THE ENDLESS VOYAGE

"Treasure Trove" Episode 124

If you think about the diversity and vastness of the ocean, and what the bottom of the ocean looks like—a cold, inhospitable place made up of mud, minus one degree centigrade and very high pressures. What we've now learned is that those mud samples contain whole new groups of microorganisms that produce antibiotics and agents to treat cancer. What a resource.

The vast majority of oil and natural gas deposits were formed from marine sediments, and trapped in marine sediments. So economically they provide one of the—the basis of our civilization.

And the fortunate fact of the matter is that in most fisheries we've made mistakes in guessing how much fish material we can sustainably take out of the oceans every year, and in those mistakes, we've sequentially degraded many of the fish stocks.

NARRATOR:
FEW WOULD DISPUTE THE NOTION THAT PLANET EARTH IS A GENEROUS PROVIDER OF DIVERSE AND VALUABLE NATURAL RESOURCES, FROM INDUSTRIAL MATERIALS LIKE COAL AND IRON THAT HELP POWER THE INDUSTRIAL WORLD, TO AGRICULTURAL RESOURCES THAT SUPPLY FOOD TO COUNTLESS MILLIONS WHO MIGHT OTHERWISE GO HUNGRY, THE LAND PROVIDES AN EXTRAORDINARY BOUNTY TO ITS INHABITANTS. BUT EARTH ALSO CONTAINS ANOTHER REPOSITORY OF NATURAL RESOURCES—THE WORLD OCEAN IS RICH NOT ONLY WITH THE CHEMICALS THAT ARE THE STUFF OF LIFE, BUT WITH A REMARKABLE ARRAY OF PLANTS, ANIMALS AND OTHER RESOURCES THAT ARE BECOMING MORE AND MORE IMPORTANT AS THE HUMAN POPULATION CONTINUES ITS UNBRIDLED EXPANSION. SOME OF THESE RESOURCES END UP IN SURPRISING PLACES.

SEAN CHAMBERLIN, Ph.D., Fullerton College:
Autotrophs, or different types of primary producers, have become quite important to us commercially. Kelp are probably the first thing that comes to mind.

RICHARD ZIMMERMAN, Ph.D., Moss Landing Marine Laboratories, CSU:
Kelp is a common term for a group of brown seaweeds in that the laminariales and kelps are distributed in cool and cold temperate waters throughout the world. They serve as an important economic resource for a number of uses.

CHAMBERLIN:
There are companies that go out and actually harvest the kelp plants along the coast of California, and use the products of those kelp plants in a whole variety of different foods and different types of products that people use.

They are harvested as a food source in the Far East. They were historically harvested as a source of potash for both the explosives industry in the early 19th century, as well as a source of fertilizer. More recently, the largest economic driver for harvesting kelp—the biggest economic reason for harvesting kelps is that they can extract these polysaccharides, cell wall polysaccharides, from the plants to make an important chemical agent that serves to emulsify, or that is, to mix a lot of things. These polysaccharides are also called alginates—alginic acids.

If you did any shaving before you came to work today, you probably used a product that had alginate or some type of product from a seaweed in it. Many different types of products—toothpaste and things that we normally don't think of as having these icky seaweeds in, actually do have promotional importance to us, and they really are present in a lot of different types of foodstuffs of which we're not, maybe, even aware.

They can be found in products ranging from ice cream to salad dressings to various food products, to cosmetics, to paints, to a wide variety of things. And so, right now, worldwide, I think the largest economic value for harvesting kelps is for the alginate industry. And in California, I think that represents something like $20 million a year industry.

NARRATOR:
AS IMPORTANT AS EVERYDAY HOUSEHOLD PRODUCTS MAY BE, MARINE RESOURCES EXTEND WELL BEYOND THE KINDS OF ITEMS FOUND AT THE CORNER GROCERY STORE. SOME OF THE WORLD'S MOST VALUABLE INDUSTRIAL PRODUCTS COME FROM THE MARINE ENVIRONMENT IN THE FORM OF SEDIMENTS.

JAY YETT, Ph.D., Orange Coast College:
Marine sediments are enormously important economically. There are certain kinds of deposits that have been found in ocean sediments that are useful today.

ROSS HEATH, Ph.D., University of Washington:
One that most people don't think about is construction material. As environmental concerns eliminate the possibility of making quarries on land, more and more gravel and sand are obtained from the ocean and used in construction. In addition, there are some exotic sediments that are also very valuable. Diamonds, I think most people would be very interested to find there are substantial offshore diamond deposits off Africa. There are things like tin and titanium, which are also found in sediments in the ocean particularly. And also things like phosphate fertilizer comes from sediments.

DONN GORSLINE, Ph.D., University of Southern California:
Probably the most famous potential deep sea deposit, are the manganese nodules. And the manganese nodules are precipitates. They're a hydrogenous sediment—they're precipitated from the ocean water very slowly. And the manganese nodules are manganese dioxide that contain large amounts of copper, nickel, cobalt, a number of

industrial useful minerals. There has been continued interest in the manganese deposits. At the present time, they're not economically significant because the cost of retrieval, and the cost of producing the metal, exceeds that of current terrestrial deposits. But in the future, those are a potential major source of those important minerals.

What's most important is that two of our major energy resources are generated from marine sediments and usually are trapped in marine sediments, and that's oil and natural gas.

The oil and gas, which is almost all obtained from sediments, is worth billions and billions of dollars.

NARRATOR:
BUT EXTRACTING THESE VALUABLE COMMODITIES IS VERY EXPENSIVE AND EXTREMELY DIFFICULT.

Most oil and gas is extracted using technology they developed back in the '20s and '30s and even earlier, which is just drilling into the rocks—in this case, the marine rocks—and having that oil and gas migrate from the sediment, the sedimentary rock, into the well, and then pumping it out. What's been found over the years is that, that extracts a good part of the oil, but not a high percentage, I suppose. One of the other techniques that's been developed in the last few years, is the idea that instead of drilling vertically into reservoirs, that you could drill horizontally through the reservoir. And it's been very successful. And the reason that it's been successful is that when you do the vertical drilling, you can extract the oil only from a certain radius around that hole. It's been found now by going horizontally through that, that you begin to pick up some of the oil that was never able to make it to those vertical wells.

NARRATOR:
THE ALLURE OF MARINE RESOURCES ISN'T LIMITED TO SEDIMENTARY DEPOSITS LIKE OIL AND GAS. IT ALSO INCLUDES OCEANIC MATERIALS THAT CAN BE USED TO MAKE PHARMACEUTICAL PRODUCTS—SOME WITH THE CAPACITY TO SAVE LIVES. WHILE THAT IDEA MIGHT SOUND FAR-FETCHED AT FIRST, IN FACT, THERE'S A PRECEDENT FOR IT THAT GOES BACK CENTURIES.

WILLIAM FENICAL, Ph.D., Scripps Institution of Oceanography, UCSD:
I think you have to think back about the whole origin of the modern pharmaceutical industry. And where you go back is 3,000 years, to an understanding of the fact that very early societies used plants and animals—that they lived very closely by and intimately with in the treatment of disease. Natural materials were clearly the foundation in the early days—the discovery of morphine from the poppy, the discovery of aspirin from the willow tree. These were seminal discoveries that really created an opportunity for the whole concept of a pharmaceutical product, a drug to be developed. And so, with this backdrop, we became fully aware that nature was the provider of products to cure disease.

This is called pseudopterogorgia, and it's a soft coral that grows in the Caribbean. What's most interesting about pseudopterogorgia is that it—if you extract it with organic solvent and then purify the products that you can isolate from it, a new anti-inflammatory agent which is called pseudopterosin A….

NARRATOR:
BIOLOGISTS HAVE EXTENDED THEIR SEARCH FOR NEW MEDICINES TO THE OCEAN, OFTEN FOCUSING THEIR RESEARCH ON CORAL REEFS.

FENICAL:
And the reason is that coral reefs are some of the most unusual and most productive of the marine environments. What's happened is that over the last 10 years, the National Cancer Institute in the U.S. has invested very heavily in studying plants and invertebrate animals, like sponges, and sea squirts and corals. And they've made significant discoveries. I'll give you a couple of examples. There's an animal that grows right here in San Diego—in fact grows on our pier. It's called Bugula Neritina, it's called a moss animal. It's a very pretty animal. You'd mistake it for a plant if you saw it growing on the pier piling. It produces a very potent molecule called bryostatin. And bryostatin has the ability to inhibit the growth of cancer cells in very effective ways. This compound, bryostatin, was developed with the assistance of the National Cancer Institute, is now in clinical trials, and is showing good control of cancer. There are many other examples. Sponges, for example, which are soft. We all know what a bath sponge looks like. But in nature, because they're soft, they have to develop a chemical method to defend themselves, and these chemical substances are used in nature to deter predators, to discourage animals from eating these sponges and so forth,. But when you look at the effects of those natural products, those chemical compounds in cancer, you see that quite a large number of them, show inhibition of cancer cell growth, and possess properties that will allow us potentially to develop a drug.

NARRATOR:
DESPITE THE PROMISE THE MARINE ENVIRONMENT HOLDS AS A SOURCE OF PHARMACEUTICAL RESOURCES, THERE ARE SOME COMPLICATING FACTORS THAT IMPEDE RESEARCH ACTIVITIES.

FENICAL:
Some of these activities are not the same as wandering through a rainforest collecting leaves. They just are not the same. They require diving, perhaps on occasion in dangerous areas with inhospitable marine life and/or inhospitable weather. They require a bit more…commitment to do that job. They're more difficult to collect in large scale. You can dry leaves and bring them back to your laboratory, but you can't dry wet, soggy marine animals.

NARRATOR:
BUT OBSTACLES OF THIS SORT, WHILE CHALLENGING, ARE CERTAINLY NOT INSURMOUNTABLE. THERE IS HOWEVER ONE MAJOR PROBLEM THAT IS ESPECIALLY DIFFICULT.

FENICAL:
And this is the problem of supply. This is the problem regarding how we are going to produce enough material to be used a drug. If you discover that an invertebrate animal contains an anti-cancer drug, you're going to need a hundred thousand pounds of that animal in order to extract it and purify from that animal the amount of potential drug to be used for clinical trials, not to mention sales. And so, how do we go about—harvesting such massive amounts of animals from the ocean? And the answer is, we really can't do that. This is one of the reasons why we began to look at organisms that you could culture, that you could bring a single drop of seawater, a few grains of sand, or a tiny bit of a sponge in from the ocean and in fact, derive something that's a renewable resource, and culturable resource.

So this is the big fermentation—large scale fermenter?

- Yeah, 50 liters.

- 50 liter fermentation. It's important that we get this kind of volume, or we'll not be able to really…get these molecules out of here in any quantity.

We've learned how to grow invertebrate animals in tanks, produce huge amounts of these animals, and then use that as a process to produce large amounts of drugs for sale. These are all new things. They're all new ways to really produce materials.

NARRATOR:
DESPITE THE EXTRAORDINARY PROGRESS THAT'S BEEN MADE IN A RELATIVELY SHORT AMOUNT OF TIME, THE EFFORT TO UTILIZE MARINE RESOURCES IN THE PRODUCTION OF PHARMACEUTICAL PRODUCTS IS VERY MUCH IN ITS INFANCY. ALONG WITH PROBLEMS OF SUPPLY, THERE ARE OTHER CHALLENGES AS WELL. CONVINCING PHARMACEUTICAL COMPANIES TO INVEST IN SOMETHING THEY DON'T FULLY UNDERSTAND IS ONE. FORGING GLOBAL ALLIANCES THAT FOSTER COOPERATION AMONG NATIONS IS ANOTHER. STILL, THE POTENTIAL CAN'T BE OVERLOOKED.

FENICAL:
Go back and think about just how diverse the natural products are, in your life, that are derived from the terrestrial environment. We have relied enormously on products from nature. The ocean is now simply just being considered. And when you look at that diversity, the possibilities of the production of such a wide variety of materials in every form of our life, in every style of product that we use, it's enormous.

NARRATOR:
FROM LIFE-SAVING PHARMACEUTICAL PRODUCTS TO PRICELESS MINERALS, MARINE RESOURCES CLEARLY POSSESS ENORMOUS VALUE. BUT IT IS THE FISHES THAT INHABIT THE WORLD OCEAN THAT ARE PROBABLY THE MOST ACCESSIBLE AND CONSISTENTLY USEFUL RESOURCE IN THE MARINE ENVIRONMENT. NOT ONLY HAVE THEY PROVIDED A SOURCE OF FOOD FOR HUMANS SINCE THE EARLIEST OF TIMES, BUT THEY PLAY A CRITICAL ROLE IN THE GLOBAL FOOD WEB AS WELL.

ANTHONY MICHAELS, Ph.D., Wrigley Institute of Environmental Studies, University of Southern California:
Fish are obviously one of the prime ways that we get protein out of the ocean. I think about a third of all the protein in the world is now coming out of the sea. And fish are just sort of an upper place on the food web. You have your plants of the sea that are actually creating biomass and things eat the plants, and things eat those animals. And it sort of transfers mass material up the food web, and at some point along the chain, you get to something that we want to eat.

NARRATOR:
PEOPLE HAVE FOUND WAYS TO GET FISH FROM THE OCEAN FOR THOUSANDS OF YEARS. BUT RECENT ADVANCES IN FISHING TECHNOLOGY HAVE BROUGHT ABOUT MAJOR CHANGES.

DALE LEAVITT, Ph.D., Woods Hole Oceanographic Institution:
There was a time when we went out with sailboats and chased fish around. And it was much more of a challenge for the fishermen to be successful. Of course, the fishing stocks—the fish supply—was a lot higher then, as well. So they were successful at using fairly archaic, primitive equipment. Now we've evolved to the point where we're using very large horsepower, fast boats, with very sophisticated fishing technologies. The trawls and the dredges and the baits have really advanced our ability to fish. So our efficiency at fishing, has greatly increased over the past 20 years.

NARRATOR:
UNFORTUNATELY, THIS INCREASE IN EFFICIENCY COMES AT A PRICE.

STACY KIM, Ph.D., Moss Landing Marine Laboratories, CSU:
The particular project that I'm working on is looking at trawling fisheries around the peninsula region and the sub-Antarctic Island Arcs. When a trawler goes out for fish, it not only captures fish, but they're dragging over the seafloor, so they capture a lot of the invertebrates that live on the seafloor as well. And I'm looking at that by-catch and trying to quantify how the trawling is impacting the habitat of the fishes. A lot of the sponges that they bring up can be hundreds to maybe even a thousand years old. And so once a trawler goes by, it takes a very long time for the community to recover and come back to normal. And you might ask why we would care about a sponge in the Antarctic. You can't really eat it, it's not directly impacting you. But the sponges provide habitat

for the fishes, and once you remove all the sponges in an area, the fish have no place to lay their eggs, they have nowhere to hide from seal predators. So it does have an impact on the fishery itself.

NARRATOR:
THE IMPACT OF NEW FISHING TECHNOLOGY GOES BEYOND ENVIRONMENTAL COSTS. THE SHEER NUMBER OF FISH BEING REMOVED FROM THE MARINE HABITAT CAN LEAD TO A SERIOUS PROBLEM KNOWN AS "OVERFISHING."

LEAVITT:
To know an area is overfished is fairly obvious. The fishermen know immediately because it is basically return per unit effort. Probably the biggest and most obvious clue is they just stop seeing the numbers of fishes in the nets that they were getting when the population was stronger.

RICK GRIGG, Ph.D., University of Hawaii at Manoa:
And if you have records that are kept by the government or the fishermen, whoever—you can see this gradual decline. And when it gets to a crisis point—for example, at a level at about 20%, where the spawning biomass is reduced by that amount, you're looking at species that can't recover—at least very fast. And you've got to stop fishing altogether. So you look at catch rates, you look at the size frequency, that means the range of sizes as the fish get smaller and smaller and smaller. Pretty soon you're at the point where they're not reproducing. You're catching them before they reproduce. And that's going to cause a collapse—a total collapse in that species.

MILTON LOVE, Ph.D., University of California, Santa Barbara:
I think that the important thing to remember is that there's almost no community in the ocean that's not what I would call "wounded." It's been altered, sometimes drastically, and mainly by fishing. Sometimes by pollution, but really mainly by fishing. The equivalent is if you went to Alaska and people had killed every wolf and every bear and every large predator and all you saw were deer, would you actually think that that was a natural environment? Well, no. You'd go, "Where's all the predator's?" And that's what happens when people dive on a typical coral reef or a reef off California, a reef off Massachusetts—they don't see these big predators like sea bass and white sea bass and groupers and things like that that used to be there. They see a lot of little fish and they go, "Oh I guess that's a natural system." But it's not. There are virtually no natural systems left.

NARRATOR:
AS CONCERNS ABOUT OVERFISHING INCREASE, THE NEED FOR EFFECTIVE FISHERY MANAGEMENT BECOMES CRITICAL.

MICHAELS:
One of the tricks of fisheries management is to balance the interest of fishermen, which is making a living, with the interest of the fishery, which is for those organisms to survive,

and from our standpoint, for the ecosystem in which they live to not be degraded by that fishing activity. And they aren't the same interest. And that blending of the business side of fishing with the ecological side of fishing is one of the places where we've then had trouble historically in managing fisheries.

NARRATOR:
FISHERY MANAGEMENT FOCUSES PRIMARILY ON MAINTAINING A SUSTAINABLE HARVEST OF RESOURCES. THERE ARE A NUMBER OF FACTORS THAT COMPLICATE THAT PROCESS.

LEAVITT:
If you were a forestry manager, you could go out and you could measure your trees, and you could count your trees and you could look at the density and the growth rate, and it's all very simple because they're all sitting there right in front of you. Fisheries managers have a much more complex problem.

MICHAELS:
In practical sense, we can't count the fish very easily. We have very poor methods of going into the ocean and counting who's there the way you might count how many elephants are on a plane. So we have to use indirect techniques. And really one of the main techniques—the fish we see are the ones the fishermen take out of the ocean. Declining size is one of the clues that there are fewer fish. The big ones live longer. There's a longer period that they can be caught. If they're over-harvesting, the larger ones will start to disappear. So you can have a situation where the average size of a swordfish in the Atlantic a century ago might have been 2 or 300 pounds, today you're lucky if it's 100 pounds. That says that the big ones are gone, the long-lived ones are gone, and you've started taking enough fish out of a long-lived system that the population size structure has really changed.

NARRATOR:
BUT WHILE INDIRECT EVIDENCE PROVIDES SOME USEFUL INSIGHTS, THERE'S A GREAT DEAL ABOUT FISHERIES THAT REMAINS A MYSTERY.

So the fisheries managers have had to resort to numerical modeling, or using mathematics to try to predict what's going to happen with our fisheries populations, with the number of fish in the sea, if you will. And what they need to do is they need to understand how these fish function on a normal basis, and then they have to predict what's going to happen if you take away a certain number of those fish. Is the population going to be able to sustain itself? Or are you going to see a slow or rapid decrease in the population, or increase in the population?

NARRATOR:
MANY OCEANOGRAPHERS CONTEND THAT THE MODELS USED IN FISHERY MANAGEMENT ARE INHERENTLY FLAWED.

GREGOR CAILLIET, Ph.D., Moss Landing Marine Laboratories, CSU:
Fishery management requires as good a data set as possible. That data set normally assumes that a fished stock will reach an equilibrium condition that gives it a carrying capacity, or population level, that's slightly lower, or somewhat lower, than it would be if it wasn't fished. And all the models that I know of are based on equilibrium assumptions. That is, the fish stock will stay in equilibrium. Now if a fish is going out of existence, or its catch per unit effort data are going down very fast, that means it's not in equilibrium anymore. And that's the biggest fault of the fishery models we have.

NARRATOR:
IN LARGE PART TO COUNTER PROBLEMS CAUSED BY OVERFISHING, MARINE SANCTUARIES HAVE BEEN ESTABLISHED AT VARIOUS POINTS ALONG THE U.S. COASTLINES.

MICHAEL FOSTER, Ph.D., Moss Landing Marine Laboratories, CSU:
Marine sanctuaries are not unlike the concept of a National Park or a terrestrial reserve or a wilderness area. They're areas that have been designated such that human activities are reduced. The amount of reduction can vary from absolutely no touching anything by anybody, to maybe simply reduce fishing for a particular species.

NARRATOR:
ONE OF THE MAJOR CHALLENGES IN SETTING UP A SANCTUARY IS DETERMINING HOW MUCH SPACE A PARTICULAR SPECIES NEEDS.

FOSTER:
I think the general consensus is, we need more sanctuaries—marine protected areas—and the larger the better. The other part of it is that it also seems to be a way to help sustain and improve the marine environment that's different from the traditional regulatory scene, which has been, in the United States, as far as I'm concerned, largely a huge failure.

NARRATOR:
IN RECENT YEARS, THE RELATIONSHIP BETWEEN FISHERMEN AND REGULATORY AGENCIES HAS GROWN INCREASINGLY STRAINED.

CAILLIET:
In the old days, and I would say in the last 100, 200 years, the fishermen would fish certain resources, and when they found that they had declined, they would most likely switch or fish a different resource. And then go back and forth. As the human population has expanded rapidly, the fishing pressure has increased amazingly, thus causing fishery management agencies to be more numerous and to wield more power. So the relationship between the fishing industry and the management agencies has become less comfortable because the management agencies have had to impose more strict regulations and rules.

The best application is at the local level, where the community recognizes the need to control. And then you get community-based management…regimens or programs that are put into place. Those seem to work best, because then the local people take charge. I think, really, you need to get done to the level of the fishermen and make it somehow in their interest to control what they're doing. Give them incentives to follow regulations. You have to make it in their interest to preserve the fish that they're targeting.

The trouble is, they don't know the amount of fish that they're fishing, that are available, any more than the fishery management agencies do. So ultimately I think the Canadian example might be used. And that is to use the fishing industry with the fishing management agencies to gather the data that are then used by committee in general to manage those resources.