U.S. Fish and Wildlife Service in Cooperation with National Marine Fisheries Service
American Eel Status Review Workshop 1: Atlantic Coast/Islands Threats
National Conservation Training Center
Shepherdstown, West Virginia
November 29 – December 1, 2005

Session: Habitat

Session: Barriers to Successful Upstream Migration

Session: Barriers to Successful Downstream Migration

Session: Changes in Oceanic Conditions

Session: Harvest

November 29th
On November 29th there were brief opening remarks during an evening session and a time for questions and answers. Notes were not taken but the opening remarks are attached.

ATTACHMENT 1– Opening Remarks and definitions

November 30th
Present: Paul Angermeier (US Geological Survey, Virginia Cooperative Fish and Wildlife Research Unit, Blacksburg, VA), Heather Bell (USFWS, Northeast Region, Coordinator – American eel status review), Mark Cantrell (USFWS, Ecological Services, Asheville, NC), Marci Caplis (USFWS, Northeast Region), John Casselman (OMNR/Queens University, retired), Kim Damon-Randall (NOAA, NMFS, Northeast Region, Gloucester, MA), Sheila Eyler (USFWS, Maryland Fisheries Resources Office, Annapolis, MD), Kevin Friedland (NMFS Science Center, Narragansett, RI), Steve Gephard (CTDEP, Chair of ASMFC American Eel Technical Committee), Jeff Govani (NOAA, NOS, Beaufort, NC), Brian Jessop (DFO, Halifax, NS, retired), Brian Knights (Kings College, London, retired), Jake Kritzer (Environmental Defense), Wilson Laney (USFWS, South Atlantic Fisheries Coordination Office, Raleigh, NC), Rob Macgregor (OMNR, Lake Ontario Manager), Marie Maltese (USFWS, Office of Scientific Authority, Arlington, VA) Alastair Mathers (OMNR), Kevin McGrath (NY Power Authority), Martin Miller (USFWS, Northeast Region, Chief of Endangered Species), Mike Miller (Ocean Research Institute, University of Tokyo, Japan), Lydia Munger (ASMFC, American Eel Coordinator, Washington, D.C.), Ken Olivera (University of MA, Dartmouth), David Perkins (USFWS, Fisheries, Northeast Region), Bill Richkus (Versar), Michael Twohey (USFWS, Great Lakes Fisheries Office), Jeff Underwood (USFWS, Northeast Region, Deputy, Ecological Services), Jim Uphoff (MDDNR), Julie Weeder (NOAA, NMFS, St. Petersburg, FL), and Gail Wippelhauser (MEDNR).

Panel Members for Habitat and Barriers to Successful Migration:
Ken Oliveria
John Casselman
Kevin McGrath
Rob Macgregor
Brian Knights
Alastair Mathers
Bill Richkus
Paul Angermeier

8:07 AM: Marci convened the meeting, noting that we were already getting started late. She asked that we use the clock in the back of the room for time. She covered ground rules. One person speaks at a time. Sidebar conversations should be taken outside the room, because the session is being recorded. She advised where the restrooms were located. Breaks will be in the vestibule area in the center of the hallway. Food and beverages will be provided. Everyone should have a folder.

Marci noted there were maps on the wall, done by our Geographic Information System (GIS) shop. There are questions by each. She asked that we answer the questions. She reviewed the questions. The questions all had to do with assessing the impact on eels and their habitat caused by dams. She asked Heather how she wanted to obtain answers to these questions.

1) Is the approach we have taken, mapping terminal dams and habitat downstream, a worthwhile approach if the aim is to map the minimum existing freshwater habitat?
2) How do we estimate the degree to which dams impact eels (passage, predation, etc).
   a) Can that degree be estimated based on some general, overriding factors such as:
      i) dam type (hydro or non-hydro),
      ii) dam size,
      iii) turbine parameters,
      iv) watershed size,
      v) river flow, etc?
   b) Or do we need to go into more detail such as:
      i) dam characterization? - slope of dam, dam material, roughness, etc.
      ii) characterization of the environment surrounding the dam? bypass channel or locks present, river flow at dam, etc.
      iii) dam operation? storage capacity, dimensions, material, no. of turbines, impoundment surface area, etc.
      iv) size of watershed? river miles and acres of ponds/lakes, et.c et.c etc
3) Can we focus on a few large watersheds, or one large river and one small within a region? How far can we extrapolate?
4) How best could we characterize the maximum freshwater habitat?
5) How best could we characterize the percent of habitat that has been isolated/fragmented by dams?

6) What is the best way to represent habitat area above dams (e.g., watershed, watered area, or stream miles)? Or
7) Should we mirror the Verreault et al, 2004? Or some other previously done analysis?

Heather asked that everyone take a look at the maps while here, and give her any thoughts. She indicated she would be happy to hear from our experts, as well as FWS staff who were attending the meeting. E-mails would be fine as well. Heather indicated she wanted to make sure that everyone had provided their completed questionnaires to her. Marie indicated that she would be changing the audio tape every 45 minutes, and would ask us to quit talking briefly during those periods.

Heather indicated that Lydia Munger had volunteered to take notes for the first session. She asked that an FWS staff volunteer thereafter.

Kevin asked if we could do introductions. Marci indicated that we should do so. Everyone did self-introductions. Marci asked that we make sure that a sign-up sheet was sent around.

Session: Habitat
8:21 AM: Marci asked that we begin the habitat session. Heather indicated that she had a lot of papers on habitats, and hadn't spent her time trying to summarize the information. She wanted to get some sense of what habitats were important to American eels.

Marci asked the questions in the order they were given. Someone asked for a written copy of the questions. Marci suggested that we have the questions projected on the screen, but in the meantime, she wanted to begin the dialog.
Question:
#1. What are the current hypotheses about the importance of fresthwater habitat to the sustainability of the eel population?

Brian Knights noted he didn't realize that we were going to discuss this question. He noted that he had presented a paper on the subject, and would present some of that information tomorrow. He had reviewed a huge amount of literature. The only constant factors that he could discern were the overall composition of the eel population within a single watershed, and the demographics as one ascended the watershed. In England, the numbers of females in the estuaries are significant as well. He noted there is a tendency to focus on freshwaters, and we tend to forget that there are a lot more eels in estuarine waters, than in freshwaters. He indicated again that he could present some of that information in his presentation tomorrow.

Heather asked him to restate the conclusions. Brian indicated that gross distance from the spawning area was a factor, or distance from the edge of the continental shelf. The other factor was relationships with distance upstream from the tidal limit.

John Casselman agreed that it was important to try to assess the numbers of eels in tidal areas. He noted that it was hard to quantify the estuarine/marine component. The freshwater

component though, is very important and may be the one that drives the reproductive aspects.

Paul Angermeier asked if the freshwater component was crucial. If they were prevented from entering freshwater at all, what would happen to the population? He felt that was a key question.

Brian Jessop felt there were two questions. First is that no one has attempted to quantify the numbers of eels in estuarine habitats. The second is to derive densities. He noted the first step is to do some GIS work, then we can make some estimates.

Kevin McGrath indicated that the only fishery of which he was aware was the pot fishery in the Chesapeake. Jim Uphoff stated it was mainly Maryland and Virginia, but there was some in NC, but he felt it was small.
Brian Knights noted that there are fisheries in the UK. These tend to be small fisheries in lakes, which are fished out, and then fished again five years later. The Thames River estuary is fished more continuously, since the fishery is constantly replenished.

Bill Richkus asked Brian Jessop if the Canadian fisheries were estuarine, or riverine. Brian indicated the majority were riverine, but there were estuarine fisheries as well. Kevin asked if those were silver eel fisheries. Brian indicated the freshwater ones were a mix of both yellow and silver, but the estuarine ones targeted yellow eels.

Marci noted that we would discuss harvest tomorrow. Bill noted that harvest was an important threat. Jim Uphoff wondered if freshwater habitat could be considered a refuge.

John Casselman noted that we definitely need to quantify the harvest of silver, versus yellow eels. He asked Heather if the maps on the wall were an attempt to capture current freshwater habitat. She indicated that she was trying to get at what the minimum habitat was.

Jeff Govani indicated that he agreed it was important to document the yellow and silver eel fisheries. He noted that in the US, there is a fishery for bait eels as well, and asked Wilson if he agreed. Wilson agreed, and asked Lydia to comment on the data. Lydia noted to the group that there are some data, and asked Steve Gephard to chime in as he wished. She noted that it was difficult to quantify those eels taken for bait.

8:37 AM: Heather asked us to try to stick to the issue of habitat, although she recognized that these other factors were linked. She wanted to focus on the freshwater habitat, with a focus on fecundity, and the refuge value of freshwater habitats. She asked Ken Olivera to comment.

Ken noted that the current hypothesis is that habitats that allow a reduction in density, may generate more females, or that females are found in lower density habitats. Heather asked if the question was, does freshwater habitat provide this? She noted that we don't know if we have large female eels in estuarine habitats also. Bill Richkus noted if they are fished heavily, we might not get females.

Brian Knights noted that in Britain the females increase proportionately in the catch as you move upstream, and as you move toward the sea.

Brian asked if there was an estimate of the total length of river that we're discussing, in the US. Heather indicated that information could be provided. Brian noted that he had calculated the total area for the UK, and generated some total densities. He indicated this could generate some estimates of the total number of males and females in the population, using this approach. The estimate will be crude, but at least we have some idea.

Brian Jessop indicated that he was going to ask, with all the dams marked, have we done the next step and worked out the available habitat above the dams, and downstream, and knew what that area was. Heather indicated the GIS staff is going to estimate that number. She stated, the question is, are we going to do this exercise? She noted that another question is, what about the area upstream? How much do we consider useable? That is why she began with mapping only what is downstream of the terminal dam on each system.

John Casselman indicated that we would want to know the historic distribution. Then, what are you going to use as habitat? He asked Brian Knights how he had approached this issue. Also, he asked how he defined impassable structures?

Brian Knights indicated that he had used river/stream length data, and average width, and area of still waters, and estuarine areas. He didn't like using the total catchment area. He felt that knowing the eel density was the key. What he would have liked to do, is to have the data on how many kilometers of habitat exist upstream and downstream of the dams. Also, he wanted to know how far inland the densities began to drop off. He noted the densities seem to peak around 50-80 km from the coast. Heather indicated that she would ask her GIS person for the information.

Jim Uphoff noted that the information for Maryland is in the American eel Addendum 1 scoping document.

Wilson noted that the Busch et al. (1998) work did provide an estimate of what percentage of freshwater habitat is still accessible, downstream of the terminal dams. There is 84 percent blocked, and 16 percent open, on the US east coast (see ASMFC, Fishery Management Report No. 36, Interstate Fishery Management Plan for American Eel, page 36). Heather noted that she had talked to several of the folks that did that work, and they had agreed that the estimates were crude, and we can likely generate a better one.

Bill Richkus noted that a dam was not a dam, in terms of constituting a blockage, and it was far more complicated than that.

Heather agreed. She noted that we were getting into a discussion of barriers and dams, and she didn't want to go there now.

Paul Angermeier noted that we really need to try to understand habitat in light of sustainability. He noted that we might not know enough about the estuarine/marine component to say how important it is or isn't. Paul noted there seems to be a relationship between eel density and production of females. That is important knowledge. Also, perhaps size is important, for female fecundity, so maybe we are better off if we have fewer, larger, females. We need to understand the value of freshwater habitats in this regard.

Jim Uphoff indicated he wasn't sure where to insert this comment. Most of the discussion of freshwater habitat was in relation to barriers, but there is another issue, which is the productivity of the stream segment itself. He noted there are some general rules about watershed development and loss of productivity. He suggested that if we're doing a mapping exercise, we might want to consider that as well. He noted that eels are tough, but they have to eat and breathe, so looking are areas where human population growth has produced over 10 percent impervious surface could be another factor. He asked where that fits in? Heather indicated that urbanization would be considered, but right now, she is trying to determine what are the most important habitats, and are they threatened, and to what extent, and could it drive the species to extinction? Heather noted that contaminants, for example, would be discussed at the second workshop.

Jim Uphoff indicated that from a fisheries standpoint, keeping fisheries management simple has been advocated by the International Council for Exploration of the Seas (ICES). He noted that saving the megaspawners, the big, old, females, might be a significant factor.

Brian Knights asked if there was a danger if you took that approach. Why wouldn't it be better to have a larger number of smaller females, and yield the same number of offspring? Jim Uphoff stated that the larger animals might yield higher numbers of viable offspring. He noted the reproduction strategy of the American eel, to draw out reproduction over a long period of time, and suggested that the large females from freshwater were in fact more important. Heather asked Jim if the point was that a given year-class is spawning over multiple years? Jim indicated that it acts like a multiple spawner, but it really isn't.

Brian Jessop noted that we were focusing on freshwater because that is from where we have most of the information on eels. We don't know very much about the size composition, and other factors, in estuarine areas. There is a general lack of information. There may be substantial proportions of silver eels produced in coastal and estuarine areas. Brian indicated he didn't know if their size was comparable to those silvers produced from the upper St. Lawrence. There are differences in quantities, but the silver eels are produced elsewhere, just not as abundantly as they are in the upper St. Lawrence. We just don't know enough. For some freshwater systems, there is a periodic migration between stream habitat and coastal/estuarine areas, based on otolith microchemistry studies of strontium/calcium (SR/CA) ratios. He noted that some of the eels found in freshwaters, might be in the estuary in the same year. The converse is true as well. The thing is the total population for a watershed has to consider both habitats.

Rob indicated the US Endangered Species Act (ESA) seems to be driven by extinction. He asked if the question was, if we loose the freshwater habitat, will the American eel go extinct? Heather stated that was really the question, but the lawyer won't let us ask the question. She said what she can ask, is whether the freshwater habitats are important for sustainability? She noted that fecundity was an important consideration. She indicated that she had been making a list on the easel of factors that might be important.

Rob indicated that he thought the question wasn't answerable at this point. Rob noted the genetic issue as well. He stated we need to look at heterozygosity, and at the marine habitats. He suggested that we need to ask if we are prepared to loose eels from freshwater? Heather stated that we have to look at the species throughout its range.

Mike Miller indicated he agreed with what has been said about the use of estuarine habitats, but wanted to encourage caution. He noted that a lot of the studies had looked at areas close to the estuary. He noted that if we looked at SR/CA ratios from eels coming down a large watershed, we might find that most were originating in freshwater habitats. He noted that it would be easy for us to overlook this.

Paul Angermeier indicated that he agreed with many of the comments made. The issue of freshwater versus marine is perhaps intractable at present. He asked if we shouldn't make some assumptions, such as assuming that freshwater is critical, and moving on from that point. What does that do? What sort of threats should we identify?

Brian Knights noted again there isn't sufficient information for the estuarine/marine habitats. He noted that lakes also could be important in the production of females, so the area of still waters might be very important. Heather and Marci noted that lake habitats would be discussed in January. Brian noted that the area of lake habitat could also be very important.

Steve Gephard noted that some of the discussion reflects researchers that want to quantify and define very precisely. For the big picture, he thought that this missed the point. He noted the animal forces itself upstream into freshwater habitat, and in Connecticut, it is the most widespread and abundant animal present in such habitats. It seemed arrogant to him to even question the importance of this habitat to them. It would be similar to him to questioning the value of tropical habitat for scarlet tanagers wintering, for example. If we question the value of freshwater habitat, we're questioning the catadromous nature of the species.

Brian Jessop indicated that he agreed with Steve regarding the value of freshwater habitat. Brian noted that the interplay between estuarine and freshwater habitats may change, in rivers that are unblocked. He noted that he had done some work, and couldn't conclude that migratory behavior decreased upstream. He found the behavior patchy. He suggested that in a larger (and likely longer) river system, migratory behavior between estuary and upstream areas might diminish.

John Casselman noted that at one time, eels were half the inshore biomass in the Great Lakes,

and they aren't today. He viewed the freshwater habitat as really critical.

Mark Cantrell wanted to ask the question in a different way. That is, why would an eel invest such time and effort in swimming hundreds of miles upstream to reach headwater habitats? What are the important constituent elements of those habitats that induce females and ultimately the desire to go out? Marci noted there were lots of nods in assent to Mark's comment around the table.

Heather asked us to go back to question one, and ask each panelist for an answer, and put Mark's questions on hold. Heather asked if we have captured what the current hypotheses are relative to the importance of freshwater habitat.

Freshwater Habitat Flip chart bullets

- Overall structure in catchment
- Gross distance of migration from breeding area – migration pathway
- Distance from upstream tidal limit
- Quantify marine component
- Fecundity – by allowing for reduction in density more females (abundance in spawners), including megaspawners are produced.
- Refuge – protected from predators as they are often top dog in these freshwater systems. May also be a refuge from coastal harvest pressure.
- Year class

Bill Richkus stated yes, to part of the first question. He asked for Heather to recap the points that she had on the board. Bill indicated that freshwater habitat is unquestionably important, but what we don't know is the relative importance.

Ken Olivera stated that the low density is important, and that the importance of lakes can't be understated. They are significant. Sex ratio is also important.

Bill Richkus noted that it has always been curious to him that studies show home ranges for eels, and how to reconcile that with the upstream migration of subadults that occurs for years. He wasn't sure how that relates, possibly to density. Density factors in to how important habitats will be, especially if there is a large year class.

Kevin McGrath asked, given that all the other anguillid species have a freshwater component, how important is it? Mike Miller noted that none of the species depend on strictly estuarine

habitats. He noted that in Japan, the estuary/river systems are shorter, so they don't have the length of systems we do in the US. We don't know to what extent tropical eels might use marine systems. Kevin noted that he wasn't going to answer question one, because he found it hard to understand.

Mike Miller noted the Japanese eel studies looking at SR/CA ratios, were sampling in estuarine waters, where rivers weren't nearby. If the study was done in freshwater portions, the results might differ dramatically. Mike noted that no one has done a study in a really long river system.

Alastair noted that it was clear that freshwater was important to eel life history, and clearly was threatened. He agreed with what Steve and Mark had said earlier, that it was presumptive for us to compare it in importance to estuarine habitat. Heather noted that someone had already pointed out the question was incomprehensible. Marci noted that she and Heather would have to sit down at the break, and revise the questions, so that we can make them more appropriate.

Rob thought the question was unanswerable. He noted that you need to look at heterozygosity and need to look at the marine environment as well. He asked are we prepared to lose eels in freshwater, regardless of how important that area is for the species?

Heather noted that the ESA is concerned with the status of the population range-wide.

Paul noted the quandary of the importance of marine vs. estuarine vs. freshwater – can we just say we don't know enough about the relative importance of those areas to rule any one thing out, but for the sake of this process, assume that freshwater is critical and move forward under that assumption. This is the precautionary approach but we know a lot about freshwater and can quantify many of the threats in this area.

Brian Knights stated he didn't believe the species would go extinct, if it didn't have freshwater. He stated the anguillids evolved to use freshwater, and find it useful, but not essential. He noted one paper on eel archeological studies noted the eels' range was pushed far south, during the last Ice Age, and the species survived that event and reestablished. In SE Asia, they survive monsoon washouts. He didn't feel freshwater was essential. Brian stated his answer to the question would be no, if asked if the lack of freshwater would cause extinction.

Steve – some of this discussion reflects researchers who have a desire to quantify and define very precisely, but for the big picture he wonders whether this misses a larger point. We know this is an animal that by its nature forces its way upstream into freshwater. In CT it's the most widespread finfish present in freshwaters. It seems arrogant to question the importance of freshwater for eels. If you question the value of freshwater habitat, you're questioning the catadromous nature of eels. Does anyone really think that freshwater is not important to the species?
Steve – some of this discussion reflects researchers who have a desire to quantify and define very precisely, but for the big picture he wonders whether this misses a larger point. We know this is an animal that by its nature forces its way upstream into freshwater. In CT it's the most

widespread finfish present in freshwaters. It seems arrogant to question the importance of freshwater for eels. If you question the value of freshwater habitat, you're questioning the catadromous nature of eels. Does anyone really think that freshwater is not important to the species?

John Casselman noted that there were advantageous factors in freshwater. He viewed it as critically important. The eels would survive, but not at a productive level.

Mark – What is important about freshwater habitat? Why would an eel invest time and effort to swim 400 miles upstream to high elevations if this habitat were not important? What are the important constituent elements of freshwater that would cause these animals to do this? What are these females in particular finding up there that leads to their growth and development? What is important up there? Why are they doing that? Heather noted that this is question #4.

Paul Angermeier stated there were an awful lot of questions. He wasn't sure they would go extinct, because the homework wasn't done. He asked about use of the term "refuge" as applied to freshwater. He could see how there might be less predation there.

Jim Uphoff noted that there is a certain level of protection from an annual fishery, in the Maryland area. He could see how there is some refuge from predation, but there may just be a suite of different animals trying to eat them in freshwater.

Paul noted there isn't much in the upper reaches of the Shenandoah Park, that eats eels, so that might be an advantage.

Heather wants to ask each panelist their answer to question 1. Have we captured what the current hypotheses are with regard to the importance of freshwater habitat?
Bill – a) yes. Yes, freshwater is important, the relative importance is what we don't know.
Ken – Density, sex ratio, importance of lakes cannot be underestimated.
Kevin – asked Mike about other *Anguillids*, all of which utilize freshwater habitat. Question 1 is incomprehensible, he can't answer it. Freshwater is very important to American eel, he's not sure if it's critical.
Alastair – the question is tough to answer as written. Freshwater is important, it's a part of their life history that has threats in terms of quantity and quality of habitat. Agrees that it's presumptuous to say that it's critical relative to other components of their habitat.
Rob – It would be irresponsible to say anything other than freshwater habitat is critical, given the information we have available. The information is not available to say whether eels would go extinct without freshwater habitat.
Brian Knights – his opinion is that eels would not likely go extinct if they did not have freshwater habitat available. On geological time scales, the range of the European eel and American eel was pushed far south during the ice age to areas where the freshwater habitat was greatly restricted and they survived. Over time, there have been highly variable amounts of freshwater habitat available. It's helpful but not absolutely essential to the survival of the species. Is a lack of freshwater habitat endangering the species now? No.

John – if you look at freshwater just as a case of available habitat and productivity/quality of that habitat… If you expect to have eels in freshwater, you need to manage that part of the habitat. They would survive without freshwater but not at a productive level. The fecundity coming out of freshwater is important to the species.
Paul – Inclined to think that freshwater is crucial, but not sure whether absence of availability of freshwater would make eels go extinct. Freshwater might be a valuable predation refuge due to the presence of fewer large predators in freshwater. Uphoff noted that the main predator in freshwater is probably the eel pot fishermen, but could be a predation refuge as well. Paul – there are fewer large predators upstream than in estuarine/marine environments.

Bill – isn't sure how to reconcile the studies that show home ranges for eels in various habitats with the migration of animals upstream over many years. Upstream habitat may be more important in different circumstances, for example, for large year classes.

Wilson noted to the group that we should all bear in mind the fact that the ecological system at which we are looking is highly altered. He noted that all the studies of eels in estuaries have taken place largely after the construction of the system of dams that precluded their upstream migration. He noted the recent data collected by Dominion Generation, below Roanoke Rapids Dam, show tens of thousands of juvenile eels moving upstream, and being marked, and many of them disappearing (i.e., not being immediately recaptured), presumably back downstream, and possibly being consumed by predators. He suggested that any studies of migratory and movement behavior done after construction of the dams needs to consider the fact that eels can no longer move nearly as far upstream as they could historically. On the Roanoke, for example, they can only go to mile 137.5 rather than hundreds of miles upstream as they did historically. He noted that Mike miller had alluded to that point earlier in the conversation.

Marie suggested that it might be beneficial to state for everyone the five factors that FWS has to use in doing the Status Review. Heather stated them for the benefit of the group. Maria asked if it would be beneficial to provide the regulatory language for that section. Heather stated it was deliberately not provided, because that is our job.

9:29 AM: Marci noted that we were about 30 minutes from the end of the session, and asked how the authors of the questions wanted to proceed. She noted that we had spent an hour and ten minutes on one question, and noted that Mark Cantrell had asked a really good one.

Heather stated that she couldn't eliminate any questions. **Question 4 (What do we know about the importance of specific freshwater habitat features that are essential for the sustainability of the eel population?)** was particularly important. Heather asked for suggestions on how to proceed, from Marty or any other FWS staff.

Bill Richkus asked if it would be advisable to give each panelist two minutes and have them state their answers to the question.

David Perkins suggested that if we go back to **Question 2b (Is there evidence that we may**

already be below the minimum level of habitat necessary to sustain the American eel population?), we could get some answers that would help us focus on questions important for the status review. The two Brians agreed the short answer to that question was "no."
No.
Rob – are we assuming that this species is panmictic? Heather – yes
Rob – No, and we don't know. These are two different things.
Uphoff – no quantification of this whatsoever.
Jessop – argues against "We don't know" – opening it to the interpretation that we're expecting an eminent collapse – if you have passed this threshold you're on the road to extinction, and he doesn't think you can say that because there is lots of habitat available.
Paul – If sustain means "existence" that is different than "sustaining where they are now" or "sustaining where they were 50 years ago." It's not that there is no evidence that freshwater habitat has been reduced and this is coincident with population declines, but it all depends what this question is asking. Heather pointed out that a decline is not a reason to list the species – they are trying to learn whether eels will remain on this planet in the future. If the species is on a downward slope, it could be listed as threatened.

Martin – it might make it easier to exchange "sustainability" with "long term persistence". Is there any reason to believe that this species is dependent on some minimum population size to sustain the species? Is there some min level of freshwater habitat that is needed to sustain this min population size? Does the species depend on some minimum level of population abundance?

Rob Macgregor noted that he was assuming that the American eel is panmictic. Heather stated that was a valid assumption. Rob stated the answer to 2b, was "no," and "we don't know." Rob noted that "no" was different from "we don't know."

Brian Jessop argued against us saying "no." He stated that opening it to the interpretation that we're expecting an eminent collapse – if you have passed this threshold you're on the road to extinction, and he doesn't think you can say that because there is lots of habitat available.

Rob indicated he would agree that there are lots of habitats. Jim noted they wouldn't be sustainable, in terms of fisheries.

Heather noted that "sustainable" here didn't relate to fishery use. She noted that she didn't add enough eels to provide for fishery use, in a Status Review, only those necessary to sustain the population viability and keep it from going extinct.

Paul-If sustain means "existence" that is different than "sustaining where they are now" or "sustaining where they were 50 years ago." It's not that there is no evidence that freshwater habitat has been reduced and this is coincident with population declines, but it all depends what this question is asking. He disagreed that we didn't know enough. He noted there have been eel declines. He noted there has been a huge habitat decline, and it could very well be there is a correlation, so we can't say there is no evidence. With regard to sustainability, he would say there is strong evidence that we may have passed some habitat loss threshold, beyond which

declines will continue, unless the habitat is restored.

Heather noted that a decline is not a reason for listing. The issue is whether it will remain on the planet at a level which is sustainable for the population. But, it can't be on some downward trend that will continue. That would mean we list it as threatened.

Paul noted we don't know what the true trend is at all.

Marty indicated we should be talking about long-term persistence. He asked if there was any threshold of population, below which the population would collapse. Is there some minimum amount of freshwater habitat, below which the species would decline irreversibly? He asked if the species actually depends on some minimal level of habitat in freshwater, or is it based on numbers of sexually mature individuals finding each other in the Sargasso Sea? He noted that is kind of where they need to head, in terms of discussion. He felt it was better to stay away from the sustainability issue.

Kim noted they use the term "sustained viable population" in NOAA-Fisheries.

Jake asked for clarification. He said we had been told not to discuss extinction, but we are tip-toeing around that issue.

Heather noted that we aren't asking the question directly, but that is the case.

Jake suggested that we then discuss what factors would cause a decline in eels. Those factors would lead to a non-persistent, non-sustainable population. He suggested that we discuss what about freshwater habitat loss could cause a decline.

Jim Uphoff suggested that we ask if the population had a compensatory reserve, or was density dependent? If the default assumption is that the stock is affected by density-independent factors, it will have an impact, unless there is some compensatory reserve. He felt that was the basic question.

Rob asked if there could be locally threatened areas, given a panmictic species? Heather asked that we hold that question.

9:43 AM: Heather asked that the experts look through the questions and decide which ones they can answer. She noted that "continental" should read "Continental Shelf."

ATTACHMENT - HABITAT QUESTIONS

Marty indicated that we had discussed the relative importance of freshwater and marine habitats. He wasn't sure how much further we can go. He noted that we had heard that freshwater isn't important (given survival through the Ice Age), and that it is critically important, given the number of females eels it is producing. He asked if there was any information that anyone

wanted to provide that would help inform the FWS deliberations.

Someone asked Heather about the significance of Continental Shelf habitat. Heather indicated she wanted to distinguish the coastal from inland habitats.

Mike Miller noted he wasn't aware of any study that looked at "marine" eels. He noted that such eels may still be linked to estuaries. He wasn't aware of any studies that found eels offshore, outside an estuary. He didn't see any evidence that suggested eels will live offshore, outside an estuary.

Brian Jessop noted he had a discussion with a colleague who had looked at bycatch data, and they found eels rarely there. Brian noted there were very small numbers of instances of adult eels being captured in offshore waters. There are no data that would allow you to estimate density.

Brian Knights noted that any adults captured offshore could be migrating to the spawning areas.

Heather asked if the offshore questions should just be combined. The two last sets of questions should really be combined because there isn't sufficient information to move out further.

Jessop – we don't know what distances offshore eels could be found. Do we know if, in the Baltic, eels are distributed out there?

Knights – fisheries are in shallow waters to capture migrating eels.

Jessop – eels tend to inhabit waters less than 10-20m depth, so you can look for coastal distributions in those depths. This may be true in many estuarine/coastal areas. Knights noted that there are major fyke net fisheries off the coast of Sweden, but Jessop pointed out that these take place in fairly shallow coastal waters. Knights noted that there do seem to be marine fisheries in Europe.

Knights disagrees – a number of Japanese papers look at silver eels observed in marine sites. There was a wide distribution of eels across all habitat types based on Ca/Sr ratios. European studies show similar trends of eels across all habitat types, sometimes studies show that eels have not utilized freshwater at all. Brian Knights cited one paper's statistics, that showed a fairly wide distribution of eels across freshwater, brackish, and estuarine habitats, using otolith microchemistry. Some of these eels showed very clear migratory patterns on an annual basis, from the Baltic Sea. Mike Miller asked about the salinity. Brian noted the Baltic was one enormous estuary, so that was a problem.

Jim Uphoff noted he had made some crude calculations, based on an EPRI report. Jim noted that he actually used a spreadsheet. There are between 2.7 and 14 million eels, roughly from one system, for Maryland's portion of the Chesapeake.

Brian Jessop noted the issue seems to be that we don't know what kind of distance from coastal waters eels regularly inhabit, or in what densities. For the Baltic, he asked Brian if we know that eels are found in the middle of the Baltic? Brian Knights noted the fisheries tend to be in rather shallow waters, like all other silver eel fisheries. Brian Jessop noted that something else he read suggested that not a lot would be found in the middle of the Baltic Sea, so that would provide a boundary to confine area estimates.

Brian Knights noted that the use might relate to production as well, with preferred habitats around the more productive fringes.

Brian Jessop noted that the eels might not find appropriate food or temperature conditions at depth.

Brian Knights noted the fisheries were located in relatively shallow areas. He noted there was a massive big fyke net fishery near Wales, in shallow waters.

Bill Richkus referred us to **Question 7. How best can we characterize the changes in freshwater habitat over time?**
He felt it could be characterized. He noted we weren't supposed to talk about trends, but felt that we had been provided with lots of literature on this one. He noted there have been lots of changes in watersheds through time. He was interested in the ages of dams, and how that related to eel demographics. He felt the question is a very important one. It ties into the barrier question. There have been lots of changes in watersheds over time, that correspond to the period of time that changes in eel populations have been observed. He looks at age of dams vs. life cycle of the eel and the effect of all this over time.

David Perkins suggested again that we loop back to question 2b, now that we have clarified what sustainability was.

Heather felt that we had the answers from the panelists. Dave indicated if Heather was comfortable, that was fine.

Gail noted she was trying to think about ways to assess the importance of estuarine habitat. She noted that she could ask the fishermen what the salinity ranges are in which they are catching eels. Also, she noted there is a huge lobster fishery off the Maine coast, and she can ask their fishermen if they are catching any eels.

John Casselman was asked what habitat was being used by American eels in the Great Lakes. He indicated that generally it was in depths 10 meters or less but prior to migration, they become pelagic and start consuming other prey. They prefer warmer temperatures (23-24 degrees C), in shallow waters.

10:00 AM: Marci asked, what are we going to do with all the questions that weren't answered? Heather asked that all FWS staff remain for five minutes, during the break, to discuss that

subject. Marci noted that Mark had asked an additional one that was not yet answered.

Marie introduced us to Ann Roy, and Sherman Ross, Librarian and library volunteer at NCTC respectively, who were responsible for all the American eel literature that we had been given. Marie gave them a certificate of appreciation for all their hard work. Ann indicated they really appreciated the presentation. She noted that sometimes they loose sight, at NCTC, of what the FWS mission really is. She indicated they have a bottle of preserved American eels sitting in the library now, so they can take a picture of them with Sherman. She indicated it was nice to be able to put faces together with names.

10:03 AM: Marci asked that we all be back in our chairs at 10:30 AM.

The FWS staff met after the break and discussed how to proceed from this point onward. A small group was asked to reformulate the questions for the next session, which will address barriers.

Session: Barriers to Successful Upstream Migration

10:35 AM: Marci convened the next session. She noted that serious editing of the questions had been done, but the bad news was she wouldn't have them on the screen. She indicated that Mike Twohey would be leading this session. Marie indicated that there are papers on the back table for us, and she would be providing more for us tomorrow. Heather indicated these were ones she received at the last minute and hadn't been able to provide to us earlier.

Marci indicated that we would ask questions this afternoon about barriers to downstream migration, but this morning we want to focus on upstream migration. Heather asked that we focus on what we do know, and on uncertainties, and the potential implications of any uncertainties. Kevin Mcgrath asked for clarification.

Marci stated the overarching question, this is the question FWS/NMFS will ultimately have to answer. The questions to be presented to the panel are subsets of the overarching questions**.** ***Is the sustainability of the American eel population in whole or in part threatened by barriers and turbines encountered during freshwater migration?***

Steve noted that turbines were included in the overarching question, but we would deal with those later. Mike Twohey noted that the barriers would be dealt with again at the next workshop.

Question 1: What are the types of structures and their characteristics that should be considered upstream barriers to migration (examples: dams over 50 feet, % slope, locks, weirs, etc/)? What is their effectiveness as barriers (% blockage)?

Kevin Mcgrath stated the question was unanswerable. He noted on the Richelieu River, emplacement of a concrete dam eliminated the eel fishery in Lake Champlain. The eels were recruited at 350-500 mm. In another environment, elvers might be able to ascend the structure. The crib wall dam had been there for ages, but the other dam was constructed in the late 1960's.

Kevin agreed there were eels above the dam. He noted there is an eel ladder there now.

Heather asked if it was fair to say that depending on the structure, it could be a barrier?

Steve Gephard stated that once an eel gets big enough, and is far enough inland, then structures could constitute a blockage.

Wilson stated that it should be a relatively simple thing to do, to determine which dams constitute blockages and which don't, simply by looking upstream and using existing surveys that reveal an absence of American eels from the fish community.

Heather pointed out that eels are not specifically surveyed for so we would have data gaps.

Bill Richkus felt that enough information existed that we should be able to determine what sort of structure constitutes a blockage. Span of river, nature of surface (rough better for eels), height relative to eel size, angle, state of disrepair (disrepair being better for eels).

Jake suggested that we shouldn't pose the question in terms of black and white, because eel passage was a site-specific function. Heather noted that she needed some sort of guidance, because she couldn't evaluate passage at every individual structure. Brian Knights felt that Bill Richkus had laid it out.

Julie noted that we should consider whether eel passage was present on the structures. Heather agreed and noted that information, although not easily obtained, was available from FERC. Julie noted that climbing ability varied with size, with the smaller eels able to climb. She also asked if we could make an assumption about distance from tidal limits relative to size of eels.

Steve Gephard felt that spill was another important variable. He noted that some dams in CT would go years without spilling. That is an important characteristic, since it is hard to climb a dry spillway. Steve agreed with Bill this is one thing we have a good handle on, but if we try to do it with databases, without consulting with local people, it will be unanswerable. He agreed with Jake that there is a lot of site uniqueness. The dams are so unique, that it requires the knowledge of someone local to do the job of assessing them as a blockage. Steve noted that he could critique each dam in CT. Heather indicated she would call on him to do so. Steve noted that if large portions of the east coast didn't respond to direct inquiries, then assumptions would be worthless. He noted there are tons of eels upstream of some of the dams on the maps.

Gail agreed with Steve that local knowledge was essential. She noted there are lots of eels above dams in Maine as well. She noted another concern, which is that lots of dams owners are now using rubber crests, which are eliminating any spillage. So, dams that once were passable are no longer.

Brian Knights noted that it makes a difference if there is a lock, with high numbers of openings, because that provides a means of passage past the dam.

Julie noted that we are all cognizant of the limitations of the data, but we have to use the best available information. She suggested that using the GIS database, as our initial cut, then fill in with local knowledge where possible, would give us although perhaps not the best, a product that would be good enough.

Brian Jessop asked if we couldn't at least create a subset of dams that by their nature constituted 100 percent barriers. That would be a big step to begin the assessment process. Seasonality of discharge, height of the dam, and so forth could be used to define criteria for those structures. Then beyond that, we could use local knowledge. Brian indicated he was thinking of the zero percent passages structures.

Steve Gephard suggested we might be able to define the other extreme as well, which are dams that don't constitute any blockage. Brian Jessop stated he doubted that any dam would allow 100 passage.

Ken Olivera noted that proximity to the sea was an issue as well, with regard to life stages. He noted that glass eels generally wouldn't be exposed to structures beyond the first one on a given estuary/river system.

Paul Angermeier noted that natural barriers (such as Great Falls) could also impede passage as well. He suggested there might be a suite of factors associated with falls that might be useful, and dams located below or above them might be noted.

John Casselman stated his concern over cumulative impacts of multiple dams. Passage at one, and then another, will have multiple effects and you may not see eels above the second.

Bill Richkus suggested that it might be worth identifying dams that have been altered, modified, or otherwise renovated.

Julie noted that might tie in with what Gail was saying about the rubber crests. Julie suggested that we should clarify whether the habitat amount blocked is either minimum, or maximum, based on the dam.

Alastair suggested that the urge to migrate may vary with changes in eel abundance or density below the dam.

Barriers to Successful Upstream Migration Flip chart bullets
Characteristics to consider when evaluating barrier effects

- Size of eel
- Distance from tidal limit
- Span of the river
- Surface texture (rough good, smooth bad)
- Angle of face
- Spill
- State of disrepair (disrepair being good)
- Presence of eel passage
- Amount and timing of spill
- Whether bypasses, such as locks, are available
- # of Barriers
- Modernized, repaired, renovated (may be bad)
- Density below dam likely determines the need to migrate further

The types of effects of upstream barriers include:

- Sex determination;
- Increased predation rate; and/or
- Growth rate, which effects fecundity
- Mortality – only very site specific

Marci noted that Heather had a note to specify impacts to migration by life stage, and noted that Ken Olivera had already touched on that. She asked **Question 6 – What life stages or life history characteristics make the eel more or less vulnerable to the effects of barriers on upstream migration?**

Make a list by life stage of the severity of barriers. Heather wasn't sure we could answer that now, or whether she needed to go through the analysis first, before she asked that question.

Marci noted the next question was, **what are the other kinds of barriers**, would be getting off the topic.

Paul Angermeier asked if it would be useful for us to rank the impact on life stages. Say, if an elver is blocked, versus a yellow eel. He felt that if an elver encountered a barrier, it would be more impacted than a yellow eel that was already further along.

John Casselman stated if a dam creates a density that yields a sex ratio that impacts fecundity, that would be an impact.

Heather noted that we should define severity, in terms of death, or other impacts. Marie wrote on the screen: death, injury, impingement, increased exposure to mortality, indirect, loss of reproductive potential.

Brian Knights noted that he observed one catchment in which a large dam was put in place in the 50's and eels gradually disappeared, thereby eliminating that one basin from production.

Paul noted that impeding an animal's movement could affect sex determination; predation rate; and/or growth rate.

Julie indicated that the fecundity relationship to the size, which is related to the growth rate, all could be affected by dams.

Kevin Mcgrath noted that in concentrated aquaculture situations, lots of males result. He asked if there was any evidence of that, anywhere in the wild. He noted at St. Lawrence, Moses Saunders blocked the upstream migration for a long period of time, yet below the dam, 100 percent of the eels were females. John confirmed that was the case.

Ken Olivera was asked to comment. Ken noted that some of the shorter coastal rivers where glass/elvers are packed in densely are almost entirely males. Kevin asked if it mattered at what life stage the density occurred? Ken noted that we don't know at what stage sex is determined, and that at that point in the St. Lawrence the sex may already be determined.

John Casselman asked if there was any place, anywhere, where we had seen the sex ratio change, as a function of changes in density? Ken noted the only long-term sex ratio data of which he was aware, showed a consistent male dominance.

Brian Knights knew of one river where the density and sex ratio had changed (males to females), during the time series sampled. But they did not know why.

Mike Miller stated he felt death and injury were not factors in upstream migration.

Bill Richkus asked if anyone knew whether predation was increased below dams.

Wilson noted that he wasn't aware of any documentation of increased predation, but you had to be suspicious when you observed flocks of cormorants and/or seagulls below the dam coincident with upstream migration periods. Wilson also noted to Mike Miller that at Roanoke Rapids Dam, there were openings into which eels had migrated and from which they couldn't escape, leading to death, so it did occur at least in some cases.

Julie observed elvers dried up on the face of dams, but this is likely site specific.

Question: Are there other barriers to migration besides structural barriers, e.g., hydraulic, thermal, hydrological, haline and chemical that limit migration?

- Thermal barriers and variation
- Velocity barrier-site specific, highway underpass culverts
- Hydroelectric dam and change in downstream discharge due to turbines
- Chemical – more likely historic and temporary
- Multiple highway crossings within a watershed

Oxygen was mentioned, but no evidence (this was discussed in Canada).

Mark Cantrell addressed other barriers, such as thermal barriers, warm or cold, and asked if there were examples.

Steve Gephard gave an example of a velocity barrier. A Corps of Engineers flood control dam of which he is aware essentially constitutes a culvert with shallow depth, at high velocity (20 ft per second), with a smooth surface, which precludes upstream migration.

Brian Jessop gave another example analogous to Steve's. In his case, a highway underpass culvert constitutes a velocity barrier because of its length and the high velocity. Larger eels can pass it at times, but to elvers it is a total barrier. Brian Jessop stated that below the Mac....Dam on the St. John River, elvers were once found in abundance, but after they added the final two of six turbines to the dam, elvers haven't been seen since. He stated the change in discharge patterns led to the disappearance of elvers, but he noted he hadn't been able to reproduce the former elver migration pattern by turning off turbines and so forth. Cooler water temperatures he felt were a factor in upstream tributaries. He stated that not as many eels would be found in trout waters, for example.

Kim asked if hydraulic, shouldn't be changed to hydrologic, to accommodate natural barriers. Heather stated she wanted both factors considered.

Paul Angermeier noted there are a lot of problems with highway crossings that haven't been fully explored. He noted culverts may be particularly problematic in the upper portions of watersheds.

Julie asked if we should distinguish between natural, and anthropogenic barriers, as threats. She noted the natural barriers have always been there. Heather noted at the scale of analysis, we won't be able to tease those effects out anyway. She noted if there is a natural barrier, on the sole undammed stream, she would want to know, but otherwise it isn't important to distinguish.

Jeff Govoni noted that he had no doubt that highway structures did change the velocity profiles, but he noted the animals exhibited robust behavior with regard to bypassing velocity barriers by climbing around them. He asked if anyone had observed elvers or glass eels circumventing barriers.

Brian Jessop said yes, but they have to have damp pathways. He stated that it still constitutes a

barrier to some degree because it cuts down the percentage of elvers passing. Brian noted that with regard to Paul's point, there was an interesting article in Fisheries this past year, on the impact of highway construction on fish passage, and it was quite "damming."

Rob noted he was aware of a situation in the St. Lawrence, where eels were able to skirt a barrier.
Rob asked if there was any structure that you couldn't retrofit with a passage device? Rob noted there is a World Commission on Dams report, issued in 2002, that would be of interest to us.

Jake noted, in response to what Jeff Govoni said, that eel passage on damp surfaces obviously exposed the eels to sources of mortality that they wouldn't otherwise normally experience, such as raccoons, automobiles and so forth.

Brian Knights asked if anyone had any evidence of any chemical blockage. Steve Gephard gave one example where fighting a fire, with resultant input of fire retardant (latex-based) into an adjacent stream, caused eel death and downstream migration, in the Naugatuck River. He noted it suggested to him there was a potential to block eels. Brian Knights noted that the Thames had recovered from historic pollution. He stated it seemed to him that there is no such thing as a permanent chemical barrier.

Marci posed the next **Question: If there are impacts on one river system, such as the James in VA, could they be presumed, or extrapolated, for other systems?** She noted she was thinking of the paper by Goodwin and Angermeier. Paul felt that cautious extrapolation could be done, particularly if other factors, such as distance from the ocean and other factors, were taken into effect.

John Casselman indicated he thought it was difficult to extrapolate. Life stage was one factor that should be taken into consideration. He agreed with Steve that local knowledge was important, so caution had to be used.

Brian Knights agreed that factors had to be taken into consideration when extrapolation was going to be done. There is no way to compare a small stream in Virginia, for example, with one in Nova Scotia. Heather asked if it might be legitimate to use Paul's data, on a regional basis, say from MD through SC? Or, is there too big a potential for error, given that we can't go to every stream, and we don't have data for every stream. Can the analysis be valuable at some level?

Rob stated it depends on what you want to extrapolate. If you recognize that it is life stage specific, you might be able to do so, but he wasn't sure if you could do this or not. He noted that we are only talking about upstream right now.

Alastair agreed with what had been said. He felt that broad-scale, within a region, extrapolations could be done.

Kevin Mcgrath noted that he had agreed with what everyone else had stated, but Alastair had said something a little different. Kevin agreed that extrapolation could be done with caution. He noted that upstream barriers have been documented in many systems, and felt that it was pretty universal.

Ken Olivera stated yes, but it would have to be highly qualified, using life stage, and the density of them. He stated it would be highly variable from one system to another. You would have to know how factors changed.

Bill Richkus agreed with what everyone had said, but noted that it would have to be a qualitative extrapolation. Julie asked him to define what he meant by qualitative. Bill stated, use "bad, good," etc., versus actual measured percentages, such as 10 percent.

Brian Jessop asked if we could agree on a definition for life stages. He noted for elvers, for example, various definitions had been used, and not all of them could be correct. He advocated that elver be applied to only young-of-the-year. Marci noted there are a few more questions, so if we want to spend some minutes on this, we could.

Ken thought that young-of-the-year elvers were all yellow.

Brian Jessop stated he meant that young-of-the-year would only include eels from entry into a system, until their first hibernation. It would include all stages of pigmentation, until the end of their season. Ken felt they would be yellow and fully pigmented, during that period that Brian had defined. Brian stated if you wanted to further close it down, you could define it as something below Ken's stage 7, and probably caught in late August. He stated however we define it, we should come away with a definition that could be used. He stated that animals less than 10 or 15 centimeters were not elvers, in his opinion.

Jeff Govoni agreed with Brian and noted that a lot of "elvers" included even glass eels. He suggested that the definition should be based on morphology and pigmentation. He noted they undergo metamorphosis, which is not quite as abrupt as in other species, but it is certainly a change. During this period, the eels shrink in size, and when the change is complete, they begin to grow again. Jeff contended the elver stage begins at the end of that metamorphosis stage. This would set the lower limit of the elver stage. The upper limit would be young-of-the-year. That was his proposal. This is the period when they are involved in upstream migration. Marci decreed the discussion of "elver" definition over.

Barriers to Successful Upstream Migration Flip chart bullets
Is extrapolation possible? These are the considerations

- Context of where eel is trying to move to
- Take into account local geographical situation/migratory pathways
- Life stage important; use caution
- Not north/south
- Regionally given life stage and other parameters
- Exercise care and caution
- Identify all the assumptions
- Qualitatively (good, med, bad) rather than quantitatively (percent)

The next **Question: Have the effects of barriers on populations been fully realized?** She asked Dave Perkins to comment.

Dave noted that retrofitting dams with rubber crest weirs was an example about which we don't yet know the entire effect. Dave noted another way to look at this was, given that barriers have been in place for 20 years or more, have they done their damage?

Bill Richkus noted that with passage provided, the impacts can be reversed or overcome.

Gail agreed with Bill and noted that the provision of passage during the last 10 years may have begun to compensate for past impacts.

John Casselman suggested that the effect of dams on recruitment hasn't yet been fully realized yet.

Jake noted that a lot of the effects about which we are talking are going to be synergistic. He noted if oceanic changes produce smaller, weaker, glass eels, not all the effects may have been realized yet.

Brian Knights indicated that many of the barriers in England have been in place for centuries, in some cases, and he felt the recent observed declines could not be due to the barrier factor, at least not in some systems. For individual systems, he agreed that dams could be having an effect.

11:46 AM: Paul suggested it might not be useful to think of dams as monolithic in terms of

expressing their effect. For older dams, we can presume their effect has been felt. Dams built 50 years ago probably have had an impact. Other, newer dams may not have produced the ultimate effect. Also, highways and other features may be newer. It may be that stratifying the barriers might be useful, for example, saying that the larger, older dams may have had their effect.

Heather asked, if a barrier has been in place for 50 years, and every year new eels come up the river, and they experience the same impact, whatever that is, and the species is panmictic, is that impact experienced every year? That is a little different question than the impact of the lost habitat above the dam. Are we talking about the impact on the downstream population, every year?

Steve Gephard agreed that was the case.

Bill Richkus suggested that the impact was unanswerable to a degree, but would be cumulative.

John Casselman noted it was still effecting the overall health of the species, in time and space.

Paul noted that he was basically going to say the same thing. If you look at reproductive potential, putting the dam in place may not allow you to see the signals until ten years down the road. There may be no continued decline past that point.

Heather asked if that was true, even with regard to sex ratio. Paul noted that would be expressed in later generations.

Wilson asked Bill if you couldn't model the impacts. Bill noted the Beak International Corporation (2001) paper that was provided to us, which concluded that the modeling they had done contained so many assumptions that it was unrealistic.

Sheila Eyler noted that on the Susquehanna, there are no eels above the Conowingo, yet there are many below the dam. She stated the dam is having an impact on their upstream migration, based on sampling in nearby unblocked watersheds and sampling above Conowingo.

John Casselman noted one case where eel passage had been blocked by modification, but then restored.

Brian Knights noted there is an ongoing eel modeling effort, using the acronym SLIME, that may produce some useful results this spring.

Barriers to Successful Upstream Migration Flip chart bullets
Have the effects of barriers on eel populations been fully realized?

- Eel passages used to compensate for barriers on some river systems
- Eel populations may still responding to man-made barriers (generational impacts, cumulative impacts, continues to effect the reproductive potential) but there was disagreement as to the degree
- Older dams, effects to populations may have already been fully expressed. New dams (less than 50 years), those modified, and highway projects will likely result in effects that have not been fully realized.

The **Question was asked if there was any data on mortality (such as rate of mortality) caused by upstream barriers?** No one was aware of any studies. Alastair thought the likelihood was pretty low. Rob noted that placing the exit from an eel ladder close to the turbine intake was not a good idea. John Casselman noted that generation time and fecundity were likely affected.

Gail noted that when the elver fishery was really big, the fishermen were telling them where to put the eel passage structure, so at the time, they knew where they all were.

Marci asked the last **Question: What uncertainties are there?**
Brian Knights suggested that what we need are more studies at dams with passes. It would be good to have a series of dams, along the coast, and trap the runs, and generate some long time series. This is the only way we are really going to keep track of the effects of the barriers, as well as recruitment. John Casselman noted that biological data on all the fish trapped should be collected as well. Paul Angermeier noted he saw two main kinds of knowledge needed. One is to calibrate the permeability of dams. We need to know the percentages passed. Given a suite of sampling sites, you could estimate permeability with some confidence, but we don't have this. Another important question is that of the impact of an animal's ability to pass, on its subsequent reproductive condition. We need to ask, what is the population effect of keeping hundreds of thousands of eels restricted below the dams.

Bill Richkus noted even if we had great numbers, we would find it difficult to extrapolate to the entire range. Ken Olivera agreed.

Kevin Mcgrath noted he thought the GIS exercise was great, but asked how far up we were going to take the extrapolation? To third order, or fourth order streams? Where is the cutoff point?

Heather asked, if the chance of eels being there decreases significantly, above two dams, should we go any higher? She asked if it would be worth it to go higher up? The eel density gets less and less, so at some point, she will have to stop the GIS person from continuing on upstream, given there are no eels upstream.

Kevin asked Gail about the Kennebec. She noted there were 19 dams on the Kennebec, and eels used to be above all of them. Kevin noted that is one thing that needs to be addressed. He couldn't answer that question. He had no idea how far inland they extended. Bill noted that it would be good to have someone here from PA, NJ or DE to answer that question.

Alastair noted he had nothing to contribute.

Rob noted he wished we could look at the cumulative effects. He wished it could be modeled. He also wished that we had better historical records. He worried that we weren't taking into effect the cumulative impacts of all the barriers.

Brian Jessop asked that we go back to question 5. He noted that it could be interpreted in several ways, and articulated them. He noted that mortality above and below should be much the same, in equivalent habitats. Heather noted they just changed the question.

Barriers to Successful Upstream Migration Flip chart bullets

Uncertainties

- Quantification of runs over time
- Biological parameters
- Effects of barriers on recruitment (is reproductive potential affected by different growth rates, is life span reduced due to predation or other factors, what is the reproductive potential of eels which don't get past the barrier, etc.)
- Whether the effects of barriers had already been realized, or if the effects were ongoing.
- Lack of information on a range-wide basis on the permeability of dams
- Cumulative effects and need to search historic records
- Delineation of the "end" of watershed-what is the highest order stream to look at?

12:08 PM: Marci asked that we return to our chairs at 1:15 PM, after we broke for lunch.

1:27 PM: Marci noted that we are late getting started, because the door was locked.

Marie noted that Brian Jessop and Jeff Govoni need a ride to Dulles, before noon on Friday. She asked also that those needing a ride tomorrow on the five o'clock shuttle call and confirm their rides. Kim noted that she was driving to Dulles tomorrow after the meeting. Kevin indicated that he was doing the same. He indicated that he needed to leave at four. Marie indicated that if everyone could get a ride with someone else, she would cancel the shuttle. There were no objections. Ken noted that some of them leaving at four, might miss part of the proceedings. Heather indicated that we could shorten breaks and lunch, to save time.

Heather indicated that Natureserve is updating the eel distribution for her, for the US, and she has a new map, of presence/absence, by watershed. It shows current, versus historic (defined as before 1970) distribution. Red indicates the eel is absent. Canada's Natureserve equivalent also had produced a map. Brian Jessop asked if the maps could be shrunk to 8.5 by 11 and copies provided. Heather indicated that would be done. The Canadian map doesn't indicate the historic distribution. Brian noted the only thing he would add, from the Quebec meeting, that eels have been found about a 100 km north of Hamilton Inlet, which is normally considered the northern limit, so the boundary is really somewhat further north.

Kevin Mcgrath advocated that Heather solicit as much information as she could on the Caribbean, and Central and South American distribution and abundance of American eels. He stated that he has heard anecdotal accounts of large numbers of eels there. Heather noted that would be Marie's department, so she would make sure she heard that information. Mark Cantrell noted that those who were doing the work in those countries, live here, so the information should be readably accessible.

Heather showed us the conceptual American eel population dynamics model developed during Paul's workshop, and asked for comments on that and asked Paul if he wanted them. He indicated he would like to have any comments.

ATTACHMENT 3 and 4 CONCEPTUAL MODEL AND EUROPEAN DIAGRAM

Heather noted there is another diagram, for Europe, demonstrating something regarding silver eels, and she would try to put it up on the wall, with a title, for the group to review.

Marci reiterated for the group the information that Heather is seeking from participants in this workshop:

1. Suitability of information for the Status Review (fill out the questionnaire).
2. Help in characterizing threats.
3. Make sense of complex and sometimes confusing information.
4. Tell organizers about uncertainties in the information.
5. Tell them about the implications of uncertainties.

6. Individual assessments of implications of threats.

Session: Barriers to Successful Downstream Migration
Marci noted there are six questions for this session, which will last until 2:30 PM.

1. What are the types of structures and their characteristics that should be considered downstream barriers to migration? What is their effectiveness as barriers (percent blocked)?

Bill stated that we should define permeable versus impermeable barriers. Kevin stated that hydropower dams shouldn't be considered barriers. Eels do suffer mortality at them. Heather noted that in Europe, studies had shown there may be delays. Brian Knights noted that if they can get over the dam, there isn't a problem. If the only way downstream is through the turbines, then they suffer mortality.

Kevin Mcgrath noted that their tracking studies show that there wasn't any delay in downstream passage at Moses Saunders Power Dam. He noted there are no trash racks there, so nothing to impede them. Some of the eels went on downstream, to a dam with trash racks, and the longest time it took them to pass was slightly over two hours, so he felt there was no delay. He noted that he had a lot of respect for Brown and Haro's work, but they released their eels 1.5 km upstream of the dam. When eels are tagged like that, they may not resume migration immediately. He felt that the delays observed by them were a result of the surgery, and not delays due to the dam.

Jeff Underwood asked that we define what a barrier is. Is there a need to define what it is, for the purpose of the Status Review? Heather wasn't sure. She wanted to make sure that it could be either put aside, or was something on which we needed to dwell.

Steve noted that if we accept Kevin's definition that death is not an issue, then we don't need to talk about permeable or impermeable. He noted that eels can generally follow the water, regardless of whether they are in pieces or whole. Steve noted that in the spring, many reservoirs in New England are spilling, and eel life stages can swim over them. In the fall, many reservoirs are way below the spillway, and the only way they can get past is through the turbines or pumps. He felt that water supply systems have to be considered barriers. Heather summarized that under some circumstances, there could be barriers, including natural waterfalls. Steve noted that waterfalls weren't barriers, the flow there was the issue.

Bill Richkus noted that work they had done showed that eels were very sensitive to handling, so this is a caution for a lot of the smaller studies done. He felt that the work done by Kevin was likely more reflective of unbiased behavior, due to the care they took.

Rob asked if anyone had looked at systems with multiple barriers, and whether that sort of system caused delayed migration.

Steve indicated that he had a hard time believing that all hydro dams didn't cause some sort of delay, Kevin's work notwithstanding. He noted that some facilities don't generate for 24 hours. He wasn't willing to state that hydro dams didn't cause a delay. Systems with multiple dams would cause even more.

John Casselman noted that there is evidence that changes in flow will cause changes in eel movement. He agreed with Steve that any kind of impoundment would likely cause delay.

Brian Jessop suggested that the delay might not be much, when flows are going through. In other systems, where eels upriver enter a long headpond, he asked what the impact on migrating eels would be of a long headpond? If there is a spate-induced movement of eels due to a freshet upstream, what is the impact when they enter the headpond?

Paul suggested that there are many factors that might affect downstream migration. He noted that in flood control dams, they pull the water down to provide for flood storage, so there is potential to interrupt the pulse pattern because of the way the dams are operated. Heather agreed that was the case, noting that western reservoirs are huge and do have an impact on salmon migration.

Brian Knights noted that a series of impoundments is not that much different than a series of lakes. The only difference is the turbines which could cause death.

Barriers to Successful Downstream Migration Projected bullets
What are the types of structures/characteristics that should be considered?

- Water flow-variable
- Delay?
- Impoundments
- Water supply/distribution systems
- Multiple, system-wide dams
- Discharge change effecting eel movement
- Head pond effects
- Dam operations affecting migratory pulses
- Weirs and entanglement gear

Marci noted that brought us to **Question 2: What are the implications of turbines when**

looking at life stage and productivity potential? What percentage of eels (or other metric) by life stage are affected?

Julie Weeder noted that elvers and yellow eels are not likely very greatly affected. She noted that her personal opinion is that silver eels have a high probably of being killed. Bill Richkus noted the Electric Power Research Institute (EPRI) report compiled all the data on eel mortality through turbines, and found that the level was variable, but not uniformly high. Julie noted that it depended in part on how you define mortality. Delayed mortality may be occurring, and not documented. Many injuries can be internally and not immediately observable. Bill noted that some studies did x-ray the eels and/or hold them for a period of time to measure delayed mortality.

Steve Gephard noted that many of the turbine mortality studies were done at FERC dams, which are usually very large. He suggested that the studies may not have been comprehensive. Many of the dams in his work area are much smaller, and have Francis turbines. He felt that the published turbine mortality studies to date are of limited utility. Marci noted that was a good uncertainty.

Paul noted that we need to pay attention to the cumulative impacts of downstream turbine mortality. He noted we had to put it in the context of the entire catchment. Turbine mortality has to be assessed from top to bottom of the catchment. If we had numbers of mortality associated with each type of turbine, we could generate an estimated impact.

Rob noted that his issue was also cumulative mortality, and that multiple passages could cause significant mortality. He noted that a recent retrofit of some turbines could result in even greater mortality than originally assessed.

Jim Uphoff noted that if turbine mortality was as great as 30 percent, you preclude having any mortality. If you add a fishery, on top of turbine mortality, that would be very significant.

Jake asked what proportion of dams out there are hydropower? Heather indicated that she had determined that about seven percent produce hydropower, but what she didn't know was what percent of the catchment is above those dams, and other contributing factors.

John Casselman noted that they had been monitoring the eels passing the St. Lawrence, and assessed the turbine mortality, in comparison to the yellow eel fishery, and found they were about of equal magnitude, at 40 percent. Bill Richkus noted that his recollection was correct, about the EPRI study, which found that turbine mortality was most often in the range of 20-30 percent.

Brian Jessop noted the recent paper by McCleave that had been provided to the group.

Kevin Mcgrath asked if anyone knew whether yellow eels are subject to turbine mortality. He noted they don't see any dead eels in their tailrace.

Steve Gephard indicated that several parties had reported catches of fish considered as yellow eels, in silver eel weir fisheries. The relevance was that if yellow eels were moving downstream and caught by weirs, they could also be impacted by turbines.

Brian Jessop noted that yellow eels do move downstream in the fall, mixed in with silver eels. Clearly he found it conceivable there could be impacts.

John Casselman noted that Kevin had documented fallback behavior, and noted they do find damaged yellow eels below dams. Fallback behavior could be a factor in injury. Kevin noted that was behavior associated with a ladder, where eels are dropped off on the upper side of the dam, within a 100 feet or so of the turbine intakes. They did a lot of studies on this, and found that about 50 percent of the eels were subject to entrainment.

Julie Weeder noted that the EPRI report does state that the mortality estimates may represent minimums, due to the fact that there were no studies on delayed mortality. Marci noted that Steve had questioned the broad applicability of the study, due to the fact that most studies were done at larger dams. Julie noted that it also wasn't very obvious sometimes what constituted a silver eel. She noted that they had captured yellow eels in the upper Chesapeake that were likely very close to changing to silver. Brian Knights noted the converse was true as well. He indicated that some silver eels implanted with transmitters were still there a year later.

Heather noted that weirs were a type of barrier that we hadn't discussed as well. She indicated that they could constitute a barrier. Julie noted that if they weren't fishing, they didn't constitute a barrier. She noted that most of them weren't fished year-round. There was agreement that weirs could constitute a barrier.

Heather noted the size of individual eels, she had read, did affect their likelihood of mortality. She asked if the impact was greater on large females, and if so, could the impact on rivers that produce large fecund females, be larger than impacts on one that produced smaller females?

Steve Gephard noted that studies in New Zealand also showed that spillage could have a disproportionately larger impact on larger eels as well, since they were subject to a greater impact during a fall due to their higher body mass. Smaller, lighter, glass eels and elvers were much less subject to injury resulting from a fall.
Rob indicated that ultimately, we needed to look at the combined effects of some of the factors. Heather asked that participants consider whether impacts should be viewed as synergistic, or cumulative.

Jim Uphoff noted that if the approach that he and Julie developed was used, you could probably come up with some sort of partial recruitment vector, and do an exercise on paper to determine what impact the turbine impacts would have.

Barriers to Successful Downstream Migration Projected bullets

What are the implications of turbines when looking at life stage/productivity?

- Varies by turbine type, size, operation
- Potential that mortality is delayed after eels survive passage
- Must consider mortality from top-to-bottom of the watershed
- Changes in turbine size and/or design to improve electrical production- does prior data still apply?
- What percentage of dams would contain turbines? Location? Watershed area? Number of dams in watershed?
- Potential removal of large, mature females
- Spillway height vs. eel size

Question 3: To what degree do downstream barriers affect demographics due to turbines being size and or sex selective, with regards to mortality and injury?

Mark Cantrell asked about the diameter of wicket gate openings, trash rack spacing and location, and other factors, and whether anyone was looking at those sorts of details, in addition to just the turbine type? These factors should be considered as well regarding their contribution to mortality. Pressure differential is another factor.

Heather agreed that any impacts of hydropower should be considered, not just turbine type or size.

Bill Richkus noted there were a number of very thorough studies on all species that looked at those factors. Bill didn't think that there was a dramatic difference between the smaller males, and larger females, for example. Within the realm of this discussion, he didn't believe that it would make a big difference in the sex ratio. That was his opinion. He wanted to make sure that we were aware of studies having been done.

Julie asked if we change the wording of question 3, if that would address Mark's concerns. Mark Cantrell indicated that would work. Heather indicated that we might be able to do a good, versus bad, case examples.

Mark Cantrell noted that the operational mode, night versus day, and peaking or not, also would make a difference in mortality.

The wording of question 3 was changed to: **To what degree do downstream barriers affect demographics due to hydropower operations (e.g., trash rack location and operating regime) being size and or sex selective, with regards to mortality and injury?**

Kevin Mcgrath stated he didn't believe that trash rack location and size would be much of a contributing factor.

Heather noted that she needed to be able to explain to her managers what parameters might be contributing to eel mortality.

Steve noted that he felt Mark's overall point was significant, not particularly where trash racks were located, or wicket gate opening. He gave an example of a dam where generation eliminated passage. He noted that a key question is, what percentage of eels pass through the turbines. A lot of eels may miss the turbines, if generation isn't occurring. Some projects spill a lot, even while they are generating, so some eels have an alternative route.

Marci noted that she hadn't yet heard any answers to the question. Jake indicated that "to what degree" depended on the site specifics. The general demographic shift he felt would be a population of smaller, younger females and more males. The degree would be dependent on the other factors.

Jim Uphoff indicated that basically it was a product of how much of the population was above the dam, and the percentage of mortality. Adding in the proportion of females would allow assessment of the impact on the sex ratio. He noted since the entire stock was panmictic, the overall impact would be hard to assess.

Julie noted the impacts as stated by Jake would lead to reduced fecundity.

Bill Richkus noted that studies done in rivers show that all the eels tend to go through the turbines. On smaller rivers, the projects were likely to have larger impacts.

Someone asked about the percentage of dams with hydropower. Steve noted that it was seven percent, but that number was relatively meaningless in this context. Steve noted it was much more important to know, how many of the terminal dams were hydropower dams, and what percentage of the water flowing to the sea has to pass through a turbine.

Bill Richkus indicated that he still believed that if you review the literature on mortality, the demographics wouldn't be dramatically changed, unless it could be shown that the majority of females were produced by one river.

Ken noted that it might not be important to look at the ages, since multiple sizes can come out of the same river.

2:31 PM: Julie asked if it would make sense to do another GIS exercise, classifying the dams by

hydropower versus not, and also by size? She asked if we would have a more meaningful figure by characterizing them this way? Steve felt that was beneficial, but you almost would have to have a questionnaire, per project, to really assess the site-specific mortality.

Heather asked, if mortality is over 30 percent, at our major river systems (over a certain size), do we believe that it does, or doesn't, have an impact on the species? She noted that the information we want, at a certain level, isn't available, but we need something that is relative to the conditions out there.

Marci noted that we were already four minutes into the break. She suggested that we have only a fifteen minute break, especially since the food was already out there. She noted that four people still had their hands up.

2:34 PM: The group took a break. Marci asked us to return at 2:50 PM.

2:51 PM: Marci reconvened the group. Marie indicated there are now three people needing a ride Friday morning, and asked if there was anyone going then? Jim Uphoff noted that he would be pleased to take anyone by BWI tomorrow after the meeting. Marie indicated that Adam was leaving tomorrow after the meeting as well. Lydia indicated there are hotels near Dulles so people could stay overnight if needed. Heather indicated they would ask if we could get a shuttle leaving earlier Friday morning.

Mike Twohey had a comment about question one. Mike noted that we had some discussion that hydroelectric plants were not an impediment to downstream migration. He quoted from a USGS study that indicated otherwise. Kevin indicated that was specifically what he addressed in his earlier comments, which is that the study animals in question were released well upstream of the dam. He stated the observed movements were more typical of eels recovering from surgery. The studies on the St. Lawrence showed that movement occurred within two hours or less. Mike noted that these delays were at the dams, not upstream. He noted that the suggestion also was that transmitters implanted internally were better than external ones.

Steve Gephard indicated that he agreed with Mike Twohey, and disagreed with Kevin Mcgrath. Kevin Friedland noted that they had observed effects on tagged salmon for up to two weeks.

Barriers to Successful Downstream Migration Projected bullets
To what degree do downstream barriers affect river-specific demographics….?

- Population will be skewed towards smaller and younger (lower fecundity) and more males
- Product if what proportion of population is above the dam and of spawning age/maturity

Question 4: **To what degree do downstream barriers affect the timing of out-migration in such as way as to effect the population, for example, delayed spawning due to disrupted out-migration?**

Heather stated she perceived that there wasn't any delay in terms of timing of migration, but asked if the observed delays could affect reproduction.

John Casselman noted there are lots of other potential effects on migration to the Sargasso. He suggested that in most cases we have no idea. If there is such an effect, it could be very much greater than just delayed mortality.

Kevin Mcgrath stated if there are multiple dams, and the delay is multiple weeks, there could be a significant effect.

Paul noted that from what he gathered from talking to people like Jim McCleave, we don't know much about the sociality of the animals, once they reach the sea. What would the consequences be of traveling in a smaller group, assuming they travel in groups? His sense is that we don't know if it makes any difference for them to arrive weeks or a month late.

Ken Olivera felt that since the outmigration pulses occur over the course of weeks, a delay would have to be longer than months to have an impact, with delays later in the season having a correspondingly greater impact. Brian Jessop agreed.

Bill Richkus noted that silver eel staging apparently occurs in the St. Lawrence, which he found interesting.

Brian Knights noted that one silver eel fishery in England appeared to reap the benefits of delayed migration, in that the eels that didn't leave in one year, left the next.

Barriers to Successful Downstream Migration Projected bullets

To what degree do downstream barriers affect the timing of out-migration in such a way as to affect the population by, for example, delayed spawning due to disrupted out-migration?

- Significant, if several weeks/months and/or need for multiple dam passage
- Limited understanding of social structure; we don't know if it makes a difference

Question 5: What other threats cumulatively interact with downstream barriers?

Alastair noted there are fisheries below dams, and beluga whale predation, and asked if those are the sorts of things that Heather wanted? Heather clarified that she was looking for additive threats, what things should we consider together? Alastair suggested that we would have to consider all the things that we have already discussed as threats.

Heather asked Marty to explain the difference between "cumulative" and "synergistic." He indicated that "synergistic" would be parameters that acted in relation to each other.

Jim Uphoff asked if you were talking about effects on the population, or egg production? He noted that mortality from different factors could be additive, but contaminants could have an impact on egg production. He noted the total effect would be both. Heather noted that Jim had lost her. He explained that abundance would be affected by fishing, predation, and turbine mortality. Other factors such as contaminants could affect egg production later and therefore affect fecundity.

Jeff Underwood asked if we needed to clarify what other impacts were interacting with barriers. Jim felt they all would enter into play. Heather noted that geography constrained some of them, such as the fact that the introduced nematode parasite hasn't yet made it to Canada. Jim noted that since the population is panmictic, then everything ultimately comes into play.

Marci asked, if they all come into play, do we want to list them all now?

Heather noted that at the end of the workshops, we would list them all, but what she was asking now is, are there other factors associated with the barriers.

Bill Richkus stated that .....

Brian Knights.....

Marty gave an example. If an eel makes it through a turbine, but is injured, and is subject to a higher mortality rate, that would be additive. Ken Olivera gave another example, which was that dams could channel eels into a narrow passage and thereby make them more subject to striped bass predation.

Someone asked about hurricanes. Heather stated that would have affected everything, regardless.

Heather gave an example. She noted that kit foxes on drugs are subject to a higher level of mortality, because they can't move as fast on the highway.

Julie gave her individual assessment. She felt that downstream fisheries, turbine mortality, and opportunistic predation were the major factors. She didn't believe that contaminants were causing eels to behave in a bizarre way. The parasite could have an impact, perhaps having an impact on ability to migrate.

Jake asked if there was an environmental factor that might increase susceptibility to turbine mortality?

Steve Gephard noted during the ASMFC stock assessment exercise, there was concern expressed about predation by non-native predators, because they may be targeting American eels (blue catfish in particular, also flathead catfish). Steve noted the introduction and spread of non-native predators might be another factor. Heather agreed that might compound the mortality. Steve noted that it might be a factor in downstream passage as well.

Rob noted that the operating regime of the facility might have a synergistic impact. If a facility was run of river, versus operating eight hours a day, was that synergistic?

Brian Knights asked if the predators we had noted could take large emigrating silver eels. Steve noted these catfish got really large, as do the stripers. Steve noted the catfish got up to over a hundred pounds, and the stripers up to 45 at least. Bill doubted that stripers could take an eel that large.

Barriers to Successful Downstream Migration Projected bullets

What other threats cumulatively (compounding effects) interact with downstream barriers?

- Harvest
- Turbine mortality
- Predation
- Disease
- Parasite

Synergistic?

- Introduction of invasives/predation
- Operation regime of hydro plant

Question 6: What are the uncertainties and knowledge gaps? Heather noted she had some already. One is what are the impacts of delays in migration on meeting their migration cohort? We don't really know how much delay there might be in downstream migration.

Paul noted that we don't know if the delay matters or not. He noted that we already know that there are predators out there large enough to eat a silver, and more (snakeheads) may be on the way.

John Casselman noted that we don't know at all what the other effects of turbine mortality might be.

Brian Knights noted that it would be desirable to have some very large PIT tag studies done above dams to assess the proportion lost.
Rob noted his uncertainty was regarding the cumulative effects. He noted that someone had said perhaps all the large facilities with high mortality were all in one system, or had a disproportionate effect. Heater noted that was her. Rob agreed that cumulative impact was an important issue and it needed to be globally assessed. Heather clarified that we might know the impact of one dam, on one river, on eels, but we might not know the impacts of all the dams, on all the rivers. Rob restated that if all the large dams were operating on large rivers that were producing all the females, they might be having a disproportionate effect.

Brian asked Heather to change "global" to "continental."

Alastair noted we don't know about the sublethal effects of contaminants and how that might effect turbine mortality.

Kevin Mcgrath stated that we have a reasonable idea of what survival is, after passage through larger turbines, but the knowledge about mortality through smaller turbines is lacking. Marie asked about adding redesigned turbines. Heather thought she had captured that earlier.

Ken Olivera asked what proportion of the population, both males and females, are going through turbines? Ken noted that McCleave's work showed that the size of the females had a greater impact on fecundity, than turbine mortality. The uncertainty is in not knowing the size of the females and the proportion affected.

Bill Richkus noted the uncertainty regarding any delayed mortality from turbine passage. He thought that Heather had already captured that issue. He noted that another uncertainty was the representativeness of the literature with regard to behavior of eels at dams.

John Casselman noted that often what we are doing is measuring relative differences in terms of turbines. A key uncertainty is knowing the actual stock size of eels and converting that to stock size and assessing the impacts.

Marci noted that we have another hour, and would like to take it to talk about the GIS maps and the utility of those. She asked if we wanted to take a five-minute stretch break. Marie asked about the other general barrier questions. Marci asked that we discuss that after the break as well.

3:32 PM: Five-minute break.

3:42 PM: Marci reconvened the group. She asked if mapping the terminal dams was a reasonable approach to mapping the minimal amount of habitat available to eels? Someone said no. Bill Richkus noted we had discussed that this morning, and for all the reasons that we stated, that approach was not acceptable.

Heather indicated that we had all felt the terminal dam approach yielded a minimum, but it was too conservative. She asked, given that she has two months to conduct this analysis, what would be a better approach? John Casselman indicated that more information was needed. He noted that one thing was to try and determine the original distribution of eels. We need to survey local residents with regard to where eels used to be. This would get us closer to what the historic distribution was.

Mike Miller noted that we have already pointed out that it might be useful to show where all the large dams are. He noted that it would also be useful to show any major drainages that don't have any major dams, in a different color. Also, he suggested that we show how much habitat has been lost, above the dams, because his perception was that the eels went all the way upstream, unless there was a major natural blockage.

Heather noted that can be done, but she asked, how would we say what has been lost? Is it presence/absence, or what?

Mike Miller stated that using two colors would work. One could indicate clear loss of habitat, and possible loss of habitat and the other color could be used for rivers with no dams, where no habitat access has been lost. This could be done by decades, to assess and depict the cumulative losses. Major dams and waterfalls should be marked as well. Julie tried to capture what Mike recommended. Mike reiterated that doing the mapping by decadal increments would yield a visual depiction of how the habitat access has been lost, through time.

Steve Gephard noted the weakness of the approach was that it presumed that the terminal dams were blocking upstream access, and they aren't. He noted there are lots of eels upstream of some of these dams. He felt that we were on another subject, which is how many habitats have dams in them. He suspected that every inland fisheries agency has data, and maps of species distribution data. He suspected that eels were collected well upstream, and therefore you can conclude that everything in between had eels. Part of the problem was that at ASMFC, the wrong people were sitting at the table. He asked if we felt that we had the data back from the inland agencies. Heather indicated that she had gotten a very good response, but wasn't sure about the level of detail.

Steve indicated that he suspected the data she got back wasn't reflected in these data depicted on the maps on the wall. He suggested that these data be thrown away, and we go with the distribution data. Bill noted that MD was shown as all green on the Natureserve distribution map, yet there are no eels in many parts of MD. Heather noted that the Natureserve map was based on distribution records by county, so the presence of just one eel record could turn an entire county green.

Dave Perkins indicated that it might be better to focus on the distribution data and pare them back.

Marty noted the main purpose here, with the dam GIS, is to look at the threats. He noted it might not be practical to do.

Paul Angermeier noted we had to be cautious about what states do know. In the case of Virginia, he wasn't sure what data the had included. The state fish books that Steve had alluded to were really valuable. Paul noted that the books overlap a lot, and you can draw some lines on maps. He noted that Jenkins and Burkhead (Freshwater Fishes of Virginia) went all the way back to David Star Jordan. He thought that stratifying records and data based on time would be useful. He noted that a lot of the black dots on the map may have come from earlier times, pre-dam. If you look at when the dams were placed, then you can make some sense of how much of the once-available habitat is no longer available. Then you could generate maps as Mike Miller suggested.

Jake noted something simple that could be done. If you can look at how much habitat area is available between dams one and two, and two and three, and make some general assumptions about the reduction in population as we move upstream. That gives a general sense of how much

we loose as we move upstream. Heather noted that would yield some idea of the cumulative impact. Jake noted that could be done with the database in hand and give us some idea of cumulative impact. Mark Cantrell noted that would be useful. Jake noted there are a lot of dams missing on the map, from Long Island, and suggested that the dam database needed to be filled out.

Jim Uphoff noted the estimates have already been made, and are in the ASMFC Fishery Management Plan. D. Busch et al. made those estimates. Heather noted that one of the authors, Sandra Lary, is working with her to refine the estimates. She noted that we have new technology, and a better U.S. Army Corps of Engineers database. Heather noted that she had used the Busch et al. estimates in the 90-day finding. Ken Olivera asked if it was possible to have a breakout of lake versus riverine habitat, to get at the question of female versus male habitat? Steve wasn't sure that could be done. Ken noted that in Maine, the lakes are where the females are originating, and this would give you some idea of the impact.

Barriers to Successful Downstream Migration Projected bullets
What are the uncertainties and knowledge gaps?

- Does delayed migration and missing the eel's migratory cohort have a negative effect?
- Other impacts from turbines than mortality should be measured for effects.
- Disproportionate effects from large facilities, and what effect does this have on the continental eel population-uncertainty of effect of ALL dams on the entire population. If large, mature females are being disproportionately affected, how does this affect the population?
- Sub-lethal effects of contaminants and influence turbine mortality.
- Lack of information about smaller turbines.
- What proportion of population making it through turbines? Female size range and fecundity results impacted.
- Significant delayed mortality?
- Uncertainty of representativeness of behavior at dams?
- Knowing the absolute size of the population you're working with in a specific geographic location.

Question: How best could you characterize the maximum freshwater habitat?

Heather asked if there was any cutoff point they should apply in any analysis? Is all of the

Mississippi drainage equally important for American eels, or is the part further upstream worth more, because it produces more large females? Jim Uphoff stated that he thought that everyone had said no already, regarding whether freshwater was important.

Steve noted that when everyone was asked whether freshwater was important, everyone said it was.

Wilson thought that the "nos" were relative to whether the species would go extinct, or not.

Mike Miller indicated that no map would be perfect, but the maps would at least indicate the degree of potential threat in each drainage. Even if a system fills up with eels, they may not make it back to the ocean.

Heather noted that she got lost this morning, during the habitat discussion. She had decided that using the mapping to get at the threat of barriers would be more useful.

Marci read the question that elicited no, and it had to do with the evidence existing documenting freshwater habitat value, and not the value of the habitat per se.

Jim Uphoff noted that we know there are barriers out there, and the trend has been to mitigate them, or remove them, at the same time as the decline in eels has occurred. Jim noted he wasn't arguing against doing this, but questioned the utility of the exercise. He stated that it appeared that the lost habitat was substantial, but questioned whether it was especially related to the decline.

Brian Jessop stated he supported trying to estimate how much habitat has been lost from the natural range. He felt the public would see this as an important issue. He felt that we should go beyond the Lary and Busch approach and refine the estimate. He suggested that we could mark hydro dams with turbines as a major issue, and the analysis is doable and will help us to understand the issue.

Bill Richkus noted that he had neglected to make available a paper that should be very useful, done by a student of Ray Morgan's at the University of MD. The paper looks at presence/absence, and the number of samples with no eels, and the number of barriers, within each watershed. It might be applied more broadly. They did have onsite information, and defined dams as permeable, semi-permeable and impermeable. He indicated he would send the paper out, and it might serve as a basis for an approach.

Steve Gephard noted that the state fish books, and other databases, could provide data on the distribution of eels historically. If you do a watershed-by-watershed analysis, the GIS guy could click on the upstream extent for those watersheds for which we have data. For the ones we don't have data for, use the terminal dam. That would at least give us something. Once the two databases are overlapped, you could also perform the fragmentation analysis that Jake proposed. You don't know how permeable the dams might be, but you could at least say how many dams

are present. That could yield some interesting analyses. That is one approach, imperfect but something that you can do.

4:12 PM: Marci noted there are a lot more specific questions that Heather had, but we would have to discuss tonight how to proceed with them.

Mark Cantrell asked, what about defining the upper limit of American eel habitat? He wanted to know at what elevation in the landscape they would naturally stop moving, or cease to inhabit waters beyond that point.
Marci moved to the general questions.

Question Have dams created new habitat?

Brian Knights said in some ways, yes. The dams turned dry habitats into lakes. Even water control structures fragment streams, and make them a series of lakes, instead of river systems.

John Casselman indicated that was his point. Another point is that eutrophic reservoirs may increase productivity in downstream river systems as well.

Rob noted he wasn't aware of any area in Ontario where there were major utilities, where we didn't have an eel problem, so he wasn't sure that any benefits outweighed impacts. He gave specific examples. If they are creating habitats, are they fully useable?

Ken Olivera agreed that you were creating lakes, but with turbines at the lower end, so what is the net effect?

Bill Richkus noted that if you increased production by 40 percent, but turbine mortality is 40 percent, then it's a wash.

Alastair indicated he didn't see any habitat creation by dams in his area.

Kevin Mcgrath agreed with what Brian Knights has said, but agreed if it was above a hydro dam, then mortality was added.

Paul Angermeier noted that his experience in Virginia suggested that man-made dams didn't create any habitat. Beaver dams, on the other hand, might constitute an enhancement. Heather noted that beaver-trapping might be related to the decline of eels.

Gail indicated that the ME Department of Environmental Protection has looked at productivity behind dams, and concluded that it wasn't functioning in them like natural lakes, or rivers. She noted that it is different habitat, but not particularly productive.

Barriers to Successful Downstream Migration Projected bullets
Have dams created new habitat?

- Creation of lakes from installation of water control structures
- Eutrophic reservoirs increase productivity of downstream river
- Is "new eel habitat" fully accessible and productive for the species?
- Beaver dams could increase habitat b/c of extensive back-up areas, and permeability of dams important. Man-made dams not helpful.
- Dams hold up productivity upstream; may not be deep enough for benthic community, retention time may not be long enough for planktonic.

Question: Do you have any data on fish passage efficiency up- or downstream?

Kevin Mcgrath indicated that he had a lot of data on that. Dave Perkins asked if he had numbers. Kevin noted that John Casselman had done some of the work, using marked eels that were released. About 17 percent made it back to the ladder, and by the end of four years, it was up to 30 percent. Another way to look at it is what the passage is, once they have entered the ladder. The passage ranges from 80 to much lower percentages, due in part to temperature. Bill Richkus noted that Kevin hadn't mentioned the racoon factor. He noted that Kevin has video which shows the eels moving away from a preying racoon.

Jake noted that he was wary of bringing it up, but he has some colleagues in Delaware Bay that are doing a study, and found that less than 10 percent of the eels reaching a dam are being passed.

John Casselman noted that efficiency is hard to measure. He noted that fallback behavior is an issue. Also, if there is an associated lock, that is another factor, because eels can be moving via that route.

Barriers to Successful Downstream Migration Projected bullets
Have you data on fish passage efficiency of upstream and downstream passage?

- Seasonal and annual variations

Question: What are the implications of upstream and downstream barriers to the sustainability of the American eel population whole or in part?

Steve Gephard noted that he was concerned about the long-term impacts of downstream turbine mortality. Up until the 1900's, there were many dams, but they were low-head, and didn't use much water. After WWII, we saw an increase in the construction of really large hydro projects, that take much of the flow of larger rivers, and run them through turbines. So, we might just be beginning to see the impacts on a panmictic population. He noted that if we build a complete barrier to an anadromous run, we see the impact in one generation. For American eels, say on the Housatonic, we kill all the silver eels coming down, we won't see a cessation of recruitment, because of the panmictic nature of the species. He asked if the decline we're seeing now is the result of the post-WWII dam construction, and the decline will continue slowly. He noted that our modelers can simulate when the population will crash, for other species. His concern is whether we are in one of those modes, where the American eel population is in the process of a long-term crash. He noted he wouldn't use the "extinct" word. He asked if the hydropower operations already present could represent a threat to long-term sustainability?

Jake noted the Haro et al. paper in Fisheries on eel declines. About half the datasets they examined showed no change, the other half showed a decline, so the net effect was downward. He noted that if we did that study again in ten years, we might see more datasets exhibiting a decline.

Rob indicated that Steve had said what he had been trying to say, for four months now. When you add the cumulative effects of fishing on top of that, it is a real issue. He wished that someone would model it.

Brian Knights indicated that he observed an increase, post-dam, before the current decrease. Brian suggested that there may be major differences, if you go back to Medieval times, but he didn't believe there is any match, in recent years. There was an increase in the early 1980's, when you would have expected a decrease, under Steve's hypothesis. Steve asked if he meant European, or American eels? Brian indicated that he was referring to American, European and Japanese and would present the information tomorrow.

Paul Angermeier noted that we seemed to be going to a discussion of population dynamics now, and questioned the utility of us doing so. Heather noted the question was on the list. Steve noted that his scenario was relative to the impact of the dams as a threat. Paul stated that he didn't feel we could have a productive conversation regarding the population dynamics at this stage of the day.

John Casselman indicated he agreed with Paul, but needed to make some points. John noted the dramatic changes at the extremes of the range were not something we have previously observed. He noted American eels were previously abundant in the Mississippi. He noted that in the Great Lakes, they have observed that it takes three generation times to observe a change. For eel, it might be as long as 42 years (three times the 14-year generation time) before we see any changes due to the present declines.

Bill Richkus noted that he was considering the question relative to sustainability at the present time, and not in relation to the past. Heather suggested it was more complicated than that, and was regarding sustainability in general. Bill indicated that to him, the barriers were just another source of mortality, not any particular kind of special source. He noted that the enhancements made recently (upstream passage and so forth) need to be taken into account, and shouldn't be ignored. Heather concurred and noted that is why we are trying to gather the upstream passage numbers.

Rob suggested that we need to assess the cumulative impact of all sources of mortality.

Barriers to Successful Downstream Migration Projected bullets
What are the implications of both upstream and downstream barriers to the sustainability of the American eel population whole or in part?

- Concerns about long-term impacts of turbine damage and mortality.
- Larger (and more) dams have been constructed post-WW II, we may just now be seeing the damage from this construction in population declines; i.e., long-term decrease in sustainability of the American eel is just becoming apparent??
- Cumulative effect of fishing mortality? Need someone to model!!!
- B. Knights-increased recruitment for European, Japanese and American eels in 1970's and 80's.
- Loss of recruitment in Great Lakes and possibly Gulf States. Need three generation times for decline and/or re-building ~ 42 years.
- What is the cumulative impact of ALL sources of mortality?? (Barriers/dams are another source of harvest.)

Final Question: Marci asked if there was anything else that was important that we hadn't touched upon, especially if participants had expertise from another viewpoint?

Kevin Mcgrath indicated that we might be able to go to FERC and determine when projects came on line. He noted one facility on the St. Lawrence came on line in 1923. He agreed that needed to be researched more, before we head down that path. Heather indicated she had that database and it crashed her computer when it arrived. Mark Cantrell indicated that information, along with height of dam and other factors, were in the database used to generate the GIS maps.

Paul Angermeier indicated that he had a poem to share. He read it to the group and received a round of applause.

More eels

Eels in the ocean
Eels in the stream
Eels in the turbines,
I could just scream!

More eels for sushi
More eels for bass
This eel decline
Is quite a morass!

We all want more eels
Don't know who's the worst
But more eels for elvers
Have got to come first!

-Paul Angermeier

Rob noted that he had heard reference to the eel decline, several times, and asked if there was a decline? He stated he thought there is some debate about that issue. Heather noted that it has been on people's minds, and asked how important it was to have information on that at the next workshop? She noted that we didn't have time to address it at this one. She asked if it was easy to have a threat conversation, in the absence of information on any decline? Rob asked about the time frame for the ASMFC stock assessment. Heather indicated that she has to have her work done on November 18, 2006. She asked if it would be essential to have the stock assessment before she could complete the Status Review?

Jake didn't think that we had to have the stock assessment, before we did a threat analysis. He noted that the human population was clearly not in decline, but was clearly threatened by nuclear warfare. So, he noted that the threats analysis could be completed. He did note that the stock assessment would influence his opinion regarding whether the species should be threatened or endangered.

Julie indicated she supported Jake's statement.

Jim Uphoff noted that we had been told all day to dwell on barriers, and now were being asked about other factors that we didn't discuss. He wasn't sure why now we had to assess all threats to eels.

Bill Richkus noted that he didn't see how barriers present for a hundred years could be considered a threat at this point.

Brian Jessop indicated that he felt the problem was not so much whether the population was in decline, but rather the degree of the decline and whether it was a threat to sustainability. If we find that the decline doesn't threaten sustainability it isn't a problem, unless people want to have a larger population.

4:46 PM: Marci suggested that we stop. She asked us to be here and seated at eight o'clock.

Marie announced that she would like to take a group photograph of us all tomorrow, for the administrative record. If anyone wants copies, let her know. Marie indicated that she had a cab for the three folks that need a ride to Dulles, at half the price of the shuttle. Marci thanked the note takers for their work. It was noted the bar is open at 5:30, and dinner at 6:30 PM. Dinner will be open tonight.

4:49 PM: The meeting adjourned.

American Eel Status Review Workshop 1: Day 2
December 1, 2005

Present: Heather Bell, Mark Cantrell, Marci Caplis, John Casselman, Kim Damon-Randall, Sheila Eyler, Kevin Friedland, Jeff Govoni, Brian Jessop, Brian Knights, Jake Kritzer, Wilson Laney, Rob Macgregor, Marie Maltese, Kevin Mcgrath, Marty Miller, Mike Miller, Lydia Munger, Ken Olivera, Dave Perkins, Bill Richkus, Michael Twohey, Jeff Underwood, Julie Weeder, Gail Wippelhauser, and Adam Zerrenner.

Session: Changes in Oceanic Conditions

Panel Members
Kevin Friedland
Jacob Kritzer
Jeff Govoni
Brian Knights
John Casselman
Mike Miller

8:06 AM: Heather noted that she had prepared some handouts for us. One was a set of questions on how to categorize what we know about changes in oceanic conditions associated with the North Atlantic Oscillation (NAO) that we can respond to if we wish. The other is a one page summary of what we do and don't know as pulled by Heather from the leptocephalus biology summary prepared by Mike Miller. Heather indicated that she wasn't sure she had exactly captured all the information, and that it was important to have an understanding on the impact of "what we don't know" to our understanding of mechanisms/hypotheses, and noted we could discuss the handouts later.

ATTACHMENT 5 and 6 – HANDOUTS
NAO
WHAT WE DO KNOW

Marci noted that we would have two presentations this morning, by Brian Knights and Kevin Friedland, after which we would have half an hour of discussion, followed by the questions The overarching question which the agencies will need to answer is – ***Is the long term persistence of the American eel population threatened by the current oceanic conditions?.***

8:08 AM: Brian Knights began with his power point presentation. He noted that Kevin and Mike would chip in as needed. Brian indicated that he might say some controversial things. He reviewed his outline. He noted that the European and American eels show some common features. He indicated he would review oceanic factors and adaptive strategies, and later would discuss near-continent recruitment factors and strategies, catchment recruitment, and other

factors. Key common features and adaptive strategies of anguillids, relations between recruitment and oceanic indices, possible cause-effect relationships and potential threats would all be discussed.

ATTACHMENT 7– B. KNIGHTS PRESENTATION

Brian noted the elpomorphs are ancient in evolutionary terms, having been around for over 30 million years. They are generally viewed as panmictic. They are periodic life strategists (Winemiller), and delay maturation to large size (females greater than 45 cm) with high fecundity, which is to compensate for very high larval mortality. We have to remember that there is a major, major component of the life history in the oceanic environment.

Oceanic adaptive strategies: they breed over deep oligotrophic subtropical oceans, and there may be some advantage in terms of the lack of predators and competition. They undergo long migrations, and engage in resource partitioning. The leptocephalus stage has adaptations; nutrition equals marine snow and DOM, i.e. low trophic level, only indirectly dependent on phytoplankton; they have rapid and low energy cost growth of the GAGs core, and form an energy reserve. They can grow very rapidly at very low energy cost, and have a very low metabolic rate, for their size.

Northern hemispheric species show similar recruitment declines from a peak late 70-early 80's (in numbers and condition factor) plus many other synchronous ecological changes. Brian felt this led to many changes in marine and freshwater habitats. He felt there would be a common root somewhere, if we looked for it.

Brian showed us a graph of glass eel recruitment indices for American eel, European eel, Japanese eel, and Great Britain commercial CPUE (Catch – Per Unit Effort). All the curves generally tracked, and peaked around the early 70's and trended down since. There seems to be some commonality between American and European, and also Japanese.

ATTACHMENT 8 - GRAPH

Oceanic climate factors have major impacts on eels. This is indicated by relationships between recent/historical recruitment and the North Atlantic Oscillation (NAO) for American and European eels. The best evidence is the long-term Den Oever Index (DOI) time series versus the NAO, e.g. using the very “noisy” raw data and noting lags. The Den Oever glass eel catch per year, plotted against the NAOI shows corresponding patterns, in Brian’s opinion, from 1935 to the present. The actual r-squared value is awful. But, when the data are cleaned up, the basic patterns appear clear and attention should be paid to them. Index averaging yielded an r-square value of 0.50. The DOI shows low values when the NAO is high, and vice versa. Brian noted the same declines we are seeing now, also occurred in the 1940's. Brian showed the NAO index for the period 1864 through 2003, to show the long-term pattern. He indicated that proxy records from tree rings and other sources show that the NAO has been a feature over a long period of time. He noted that he would like go back through all the old newspapers and gather the

anecdotal informal about the elver fisheries, relative to whether the catches were great or poor, because this would give us further indications of any correlation between the two parameters.

What is the NAO about, what is the correlation? Brian noted that some modeling has been done, for leptocephalus drift, by Kettle and Haines (in press). Their modeling for European eels predicts the distribution of larvae up to 720 days from their origin. Brian noted they would like to do the same sort of modeling for American eel. The dispersal pattern predicts that eels could wind up on the west coast of Africa, and Brian noted there have been discounted reports of eels collected in Gambia. Brian noted that larval mortality is likely as high as 99.3 percent under some circumstances.

Other cause-effect relationships? They could include starvation, advection, and mismatches, in the breeding areas and/or during migration. Advection could carry them in the wrong direction. Mismatch would mean that migration and food sources were not matched.

8:31 AM: Bill Richkus noted the pointer that was being used didn't show up from the side. Kevin Friedland noted that Heather requested he briefly explain the North American Oscillation, for the benefit of the FWS managers in the room. Kevin explained that the oscillation was changes in atmospheric pressure, as measured between sites in Greenland and the Azores, and causes consistent changes in ocean signals as well. Jeff Govoni noted that this actually changes the course of the Gulf Stream. In some years it is higher, and other years lower, latitudinally, in deflection, and these changes are correlated with the NAO. Jeff noted the importance is in the physical oceanographic signal, as opposed to the atmospheric signal. Brian Knights agreed that was his general understanding. Brian noted there were some disagreements about relationships between air and water temperature, and other factors.

Kevin Friedland presented preliminary data on climate variation in the Sargasso Sea that may be impacting eel spp. from North America and Europe. He presented a δελτα−T analysis of the hydrostation data from Bermuda that showed that mixed layer depth has decreased in recent decades. Though the Bermuda station is not located in the spawning area for eel, it is in the area leptocehpali larvae would use during their first months of life. The mixed layer depth is the depth to which mixing is complete, relative to the layer of ocean water beneath it. He noted that the mixed layer depth also can be related to production, and is affected by a number of factors including local winds. The depth of mixing affects production via the re-supply of nutrient rich water to the surface and by controlling the exposure of phytoplankton to light at the surface. The mixed layer depth varies seasonally, being deepest during the spawning period.

Kevin used dynamic factor analysis to derive a common trend in the mixed layer depth and in recruitment for European eel. The recruitment trend time series correlated with the mixed layer depth trend. The time series were lagged by one and two years to account for the migration of larvae from the spawning grounds to European rivers. It was pointed out by Dr. Knights that all but one of the recruitment series is fishery dependant and thus likely to have some bias related to market. Dr. Friedland also did an analysis for the 50-year time series, which also suggested a good fit. He noted these analyses are preliminary.

Kevin showed a map of recruitment trends, and lagged sea surface temperatures, and it shows a strongly negative pattern. He combined the data to determine any additive benefit. Using general addition model analyses he reported a reasonable fit.

Kevin asked how the NAO relates to the mixed layer depth. He noted that it would be good to try to do the same analysis for American eel data as well.

8:44 AM: Marci asked if we wanted to move on, or ask questions now.

Kevin noted that mixed layer depth could relate to feeding opportunities for the larvae, or to transport of larvae to more favorable currents. He thought that wind and transport data should be explored further. Dr. Govoni noted that the NAO effect lies more in the advective aspects. The depth of the mixed layer he contended is probably more important in the eastern North Atlantic, than in the western. He noted the depth of the thermocline relates more to the mixed layer depth. He found Dr. Friedland's correlation interesting. Dr. Friedland indicated that Dr. Kettle's data challenges us all with regard to whether the larvae make it over with the transport currents or are delayed.

Jeff noted that he and Kevin had been arguing since their days together in graduate school. Jeff noted that he contended the NAO effect lies more in the advective aspects. The depth of the mixed layer he contended is probably more important in the eastern North Atlantic, than in the western. He noted the depth of the thermocline relates more to the mixed layer depth. He found Kevin's correlation interesting. Kevin indicated that Kettle's data challenges us all with regard to whether the larvae make it over with the transport currents or are delayed.

Jeff noted that some European larvae just don't make it to Europe, per Brian Knights' work. Brian noted that in the modeling, some of the larvae just recirculate and don't ever recruit. Jeff noted that eddies spinning off the Gulf Stream on the east coast of the US may inject larvae into east coast estuaries. He suggested that hypothesis is consistent with what we observe about the ages of leptocephalus. Differences in age and growth rates correlate.

Mike Miller asked if the same changes are true in the southern area, in the American eel spawning zone in the southern Sargasso, as observed in the area near Bermuda that Kevin has investigated. Jeff indicated there is another area, well north of Bermuda, that starts the projection toward the British Isles. Some of that water does spin off southward back into the Sargasso. The spawning area for both species is really on the southern edge of the Sargasso Sea, in the tropical convergence zone. The Gulf Stream itself is a frontal zone. Mike Miller noted that he had a map on the computer, to which we could come back.

ATTACHMENT 9- GULF STREAM MAP- M. MILLER

Jeff noted that fronts are variable, they oscillate and vary. There is movement along the front, set up by the pressure gradients. Jeff noted that eel leptocephali are truly bizarre, unique among animals.

Brian noted that it is a long way from the Sargasso to the Baltic Sea. Any transport and subsequent recruitment problems might be accentuated at the extremes of the range.

Jeff noted that in the color photo Mike Miller had put on the screen, you could clearly see large eddies that transport larvae back to the Sargasso Sea. Mike noted they do get a second chance.

Heather asked someone to explain the photo. Jeff explained there were two main deflections of the Gulf Stream. The first deflection occurs at the Charleston Bump, and sets up major instabilities in the stream. Many cyclonic eddies spin off north of the Charleston Bump and discharge water, including eel larvae, on the Continental Shelf. The second major divergence occurs at Cape Hatteras, and it causes spinoff eddies, some of which go back to the Sargasso.

Brian Jessop asked, is there a north-south, or south-north cline in the rate of spinoff of the warm core eddies, particularly on the Continental Shelf side? Also, could you characterize the area north of Hatteras, near the Chesapeake, as an eddy desert? Jeff advised you couldn't say that was the case. Brian Jessop asked if there was less probability of an eddy heading north in the zone near the Chesapeake, versus further north in the Gulf of Maine and New England? Jeff noted that he didn't know of a second zone north of Hatteras, although eddy frequency was less to the north. The current velocity in the Gulf core at Hatteras can be as high as two meters per second, but the velocity slows as the stream progresses toward the British Isles.

Brian Jessop noted that we don't have information on the relative numbers of glass eels arriving in the south, versus the north. I..e., we don't know whether Florida receives fewer or less glass eels than Maine. He asked if there is any oceanographic evidence of any clinal gradient? He stated he felt we would find evidence of changes in gradient along the coastline.

Jeff noted the only recent paper of which he was aware was the paper by Chris Powell and Stan Warlan, in which they looked at eels in NC and NJ. There are some comparisons of abundance in that paper. Jeff noted he was unaware of any CPUE data.

Brian Jessop noted they don't know anything about real densities of larvae, although they do know about length and age differences.

Brian Knights noted that some of the modeling work shows good correlations with glass eel fisheries in Britain. He noted that it is unknown how they get across the Gulf Stream.

Mike Miller noted that the most likely crossing region is to the north. In the south, they could be crossing there, or there could be recirculation occurring. Jeff Govoni noted that south of Cape Hatteras there are two bodies of water. North of the Cape, there are three bodies of water, and larvae there have to cross two fronts, from the Gulf Stream into the Slope waters, and then from the Slope into the Shelf waters.

Mike Miller noted that it wouldn't be an evolutionarily sound strategy to depend on eddy rings

spinning off as an inshore transport mechanism. He felt that swimming was a better mechanism.

Jeff explained the colors on the photograph, and keyed them to the different bodies of water.

John Casselman asked if the eddy north of Cape Hatteras shifted in time, and if there were any measures of that feature? Jeff Govoni noted that one of the papers provided looked at annual and decadal scales of the shifts. John asked if it changed. Jeff indicated it did so.

Kevin Friedland asked Marie to pull up his Atlantic salmon presentation, and he showed a slide for us (number 48), that depicted the middle wall of the Gulf Stream. He noted the feature correlates with salmon recruitment.

ATTACHMENT 10 - SALMON SLIDE PRESENTATION #48 – K. FRIEDLAND

Gail asked if there had been any change in the number of cold- and warm-core rings that spin off the Gulf Stream each year. Jeff indicated that he had been trying to look at the eddies that spin off north of the Charleston Bump, but hadn't had time to analyze the data yet. He asked Kevin about those north of the bump. Kevin noted they had been counted and numbered, but thus far nothing had emerged from that research. Brian Knights noted that it is all dynamic.

Mike Miller noted he had provided a paper that suggested that water going faster north in the Gulf Stream was not necessarily good for American eels.

John Casselman noted the modeling experiment suggested that it took over 700 days for larvae to get there, and asked how it correlated with the DOI. Brian Knights noted that the modeler doesn't seed the larvae at the same time, which doesn't fit with observations. Brian noted there may be a mismatch between breeding, and the joy ride through the areas where feeding occurs.

Mike Miller noted that if you accept the hypothesis that American eels swim west to recruit to North America, then European eels may swim to the east, to avoid negative transport. What we may see is a slightly faster eastern arrival for European data. He indicated there are no data to support that. He indicated that if we could look at the ages of the glass eels, we might understand better, but glass eel aging is difficult because they may not deposit rings part of the time.

Heather asked that the Gulf Stream photo be put back up. Jake did so. Heather noted that American eels recruit to the northern part of South America, as well as to the Mississippi, and asked for an explanation of how that could happen. Mike Miller explained, using another map, that larvae are transported into the Gulf of Mexico and Caribbean Sea. Eels could spawn in several locations and still make it to these areas. For Japanese eels, it is different, and it could be so for European eels as well. Brian Knights noted it would be nice to see what happens to American eels that are recruiting to the Gulf. He noted there were more eels there in the past. Heather noted that the general feeling seems to be that there were more eels in the Mississippi Basin in the past as well. She noted that she wants to spend some more time researching

information on the eels that go south, and try to explore the threats that are present there. She wanted to get an idea about any work occurring there as well. Mike Miller noted that there hasn't been much targeted sampling for leptocephali in the Gulf, so we really don't know what proportion go there.

ATTACHMENT 11 - GULF OF MEXICO MAP – M. MILLER

Rob asked when the larvae begin to swim. Mike Miller indicated they probably begin swimming from the day they are born, and can swim forward and backward. He noted there are no data on predation on larvae, and they may be very adept at avoiding predation, given the large eye and forward and backward swimming. He noted they may not need directional swimming until they need to get out of the Florida Current, but we have no data.

Jeff Govoni noted their swimming is serpentine, unlike other fishes. Brian Knights noted the musculature is not adapted for swimming in a direct line to Europe, but they can move very vigorously and you have to keep a lid on any container in which you have them. They can't be treated as totally passive, drifting particles.

Jeff agreed they are capable of appreciable movement. The problem with directional movement, to get from one place to another, is that the larva is embedded in a moving parcel of water. In this case it is the Gulf Stream. Larvae can sense light, and pressure, and temperature over small scales. If you want to accomplish horizontal movement, you have to be able to sense some gradient, in order to tell where you're going. Horizontal gradients are broad-scale, and a moving larva will have difficulty sensing gradients and know which way it is going. He indicated to Mike that he had a problem with intentional, directional movement. Jeff supported the spinning off hypothesis to get them closer to shore. Then they could be directional afterwards.

Mike Miller noted that he agreed that they are totally "blind" in the ocean. In the case of eels, magnetic field detection has been shown. This may be a critical way they get back to the spawning area as adults. One hypothesis is that the adults imprint on a magnetic field and home back as adults. The larvae may use magnetic fields, and this may be a very intense selection factor. This may have acted over time to establish directional swimming. Jeff noted that sea turtles use a similar mechanism.

Mike Miller noted that he had read a paper just before the meeting, that argued for cross-stream directional swimming, and hadn't digested it yet. He felt that the swimming strategy made more sense, over time. Jeff stated the magnetic hypothesis was still in its infancy, and he found it less supportable.

9:26 AM: Rob noted it was quite a strong current they are in. Can they break out of it? Jeff noted it was 1.5 m/sec, so they can break out laterally, but not horizontally. Rob asked if we needed to know anything about the Labrador Current. Jeff stated it varies, and relates to the NAO. Rob asked if the larvae were large enough by the time they reached the north, to swim against the Labrador Current.

Brian Knights noted it would be nice to know at what point we stopped seeing any glass eels.

Jake asked why we didn't believe the sun was a sufficient cue for navigation. He noted that larval fish can find Bermuda, a dot in the ocean, so he didn't see why knowing where the sun was wouldn't allow you to find a continent to the west. Mike Miller noted that there is no animal in the world that uses only one navigational technique, so a sun compass is certainly possible. He noted that for leptocephali, something has to be programmed evolutionarily. He found it difficult to believe that a sun compass mechanism would be useful at night.

Kevin Friedland noted that researchers have shown that juvenile salmon likely have a sun compass mechanism, so he felt that should be kept on the table as a plausible hypothesis.

Mike Miller noted he saw temperature fronts, salinity fronts, as useful as well. He stated that evolution to use many factors was likely, otherwise you fail.

Bill Richkus asked if it was possible that there would be any kind of long-term change in the magnetic field that might affect eel abundance, in addition to other factors. Mike Miller wasn't aware of any shifts recently, but he noted that as long as there is no change in 5-20 years, an imprinted eel would be okay. American eels just have to get close, unlike European eels. Brian Jessop indicated he didn't believe that there has been much of a shift, other than at the North Pole. Bill noted that he was thinking more of field strength, than any large shift in position.

Brian Jessop noted that coming out of the Gulf of St. Lawrence, the discharge from the St. Lawrence forms the Scotian Current, and some work he did shows a marked geographic cline in elver abundance as you move south. Presumably there might be a similar cline as you move along the coast of Maine. There is a definite increase in abundance from north to south, in Nova Scotia. Abundance decreases into the Bay of Fundy, then increases again on the west side of the Bay of Fundy, moving south. He attributed this to the Scotian Current.

Kevin McGrath asked if there was agreement that changes in NOA are correlated with eel abundance. Mike Miller stated an alternate hypothesis could be that the NAO has changed many things in the north, including community structure changes, such as copepods and fish communities. Unfortunately we don't know enough about eel early life history, and associated changes in the community, to say with certainty. Obviously the eel numbers have declined, but it could be just a chance correlation. A skeptic would argue that there would have to be a major change in the leptocephali food sources, and that hasn't been demonstrated. It is possible that it has changed. The hypothesis is sound, and it is possible that it has happened. It is likely this is more of an issue for European eels, than for American eels. Current patterns may have changed off Canada. He noted the fish community in the Gulf of Maine has changed a lot. We can't conclude that it has, but it is possible that it has.

Jeff Govoni noted that there is a strong correlation, or association, but that doesn't equate to cause and effect. Jeff noted that he disagrees with the DOM hypothesis as a food source for

leptocephai. He noted there isn't a lot of DOC in the Gulf Stream. He felt they do eat larvacean houses, but also copepod fecal pellets and other things that don't leave undigested residue in the guts. Not a lot is known, so making any conclusions about food is not possible at this time.

Ken Olivera noted the correlations make him nervous. He asked Brian Knights if he would add a longer time lag, and tried a correlation with silver eels, he wondered what he would see. He asked how the NAO would effect silver eels finding the Sargasso again. Brian noted there isn't enough data on the silver eels. He noted that you would have to presume there was always a five-year lag. Brian noted it all comes down to the time lag.

Marci asked the other folks on the panel to respond to Mike's hypothesis. Heather clarified she needed to know how the change in the NAO explains what has happened in the St. Lawrence, or on the Atlantic Coast, or in the Gulf of Mexico. Is this speculative, or should we put some weight on it? Also, what would it predict for the future?

Jake asked if you wouldn't need data on silver eel migrations, to determine whether the NAO has affected their migration. Ken Olivera explained what he meant, that you could use the different lag as a substitute for the silver eel data.

9:45 AM: Mike indicated that he would answer the question. He made several points. The first is that something could have changed regarding silver eels not finding the frontal zone, but there is no evidence for that. Changes in nutrients, or other factors, could have changed the feeding environment, with wrong-sized particles and consequent reduced survival and recruitment. Another possibility is to have slower growth and wrong size at the time of metamorphosis, with larvae not crossing the Gulf Stream because they couldn't swim across. Another possibility is that the volume of the stream increased and reduced the ability or number of larvae swimming across. He didn't believe that we could distinguish between the possibilities. Changes in oceanographic conditions could have affected the ability of larvae to recruit to the northern areas. In the past, eels may have kept moving upstream looking for less density. Now, with lower recruitment, movement up may have stopped. Mike noted that we have no research to show the NAO is, or isn't, responsible.

Brian Knights noted that we are focusing on American eel here, but given the decline in the European as well, there must be a common factor affecting both species, but he has no proof.

Kevin Friedland noted he didn't want to take mixed layer depth off the table. He noted although it is measured near Bermuda, it is consistent over a wide area, and we have a responsibility to think about it. Mixed layer depth could be analogous to the size of leptocephali habitat. It might give us a physical measure of their habitat, so the change in the layer might be correlated with larval abundance, survival or transport.

Brian Knights noted that mixed layer depth could tie in to the NAO.

John Casselman stated whenever you correct the recruitment index for the upper St. Lawrence

for age, and correlate with the DOI, it is uncanny. It suggests to him that something is going on. If you look at the indices, you see a major shift in the recruitment trends in the late 1970's, which corresponded to a regime shift. He wondered if there wasn't some other explicative factor that correlated with the other observed changes. It is immensely complicated. We know there are changes in river discharge. There are changes in the Labrador Current. We need better data on recruitment.

Brian Knights noted it is worth focusing on the DOI and recognizing that the declines have occurred in the past. This is the best correlation we have. Fisheries were still going along in the 1940's, full bore, despite the declines.

John Casselman agreed, but noted that eel densities in North America at that time were much higher than they are now.

Brian Knights noted that the declines have likely occurred back into the 18th and 19th centuries. He noted that the current winter is predicted to be really bad, similar to 1963 when elver recruitment was really high. But, he didn't see the recruitment recovering that quickly. He noted that recruitment was up slightly this year. John indicated it was slightly up on the St. Lawrence as well.

Jake noted that he thought Mike's hypothesis was good. He noted the more he read, the more he was concerned about transport. He noted there is a lot of flexibility and plasticity out in the ocean, so he felt that it was more likely that changes in delivery were the key. Brian Knights noted that if the larvae used up all their food, they did have a problem.

Kevin Friedland noted that he had thought about Jake's point as well, and very carefully walked through all the factors. The nine recruitment series that he showed were highly correlated, and that fact argues for something common in the early life history. He found it to be a stretch that transport was the key. Jake noted the nine series were all European, and he felt that the transport process changes would more greatly affect the northern populations, both in North America and Europe. He didn't find it strange that those would be correlated.

Kevin Friedland noted that the landings series for Europe and the US/Canadian fishermen, despite being affected by markets and so forth, both suggest multi-decadal patterns in recruitment. There are bumps, but the general patterns are pretty similar. The bump in Europe could be a market bump, but regardless, if they all line up, he thought that it would argue for some common early life history factor.

Brian Knights noted that the relationship between landings in the US and Canada were linked, since most of the demand was in Europe.

10:01 AM: Marci asked us to break. Marie asked us to be on the patio at 10:15 for a group photo.

10:33 AM: Marci reconvened the group. She asked if the group wanted to see Kevin's salmon data, noting that we hadn't expected him to bring eel data, but he did so. Kevin indicated that he could truncate the presentation on salmon to 10 or 15 minutes.

Kevin gave his presentation on Fisheries Oceanography of Atlantic Salmon. He briefly reviewed the life history of salmon. Consensus thinking is that the bottleneck is at sea in the early life stage, and that determines recruitment to the adult stage.

ATTACHMENT 12- SALMON PRESENTATION – K. FRIEDLAND

He noted that early on, they looked at temperature in relation to survival, by plotting thermal habitats, which was the area between an upper and lower range. They found some correlations between landings and European salmon, but there was variability. Post-smolt habitat was assessed against some high-quality tagging data from some Scottish rivers. The fish were one-sea-winter returns. Highest survival was from the 1970's, with a multi-decadal decline since then, reminiscent of the eel declines. There were some correlations between areas of suitable temperatures and recruitment.

Kevin discussed data derived from growth increments on salmon scales for the North Esk River system. The amount of growth during the post-smolt year showed a multi-decadal pattern closely correlated with the return patterns. Kevin noted this didn't sound like a lot, but it was quite helpful and useful.

The Norwegians developed a surface trawl for capturing post-smolts, and used it widely over the North Atlantic. They developed a map of post-smolt distribution. Post-smolts actively migrate to the north and west, using an oceanic nursery. Kevin noted that similar patterns were detected for a number of other European rivers, over a long time period. The fact that many stocks show the same pattern suggest that post-smolt survival is a key factor. Sustained post-smolt growth from the spring into the summer appears to control recruitment. Growth mediated predation, coincident with NAO forced gadoid outburst, might reflect improved quality and quantity of 0-group larval prey. Kevin noted that the gadoid outburst might also have been a salmon outburst, given that the same factors were involved.

10:46 AM: Kevin moved to the North American stocks. They did the same exercise and found some correlates. Winter habitat has been of great interest. It has always been a bit disturbing, because the fish have usually reached 40 cm by the time they are post-smolts. Data for North American post-smolts are sparse, but there are some. Post-smolts in the Labrador Sea, from late fall catches, were available. In some years, lots of salmon were caught in the Gulf of St. Lawrence. There is good evidence to suggest that the post-smolt nursery in North America, is unlike the nursery area in Europe. It may appear and disappear. They may use areas off Nova Scotia, and other areas, where conditions are good.

Kevin noted that because of this they decided to look at inshore areas. They did find some correlations that were interesting, occurring at the right time and place. The Gulf of St.

Lawrence appears to be the prime producing area for North American Atlantic salmon. The stock abundance signal for North American salmon correlates strongly with environmental conditions that occur in the Gulf in June/July. The fish go to sea about a month before. The fish are therefore affected during their first month at sea. Kevin analyzed a long time series for North American salmon, from 1910 to the present, which shows patterns similar to those observed in eels, suggesting that they are being affected by some common factors in the ocean. The Gulf Stream north wall index correlates with the salmon much more cleanly than with the NAO.

Finally, Kevin showed some data that no one has yet seen. For wild salmon in eastern Maine, there is a lack of any feature, despite the fact that they have shown the same trends as European fish. There is evidence that post-smolt growth fish has increased. This suggests that European fish are under a completely different recruitment pattern than North American fish. Kevin noted that he had plotted growth for the Connecticut and Merrimack Rivers as well, and they show increasing growth rates.

Steve Gephard asked about the Maine data. Kevin explained that they were just using wild fish. There is no multi-decadal pattern evident. Kevin noted the hatchery fish would be showing a different pattern. For winter growth, a different pattern is evident, so perhaps there is a winter pattern affecting them, or some early life history factor that affects the fish prior to any significant growth occurring.

10:56 AM: Marci asked for questions.

Jeff Govoni commented that earlier this morning he had tried to make a point about coupling between the atmosphere and the ocean. He noted that he also had seen this morning a rise in North American and European glass eels, and now he saw a rise in salmon smolts, after 1976. He noted that there was an increase in El Nino after that time. He noted that is a Pacific event, but it affects the atmosphere, and also the weather in North America. He asked the group whether there was anything to the 1976 date and the increase in frequency of El Nino?

Brian Knights noted that he had talked to one glass eel fisherman who said that 1976 was his worst year ever. Jeff indicated that his (Jeff's?) recollections had failed him.

John Casselman noted that regime shifts that occurred in 1977 could be related to the El Nino. That affected temperature for sure.

[Wilson ceased taking notes at 11:00 AM, to participate in a conference call. David Perkins notes follow.]

Govani-Link has been made between NAO and El Nino.

Casselman-didn't see regular recruitment in 70's.

Rob - Variation in recruitment is seen in all fish species; as managers we change exploitation

rates when recruitment is bad to protect stocks; need to figure out what fishery managers can do to protect eels.

Kevin-more recent shifts in NAO hypothesized to be related to climate change; need to go beyond fishery management to protect stocks;

Jessop-clear that eel recruitment changed in some areas, but not others. His best estimate for Maritimes is that recruitment is more than needed for available habitat; does shift in NAO and position of North Wall affect recruitment into Gulf of St. Lawrence?

Mike Miller - not intuitive why it would decrease recruitment into Gulf;
Govani - could reduce distance eels had to travel to entrance to Gulf
Miller - amount of distance the wall shifts is relatively minor;
Knights - how far is the shift?
Miller - several 100km

Marty-any connection with increased ice melt, decreased salinity in Labrador current affecting change in Gulf Stream?; hypothesis that this triggers ice age?
Miller-definitely possibility for changes in ocean currently causing community changes but we have no data on things like glass eels or elver predation; could affect where landfall of glass eels occurs

Casselman - what depth are glass eels moving at?
Miller - no data

Jake-any info on changes in subtropical convergence zone which affects where glass eels start their journey?
Miller-good thought; could certainly affect glass eels; but never seen any data prior to 1975 on location of convergence zone;

Heather - is the NAO change we're seeing within normal range of variation?
Knights-looking at correlations with tree rings, cycling goes back 1000s years; current change is within normal fluctuations
Miller-if current period ends soon, it's not unusual

11:30 AM: Knights presentation on adaptive strategies using European eel data- West shore of Great Britain closer to eel migration ways, leads to higher yellow eel density and predominance of males; east shore is further away, has fewer eels, but most are large females.

ATTACHMENT 13 - PRESENTATION ON ADAPTIVE STRATEGIES – B. KNIGHTS

There has been a 70% reduction in recruitment of glass eels to Britain from late 70's to now.

[11:48 AM: David Perkins ceased, Wilson Laney resumed note taking.]

Brian Knights was speaking about elver recruitment. Entry into freshwater is facultative and upstream migration is density-dependent, based on ladder weir-trap and fyke-netting studies. Brian presented data on CPUE and lengths, with sampling zones below and above the tidal limit in the Thames watershed. CPUE decreases with distance upstream above the head of tide, and the sex ratio changes to predominantly female. Brian indicated that perhaps Chesapeake Bay and the Susquehanna might be similar, in North America.

Brian turned to the catchment scale. Under high recruitment, the carrying capacity of the estuary is exceed and eels move upstream. Under low recruitment.....

There have been no significant changes over the last 15 years, in the Thames catchment, but very restricted compared to the 11th century (1086).

How significant are freshwater stocks? Brian stated that the main yellow eel fisheries are based in estuarine and coastal water, and.....

Evidence for sex determination being density-dependent, includes the fact that in high-density aquaculture, most animals are male. Plotting length against mean density, on a log-scale, Brian noted that below 1 eel per 100 square meters, females are produced, while above that, males are produced.

Brian summarized adaptive strategies: periodic life strategy, facultative catadromy, density dependent migrations, density-dependent sex determination, and robust and extreme generalists and opportunists. Outcome ensuring survival of the species, include flexible/wide geographical and habitat ranges; core populations sustained in regions of optimum recruitment and in coastal/estuarine habitats; if recruitment declines and density is less than 1.....

Brian expressed acknowledgment to various people. Brian asked that copies of his presentation be provided to everyone.

11:57 AM: Heather noted that John Casselman needed to leave at noon, so she wanted to give him a chance to respond to Brian. She also wanted some feedback from the group on which factors she should focus upon.

John noted that he didn't really know how to respond, because there was so much data. John agreed that density-dependence was an important factor. He noted that the St. Lawrence was at the extreme end of the range. He felt there is an oceanic effect on recruitment that he didn't know how to assess. There is an oceanic aspect of eel habitat, that we don't know anything about. By his calculations, eels have been around about 130 million years, and were likely early invaders of freshwaters, and may be contracting their range. He liked the ocean analysis as an explanation.

Heather noted that she was left with certainty, and uncertainty, and we were faced with making a

decision that had a high level of uncertainty. She noted that things may change next year in terms of recruitment, but that any response in terms of production might take years. She noted there was a lot of speculation today about factors that may be influencing things, but she has to make a decision regarding the status of the species.

John Casselman asked if Heather was going to generate a prioritized list, from these various themes, of on what we should focus, and how they should be performed. Heather indicated that was not part of her job in the next few months. In the long-run, it would be a good thing to do. She noted it was hoped that the information gathered now will drive the planning process and that the dialog won't continue for another five years.

John Casselman expressed the hope that there should be a lot of collaboration and interaction, as well as focus, on solving the common problems with European, Japanese and American eels.

Brian Knights noted there had been a lot of discussion in Europe, and the precautionary principle had been applied. He suggested that if the decision was made not to list, that application of the precautionary principle was an option. John asked if that was happening in Europe. Brian indicated that more restrictive regulations are being applied. He noted that they are stopping short of listing it as an endangered species.

Mike Miller indicated he thought that we couldn't afford to look at the oceanic, and freshwater problems, as separate and independent. He noted when Heather's GIS maps were done, they would no doubt show a drastically reduced habitat, which in turn would lead to reduced fecundity and recruitment over time. He stressed that the oceanic conditions, coupled with the loss of freshwater habitat, could worsen the entire situation. Reduced fecundity, and or reduced production of females, could result in insufficient larvae to fill up the available habitat.

Heather noted it is at that point she would like to apply the precautionary principle. She noted that we shouldn't presume that reproductive capacity can be met by solely the estuarine/marine component of the population. Heather noted to Brian that this current decline may not exactly be analogous to the Ice Age.

Brian Jessop stated that the key to him is deciding whether the recent observed density declines are within the normal historical range of things, or whether it is reaching a level that we all believe is critical to the continued successful maintenance of the population itself. We don't know where that range is, but we have to decide whether we are anywhere near that, and therefore warrants listing, or whether we will have to live with it at a reduced level. We can make changes in the fisheries, and we also can provide fish passage.

Marci noted that she has heard that there are other anthropogenic changes that have occurred, that might make these recent declines more difficult to overcome.

Heather agreed. She noted if the NAO has gone as it is now, for hundreds of years, the current decline may just reflect that cycle. She needs to decide which of the other factors are the most

important to spend her time upon in the next months.

12:10 PM: Marci dismissed us for lunch, asking that we return by 1:15 PM.

John Casselman asked to speak before he left. Their modeling suggested that there were in the past 9-11 million eels in Lake Ontario. They were big eels. Now, they have only about 100,000, with 10,000 leaving each year. That means that up to 10-15 percent of the entire spawning stock biomass could have come from that one basin, so it represents a major loss.

Heather agreed that was important. Heather asked the Ocean Panel to review the list she had handed out and make sure that she had captured everything.

12P12 PM: The group broke for lunch.

1:26 PM: Marci reconvened the group. She indicated that Jake had done some research at lunch that he wanted to share with us.

Jake indicated that in his former incarnation as a post-doc, a colleague was doing swimming speeds of fish larvae, and did some work on leptocephali, and found they had a eucritical swimming speed of 14.5 cm/sec. Jake noted the leptocephali used were in all probability bonefish larvae. This was a sustained swimming speed.

Session: Harvest

Panel Members
Ken Oliveria
Julie Weeder
James Uphoff
Gail Wippelhauser
Alastair Mathers
Brian Jessop

Marci welcomed us all to the harvest session. She noted that we were making sure that we are getting all the information that we need. The overarching question is:

The overarching question, which the agencies will have to answer, is: ***To what degree is the long-term persistence of the American eel population threatened by the current level of harvest?***

Kim Damon-Randall noted there are three graphs on the wall for us to view. The hard copy we received today depicts the corrected landings data for the US and Canada (original graphs sent to the experts had errors that have since been corrected). There are two other tables on the wall as well.

ATTACHMENT 14, 15, 16 – HARVEST GRAPHS
Marie indicated that the three people taking the cab tomorrow wanted to change the time to 9:00 AM, and she wanted to verify that with Jeff, Julie and the other person.

Jim Uphoff indicated that he had a ten-minute presentation that he could give to help get us started. It was entitled a Quick and Dirty Analysis of Factors Influencing U.S. Atlantic Coast Eel Harvest. Jim stressed this was his individual view. He concentrated on the harvest data because it was the longest-term dataset. He felt that there should be a signal in the data, somewhere.

ATTACHMENT 17- PRESENTATION – J. UPHOFF

Jim showed the graph of harvest and dollar-value versus time, for 1950 through 2005. The value of the dollars, adjusted for inflation using the Consumer Price Index, showed a more consistent trend, being low in the early decades and higher in later years.

Jim noted he had presumed that if eels are worth more, people will gear up and fish for them. So, metric tons, divided by dollars, should yield a proxy index for what might be going on environmentally. He noted the depressed values in some years might related to the high-value glass eel fishery.

Using the NAO index from the ICES working group, Jim plotted it versus landings, lagged three years. The resultant graph shows a curvilinear fit, with negative indices having the highest harvest, and the positive indices having the lowest.

Plotting harvest in metric tons, versus the dollar/CPI effort proxy, shows a relatively linear fit, with some outlying years. Jim ran a multiple regression model, and noted that it contained an autocorrelation between the economics and the harvest. The NAO is a gradual thing, rather than really being jumpy. The partial r-square values indicated that most of the variability was from the NAOI (0.63). Jim noted the partial correlation coefficients could be biased, but he hadn't worked through it yet. He noted that you are essentially fitting a Baranoff catch equation, if the value/CPI approximates effort. The model may be equivalent to the equation: Catch = F*average biomass, where NAOI is the biomass proxy, and F=catchability*effort.

Jim presented an "ugly" table of landings and NAOI correlations, using the landings data provided to us. Jim noted that some of the Canadian data are positive, regardless of whether a lag is employed or not. The correlation is strongly negative in Quebec. In the US, the values were positive. Jim indicated the harvest, with or without a lag, does seem to indicate that what is going on is gradual and shows up no matter what you do.

Jim noted that he had plotted Conowingo Dam lift data, versus the NAOI index. The plot suggests that either the data are somehow screwed up, or something else is going on. He plotted the MD eel harvest, and Conowingo lift index (approximated from the EPRI scoping document) versus time, which showed that natural recruitment may have gone up (?).

Alastair noted that John Casselman had done some relationships between Lake Ontario and the eel ladder data and found an eight-year lag. Another analysis found a two to three-year lag. Jim noted that he had just taken a guess. He wouldn't doubt that some other lag might be more appropriate. He stated that you might not necessarily be losing the signal. He noted that with a tiny bit of knowledge and a spreadsheet, you could have a lot of fun.

Rob asked why some of the values might be negative. Jim thought it had to do with the ocean changes. He noted the Gulf of St. Lawrence is a long way from everything. He noted that one indication of some sort of environmental shift is a contraction in the natural range. He noted also that the eels were moving from very warm, to cold water, and that might have something to do with it.

Brian Jessop noted that the Scotian landings had been going up, counter to the other trends. Jim asked if the effort was going up. Brian didn't think it was, all that much, although individual fishermen might be putting out more gear. If they are catching more, it is probably because there are more. They have decent markets that are encouraging them to expand a bit. Jim wondered if effort or efficiency had gone up a bit. Brian noted that he had the effort data, but he didn't remember what it was. The catches themselves are climbing gently, versus being stable.

Marci asked that we return to the overarching question. She asked the panel to respond.

Marci repeated the question for the panel.

Heather suggested that it might be good to use the last five years as "current" conditions, since what occurred in the 1970's might not be realistic now, or in the future. She asked for feedback around some of the definitions.

Julie indicated she could say what was experienced in MD, and noted the logical question was how that related to the rest of the range. Julie noted that she and Jim believed that harvest was too high in MD to sustain the stock, but noted that the panmictic nature of the stock meant that wasn't the full story. For there to be decent recruitment, there have to be sufficient spawners coming from somewhere. Their model demonstrated that at least 33 percent escapement was needed, and that was not happening anywhere. Heather asked what year they studied. Jim indicated that it was in 1999.

Jim noted that one thing they based this analysis on, was a synthesis paper by Mason and Sissenwine, determining how much SPR (Spawning Potential Ratio) is needed for various fish stocks. That is where the 33 percent value arose. Eels are very plastic and robust, but the replacement value makes them pretty sensitive. In the cumulative distribution of the fish they used in the paper, eels are at about the 80^{th} percentile, meaning that most of the other species have a more robust spawning potential. He and Julie stand by their analysis. Jim noted the mortality doesn't have to be fishing mortality, and noted that mortality caused by barriers acts just like fishing mortality. Rises in predation also could be a factor.

Jake noted that made perfect sense to him, since there is no way to allow an eel to spawn prior to harvest. He wouldn't doubt the analysis at all.

Julie noted that the things some might disagree with are things on which comments have been made. She noted that all the eels they analyzed were caught in estuarine waters, and never lived in freshwater. The eel fishery in the Chesapeake is totally in estuarine waters and not allowed in freshwater. The eels do grow to a relatively large size, when allowed to do so, so we don't potentially have to worry about the freshwater component.

Bill Richkus asked what the probability of an individual eel getting out of the Bay and reaching sexual maturity was. Jim indicated he did have that number. Jim shared that % Maximum Spawning Potential was between 1 and 4 percent, and in another case was 28 percent, which indicated to him that the fisheries were very site-specific, which made things difficult to assess. He noted that the Chesapeake was in sort of the heart of the fishery. You don't know what is going on in the other areas. Jim noted that he didn't believe that you could fit the conventional fishery management model. He noted that a very robust management regime was going to have to be put in place. He noted a six-inch size limit is the only measure in effect coastwide. He noted the simplistic view developed by ICES: let them spawn, let them grow, and let them live. He noted that allowing eels to spawn was not so easy. He advised concentrate on the management of the stock and not dwell on the weakness of the assessment.

Sheila asked why, if they had figured out six years ago that the eel was overfished, why weren't management regulations changed then? Jim stated it wasn't that easy. Julie noted that ASMFC has to work within the multi-state FMP (Fisheries Management Plan). The fishery extends across state lines. Sheila noted that a state can be more restrictive. Julie noted that was not likely to happen in MD. Sheila noted that it was still of interest that they reached this conclusion six years ago. Julie noted there were other factors.

Marty asked if they had an estimate of the percentage females in the Bay. Julie indicated they didn't develop that information. Most of the silver eels were female, but the mesh was large so some of them may have escaped. Of the yellow eels, about 35 percent were male, but that isn't a very useful value when trying to determine SSB (Spawning Stock Biomass).

Heather noted that with eels, there are multiple fisheries, on multiple life stages, and she could wind up with a very colorful map, if she mapped them all. She asked what are the important factors? The area of harvest, regional differences? She asked for any thoughts on how to characterize the different impacts on the different life stages**. (Question 4 Characterizing harvest, and 7 What life stage does harvest disproportionately effect that would effect sustainability of the eel population – Beak 2000 modeling suggested yellow eels)** She noted that Paul Angermeier (at a prior population dynamics workshop) had asked that question and gotten varying answers back.

Harvest Flip chart bullets
What life stage does harvest disproportionately effect that would affect sustainability of the eel population?

- Glass eel fishery may reduce density thereby increasing number of females
- Yellow eel fishery may reduce density by targeting mostly females
- Silver eel fishery targets females
- Mesh restrictions have greater impact on females

Ken Olivera indicated a life-stage specific approach might be appropriate. Removing glass eels could shift the stock toward females. Yellow eel fisheries could be targeting more females as well. The silver eel fishery targets females. He noted that Maine had a half-inch mesh size in the weir fishery, definitely culling females.

Gail noted she agreed with some of the things Ken said. Maine and New York both had weir fisheries, and both targeted females. The Maine fishery is about gone. Based on the lengths, the weir fisheries targeted almost all females. Gail noted that all the east coast states have pot fisheries, and they are differentially targeting females as well, based on the mesh sizes used. She noted they had discussed putting a restrictor on the pot opening, so that large females would be excluded.

Julie noted that an analysis had been done. She asked Brian Jessop to help her recall that study. Julie noted there has been discussion of phasing out the silver eel fishery. The elver fishery also has been reduced, and the market hasn't been strong, so there hasn't been a consistent fishery. The commercial landings by region show that NY through VA makes up the greatest portion of the mid-Atlantic landings. Those fisheries are similar to MD's. What they are finding in MD is definitely representative of the mid-Atlantic, and that region seems to represent what is going on coastwide. In her individual opinion, the yellow eel harvest constitutes the greatest threat to stock sustainability. She noted that a dead eel, is a dead eel, and won't contribute to the stock.

Brian Jessop asked if they had any data on the density of eels in freshwater in MD. Jim noted that MD has an active sampling program in freshwater, for a decade now. He noted the data are in the scoping document for Addendum 1 to the eel amendment. There are actually pretty good data, but they haven't been analyzed for this kind of thing. Bill Richkus noted there is now a 10-year time series of density data, but the confidence limits around the estimates are quite large due to the nature of the sampling. Brian noted it could provide information on unfished stocks, and should be considered when we're trying to assess production. It could be an important to spawning stock biomass that should be recognized.

Brian Knights noted that a lot of the mortality estimates are presumed. He asked if there were any estimates from unfished populations. He noted that in GB, they had attempted to make some estimates, but there were too many compounding factors, such as emigration, and it varied through the year, due to varying size.

Julie noted they simply based natural mortality on maximum age, and didn't consider the value very robust, although it did compare well with other estimates.

Brian Knights noted the Thames estuary hadn't changed at all since the middle 1980's, and the Bay was more of an open system, than the Thames estuary.

Julie wasn't sure what Brian was saying.

Brian noted that you couldn't really say what the difference was, unless you compared a fished to an unfished population.

Jim noted they didn't really have any unfished populations. He explained how the model they used worked. The assumption made regarding natural mortality wasn't too problematic to fishery folks, in fact they had a bigger problem with varying natural mortality, than with a constant one.

Jake noted he agreed with most of what Julie stated, except her comment that a dead eel was a dead eel. At any different life stage, the differential probability of reproduction changes, with the larger ones having run the gamut and therefore being of more value. He suggested that a maximum size limit for eel might be of more value than a minimum.

Julie agreed with him. She agreed that by the time the eels were larger, they should be more protected. She noted the low size limit was really protecting the small eels.

Jake indicated that we were talking about a very heterogenous species, and very heterogenous fisheries. It seemed to him that we should identify the areas of most important habitat, and regulate the fisheries there. We should zero in on key areas for eel reproduction and focus on those areas.

Heather agreed it would be good to identify those areas where females are being caught and not going out to spawn, but it would be hard to do that in the time we have. She asked if we needed to weight different life stages or areas, and wondered if anyone had done that, and suggested it ties in to Jake's suggestion.

Julie indicated that she wanted to respond to Brian Jessop's last comment, about the freshwater areas possibly serving as some sort of reservoir for spawners. Julie noted that the eels coming from those areas remain in the Bay for a long time, while they undergo the metamorphosis to silver. Some of them do pot. Also, Julie noted the pound net fisheries in the Bay catch silver eels. With regard to particularly important areas, she invited ASMFC American eel Technical

Committee members to look for really productive areas, such as the Chesapeake, as particularly good areas for application of specific management, which would be more effective than trying to manage a lot of little areas running down the coast.

Brian Jessop suggested it would be instructive to look at the areas fished, versus those unfished, if the information can be obtained. He meant mapping the unfished and fished areas within a watershed, so that we would have an idea of the area from which recruitment is occurring. He referred us back to the key question again. At the moment, he is unconvinced that the existing degree of fishing, and degree of decline, while the population might be reduced from the level of the 1970's, is anywhere near approaching a level that would affect the existence of the species. No one knows what the tipping point is, but Brian noted he is thinking about the vast areas that are unfished, and can't match that with being anywhere close to a tipping point.

Jim Uphoff noted he agreed. He felt the signal he is getting from the landings is more suggestive of the ocean changes driving the observations. Jim noted that in the Bay, they are betting that the other areas aren't fished that hard, so the landings are being driven by oceanographic conditions, with some minor signal from the fishery itself.

Rob indicated he thought he had heard that there is recruitment overfishing in the Bay. Jim confirmed that was the case, but overall, that is only a portion of the range. That intensive fishery doesn't appear to him to be the main driver of the catch. Rob asked if he wasn't saying that the stock is very sensitive to overexploitation. Jim agreed they potentially are sensitive, and the anthropogenic influences don't have to be really massive to cause overfishing. He questioned how you would synthesize the information on all the other mortality sources. He noted again that climatic factors seem to be the driver.

Rob asked how ASMFC sets harvest policies? Heather and Marci asked that we wait to have that discussion. Lydia indicated she would talk to Rob at the break about that. Rob noted that all the other factors needed to be taken into consideration by the management body.

Kim noted that we may not be influencing eel abundance over time, but asked Jim if the fishing pressure remained the same, or increased over time, could it threaten long-time persistence? She noted that a "threatened" designation had a time associated with it.

Brian Jessop indicated that if the fishery expanded greatly, there might be a great impact, but he didn't see any such expansion. If anything, more and more restrictions are being imposed, and the market for eels seems to be slowly changing. Older fishermen are dropping out and not being replaced. In many places, Brian believes the fishery is going to disappear. There is an issue in places where management is allowing overfishing.

Kim noted that Brian Jessop had suggested mapping the areas where fishing was and wasn't occurring. She asked where those data might be occurring. Brian noted that they had done a crude cut (in Canada), using the knowledge of individual biologists, and were interested to see how concentrated some of the fishery areas were.

Jim noted that if we don't have robust management strategies in place, a six-inch size limit doesn't provide much protection. You could have more regulations in place and still have a fishery.

Brian Knights noted the landings graph appeared to him to be related to the NAO. He noted that declining markets are also a factor making the landings decline. He noted that the entire fishery in North America is matching the catch in England and Wales alone, so he can't believe the pressure on the fishery is that great. Heather noted that Brian Knights and Willem Dekker would agree on that, since Will had sent her an e-mail message saying that the US harvest was a "piffling ant" in terms of the international harvest and had shared with her a recent FAO report which is up on the wall. She noted the Japanese are now also increasing their market share, due to aquaculture.

ATTACHMENT 18 - FAO INTERNATIONAL HARVEST TABLE

Julie noted she had been saving up some things. Regarding Brian Jessop's argument of unfished areas protecting eels, there are really no closures in tidal waters. Julie argued that if it wasn't closed, it could be fished. Wilson noted that in NC, there are Primary Nursery Areas that are closed to everything. She noted that it would be pretty much the freshwater areas that would be closed, if they exist. Wilson noted upon second thought that the Primary Nursery Areas in NC were only closed to trawling and not necessarily closed to eel-potting. Heather noted that the issue of closures was separate and apart from the areas actually being fished, or not. Julie noted that it would be difficult if not impossible to determine areas that are or are not being fished. Julie questioned the validity of the landings. She doubted that most fishermen are reporting all or even part of their landings. Heather asked if we were at 50 percent or what? Julie indicated she didn't know. She did believe the recreational landings were not very large.

Julie's final point was that if the NAO is driving the landings, she views that as an environmental baseline that we can't change in the short run. When the threat is being assessed, she advocated looking at it during a period when recruitment is very low for some number of years. You could argue that fishing might have a greater effect during those years. She argued that the effects of the NAO and fishing are synergistic and have to be considered together.

Heather noted that she had been trying to get everyone to identify threats, and not bring everything together just yet. Marci suggested that we discuss that after break.

2:43 PM: We took a break.

3:04 PM: Marci reconvened the meeting.

She asked for sources of information for answering the question regarding to what degree the long-term persistence of the American eel population is threatened by the current level of harvest?

Alastair noted the Beak report does summarize sources of mortality in Lake Ontario. Gail indicated she had no idea. Ken Olivera noted there isn't much of a silver eel fishery left, so the yellow eel and glass eel fishery together would constitute the principle source of mortality. Kim noted that the only reported glass eel landings were in Maine and Canada. Although they are technically allowable in SC and FL, there are no fisheries there. Jim stated that the ASMFC stock assessment, and the ICES analysis that is on the CD, are the two best. He noted what we really needed, a traditional assessment, wouldn't be available. Julie indicated that she would go back and look in her database, but couldn't think of any other papers that hadn't already been mentioned. Heather noted that the oceans issue was way too big to handle. She indicated that she wanted recommendations on which papers to use. Kim noted that it was important to know about the fishery characterization as well. Julie noted that on her questionnaire, she had identified what she thought was the most relevant literature. Brian Jessop noted he felt the latest draft of the Canadian stock assessment, the RESDOC one was most useful. Heather indicated that she would be receiving that document. Brian noted maybe the only other thing he could say would be to use the commercial fishery catch, although people seem to distrust that. He noted there is prior catch data available from other people, that we might try to obtain those. Julie asked if Brian was talking about the Delaware Valley Fish Company data. Heather indicated she already had those data.

Alastair noted that for Lake Ontario, harvest data have been plotted, and clearly was a major impact there, as reflected in the Beak work and some of John Casselman's work. The harvest was comparable to any other source of mortality. Kim noted that they were talking about the American eel population rangewide. Gail noted that it might be helpful if the ASMFC could query every state to determine where the pot fisheries are located. Gail indicated that in Maine, the fisheries occur in the Penobscot, Kennebec and Androscoggin. Those are the three big rivers. Julie noted the question should be asked about areas closed, as well.

Marci indicated there are some other questions that we should be able to answer quickly.

Question: Is there any suggestion that subsistence, recreational and/or bait harvest a concern at a population level?

Alastair indicated that eel are occasionally caught but rarely kept in the recreational fishery. Subsistence was historically important, but he isn't aware of any present harvest. Kim asked if recreational harvest was actually low, or just reported low. Alastair indicated these data were from creel surveys. Bill Richkus noted a Delaware River creel survey was done in 2002 and he can provide the eel data from that survey. Alastair indicated (in Ontario) there is no harvest for bait.

Gail indicated they report those landings. More is going towards bait. The subsistence fishery was larger in the past than today, in part because many of the eels contain contaminants. She wasn't aware of any recreational fishery. Steve Gephard asked if ME had a personal use policy for eels, to be used for bait, which might not be reported. Gail thought they had such a

provision, but she didn't believe it was that many. Jake asked if subsistence, was meant for Native Americans, versus low-income socioeconomic groups. Heather indicated it did.

Ken noted he wasn't aware of any subsistence fishing. He indicated he was aware of several bait dealers who pot for eels, but don't report the harvest. That could be substantial if expanded. There is no recreational harvest as far as he knows.

Jim indicated the bait fishery landings are reported. There are no recognized Native American tribes in MD, so there is no subsistence fishery. He had recollections of recreational anglers killing eels caught incidental to fishing for other species. He didn't see any of the three fisheries as a threat.

Julie didn't see any of the three as a threat. She didn't know what is going on in FL. In MD, there was a persistent market for small eels, for bait, but those should be captured (in commercial harvest data). She didn't believe all those landings are captured. She felt any landings of these small eels wouldn't be shown, since the eels are not reported by size. She knew of no subsistence fishing. Recreational anglers responded to her inquiries with disgust and dismay.

Jim noted that three years or so ago, they did a survey of bait dealers in MD, and Harley Speir could say what they did. Jim didn't recall what they measured. He didn't believe it was much of a threat.

Julie indicated that the bait eels used for striped bass cost a dollar apiece. She felt that the numbers would be fairly small. She didn't believe it was anywhere near the scale of the commercial landings. She didn't believe that anyone would go out and buy 100 eels for recreational fishing. Jim noted that a lot of this was speculation.

Brian Jessop indicated that a recreational fishery was allowed in the Maritimes, but was virtually nil. Subsistence fishing was allowed, but most Native Americans do it under a commercial license. All quantities are supposed to be reported back. Most things should be reported in the commercial statistics. He didn't believe that anyone was using them for bait in the Maritimes.

Wilson reported that he understood that glass eels were being imported from Canada to NC, and grown out for bait. Brian Jessop indicated that he was aware that small elvers were being exported and grown, but he didn't believe the numbers were very large.

Kevin McGrath asked about the Delaware Valley Fish Company data, and if they could be translated into numbers. Lydia indicated the data are reported in weight. Kevin indicated that if the weight could be converted into numbers, they might be of more use. Lydia noted that Mitch Feigenbaum had indicated that he could do the analysis, and she knew that he had more data than he had shared, but they hadn't pursued that.

Heather asked if they needed to get landings data for American eels, for other countries. She noted that FAO data could be assembled. Brian felt that the data didn't say a whole lot, but the

main question was, how representative are the data? He indicated that information on the true distribution and abundance of eels in the southern part of the range would be useful, but he didn't envision us having them any time soon.

Julie felt that we should try to get the data, just to acknowledge the fact that the species ranges beyond the US. There is no reason not to get the data. Heather stated it was a long process to go to the other countries and ask, especially if we didn't believe it was important to the harvest issue.

Brian Jessop suggested that we might have better success getting information from Puerto Rico. He has heard they have a significant elver return, and some fisheries, and perhaps someone has some information there on stream densities. Heather indicated that she did have some data from the National Park Service. Julie indicated that one of the papers on the diskette did have some data on foreign landings. She would review the paper. Heather indicated she had used those data in the 90-day finding, and the landings were small. Julie indicated that she didn't believe it was important to pursue the data in that case.

Marci asked if the **Question: Is there any evidence of harvest occurring outside the EEZ, in international waters.** No one knew of any such harvest.

3:32 PM: Marci asked that we make a list for this one. **Question - What life stages, or factors make this species threatened by harvest?**

Jim stated it was delayed reproduction, since the species is harvested prior to reproduction. Brian Jessop stated long life span. Gail stated sexual dimorphism. Julie stated the long migration to the Sargasso Sea was a factor. Marci noted we had five factors. Julie changed her factor to fishing on multiple life stages, rather than the long migration.

Harvest Flip chart bullets

What life stages or factors make this species threatened by harvest?

- Delayed sexual maturity
- Semilparity (spawn only once)
- Long life span
- Sexual dimorphism/length at maturity
- Fishing at multiple life stages

Conversely, Marci asked for a new list. **Question - What life stages or characteristics or strategies make the species least vulnerable?**

Jim stated it lives everywhere. Julie stated plasticity in growth rate. Brian stated high fecundity. Jim stated it has been around forever. Jeff stated robustness on an individual basis. Brian noted they are multiple year class spawners. Jake noted their omnivorous diet. Julie noted they are generalists. Jim noted that we don't even know where they spawn, exactly. Several participants noted that is probably a good thing. Mike Miller noted they have a transparent larva, which helps avoid predation. Also, they recruit to freshwaters, which is a large area. Julie indicated they tolerate a wide salinity gradient, are euryhaline.

Harvest Flip chart bullets

What life stages life stages or characteristics or strategies make the species least vulnerable?

- Lives everywhere
- Panmixia
- Plasticity/growth rate
- High fecundity
- Been around for over one million years
- Robustness
- Multiple year class spawners
- Generalist diet
- "Secret" spawning location
- Transparent larvae
- Recruit to freshwater and estuaries at relatively large size compared with other species
- Euryhaline (tolerate wide salinity ranges

Question: What factors drive International demand for American eels?

Marci moved to the international market. Heather indicated that she just wanted to make sure we are on the right track. The major factors to her seemed to be the availability of other eels, and the relative strength of the dollar compared to the Euro. Brian Knights stated in terms of glass

eels, the American species is least desirable because it doesn't grow as well.

Heather asked what life stage was of most value on the international market. She understood glass eels for grow-out in Japan. Brian Knights advised it was silver eels from America for the European market.

Question: Given the answers to the previous question, is there any reason to think the recent announcement of the upcoming change in EU harvest regulations would impact American eel harvest?

Heather noted the European Union had changed the harvest regulations for eels, allowing only two weeks out of each month. She wondered how that would affect the US harvest. Given that China was now growing a lot of eels, she asked if there was any reason to think that the US harvest would increase. Brian Jessop thought that it might, if demand increased, and the value increased, people would say, "Let's fish." Marie noted that every time restrictions increased in the caviar fishery in Europe, the US market demand increased. Heather noted in this case, China is growing European and American eels, and their market is unrestricted, so that might compensate. They can grow the eels to a uniform size. Mark Cantrell noted they had to get the eels from somewhere to grow out.

Brian Knights noted they are still a bit off from implementing the 15-day rule, because the Eel Working Group hadn't yet met. He will provide the report as soon as he has it.

Marci gave us **the last Question** for the day: **Are there other threats that directly or cumulatively exacerbate the effects of harvest?**

Jim stated habitat loss, power plant mortality, oceanic conditions, all act together. Heather noted that all threats become additive due to the panmictic nature of the stock. She noted that for salmon, barriers and contaminants might be issues on separate spawning stocks. She asked if because of the panmictic nature of this stock, all the threats are additive. Jim agreed that was the case. Julie noted that the proportionate impact could go up or down, as a function of recruitment. Heather noted we didn't need to spend any more time on this question.

Heather indicated that she wanted to move back to the question of synergy. She asked if there was anything that jumped out at us in that case? She noted for example that drought can become a multiplier for some species of plants, affecting disease resistance.

Jim Uphoff indicated that any such response was likely to be nonlinear. The reason there are so many threats is that the land mass is so huge, and they then go into the ocean, so there isn't a whole lot left for them to experience.

Heather noted that for some fish, when the population is fished, factors such as age structure, or fecundity change, and they become less fit.

Rob wondered if we had any information to suggest that harvest is selecting for mostly females. He wondered the same about turbine mortality. Mike Miller indicated that he wanted to make an obvious point, so it is recorded. This species being catadromous differs from any other species, because we can get no idea of how many spawners there are. There is no way we can do that for American eel, which is a fundamental difference from any other species. No one is monitoring silver eel escapement. Until we get a handle on that, we will have no idea how to answer any of the other questions being asked. Brian Jessop indicated the only thing he would add is that we are forced, Mike's point being absolutely correct, to look at it on a relative sense. That is where the issue of fished versus habitat, throughout the range, comes into play and that is the closest we can come to answering Mike's question.

Rob asked if recruitment is low, but everything else stays the same, there is more of an effect. Exploitation strategies are of more concern depending on the level of recruitment. Heather asked if not having a handle on recruitment, was problematic, given that habitat loss and fishing might not go down. Rob noted that habitat loss might be diminished, given fish passage. He noted that we need to look at the cumulative sources of mortality. When recruitment goes down, are we altering our management strategies? He didn't believe that fishing would continue to extinction. He asked Heather if that was what she was asking. Heather indicated it was hard to ask that question in isolation.

Harvest Projected bullets
Other threats that directly or cumulatively exacerbate the effects of harvest?

- Habitat loss
- Contaminants
- Losses at hydropower facilities
- Oceanic conditions

Marci noted that Ken, Kevin and Rob had to leave at four, and she wanted to give them a chance to say anything else. Kevin McGrath indicated that the international aspect, the southern distribution in the Caribbean and South America, getting harvest data is likely impossible, but he felt that it was important to get some idea of the relative abundance. If they were, and currently aren't, or if there was and still is a large population there, that is important to know because it could be an important refuge. Rob noted this was a wonderful workshop, and he had learned a lot from it. He noted there are at least 12 jurisdictions involved and much cooperation would be involved to manage it properly.

Harvest Projected bullets

Unknowns

- Is harvest selecting mostly females?
- Information on abundance and harvest is missing from large areas such as South America and the Islands
- Spawner escapement is unknown
- Cumulative sources of mortality

Heather asked of the three leaving, and the rest of the group, relative to the next workshop coming up, that we were going to spend more time on threats, and Canadian harvest and barriers, and disease, bringing in Ken's work on the parasite, and contaminants, and population dynamics. Paul Angermeier is going to help with the latter. Heather asked for any suggestions for the next one. Ken suggested shortening the list of papers on the CDs. Heather noted that she could do that thanks to the input from those to filled out the questionnaire. Heather noted that it would be different now, not necessarily shorter.

Kim asked if bycatch was an issue for American eels. Ken thought not. No one else was aware. Rob noted for the next workshop, we need to get to the combined effects, and the rate of sustainable harvest.

Marie indicated that additional papers are on the back and side tables for everyone.

Marci asked everyone to pick those up. Marie indicated she would e-mail the list of participants.

Rob indicated that Quebec was redoing modeling on escapement. Alastair indicated that Guy Verreault is the one to talk to about that. Alastair asked about Sargassum harvest as a factor. Kim indicated that someone at the Southeast Fishery Science Center was writing a report on that issue. Heather indicated a report should be prepared by January.

Bill Richkus suggested that any further discussion of what we discussed here should be banned, and spend the entire day on the population dynamics. Someone stated we should discuss parasites and contaminants.

Wilson asked, given that we don't have fish passage on all systems now, should we, or should we not, be passing eels upstream? He asked if anyone had any insight on whether passing eels upstream into currently unoccupied habitat, and then having them subject to turbine mortality when returning downstream, was better than just leaving them to take their chances downstream?

Julie stated that we needed to know the turbine mortality rates. Gail noted that Jim McCleave did some modeling on that, and found that the benefits of upstream passage outweighed any downstream passage mortality. She also noted that we had 15 years to figure that out. Brian Jessop noted that it depends on the amount of habitat upstream. Also, it would depend on the number coming out, if large enough, it would be worthwhile. Steve Gephard noted that in CT, many of their dams are at head of tide, so they are dealing with glass eels. The converse argument is not to pass those, and let them grow up, but if you are a gambler, and want to let them grow to silverhood, he would put his money on throwing them over the dam and seeing what happens. Alastair noted he agreed with the modeling comments, and also noted that it restored the ecological integrity upstream. Bill asked, is there some sort of density-dependent mortality rate at play, that would have caused their loss anyway, so why not pass them? Bill noted that he has always wondered, when he sees the swarms of elvers at a blockage, what do they do? Do they keep banging their heads, or do they go back downstream? He wondered. Kevin Friedland asked if we were going to spend any time talking about climate change in freshwater. Heather noted that Jake had brought that up in his questionnaire.

Wilson noted that the AFS Resources Policy Committee is doing a policy paper on the impact of climate change on fisheries, which should be available soon. Also, with regard to Bill's question, he noted that of the tens of thousands of eels trapped below Roanoke Rapids, only a few had been recaptured.

Brian Knights suggested that passing eels upstream should consider the potential impacts on the ecosystem above the dam, and also on the sex ratio that might result.

Kim and Heather indicated they might be sending out some questions via e-mail.

Marci asked for any additional comments.

Bill Richkus noted that he really appreciated the workshop.

Julie asked if we felt we got what we needed. Heather noted that we were going to spend some time debriefing tonight. She felt that we did have some sideboards, and some areas in which to focus. She felt that we are narrowing things down a bit. She asked Marty for his thoughts. Marty indicated it was very good. We have to go back and draw conclusions on a lot of these issues. He noted that there are a number of different conclusions that can be drawn, and we have to say why we selected some and rejected others. We have to demonstrate how the rationale supports one opinion or another.

Marie Maltese indicated that she really needed to synthesize, with regard to the international issues. She thanked everyone for their time and being allowed to pick their brains, and hoped everyone had learned a lot.

Julie Weeder asked what the process was after this. Her understanding is that information will

be provided to managers in March, and the managers will make a decision. Heather indicated the managers will be provided the information from the workshop, and staff analysis, and will then apply policy and render judgment, and make a recommendation to our Director, who will make a Finding. If the Finding is that it won't be listed, that is the end of things. Another Finding would be that it should be listed, in which case a Proposed Rule would be prepared, then a year would elapse prior to any Final Rule being issued. Heather indicated the hope is to wrap things up by February. Then Adam will need a month to look things over, before it goes any further. Julie asked if we could expect to see something by the middle of the year.

Marci thanked everyone for sharing their time. She noted as a reward, everyone gets to go to Buffalo in January. Marci asked that anyone send any comments on the GIS graphs to Heather, and also any comments on parasites or other issues. Marie was thanked for her logistical support, which allowed Heather to listen to every word. Marci advised everyone not to forget the papers on the back table.

4:19 PM: The meeting adjourned.