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American Eel: A Symposium. Session Three

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AMERICAN EEL: A SYMPOSIUM
SESSION THREE: THREATS TO EEL

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Professor Jeff Thaler[1]
***Panelists**:*
Steven Shepard[2]
Dr. Gail Wippelhauser[3]
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OVERVIEW OF MAJOR THREATS

Jeff Thaler:

Good afternoon. I am Jeff Thaler, [and I will be moderating] this next panel; I will also do the [first presentation] for the panel. We are going to talk about threats to [the American] eel. You have already heard some of that this morning. On the panel will be myself; I am from the Maine Law School, and the University of Maine. I have been an attorney and done environmental and energy work for a number of years. I am also a professor teaching at the University of Maine, and primarily Maine Law School. . . . Steve Shepherd from the U.S. Fish and Wildlife will come next, speaking . . . on the recent listing decision for U.S. Fish and Wildlife among other issues. Gail Wippelhauser from Maine Department of Marine Resources will go third, talking about threats and how they have been managed at the state level. And then fourth, but definitely not least, will be Jon Truebe, who is an environmental engineer who actually designs fish passage facilities for hydroelectric projects in the northeast. He will have some very good visuals that he will share with you that will not appear on the screen but will be physical, to give us a chance to have some hands-on activity.

[Turning to eel threats, we must first get some perspective on the commercial harvesting of elvers. Maine and South Carolina the only states where such harvesting is allowed. The market has exploded in the past few years, since Asia consumers are increasingly demanding more elvers. In 2013, 18,076 landings of Glass eels were reported in Maine, with a value of $32,926,991. In 2015, the price of eels skyrocketed in Maine to approximately $1,900 per pound. Commercial fishing of eels does not go unregulated in Maine. Maine's commercial eel quota for the 2015-2017 fishing seasons is set at 9,688 pounds annually.] Gail [Wippelhauser] is going to talk more about that and about the commercial eel quota; . . . you can compare that with other places, to the extent that there are quotas as well.

Predation is another threat and you will hear more about that. Striped bass is one threat; certain sharks that we have heard about in the Sargasso Sea [are another threat, and] we will hear more about [them this afternoon].

[As for the threats from parasites, there are three exotic parasites affecting eels in North America. The parasitic nematode *Anguillicoloide crassus* is the most prevalent threat in fresh water

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in America, and is widely distributed in the northeast and in Maine. *A. crassus* is highly infectious and affects the swimbladder of eels. Studies indicate these parasites cause starvation, reproductive failure, and high mortality at temperatures below 4℃. *Pseudodactylogyrus bini* and *P. anguillae* are two other parasitic species, but cause few if any problems.]

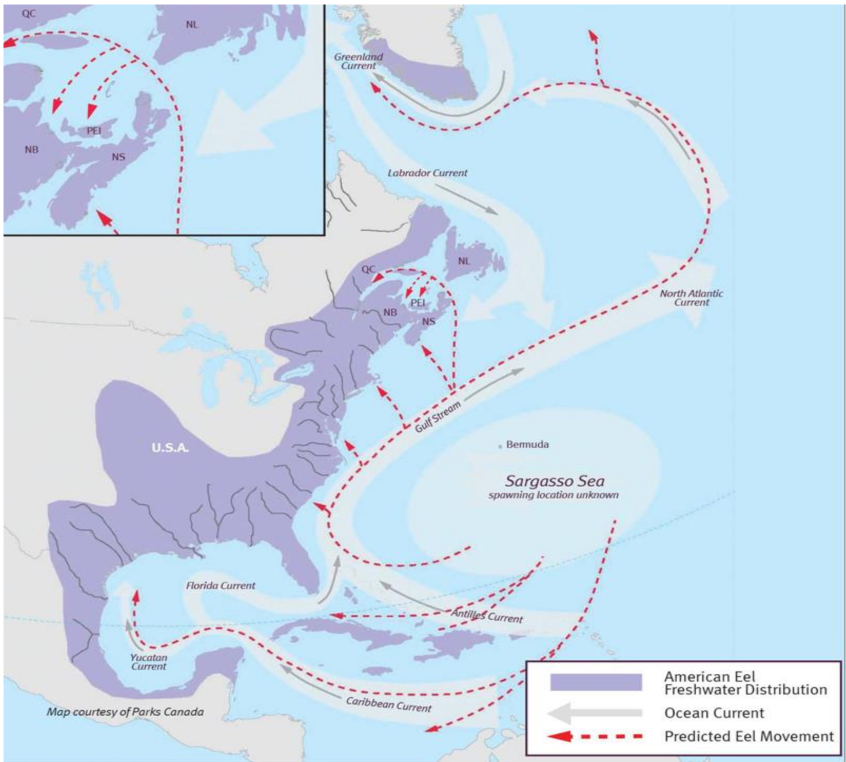

Figure 1. American Eel Locations.

[Looking at Figure 1,] you have seen a version of this map already in terms of where the eels are. I wanted to show this map in particular because [it shows] the currents [in the ocean]. [This morning] we heard talk about Greenland and Iceland. You can see the Greenland current going up here, the Sargasso Sea generally here. The Gulf Stream going out this way, the North Atlantic Current, the Antilles Current, Florida Current, the Caribbean Current, Yucatan Current. [Thus] you can see how critical are the currents in terms of the distribution of the eel and these red lines are the predicted eel movements. . . . Then you can see again up here, more particularly in northeastern Canada, where some of the eels are moving. . . .

Global warming and climate change [are the subject of the next few Figures]. This is another area where the interplay between science and policy [is very interesting, especially] how difficult it is to get policy makers and decision makers to move where there is perception of uncertain science. But certainly it seems like, at least and there will be others in the Q & A that can speak up on this, that the impact of climate change and ocean warming [upon] the eel is still a little bit uncertain; [however] that there do seem to be some rising ocean temperatures in the Sargasso Sea area. Query: how much of that is affecting [eel] habitat, or not. And again, we have talked about changing ocean currents and decreasing food availability to larval eels.

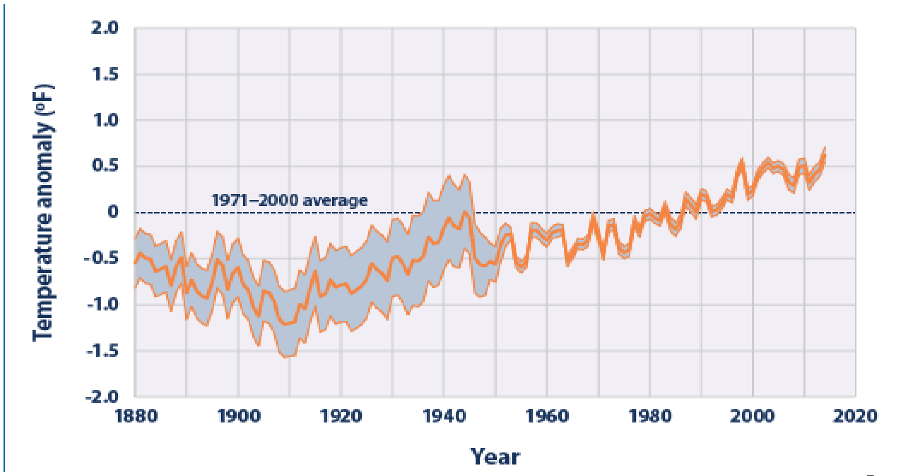

Figure 2. Average Global Sea Surface Temperature, 1880-2014.[5]

[Figure 2 graphs] average global sea surface temperature. You can see over a two hundred year period . . . how the trend is certainly going up, mapping and really tracking what is going on with carbon dioxide in the atmosphere and this is by degrees Fahrenheit.

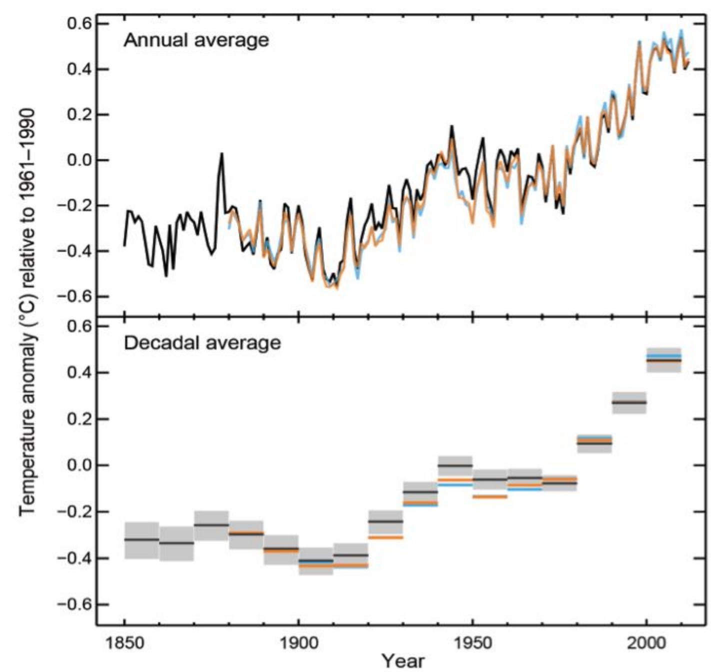

Figure 3. Observed Globally Averaged Combined Land and Ocean Surface Temperature.[6]

[Figure 3 depicts the] combined land and ocean surface temperatures. [The average rose, leveled off, and then over the last three decades has greatly accelerated, and is still doing so.] That is significant, and [fuels every adverse] impact [upon both] terrestrial as well as marine wildlife.

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[5] Climate Change Indicators in the United States, ENVIRONMENTAL PROTECTION AGENCY (2015), http://www3.epa.gov/climatechange/science/indicators/oceans/sea-surface-temp.html.
[6] CENTER FOR CLIMATE AND ENERGY SOLUTIONS (2014), http://www.c2es.org/docUploads/basics-0-09-2014.png.

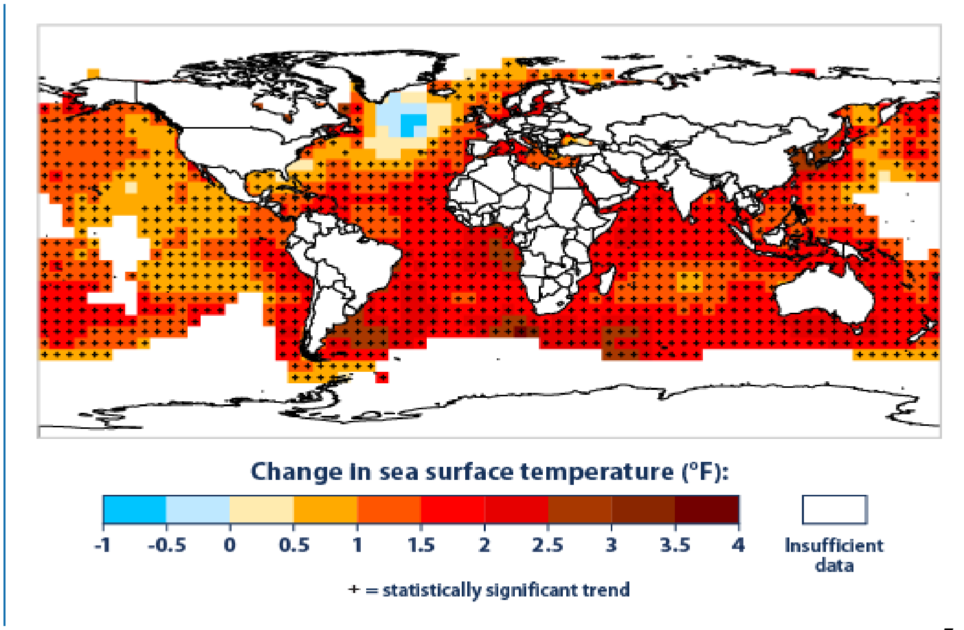

Figure 4. Change is Sea Surface Temperature Between 1901 and 2014.[7]

[Likewise, if you look at Figure 4, global] changes in sea surface temperature and where it is particularly happening; it is happening in most places, but the darker red, the deeper red is where it is more significant. Again where the eels go (up toward the northern Atlantic) is really the only area of the world where the temperature may be at the sea surface getting a little colder or [leveled] but everywhere else it is pretty much increasing significantly[, including in areas of eel habitat].

This [next slide] is from an article that again talked about the hypothesis about global warming trends and [their possible] impacts in terms of . . . both starvation and predation losses . . . .[8] And to get you back to the North Atlantic Oscillation Index (Figure 5 below) that was also talked about and its impact, people are hypothesizing and trying to determine as much as they can what the cause and effect [may be]. Ultimately that is part of I think what Steve [Shepard] will be talking about in particular from a policy and legal perspective; causation is a big deal. So unless you can show that more likely than not or to some degree of certainty [that] a cause creates a particular effect, it is unlikely that your regulator, decision-maker, or judge [will] ultimately rule in your favor as opposed to stasis or status quo.

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[7] Climate Change Indicators in the United States, ENVIRONMENTAL PROTECTION AGENCY (2015), http://www3.epa.gov/climatechange/science/indicators/oceans/sea-surface-temp.html.

[8] "It is hypothesised that, associated with global warming trends, STG warming inhibits spring thermocline mixing and nutrient circulation, with negative impacts on productivity and hence food for leptocephalus larvae. Concurrent gyre spin-up also affects major currents and slowing of oceanic migration has probably enhanced starvation and predation losses." B. Knights, *A review of the possible impacts of long-term oceanic and climate changes and fishing mortality on recruitment of anguillid eels of the Northern Hemisphere*, SCIENCE OF THE TOTAL ENVIRONMENT (2003), *available at* http://www.sciencedirect.com/science/article/pii/S0048969702006447.

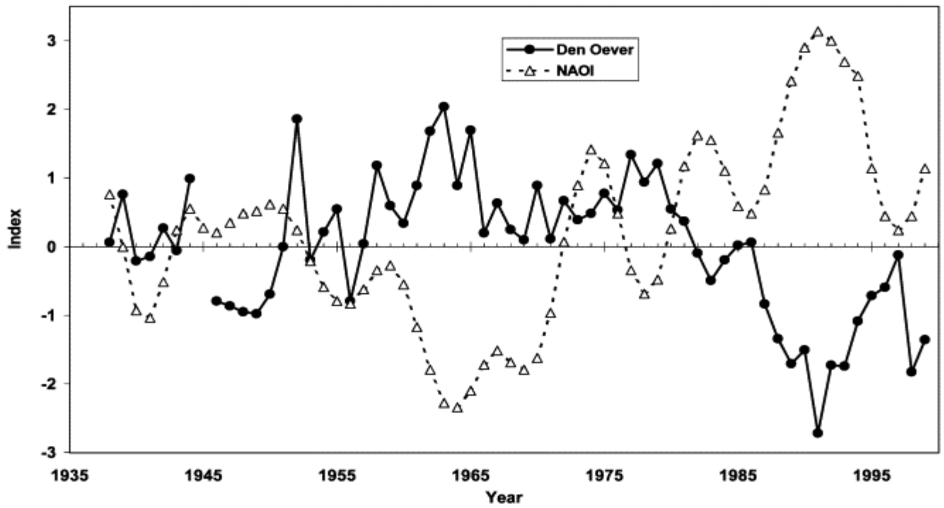

Figure 5. DOI and NAOI between 1938 and 1999.[9]

[Figure 5] is a chart similar to what you saw this morning in terms of the trend of the ocean current, and it is from a review of long term oceanic climate change and fishing mortality and recruitment so again you saw that earlier and you can see the inverse correlation.

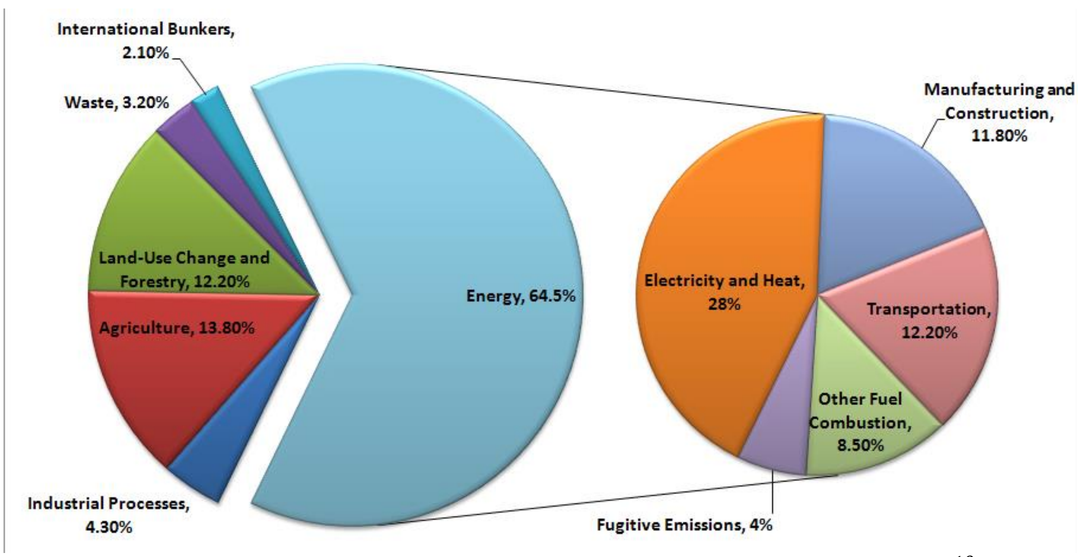

Figure 6. Global Anthropogenic GHG Emissions by Sector 2005.[10]

I show [Figure 6] because . . . if you are talking policy [development], our use of energy is the dominant factor in the generation of greenhouse gas emissions. Then if you break down energy, people often think it is transportation [that is the most significant factor] because we primarily drive with petroleum, but electricity and heat [are also significant energy demands]. . . .

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9 *Id.*, *available at* http://dx.doi.org/10.1016/S0048-9697(02)00644-7.

10 CENTER FOR CLIMATE AND ENERGY SOLUTIONS, http://www.c2es.org/facts-figures/international-emissions/sector.

An interesting dilemma [comes when] people talk about adding [more] hydropower to reduce carbon emissions but of course if you have dams . . . , then that has consequences for [eel and fish] passage. And so speaking of passage, there literally are tens of thousands of barriers [already in the U.S.], most of which do not have upstream or downstream [facilities]. It is really only hydroelectric dams that generate power that are licensed by the Federal Energy Regulatory Commission [and which] are required to have passage; and [as to those dams, they] only be required to have passage when there is [a] relicensing [proceeding]. Hydroelectric dams in the U.S. generally [have] 40 to 50 year-long licenses, [and thus only] when the relicensing is starting to come up [do] issues of salmon and eel passage [significantly come into play].

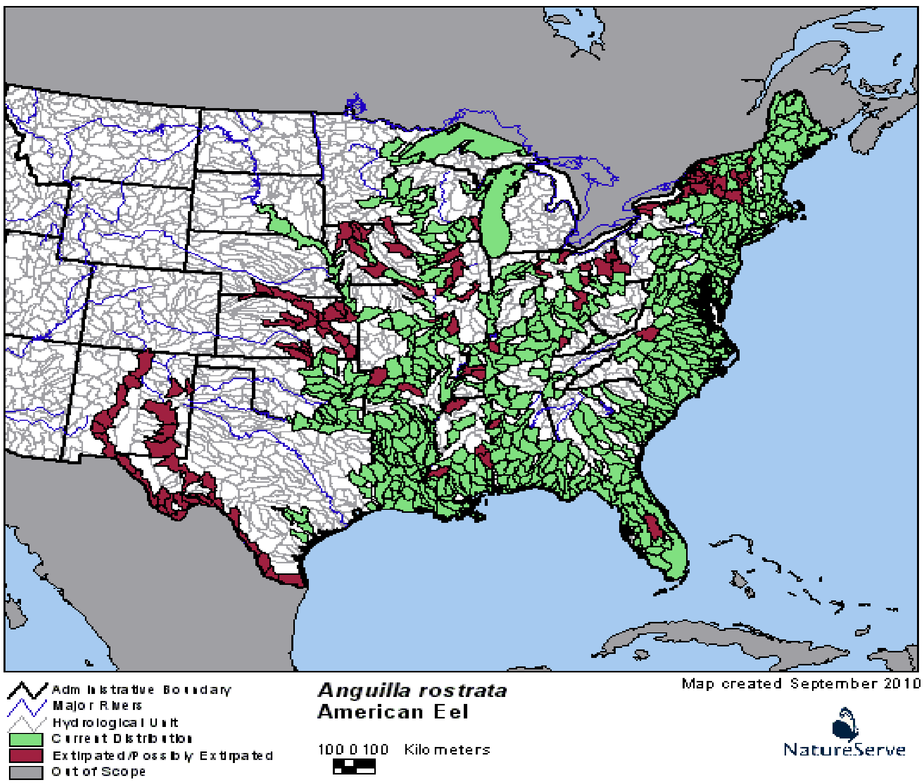

Figure 7. U.S. Distribution of the American Eel.[11]

[Figure 7] is an adaptation from another map that you saw this morning, [of the] distribution of the eels: the green is current distribution; the red is where the eel is either extirpated or possibly extirpated and you can see all these red areas where the eel used to be but is not anymore. . . . You can see Maine is largely still current distribution, [as are several of] the Great Lakes as well. You also can see a fair number of areas where they used to be and are no longer.

To quickly close my remarks, habitat loss is another threat that has been evaluated. [Estuary habitats have been lost due to dredging and filling for residential and commercial developments and for navigation, changing estuary depth and salinity. Another threat comes from the overboard disposal of contaminants. Hurricanes and non-tropical coastal storms also can

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[11] *Anguilla rostrata*, NATURESERVE (2010), *available at* http://explorer.natureserve.org/servlet/NatureServe?searchName=Anguilla+rostrata.

adversely change coastal wetlands and estuaries. Last, water quality issues in lakes, reservoirs, and wetlands affect the maturation of female eels in particular.]

So, with that, we have now done the entire U.S. fish listing. *[Laughter.]* You will hear now from Steve Shepard. He is going to hit on some of the same issues I did but in a more applied way, and talk about the U.S. Fish and Wildlife Biological Report's findings. It is a very interesting document, and Steve will explain to you the basis of their decision [not to list the American eel as either "threatened" or "endangered"].

LISTING DECISION AND MANAGEMENT IN THE UNITED STATES

Steven Shepherd:

Thanks, Jeff. I am Steve Shepard. I am a biologist with the U.S. Fish and Wildlife Service. I am actually in the position of being a scientist who is charged with telling policy makers what to do. It is that unfortunate circumstance that I think Jim [McCleave] alluded to earlier in the question and answer.

I think that same question that has been raised a number of times, "How do you do that?" "How do you advise policy makers in the face of uncertainty?" That has been a difficult part of this assessment of the petition to list the American eel.

. . . I assume you [who] are here know that our decision was not to list the American eel. That listing is not warranted. The listing was published on October 8th, [2015,] a couple of weeks ago. That was actually just an announcement, a match finding, with a bunch of decisions. I think there were, maybe, a dozen or fifteen species included in that. It would have directed you to this website.[12] That is where the actual listing material can all be found. That is in particular, this is the twelfth month finding that is there. That is the statutory document that describes all the criteria that we have to address in the ESA statute to make a determination. It also takes you directly to this biological species report which I will mostly be talking about today. That is the source document and it has been peer reviewed. It represents a new approach . . . to ESA petitions. We, in the past, we used to just write the status review document, but now we are trying to do a good solid piece of science describing everything we know about the species at the front end of the listing process. And that does not necessarily get structured according to the statutory criteria. In this case, we wrote a great deal about the biology of the species, its distributions, as well as the threats and the issues that might lead to listing it. Because this species happened to have been petitioned in 2004, we had some relatively recent information, and if you go to that website you will be directed also to the information from the 2004 petition. In summary, we have a wealth of information. If you read anything, read the biological species report because I was the primary author of that and it is a damn good document. *[Laughter.]* Thanks, Jeff.

[12] The American Eel, U.S. FISH & WILDLIFE SERVICE, NORTHEAST REGION (2015), http://www.fws.gov/northeast/americaneel/.

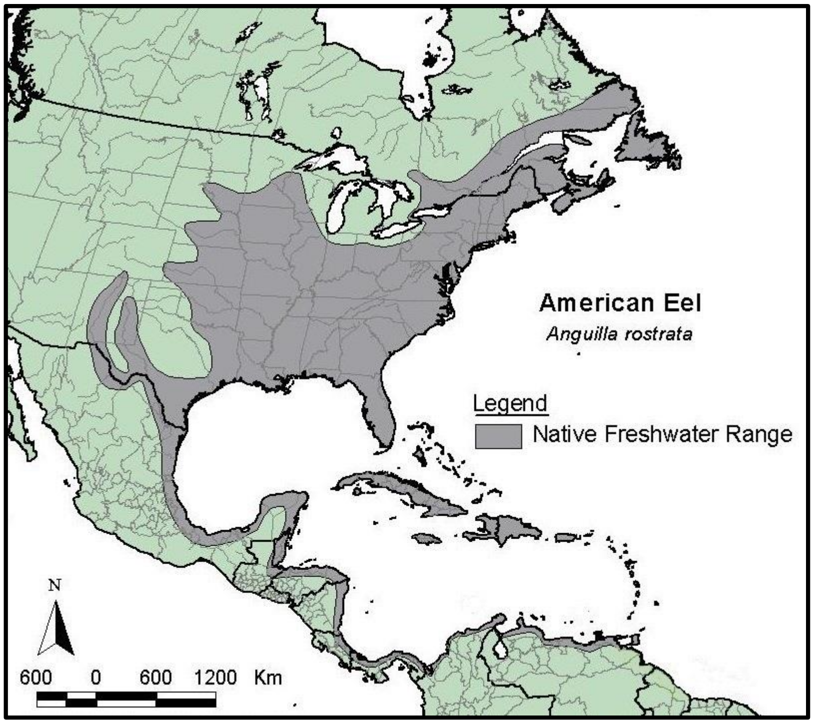

Figure 8. Native Range of American Eel.

You have seen some of the material I am going to present; you have already seen similar slides today. This range map [in Figure 8] looks similar to one you have seen. This is based on information from the 2006 NatureServe Data, but we have tweaked it in the Southern Distribution to reflect the information that Jim [McCleave] and José [Benchetrit] ventured and brought to light on distribution in the Caribbean. Most of the rest of it remains the same. I did omit Greenland. I would happy to talk about Greenland . . . but that is actually maybe perhaps a bit more complicated than a straightforward representation on some of the other maps.

We are going to get right to the meat of our analysis. I am going to spend most of my time talking about these two subjects. In the simplest sense our evaluation of whether this should be listed or not comes down to an analysis of the abundance in trends of the species; how many are out there; where are they distributed; are those trends going up or down over time; and what are the threats to the eel and the possibility of extinction, either in the near term or sometime in the foreseeable future. Foreseeable future is the statutory term in the ESA that relates to a threatened listing. That is what petitioner actually asked for was a threatened listing for American eel. So we had to assess: is it likely to become extinct in the foreseeable future?

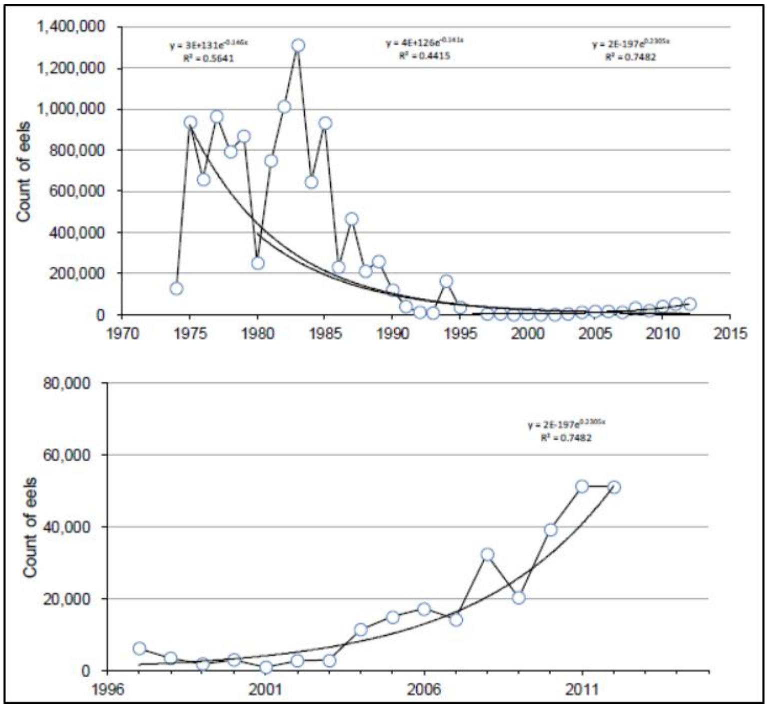

Figure 9. Number of Eels in the St. Lawrence River.

On the abundance side, again, some things you may have seen, this portion of the St. Lawrence graph was presented earlier. The lower part of that graph shows just the recent years. Scaling makes a big difference in what it looks like. In fact if this fish way had never been installed until 1996 there might be a much different interpretation of what those data meant. There is indications of at least some, some recovery in the last decade or more.

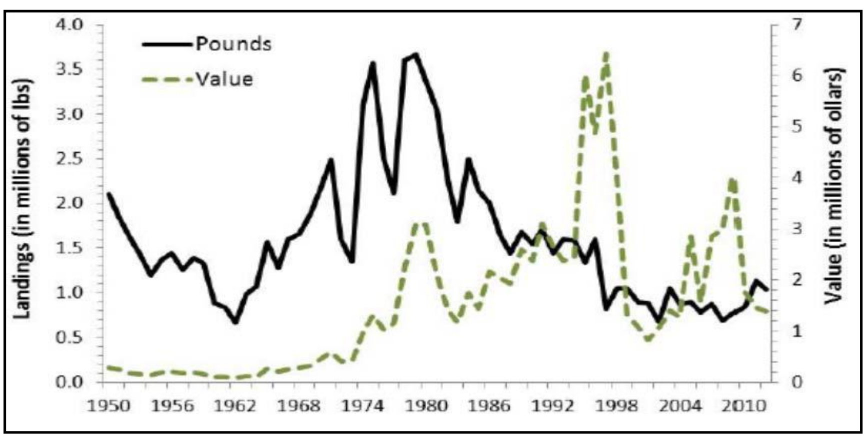

Figure 10. Yellow Eel Harvest on the East Coast Since 1950.

[Figure 10] . . . is yellow eel harvest on the east coast since 1950. That is the ASMFC data. And we have to assess what these landings mean over time? Are there reasons, as Mitch [Feigenbaum] noted, that they may have declined due to availability of aquaculture fish? Or are there reasons of decline because of other market conditions? The price paid to the fishers, for example, or the desirability of eel as a food product – many things. Since many eel fisherman are only part time eel fishers they fish other fisheries, where are they making their money? Would they switch between commercial fisheries that are available to them to make more money? Could the decline represent aspects of that? This type of graph is often thrown out as an indication for eel decline over time but it may also represent many other factors.

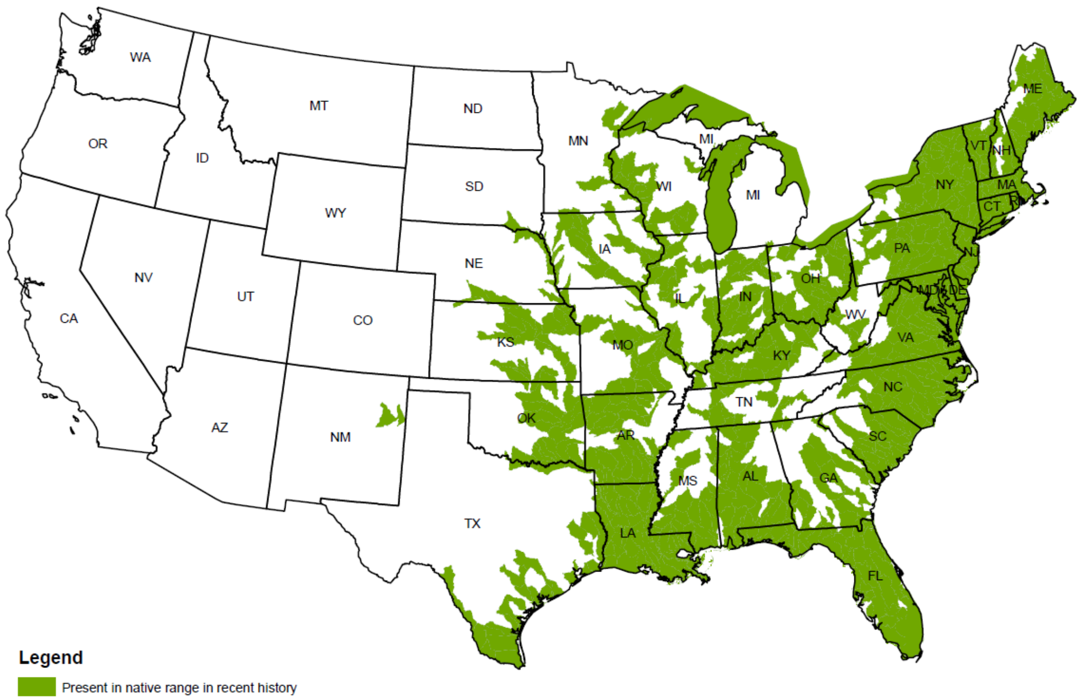

Figure 11. Distribution of American Eel in the United States Based on Presence/Absence in HUC 8 Watersheds.

[Figure 11] actually represents . . . a lot of work done by a number of people over many years going back to the previous listing. This is eel distribution in the continental United States based on presence/absence in HUC 8 watersheds. If you do not know what HUC 8 watershed is, all you need to know is it is very large. That was about as good as we could do in assessing their abundance, their distribution rather, in all of these areas. What is hidden in this, while it demonstrates a very wide distribution relative to the historic distribution, some of these watersheds may only have a handful of records in the last decade. That is generally what we were looking at. What shows up as green does not really indicate abundance and it certainly does not tell you anything about trends. But it is part of what we considered. Actually, I will note here there are thirty six affected states and we were pretty successful in getting information from a lot of them so this is based on recent electrofishing surveys other research data from state's trawls, or, in some cases, angling data, electrofishing, many things that provide us recent records. A lot of people spent some time working on this to collect that data. . . . Of those thirty-six states, we probably got data from thirty of them.

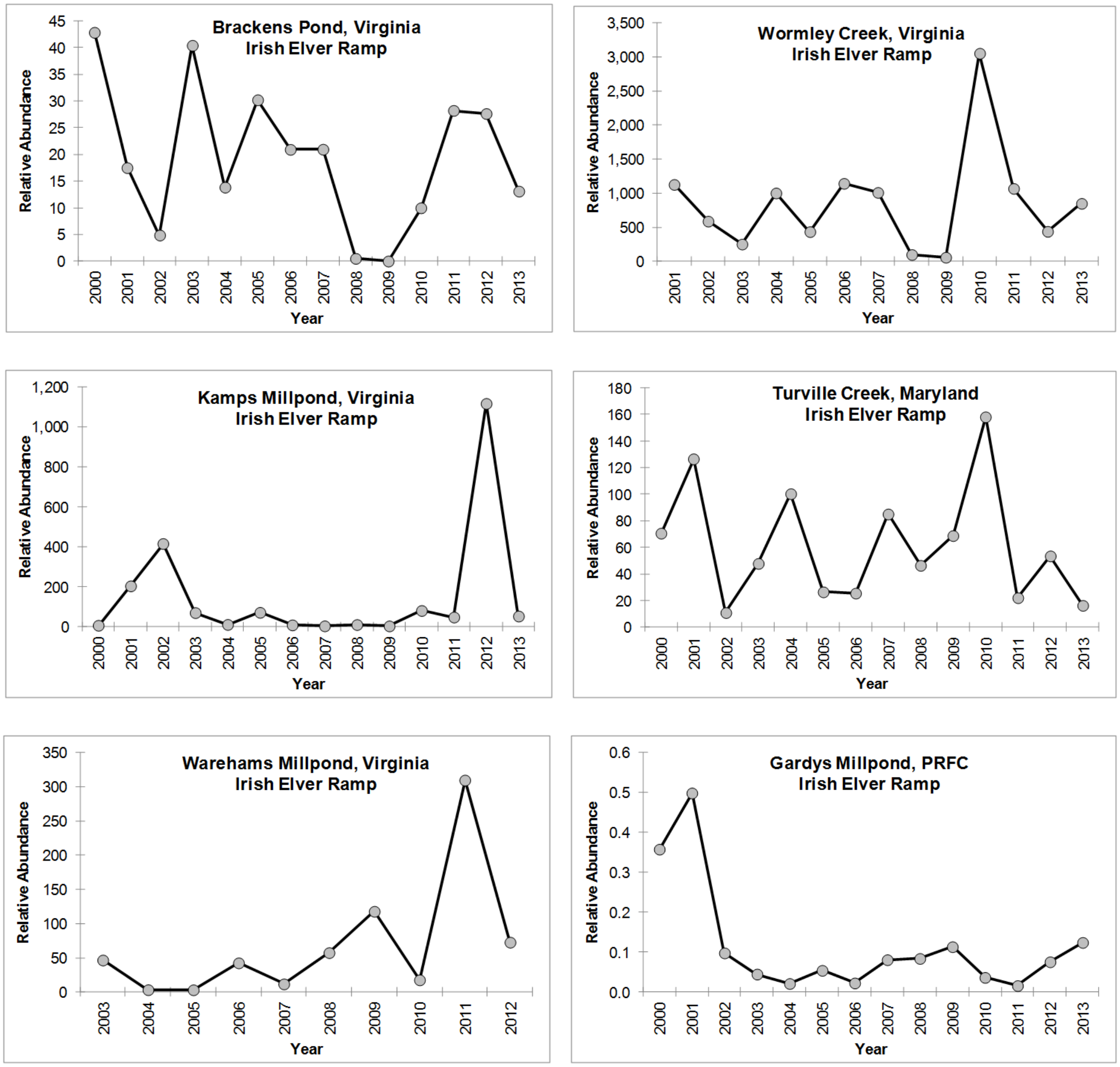

Figure 12. Elver Abundance Trends.

[The] data [in Figure 12] also figured into our analysis. These are just six elver abundance indices that I grabbed, more ASMFC stuff. Mike [Waine] is nodding his head; he has seen them all. There are what – a dozen more, two dozen more? I don’t know. Many other graphs of a similar nature, some go pretty flat and go up, some are going down, some are all over the place showing variability. Scaling of them differs, some of these eel abundance trends. They are all required by ASMFC management, these particular data sets. And they are all done the same way year in year out to evaluate the abundance of eels in the fishery and what management action should be taken. But it is hard to make conclusions from these as well. . . . I think depleted but stable is the general terminology for how [ASMFC] characterize the stock. These are the extended ones, three years were added. There was a 2012 stock assessment data and then these elver trends were recently supplemented in 2014 to cover up to three more additional years of data. We looked at those as well.

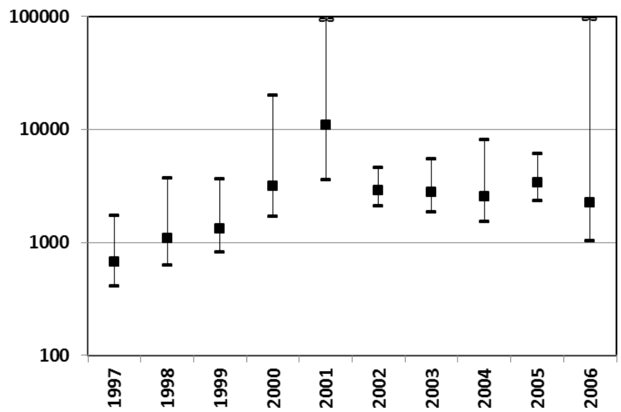

Figure 13. Index of the Number of Breeding Eels Contributing to Each Cohort.[13]

The paper by Côté and co-authors on the genetic parameters of the North Atlantic Oscillation and other data [has been referenced earlier]. I hesitated to put [Figure 13] in because I am showing a table of data that they presented on breeders per cohort and they make some assumptions and talk about effective population size and the relationship to census population. I have termed it an index of breeding eels contributing to each cohort. Ignore the y-axis; I am really only trying to show you the trend here from the 1990s and early-mid 2000s they seem to show, perhaps some recovery and stable populations over time. I could have shown you the table but it is easier to see these in a graphical format. It is something else we considered. In the authors' discussion of these data they extend their analysis to make some guesses, let's say, about what the spawning population size may be. And they opine that it could be 5 million to 109 million spawning eels in the Sargasso Sea over this period of time, actually extended a couple years further with some other data. We repeated those numbers in our biological report because they do come directly from the authors but I think they are extremely speculative and they involve some assumptions about what is the relationship between these data, n sub b, and a census population size. We repeated those numbers and they may be off by order of magnitude one way or the other, could be greater than the numbers there I suppose.

On the threats side, what is involved in our analysis of threats and the possibility of extinction? Things like turbine mortality – I am sure you are all aware of the impact of turbines on eels. The commercial fisheries. Also, the other stressors, all this lists all the stressors dealt with in the report.[14] Again, the report did not have to be structured according to the statutory criteria so we just took everything we could find in the literature and got into all of these categories of threats. I will have more to say about the first ones on the list, probably a little less I will try to respect the time of my panel members. I strike out threats here because some words have a statutory context, a statutory meaning. When we talk about threats that has a specific meaning in the Endangered Species Act. In the biological report, if you have read it, we were always talking about stressors in there because that word has no statutory meaning. So we have to be careful about how we

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[13] C. Côté et al., *Population genetics of the American eel (Anguilla rostrata): FST = 0 and North Atlantic Oscillation effects on demographic fluctuations of a panmictic species, in* MOLECULAR ECOLOGY 22 (2003).
[14] Climate change; parasites; predation; habitat loss and fragmentation; migratory impacts from dams; commercial harvests; contaminants.

characterize these things in the supporting documents for the analysis and in the statutory document for the analysis.

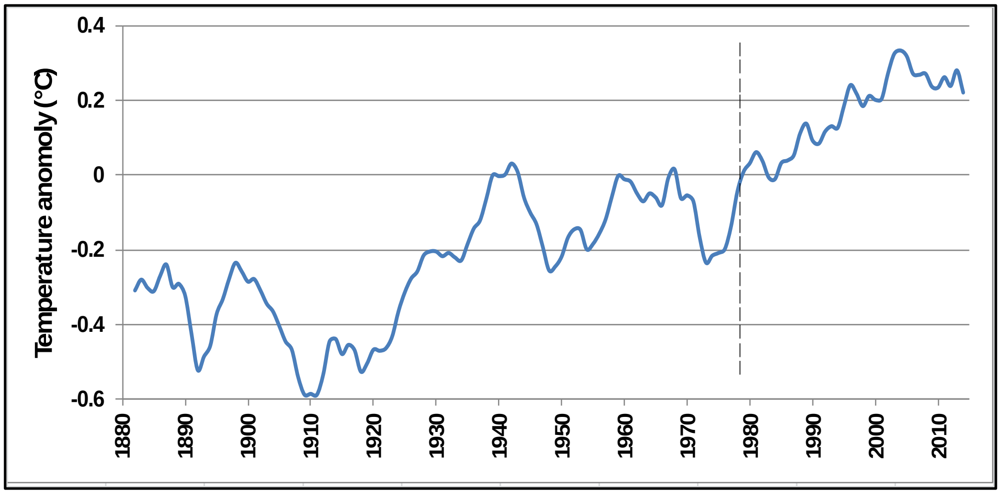

Figure 14. Average Atlantic Ocean sea surface temperature anomaly from 1880-2014 at 0°N to 30°N.

[Figure 14 is a] graph is from the report. It is from NOAA data, from the lower 0 degrees to 30 degrees north. It overlaps, comes the closest to overlapping the Sargasso Sea. It is just meant again to show the trend over time. This is the sea surface temperature, anomalies, departure from the mean over time and the point being there is this pretty steady decline similar to the graph that Jeff [Thaler] just showed. I threw in this vertical dash line, it has some relevance to the next slide, the point in the time series. [I think] the authors of the paper Bonhommeau *et al.*[15] . . . described it as a "regime shift" in ocean temperatures that could affect eel spawning.

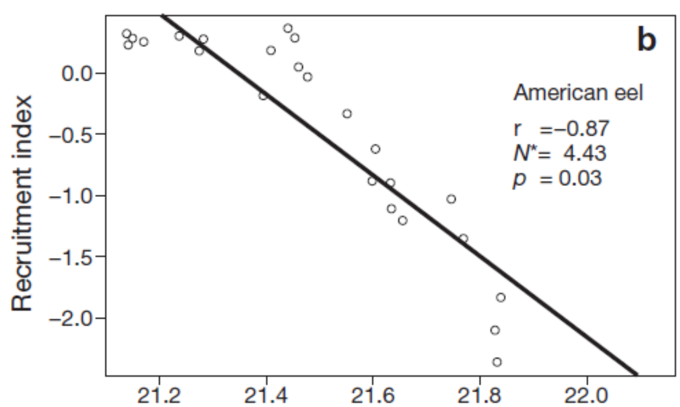

Figure 15. American Eel Recruitment Index Versus Sargasso Sea Surface Temperature.[16]

Figure [15 is also] included in the report. The authors include these data for American eel, similar data sets for *Anguilla japonica* and the *Anguilla anguilla*. The same sort of relationship

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[15] SYLVAIN BONHOMMEAU ET AL., HOW FAST CAN THE EUROPEAN EEL (*ANGUILLA ANGUILLA*) LARVAE CROSS THE ATLANTIC OCEAN? (2008).
[16] *Id.*

with temperature and recruitment for the American eel – one happens to be based on a couple of eel indices, this is juvenile eels counted, again the methodology is counting them the same way year after year, a reliable index and two them are pooled together for this analysis and the sea surface temperatures that affect their spawning as described earlier, there is a definite relationship there. Pretty darn good relationship statistically.

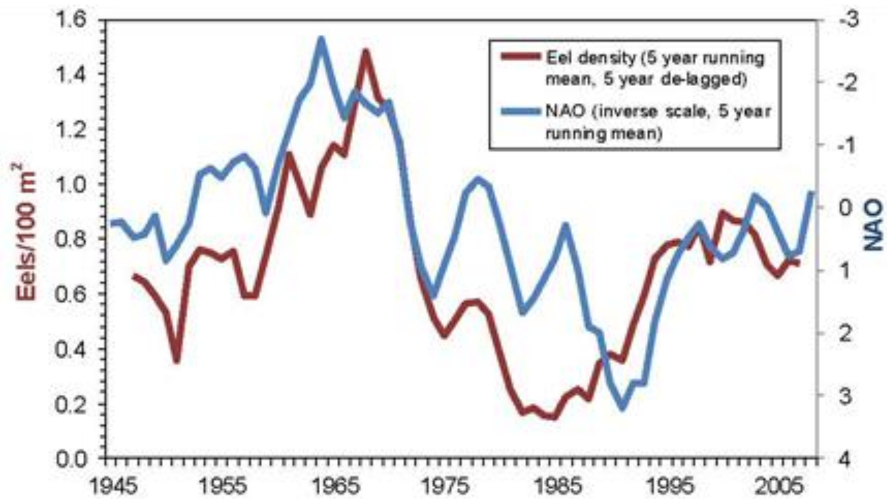

Figure 16. The Inverse Relationship Between Juvenile Eel Density and the NAO.[17]

The NAO data that has been described earlier from David Cairns' paper in 2014 and authors. The NAO scale is reversed here this inverse relationship depicted that way in a previous, earlier slide. Eel density: this is Miramichi eels; the other data were European eels. I was struggling to find one that was a pretty good relationship for American eels. One of the longer time series I found goes back to the late 1940s and shows, again, a pretty good relationship between the NAO and these are a little bit older eels than Miramichi, generally . . .

David Cairns:

Five years.

Steven Shepherd:

It is a five year lag for roughly five year old fish.

There is some speculation, and I think this was also mentioned earlier, about how that relationship works. What it is about the NAO, the NAO being the pressure gradient between the Azores and Iceland and how that drives sea surface currents and could directly affect carrying larvae from the east coast of North America up to spawn to rearing areas. The changes in ocean productivity that affect larval food availability could also be related to these spawning fronts and that temperature in the previous graphic and where and when do those temperatures occur. Do they match up with the timing of migration of eels to the spawning grounds? I mentioned in the previous

[17] DAVID CAIRNS ET AL., AMERICAN EEL LIFE HISTORY DISTRIBUTION LANDINGS STATUS DEMOGRAPHICS (2014).

graphic, the earlier graphic from another author showed that relationship from the European eel. Same thing exists.

In summary on climate change, our threat analysis determined that there is certainly a smoking gun here, there is a relationship – causation is not causality – but this relationship indicates that there is something going on. Maybe even a smoking gun of something impacting eels here. But there is so much uncertainty in these data. What are the mechanisms? What are the exact relationships? What is the long term abundance of eels absent some of these things? How much does climate change contribute to? Does the discharge of greenhouse gases contribute to? With all that uncertainty in the context of an ESA determination, uncertainty prevents you from making a positive finding on a petition. I was speaking with Matthew [Gollock] about the IUCN decision and there they had a different threshold to evaluate. In this case we had to demonstrate that that smoking gun is there that there is an effect, a cause, related to the effects we see in climate change and we could not really determine that we determined that there is still a great deal of uncertainty in these relationships.

Anguillicoloides crassus: this other significant issue brought forward in the petition. It is an exotic parasite nematode from Asia. It infests the swim bladder. It requires warmer waters. I could have said it does not do well in cold waters. But there is a threshold, perhaps close to ten degrees below which the parasite does not do very well. Also it does not survive well in full salinity waters. It will survive in estuaries. If I had to put a number to it perhaps 17 parts per thousand. Something like that. It does not do well very well above that. It has a lot of intermediate hosts which is in North America as well as in Europe which is in contrast to its native distribution in the western Pacific.

When it is in *Anguilla japonica* it has virtually no intermediate hosts, just a few and also in contrast to *Anguilla japonica* it does not cause any mortality, typically. It is known to cause some mortality in American eel. Typically only in crowded aquaculture conditions where D.O. and something else may be low and temperatures high, crowding causes stress and so on. But it does have chronic sub-lethal affects which are of great concern. Those are primarily related to buoyancy regulation, impacts on the swim bladder over time, perhaps scarring, perhaps loss of gas regulatory ability and ability to maintain depth in the water, to regulate swimming depth. In freshwater that is not really going to make a great deal of difference; they are primarily bottom dwelling at that time anyways. But in their migration to spawning grounds that could have a profound impact. In the case of European eel, that has been studied to some degree and there are some issues with the studies but certain authors . . . conclude there could be impact on swimming ability during the spawn migration. In North America this has been around for about two decades, the European situation is about a decade longer. The two infestations and expansion of the parasite parallel each other pretty well. In North America it first showed up in Texas and South Carolina. This where aquaculture introductions or transfers of aquaculture fish. These were two aquaculture operations, it was theorized, where it showed up. The Texas one never took off but the South Carolina one did. By 1998 it was found in a number of mid-Atlantic states, even in the Hudson River. And by 2005 pretty widespread and not yet in Canada. 2007 is the first occurrence in Canada. And that is probably a ballast water transfer since it leapfrogged other areas of the distribution. Ballast water transfer may or may not be a significant route of transfer. There are records in the European situation seem to indicate that perhaps it was transferred in the ballast water transfers but in the U.S. it does show up in greater abundance in heavily commercial ports – New York and certain mid-Atlantic spots. But that is on another uncertain to the degree by which it has spread by ballast water transfer.

Currently, we have been able to verify that it still does not occur in the Mississippi River basin. The gulf states, I am not so sure, it appears to perhaps not occur in the gulf states as well.

We have heard a bit about this as well: predation issues. Much of this comes from these satellite pop off transmitter studies. These have again been done in Europe for a bit longer with European eel than have been in North America with American eel. I think I even had the word "novel" in there at one point. The transmitters are rather large so it is uncertain whether they are impairing the swimming ability perhaps contributing to predation. Certainly some of the results are not what you would expect of a successful migration of a fish in these areas to the Sargasso. Somebody just sent me a paper, today, that I looked at over lunch quickly, another satellite telemetry study that indicates better results. This time they did get some fish going all the way to the Sargasso Sea. These things also record temperature, typically in daylight. It is pretty certain when these have been predated that it has been by fish species and oftentimes the temperature indicates by these thermo regulating fishes. Porbeagle shark seems to be the likely culprit. Some of the European work indicates thresher shark and some of the predations where it's colder temperature it might be tuna. The rates in some of these studies are disturbing if they really represent normal predation rates then it would be quite high. Quite an impact. But it is uncertain. Again there is some uncertainty in these studies. Only a few have been for American eel. So it is uncertain exactly what they represent. Is this really the dynamic in the migrations of adult eels?

Moving on to the other four. Those are the ones we chiefly focused on in the petition because those were the ones raised by petitioner that were new or not fully investigated in the previous response. These others had all been pretty well-investigated in the previous response so we supplemented those where we have additional data and I will go through those briefly.

It has been noted that very large dams are probably totally impassable to eels. Some are not passable because they have ineffective eel passage. This is an eel fish way that the licensee of the dam modified without any input from the agencies and this configuration was utterly ineffective. The entrance was in totally in the wrong place and not passable for eels. The attention has to be paid to how those are put in.

In perhaps many ways, the most significant impact is mortality due to downstream passage. Upstream fish ways . . . are relatively simple, relatively cheap, and they can be very effective if they are designed properly, sited in the right place, and maintained and operated properly. This one is one of the more recent ones, the Roanoke Rapids dam in North Carolina and as they worked out the bugs and actually installed the second fish way the passage increased here to 800,000 eels in 2013 and again in 2014 about 800,000 eels.

Mitch Feigenbaum:

And they are not glass eels either, are they?

Steven Shepard:

No, this is, I forgot, a hundred and some kilometers; it is quite a ways up the Roanoke River in any event and I think the animals tend to be three or four year old. But this year I have just gotten early reports back that it may be only tens of thousands this year. For some reason it just dropped through the floor this year. At this point nobody knows quite why. So, again, great variability in these things. But that was extremely promising for a few years. It built up much like the trajectory the Moses-Saunder did when it was first installed in 1976. Quickly built up to large numbers of eels passing around a million for number of years.

Down-stream passage – not so simple; not so cheap; very ineffective. This is a smaller turbine, a francis wheel and you can see what happens to large eels and probably the mortality rate at this site could be approaching 100%, 80%, 90%, something very high. Great lethality to eels.

Some of these areas where eels are not present may represent natural barriers but I think in many cases they represent the fragmentation of habitat. As I noted earlier, a lot of these HUC 8's have very low densities of eels and, again, as you get further up into these watersheds the presence of large hydroelectric dams or even large storage dams may be precluding the passage of eels, so low density. Up the spine of the Appalachians may be that is historically inaccessible. But maybe a lot of these areas just have been wiped out over time because eels cannot get there anymore.

Commercial harvests also identified as a threat. If this is indicative of abundance over time then to what extent did possibly over-harvesting play a role in the decline? There are better management mechanisms in place now to reduce these harvests. When you look at price, commercial value of these harvests, something goes on from time to time. Although much lower numbers are caught, the value is very high. So something is going on there, and it is hard to tease out where the threat is. Similarly, in glass eels, obviously something is going on. It has been pointed out that limits were put on the overall catch and quotas in 2014. In any event 2012 and 2013 the harvests were extremely high without that quota and then declined. There also was a limited entry at some point all this graph was after the license reduction. In any event some management things have been put into place but clearly there is still a lot going on with elver harvests that are resulting in extremely high harvests for some years. And if you calculate what 20,000 pounds is at, I believe 2,500 fish per pound, you are talking about harvests of 40 million elvers out of Maine waters in a given year. That is a lot of fish leaving Maine streams.

I wanted to summarize on the dam impacts. Obviously hydro electric dams are having a significant impact on the distribution of eels and on mortality of eels and on the ability, the demographics, if you will, of those freshwater eels that maybe have been slowly compromised over time and that can affect the resiliency and redundancy of the species over time. Primarily, all that is left is the estuary or marine phase of the life of eels. Likewise, with commercial harvest while this has perhaps been excessively high at times regulatory mechanisms have been put in place that seem to mitigate the impact of that.

AMERICAN EELS FROM A MAINE REGULATORY AGENCY PERSPECTIVE

Gail Wippelhauser:

Good afternoon. I am going to be talking about management of the threats or stressors on American eel in Maine. And that pretty much started in maybe 1994, 1995, 1996. I have been working with the department since 1996 and I was specifically hired to work on eels. So we will start with the commercial fishery; that is one of the big stressors. When I started there were three types of fisheries in Maine. So there was a harvest for silver eels. That was done with weirs and that occurred in inland waters and it was permitted minimally by the Department of Inland Fish and Wildlife, which is our sister organization. There were also fisheries for yellow eels, with pots. They either occurred in coastal waters, permitted through DMR (Department of Marine Resources) or they were permitted through the Inland Fish and Wildlife. And, finally, there was a glass eel fishery it was fairly new and just started in the 1970s.

There are a couple of ways we can manage the fisheries. The legislature can pass laws and, in fact, that is actually how management started in 1996. DMR also has the ability to promulgate rules. It is a little bit of a faster process; it may take about 90 days. Then there is the Atlantic States Marine Fisheries Commission, which is a compact of all the states on the east coast and we basically co-manage migratory species. For every species or species group (for instance, River Herring is a species group) there is a fisheries management plan that is developed. There are certain requirements and each state has to abide by those and has to stay in compliance. Then, if there are changes to the management that are made, it is either an addendum or an amendment. If those are passed, then again, all the states have to be in compliance with that.

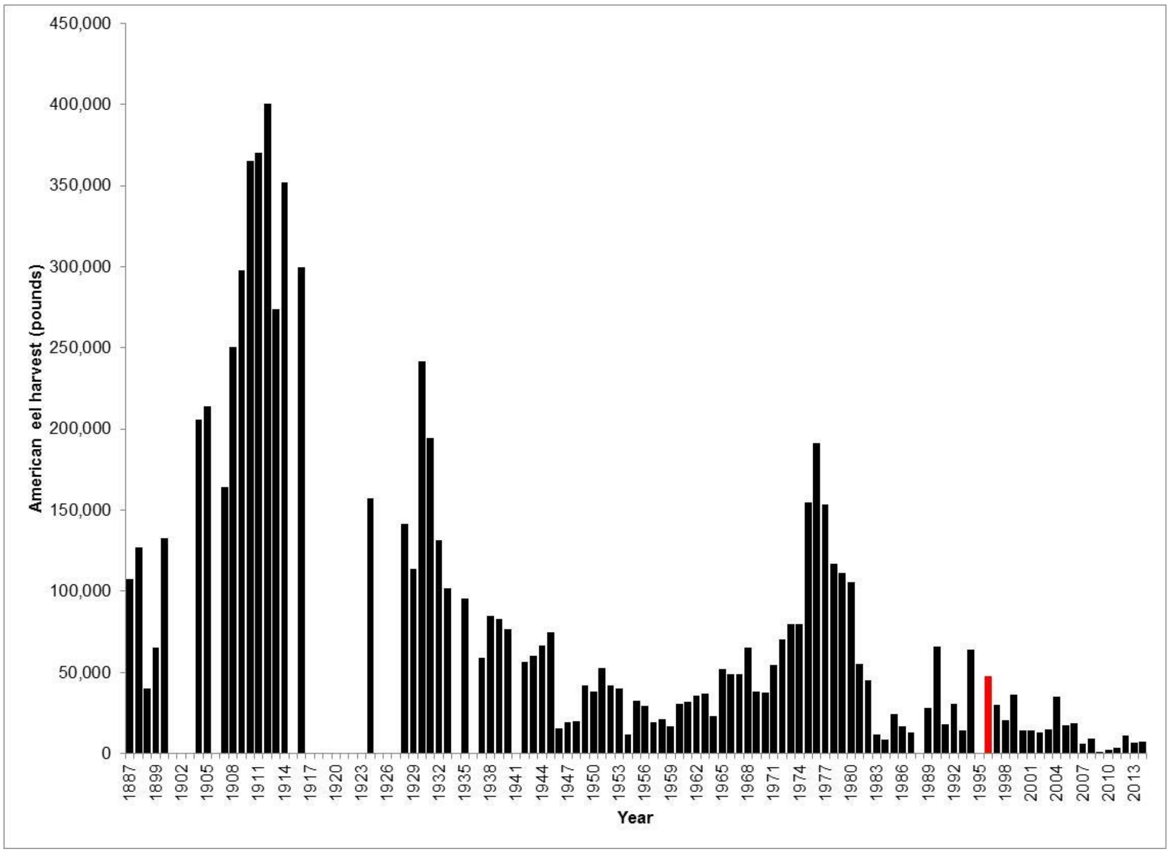

Figure 17. Harvest of Eels in Maine.

[Figure 17] is a graph of the harvest, and I am just going to call them big eels in Maine. It goes from 1887 up to 2014; I actually updated it. . . . There was a peak, I think it was in 1912, another peak in the 1930s and this was in the 1970s. 1996 is the red bar and that is when Maine first started really doing some serious management of the eel fishery. That year the legislature passed a law that placed a moratorium on the silver eel fishery. At that time, I think there were 24 people fishing 48 sites and it basically froze the fishery at that with the idea that gradually those people would drop out of the fishery and the silver eel fishery would disappear. There was also changes made for the yellow eel fisheries, this is in both coastal waters and in inland waters. People had to get a permit for an individual site, they had to pay gear fees.

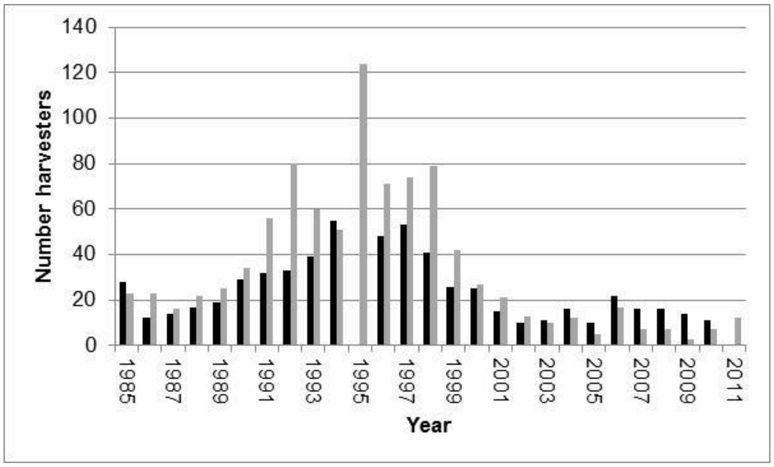

Figure 18. Number of Pot Harvesters in the Eel Fishery in Maine.

The little insert . . . at the top [of Figure 18] is the number of pot fisherman that were in the fishery. The black bars are the coastal waters and the gray bars are the inland waters. You can see that there was peak about when the glass eel fishery took off in 1996, but since then has dropped off pretty much.

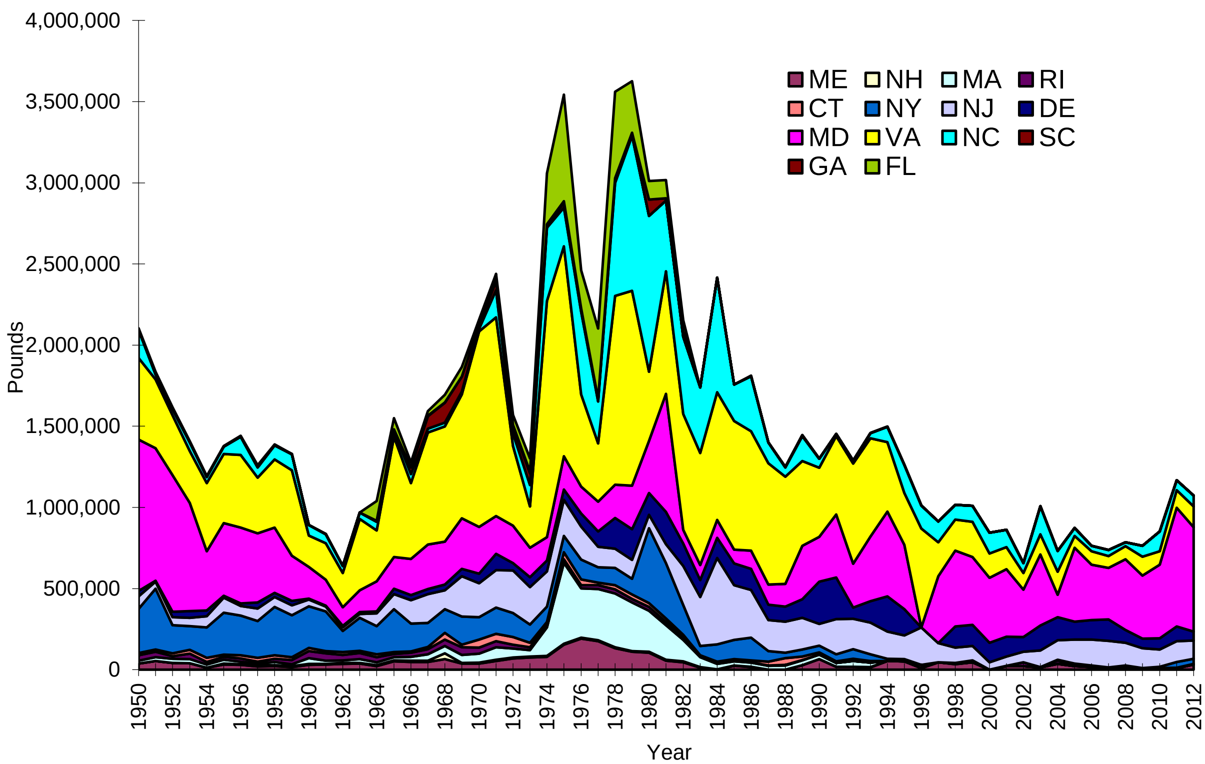

Figure 19. Atlantic Coast Commercial Landings of American Eel.

This very colorful slide (Figure 19) is the total big fish landings, big eel landings for the Atlantic coast. It is by state and it runs from north. It is like an archaeological dig. So this is the north, this is Maine information here, and then Florida is in green so you can work your way down the coast. You can see most of the catch occurs in the Chesapeake Bay area of Virginia, Maryland, New Jersey, around there. Again, this is mostly big eels. Most every state on the east coast has a pot fishery that occurs in coastal waters. There is a weir fishery, again in New York state, harvest in the upper Delaware River. I think this also includes, some of the states have fyke net fisheries in the fall, so they would also have caught some big eels. And I have seen data that was provided to ASMFC by some of the individual states and if you look at the size ranges of the fish that are caught, it is almost always big eels larger than 400 millimeters, so they would mostly be females.

This is some of the data that was used ASMFC when they did their stock assessment. As a result of this, and the young at year indices and some other information, the stock assessment committee and the technical committee determined that the yellow eel stock on the east coast was depleted and there were two addendum that were passed. Addendum III basically tried to shut out the harvest of small yellow eels. They were not being harvested and did not want that to actually happen, so there was 9-inch minimum size range that was instituted. It also basically shut down the silver eel harvest except for the one in New York state and Delaware River.

Year	Harvest (pounds)	Number licenses	Number fyke nets	Number dip nets	Total nets	Value	Mean price per pound	Management
2015	5,242					$11,389,864	$2,172	Addendum IV (9,688 pounds annually for 2015-2018
2014	9,332	1,071	393	801	1,194	$8,474,302	$874	ME instituted quota (11,479 pounds=35% reduction)
2013	18,076	658	474	336	810	$32,926,991	$1,822	tribes can issues permits; fines and loss of license
2012	20,764	557	340	172	512	$37,717,192	$1,816	lottery restarted, gear not to exceed 2011 count; civil fines increased
2011	8,585	407	350	175	525	$7,653,332	$891	
2010	3,158	429	366	185	551	$584,851	$185	
2009	5,199	451	382	195	577	$519,569	$100	
2008	6,952	468	393	199	592	$1,486,353	$214	
2007	3,714	510	428	211	639	$1,287,479	$347	
2006	6,967	653	510	279	789	$427,161	$61	lottery ended
2005	5,476	284	320	103	423	$1,299,252	$237	
2004	1,284	267	228	93	321	$119,614	$93	
2003	3,325	462	506	190	696	$84,068	$25	
2002	9,654	443	496	231	727	$278,278	$29	
2001	1,687	459	521	251	772	$40,568	$24	
2000	2,625	665	754	378	1,132		$11	lottery started; ASMFC plan-status quo or reduced fishery; YOY survey; catch and effort reporting
1999	3,587	744	804	438	1,242		$25	cap of 827 licenses, gear and season reduced, gear definitions, minimum age, gear placement, dealer reports
1998	14,360	2,314	3,806	2,111	5,917		$300	two closed days; gear definitions
1997	7,360	1,399	1,844	1,283	3,127		$300	cost of gear reduced; excluder panel; gear definitions
1996	10,193	2,207	2,632	2,075	4,707		$300	Legislation: elvers in coastal water, yellow eel by pot in coastal and inland water; silver eel moratorium; elver license, gear cap, gear fees, season, closed day, middle third open, eel and elver fund;
1995	16,599	< 1,868					$230	finfish license; development of ME management plan
1994	7,374							finfish license
1978	16,645							finfish license
1977	22,000							finfish license; no rules or regulations
1974								elver report issued
1971-72								study of elver run

Figure 20. Summary of Maine's Glass Eel Fishery.

[Figure 20] is my summary slide for the glass eel fishery in Maine. The columns are the year; the total harvest; number of people that were licensed in the fishery; how fyke nets there were; dip nets; the total nets; value, if we know it; the approximate price per pound; and then I have some notes on the actual management. So there was no fishery in 1971. It actually started, the Department of Marine Resources contracted with Bill Sheldon who was a fisherman . . . to see if we could start an elver fishery, and he went out and did some sampling and he checked some different sites and he created a report, and, yes, there could be an elver fishery and there was really nothing that happened very much until 1977 and 1978. I think the problem was trying to determine how to ship eels out of the country. They had to work out that methodology.

So in 1977 and 1978 there were quite a bit of eels taken. They also used to take small pigmented eels because that is how I knew where put some of my eel passage in when we actually were doing it. Some of the fisherman said, "Hey, you can catch them right here."

Things got quiet until 1994. People started fishing for glass eels. The State of Maine did a management plan; Jim McCleave helped write that. There was really minimal management for the glass eel fishery, all you needed was a fin fish license. There was an unlimited number of gear you could put in the water, you could fish anywhere, anytime.

Finally in 1996, when the prices were pretty good, the legislature decided that they were going to do something, so they required the harvesters get a special elver license. We could actually track how many there were. They were only allowed to fish in coastal waters. There was a season that was initiated, so it went from, I think it was March 15th to June 15th initially. It put a limit to the amount of gear you could have – five fyke nets and a dip net until that time was unlimited. You could not put a net in the middle third of the watershed. That worked a little bit.

The next two years they tinkered around with some things. They actually reduced gear fees. They defined a net because some nets had wings that went out 50 to 100 feet into the river.

It was still pretty crazy, so in 1999 the legislature decided they were going to actually put a cap on the fishery. They only allowed people that had been licensed for each of the three previous years. They reduced the amount of gear you could have – two nets, two fyke nets and a dip net was the maximum. That same year the price went down from $300 dollars a pound to $25 a pound. What you see after that was the number of people in the fishery slowly decreased, the harvest was kind of low. It was not too bad, then the price started going up again. More people got in the fishery. The legislature had started a lottery so there would be some new people that come in to the fishery, they finally ended that.

Then finally here, the price shot way up. We did a stock assessment in 2012. Then the next year the Native American tribes started issuing permits. So all of a sudden there were a lot more people fishing.

Then in 2014 the state of Maine proactively capped the amount of glass eels that could be taken totally statewide. That was kind of an arbitrary number, it was a 35 percent reduction from the previous year. And now Addendum IV that has been passed put an absolute maximum, 9,000 pounds. So the glass eel fishery is somewhat under control in Maine.

Now I will just talk a little bit about the other threat that we have, which is upstream and downstream passage. The real problem is hydro power projects. There were a couple of sites in Maine that were very bad. The hydro power projects are mostly federally licensed anywhere from 30 to 50 years, so I have exactly one shot of getting it right, then the next biologist is going to have to work on it. We can make recommendations to the company about what they should do for passage, but we cannot force them to do something. The federal agencies can write prescriptions which do go into the license but there is now, as part of the licensing process, I think if the company disagrees it can go through an adjudicatory proceeding which of course everybody wants to avoid.

Another problem is some of the dams are non-jurisdictional, which means that they are not federally licensed. There are a couple on the St. Croix watershed. So we really cannot do anything about requiring passage there.

Then some are exempt, which does not mean what you think it might mean. It means they are exempt from the long, drawn out licensing process. They go through a shorter process, its usually small projects, and the agencies can say what they need to do for passage and that goes right in the license.

More recently, there is green power certification, a project will get more money for its power. But they have to be certified, which means they have to prove they are providing passage if it is required. I was [basically] able to go to several projects that have already been licensed, that did not have eel passage in their license requirements and they agreed to do it. Finally, for non-hydro power dams, we can do a state fish way proceeding.

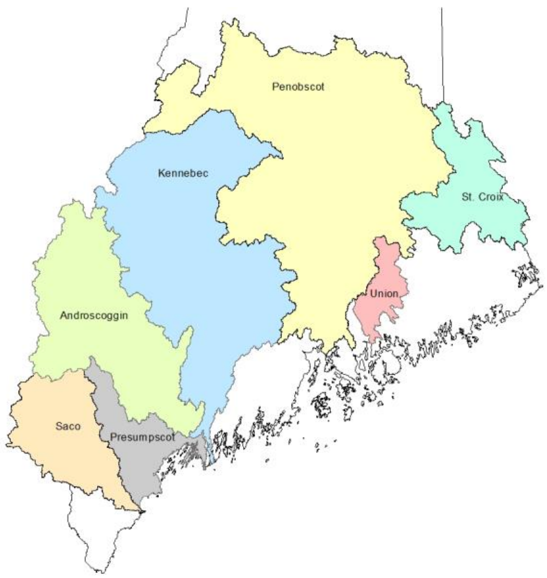

Figure 21. Map of Select Maine Counties.

[Figure 21] is Maine; Aroostook County has been chopped off because I do not think there are any eels up there. I have just shown you major watersheds and what I did was go through my dam database. I estimated for each one of the big watersheds how far eels went up the watershed, and then how many hydro power barriers were actually in their way, and the grand total is 117. Then I went back through and counted up how many of those dams have had upstream passage for eels installed since 1996 – 37. How many have downstream passage, and the downstream passage is not necessarily just for eels, it may be a more general downstream passage, and those are at 31. So we are roughly at a third, which is not bad for about twenty years.

That is it. I turn it over to the next speaker.

DESIGNING UPSTREAM EEL PASSAGE AT HYDROELECTIC FACILITIES

Jon Truebe:

My name is Jon Truebe. I have worked on installation and designed of 29 upstream fish passage for eel. 27 of them we designed the build on, which every time we do one we learn a little bit more.

Basic considerations in designing up stream passage for eels: the key feature is to locate the fish way where the fish are. That cannot be said strong enough for the finding that sweet spot for fish passage. That is generally done by biologists who put portable ramp traps in, submerged pot traps, or night observations. Other things to consider are predation, traction place, we have got to have flow to motivate the eels to go, how the eels will move past through obstruction, and location where they will be discharged so they will not get swept back down stream and would just defeat the whole purpose of the process. And another part of the facilities we build is generally required to have some sort of a means of determining if it is effective. . . .

A critical component of the ramps are the substrate and slope and we have been building a lot of these for many years but I do not think there has been real great research to analyze all the different processes, the different sizes, but we are slowly getting experience in.

The smaller eels will, just can go up on the surface, the producing water surface, the surface tension in the water, they can just go right up the concrete wall. Generally, the maximum slope that is accepted is forty degrees but if you saw in that Roanoke Rapids slide that's pushing, that's over, that is a very steep slope. The steeper slopes for larger eels require different substrate and greater pegs and projections. . . .

Covering the eel ways helps with the predation. From the video observations we have made, it keeps them moving around the clock. They do not seem to slow up during the day. Eels need water to motivate them, to keep them moving. Generally, the rule of thumb, at the entrance of the eel way is about 50 gallons a minute directly in the entrance but you need a larger quantity off to the side to get them in the area. They work the peripheral edges of that. It takes very little water to transport them up to the ramp itself. They have also been observed just to go in to damp grass around the obstructions. . . .

There are various spray bar designs. . . . There are several types of, basically, eel ramps, I will go through them separately.

There is a gravity flow ramp, which you do not have to maintain. It maintains itself. But these are very sensitive to head pond. You can make a "V" in the crest of the dam which will compensate for headwater changes by putting substrate on the edges of the "v" and that 45 degree v will usually compensate for two feet of headwater. There is a brush you can put on the side wall or just put the substrate on the dam which is very sensitive to headwater. . . . The eels in this area working the boundaries, usually, and the headwater goes up into that brush it reduces the force they have to work themselves against.

The next type would be a gravity flow trap where you have your trap system, a ramp leading to a trap. And that takes extensive tending; you have to move the fish, check the trap periodically to move upstream. . . .

The most common we seem to run into is the pump water with a trap or sluices to the head pond. Once it becomes successful, they can just go out into the head pond themselves. . . .

Eel lifts are used at certain sites where the head is extensive or where there is extenuating conditions where they're afraid of the eel way being moved by the high flows, *et cetera*. They do require power. . . .

There are some excellent papers available from the U.K. on design of passes. They are all available on the internet; I highly recommend them. Thank you.

MODERATED DISCUSSION AND QUESTION & ANSWER PERIOD

Jeff Thaler:

There are thousands of other barriers in Maine. I just want people to understand that those were not the only barriers. There are a lot of others in Canada, also of non-hydroelectric dams, barriers that exist that are not licensed and will not have passage. Questions?

William Bradnee Chambers:[18]

There was a question this morning about the uncertainty surrounding eel policy, development and possibilities of future eel policies. I wanted to ask Steven [Shepard], in evaluating the petition didn't the precautionary principle come in to play at all in the determination? And, if it did, what kind of criteria did you use to be able to apply it?

Steven Shepard:

Well, the interaction of the evaluation of the status, population abundance, and trends and threats, that is circular. There is feedback. If the species were severely depleted and you could demonstrate a significant decline then you would be more likely to be able to link that to one of the threats. In this case, the declines were largely already manifested, historic, and the indications were relatively stable, so if we have look at those threats then in the context of current management situation of the eel. We had just gone through status review through a petition eight years previous and what had changed since then. In fact some of the threats have improved. More fishways are in place on hydro dams. Some of the threats that had not been evaluated – parasites and climate change, notably – had so much uncertainty surrounding them that the way the statute really is worded is that in the face of uncertainty you cannot list. When the entities involved in the listing can just as easily sue you for the impacts of ESA with a listed species which should not have been listed as could a petitioner list you for not having taken the action they wanted. So it is a difficult analysis to make a definitive conclusion on whether to list or not. The statutory criteria for endangered is, is there an imminent threat of extinction? For threatened, is there a threat of extinction in the foreseeable future? That is almost exactly the statutory language for those two criteria for those two listing statuses.

Jeff Thaler:

What is an interesting thing in American law is the precautionary principle really is not quite incorporated into most of our environmental laws, as opposed to maybe some European places. But again, it is not often incorporated into many other areas as well. It is a good question, but in American law it is generally not the driver of environmental protection. Other questions?

Laura Hussey-Bondt:[19]

Is the listing assessment process in the U.S., is it strictly a scientific exercise or are socioeconomic impacts assessed as part of the decision?

Steven Shepard:

Should the decision be to list a species, then the way the law has been modified is one of the amendments is to designate critical habitat at that time. It is the designation of critical habitat

[18] Executive Secretary, Convention on Migratory Species.
[19] Senior Advisor, Fisheries and Oceans Canada.

that triggers economic analysis. So, what impact does the critical habitat description on that area affected? And what actions can or cannot be taken in that critical habitat? Then, what is the economic impact of those?

Laura Hussey-Bondt:

As part of the Canadian listing assessment process we actually do a socio-economic impacts assessment that is actually, explicitly considered [as part of the listing decision].

Steven Shepard:

In one sense the original version of the ESA was much more powerful in that regard in that it ignored any economics completely. But in the amendments, that is what came. Another difficulty of listing, of course, would have been had we listed, there is yet another avenue opened to us is that critical habitat is supposed to be done, must be found by statute when the listing occurs. In this case, we would have had to have fallen into the category of "prudent but not determinable" for it to be critical habitat. You can imagine what critical habitat looked like for the American eel in the eastern United States from the Mississippi basin eastward. That would have been a job of years to determine what that critical habitat is and what actions are prohibited – everything from a town replacing a culvert, to fishing discharge licenses of commercial fisheries, so many things would have been impacted that it would have taken many years to determine. So, had we found a listing warranted, we would still be working on that critical habitat or likely we would have found it prudent and not determinable.

Jeff Thaler:

Other questions?

Mike Waine:[20]

Question for Steve [Shepard] and this is actually Gail [Wippelhauser]'s question when she asked it on one of our technical committee calls. I think it is a relevant question; one I am interested in and probably the panel as well. The question is that no fisheries had a not warranted finding for river herring but established a conservation plan to get at some of the data gaps and did a funding process to do that. Is that something that is planned for eels as well, or was that unique for river herring?

Steven Shepard:

That was a policy measure within NOAA's way of handling ESA's process. That is something NOAA did; that is not something the Fish and Wildlife Service does. Sometimes we have joint listings, like Atlantic Salmon. We have to work out those policy differences and how they are implemented. We have had other policy categories. Because of the quantity of listings – currently we have a backlog of several hundred petitions and have hundreds more yet to do – the

[20] Senior Fishery Management Plan Coordinator, Atlantic States Marine Fisheries Commission.

ESA is used by non-governmental organizations, frankly, as club to beat us over the head to get things they want done. The species, is sometimes perhaps a tool to get what they want or whether the species really merits that process. We are trying to simplify it we are trying to make the ESA a more scientific process but we do not have that sort of thing. At the same time, what we tried to do with eel is to try to not preclude things. So, for instance, siting, we do have an active, ongoing, sitings amendment process and we have structured the ESA for a finding so as to support that. . . We also do not want to undermine conservation measures and we do describe these conservation measures in the finding, things like getting eel passage put in place for hydro dams. That is very important for the recovery; very important to the conservation of the species. And harvest reductions as well – we are very actively supporting conservation efforts and recovery.