

SCIENTIFIC AMERICAN FRONTIERS program #1306,  
"Deep Crisis"  
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Intro

Out West - Conquering the Columbia  
Down East - The Extinction Vortex  
Rocking the Bluefin Boat

ALAN ALDA These young salmon are some of over 100 million that each year start their journey down the Columbia River, and out thousands of miles into the Pacific. But scientists say that America's salmon are at risk of becoming extinct. On this edition of Scientific American Frontiers, we're looking at the future of the ocean's long distance travelers.

ALAN ALDA (NARRATION) In the Northeast, can biologists figure out what makes Atlantic salmon tick, before the last few rivers lose their wild fish? In the Pacific Northwest, will elaborate engineering save the Columbia River's salmon? And in the Atlantic Ocean, scientists are beginning to understand the giant bluefin tuna -- but will the rest of us put that knowledge to good use?

ALAN ALDA I'm Alan Alda. Join me now as we plunge into a Deep Crisis.

INTRO

ALAN ALDA Inside this building there's a small food processing company. There must be thousands like it around the country. Nothing special about that, right? Well in fact, what goes on in here is really special, and when you think about it, really surprising. Because what they do is prepare meat from wild animals, for shipping to the shops and markets where we'll all buy it. Let's take a look. That's right -- fish. Fish are wild animals, with some exceptions, which we'll get to in a minute. 10,000 years after humans domesticated cattle and sheep and pigs, and figured out how to cultivate crops, we're still out there hunting down wild fish to put on the table. Today, seafood is the main source of animal protein for about a billion people around the world, and its importance is growing rapidly. Fish consumption has gone up fivefold since 1950, and it's still going up. The results are not hard to imagine -- marine fish stocks are being overfished, and they're declining fast. What to do about damaged fisheries is a terrifically complicated

question, that involves many interests -- industry, fishermen, environmentalists, local economies and livelihoods, even foreign policy. But this program is going to concentrate on what all those interests need to know before they start to argue -- the science. We have to know how fish behave, where they feed, where they breed, before we can begin to figure out how best to conserve them. We're going to concentrate on two kinds of fish we in America love to eat -- salmon and tuna. Even though salmon farming is big business, wild Atlantic salmon are now officially endangered in the US. And even though millions of young Pacific salmon are raised in hatcheries in the Pacific Northwest, several species of wild Pacific salmon are officially endangered, too. We'll look at the work of biologists on both coasts, who are now trying to determine how wild salmon can have a future. And we'll look at the efforts to study the giant bluefin tuna, another long-distance ocean traveler. Studying bluefin is especially challenging, because an individual fish may range over enormous distances -- across the entire Atlantic, for example. Scientists are just beginning to find out about the ocean wanderings of the giant bluefin. Even something as basic as counting fish in the wild hasn't been attempted until recently. And guess what -- everything we discover comes as a surprise. OK -- let's dive into a fish's world.

#### OUT WEST -- CONQUERING THE COLUMBIA

ALAN ALDA (NARRATION) When Lewis and Clark explored the West 200 year ago, they saw sights like this. On the Columbia River, the salmon were "jumping very thick," wrote John Ordway, the expedition's senior sergeant.

ALAN ALDA So what are all these slots in here?

ALAN ALDA (NARRATION) Today the Columbia is just one part of a settled and industrialized Pacific Northwest. It's not impossible to see a wild salmon jumping a waterfall -- just a lot harder. Dams are the most visible of many reasons for the decline of the Northwest's salmon. Here on the Washington-Oregon border, the Army Corps of Engineers' McNary dam -- opened in 1953 -- reaches for a mile across the river. It's one of hundreds of large dams distributed throughout the enormous Columbia-Snake river system, which stretches across 4 states and up into Canada. Several of those dams completely blocked fish from going upstream, knocking out more than a third of the system's salmon habitat. The dams made life for the remaining salmon much harder. When young fish head out to the ocean, for example, they have to contend with this. McNary's electric generating turbines can kill young fish, but about 15 years ago the way the dam was run began to change.

ALAN ALDA Is it that the environmental protection laws have required you to run the plant in a way that's best for the fish?

DAVE COLEMAN Oh, yes.

ALAN ALDA So its not just running the plant, you have to worry about the fish as part of your job now?

DAVE COLEMAN Guaranteed. I mean when I first hired on the Corps the most important thing in this facility was the safety of the employees, navigation law, and power. Since I have been here safety is number one, fish is number two.

ALAN ALDA (NARRATION) You can see the result in the control room. The 14 turbines could together produce 980 megawatts, but today they're running at less than 860. This is a salmon smolt, a one-year-old fish that's ready to move down river to the ocean. It's about to experience McNary's turbines first hand -- and then report back. First there's a mild anesthetic, so a radio transmitter and flotation balloons can be attached. This is one of millions of smolts raised in hatcheries each year. At the last instant a foam mixture is added to the balloons, and then...

ALAN ALDA Now he goes down through the turbine?

RESEARCHER Yes, he's going right through the turbine.

ALAN ALDA (NARRATION) Down it goes, 70 feet deep, through the spinning turbine blades, then out below the power house. By now the flotation balloons will have inflated, so the fish will be somewhere downstream, on the surface. Meanwhile the researchers are sending down a somewhat less lively instrument package. In the river below the dam, the recovery crew is on the lookout. Within minutes they pick up the radio signals from the fish and the instrument package.

RESEARCHER Three o'clock.

ALAN ALDA (NARRATION) Surprisingly enough, the smolt made it through unharmed. In fact around 90% survive, if the turbines are run at flow rates which reduce forces on the fish -- as they are today. Those forces can be measured with the instrument package, while turbine speeds are adjusted. Now all the Army Corp's Columbia turbines are run to minimize fish losses. On a typical Columbia dam, half the structure is the power house, the rest is spillway. As with the turbines, spillways are also now operated with fish in mind.

ALAN ALDA That's a great sound. It sounds like Niagara Falls.

DAVE COLEMAN It is like that. We spill likeS. today we're spilling about 100 kcfs.

ALAN ALDA That's a spectacular sight. The ability to do a spill like this on the dam, was that intended originally as a kind of a pressure valve when there were flood conditions?

DAVE COLEMAN Correct.

ALAN ALDA It wasn't with the fish in mind at all?

DAVE COLEMAN No way.

ALAN ALDA Now you open the spill for the fish as well as for the flood. DAVE COLEMAN And it's an interesting story. Originally when you had a spring runoff like this that's forced spill, it used to cause a lot of harm for fish because the water used to plunge straight down, super-saturate the water with nitrogen, they'd get like the bends and it'd cause a lot of mortality. So all the dams have been retrofit with what they call flip lips that actually slides the water kinda out instead of plunging it down.

ALAN ALDA (NARRATION) With flip-lips, and if the flow rates are just right, approaching 100% of young salmon can make it through a spillway. So it doesn't sound too hard for a young fish to get past McNary dam. But that's a small part of the challenges facing the Pacific Northwest's salmon. Let's take a look at the Columbia system from a salmon's point of view. In we come from the Pacific Ocean, through the estuary. We've been using our internal compass to get here, but now as we head upstream we're beginning to pick up the distinctive smell that we remember from the water where we hatched, 4 or 5 year ago. We're determined to spawn in the exact same river, lake or stream, and we're prepared to travel 500 miles inland -- 1,000 or so river miles -- to get here. Now we've arrived, in central Idaho or eastern Oregon. Once there were hundreds of different groups of us salmon in the Columbia system -- distinct stocks that each used the system in its own unique way. We find the stream, find the right kind of gravel, find a mate, and make a nest for the eggs. Next spring the fry hatch, then hang out and grow for a year before hitching a ride, as smolts, on the following spring runoff. Down the river we go, out to sea for a couple of years to eat and grow. Today more than half the Columbia's original stocks are extinct. For thousands of years, native Americans were the only people who exploited the Columbia's salmon, but that couldn't make a dent in the 10 to 15 million fish that returned each year. Then as the numbers of settlers grew in the nineteenth century, salmon came under increasing pressure. Large scale net fisheries were established in the Columbia estuary. Canneries were set up. By the 1930s returning fish numbers were down by half. At the same time another bonanza was under way in the forests through which many salmon rivers and streams flowed.

FILM SOUNDTRACK Timber. Shoot them off the hillside. Snake them down the creek. Raft them down the river. Out to the Pacific, to Africa and Australia and Ireland. Feeder logs for the plywood mills of Japan, ties for the Trans Siberian Railway, timbers for North China mines.

ALAN ALDA (NARRATION) Logging was devastating for the salmon. It turned clear, cool streams into muddy, warm pools that no longer support spawning. Some attempts are made to protect streams today, but it's still a serious problem. And then on top of the fishing pressure and the logging...

FILM SOUNDTRACK At Bonneville, Oregon, Man takes up the struggle against the frontier. Cascade rapids, since pioneer days the graveyard of ill fated ships, in 1933 make way for Bonneville dam. America's conquest of the Columbia has begun Just as the Nile is the lifeblood of the historic land it drains, so this river of the west is the key to the future of the Oregon country. An unshackled giant becomes a seaway to an empire. The promise of power for every corner of the Northwest. Power to make a million and a quarter acres bloom again. Power to push the city to the farthest county line. To bring better crops and better living to the farmers of the region. Power for the home, good light for Billy's eyes, electric cooking for mother, the comfort of electric heat and electric cold. Leisure to replace the burdens of an outworn era. Power to make the American dream come true.

ALAN ALDA (NARRATION) As far back as the 1870s it was thought that we could have the America dream, and salmon too, by building these. It's a hatchery where young salmon are raised for a year until they're ready to go to sea as smolts. There are about a hundred hatcheries in the Columbia system, producing about 200 million smolts a year. All hatchery smolts are marked by clipping a fin that's not used for swimming -- an evolutionary leftover. This mark persists with the adult fish, so it's been possible to track how well hatchery fish do, compared to their wild companions. Only about 10% of the smolts in the Columbia system are wild -- spawned, hatched and raised naturally, without human intervention. But up to 30% of the adults that make it back from the ocean were wild smolts. Wild fish do much better, in the ocean and the river. Biologists think they're more aggressive, know how to avoid predators -- just smarter and tougher. Dams have made the river more difficult for all smolts, wild and hatchery. For example, there's not enough flow in the reservoirs behind the dams to carry young fish downstream, so they have to use precious energy to swim. Since the 1970s, a lot of effort, and hundreds of millions of dollars, have been put into helping smolts down the river. The most important dams have been fitted with elaborate screen systems to catch the smolts and divert them around the turbines and spillways. This is just one part of one of the 42 fish screens at McNary dam. The system works by directing the young fish up and away from the turbine intakes, and into a separate channel inside the dam. The channel leads to a special fish

processing facility. At the heart of the system are stainless steel screens that create a cushion of water to guide the fish. This is sophisticated -- and expensive -- engineering. McNary's screens alone cost 17 million dollars.

ALAN ALDA The water's hitting that screen.

DAVE COLEMAN Correct.

ALAN ALDA And its backing up a little bit.

DAVE COLEMAN Yes, and the fish are actually tumbling kinda back with their tail to the stream.

ALAN ALDA Why are the fish going backwards?

DAVE COLEMAN They are not really swimming to the ocean, they're just flowing with the current heading to the sea.

ALAN ALDA Ah, is that how they ordinarily go down?

DAVE COLEMAN Yeah...and the big spring run off, just mother nature takes care of them and flushes them.

ALAN ALDA You know, you could have asked me a million times I would have never have said they go backwards to the ocean. I mean that just...

ALAN ALDA What's happening here?

DAVE COLEMAN We're closing down the shop. They've got work to do. You're OK. If you don't move you're OK. You're OK if you don't move.

ALAN ALDA (NARRATION) Dave Coleman took me down inside the dam to see the channel where the separated fish end up.

DAVE COLEMAN We're entering the juvenile collection channel...

ALAN ALDA (NARRATION) We're here at the height of spring runoff, when they're collecting 350,000 smolts a day. The screens are not perfect -- they catch 75% of some species, but only 30% of others.

ALAN ALDA Don't they get shaken up a lot? That's really going very fast, isn't it?

DAVE COLEMAN That's engineering by the greatest fish design engineers in the world and that's perfectly acceptable.

ALAN ALDA (NARRATION) The quarter-mile-long channel is just the beginning of a peculiar journey for the young fish. I saw my chance to check if they really were going backwards.

DAVE COLEMAN You can start seeing some of the fish right here. There's one, there's one, there's one.

ALAN ALDA Oh yeah, now I can see them.

ALAN ALDA (NARRATION) Dave was right. They do go backwards.

ALAN ALDA You know what it is? When you go some place in the car, you can't find your way back because the scenery looks different in the other direction. They go backwards, so they see what it looks like coming the other way, so they know where to go.

ALAN ALDA (NARRATION) Actually they head into the flow because that gives them maximum control. The diverted fish emerge from the dam in this pipe, which loops down into the fish facility. A sample is anesthetized so they can be identified and counted. The Columbia has 5 salmon species, and 2 closely related steelhead. Hatchery and wild fish are counted. And now the smolts' journey is about to get more peculiar. For 15 years, about half the smolts in the Columbia system have been given a ride downstream, courtesy of the Army Corps of Engineers. They're loaded into specially built barges, a quarter of a million fish at a time, and driven down river in luxury -- safe from turbines, spillways, predatory fish and hungry birds. It takes a couple of days for smolts to get down below the Bonneville dam, the last on the river. Almost all survive the barge trip, and a higher proportion of barged fish return as adults, compared to those that came down the river on their own. But the return rate for both groups is very low, only a percent or two -- much less, it's believed, than made it back historically. There's a net system used to count smolts as they leave the river. One theory is that both groups are in poor shape as they go out to sea -- the barged fish because they have to cope with salt water before they're ready, and the others because their river journey has been so stressful. Many smolts heading out to sea -- still backwards -- have electronic tags that the net system detects. They're called PIT tags -- microchips, containing unique ID numbers. Once implanted, the tags stay with the fish for life. In the last decade more than 5 million have been used on the Columbia, and they've revolutionized research. PIT tags have told us about the effects of barging -- these fish are part of the continuing barging study. They've told us about the effects of turbines and spillways. They're a sophisticated tool to match the technology that -- to the dismay of environmentalists -- is now an integral part of the life of Columbia river salmon.

MIKE SCHIEWE These are fish that have been collected up on the base of the dam, and through a series of pipes...

ALAN ALDA (NARRATION) I'm at the McNary fish facility with Mike Schiewe, the biologist who runs much of the research on the effects of technology on fish.

MIKE SCHIEWE This is the juvenile fish separator, and this is where the different size juveniles are sorted.

ALAN ALDA (NARRATION) The facility is a maze of pipes and channels, equipped to detect PIT tags and automatically divert a fish that's part of a study, for example.

MIKE SCHIEWE If it were to detect a fish, what would happen is...

ALAN ALDA Ha, ha, ha...

MIKE SCHIEWE Then the fish just drops down below.

ALAN ALDA It's like an amusement park.

MIKE SCHIEWE Oh it is yeah. It's quite amazing. Let me do that again.

ALAN ALDA So what, the fish goes through here?

MIKE SCHIEWE Yes.

ALAN ALDA And the tag is read by the computer, and that gate opens that fast, so by the time the fish gets there the gate's open.

MIKE SCHIEWE That's correct. It's an amazing system. It's what the computer age has brought to fisheries.

ALAN ALDA (NARRATION) The computer age arrived on the Columbia just in time to help study a crisis. In the O60s and O70s, four new dams were built on the Snake river. Now Snake river fish had twice as many dams to pass to reach the ocean. Four salmon stocks began to collapse. They and eight more stocks elsewhere in the system were declared endangered. For West Coast salmon today, the count is 26 endangered stocks -- half those that are left. The response at the eight Snake and Columbia dams was the measures we've seen -- fish screens, spilling water and adjusting the turbines. Even so about 10% of smolts are lost at each dam. Bypassing with barges helps make up some of the losses.



ALAN ALDA Does the fact that 10% die lead you to think that maybe the dams are stressing the fish, and that's why a lot of that 10% may be perishing?

MIKE SCHIEWE Well, I don't think there's a question that fish would survive at a higher rate without the dams. We've made major improvements, I think, in the system and how it operates in the last twenty years. The survival now for the yearling fish is roughly fifty to sixty percent through the whole system. The eight dams coming down from the Snake River to below the Bonneville dam at the Pacific Ocean. This compares with what the survival was about twenty to thirty years ago when there were only four dams in place. But we hit a real low point in the 70s when more dams were coming on line, when the operations were not as safe for fish. So we're making progress in that regard.

ALAN ALDA (NARRATION) We're heading back to where we picked up the smolt that came through the turbine. It's a measure of how unnatural things are that there is a program to reduce the number of predators that hunt salmon smolts. Smolts make easy prey in the reservoirs where there's no shelter, and also as they emerge, disoriented, from the turbines and the spillways.

TOM FRIESEN Be careful not to touch the water when the generator is on.

ALAN ALDA Okay.

TOM FRIESEN It might give you a little buzz.

ALAN ALDA Don't touch the water while the generator's on. Liable to get electrocuted.

ALAN ALDA (NARRATION) The electric shock stuns all the fish around the boat for a few seconds.

TOM FRIESEN These are American shad. They're a game fish introduced from the East Coast.

ALAN ALDA (NARRATION) We're going to pick out the three important smolt predators.

TOM FRIESEN Those are all large scale suckers. That's what we're looking for. Got a keeper. This is a walleye.

ALAN ALDA Now, that's a predator?

TOM FRIESEN That is a predator.

ALAN ALDA (NARRATION) Back at the dock, the unfortunate walleye showed us where about 12 million smolts a year end up -- 6 percent of the smolts in the system.

TOM FRIESEN That is a fish that just popped out of his stomach

ALAN ALDA (NARRATION) Then Tom Friesen did a surprising thing.

TOM FRIESEN Back in the water.

ALAN ALDA Now if he's a predator why do you release him? Because he's going to be able to get more salmon right?

TOM FRIESEN Right, walleye are pretty highly regarded game fish so if we just removed all we could, there would be people upset that they couldn't fish for walleye anymore. And smallmouth bass are the same way.

ALAN ALDA (NARRATION) So our smallmouth bass was also released. But not so the third fish. There's a million or more of them, they're not game fish, and fishermen are paid to catch them.

TOM FRIESEN Northern pikeminnow...

ALAN ALDA (NARRATION) It's hard to know how much effect this all has on how many adult salmon eventually make it back from the ocean -- and that's the case with virtually everything we're doing on the river. This is the fish ladder at McNary, and right now it's full of returning adults. Last year was pretty good too, with a million returns. That's good news, but it's confusing. They got down to only a quarter of a million returns in the 1990s, just when all the efforts to help juvenile fish survive the downstream trip should have been paying off. So there are still big unknowns out at sea.

ALAN ALDA These are big guys aren't they?

MIKE SCHIEWE Ah they're beautiful fish. These are summer chinook. They've been down through the system as juveniles and been out to sea for 2, 3, 4 years and now they're coming back.

ALAN ALDA Do you count every single fish that comes through?

MIKE SCHIEWE Every fish that comes through the ladder comes by this window.

ALAN ALDA So this is where they come in?

MIKE SCHIEWE Yes, it is.

ALAN ALDA So you see, what... you narrow it down so that you only get one at a time?

MIKE SCHIEWE Exactly. Now that's a shad, big chinook, another chinook.

ALAN ALDA That ladder looked like a pretty long structure. Is...does that put them through more work than they would ordinarily have to go through to get up the river if there weren't a dam they had to climb up?

MIKE SCHIEWE Well, before the dams they definitely climbed the falls and so they went through those kinds of structures. Sometimes they have a little trouble finding the entrance to the fish ladder but once they do, they move through it fairly quickly. Fish ladders are one of the real success stories of salmon migration.

ALAN ALDA (NARRATION) As the observers do the count, they distinguish between wild and hatchery fish. Here's a wild chinook, with its rear fin intact And here's a hatchery fish, with the fin missing. Overall about two thirds of adults are from hatcheries. Hatchery fish saved the salmon fishing industry in the Northwest, but one concern is that hatchery and wild fish may interbreed. The remaining wild stocks could begin to lose their unique adaptations. Some wild stocks are now down to a few thousand returning adults. With some, only half of one percent of the smolts that went to sea make it back. So there may be a million salmon in the Columbia, but some may still be headed for extinction. It's vital, says Mike Schiewe, to preserve the variety of salmon stocks that we still have left.

ALAN ALDA Its not just saving some salmon, its trying to save as many kinds of salmon as you can. Otherwise, you're just leaving them open to the elements and they could get wiped out anytime. We couldn't predict when, huh?

MIKE SCHIEWE No, that's exactly right. You're buying insurance against variations that are bound to occur. Populations of fish rise and fall over the years. And this diversity of different life forms utilizing the habitats and the food resources in different ways allow the salmon to persist at the levels that they do. So saving the diversity of salmon is every bit as important as just talking about numbers.

DOWN EAST -- THE EXTINCTION VORTEX

ALAN ALDA (NARRATION) We're heading up the Narraguagus River in Downeast Maine. For the biologists we're with, this rugged and beautiful country is in the grips of a catastrophe. This river, along with seven others nearby, is losing its last few wild Atlantic salmon - and they don't know why. It's spring runoff, and the traps in the river have been set to sample the two-year-old salmon smolts heading downstream to the Atlantic ocean. Every year the numbers go down -- just 2,000 this year, one tenth of the numbers in the past.

JOHN KOCIK One American eel.

ALAN ALDA (NARRATION) The traps catch everything. The smolts they are looking for are wild - descended from wild parents that know only this river.

JOHN KOCIK One salmon smolt. OK we've got two smolts.

ALAN ALDA (NARRATION) As in the Pacific Northwest, hatchery fish that are not adapted to a particular place are not counted as wild. RESEARCHER Dorsal score?

JOHN KOCIK Zero.

ALAN ALDA (NARRATION) The last wild Atlantic salmon in the US are confined to 8 Maine rivers, and all 8 stocks are officially endangered. RESEARCHER Weight?

ALAN ALDA (NARRATION) The numbers are incredibly low. In 2001, less than 150 wild adult fish returned to all 8 rivers combined. The numbers of smolts heading out are correspondingly low - for example, in the nearby Pleasant River.

JOHN KOCIK Our crew here is...I think they're really feeling the numbers going down. It's not just looking at them on paper. Having been here last year, handled 60, 70 smolts a day, this year we haven't even broke twenty smolts a day.

ALAN ALDA (NARRATION) Things got this way in the Northeast for the same reasons the Columbia salmon declined. Atlantic salmon were once abundant everywhere north of the Hudson River. But change came with colonization. There was large-scale fishing. Thousands of dams were built to power mills and factories. The Connecticut River, a major salmon habitat, was completely blocked. Logging, agriculture and water pollution all took their toll. Throughout the Atlantic salmon's range, from Canada to Russia, the same processes were underway. It's now extinct in half the 50 or so major river systems it once inhabited. Healthy populations remain in parts of just four countries. The big concern is that numbers have continued to plummet, even after heavy fishing in the salmon's ocean feeding grounds off Greenland was stopped 15 years ago. In

Maine, research is going on to try to understand the causes. They're going to implant an acoustic transmitter in a smolt, and then follow it down the river and out into the Gulf of Maine. At the start of the research, they tested the effects of the implant and, surprisingly enough, neither the fish's behavior nor its health seem to be affected.

KEN BELAND The body cavity starts healing almost immediately post surgery. Within a very short period of time, everything will be back to normal and the fish'll be on their way into the river and then out to sea.

ALAN ALDA (NARRATION) Once the smolt has recovered from the anesthetic, it's released.

JOHN KOCIK OK, we got a good signal on him.

ALAN ALDA (NARRATION) They follow the fish for a few hours to make sure it's healthy and the system's working.

KEN BELAND The signal's really strong. The fish is quite close to us, probably within forty or fifty feet, right up against the river bank.

ALAN ALDA (NARRATION) Right now we know surprisingly little about the life of an Atlantic salmon smolt.

KEN BELAND What we're hoping is, by understanding where mortality may or may not be occurring, is there a single smoking gun? Are there a number of factors each of which contributes a little bit? And in total, we're really sort of writing a missing chapter in the life history book.

ALAN ALDA (NARRATION) An array of 20 remote receivers is set out in the river and the ocean just offshore. They'll record the signal if the fish passes. So far they've tracked 400 smolts, and only half have made it out to sea. That's as bad as the smolts that have to get through 8 Columbia River dams, and it's a surprise. But there is a pattern emerging.

KEN BELAND It's a little suspicious that we're having more mortality than expected and it seems to be occurring disproportionately in or about the area where they first hit salt water.

ALAN ALDA (NARRATION) Research in Norway suggests that young salmon from acidified rivers have trouble regulating salt. So New England's notorious acid rain may be, if not the smoking gun, at least one of them. In the 1980s the Pleasant River had a couple of dozen adult returns a year. It's just a few now, in some years none. It's called an extinction vortex - not enough breeding adults to

stay ahead of the losses. As a last desperate measure, biologists are trapping and removing smolts, to be raised in captivity. This is the strategy being tried with the California condor, for example.

RESEARCHER Yup. Smolt.

ALAN ALDA (NARRATION) The young fish has the special adaptations that suit it to just this river. As in the Columbia, the only way to keep wild fish in the river is to preserve each unique stock.

JOHN KOCIK There are differences between this river and the Narraguagus River right down the road. Differences in rearing habitat that we think, over time, have led to local adaptations. So it's important to put fish back into the river their parents came from.

ALAN ALDA (NARRATION) Young fish from 6 of the 8 Maine rivers have now been removed for captive breeding. Genetic tests have confirmed that each river's fish are distinct. They're kept separately, and they're only bred within their own group. This is exactly what salmon hatcheries in both the Northeast and Northwest have not done, which is one reason hatchery fish have low survival rates. Their genetic adaptations have been mixed up, so they don't know how to use particular places. A puff of air helps this Machias river female release her eggs. She was brought here as a 6-inch-long smolt, 3 years ago, so now she's ready to breed. Her mate has the same impeccable credentials. The eggs hatch in spring, as they would in the river, and in about a month they're one-inch-long fry. These are what will go back into the wild, to the specific river their parents came from. We're on the Machias river for spring fry stocking. This river also gets very low or zero adult returns.

RESEARCHER Run her all the way through, Dan.

ALAN ALDA (NARRATION) River-specific breeding and fry stocking have been in operation in 6 Maine rivers since the mid-1990s, with over a million fry a year distributed.

RESEARCHER Why don't we swing close to these little rocks over here and I'll put out a few.

ALAN ALDA (NARRATION) It's no exaggeration to say that whether or not wild Atlantic salmon have a future in the United States depends on the river-specific program. If it doesn't work, there's very little chance that the species can recover on its own. The fry hang out in the river for two years, until they're ready to go to sea as smolts. Then they catch a ride on the spring runoff, like the Pacific salmon, and head out to Greenland to feed and grow. Two years later the

survivors should be back in the same river to mate, and the cycle begins again. We're back on the Machias river, in the fall of 2000 - five years since the river-specific program geared up on this river. It's the first year we could see a boost in the number of returning adults.

BETH BOISVERT Do you know how many there were here last year or the year before?

ERNIE ATKINSON The year before I counted ten or eleven in here.

ALAN ALDA (NARRATION) We're looking for salmon nests, or redds, in the gravel.

ERNIE ATKINSON There's no redds, it's kind of surprising. This is a really nice spot here, you have the ideal, or the classic type spawning gravel here.

BETH BOISVERT Here's one here.

ERNIE ATKINSON There's a redd?

ALAN ALDA (NARRATION) The patch of disturbed gravel is easy to spot. Each female typically builds two redds during the fall spawning season, so it's not hard to estimate adult numbers by counting redds. This disturbance in the gravel is where the female flapped her tail to create a pile of stones to cover the eggs just downstream.

BETH BOISVERT Zero, five, eight, nine...

ALAN ALDA (NARRATION) They note the GPS coordinates of the redd, so they can come back to check how it does. The Machias had 23 redds in the year 2000, representing 2 dozen adult fish - not bad, but not a clear improvement. Numbers are unchanged or still declining in the other Maine rivers. So we don't yet know if the river-specific program is going to work. Wild salmon are in trouble everywhere, but there's no shortage of salmon. In the last 20 years, salmon farming has become a major industry, with more than 600,000 tons of fish produced a year. 80 percent is raised in Norway and Scotland, while Maine has a small industry. Small is relative, though. There's a hundred tons of Maine farmed salmon to each individual wild Maine fish. Everywhere, salmon cages are usually very close to salmon rivers. Biologists say the cages that give us cheap salmon are nothing but trouble for the wild fish. One problem is disease. In Norway, for example, they found that young wild salmon can pick up a lethal dose of parasites as they pass near farm cages, on their way to the ocean. Salmon farmers check and treat their fish, but you can never be perfect. Another problem is escaped fish. Fish escape everywhere. Here in Norway an astonishing 1

million fish a year get out. Many run up the rivers and compete with wild fish for food and spawning sites. But Norwegian research shows the offspring are much less successful than their wild neighbors. On this river, scientists have developed an experimental system to remotely detect escaped farmed salmon. It's based simply on how the fish look.

TORE EIDE What we have built here is the monitoring unit, with a transparent channel that the salmon has to swim through. And we're using five mirrors and a video camera to create an image with both a side view and a top view of the fish.

ALAN ALDA (NARRATION) The video pictures are monitored a hundred yards from the fish ladder. A returning adult is about to get its picture taken.

ODD-IVAR LEKANG [In Norwegian] Here it comes.

ALAN ALDA (NARRATION) The system takes a frame of the top and side views of the fish, then makes a simple outline. The basic idea is that wild fish - like this one - are literally in better shape. They're slimmer, and their fins are sharper and less worn.

TORE EIDE If you look at the left image of the wild salmon, you can see that the fins are very nice. The dorsal fin is more pointed than the farmed one, which shows signs of wear on the fins.

ALAN ALDA (NARRATION) It's the same with the tail. Wild fish on the left, farmed on the right. Farmed fish get bitten and knocked around in the crowded cages. They also don't get much exercise, so they're fatter. The system's software makes a series of measurements on each fish's profile, then compares the results to typical values. It's right more than 98 percent of the time. On this river - one of the healthiest in the world - only about 2 percent of its 5,000 returning adults are farm escapees. It has no nearby farms, but other Norwegian rivers get up to 90 percent farmed fish. The danger is that interbreeding will steadily dilute the special local adaptations of native salmon, until there are no fish left that know how to use a particular river. That is a real risk here in Maine. There have already been large farm escapes, and at some point the tiny remaining number of wild fish could simply get swamped. The challenge for scientists is to fully understand why Maine's salmon are still declining. That applies equally to many rivers in Canada, Scotland and Norway, which until recently were regarded as healthy. If the challenge is not met, then the future of wild Atlantic salmon is not bright.

ROCKING THE BLUEFIN BOAT



ALAN ALDA How long have you been coming out here with the fishing boats?

MOLLY LUTCAVAGE I started on tuna in 1993.

ALAN ALDA (NARRATION) It's early on a summer morning, and I'm going fishing with Molly Lutcavage, a marine biologist. We're licensed to catch giant bluefin tuna, but we're also licensed to attach satellite trackers to them - and there aren't many charter boats that can say that. Fishermen have been leaving this harbor for over 300 years, but it's only in the last 30 that anyone's gone after giant bluefin.

ALAN ALDA How do you know when you're near a place where you're liable to catch a fish?

COOKIE MURRAY Sometimes you see the fish jumping or see them on the surface. Sometimes there's a lot of bait or birds, maybe.

ALAN ALDA (NARRATION) We're heading out to the giant bluefin's summer feeding grounds. In the 1970s a gold rush developed for bluefin, which are in demand for sushi. They can weigh up to 1500 pounds, so a single fish may be worth thousands of dollars. The record is 173,000 dollars for a fish caught near Japan. Fifty miles out, we begin to see dolphins and whales. It means we're in the right area.

MOLLY LUTCAVAGE We often actually track tuna that are following whales. They sometimes accompany fin whales or humpback whales. So most fisherman are very pleased to see the fins of the whales, because that's a sign that the tuna may be there as well.

ALAN ALDA (NARRATION) Bluefin are ocean travelers. We know they feed here in summer, and spawn in the Gulf of Mexico in spring. Across the Atlantic we know they feed off the coast of Africa, and spawn in the Mediterranean. We're on the Italian island of Sardinia. This is the village of Carloforte. Everyone's shown up for a celebration of spring. The 500 pound giant bluefin showed up to spawn, but the fishermen's nets were waiting - as they have been every spring for maybe 2000 years. The traditional "mattanza" - it simply means the killing - is celebrated in many Italian fishing villages. Many Mediterranean countries have traditionally fished for tuna, but with the coming of industrial-scale fishing in the 1960s, traditional gave way to modern. Catches shot up, and quotas were imposed -- on both sides of the Atlantic. Back in the Gulf of Maine, we've had a strike on one of our lines. The quotas were based less on bluefin biology than on how many had been caught in the past. Now biologists like Molly are trying to build up a

scientific understanding of bluefin. High tech tags like this one are one of the key tools. Our bluefin's putting up quite a fight.

MOLLY LUTCAVAGE It's about 150 pounds. So it's a small one.

ALAN ALDA (NARRATION) Our 150 pound fish is four years old and half the legal size for sale. It won't spawn until it's reached 8 years. The official estimate is that there are up to 20,000 tuna over spawning age in the western Atlantic. The tag has to be anchored into the strong tendons around the dorsal fin.

MOLLY LUTCAVAGE Wait for the shot. Nice one.

ALAN ALDA (NARRATION) The tag was placed perfectly. But then we decided the fish was likely to be in poor shape after the long struggle. So the catch was brought in to end up on the table. One non-commercial keeper per trip is permitted. Over the last 5 years, the boat has tagged about 50 fish for Molly. The tags are designed to record where the fish go, then at a pre-set date automatically release from the fish, float to the surface and upload their data to a satellite. They're called pop-up tags. Pop-ups have revolutionized research on ocean travelers like bluefin. We no longer have to make guesses about their habits, based on where they happen to get caught. But you still have to catch a fish before you can tag it, and for that scientists like Molly depend on fishermen. These guys don't have to take Molly out for free, or stay out after they've reached their 2-fish-a-day bag limit. They see the value of good information. They know in the long run, it's the only thing that will preserve bluefin -- and jobs. Soon after we caught our fish, we almost literally ran into another boat that Molly works closely with.

MOLLY LUTCAVAGE Hey. We got it. We got one.

ALAN ALDA (NARRATION) Actually they were just dropping off some fresh bread. This is a commercial tuna boat, that uses nets. They're interested in good science too.

MOLLY LUTCAVAGE Thanks for the bread. Good luck. See you guys! It's a vital part of our research program is the fisherman partnership. And not just recreational fisherman but you can clearly see that the commercial fisherman here have been the backbone of our studies for years. And they've really given us our primary fishing and tagging platforms. They've done it, for the most part, on a strictly voluntary basis. And they've brought all their expertise to the table. And we didn't have those skills and we couldn't have done this work without their input.

ALAN ALDA (NARRATION) Molly first began working with tuna fishermen in 1993. They were convinced, based on what their spotter planes saw, that there were more fish out here than the official estimates. Of course fishermen always make claims like that, but here was a chance to really check out their story. Molly and her colleagues decided to simply count the tuna, using aerial photographs and a mapping system that they set the spotter pilots up with. Every summer for 5 years the pilots handed in their pictures, and Molly's team laboriously counted every fish they could see. The result surprised even the fishermen. There were huge numbers. On one single day, 17,000 fish were counted just in the Gulf of Maine - about the same as the official estimate for the entire western Atlantic at the time. But could they have counted the same fish in different places? And also how many fish might have been out of sight, below the surface? So next they marked fish with acoustic tags and followed them. The aim was to measure tuna swimming speeds -- to eliminate double counting -- and also to assess typical diving behavior.

MOLLY LUTCAVAGE We found out that they travel anywhere from 24 miles to say 30 miles in a single day. And that they spent less than ten percent of their time in a single day at the surface where we can see them.

ALAN ALDA They spend less than ten percent of the time at the surface? So does that mean, on the day that you photographed seventeen thousand fish in one area--in one part of the Atlantic, that that might have only, the chances were pretty good that that was only ten percent of the fish in that area?

MOLLY LUTCAVAGE We don't exactly know what percentage...

ALAN ALDA Or do they all go down at the same time?

MOLLY LUTCAVAGE You're absolutely right. It showed us that that represents only a small portion of the population that's going to be in the area. Because we know that we're only seeing a tiny slice of the water column at the surface.

ALAN ALDA (NARRATION) We're out on the commercial tuna boat we saw earlier. Molly's team now estimates that there are up to 65,000 giant bluefin just in the Gulf of Maine. The research headed off a move to get the western Atlantic quota cut in half. She was popular with fishermen, but environmentalists said she was irresponsible. The western Atlantic quota is about 10,000 large fish a year, which it's believed is sustainable. This boat's quota is 50 tons - about 200 large fish. The fishermen are happy to help Molly with her pop-up tag research, even though letting some fish go means it takes longer to fill their quota. In the last 5 years this boat has tagged nearly 100 fish - more than half the tags put out by all of Molly's collaborating boats. The last few fish in the net find they're not going to end up as sushi. It's probably fair to say that western Atlantic bluefin fishing is

under control. It's well regulated and catches are reasonable. Things are different on the other side of the ocean. We're back in Sardinia, where Italian scientists are preparing to take advantage of the mattanza to tag some bluefin with pop-ups. The bluefin quota in the Mediterranean and eastern Atlantic is enormous and probably unsustainable - 20 times the west's. That's because of history and politics, not science. For years catch quotas were based on the assumption that eastern and western bluefin are separate stocks. But scientists from both sides are now telling regulators they have to think again. So far on this side they've got results from 23 pop-ups. Here are all the results to date - Molly's, the Italian group's, and also those from a Stanford University group that tagged fish off North Carolina. The clear evidence of the pop-ups is that tuna go all over the place - sometimes right across the ocean, and across the theoretical dividing line that's used to separate eastern fish from western.

ALAN ALDA Has this radically changed what we know about tuna?

MOLLY LUTCAVAGE It's absolutely radically overturned what was thought about what bluefin did.

ALAN ALDA Oh, in what way? To what extent?

MOLLY LUTCAVAGE Well, I suppose the biggest point is that the fish are mixing at a much higher rate than was ever believed. So we immediately learned that these fish are not following the rules that everyone laid out for them. And that there's no line down the middle of the ocean and that they hit and they turn around. So that was an eye opener to, I think, fisheries biologists and managers, because they realized that what happens on one side of the ocean, effects what happens to the fish and the population on the other side.

ALAN ALDA (NARRATION) So it could be that large catches in the east are being fed by good conservation in the west. If that's so there'll be political problems down the road. The pop-up results offered another eye-opener. Many fish ended up, in the spring, in the wrong place.

MOLLY LUTCAVAGE The giant fish that we assume were going to spawn, after they got nice and fat and ready to go, they should have been in the known spawning areas during the spawning period. And that would be the Gulf of Mexico or the Med. And for the first three years in a row, none of the giant bluefin that we tagged here were in either known spawning area during the presumed spawning period.

ALAN ALDA So that suggests that there's some area that you haven't identified yet.

MOLLY LUTCAVAGE It raised the question, Is it possible that bluefin are spawning elsewhere?

ALAN ALDA Or do they just take a break?

MOLLY LUTCAVAGE Or do they take a break?

ALAN ALDA It's amazing how much there is to learn about these. You've been studying them carefully for years.

MOLLY LUTCAVAGE Absolutely. I think that our independent tagging studies have only raised more questions about what bluefin do for a living.

ALAN ALDA (NARRATION) You can be sure that Molly and her fellow scientists are going to be raising questions about bluefin -- and about salmon -- for a while. Regulators are going to be uncomfortable with the process, and fishermen may or may not welcome the results -- but the bluefin and the salmon could at least come out of it with a future.

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