Male Speaker: So, we have the privilege and treat of coming here and hearing someone tell us about something fascinating. Also, I want to thank the ladies in the back who we also take for granted. They are there every last Monday of the month with delicious cookies and coffee and tea. We are very, very grateful.

[applause]

Yes. Thank you, ladies. Today, we are going to hear about a subject which is the reason that this laboratory is here. We came here because the fisheries was already here and had established a laboratory. It started because the fishermen were worried about the depletion of the fish supply. So, they wanted a study made. But we are still studying. We have Russell Brown here from the fisheries to tell us about the current status of fish stocks. Russell.

Russell Brown: Thank you.

[applause]

I'm sort of a wanderer. So, I'm going to try and pull the mic out here and perhaps walk around if that's okay. Really, my role is as a fishery stock assessment biologist for NOAA Fisheries down the street. For the last six years or so, I've had the responsibility of following a long line of prominent scientists who have done work on the Georges Bank haddock stock assessment. The Georges Bank assessment is very significant because of the long time series that we have of data for that particular stock. It really lends itself well to sort of a historical context like we'll take with the talk today. I think it might help if we try and get off at least one set of mics.

MS: [inaudible] over there.

RB: If we do that…

MS: Get the other one. Get the other one. That too.

Female Speaker: What about that [inaudible]?

MS: That is fine.

RB: Okay. Can everybody still see their cookies? [laughter] Good. Good. So, really, what we're going to talk about today is history revisiting. I'm going to start out giving you a little historical context of Georges Bank haddock and why it's so important to the Woods Hole community here and why it's so important in fisheries in general. But I'm going to finish up talking about our efforts to rebuild this dock. One of the things that people often ask is, well, what do I do for a living? There are different opinions on that. [laughter] The one I sort of like is the one that my five-year-old son has. His opinion is that daddy counts fish on paper. Really, that's a very simplistic explanation of what I do. It's actually not bad. But there are other opinions out there. Here's one that one of our favorite critics, Molly Benjamin, has. That is that federal fish crats under the guise of science naively rely on computer models instead of observing what actually goes on in the ocean. So, there are some differences [laughter] of

opinion in terms of what the science is saying to us. Obviously, unless you've been living under a rock, you know that we do have some problems with some of the fish stocks that we're managing. Headlines like this have appeared in the past. How did it get this bad? Criticisms of the fisheries data that the data's called uneven. Fishery data collection is catch-as-catch-can. There's a nice picture of Molly Benjamin for you. [laughter] But really, the conclusion has been that stock assessment biologists in general have been the prophets of doom. What I'm here to talk to you today about is that it's not always bad news. If we take a look back, historically, obviously, these three gentlemen and others like them have been very important in the development of fishery science in the Woods Hole region. Obviously, Spencer Baird was the first commissioner of the U.S. Fish Commission and really was responsible for establishing the first dedicated fisheries research lab here in Woods Hole. Spencer and his colleagues really spent the last part of the 1800s and the first part of the 1900s, doing a lot of very critical, descriptive work on the ecology and the distribution of fishes. In general, the biological work was extremely important. But it really did usher in that first age of science. That is sort of the descriptive part of science. They did their work on a lot of our old historical research vessels. I've got pictures of three of them here. This is the RV *Grampus*, which is a sailing schooner actually. This is the research vessel *Albatross I*. Of course, we've gone through four iterations. Perhaps sometime this decade, we'll be issuing *Albatross V*. Then here is the R/V *Fish Hawk II* that we used for a short period of time. A lot of this descriptive work was very important in terms of describing where fisheries occurred, where landings were coming from, and where fish spawned. A whole plethora of biological information that led to things like the publication of Bigelow and Schroeder, which was really one of the preeminent publications in terms of describing the ecology and biology of fish. Another important thing that came out of much of this work and some work that followed was really the stock definitions that we use for both U.S. cod and U.S. haddock stocks. Well, obviously, people that have sat and thought about Georges Bank said, "Well, didn't cod really dominate things?" For much of the fishery, they did because of the method of removal that was used to harvest fisheries. So, why are we talking about haddock? Well, first of all, that's what I work on. So, I get to talk on [laughter] what I work on. But more importantly is that we have a much longer historical context in terms of quantitative estimates of what's happened to this population. Haddock became a much more important component of the landings once otter trawl gear was introduced into the fisheries. Haddock landings really dominated over cod landings for the early part of this century. I think it's important, as we go through this story, to really think about the role of technological advances in terms of how these fisheries developed. Obviously, there's been a big progression in terms of the research or the fishing vessels that have been used. There've been some key important innovations in terms of the shift from sailing schooners to gasoline and diesel-powered vessels, improvements in gear, and so forth. As we look back on the history of the haddock fishery, we see that the fishery really starts to develop as some sort of targeted fishery around 1850. The reason that it starts about then is because of refinements in preservation techniques. This is about the point in time where ice is used as a preservation method instead of salting. The reason the haddock weren't taken where they were really considered an undesirable species before 1850 was that basically, they didn't salt well. We see by 1865, that line trawls are being used to target haddock. By 1915, we see the introduction of otter trawling. Otter trawling is very important because it allows the fishery to target haddock to a much greater extent than they had been previously. So, in 1915, there were twelve otter trawlers. They accounted for about 26 percent of the haddock landings in New England. Then we see over the next fifteen years that there's

sort of an explosion in the amount of effort so that by 1930, we have 200 otter trawlers. They're accounting for 82,000 metric tons of haddock landings. So, what we see in sort of the development stage of the fishery is that early on in the early 1900s, which is about the first time that we really have reliable measures of landings, we see landings are averaging about 20,000 metric tons perhaps. We can see, as the fishery develops, there is a sharp increase in landings from the mid-1920s until about 1930. Of course, we can probably all predict what happened next. That is a very sharp decline in the fisheries. This event was very important in terms of the development of fishery science here in Woods Hole because it really did initiate the agency – at the time, the Bureau of Commercial Fisheries – to initiate a long-term investigation of haddock. This was began between 1930 and 1932. But what this started was sort of the collection of a long-term data series on both the size and age composition of the commercial catch. At the time that they collected these data, the models that these data now fuel weren't even developed yet in real practical terms. But the data collection itself occurred. It allowed model development based on that data. Some of these methodologies we still use today. So, really, the 1930s represent, for our laboratory and for fishery science in general, the initiation of a new age. That is getting away, not necessarily getting away from the biology and ecology of fish, but really more in terms of the quantitative area of fishery science. This haddock assessment was really initiated by William Herrington shown here and his colleagues. This is a picture of William shown sampling haddock in 1938 on a commercial fishery vessel. There were all kinds of studies that went on. This is a beautifully clear picture taken in 1935 of somebody who's actually in the process of tagging a haddock to release, to basically take a look at growth and distribution rates. So, these activities continued between the early 1930s and basically, 1960. We can see here one of the Bureau of Commercial Fisheries personnel sampling haddock around 1948 in Boston. Boston was really the epicenter of haddock landings. The reason it was, was because the fresh fish market was so developed there. So, Boston was basically the key haddock court during this period. We could see here –real, fortunate actually that I managed to stick this in [laughter] because the individual shown here, according to the label on the photo, is Bob Livingston. Bob is sitting right here in the audience. [laughter] So, this is approximately 1958. Bob, does that look like you? [laughter]

Robert Livingston: Was this in Boston?

RB: I can't tell you.

RL: Because I had that project called Galloping Gonads. We used to leave here at 4:30 a.m. and go to Boston. [laughter]

RB: Okay. So, what Bob's saying is he's galling through gonads here. We'll let him explain that to you later. But essentially, we can see that throughout this period, if you look in this lower left hand graph, we essentially have a stable period of landings. So, we have these small fishing vessels, that are U.S.-based primarily, catching significant numbers of haddock so that the landings are basically averaging between 40,000 and 60,000 metric tons through this period. But these are actually remarkably stable landings for commercial fishery. This isn't physics. This is a biological system that's basically pumping out consistent landings of haddock throughout the whole period. So, what we have is fishery scientists going out and collecting data between 1931 and 1960 or so, getting a nice, long-term time series of biological data on what the fishery looks

like when it's stable. Really, in clearer terms, we can see this period of stable landings occurring here between 1935 and 1960. This is sort of the closest thing that we can demonstrate to sustainability in fisheries of any of the fifty stocks that we managed at the Northeast Fishery Science Center. Well, then the 1960s came. Basically, the rest of the world found Georges. Basically, what happened in the early 1960s is that we saw that the Soviet fleet came over and started exploiting Georges Bank. Initially, their target was not haddock. It was actually herring. They basically came over with midwater trawling vessels searching for herring. What they encountered though were two very large-year classes of haddock. One occurring in 1962, which would've been the largest year class recorded in history, except for the 1963-year class was about three times the size of the 1962-year class. So, the 1963-year class was essentially a gigantic year class. Basically, what the Soviet fleet did was they started to detect these fish in their midwater trawls, realized that there was a real potential here to harvest haddock. So, the fleet goes home over the winter. They basically retool. They come back. Between 1965 and 1966, haddock landings reach 150,000 metric tons, higher than we've ever seen it before. By 1970, the stocks had basically collapsed.

RL: What is the definition of a year class?

RB: A year class is basically a cohort of fish that's born in the same year. Every year, haddock spawn about the same time. They all spawn between February and April. So, a year class basically constitutes all of the young fish that are produced during that year. Essentially, they're all spawned in that February to April period. They all become commercial juveniles at some point during the summer. It's really sort of that variability and cohort size that makes managing fisheries interesting because it's not like the U.S. population where you can go out and project. You can say, "Well, at a certain birth rate, we expect the population to increase or decrease here." We see a great deal of variability in terms of the size of those cohorts that are produced from year to year. I'll show you some of that a little bit later.

RL: Thank you.

FS: Dr., when you were sampling, they were measuring and weighing and assessing and engaging. Anything else?

RB: Well, they were collecting maturity data. There were samples both in terms of research vessel samples and also commercial fisheries landings. Basically, what that allows us to do is to see the relative strength and the relative contribution of each annual cohort to the fishery. I'll show you some of that in a minute too. Yes.

FS: How come it takes five years for the crash to happen?

RB: Well, essentially, it takes the fishery about that much time to remove the majority of the biomass. What happens is there's a tremendous amount of biomass built up. A lot of the early removals in 1964 and 1965 were relatively small fish because they were fishing with very small mesh sizes at that point. But basically, five years is actually pretty quick to collapse the population to the degree that that they ended up doing. Yes.

FS: Were there observers on the Russian ships? Or how do you have an accurate reading on [inaudible]?

RB: We don't have an accurate reading on what the Soviet fleet removed. If anything, the removals that we're showing here are perhaps an underestimate of what actually occurred. We had some enforcement surveillance that was trying to monitor activity, but it was really sort of an open and unregulated fishery. So, in a sense, if there's any uncertainty about landings data through this time period, it's certainly from that 1963 to 1968 time period. Yes.

MS: Are these figures from the commercial boats, or are they from sampling fisheries?

RB: We don't necessarily sample fisheries to get landings. These are basically reported to us through dealers. A lot of the landings that comprise this peak here are reported by the Soviet Union. So, the guess here is that this is probably an underestimate of what was actually removed. I guess the early 1960s really were important from another standpoint. That is that they ushered in the age of our research vessel surveys. This is a picture of the *Albatross IV*. Beginning in basically autumn of 1963, we initiated a bottom trawl survey that's gone out annually since then up until the present day. That research vessel survey has really given us a long-term view of what the stock has done. By initiating the survey in 1963, we were very fortuitous in the sense that we were able to capture the dynamics of those large 1962 and 1963 cohorts. We were also able to monitor the fishery through its collapse. This is a picture of actually some of the haddock that were caught on that initial survey in 1963. But really, what the survey gave us was a standardized time series of abundance and biomass data. It did capture the dynamics of the two large year classes. It really gives us an invaluable long-term view of stock status in addition to the commercial fisheries data that were collected previously in the [19]30s through [19]50s time period. Well, the collapse of haddock obviously attracted some attention. You might be wondering what [inaudible] and Ted Kennedy were doing in the Aquarium building during election year in 1968. [laughter] They were actually doing the same thing. They were there for the same reason that you are today, and that is to talk about the history of haddock. In a sense, there was a great deal of political concern in terms of the foreign fishery removals that eventually resulted in us extending our jurisdiction. Basically, the EEZ line out to 200 miles beyond the coast. So, we have a Northeast groundfish fishery that basically has four centuries of history. The fishery is really characterized by large numbers of small independent operators which, in a sense, makes it sometimes hard to build a consensus about what to do. There were large increases in investment in our domestic fleet following the establishment of the EEZ. So, what we essentially did was we removed the foreign fishing effort, but then we filled in with our own fishing effort. There's sort of been a history of controversy about the ownership of the resource. I'm not going to go into great detail about the Hague Line decision. But obviously, there was a process by which we went through to divide up the Georges Bank resources after the initiation of the EEZ. When Canada and the United States both draw 200-mile lines, about half of Georges Bank falls into an area of dispute. The process by which it took to sort that out took almost a decade to sort out. Finally, the World Court drew the line for the two countries that's shown here. This is important in a sense because it looks like the United States has the majority of the bank, and that's true. However, some of the most productive fisheries occur up here on the Northeast peak in Canadian waters. So, as we start to think about what's happening to the stock and what we might want to do to rebuild these fisheries, we have

to think in a binational sense, not just in terms of what we want to do in the United States. But while all that Hague Line decision was going on, we actually did have an opportunity to rebuild the stocks. Basically, what happened – and I'll show you later – was we had the recruitment of a couple of large year classes that occurred here in the mid- to late-1970s. Those two year-classes were the 1975 year-class and the 1978 year-class. They were both very large relative to what we had seen in the prior decade. They resulted in an increase in landings. But unfortunately, what happened to those two year-classes was that they were fished with fairly small mesh sizes that were mismatched with the minimum size regulations that were in effect at the time. Basically, much of those two large year classes were discarded in the fishery because they were too small to be marketed. They were too small for the minimum size limit. They were basically discarded before they had a chance to spawn. So, our first real opportunity to rebuild the stock was in this time period here. We do see an increase in the landings. However, the landings start to decline again toward 1990. So, we really had three or four periods of landings, this stable period that I referred to, from 1935 to 1960. We have a period regular fishing by distant water fleets that results in stock collapse by about 1970. We have our first chance to recover the population. But unfortunately, we don't take advantage of the two year-classes that nature provides us, and the landings continue to decline. So, by the early 1990s, what we see is basically record low landings from the fishery. Now, when we start to combine some of this information in an analytical way, what we see is a pretty good coherence in terms of the pattern that we see in landings here shown in red. High landings in the 1960s collapsing to a low level, increasing with those two cohorts, and then declining to record low levels by the early 1990s. The fishing mortality rate that we're estimating based on the commercial fisheries catch and the research vessel survey information that we have, we can see that the fishing mortality rate was extremely high around the early 1930s. That's the period when we saw the first stock collapse, when we saw the blennies go to a very high level and then ultimately collapse. So, we can see in the first year that we're able to estimate fishing mortality. It's starting to drop in association with management measures that were put into effect in the early 1930s. We can see the fishing mortality drops sharply again, just prior to 1960. This occurred just prior to the big buildup of haddock in those two large year-classes. Fishing mortality drops again in the early to mid-1970s, just prior to a buildup in spawning stock biomass and landings that occurred in the late 1970s. So, what it appears is that basically every time the fishing mortality drops significantly, there's some response in the stock in terms of increased landings and potentially increase in spawning stock biomass. I'll show you in a second. Yes.

FS: How do you define fishing mortality?

RB: Fishing mortality is basically a removal rate of fisheries from the population. In this case, the fishing mortality rate we use really is kind of on an exponential scale. So, you can't really put it into percentages. But basically, the one thing that I failed to point out is that this is what we define currently as being perhaps a safe fishing mortality rate on a fully recovered stock. What you'll see is through much of this time period that we've been above that, it seems like every time that we drop the fishing mortality rate below that level, we seem to get some measure of stock rebuilding. Well, the prevailing attitude in much of the commercial fishery sector is sort of typified by this quote. That is, "What good is a fish if nobody catches it?" This quote is actually by a member of the New England Fishery Management Council who is charged with managing these fisheries. The answer to that, of course, is given by one of my former colleagues

who's now retired, Dr. Vaughan Anthony. Dr. Anthony says, "Step one is you've got to have parents before you have offspring." Obviously, having some spawning stock biomass, some spawners out in the population is absolutely critical to the future of the fishery. If we take a look at what's gone on historically by analyzing all of that data that's been collected, we can see a picture that looks something like this. Basically, this red line is what we estimate the spawning stock biomass to be. This is just basically the weight of spawners that we estimate to be out in the population. This is an index of how many parents are out there. So, we can see that it was fairly stable but perhaps increasing through this period from the 1930s to the 1950s. We can see that it gets to a fairly high level in the early 1960s, spikes a little bit again, and then drops exactly at the same time as the landings drop. We can see that there's some buildup in spawning stock biomass that occurs in the late 1970s to early 1980s. Then it declines to record low levels by about 1990 or 1992. Now, what the blue bars are on here, these are the relative strengths of each one of the cohorts that are produced from that spawning stock biomass. These are basically recruitment in millions of fish. So, what we can see is that recruitment was much stronger during the stable period, generally ranging between 40 and 60 million fish, but occasionally, large year classes thrown in at some increment here that range from a hundred to 140 million fish. You can see these two large year classes that occur in 1962 and 1963. That 1963-year class is so large, in fact, that it would be up on the second floor of this building if we extended that bar up. [laughter] That number about 462. The scale over here is only 200. So, that year class was just huge. But what we can see in fact is that we never see an increase in spawning stock biomass per se. That really comes about from these two year-classes. Because the year classes are removed by the fishery before they have a chance to mature, we can see this little pulse as the front edge of those year classes start to mature. But the fish are basically removed from the population so quickly that they never had a chance to spawn. What really causes the collapse in both the biomass and the landings is the fact that there's no recruitment occurring in the late 1960s to early 1970s. You can see sort of a marked contrast here in the relative size of the year classes. Generally, less than 20,000 metric tons as opposed to the 40,000 to 60,000 metric tons that we saw previously. What you can see with this bar and that bar are the two large year classes that are referred to 1975 and the 1978 year classes. Really, both prop up spawning stock biomass here. They also prop up the fishery for a few years. But like I said, those year classes were not utilized for stock rebuilding. They were over-utilized for landings. So, what causes that variability in cohort size? I mean, why are there so many more fish produced in one year than the next? Really, what causes it is sort of the ecology of haddock and cod. That is, the spawning occurs in two primary spawning areas. One up here on the Northeast Peak. A second one down here in the Great South Channel. Of course, there's this clockwise gyre running around the bank that basically circulates the eggs and larvae around the bank. When large numbers of these eggs and larvae end up settling on the bank, that's when you get a stronger year class or a bigger cohort of fish produced in that year. When large numbers of these fish are basically spun off the bank and into the offshore currents, those are the years when we seem to get a smaller cohort or smaller year class. The mechanism here is certainly not fully understood. It's certainly an area that's the subject of a very intense study by the GLOMAC Program at this point. But this is sort of a simplified explanation of why there's so much variability. Over the long term, of course, you can basically reduce some of this variability by having more spawners in the population because the spawners basically spawn in a wider geographic area across the bank. They spawn at different times. Then basically, for lack of a better term, you basically put more eggs out in your basket to get spun around the bank. There's a greater chance of significant

numbers of eggs settling on the bank. One of the real important pieces of information that our research vessel surveys have given us is basically a picture of the spatial distribution of haddock on Georges Bank. This is a picture that we saw in 1963, basically from 1963 through 1967. What I've done is basically plotted up the numbers of haddock earlier distributed down from Long Island through New Jersey, just sort of sporadic catches. But this is a spatial distribution that we saw from 1963 to 1967, over a five-year period when the stock was at fairly high levels of abundance. Stock, of course, is collapsing through this period. But this is a period when we can see spatially what the distribution might have looked like historically. We sort of contrast that to what we saw in the early 1990s. I think that the picture here is pretty stark in a sense. 1963 through 1967, and then 1988 through 1992. What we can see is the only concentrations of haddock that we have left are up on the Canadian peak, up on the Northeast peak of Georges Bank and Canadian waters, and then some concentrations down here in the Great South Channel.

RL: What is the age composition where all [inaudible]?

RB: These are actually all ages. Your question is a valid one because the earlier graph does incorporate some of the high catches of the [19]62 and [19]63 year classes. But the picture nonetheless is that we see the stock basically contrast into smaller areas up here along the Northeast peak and down here in the Great South Channel. This spatial distribution is very important in terms of the management regulations that we use to ultimately try and rebuild the stock. So, what we can see by the early 1990s is the haddock landings have declined to record low levels. We can see that haddock spawning stock biomass has declined to record low levels. There was a lot of controversy about what caused the stock collapse. I think scientists at our center didn't have particularly a lot of controversy about what caused the stock collapse. But there were a lot of hypotheses out there in terms of what might have gone on. Was it habitat damage? Was it pollution? Was it some complex measure of environmental factors? Was there too much competition from skates and dogfish? Because one of the things that we saw is that as cod and haddock stocks collapsed on Georges Bank, we saw sharp increases in skates and dogfish. Did the ecosystem somehow flip in a manner that we'd never get back to the fishery or the fish community that we once had on Georges Bank? So, there were lots of questions. It became really a political issue in a sense. This is a quote from our former governor, Governor William Weld. Governor Weld was basically angling at this point to get some FEMA emergency disaster funds. So, his spin on the issue was perhaps this was a natural disaster. If he could prove that, then he would actually qualify for FEMA funds. There was actually some precedent for that with the salmon collapse on the West Coast, which was essentially linked to El Nino. So, Governor Weld's quote on this was, "The precipitous collapse of groundfish took the industry by surprise and was caused in large part by poorly understood natural factors." But one of the beauties of being a retiree is that you can actually say what you want to say. So, this is a quote from Walter Bickford, who was the former Massachusetts Fisheries Commissioner. [laughter] Walter's quote is, "The decline of fisheries is no more a natural disaster than someone burning down his own house." [laughter] It was a good day at the lab when Walter put his quote out. [laughter] It was the kind of thing that we all wanted to say but couldn't.

MS: Why not?

RB: I should point out that actually, I gave a talk at the Rotary Club last month. There was sort

of a little bit of a resentment toward this quote. I had somebody in the audience who was an industry member and who had done quite a bit of work in Gloucester. His comment when we got to the question period was, "Well, we all know that the foreign fishing fleets were the ones that caused the collapse. Showing this quote is really sort of a disservice to the picture of what really went on." My response to that was, "Well, yes, the initial collapse in the 1960s certainly was caused by the influx of foreign fisheries effort. But what's happened since?" I gave them this argument orally. I've since developed it graphically. That is, how long are we going to wait to rebuild the stocks basically? The stock collapsed in 1968. Really, that was approximately three haddock generations ago, if you assume they had to live about ten years or so. But more importantly than that – this is a picture of my family. My wife took the pictures. So, she's not in there. These are my two sons. This is Lucas. He's four. This is Jacob. He's seven. To put things in perspective here, I was Lucas's age, I was four years old when the stock collapsed. My hair has changed color since then. I was sort of a blonde. Now my hair's starting to go back to the same color that Lucas' is now. The question is, how many human generations are we going to wait to initiate the stock rebuilding? So, why can't we stop over-fishing? It seems pretty simple. We just tell people to stop fishing. Well, I think Dick (Hedomith?) really put it in perspective in a sense. He says, "The political forces that can be brought to bear to dissuade efforts to prevent overfishing have been remarkably strong." Here's another quote from Dr. Brian Rothschild who's now over at the University of Massachusetts. Brian's quote is, "New England is unique in the system because the science for its fishery is so good. New England's problem is politics, not science." Now, I'm not going to stand up here and be so heinous to say that the science has always been perfect. It hasn't. But the reality is the science has been good enough to motivate sound management of this resource if reused appropriately. Well, it's really difficult in a sense to brand over fishing. [laughter] This is sort of what we feel like sometimes [laughter] when we try and slap that overfishing label on the industry in terms of the political [laughter] pressure that we get back on the agency. So, if we look at groundfish management up to this point, it's really been a broad scale management strategy. We've had regulations that have been put into effect over large geographic areas, over many different fishing ports. We tend to use indirect management measures. We never say, "This is how many fish you can go out and catch. Once you catch that many fish, you're done." What we say is, "Use this mesh size and go out for this many days, and we'll close this little block for this season." We're trying to limit the fishery to this many landings. But if we miss the target and go over by two or threefold, there aren't any implications to the management. There's been little or no international cooperation between Canada and the United States in terms of management arenas. I'd like to emphasize that the research coordination and the preparation of stock assessments has been very good. As a matter of fact, I was in a stock assessment meeting with Canadian biologists last week to prepare the 2001 Georges Bank haddock assessment. I'll be in St. Andrews in about three weeks to present that to industry members from both sides, from both Canada and the United States. The coordination there has been exceptional. What we're trying to do now is to get through some of the allocation issues and to try and get a joint vision for what the stock rebuilding might look like. The management decisions have obviously been highly political. Well, this is sort of the impression that I'm worried that people have been left with since the explosion of concern about the groundfish stocks in the early 1990s. Vaughan Anthony was former director of our stock assessment group. He has a couple of quotes. The first one is, "Stock is a basket case." The second quote in 1994 is, "This is a terrible situation bordering on disaster. We couldn't find anything good to say about this species, or I'd say it now." So, the situation looked really grim at

the point where we started to get serious about a second attempt at stock rebuilding. The situation was so grim that the assessment that we could even succeed was fairly pessimistic. This is a quote from Peter Shelley of the Conservation Law Foundation. Conservation Law Foundation is very significant for the fact that they were basically the institution that sued the National Marine Fisheries Service and really initiated the stock rebuilding efforts that have occurred in the 1990s. Some might say that the agency actually sued itself in a sense. I think the agency knew what needed to be done, but it needed a legal push to get down the right road. Peter's quote is, "Even if all harvesting by humans ends, cod, haddock and flounder numbers might not recover. We think this will be the most complex job the fishery service has ever had to do." Now, that may be overstating the case, but the emphasis is that it was a fairly complex job of rebuilding. Highlight some of our rebuilding efforts real quick. These were basically initiated starting in 1994. What fisheries managers recognize with it is that they had sort of an elevated, kind of a smallish but year class of haddock in 1992 that looked to be a little bit bigger than the surrounding year classes. They hoped to use that year class to try and start rebuilding the stocks. So, the thinking was, "Well, let's try and conserve this one-year class and let it spawn a couple of times. See if we can start to fuel some of the stock rebuilding that will go on here." So, there were a number of strategies that went on. Of course, this was a multi-species plan. So, there were other species that were considered, like cod and yellowtail flounder and a whole suite of other groundfish species. But the strategy was these large year-round area closures that were initiated in December of 1994. These areas are shown here. The two most significant ones for haddock were up here on the Northeast peak. Basically, most of the U.S. waters up near the Northeast peak, and then this area here, closed area one, which is around the Great South Channel, these areas were closed on a year-round basis to any gear capable of taking groundfish from December of 1994. They're still closed today. There had been a couple of small exceptions, most notably the scallop fishing that was allowed to occur in the southern part of closed area two to allow removable scallops. But for the most part, we've kept the effort that we'd be capable of taking groundfish out of the area successfully since December of 1994. Some of the other management measures that we've worked on, there's obviously been a large effort reduction program. This is the days-at-sea program where we essentially limit each permitee to a certain number of days that they're allowed to go out fishing. This has been very important in a sense that it has reduced the total amount of effort in the total fishery removals from the fishery. There was a very highly publicized vessel-buyback program. We spent about $26 million buying back vessels, and more importantly, permits from the fishery. This really, in hindsight, will be viewed as something that was very short term and very political in nature. I don't think it's my personal opinion that it had very little contribution to any stock rebuilding that we've seen because effort basically flowed back into the fishery to replace that effort. Some of the operators who operated those vessels that were bought out of the fishery are certainly back in the fishery now, basically, fishing from different vessels. So, this was a management measure that was largely politically motivated. Did not have a great deal of effect. We had trip limit regulations first on haddock and then on cod. The haddock trip limits that were instituted in 1994 were very restrictive on the order of 500 pounds per trip. They basically resulted in very large discarding of haddock between 1994 and 1997. During that period upwards, at times, the percentage of the haddock catch that was discharged was up to 70 percent of the total catch. However, the trip limits were successful in the sense that they did dissuade the industry from fishing on large concentrations of haddock. Generally, those large discards occurred by accident when the industry happened to stumble on large concentrations of haddock. Trip limits were not our

preferred mode of management operation. They were sort of a management action that the management council thought that they could swallow. They seemed fair. They're not the most efficient way to manage, but they did contribute to stock rebuilding. We had mesh size increases. It's important to point out that the mesh sizes that were being fished during the 1930s through the 1960s ranged from 2 to 3 inches of mesh, which is a very small mesh size. They tended to catch large numbers of small haddock that were ultimately discarded because they were too small for the market. In this case, there's been gradual increases in mesh size that have occurred throughout the time period. The most recent one was to go to 6-inch mesh and 6.5-inch mesh. That depends on whether you're fishing diamond or square mesh. The idea here is to try and select larger individuals from the population and allow some of those smaller individuals to mature and spawn before they're captured by the fishery. I think that we can't underemphasize the importance of Canadian management. At the same time that we were initiating all these U.S. management measures, the Canadians had significant quota reductions. They're under what's called an individual transferable quota system. So, each operator is given a certain share of the fishery. An overall quota is established. Then each operator gets a certain share of that quota. But those quotas were reduced substantially in the early 1990s to try and reduce fishing mortality. Their fisheries essentially close from January 1st until sometime in May annually. The entire section of their waters at Georges Bank is closed to ground fishing as a conservation measure. Well, how effective were these management measures? What you can see in a sense is that fishing mortality rates in the early 1990s declined substantially down to some of the lowest levels that we've seen throughout the historical time series. This sort of period of being down below this safe fishing level is the longest period that we've seen throughout the entire time series. So, it does look like the management measures that we've put into effect have been successful in reducing fishing mortality rates. Now, the question is, has there been any response from the stock? The answer is yes. We have seen some significant stock rebuilding. What we can see here is sort of the increase in spawning stock biomass that's occurred since the early 1990s. We can see that we're starting to get up to some of the highest levels that we've seen since the mid-1970s. What's important to point out is that this is sort of a broad-based rebuilding of the stock. It's not just one or two year classes. It's not just jellyfish. We've seen broadening of the age structure throughout the population. So, the build up here is probably more significant than what we saw during the late [19]70s and early 1980s. If we make two simple assumptions about what's going to happen over the next three years, what we can see, the two simple assumptions are, the fishing mortality rate will stay at a stable level and that our current estimates of incoming recruitment or incoming year class size from our surveys are accurate. If you're willing to make those two assumptions, these are the projections that we're coming out with for how fast spawning stock biomass is going to rebuild over the next three to four years. This is significant because this level of spawning stock biomass is approximately what we saw throughout the time period here. Well, the question is, well, perhaps we have significant numbers of spawners and basically, that's being fueled off of seeing stronger recruitment coming up in the most recent year classes. You can see that we have a fairly large 1998-year class relative to anything that we've seen since about 1978. The 1999-year class looks fairly strong. We are not permitted to release the results of the 2001 assessment that will get us our initial estimate of the stock size for the 2000-year class. But let me just characterize that as being extremely optimistic. So, those three year classes are going to allow the rebuilding of spawning stock biomass, assuming fishing mortality rate stays low. I think it's important to take a look at that relationship between those year class sizes and the amount of spawning stock biomass or

parents that we have out there. So, what we have is our index of parents down here, and we have our index of offspring here. What we can see is that there have been different periods of time that have occurred. This is the relationship that we saw during the 1930s through 1960s period. Now, if you're a physicist, plots like that normally bother you. They sort of bother us too, but we're getting used to them because this is typically the shotgun pattern that we see for a lot of fisheries. It's highly variable. But it's relatively at a fairly high level relative to what I'm going to show you. During that period of destabilization when the stock size grew large in the 1960s and then ultimately collapsed, we see this cloud of points. Basically, stock size increases like this, we get that extremely large year class, and then we have recruitment failure. So, we basically get this point, this point, this point, that point right on down into the origin, where we see almost complete recruitment failure. For most of my lifetime, we generated this cloud of points, basically, very low levels of recruitment that haven't allowed any stock rebuilding. The two chances that Mother Nature gave us to rebuild this stock were the 1975 year class, which pushed spawning stock biomass up to this level by 1978, producing this year class. This was perhaps our chance to jump from this cloud of points back into this cloud of points. But again, largely because of fishery management regulations, we ended up discarding these two year classes instead of putting them into the bank, basically to rebuild the stock. What we see in the most recent time period is this cloud of blue points here. Perhaps our second chance to rebuild to the historical stock recruitment relationship that we've seen. The last three points in this series are these three year-classes, the 1998 through 2000-year class. I think the other question that we always have about spawning stock biomass is, what is the age structure? Generally, the belief is that age structure is important in terms of having a quality spawning stock biomass. What we can see here is basically age plotted out along this axis. We can see time plotted out along this axis. What you can see is if you follow these diagonals down, you can see the effect of a large year class. In this case, this is a 1963-year class coming down as age five, as age six, as age seven, as age eight. You can see it carry through the age direction. This one's taken from a research vessel survey. But you can see the same thing if you look at a commercial fishery sampling plot. You can see the seventy-five-year class coming down here, but basically being largely extinguished by the time it's five years old. These fish basically don't mature until they're about four years old. So, what we want to see is rebuilding of stock size out here that can contribute to recruitment. What we can see here is sort of that broadening of the age distribution starting to occur in the early 1990s. We could see these larger recruitment events starting to occur in the late 1990s. We get much the same picture if we look at the results of the Allard survey. This is sort of the power that those long-term data sets give us, that allows us to look at year classes coming through and to basically look at broadening of age structure that we think is critical to rebuild the stock. So, really what I wanted to emphasize is the importance of these long-term data collection systems. Here's William Herrington collecting haddock data in 1938. Here's me hopelessly trying to get an [inaudible] of a juvenile haddock in 1998. [laughter] I think the future of stock rebuilding, we have the potential to restore historical abundance capable of producing historical yields. But it's going to require continued low fishing mortality for another five years. The question is, will managers and industry members have the internal fortitude to make that investment to complete the stock rebuilding picture here? So, really getting back to the title of my talk, we talked about a return to history. But really, I'll end my talk with a question. That is, which history are we going to return to? Are we going to return to the late 1970s when we had a false start on stock rebuilding that was derailed by increased fishing effort in high discards? Or are we going to return to that 1935 to 1960 period when we

managed with stable yields averaging 40,000 to 60,000 metric tons a year, and possibly fine tune the system to produce yields even higher? I think Gerry Studds put it best when he said, "If we learn nothing else from the tragedy in New England, it must be that it can never be allowed to occur again." I'll stop there. Thank you.

[applause]

MS: Well, we feel educated and very rewarded. I hope that you will talk a lot to the fishing people. [laughter]

MS: The people who really do it.

RB: I get to do that some. It is very important. We sort of try and keep the science separate from the management. You can see how much influence politics has had over the management. My feeling is that politics has had very little influence over the science. That's the way we hope to keep it. We do talk to commercial fishing industry members. I think it's important to recognize that their frame of mind is different than ours. I mean, their initial concern is, "How am I going to make the mortgage payment next month on my boat? How am I going to keep the business going for another year?" Whereas our viewpoint is a little more long-term. It's important to understand that sort of disconnect. Their pressures are real. There are reasons why they're motivated to respond to efforts to rebuild the stock in the way that they do. Let me go back there.

MS: Yes. In 1970, just after that monstrous collapse, did the Soviet trawls not return on their own or because of Magnus Law?

RB: They moved off the bank in a sense because the fishing was not as economically profitable for them anymore. In a sense, these distant water fleets were like a roving flock of locusts in a sense. They would move from one area to the next, essentially depleting fisheries. There was still some fishing activity that occurred in the 1970s right up until the point where we extended the 200 -mile jurisdiction in 1976. However, their landings were much, much lower than they were during the mid-1960s.

MS: Do you have any opinion as to which of the regulations was more effective in reducing the amount of fish stocks or do you have any figures on that?

RB: It's interesting. One of the things that happened in the mid-1990s, it was, we were essentially in crisis mode. We wanted to do something. We wanted to do something fast. From a classical fisheries management context, what normally would occur was you would implement a management action. Then you would wait and evaluate it and see how it works. Then you would implement the next management action. You would wait and evaluate how it works. But what we essentially did between 1994 and 1996 was we implemented about twelve different management actions simultaneously. Some of them worked. Some of them didn't. The reality is that we really don't have the data or the technical expertise to say which one worked conclusively. We can make some broad scale statements such as, the vessel-buyback program probably wasn't very effective. The closed areas probably were. I've actually done some

research showing the buildup of biomass within those closed areas, which has been very significant. When you're out on the research vessel survey on the *Albatross*, when you cross the line into a closed area, you know it. You know it just by what you bring up on the internet. [laughter]

FS: Are you at all worried about what is happening with the meat industry so that people are going to shift to eating fish? I think that is going to happen in our family. [laughter] I would think would be a much bigger demand for fish and [inaudible].

RB: It's possible that we could see a ship like that. I mean, the fish market is very broad scale in the sense that cod and haddock and yellowtail flounder comprised of a fairly small percentage of the overall fish market. I don't see that happening on a real basis per se, just because of the price difference. If we all run down to Stop & Shop right now, I think the price that you'll find on cod and haddock glaze is about $5.99 to $6.99 a pound, which buys you some really nice beef. [laughter] The reality is that I work on haddock. I can't even afford to buy the filets for them. [laughter] What's going to be really interesting is if we rebuild the stock, whether we'll see the prices start to come down or whether we'll see them stay at that same level. It really comes down to a willingness to pay. I mean, the prices rose up to that level. There's enough of a market that's willing to pay that price that so far, that's sustained the market. That's been very important for the commercial fishing industry too. The fact that they are getting better prices for their fish has allowed them to subsist on a lower level of landings throughout this four or five-year rebuilding period. That's been very critical. Now, what we're able to deliver to them is basically significantly more landings while keeping the fishing mortality rates stable. That's the reward that the fishing industry has been working toward, and that's what they're going to get. That's what they got this past year. The 2000 landings for U.S. fishermen increased by about 25 percent while the fishing mortality rate really didn't go up at all. That's significant. Yes.

MS: At the beginning of the laboratory, there seemed to be a lot of emphasis on fish hatchery. Does that have any part of the picture?

RB: I think in a sense, I have a pretty strong opinion about augmentation from hatcheries. I'll point out that my other job is to work on Atlantic salmon which were just listed under the Endangered Species Act. Hatchery systems for the rebuilding of Atlantic salmon stocks play a critical role. Basically, the distinction is hatcheries tend to be more effective for fish that basically produce less eggs and less offspring per year. If you think about a salmon, a salmon produces an egg that's very large. The fecundity of a salmon is basically maybe between 2,000 and 10,000 eggs total. The fecundity of a haddock the same size is between a half million and 2 eggs. Haddock's life history strategy is to quit. Ton of eggs out in the environment and hope a couple of them survive, literally. They broadcast spawn. They just put the eggs out there. They spin around the bank. They hope they survive. With the salmon, they're obviously putting much more parental care. They swim up to a specialized habitat. They dig a nest. They guard the nest. They spawn the eggs in the nest. There's far less eggs. Basically, the survival rate of those eggs has to be much higher. Hatchery augmentation works for populations that have more parental investment in both the somatic composition of the egg and the parental care that's given to the egg. You'll see that there are efforts where hatchery augmentation has made a significant contribution. That's just my personal opinion. Other people may have a difference. Yes.

MS: Going back about two decades, there were two species on Georges Bank that were looked upon as possibly lethal to the development of the embryo. One was squid, which was thought to be feeding on fry, and a cnidarian, possibly will be here, in which the medusa stage was also lethal on the developing embryo. Where is that research now?

RB: Well, I think in a sense, there still is a lot of research in terms of basically, larval and juvenile predators on both cod and haddock stocks. There's no question that, A, it occurs, but, B, is it important enough and has it shifted enough annually to make a difference? I think that's still essentially an open question. I think there are cases where natural fluctuations in populations cause periods of high productivity and low productivity for fisheries through mechanisms such as predation, as you've cited. But the question is, essentially, what has the largest effect on the population in – are these shifts that we see decadal in nature? Can they account for the shifts in the populations that we've seen? I haven't seen any evidence that's convinced me of that.

MS: Is the haddock embryo developed on the surface, or is it developed in bottom water?

RB: It's not on the bottom. It is up in the water column. It's not necessarily on the surface. But essentially, the eggs are fairly buoyant. The larvae are basically midwater for about the first three months of their lives. Essentially, once they reach a certain size, then they go domicile. So, they are up in the water column. Yes.

MS: I could not understand why the trip limits led to so much discard. Why is that?

RB: What you have to recognize about the fishery out there is the fishery is not just for haddock. Many of these groundfish trips are landing up to nine or ten different groundfish species all at the same time. What we found was the vessel operators were willing to essentially trawl through large concentrations of haddock to make fairly small catches of cod and other species that they could legally retain. Some of it was accidental. Frankly, some of it was intentional. We actually have sea sample data that shows some of the intentionality of it, where you see an operator get a huge bycatch of haddock, which he discards. He just goes back to the same area over and over again. That's when the behavioral expectation of the regulation isn't realized by the operator. If anybody needs to leave, you will not offend me. We're over on time. So, if you do – but I will answer a couple more questions.

MS: Does anybody [inaudible]?

RB: Of effective what?

MS: Subsidy. Like the cannery in the maritime zone –

RB: Well, I think there have been a number of economic analyses done on the effects of subsidies on fisheries. Subsidies are basically when governments come in and basically prop up a fishery. In a sense, we may still be doing that today with the groundfish fishery. I think the general consensus from classical fisheries is that subsidies are usually not a good idea in the sense that they do artificially prop up effort in instances where essentially, we have too much

effort in most of our fisheries today. That's probably as far as I can go in terms of representing the research. But in general, a negative view of subsidies. Okay. I'd like to thank everybody for coming. If you have additional questions –

[applause]

[end of transcript]