of the latest developments in archeology is the use of human bone chemistry, instead of the earlier technique of radio-carbon dating. Like a forensic detective, Dr. Bourque can actually use bones to find signatures for the amount of protein in a person or animal's diet that came from marine sources. He can tell if people were eating fish and what the fish they were eating were eating!

(Bruce Bourque)
One of the ways we can reconstruct what people ate for protein food is to send their bone samples to a lab. They come back with ratios of nitrogen isotopes and carbon isotopes.

(Narrator)
Each ellipse on such a graph represents a population and how much fish they were eating. Here he compares one Maine group's bone samples from thousands of years ago with a kindred population from the same period in New Foundland. Both rate very highly on the scale of marine-orientated, protein diets.

(Narrator)
As scientists uncover these clues, they start to piece together the history of human influence in the Gulf of Maine.

(Bruce Bourque)
We really only begin to pick up a coherent story around 5,000 years ago, and that's the point at which we see people already hunting swordfish. We think they were captured by people in dugout canoes. Cod was one of their staple foods, and as well swordfish, which we think is pretty amazing now, but we know that they were catching huge numbers of very large swordfish, we're talking 15-hundred pounders, big females, the ones that lull on the surface. This is an incredibly exciting and dynamic culture and it builds to a crescendo and then thirty-eight hundred years ago it just ended, as if overnight.

This group of immigrants shows up, come in from the southern Appalachians and they did everything different; They pay no attention to cod, no attention to swordfish. They come, they go. There's an empty period where we don't have a story to tell, and then the record picks up around 2800 years ago with a pottery making people and that tradition is pretty coherent right up to the arrival of the Europeans.

(Narrator)
Evidence suggests that the American Indians were fairly nomadic, so even though they might fish out a marine species in one spot, when they moved on, the stock could replenish itself.

Chief Hugh Akagi uniquely combines scientific and native outlooks, being both the Chief of the Canadian Passamaquoddy and a fisheries research technician.

(Hugh Akagi)
If you were harvesting as much as you could in one area, it was because this was your winter food supply and if you didn't get it there, then you might not make it through the winter. However, natives probably never did have the resources to really deplete the stock…

(Narrator)
This latest scientific archeology proves that even 5000 years ago, humans were having an impact on the ecosystem, calling into question the "natural" state of the oceans that many assumed existed before Europeans arrived.

On the other hand, there's a huge difference between the native impact and that of European settlers because the Europeans weren't just fishing for themselves. They began taking away fish to supply the world.-

(Andrew Rosenberg)
One thing that is sometimes confusing is we're trying to understand what occurred through the period in the marine environment. That's a little different than saying we're trying to restore the ocean back to the way it was in 1640. That's not the point. The point is can we understand as much as we can what happened to the population under different levels of use by humans and then from that understand where we are now and where we might like to be and from that make an informed policy decision.

(Narrator)
To understand any ecosystem then is a monumental task. This infinitely complex web of life not only changed throughout time, but is continually changing and re-balancing itself in the present.

Even if it's difficult to know what is an ideal, natural state for the Gulf of Maine, scientists focus on understanding certain elements that healthy ocean ecosystems have in common.

On the simplest level, to create an ocean ecosystem, we would start with water…a unique blend of minerals… and sun….Sunlight is the energy that drives most ecosystems.

Uncountable numbers of minute plants, commonly called algae, use photosynthesis to process the sunlight into energy. This algae, also known as phytoplankton, live in the surface waters and form the base of the food web

The smallest animals, called zooplankton are even more numerous. They can be visible to the eye or so small, you need a microscope to see them, coming in an amazing diversity of sizes and shapes.

(Music)

When scientists refer to plankton, they mean both these phytoplankton, the plants, and zooplankton, the animals.

(Cynthia Pilskaln)
If you're an algae, basically your life is photosynthesizing in the surface waters, growing primarily from spring to summer and in the fall and once you have grown and reproduced many, many times, you will then die and you will sink through the ocean….Before you die though, and probably after you die as well, you will be consumed by zooplankton. The most abundant creatures in the world are filter-feeding zooplankton, they just filter lots and lots of water um, through these wonderful little appendages that bring particles and water into their mouth parts and they process a lot, a lot of water and a lot of particles per hour, per day. So you would be consumed by, by these zooplanktors and then you might end up in a fecal pellet because the zooplankton produce fecal material

(Narrator)
The Gulf of Maine is one of the most fertile and productive bodies of water in the world. Because of its history as a semi-enclosed sea, the Gulf's bottom is not as deep as the central Atlantic ocean and huge numbers of plankton grow, die and settle in its relatively shallow waters.

Even these smallest of species, and those even smaller such as marine bacteria, can have profound effects on an entire ecosystem.

(Narrator)

A concern with climate change is that excess human-produced carbon dioxide or CO2 is warming our planet. Scientists like Dr. Pilskaln are looking at the role of phytoplankton that remove carbon dioxide from the atmosphere through their normal process of photosynthesis.

(Cynthia Pilskaln)
The overall objective of this type of work is to provide information about carbon cycling on the planet and in the oceans and put this into models. Because ultimately we want to understand what the ocean's role is in taking up atmospheric CO2 .

When you're interested in looking at how much material is sinking through the ocean we use equipment called sediment traps.
We take those samples back and we analyze them in the lab and what we're looking at is how much organic carbon, organic nitrogen is making it to the sediments, to the deeper regions of the Gulf of Maine as a function of production in the surface waters.

The sediment trap work provides us with the ability to do chemistry on the sinking material, but we don't have a handle really on what the particles look like. So to do that we go down, using an ROV, we analyze lots of video, images of particles in the ocean, which then tells us a lot about how material moves through the ocean, how it sinks.

(Narrator)
These small plants could be key in our attempts to slow global warming. If what ends up on the bottom of the ocean floor tells scientists about what's going on in the atmosphere, then a model for an ocean ecosystem clearly includes the air and land around it. What flows into the Gulf of Maine from rivers, and what habitat is altered on its shores, directly affects life under the waves.

Coastal development can remove natural buffers, increasing run-off.
Silt and chemical pollution can actually cause more phytoplankton to form, while poisoning other plants or animals.

In order to understand the effects of humans on Gulf habitat, scientists ask what should the sea floor of a healthy ecosystem include?

Les Watling from the University of Maine's Darling Marine Center has taken sediment samples from all over the Gulf of Maine. He's interested in the sea floor as the habitat of invertebrates, animals without skeletons that comprise over 75% of all ocean animals.

(Captain)
Outboard.

(Les Watling)
Outboard

(Captain)
Lowering

(Les Watling)
The Gulf of Maine has this strange geological history and we do have rocky ledges and gravel areas and things like that, that were left by the glaciers.

But there is a lot of muddy bottom, and a lot of people when they look at muddy bottom think that there's nothing there. I recoil always at the term biological desert which has been used, but in fact if you look at muddy bottoms more closely, then you start seeing interesting things. Almost all the action in mud is inside the mud, not on top of it.

Most of the animals are worms or small bi-valves, small clams that feed on mud; everybody feeds on mud if they're in muddy basins. The mud is both the place where the animal lives, but it's also a source of food, so you sort of eat your house around you.

This worm I have, it's called an Ampharetid, it stores in the roof of its mouth, what looks like a 20-fingered glove. (Laugh) and when it feeds, it pushes this 20-fingered glove out of the roof of it's mouth -- I kind of view it like this -- and wiggles it around and it's literally like a big glove gathering particles and it's turned all these sediment particles into a log, And it takes this log and puts it up on the back of the tube and that's how it adds to it's house.

(Narrator)
In his research, Dr. Watling sees first hand the human impact on invertebrate habitat.

(Les Watling)
Mobil fishing gear, and its use in the Gulf of Maine I think has had pretty dramatic consequences for the lives of small animals. As this fishing gear passes over the surface of the sea floor, it sometimes kicks everything up so an animal that's less than an inch long will have it's entire house destroyed.

…So suddenly from facing up into the water it's now facing down into the mud, and it can't feed, it might not be able to breath, things like that can happen and so the organism will die, and those kind of habitat changes are pretty severe and they're long term.

(Narrator)
In recent years, fishermen have tried to develop what they call "habitat friendly" fishing gear that includes rock hopper trawling nets. There remains a great deal of controversy about how gentle even advanced trawling gear is on the delicate balance of an ocean floor.

Even in rocky areas, trawling can disturb numerous organisms that attach themselves to the rocks. Some are plants like kelp and various other sea weeds. Others are actually animals -- like barnacles, sea anemones, and coral. Many people are surprised to learn that there are corals in the Gulf of Maine.

(Les Watling)
Corals are animals, corals are colonial animals. They consist, just like corals that you see in the tropics, they're built exactly the same way with a skeleton on which these little polyps sit. The little polyps feed on particulate matter that's coming by in the water so whatever is drifting past is what they get for food.

They in some ways have been called the red woods of the sea, but deep-water corals actually have been known since well into the sixteen-hundreds or fifteen-hundreds.

What we didn't know, however, was that there were corals, these deep-water corals were common in the Gulf of Maine, The large primnolas that we have is the large bright orange coral. Those corals are on average probably a hundred and twenty-five years old, and that's actually a fairly young age for large deep water corals. We know of large trees that are over a thousand years old, and it seems a shame actually to bring to the surface organisms that have sat in the dark, feeding and growing for a thousand years.

In shore, in the Gulf of Maine it's likely that gill nets removed a lot of the corals before anyone was paying any attention at all.

(Music)

(Narrator)
At the next level in the food chain are the organisms we more commonly think of as marine animals…

Some, like starfish and sea urchins, are unique in the entire animal kingdom because they have radial symmetry – or a circular body with identical parts on all sides.

Other animals at this point in the food chain are categorized together because they are free swimming and have segmented spinal columns – commonly they're called "fish." Here the great diversity of life in the Gulf becomes apparent.

(Peter Auster)
There are more than 200 species of fish that live in the Gulf of Maine and so the Gulf is full of fish. The dominant, most abundant animals are animals like cod and flounder and red fish and cusk, those animals that tend to be of economic importance. But then there are also a large number of species that nobody hears about like snake blennies and radiated shanies. Those are small animals that live on the sea floor, some live in boroughs, so lots of little known fish.

Animals have to do two things every day of their lives: they've got to avoid being eaten and they've got to find things to eat, and at least once a year they've got to find a bunch of individuals of the same species in order to reproduce, and even when they do that, they've got to ensure that they are not going to be eaten by some large predator. So there's this balance, so animals occur in habitats that optimize their ability to avoid predators and make it easy to find prey. So if you're a flounder that eats organisms that occur in mud, you are going to live in muddy habitats. And so it's particularly important when animals are small that there are some aspects or seafloor habitats that are used for finding shelter from predators.

(Narrator)
Of all the fish in the Gulf of Maine, one that has had probably the closest ties to the economic, social and historic stories of humans, has been cod.

(Bruce Bourque)
What the explorers tell us is that first of all, the fish were so abundant they could not believe it. They were just amazed, just drop a hook overboard and just haul cod on, into the boat and then they would find they caught so many they would throw half of them overboard they just overshot they didn't want to treat all those cod they couldn't eat them, they couldn't salt them. Lobsters great huge lobsters in huge abundance, porpoises, seals everything was just very abundant.

(Andrew Rosenberg)
The project that I'm involved in is to try to reconstruct the history of what happened in the Gulf of Maine, primarily in the 19th century. We have very good log book information from the 1850's because the government at that time actually paid fishermen a bounty per cod that they caught as a trade promotion exercise.

Some of the images that you actually find in the log books are fascinating. In many cases captains would draw vessels that they saw.

The average size of fish was so much larger than it is now. We think of market categories of things like whale

cod as being big cod that you'd see now. I'd have to check, but a whale cod is a cod more than 10 pounds or something like that, well there were 80 or 100 pound cod back then. That was a whale cod.

(Narrator)
Some surprising records that Dr. Rosenberg discovered concern an area known as the Scotian shelf, just outside the Gulf of Maine, along Nova Scotia.

(Andrew Rosenberg)
One startling pattern that we see…is that the fleet that was fishing on the Scotian shelf in the mid 19th century, of sailing vessels fishing with hooks over the side, was actually catching more than the entire Canadian fleet fishing on the Scotian shelf is now for cod. The reason is not because their vessels were more powerful or they had better engines or better positioning systems obviously. It's because the abundance of cod they were fishing on was so much larger that their catch was quite a bit larger than the entire Canadian catch of cod in that area is now.

(Ransom Myers)
Cod had been declared an endangered species in most of Canada. This is a fishery that supported tens of thousands of people for five centuries and it now reduced such a state that it's being declared endangered. And that shows no sign of recovery, that is reduced the stock to such a low level that recovery doesn't appear to be occurring. Now this is totally unexpected, totally unpredicted from previous models. That we could we could do such a thing and so I think that you have to be careful when you think about, about over fishing because fisheries are enormously resilient and can take an enormous amount of over harvesting, but at some point the fisheries collapse and then the ecosystem changes in ways that no scientist or fishermen can predict and sometimes recovery just doesn't seem to occur

(Andrew Rosenberg)
There is an important question in public policy right now, and a major debate going on about if cod can come back. I think they absolutely can. I don't see a biological reason why they can't. I see a biological reason why they haven't. It's two-fold. It's because we really have not reduced the fishing pressure on cod nearly as much as we need to. Secondly, because of the biology of the way cod reproduce, you need really good reproduction, a lot of babies in one year that survive to spawn again, to start to build up a spawning population of cod again.

(Narrator)
Before scientists can help increase cod stocks, they need to know more about where and when cod spawn or reproduce.

Shelly Tallack from the Gulf of Maine Research Institute directs a program to tag up to one hundred thousand cod over a two-year period.

Designed as a collaboration between fishermen and scientists, they hope to learn more about the migration patterns of cod on the largest scale ever attempted in the Gulf of Maine.

(Natural sound boat)

(Shelly Tallack)
The tagging takes place on commercial trawl vessels, commercial hook vessels, even some lobster vessels.

So we will fish doing the commercial techniques but they are modified in preserving the health of the fish because there is no point in us tagging fish that die.

We bring them up slowly. We also put them straight into live wells which have fresh flowing seawater. That way we are encouraging oxygen to get over their gills again, after being hauled in over the stern of a boat. If we have a fish that seems a little sluggish, we will really try to work it through the water and to get as much oxygen flow as possible.

We record the date, the location that they were caught, the location that they were released, depth of water, the water temperature, the fish length, tag number and any other notable things like spawning condition, whether they are releasing any eggs or releasing milt, or whether they have lice or any old injury that's healed; we make a note of all these things

Then we release them as quickly as we can. The tagging process takes maybe 30 seconds per fish, if that, so it's a pretty quick process.

There's a 1-800 number on the tag, which is toll free from both Canada and the U.S., and there's also a web site, so they can report a tag through either of those.

(Narrator)
By reporting tagged fish, fishermen hope to join scientists in gathering the information they need to revitalize the cod fishery.

(Narrator)
The predator at the top of a food chain is called the apex predator. At one time in the Gulf of Maine, the huge cod fish, sometimes weighing 200 pounds, filled that niche. Feeding on lobsters and crabs, they ruled the ocean. Now, in ecosystems where cod has been fished out, lobsters and crabs are the apex predators. And today, lobster fishing has replaced cod fishing as the largest fishing industry in the Gulf of Maine.

(Music)

(Linda Greenlaw)
I think one thing I found really surprising was, the first time I saw videotape of a lobster trap at the bottom of the ocean, I saw lobsters crawling in and out of the trap quite freely. I wondered why we even call them traps -- it's like a drive-though restaurant; lobsters come in, have something to eat, get bored and leave.

(Narrator)
Linda Greenlaw, as a lobster fisherman, is well aware of the life cycle of lobsters that can effect her catch.

(Linda Greenlaw)
Lobsters in their very early stages have many predators. Fish eat them, birds eat them. A female lobster, an egg bearing lobster, she may release as many as 20,000 fertilized eggs, but I think a very small percentage of those actually grow to a legal size lobster.

(Narrator)
A lot of marine life such as lobsters and cod, don't just exist in a single niche in the food web. They start their lives in a much more vulnerable state, carried on the ocean currents. The currents become as much a part of an ecosystem as the biology, chemistry or geology of an area.

(Lewis Incze)
The early life stages of lobsters are planktonic; they live up in the surface of the ocean, so they get carried in the currents.

The currents aren't the same every year and they aren't the same in all places and so where larva get released, how far they travel before they settle down, and whether there is good settlement territory around for them when they are ready to do that, has a lot to do with the local production of lobsters.

(Narrator)
Compounding the complexity of an ecosystem where an animal can change from the smallest prey to largest predator as it grows, are the difficulties of tracking organisms in the interconnected oceans, where species from other ecosystems come and go. Some mammals, like seals and whales, appear in the Gulf seasonally.

(Marriane Farrington)
The types of seals that you will see in the Gulf of Maine are harbor and grays, those are the main ones, but you will also see harps and hoodeds they come down from the Maritimes mostly in the summer.

Predominantly when you see whales in the Gulf of Maine, what they are doing is they are here to feed, they are here to put on a lot of weight.

Whales are divided into two groups, one is the toothed whales and one group is the baleen whales. Instead of teeth in their mouth, they have a thing called baleen, it actually looks like a comb in their mouth,

(Narrator)
As baleen whales sweep through the water, their baleen captures small fish and crustaceans, some almost microscopic in size.

(Marianne Farrington)
What I have in my hand is a piece of baleen whale, this is sort of like one tooth of that comb that I described before. It isn't curled like this, normally it would be a straight flat piece, it curled when it dried up. This is the side that would be on the outside of the whale, so this would be the side that you see when the whale opens its mouth. And then these are the things that will actually intertwine it and make that net.

The thing that you have to think is really interesting about all of this, or exciting, or unusual, or "oh my god how does that happen," is that these are big huge whales, that go from 30 feet to 100 feet, blue whales are 100 feet long, they feed on these animals that are really, really tiny.

We are all very familiar with toothed whales, those are porpoise and dolphin and also sperm whales, so their type of eating is very different. Instead of just grazing through a whole school of krill, these guys are actually going through and picking out individuals and chomping them down.

(Narrator)
It's easy to picture the traditional concept of a food chain, with bigger animals eating smaller animals, who in turn eat smaller animals still, and so on. However, that chain is in truth more often a web. As we see the baleen whales, larger than even dinosaurs, directly feeding on some of the smallest animals in the sea.

Although whales have few natural predators and cannot be hunted in the Gulf of Maine, most whale species are endangered, if not on the verge of extinction.

(Marianne Farrington)
The North Atlantic right whale is the most endangered whale. Right now there is approximately 300 to 400 individuals

One of the ways they die is ship strikes. Part of the reason for that is whales usually spend a little bit of their

time just underneath the water. North Atlantic right whales have no fins so they are really hard to spot and apparently they don't swim out of the way for these big huge ships.

Another way that they die is entanglements. They get entangled in fishing gear.

In the past the New England Aquarium has actually taken individuals that were injured during strandings, and they were actually able to rehabilitate these animals.

(Natural sound intensive care)
(Nurse)
Don't forget to get weight.

(Marianne Farrington)
Another animal that the New England Aquarium will rehabilitate are marine turtles. All marine turtles, no matter what kind they are, are considered to be endangered or threatened. And what happens in the winter is animals are still in the Gulf Stream which is, of course, warm water and in the early parts of winter they will get out of that Gulf Stream and come into the colder waters that we have here and they will become cold shock. When they become cold shock, its sort of as though the turtle is dead but he really doesn't know it yet.

(Narrator)
The cold shocked turtles are unable to swim and strand on shore. Some are rescued in time and brought to the New England Aquarium in Boston for rehabilitation.

(Marianne Farrington)
When they are deemed healthy these turtles get flown back to places like Florida or the Caribbean and they get reintroduced back into their environment.

(Narrator)
Along with various species, like turtles, seals and whales that enter the Gulf seasonally, are the many estuary or shore creatures that interact with the oceans. At some point in their life cycle a myriad of birds and animals call the Gulf home and have an effect on the Gulf system.

As we have seen, there is one creature that lives on land and at sea, whose impact on the ocean ecosystem is without question the strongest --humans.

Uniquely adapted to live in various ecosystems, humans are changing the world more and more into one continuous ecosystem, as we carry organisms with us from one system into another.

(James Carlton)
One of our concerns today is that we get the bigger picture of how the world works.

In the Gulf of Maine, for example, we have seen many invasions of non-native species over many decades, in fact over several hundred years since colonial times. Our concern with invasions is that a single species can come in and alter the ecosystem.

(Narrator)
Many species, such as periwinkle snails, that people think are native, are not. The periwinkle is a European snail that arrived here in the 1860's. Scientists like James Carlton believe theses animals have had considerable impact on the shore ecosystem.

(James Carlton)
An amazing example, of course with the Gulf of Maine, started about a century ago when the European Green Crab, came north from Cape Cod flowed along the Gulf of Maine coast and had major impacts on the shellfish fisheries especially the soft-shelled clam.

Here we are, one-hundred years later, and another crab is invading. This is the Asian shore crab, *hemigrapsis senguinius, v*ery characteristic purple stripes on the legs and purple spots on the claws.

It's one of the world's most omnivorous crabs. It eats seaweed, it eats small invertebrates, it eats barnacles, it eats small snails like popcorn. The concern, of course, is the ecosystem cascade. If you introduce a predator into the ecosystem, it alters the prey. Not only will the prey, of course, become reduced, but the prey we have to remember, are also interacting with other species.

What we've seen south of Cape Cod is that where the newly introduced Asian shorecrab comes in, all other species of crabs tend to become rare.

Virtually everything that we're seeing here is composed of non-native species. This large sea squirt here comes to us from Asia, the bryozoans are native to Europe. The sponge is native to Europe. These are skeleton shrimp. They're not really shrimp at all, but they're arthropod crustaceans native to Japan. So here's a fouling community, typical of what we might see on boat bottoms or on these experimental racks which are composed almost entirely of introduced species.

(Narrator)
Before an empty ship leaves to pick up cargo, it has sea water pumped into it. This ballast water makes the otherwise empty ship float properly. Once the ship arrives in port, often thousands of miles away, it releases the ballast water and picks up its cargo.

(James Carlton)
There are tens of thousands of ships sailing around the world every day, and our calculations would suggest that at any one moment, thousands of species are in ballast water flowing around the world.

And the public actually has a tremendous affect on what gets released into the natural environment. The release of species from the home aquarium has in fact caused many invasions around the country and around the world. Moving live bait around can have an impact of releasing species from one place and now you have released them into another place and caused an invasion.

(Narrator)
If the boundaries between ecosystems have become blurred from species being moved around, how can scientists judge what a healthy balance is in an ecosystem like the Gulf of Maine?

(Lewis Incze)
The Census of Marine Life is aimed at exploring much more of the ocean than we have to date.

The word census in the Census of Marine Life is a little bit of a misnomer. At this point, you can not take a census, because there are thousands and thousands of critters that don't even have names on them yet. We don't know what creatures will emerge as the important things and I think that's one of the reasons why we really have to think of conserving the full spectrum of diversity in the ocean, or in all environments, because we really don't understand how they function or what their roles might be in the future.

(Narrator)
In light of the limited information we have about the marine environment, how can we manage the Gulf of

Maine?

(Ransom Myers)
Right now the National Marine Fisheries Service has a plan to increase the abundance of fish by a factor of three in the Gulf of Maine and George's Bank.

That is three times increase in the amount of fish in the Gulf of Maine and result in three times the catch in the Gulf of Maine. If this succeeds, this will be an enormous accomplishment, something that has rarely, if ever, been accomplished anywhere else because it's very difficult to rehabilitate fisheries because it requires fishermen to fish less for some amount of time so that you can fish more at a later time. And this is just very difficult to carry out.

Conservation and economics in the case of fisheries are not really at odds, it's something that that reducing over fishing is good for both. It's much better to catch a larger fish in terms of value than two smaller fish So just simply by fishing at a reasonable level, you can have more fish and greater variety of fish and larger fish, more valuable fish. It's good for the economy and it's good for conservation.

(Auctioneer)
Good afternoon, welcome to the Portland Fish Exchange Auction…52, 3, 54…

(Narrator)
Through recent conservation measures, most fish in the Gulf of Maine have increased by 150 percent from their lowest levels in the '90's. However, many scientists believe we have a long way to go.

(Fish broker)
I'll take them all.

(Ransom Myers)
I think that the recent success, limited success, but success none the less of increasing the bio-mass of fish in the Gulf of Maine is something to be proud of. It's vary rarely been achieved anywhere else in the world to actually manage your fisheries so you can actually get more fish out in the long term and an increase in bio-mass. It's very difficult to do because fishermen always want to catch the fish today or else his neighbor, his evil neighbor who will come and catch it instead of him.

(Robert Steneck)
If the trend is going upward, that is better than a trend that is going downward. And on that I would agree. However, the level of fish that we have today, versus the level of fish that we had twenty years ago, let alone two-hundred or two-thousand years ago, are just orders of magnitude, we're talking night and day differences.

(Narrator)
Going just by the numbers, scientists say that we would need to let some species increase by 40 times or more to return them to original levels. Most of the goals that scientists urge marine managers to set would increase stocks just three or four times. At this level, the species can at least be sustained with limited fishing.

Even if we could agree to work toward these goals, some animals have already become extinct. These include the sea mink…and the great auk, a plump, penguin like bird that was hunted to extinction more than 100 years ago.

(Ransom Myers)
When you think about balance you really need to think about what happened to humans when we arrived in

North America. We immediately eliminated all the large mammals, 75%, 80% of the large mammals like mammoths, mastodons, wooly rhinoceros, giant ground sloths, giant beavers. When humans started hunting, species started going extinct. We did this on land very rapidly and what is left in wild North America is a mere ghost of what there used to be. The same thing is happening in the ocean. Where you're going to the ocean, we're harvesting phenomenal levels, the sharks that used to be in the Gulf of Maine aren't there any more, like Great White sharks, Hammerheads, Threshers, species that used to be used to occur there, basically don't, you don't find them there any more.

Part of being a human is to love big animals, we love to hunt them, we want to shoot them, we want to fish them, we like to look at them, I mean there's this part of being what a human is and if you have any doubt about this ask a 5-year-old boy or a 6-year-old girl -- they love big animals.

(Narrator)
This phenomenon whereby humans remove the largest animal, then the next largest and so on, has been dubbed by scientists as fishing down the food chain.

(Robert Steneck)
I'd say that there's a growing consensus that most marine systems are structured from the top down. That the loss of predators is having a cascading effect on the organisms below it in this food web. So as you move down to the next site, you actually have another possibility for a cascade if you remove that layer. So you're taking a pyramid and you're removing it layer by layer from the top to the bottom, so logically what you're going to end up with are the producers, the seaweed.

(Narrator)
In the same way a rain forest once burned, will come back with weeds, an over-fished ocean loses its rich diversity. Once destroyed, the multitude of species that lives in a place is usually replaced by the few opportunistic species that can move in quickly and reproduce.

Trying to maintain diversity then, is at the core of an ecosystem based approach to creating a healthy Gulf of Maine. Every organism has value within the system. Scientists believe that protecting diversity cannot be separated out from modern wildlife management.

(Andrew Rosenberg)
If you're managing fisheries, one approach is just look at the fishing impacts on those things that we happen to like to eat. And forget about all the other stuff that lives in the ocean that we either don't catch or don't like to eat.

The words are carefully chosen. It is not ecosystem management. We don't manage ecosystems. We manage the human activity that impacts on ecosystems. So ecosystem based management says look at a broader set of impacts because what you want is a healthy, functioning ecosystem. Not, well, that's okay, everything else is dead, but at least we have cod.

(Hugh Akagi)I
The true ecosystem concept is all encompassing and of course if it is all encompassing, you have got to include yourself in the picture.

(Narrator)
If the issue is to see the entire picture then fishermen are key to scientific study. in the same way that a fisherman may not know how to design studies for scientific literature, the scientists often use methods that may not take into account the knowledge of the fishermen. The fishermen fish where the fish are, scientists study

both where the fish are and where they aren't.

(Lewis Incze)
The standard scientific way of assessing a population is to go out and make a grid of stations. When a population is abundant that works very well. Often times when a population shrinks, the fish and whatever it is you are trying to assess doesn't occur everywhere, it occurs in its preferred habitats, in isolated places. The fishermen know where those places are…

(Lewis Incze)
So the idea of how you asses a stock, how do you estimate how much is there and where it's going can benefit a lot from fisherman's information.

(Mark Leeman)
Absolutely.

(Lewis Incze)
I believe that…

(Mark Leeman)
I agree with you 100 percent. Believe me, but…the scientists don't know where the fish are. They really don't. I do. I've been doing it for 25 years….

(Lewis Incze)
And I believe you.

(Narrator)
Fisherman Pat White has been working hand-in-hand with scientists, travelling throughout the country interviewing fellow fishermen.

(Pat White)
The fishermen have tried to impart their knowledge of what they see out in the ocean to the scientists. They have always felt that the scientists were liars and the scientists always felt that fishermen were. And I think now they're realizing that they both have their own focus and we have got to come up with a happy blend of the two.

(Peter Auster)
One fundamental problem is that there are separate groups that manage the ocean, but there's not an over riding agency that puts it all together.

(Pat White)
In the ground fishery, we've got 3 or 4 groups just in Maine coming up with new ideas. It's not…it isn't going to work, and I don't think the solution to our problem is going to be easy, but there is a solution out there and its got to have groups of people working together.

(Narrator)
With a greater understanding of history, as well as the interactions of organisms in their environment, scientists from many fields are pooling their knowledge with fishermen. Can their findings lead us to a common goal for the Gulf of Maine?

(Pat White)
The resource is our future. If we don't manage our resource well, then we're not going to have a future.

(Peter Auster)
I'm not trying to stop fishing. A lot of this is converted fish and butter and wine and chocolate for dessert, but I think the issue is where do we fish, what do we fish with, or how do we fish, and how much should we remove. Those are the fundamental questions in environmental management.

(Shelly Tallack)
Many fishermen are conservationists, they don't want to see the resource disappear, but they also have to make a living.

(Peter Auster)
When people began to deal with conservation on land over 100 years ago in the fledgling national park service, they didn't send out ecologists and biologists to the west to bring back data. They sent out landscape painters and photographers to bring back pictures of the landscape to convince people back east that there were places that were worth conserving.

I mean, the data is interesting and it's intellectually stimulating and we'll write various scientific papers from this work, but I think the greatest thing was seeing these places.

(Andrew Rosenberg)
As we lose ocean ecosystems, we lose the ecological basis on which all natural life depends.

(Les Watling)
But when it comes right down to it, it's a moral argument; we have a moral obligation, I think, to use our intelligence in a way that doesn't destroy the rest of the planet for other organisms that are living there.

(Hugh Akagi)
The native has a feeling, it's almost a spiritual feeling, that mother earth is in pain, mother earth is crying.

(Andrew Rosenberg)
If you go to the beach even if you're not a fisherman, you have an interest in knowing that the ocean you're looking out on is healthy and has animals living in it and that's a genuine public interest. All those resources are held in the public trust. And so it's an important question to ask what is possible, how would we get there and do we want to do it?

(Hugh Akagi)
If it's difficult, we do it immediately; if it's impossible it takes a little longer.

(Linda Greenlaw)

By looking at the entire ecosystem, you do get an idea of how complex it is and realize that no one has figured it out. What is clear is that marine plants and animals need all of our help: fishermen, scientists, and the public.

Through the sacrifice of fishermen, the Gulf has come a long way in recent years.
And by balancing all of our interests, I look forward to a future of a thriving ecosystem in this special place. I'm Linda Greenlaw. Thanks for joining me on this "Quest."

(Music)