

**QUEST #604**  
***Aquaculture: Down on the Salmon Farm***

(NARRATOR)

It's the most popular seafood in America – fresh Atlantic salmon. We like it because it's healthy and tasty, but we're a bit ambivalent about it coming from fish raised in crowded pens on industrial farms.

(Erick Swanson)

Used to be 35,000 fish within a family farm. You get that in one cage today. You know, family farm today is about 350,000 fish.

(Narrator)

Family fish farmers like Erick Swanson are a disappearing breed. Multinational companies are into salmon farming, or aquaculture, in a huge way. Ingenious ways are being devised to get salmon to restaurants and markets far removed from the coastal waters that produce them. Is it now a stretch to call all of it, “fresh” Atlantic salmon?

(Narrator)

Fish farming is supposed to take the pressure off failing wild fish stocks. But is aquaculture actually creating more problems than it's solving?

(Fred Whoriskey)

It's basically a standard breeding program that animal breeders have used for thousands of years. And what you're trying to do is favor the genetic changes that make these fish superbly adapted to the cage culture environment – they produce all the benefits you want – the fast growth rate, a uniform growth rate – all the things that a fish farmer needs to compete in a viscously competitive global market. But that's not what nature is looking for.

(Narrator)

And what about the reported high levels of PCBs and dioxins in salmon?

(David Carpenter)

The levels of PCB's in farmed salmon are higher than almost any other food stuff.

(Richard Langan)

...if you listen to the nutritionists... they said the health benefits of eating salmon far outweigh any of the risks that are posed by those levels of compounds in the salmon.

(Narrator)

We've had 6,000 years worth of trial and error to figure out how to raise crops on land.

This young industry has spent 30 years addressing one controversy after another. Scientists are racing to come up with innovations to help fish farmers deal with pollution, disease and other problems. Some are convinced land-based systems are the answer. Others want to move it all offshore.

(Neal Pettigrew)

...the flow is much stronger, the tides are stronger and there's a great deal of flushing and dilution and so from that point of view the environmental impacts become minimal.

(Inka Milewski)

Open ocean aquaculture in my view represents an old mentality and that is treating the oceans like a giant toilet. And I don't think that the public would find that acceptable.

(Narrator)

It's been a steep learning curve for everyone involved in this industry, especially the salmon farmers of northern New England.

They may have a good track record, but their industry has a bad name.

That's makes it pretty tough on those trying to do it right.

(Erick Swanson)

I'm very determined to remain as a small family business. But it's getting more difficult all the time.

(Linda Greenlaw)

Hi I'm Linda Greenlaw. As a commercial fisherman, I've always been curious about the farm raising of fish.

Like a lot of people I have mixed feelings about aquaculture. As a consumer, I certainly enjoy a beautiful fresh, reasonably priced, salmon like this.

But as a fisherman, I'm concerned about the experimenting going on with the raising of halibut, codfish and haddock. It makes you wonder, what's next?

(Narrator)

When aquaculture first came on the scene along the Gulf of Maine in the 1980s, many jumped at the chance to try fish farming. Erick Swanson was one of them.

What he never imagined was that he'd be caught up in one storm of controversy after another. And his business would undergo so much change.

Like most kinds of farmers, Swanson quickly saw it all - from brief flings with success to the cold, harsh lessons caused by disease or things even more mysterious.

(Erick Swanson)

Within 48 hours they were gone, it was over. When you got it you got it bad, it usually doesn't affect just a cage or you know part of a cage it usually just takes them.

(Narrator)

In February 2003, Swanson was wiped out in a matter of days.

All 270,000 of his fish died from something only marine biologists would know about... "super chill" which happens when ocean fish are exposed to ice.

It's not even something fish farmers can see coming.

Even microscopically small ice crystals in the water can be lethal if they come into contact with salmon.

Swanson has one of the few remaining family-owned fish farms left on the Maine coast.

(Erick Swanson)

Used to be 35,000 fish with a family farm. You get that in one cage today. You know, a family farm today is about 350,000 fish. So you get much bigger volumes that the plant would run at times, 24 hours, and that's how you get the economies of scale to be able to compete with countries like Chile.

(Narrator)

These days Swanson spends a lot of time just trying to stay afloat in an industry reeling in controversy and problems to solve.

When he started Trumpet Island Salmon Farm, he owned the hatchery, pen operation and processor. Now Swanson's just a fish farmer.

(Erick Swanson)

That's about a 4 \_ kilo Penobscot Atlantic Salmon. Let's get him back in the water before he loses patience with me.

(Narrator)

He buys one year old smolts from an egg factory and a fry hatchery, and spends a year or more raising them to market size. When they're ready to sell, a barge from New Brunswick pulls up and begins processing them right on the water.

Once on board, the salmon are run through a percussion stunning machine. Then their gills are slit and they're put on ice until they're unloaded at the processing plant in Canada.

One thing has hasn't changed for Swanson. His faith in fish farming.

(Erick Swanson)

The truth is that aquaculture is the wave of the future. We can't survive without farming. Just as we turn to farming and terrestrial food supply – can you imagine trying to live off the land today eating nuts and berries, you know, foraging?

(Narrator)

Even though traditional aquaculture began in China thousands of years ago, large-scale aquaculture is barely 30 years old in North America. Much has happened in those three decades.

Raising hundreds of thousands of fish in floating pens has turned salmon from a seasonal to a year-round commodity.

More than half of the world's salmon is now farmed.

Farm-raised salmon sells for about \$4 to 5 a pound, about a third of what some wild salmon goes for.

Even though it's now at the mercy of international market fluctuations, it's the fastest growing form of food production.

(Erick Swanson)

We were doubling production it seemed every other year, and the worldwide growth of salmon farming has been phenomenal. It went from virtually nothing 10 years ago, not even making the top 10 seafood list to the most popular. Now it's the most popular food item in the United States, for seafood. Alaska used to be the major producer of salmon in the world. Now they're further down the scale as farm salmon is taking that over.

(Narrator)

Labels have changed too.

"Fresh Atlantic salmon" now means farm-raised salmon.

The meaning of "fresh" has evolved too.

Order salmon today and you may get a frozen form of farm-raised fish.

(Bob Peacock)

It's basically filleted, skinned and boned, portioned and frozen within 30 minutes from the time that it comes out of the ocean. So we have a really quality product because we control the entire handling of the fish from one end to the other.

(Narrator)

Bob Peacock is a fifth generation fish processor from Lubec.

Today, plants of his around the world are on the cutting edge of the farmed salmon explosion.

(Bob Peacock)

The result is we have a really premium frozen product that's flash frozen. It takes anywhere from 12-14 minutes to freeze the core temperature of the fish from 35-40 degrees down to minus 20. It's so fast that there's no cellular destruction and that's the key. Ice crystals don't form inside the cells so when the product thaws out, those crystals don't break the cell membrane. You don't get the purge in the package from the product and it's just like the day it was packed.

The thing that we can assure the chef is the quality and there's no waste because he only needs to thaw out what he is going to cook that day.

(Narrator)

Fresh Atlantic salmon is being farmed in waters all over the world, including British Columbia, Australia, and Chile.

(Fred Whoriskey)

We've grown to an industry that is well beyond what anybody considered and because of that, the unexpected and unintended impacts of the industry were never perceived at the time that the promotion was occurring.

(Narrator)

Up until the 1970s, the oceans were seen as infinitely abundant, capable of providing an endless supply of fish to humans.

That's not the case anymore.

Bigger boats and advances in fishing technology led to the collapse of many fisheries.

By some estimates, 90 percent of the large species have been fished out.

Also among the imperiled - wild salmon.

Conservationists remember the first warning signs about wild salmon 30 years ago.

(Fred Whoriskey)

At that time, the Atlantic salmon that migrated out to the Atlantic Ocean for their feeding grounds off of Greenland were passing through international waters and being intercepted in those international waters by fleets of convenience flags that were gill netting them to a great extent... It was an unchecked fishery. What was happening was the numbers coming back to our North American sites were declining rapidly and we thought they were going to go biologically extinct from this over fishing. They could not be controlled cause there were no conventions. No international mechanisms to control it.

(Richard Langan)

If we go back about 20 years, I was a commercial fisherman. There were a couple of things I took away from my commercial fishing experience. One is that we were catching way too many fish, and it wasn't going to last. And at that time, 1980, aquaculture was something very, very new in this country. But I'd heard of it and I said this is something worth looking into.

(Narrator)

At first, farm-raised salmon was considered a way to take the pressure off wild stocks so that they could rebuild.

But as wild salmon continued their spiral downward, aquaculture was confronted with its first major crisis.

It had barely established itself when conservationists started fearing the worst: farmed salmon could spell the end of wild stocks.

(Fred Whoriskey)

When you have these domesticated salmon from the farms getting free into river systems and spawning with the wild fish, they contribute to what's called an extinction vortex. You are basically driving away successful reproduction and contributing to declines to populations that could lead ultimately to their extinction.

(Pat Keliher)

I would place aquaculture as a medium threat.

...there are over 40 threat categories with up to 180 subcategories. They are wide-ranging from water quality, pH issues within many of the rivers, especially the Downeast rivers, issues relating to runoff.....climate change, global warming. It's a very diverse threat, threats that are challenging the recovery of Atlantic salmon.

(Narrator)

In the early years of the industry, there was no doubt that farmed salmon were escaping their pens.

Before the advent of special predator nets, seals and other predators would chew through nets allowing salmon to escape.

(Erick Swanson)

They spend their whole lives looking for a window. You know if a seal chews a hole in the net, it's amazing how quick they'll just file right up and out they go.

In the early days of the industry we had a lot of small losses, you know, get a small hole in the net or things would happen, the crew wasn't trained as well, we didn't have our procedures down as well... So we had trickle losses, nickel and dime stuff. As we improved all that, it improved to the point where now you don't get the nickel and dime losses, you get the big ones, you know, when a bad storm event comes through and there's a massive break up of the cage system. You know, you have 150,000 fish get away instead of 50.

(Fred Whoriskey)

In a sense it is a good issue to be working on because it is in the economic and public relations interest of the industry itself to stop escapes. They don't want to see their fish swimming away from the cages because that's money lost.

(Narrator)

There are several potential problems with salmon interbreeding.

Some wild salmon stay in the ocean just a year before returning to spawn in the calm flat waters they came from.

Other strains are required to swim up waterfalls, and need stronger, larger bodies so they'll take the risk of staying out in the ocean longer before spawning.

Either way, they're encoded to return to their rivers of origin.

(Fred Whoriskey)

The biology of the Atlantic salmon is such is that these fish that go off to these long-distance migrations to Greenland home back to their river of origin when they're spawning. As a matter of fact, some of the work that's been done shows that, not only

will an adult come back to the river of origin, but they'll come back to within roughly 100 meters of where they grew up as a juvenile salmon and spawn there. And that makes evolutionary sense: it worked for the parent – it was a safe place to grow up, a good neighborhood, you want to come back to put your children into that particular area to grow and have all the benefits you had.

(Narrator)

Many farmed-raised fish come from European genetic strains, not local ones. So when farmed salmon escape and mix with wild stocks, their offspring may not be suited for those rivers.

(Pat Keliher)

That's one of the concerns when you have these traits bred into these fish and then those fish breed with the wild fish ... It definitely changes the species.

The biologists are all very concerned about the genetic intrusions that could be caused from the aquaculture fish. It's something that we have to be very vigilant with.

(Narrator)

The genetic traits fish farmers are looking for are probably not the same ones that work best in the wild.

It's similar to how animals are domesticated.

Humans remove a wild animal from its natural environment and over a few generations, breed out certain characteristics of the animal while emphasizing others, making the species more suited to the job humans require.

(Fred Whoriskey)

It's basically a standard breeding program that animal breeders have used for thousands of years. And what you're trying to do is favor the genetic changes that make these fish superbly adapted to the cage culture environment – they produce all the benefits you want – the fast growth rate, a uniform growth rate – all the things that a fish farmer needs to compete in a viscously competitive global market. But that's not what nature is looking for. Nature is a highly variable world and what happens is conditions in a river, conditions in the ocean, change from one year to the next.

(Narrator)

As aquaculture branches out into other finfish species, such as cod, haddock and halibut, escapes may again be an issue.

Very little is known about the regional differences these species may carry and if they too are best suited for very specific areas.

But for now, as far as escapes are concerned, fish farmers have a success story.

To shore up losses from escapes, Erick Swanson recently invested in steel cages and escapes are now rare.

(Erick Swanson)

We haven't lost anything since we put in the new system, since we changed to this new steel system that you've seen out here. We haven't had any escapes..

(Narrator)

As fish farmers continue to come up with ways to eliminate escapes, several new controversies are churning up the waters.

Something as simple as what farm-raised salmon are fed has caused the industry to stop and rethink what it is doing.

Salmon are carnivores. They eat other fish.

Typically, they feed on fish species lower on the food chain, such as anchovies or herring, which are caught and processed into fish meal and fish oil.

(Erick Swanson)

Aquaculture is really converting one form of protein to another. You know the pelagic species that are being used solely for fish meal because nobody wants to eat them, and there's a major industry that has been around for a long time. They have used it traditionally for fertilizer, supplements for cattle feed, hog feed, in fact even today these are the major uses for fish meal, we simply compete in that market. It just makes sense to convert that into a higher value food source that people want to eat such as salmon or tuna or other species of fish.

(Narrator)

Some ecologists argue that less valued fish species, like anchovies and herring, are being fed to salmon and that could unravel some of the ocean's intricate food webs.

Simply because there are so many farmed salmon to feed.

(Inka Milewski)

There are more salmon on fish farms than there ever were wild salmon roaming the oceans. I think it's something like 5 to 1. There are five times more salmon in farms than there ever were.

(Narrator)

To make matters worse for aquaculture, in 2004, farmed salmon was thrust in the middle of a PCB and dioxin scare.

A major study found that farm-raised salmon have more of these potential carcinogens than do wild salmon.

How could this be?

Farmed salmon eat a concentrate of fish oil and meal.

Since toxins head straight for fats and oils, contaminants typically get ingested faster than they can be eliminated.

So they "bio-accumulate" as the farmed fish eat more of the fish meal concentrate.

Although wild salmon are also exposed to toxins when they eat other fish, they tend to accumulate them slower since they're not eating oil-rich feed.

(David Carpenter)

The levels of PCB's in farmed salmon are higher than almost any other food stuff.

(Narrator)

Yet depending on what part of the world it comes from farmed salmon was found to have substantially different levels of these contaminants. Northern Europe has the most contaminants, followed by North America and Chile.

Most farm-raised salmon sold in the United States comes from Chile, which actually has fewer toxins than in some wild salmon.

But this study still recommends eating less farmed salmon.

Most toxicologists say that the data point to a much more nuanced interpretation.

They say people need to balance the benefits of heart-healthy omega three fatty acids- found in all kinds of salmon - with the risks of having PCBs and dioxins accumulating in their bodies.

(Andrew Smith)

If you're someone like me and you're middle-aged and you're thinking much more about heart disease and making sure you have a healthy diet, eating a meal a week of salmon, farmed-raised salmon may be the right choice, the right balance of these competing risks and benefits because it is such a significant source of omega 3 fatty acids, which again have been shown important in reducing the risk of deaths from sudden cardiac arrest. If on the other hand you're a young child, especially a female child or a young woman and you're worried about your body's burden of these chemicals – because these are chemicals that stay in your body a long period of time and build up over time. So it's not your short-term consumption that matters it's your long-term consumption and for you avoiding this fish might be the right decision because it would represent a significant source if you were to consume them frequently.

(Narrator)

But there have been many complaints about this study.

As a practical matter, it's nearly impossible for consumers to tell where the farmed salmon they're buying comes from. Unless your retailer can tell you, it's nowhere to be found on the label.

Besides, other foods that we eat expose us much more to these dangerous contaminants.

(David Carpenter)

I was surprised to find that you can't eat a Big Mac without getting some PCBs. In general the levels in beef, poultry, chicken, dairy products, milk and butter, are less than the levels we found in salmon. Now some people in an effort to criticize our study, and I don't think it's a criticism, have said, "yes, but most of us eat more meats than we eat fish." That is absolutely correct. It is likely that most people's body accumulation is more from other foodstuffs than it is from salmon, just because of how much salmon they eat.

(Richard Langan)

The other part of this is if you listen to the nutritionists who reacted to that, and these are unbiased people, people who are reporting on the nutritional value of foods, when they looked at that report they said the health benefits of eating salmon far outweigh any of the risks that are posed by those levels of compounds in the salmon. And I know it was sensationalism. I know it was another blow against the salmon industry, but I really think it was taken out of context and misinterpreted by the press.

(Narrator)

Even though the Food and Drug Administration and toxicologists think the level of PCBs is too low to be of concern, the aquaculture industry felt it had to respond to the widely publicized study.

It took its cue from another recommendation of the report.

(Erick Swanson)

We've talked to the feed manufacturers about removing PCBs and dioxin from the feed. And they can do that, but the argument they come back with is, 'When you're already at 3% of the tolerable level, why do you want to do that?' And you know, our argument back is, as a marketing position, we want to have zero in there if we can because of the constant attacks we get from some environmental groups. Not all, but those that really want to make an issue of this. But it's still hard to justify when you're only at 3% of the tolerable level in less than most of the other foods that we eat. Do you spend the money to remove that last little bit to make it 100% pure? But I think that's what we're going to have to do.

(David Carpenter)

The solution is a very simple one and a very straightforward one—we need to stop feeding the animals we eat food that contains carcinogens.

(Narrator)

In some cases, consumers are already demanding it.

Much like organic vegetables and fruits, salmon from European organic farm operations is now showing up in stores.

(Erick Swanson)

We're trying to get certified organic. There are some certification agencies out there now or entities. They don't really have clear cut standards in the US yet for... fish but we're hopeful with in two year's we'll be certified organic.

(Narrator)

There are other changes salmon farmers have been forced to deal with.

Not everyone thinks fish pens are the right image for our scenic coastline.

(Erick Swanson)

I think in some of the early days such as Cobscook Bay, the Bay just filled up with farms, and people were concerned that, that was going to happen to the rest of the coast.

(Richard Langan)

Well, you know, number one, real estate is really tight if you look at our bays and estuaries. Even in the state of Maine, which is sparsely populated. There's a lot of things going on there. There's a lot of recreational activities, there's lobstering and commercial fishing and add one more activity and it starts to ruffle feathers.

(Narrator)

Unlike farming on land, aquaculture is on property that's a common resource. Oceanographers are often called in to comment on proposed locations for these farms. Much rides on these decisions. If a poor choice is made, pollution can easily become an issue.

(Neal Pettigrew)

One important consideration in assessing the suitability of a site for a net pen aquaculture is the rate in which the site flushes. As you can imagine out in the open Gulf, flushing is quite rapid and complete and as you get into some of the backwater and estuaries, it may be very, very slow.

(Narrator)

Jon Lewis works for the state of Maine inspecting existing and potential aquaculture sites. Maine has one of the most rigorous, comprehensive and successful monitoring programs in the world.

(Jon Lewis)

One of the things we don't want to do is site a farm at the head of a bay where any organic waste is going to accumulate, be transported from underneath the farm and accumulate. But we do require as part of our application process measurements of current velocity, current direction, water depth, dissolved oxygen in the water, benthic organism, granulometry or bottom composition. So we get a fair amount of information.

(Narrator)

Farmed salmon introduce large amounts of two kinds of organic waste into the water - uneaten feed and fish feces. Both contain nitrogen. Nitrogen is a nutrient which occurs naturally in the ocean. However, too much nitrogen can stimulate the growth of an algae bloom, initiating a process called eutrophication which can lead to a total loss of oxygen from that particular ecosystem. Without oxygen, nothing can survive except a very few species of worms and bacteria. The result is a dead zone. When he began salmon farming in Blue Hill Bay, Erick Swanson knew little about either of these kinds of pollution.

(Erick Swanson)

When we started, it was a true mom and pop – shoveling feed out of wheelbarrows, you know, a lot of homemade wooden equipment, home made pens, it was really crude. Initially we fed twice a day by hand out of a boat. You pull up to a cage, shovel in, just looking from the surface at what you saw and spreading it with a shovel or a scoop, and then you'd move on to the next cage. There are two critical factors it turns out in feeding fish properly. One is the rate of delivery, how fast, how many kilograms per minute you're delivering to a certain biomass of fish under a given set of conditions and then the stop feed signal, when to quit. You have to have an accurate method other than just looking from the top. The result was with a lot of hand feeding you would over feed and under feed at the same time.

You're feeding too fast for the fish to eat it all so the feed would go to the bottom and then as the fish were chasing it down, you'd think they're full, and then you would stop. So the fish were not getting enough feed, but the feed they were getting was delivered faster than they could eat it all, and you'd end up with an impacted bottom.

(Narrator)

There are several ways for biologists to tell if marine life under a salmon farm is out of balance.

If organic material is falling to the bottom at a rate faster than the normal bottom fauna can digest it, reddish patches of feed and a whitish mat of bacteria called bebbiata can be seen.

(Jon Lewis)

What happens is when you get a breakdown of organic products you get something called methane and hydrogen sulfide. And if you have been in a swampy wetland and smelled the muck around you, that's the same gas. It is a breakdown of organic products. When a site is very heavily loaded, you get a depletion of oxygen you get sulfur reducing bacteria. With that comes gas, swamp gas, if you will.

(Narrator)

To get the best picture of what's going on, divers and underwater cameras are sent down. In Maine, this is done twice a year - under all active farms.

(Jon Lewis)

The diver actually digs down into the mud and makes a sweep, uncovers that gas and lets it bubble to the surface and we see that on video that is a clear indication that there is a problem.

(Narrator)

What happens when pollution from a fish farm located on a poor site goes unchecked? In 1999 this happened in New Brunswick.

In a bay crowded with salmon farms, a highly contagious, flu-like disease called Infectious Salmon Anemia broke out.

One aquaculture company was particularly hit hard and needed to quickly relocate their fish.

It was allowed to set up two temporary net pens in Crow Harbour, a New Brunswick estuary on the Gulf of Maine.

But after just two years, the bottom was showing symptoms of severe pollution and the company was ordered to vacate the bay.

Canadian marine biologist Inka Milewski immediately began testing the bottom underneath the pens for signs of organic pollution from uneaten feed and feces, also called nutrient loading.

(Inka Milewski)

For most people nutrient loading implies a good thing. It's nutrients – it's a word that sounds like it's positive and a little bit of nutrients are obviously very good. But in the case of these point sources like salmon farms or pulp mills or sewage plants, we're talking about a lot of nutrients.

(Narrator)

Milewski documented the recovery process in Crow Harbor. She ran video surveys and got core samples from the bottom to test for oxygen reduction as well as changes in the make-up of organisms living there.

(Inka Milewski)

In the first year of our sampling, when we pulled up the core samples, you could see the sediment was black and it had a strong hydrogen sulfide smell, that rotten egg smell. In the second year, the intensity of the blackness was gone, there was much less of an odor, considerably less hydrogen sulfide odor. This year the sediments looked grayish, there was very little black and there was no smell of hydrogen sulfide. So the process of recovery had taken place very nicely. Nature had done its job.

(Narrator)

What started out as a case study on how badly a coastal site can get polluted, also became a study on natural restoration.

(Inka Milewski)

That's really very nice. We've got nice recovery in the sediments.

(Narrator)

But pollution is an ongoing concern for any fish farmer.

The aquaculture industry thinks it has a remedy for pollution from uneaten feed – automation.

(Erick Swanson)

What's changed now with the computerized systems is you have very precise control on how fast you feed the fish throughout the meal. You can control it in stages where it starts out at a higher rate and slows down as it gets towards the end of each meal and you can afford to feed them all day long. We do six feedings a day; with the amount of time it takes to run a boat from one cage to the next it turned out we were spending three hours a day moving the boat around with the computerized systems now it's fifteen seconds.

It took us a while to figure out how to come up with the right formula that kept the fish full and didn't have any feed on the bottom. But we finally achieved that and it really works well. It frees up the crew to do other things all day long automatically feeding the fish and then we finish them up with one person manually at the end of the day, operating the feeding system with the remote control...It's just made a huge difference, the old days of manually lifting all the bags of feed – tons of feed – and moving it around and getting the fish oil and fish meal all over you and you know, being a stinky mess, nobody liked that. And now no one ever touches it. We handle it with a forklift and a remote control it's much more attractive to the crew. And my wife doesn't make me strip down before I walk into the house at night, that's another improvement.

(Narrator)

Pollution from fish feces is another matter.  
This is where having a good site is critical.

(Neal Pettigrew)

In my opinion the best site for aquaculture is actually not in any of the bays or estuaries but outside the bays and estuaries perhaps on the Maine shelf. Once you get outside these semi-enclosed water bodies and get out onto the Maine shelf then you are in a regime that we call the Maine coastal current. And that location the flow is much stronger, the tides are stronger and there is a great deal of flushing and dilution and so from that point of view the environmental impacts become minimal.

(Jon Lewis)

My experience has been a blanket statement like that can be a problem. We have some farms that are situated in relatively low current velocities and have been run quite well and we have other farms in fairly high current velocities they've not been run as well. Largely it is a result of husbandry, paying attention to feeding practices, paying attention to when to stop feeding, when to start feeding. You can take a good site and make it bad or a bad site and make it good, depending upon how you balance your operation with the environment.

(Narrator)

Despite all the scares, bad press and mistakes made along the way, aquaculture is bigger than ever.

Many of those involved in this industry now seem to be in a race to come up with the boldest innovations possible.

That's why researchers at the University of New Hampshire are taking their ideas offshore.

Out near the Isles of Shoals in New Hampshire, haddock, cod and halibut are being farmed in submersible net cages.

(Richard Langan)

We're getting a tremendous amount of water that flows by. We get billions of gallons a day, we're in deeper water so any kind of wastes that we produce out there are dispersed

over a much broader area. I think you have to still be looking at the concentration of cages and fish that you have out there and understanding at what level of production am I to start seeing impacts and you want to avoid that. At the same time, we want to be looking at technologies that can somehow control that waste. And I think that if you look at the salmon industry, they have made tremendous strides in reducing the amount of wasted feed and reducing antibiotics going in there. If we could see what's happened – we've stalled the permit applications in Maine... I think the opportunities for additional cages in in-shore areas is going to be fairly limited. So we have to look at the next horizon. We need more locations – this is an obvious place to look.

(Narrator)

Six miles from shore, UNH is installing submersible cages for growing finfish. Thirty feet below the surface, the cages are held in place with tethers to the ocean floor - 150 feet below.

They look like toy tops, except they're 80 feet wide and 50 feet tall.

A feed buoy in the center is activated remotely from a university lab 15 miles away.

Researchers also use wireless video to watch how the system is doing on the high seas.

(Michael Chambers)

It's a high energy environment. We have incredible amounts of water that flow through the cage every minute and as a result, we maintain a very high health within the cage. We haven't gone with any great densities or high biomass within them yet. That's something we're going to work up to...

I think initially we wanted to see, okay "can we put a cage system out here that would survive?" Yes it did.

"Will the fish survive?" Yes they will. "Will they grow?" Well if we get a feeder out there that will feed them year round, yes they will grow. So we're kind of going step by step and proving these things as we move along. So now we're at a point where we've got to prove scale of economies. We have to get bigger cages, bigger feeders, so that economically it'll look attractive.

(Narrator)

There are even competing ideas out there now for offshore aquaculture.

(Cliff Goudey)

Typical model is to have a cage or an array of multiple cages anchored fixed over one spot using multiple anchors pointing out in every direction. This is specifically to keep the cage over one spot which has a lot to do with the way permits are issued. But from a standpoint of having an impact on the bottom is exactly the worst thing you might want to do. So, there's absolutely no reason to repeat that kind of a model in offshore.

(Narrator)

Goudy imagines cages filled with juvenile fish in Florida that drift along the Gulf Stream until they reach Europe, at which point the fish will be ready for market.

(Cliff Goudey)

These cages could have some form of propulsion that could move them slightly or at a very slow speed. But basically they'd be at the mercy of currents. It's the kind of concept that wouldn't work on a small scale. You'd have to accept the idea of a large scale operation – you'd have an endless series of these cages being deployed, being serviced by ships that travel along the same route re-supply the cage with feed, re-supply the cage with fuel if necessary, change out personnel if it's a manned facility and all of this is one big operation that is now using parts of the ocean that have never before been considered for this kind of activity.

(Inka Milewski)

And open ocean aquaculture in my view represents an old mentality and that is treating the oceans like a giant toilet. And I don't think that the public would find that acceptable. This is the 21st century we send satellites that travel for decades we've got nanotechnology that can send a robot up your vein that can fix your heart valve I mean it's just remarkable. And to think that the way that we're going to deal with waste is to simply dump it into the oceans is really unbelievable and it's wrong headed.

(Narrator)

At his research facility in South Burlington, Vermont, John Todd farms fish too – with a goal of no wastes.

His "Living Machine" is a closed loop. Wastes from one process are used to fuel others.

(John Todd)

This is a compost pile on top of a screened grate. The water level is here, so any gases, this is the first tank any gases that come off just get absorbed.

(Narrator)

Everything from fungi to fish are grown and then the waste by-products are recycled to create other crops.

To Todd, it's an ecological symphony.

(John Todd)

And they're very productive and they're self-purifying. They are, in a sense, miniature worlds, designed with an end in mind. In some cases, its growing foods, in other cases its treating waste...in some cases we even design them to produce fuels.

(Narrator)

Todd wants to raise fish in a way that's self-sustaining and does not rely on commercial feeds containing fish meal harvested from the ocean.

Nutrient-rich water from the fish tanks is used to grow a variety of vegetable crops.

Solid wastes are used to grow worms that can be fed back to the fish.

(John Todd)

And this kind of aquaculture is not easy to fund – its so out of the mainstream pattern of how things are done – things are usually done as a single species - feed it hard, use a lot of equipment to clean up the water and recycle it and a lot of energy and that's the way to go. One of the benefits of closed system aquaculture – or mostly closed - is that the farm is responsible for its own waste treatment. It doesn't ask a wild environment to do it for them. And I think that's the huge difference.

(Inka Milewski)

The aquaculture industry has a responsibility to process, or manage its waste. Like every other industry and the way it needs to do this is to bring it on to land, collect the waste, treat the waste. Right now they're getting a free ride from the environment. The environment is paying the price of having this waste discharged.

(Erick Swanson)

Net pens are really a natural system. Everything that was here is still here underneath the pens. We rely on nature to do all the pumping for us, so we're not running up all kinds of fossil fuels and energy costs. They're really a marvel of efficiency. But I guess you have to have one to really appreciate that. (laughs)

(Narrator)

But there are others who think the future of fish farming may be on land, not in the ocean. A variety of land-based systems at this University of Maine facility are growing cod and halibut.

To have control over something as basic as water temperature is a huge advantage over ocean aquaculture.

(Nick Brown)

In Maine we have quite extremes of temperatures. We have quite low temps in the winter and quite high in some places quite high in the summer. So that's one of the reasons why it's a good option for Maine.

(Narrator)

If all goes well at this research center, these University of Maine halibut should be ready for market in two to three years.

Another idea is to make sure all the essential parts of nature are there on fish farms so there's less stress on the environment.

Using up all the nutrients is the key to Ike Levine's seaweed polyculture experiment.

(Ike Levine)

So in the ideal world of polyculture you would have a finfish, you'd have a shellfish, and you would have a sea vegetable. The vegetables would of course would absorb the nitrogen and phosphorous that's dissolved, the shellfish would filter the particulate

nitrogen perhaps the uneaten feed particles of a salmon cage and of course the salmon would produce protein.

(Narrator)

What does the future hold for this controversial industry?  
Is there enough room for these new ideas and the more traditional coastal aquaculture?  
Is it possible for multi-national companies and small farmers to co-exist?

(Erick Swanson)

I'm very determined to remain as a small family business. But it's getting more difficult all the time. We'll have to wait and see.

(Narrator)

But since his interview, Erick Swanson decided he can no longer compete, despite all the changes he's made to reduce pollution at his farm and everything he's done to address regulators' and the public's concerns.  
He plans to sell out sometime in 2005.  
But he's not getting out of aquaculture altogether.

He hopes to carve out a niche for himself by growing mussels and by raising fewer and higher quality salmon for local markets.

(Narrator)

Then there's the question of how we balance our wild fisheries with fish farming.

(Richard Langan)

I'm not going to claim that aquaculture is going to be the savior. I really think that we need to be looking at our capture fisheries, managing those properly, getting the most we can get out of those, and to do it in a sustainable manner. The other piece of the pie is aquaculture. So I think the two really need to be working together and looking at it in terms of overall seafood production.

I think in 5 years from now I think you're going to see some large offshore farms producing a very wide variety of species of finfish. I think you're going to see a lot of shellfish culture going on off shore, primarily the species would be mussels, sea scallops, maybe a couple of oyster species. So I think you're going to see some fairly substantial commercial production in a 5 year period.

(Inka Milewski)

Our oceans are in serious trouble. Not only do we have a loss of fisheries, a loss of habitat but the quality of the marine environment, the water quality is very poor. So for us to... to still be hanging on to this notion that the oceans are infinite and can absorb all the waste that we produce is just not acceptable. We must do better. We can do better.

(Richard Langan)

Let's look at the problems that we've seen develop through the industry and let's continue to try to solve those problems. How do we minimize the waste? How do we

develop feeds that are not using as much fish oil and fish meal that break down more quickly, that are more digestible for the fish? So there's a whole lot of work that we can do. The science and technology end of things can really help with that.