

IMPACTS OF DREDGING ON ANADROMOUS FISH

A TRANSCRIPT OF PRESENTATIONS

AT A WORKSHOP

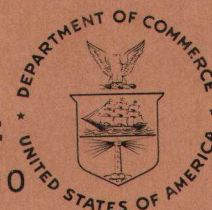
RALEIGH, NORTH CAROLINA

SEPTEMBER 18-19, 1987

CONVENED AND EDITED BY CHARLES S. MANOOCH, III

SPONSORED BY U.S. ARMY CORPS OF ENGINEERS
WATERWAYS EXPERIMENT STATION
VICKSBURG, MS 39180

HOSTED BY U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SOUTHEAST FISHERIES CENTER
BEAUFORT LABORATORY
BEAUFORT, NC 28516



NOAA TECHNICAL MEMORANDUM NMFS-SEFC-210

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CO-EDITED BY ANN BOWMAN MANOOCH

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U. S. DEPARTMENT OF COMMERCE
C. WILLIAM VERITY, JR., SECRETARY
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
WILLIAM E. EVANS, ASSISTANT ADMINISTRATOR FOR FISHERIES

SEPTEMBER 1988

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The following authors who made Experience Presentations at this workshop have prepared more technical papers on their subject material:

Mark W. LaSalle
Joseph G. Losech
Richard Eager
Mark R. Gibson
John W. McCord

These papers will be compiled into a supplementary NOAA Technical Memorandum. In the interim copies of these papers may be obtained by writing to Charles S. Manooch, III, National Marine Fisheries Service, Beaufort Laboratory, Beaufort, NC 28516.

Welcome and General Introduction

Charles S. Manooch, III
National Marine Fisheries Service
Beaufort, NC 28516

It is certainly a pleasure for me to welcome you to Raleigh and to thank you for taking the time to participate in this workshop on dredging and anadromous fish.

You will recall from our earlier correspondence that I have been asked by the U.S. Army Corps of Engineers, Waterways Experiment Station in Vicksburg, Mississippi, to coordinate the activities of this working group and to serve as editor for the publication of a transcript of this meeting.

Since July I have been actively involved in trying to put together the program for this day and a half meeting. During that time, I have learned quite a bit about most of you, your interests and areas of expertise. It was somewhat surprising to me to learn that there are so relatively few people actively involved in the management and biology of alosids, particularly as impacted by dredging operations.

Nevertheless, I believe that we have gathered here today a nucleus of individuals who share the desire to see that our fisheries resources are protected as man alters the natural environment. We come together with that basic understanding.

We will be challenged in this next day and a half to listen, to learn, and to work together to prepare a document which will outline specific research needs to evaluate how dredging-induced environmental alterations affect fish movement in the vicinity of an operating dredge. I would assume that we would address the topic of fish survival in that area as well.

An underlying problem is that the effects in the field remain poorly known. This lack of understanding often has led to opposition to regulations which are based upon the criterion, "Reason to Believe". This in itself, has caused some problems, even confrontation, between Corps of Engineers districts that are directed to maintain and create waterways for safe vessel passage, and the state and federal agencies charged with protecting and managing fishery resources.

Complicating the use of this criterion, "Reason to Believe," is the fact that our coastal areas are changing drastically. You only have to live on the coast to realize that coastal environments are changing. For instance, what before might have been considered relatively simple problems associated with suspended sediments are today beset with potential problems of chemical and pathogenic releases. The pathogenic aspect is just now being realized and some alarming discoveries are being made. The scientific community knows very little about the role of toxic substances in the marine environment, and certainly even less about the identification and dispersion of marine viral and pathogenic bacterial organisms. Needless to say the "Reason to Believe" criterion will be with us for some time.

I have recently read a synopsis of the literature pertaining to the impacts of dredging on finfish and shellfish resources. After I completed that reading, it seemed fairly obvious to me that an agency could either argue for or against a dredging operation based upon selected scientific publications. One is able to justify his actions. What we must do over the next couple of days is to serve as an unbiased jury of experts, and submit our recommendations based on fact, and the attempt to ascertain facts. Individual and agency opinions and positions are certainly welcome. That is the reason you have been invited to take part in this workshop.

I think that through our combined efforts we will produce a document that can be used as a guideline for dredging operations in the future. That is our major objective.

Now I would like to briefly discuss a few ground rules. We will transcribe this meeting and produce a published document. The publication will resemble a NOAA Technical Memorandum, or one of the documents like the Corps of Engineers produces. Dr. Homziak and I will work together on the format that is approved by my agency, the National Fisheries Service, and also by the Corps of Engineers.

As we go through the program if you have a question or other comment to make, please identify yourself and give your affiliation.

Now, let's refer to our agenda. Next on the program is Dr. Jurij Homziak.

Specific Topics and Objectives

Jurij Homziak
U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, MS

I'd like to reiterate the thanks that Chuck has made to all of you for coming here on this weekend, but I also think that we have an important and interesting piece of work to address in this meeting. I would request that everyone serve on that impartial jury that Chuck suggested earlier. While keeping your agency or political views in place, try to act as managers, technicians and scientists who are knowledgeable in the field. Try to put your best effort into helping us resolve these dredging problems.

This particular workshop is coming out under the auspices of a work unit in which I am the principal investigator. This work unit is the "Seasonal Restrictions and Dredging Program." It is a multi-year investigation charged with evaluating the technical basis for seasonal restrictions on dredging in coastal waters and Great Lakes region of the United States.

We have a sister agency in the Waterways Experiment Station that is looking at restrictions concerning fresh water issues. We have a representative here from that group and he will be working in fresh water systems.

We are charged with providing recommendations and guidance to Corps districts and divisions in resolving contentious seasonal restrictions issues. The key word is "contention." This work is funded through what is known as the Environmental Effects of Dredging Program. And the representative from that group in the Corps of Engineers, Mr. Tom Patin, is here as well. The focus of this program is to provide assistance to field offices of the Corps of Engineers. This effort goes back to the Corps mission which in part, or a large part, requires that the Corps maintain and create navigable waterways. And as a matter of fact, as you need to break eggs to make an omelet, as once was said, you need to dredge and dispose of sediment when you create and maintain waterways.

This particular activity, the dredging and disposal of sediments, is the reason for concern for important environmental or biological resources. Resource management agencies express this concern when they view the environmental effects of dredging and disposal as negative effects upon the resident wildlife, or resident resources, in the particular area being dredged.

Physical and chemical alterations associated with dredging have tended to be viewed as a negative effect. While I am not going to defend it and to say that they are not negative, or say that they are positive, I would like to point out that the broad perception is that they have a negative effect. That is sort of "ground-zero." We are starting from that point.

This concern that dredging has a negative effect on resources is expressed by the placement of seasonal restrictions on dredging when a vulnerable life-stage of a particular resource is present in the area that the dredging is to take place.

The focus of this meeting will be on the effects of the dredging side of the operation. Disposal of dredged materials is fairly dramatic and relatively obvious. I don't think any of us have any question that there is a significant and very evident effect of disposal. However, the effects of dredging are much less dramatic. They are a lot more subtle, and may be a bit more difficult to interpret.

When restrictions on dredging are requested by a resource management agency, that could be a state agency, a federal agency, or a municipality, the Corps of Engineers tends to comply with these restrictions.

However, you must recognize that the Corps of Engineers is like any construction agency, and that restrictions are not without costs and costs in many cases may be very significant. Restrictions and costs complicate scheduling and increase scheduling difficulties. For example, we have a very limited dredging window of a number of months. We have three dredging projects and only one or two pieces of equipment that can be mobilized to address all the dredging projects. We just simply cannot move a dredge across the continent, or up and down a thousand miles of coast in a short period of time.

Restrictions could potentially increase hazards to personnel working on the dredges. For example, dredging in mid-winter somewhere in the Great Lakes or in northern regions may be very hazardous.

Restrictions can also limit the effectiveness of the dredging operation. For example, limiting dredging to a spring window in an area where all the sediments, or most of the sediments, are deposited in one large spring freshet, will force the agency to dredge immediately prior to all the sediment being deposited. Thus, the harbor will be cleared for a month. The spring freshet deposits all the sediments; then you have eleven months with a clogged harbor again.

So, complications and costs are significant. While these costs are recognized, we also have to look at the fact that reasons given for restrictions are sometimes inadequate, or not well known. As a result, a confusion in the mission of the various agencies involved is sometimes indicated. And, as a result, confrontations often arise between the agencies.

The principle reason for confusion and confrontation is the fact that the availability, quality, and application of the data are varied. For example, support for seasonal restrictions has been documented through our surveys and our work with the Corps districts and divisions, to arrange, in roughly decreasing order of credibility, from detailed, accurate data on a particular species about a particular circumstance to data for related circumstances or species, to deductive reasoning. Going further afield, to expert opinion and consensus by qualified experts, and then going down to gut feelings, decisions based on erroneous or out-of-date, or misinterpreted data, we get to judgments by unqualified personnel. Finally, we have had occasions where no reasons at all were given. It just said, "This is so." "This is fiat." "This is the way it's going to be." The above mentioned types of comments are supported by actual case histories.

We also encounter variability or inconsistency in the application of restrictions to dredging operations. Variability is a very significant problem. I will use an example with the penaeid shrimps. Within the Southeastern Division of the Corps of Engineers, there are a number of districts that extend from the central east coast down across the Gulf. In two of these, the Wilmington District and the Galveston District, they require or have dredging restrictions in place to protect the penaeid shrimp resources when they are in season. However, in the major fishing areas of Florida, along the Gulf coast and Louisiana there are no restrictions on dredging at the same time, when Galveston and Wilmington are imposing theirs. So, for the Southeastern Division, which is charged with managing dredging and trying to protect this shrimp resource at the same time, how do you manage your operation, under these circumstances, when application of the standards vary across a region?

For a given resource or a species of interest, the reasons for restriction may vary across time or across region. For anadromous fish, for example, in the North Atlantic Division (which includes the North Atlantic Region) in the Norfolk District, physical damage to the fish is cited as being the major reason for restrictions.

A little farther up the road in Baltimore, the concern is for entrainment of the fish by the dredge. When questioned about the effects of physical damage, the resource management agencies recognize the fact that it is really a minor concern at the sediment levels created by a dredge. Furthermore, in the Philadelphia District, the main concern is that optical turbidity is going to block migration by fish. Other reasons are not cited.

So, we have a variety of reasons to apply in one Corps district. We need to find out which of these reasons are valid, which ones are applicable and we can work with, and which, on the other hand, are based on gut feelings or "Reason to Believe."

We need to define the issues. There is no consistent set of reasons applied to the management of anadromous fish in regard to dredging operations. In view of these difficulties, the Corps districts and divisions have expressed a need for guidance in resolving the seasonal restrictions issues when they are confronted with them.

Where the data exists, or there is scientific or technical merit to the request, either going through the range of data, dated data, deductive reasoning, or expert opinion, then the requests for restrictions on dredging are honored, whenever possible. They are honored unquestionably. However, if the merit of the request is technically questionable or the data are lacking, then no reasonable decision on whether to impose a restriction or to remove a restriction can be really made. Abiding by a restriction that is based on faulty data or lacking data is really a poor management decision.

Every coastal and Great Lakes district has a seasonal restriction placed on its operations.

We at the Coastal Ecology Group at the Waterways Experiment Station have conducted a telephone and mail survey of all coastal and Great Lakes districts and divisions to determine what resources were being protected by restrictions, what were the environmental effects of concern, and other information such as dates of the restrictions and the project types and the agencies involved. Anadromous fish and colonial nesting birds were tied for first place as the most frequently cited reason for restrictions in the Corps districts and divisions surveyed. Well over 50% of the Corps districts surveyed reported restrictions based on anadromous fish.

The environmental alterations resulting in seasonal restrictions most often cited as being threatening to this particular resource were suspended sediments and/or optical turbidity, and their effects on the behavior of anadromous fish.

We followed up this survey by reviewing the literature and found that there really is very little data available with which to make a decision about this particular issue. There have been very few studies, very few field observations. There really was not much information available.

So, rather than remain uninformed on this particular issue, we decided to resolve this through this workshop, or experts' consensus or experts' opinion-type of an approach. This approach has been utilized by a number of groups. In fact, we have had a fair amount of success with it in the Army Corps recently.

Mark LaSalle, attending today, has been involved in a similar earlier workshop in the Chesapeake Bay. Glenn Earhart (from the Baltimore district) sponsored the workshop, where we were concerned with the entrainment of oyster larvae by hydraulic dredging. The workshop successfully cross-educated the participants in a variety of environmental, management, and engineering aspects of the problem. They developed approaches for productive discussions of the issues, identified the issues that were tractable, and set aside those that were not manageable or tractable. The workshop provided recommendations to guide the actions of the resource management agencies and the Corps of Engineers in dealing with the entrainment of larval oysters.

We are trying to do the very same thing here. The purpose of this meeting is to gather a selected group of experts who are familiar with anadromous fish, their biology and management, and dredging-related environmental effects.

We limited the scope to the east coast, and to alosid fish, because the complications arising from trying to bring in salmonid issues would make the group too large and thus unmanageable.

We will hold a meeting, either later on this year or early next year, on the west coast, to include the Great Lakes and the west coast salmonid fisheries resources and this particular question.

The goal of this meeting, today and tomorrow, is to develop the best approach by which to determine if dredging-induced environmental alterations affect the movement of anadromous fish in the vicinity of an operating dredge. To do so will require a review of previous laboratory fish research and the effects of dredging on water quality, and the responses of known species to physical alterations associated with dredging operations.

We have invited speakers on the agenda who are knowledgeable in these issues and who will serve to cross-educate the group in their particular areas of expertise. These presentations will serve to identify what is known from that which we do not know. Where data gaps exist and where information on the effects are limited, specific research issues for concerns are to be identified. That

identification process will be the focus of the subgroup meeting tomorrow. The subgroups will be defined, each charged with identifying the specific research needs of one of three life-history stages of anadromous fish: eggs and larvae, juveniles, and adults. Once these group concerns are identified a discussion of the gear and techniques necessary to accomplish any suggested work are to be included.

We consider gear and techniques to be a particular stumbling block in attempting to address the research needed to resolve anadromous fish questions. The lack of agreement on gear is the last thing we want to stumble over, but it has happened time and again. So, we need to have some discussion of what is appropriate for addressing particular problems.

It is also particularly important that we focus on identifying issues for which we can find solutions. Issues and research approaches that are not tractable, that we do not have the technology for, or are way out of the time frame that we can deal with should be identified and set aside. However, we should not be hung-up on trying to identify all of the tractable issues. We must focus on the ones that we can get a handle on in some way. Efforts should be directed toward solvable problems.

The final products of this working group meeting will be a series of recommendations of studies designed to most efficiently and unambiguously answer the unresolved issues of concern regarding the effects of physical alterations associated with dredging on anadromous fish behavior. These recommendations will, in turn, guide the Corps and other agencies in their research efforts in this area in the future. Importantly, they will also serve to more closely tie the Corps research efforts to those of the various resource and research agencies involved in the management and research on anadromous fish on the east coast.

That concludes my presentation. If there are any questions, I will entertain them now, or I will be glad to talk to you about them during the break. If there are no questions, I'd like to introduce our next speaker, Dr. Mike Palermo from the Waterways Experiment Station.

Overview of Dredging Operations
(Physical)
Mike Palermo
U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, MS

I know that there are a number of people in this room who know a lot about dredging and dredging operations. You will have to bear with me, because I understand there are many here today who do not know very much at all about dredging, how dredges work and how they operate.

I was asked to provide a brief description of various dredges, how they work, and, also, I will try to describe some of the sediment interactions with the dredge.

I am the first of three or four speakers from the Waterways Experiment Station who will be making a presentation. For those of you who have never been to Waterways, it is a large facility. There are five different laboratories. All the speakers here at this group today are from the environmental laboratory at WES. But we have a large number of people at WES who work on research projects or research work units that are concerned with dredging and dredging material disposal. These researchers come from a number of different laboratories, not just the environmental lab.

I am going to address strictly engineering aspects that are related to dredging. I will discuss three major dredge types: mechanical, pipeline, and hopper.

When someone says mechanical dredges, they may refer to a number of different kinds of mechanical dredges. I will stress the bucket because it is the type that does most of the work of mechanical dredging for the Corps (slide).

There is also a dipper dredge which is really a steam shovel mounted on a barge. It is good for excavating various compacted materials, new-work type of dredging (slide).

Also, there is a piece of equipment called a ladder dredge, which is like an endless chain of bucket dredges. It is not used in navigation dredging work here in the United States. It is primarily used in mining applications (slide).

I will stress this type (slide). It is really nothing but a crane on a barge with a bucket on the front.

I will also talk about hopper dredges which are ocean-going vessels using a trailing drag-arm and a hydraulic dredge pump to excavate materials hydraulically (slide).

Last, I will discuss what I call hydraulic pipeline dredges (slide). There are several ways that this type of dredge can be operated and used. Plain suction, which is not used very often, cutter head, which is probably the most common, and wide-cutter head dredges of all different sizes. In addition there is something called a dust pan dredge which is used commonly on free-flowing rivers with sand substrates (slide).

I am not going to elaborate on disposal, but I am going to bring in a couple of aspects of disposal, because when we talk about selecting the proper piece of dredging equipment for a given project, we must consider what we are going to do with the dredged sediment. Generally, there are three different ways we can dispose sediments: put it back into open water disposal sites, put it in a diked upland containment area, or construct a containment area in open water commonly known to Great Lakes or a coastal area.

Each of these types of disposal alternatives has certain advantages and certain disadvantages. The only point I would like to make here is that you have to consider what you are going to do with disposal before you can select the proper piece of equipment - they must match up.

Let's talk a little bit about mechanical dredging first. This is a mechanical dredge (slide). As I mentioned, a clam shell or bucket dredge is really nothing more than a crane on a barge. It uses a clam shell bucket, like this, lowered into the water. It takes a bite, mechanically, of the sediment to be moved, raises that up through the water column, swings over, and places it into a barge or a scow, which is used to transport the excavated material off to the disposal site. Here is a closeup view (slide). You can see this is not a real clean type of an operation. This is black sediment and is what we commonly see in the coastal areas along the east coast, gulf coast, and west coast. It all looks the same no matter where you are. There may be different properties associated with the sediment, but visually it appears to be very similar.

With an open clam shell bucket like this (slide) we have sediment losses during the dredging operation. Water is mixed with the sediment and some materials are washed out as the bucket is raised. More sediments are spilled as you raise the bucket out of the water and swing it over to the barge. So, we have erosion of this load as we bring it up.

Most sediments settle very close to the dredging operation. And, of course, some of it is transported a certain distance away in the water column depending on hydrodynamics at the dredging site. We have monitored suspended sediment plumes around these types of operations in a number of different situations. What we usually find is right around the dredging operation. We may have several grams per liter suspended solids in the water column out to a distance of maybe, up to a 100 feet or so. As you get out 200 or 400 feet from the dredging operation turbidity decreases. By the time you get out to 400-600 feet, you cannot really tell too much difference between the suspended sediment of the water column and background suspended sediment levels. So, we have an area that will be affected as far as suspended sediment is concerned, out to some distance, depending on the hydraulics of the specific situation. This turbidity situation applies to fine-grained sediments. For sandy sediments, of course, much less suspended solids would remain in the water column.

This is a black and white slide of an enclosed bucket. This is one that we have evaluated and compared to conventional clam-shell buckets. And really, the closed bucket seems to have a great positive effect on how much sediment we leave in the water column while we are dredging. It is the same kind of a bucket except plates have been welded on it to allow the bucket to close, thus preventing a lot of the spillage and much of the washing out of material as this bucket is raised up through the water column. It does not adversely affect dredge production. This is something we could do if we see we do have a potential problem with a situation for mechanical operation. It may be used for a little extra cost and really does not affect dredge production.

This the same bucket without the plates (slide). You can see there is a dramatic difference between the amount of sediment spilled out, with or without an enclosed bucket. We have estimated the difference to be about 60%.

This mechanical dredge is putting material into a barge or a scow (slide). In some cases there are loading benefits associated with the practice of overflowing the scow. That is, we are filling it up to the edge, but we keep adding material and allowing it to overflow the side of the barge. This practice for mechanical dredging can have loading benefits because what we are doing is bringing up a load of sediment from the bottom which is more or less at the same density (or water content) as it exists on the bottom. You may have some water associated with it. But no matter what the solids concentration of this water is in this barge, if we continue to load it and continue to overflow we are gaining a load in that barge, up to a certain point. By overflowing barges, you can get an economic loading benefit.

Once a barge is loaded up to the desired point, it usually is transported out to a disposal site. In most cases there is an open water disposal site for this type of a dredge.

These barges usually are a split hull design. They can be transported a long distance. The hull opens and the material drops down at the open water disposal site striking the bottom. I will talk about that briefly when I discuss hopper dredging. One of the big advantages with mechanical dredges is that the material can be transported a long distance with no pipeline involved, and a minimal amount of water is transported. Also, mechanical dredges can be used with confined disposal sites. You can bring the barge beside a diked area, mechanically rehandle the material and place it in the dike disposal area. This practice seems to be becoming more common in the Great Lakes Region. Also, we can hydraulically off-load the barges. This is done in Baltimore at the Hart Miller Island Disposal site.

Let me talk a bit now about hopper dredges (slide). Hopper dredges are ocean-going vessels. Their big advantage is that they can continue to dredge, or continue to excavate sediment and not obstruct the navigation channel. They also can dredge in environments where no other dredging equipment can effectively operate, such as in wave conditions. They can get in there and operate because they are an ocean-going vessel. Hopper dredges resemble a ship except they have equipment which allow them to do the dredging.

These are drag-arms or trailing drag-arms (slide). Sometimes you hear the term "trailing suction dredge" applied to this type of equipment. They drag this arm behind them. You saw the schematic earlier. Water is entrained with the sediments. So, what is being pumped through the drag-arm is a slurry, a mixture of the sediments from the bottom and the overlying water. The slurry goes into the hopper, at maybe 100 to 150 grams per liter. Maybe more, maybe less, depending on how compacted the sediment is. It also depends on whether the dredging is new work or maintenance dredging. The dredged material is stored in the hopper. As the pumping continues, the hopper load is increased and it can overflow just as the barge overflows.

This is a view of another hopper dredge (slide). This is more of a sandy type of sediment which is the more common practice when you overflow.

This is a trough (slide). The trough is used for the overflow. Once the hopper fills up, the material begins to spill over into the trough. The object of doing this is, especially for sandy sediments, as we continue to pump, is so the coarser sediments will continue to accumulate in the hopper. Lower suspended solids material will overflow into the trough. So, we continue to gain a denser load by the practice of overflowing. There are a number of ways that the equipment can be configured to allow this overflow process to occur (slide).

The effectiveness of a given hopper dredge in retaining solids during overflow is dependent on not only the sediment that is dredged but also the way the equipment is designed.

Hopper dredges commonly go out to an open water disposal site to drop the material in open water. This schematic illustrates some of the major processes that occur as a load descends from the hopper. The same process occurs for barge disposal (slide). The main part of the disposed load descends quickly to the bottom. There is a spreading along the bottom to a certain extent. A certain amount of this material is suspended into the water column. And there is a certain amount of stripping of material off the load as it descends through the water column. But these portions of the load are within the range of several percent to 5-10%. It depends on the type of material that is being dredged. Obviously, for a finer grain, looser material, more of it initially is left in the water column. How far it goes, once again, depends on the hydraulics of the situation. There are ways to predict what this behavior will be.

I will talk now about the third type of dredge. This is the hydraulic pipeline dredge (slide), a small pipeline dredge. You see a couple of aspects that are important. These objects are spuds. They are also used in mechanical dredges, and hold a dredge in place while it is excavating sediment. This is the ladder, a structural assembly to get the business end of the dredge down to the bottom. This is the cutter head, the suction end of the dredge. A basket surrounds the cutter head. You can see it better in this picture (slide). The cutters turn and loosen up sediment. The cutter turns more or less the speed that my hand is moving. It goes relatively slowly, a few revolutions, one or two revolutions, per second. It tends to loosen sediment. It brings some sediment back up into the water column, but it is the cleanest dredge as far as suspended sediment of all the conventional dredges.

Some of the suspended sediment does come back into the water column, and we have monitored around it. We find at a maximum, somewhere maybe in the order of one or two grams per liter, in the immediate vicinity of the cutter head, and of course it decreases as you go farther out. Once you get out several hundred feet, low concentrations with fine sediment are encountered. If dredging is in sandy sediment, concentrations are much less.

You saw the spuds in the slide two slides back. Spuds are used to pivot this dredge (slide). It is not a self-powered dredge. It has to work by pivoting with anchors and winches and cable. One of these spuds is located at one point of the dredge and will be embedded in the sediment, the other is not. By pulling on the anchors and the cables the dredge swings back and forth in an arc. The cutter head is buried in the sediment, usually fully buried, swinging in an arc and pumping is continued. The way the spuds on the back of this dredge are worked will enable the dredge to cover a complete arc. As it swings back, it will have an area of overlap that has already been dredged when the

dredge swings back in the opposite direction. If you stand at the pumping or discharge end of the dredge, you will see a variation of suspended solids concentration. In one instance high solids, in another instance almost pure water. So, there is a variation.

Hydraulic dredges come in all shapes and sizes. From thirty-inch, large, very high flow rate (up to maybe 100 CFS or so), down to very small portable hydraulic dredges like this little Mudcat dredge which you could rent on your National Car Rental credit card (slide). You could go out there and dredge if you are inclined to. They come in all shapes and sizes.

Flow rates vary greatly, and the selection of the proper dredge size has a lot to do with how much material you have to move, how far your dredging site is away from the disposal site, etc.

In some cases hydraulic pipeline dredges dispose of the material in open water with a pipeline discharge like this (slide). This is a very common practice on some of the riverine types of dredging projects that usually involve more or less pure sand. But we can dispose in open water, and this thing is really neat to watch. It usually has a baffle plate on the end. The momentum of the water can be used to swing the apparatus and move it around, thus spreading the material out.

More commonly, a hydraulic pipeline dredge pumps material into a diked area, such as I showed you on that slide with three disposal alternatives.

This is the same dark color, fine grain sediment that we saw in the clam shell dredge (slide). This time though it is a slurry because the hydraulic pipeline dredge works just like the hopper dredge. It mixes sediment with overlying water and pumps it through the pipeline as a slurry. Usually the concentration of the slurry is about the same as the concentration of the material pumped up into a hopper dredge. It holds somewhere around 100 to 150 grams per liter. And, of course, the object of pumping into a confined site is to let most of the material settle out into a confined site which has a very low suspended solids concentration for the effluent water.

This is another view of a pipeline going into a confined site (slide), and this one is doing new-work dredging. Note the clay balls. This was a clay material. What this dredge is doing is cutting this clay into slices, and as the clay goes through the pipeline it erodes into a ball, like those shown. Therefore, you have a mixture of clay balls and slurry. The clay balls are in the same condition that they were at the bottom of the channel. They do not have water mixed in with them. You could walk on this material as soon as it is pumped. There is a great difference between what we see when we dredge maintenance sediment (that has come in just a few years), or new-work dredging, material that has never been dredged before.

You see a lot of difference between how the dredge works and how the disposal works. Confined disposal sites are nothing more than a diked area where we pond water to allow settling to occur. Coming in on one end, 150 grams per liter, and coming out of the other end, if you are in salt water, should be in the tens of milligrams per liter suspended solids, if the site is operated properly.

If you are in fresh water, it may be up to a gram per liter or several grams per liter, because the settling processes do not work as effectively in fresh water as they do in salt water. Of course there are a lot of different things we can do to improve that if we need to do something.

I did not address other dredge types. This is a pneumatic dredge (slide). I will just remark that there are a lot of different kinds of dredges other than the three major types that I have described to you. However, the three major types do 99.9% of the work on navigation projects in the United States. Special dredges, like the pneumatic dredge, or others that you may have heard about, are used for other applications. They are usually not available, but will produce a lot less suspended solids in the water column, an aspect of interest to this group.

I will stress that the production of those types of dredges is not up to the production rates that we need to have to effectively maintain navigation projects. So, those should be considered only in special cases where we have, for instance, highly contaminated sediments.

So, really, the three dredge types that I described are the ones that we should be mostly concerned with in this working group.

I have taken about 20 minutes. I have described very briefly a fairly complicated subject. If you have any questions I will be glad to entertain them at this time.

Q: (BY DR. RICKHUS). I realize that it varies from place to place, but what are some typical kinds of maintenance dredging requirements in terms of time? Say, something like up in the Delaware River. How much maintenance dredging would have to be done, typically, in a year?

A: (BY DR. PALERMO). Well, this is a very project-dependent thing. We have districts that have maintenance-dredging requirements. I can give you an example. Norfolk Harbor has a maintenance-dredging requirement of five million cubic yards every year from the Hampton Roads area.

Then you have other projects that may involve a hundred thousand cubic yards every five years. There's such a wide variety of the volumes that have to be moved that you really can't make a blanket statement.

But this has a lot to do with selecting a proper piece of dredging equipment, and the type of disposal alternative that really is feasible for use on a certain project.

So, really there's a great variety.

Q: (BY DR. RULIFSON). I have two questions. One is, what degree of precision do you have in the dredging operation itself? In other words, if you wanted to dredge to fourteen feet water depth, is that a plus or minus a foot or--

A: (BY DR. PALERMO). Well, it depends on the water depth and it depends on the type of equipment you use. But generally, for a hydraulic pipeline dredge, I would say that the precision that we know that we're cutting was plus or minus half a foot to a foot, something like that.

Q: (BY DR. RULIFSON). I suppose there are several different ways that the actual dredging can influence how much sediment appears in the water around the dredge. Can you quantify from the dredge out, say in a river system, how much the sediment load is and how far out it would go? Just in this, whether it was a hopper dredge or a hydraulic dredge, either one?

A: (BY DR. LASALLE). I'll get to that in a minute.

A: (BY DR. PALERMO). He's going to be talking about sediment concentration from various dredge types which is based on some data that we both have looked at. We have done a lot of monitoring of different dredge types, especially these three, what I call, "conventional dredge types," what types of suspended sediment they produce. So, those numbers are known for a number of projects. There are ranges. I'll just say this, it depends on the dredge. It depends on the sediment. It depends on the hydraulics. So, you've got a lot of variables.

Q: (BY MS. DORE). You showed and talked about dredging where you are pumping material into some kind of a hopper or into the scow and you were allowing overboard plume to escape so that you can get your maximum concentration of material to be moved. Have you done a study on what fines are in that overboard discharge and how far it travels?

A: (BY DR. PALERMO). Those have been done for a few studies and we're in the process this year of doing some additional studies on overflow.

But I do know this, I can quote you numbers from one mechanical dredging operation. This filling of the scow with the bucket. It was done in the New York district. And there they found that the overflow of the barge contributed about the same amount of sediment to the water column as did the mechanical dredging operation itself. And that was a silt material. So, I'm not going to say that that's going to be the same numbers because that could depend on things like the depth of the water and type of bucket you use, the size of the bucket, and a lot of different things. But, generally, I would say that overflow from the scow would be on the same relative order as the amount of sediment resuspended by the dredge itself, if you overflow.

Q: (BY MS. DORE). All right, I've got another question too.

A: (BY DR. PALERMO). Fine grain sediment?

Q: (BY MS. DORE). Yes. You showed a device on a clamshell dredge which further contained the material to the dredge rather than it being spilled over the sides. What latitude does the Corps of Engineers have with private contractors in stipulating what kind of criteria that contractor will use in order to do a dredging project? The Corps of Engineers doesn't actually dredge every single thing, not in my experience.

A: (BY DR. PALERMO). That's true. But we do have the latitude to put things like that in contracts. But, I will make the statement that we would not be inclined to do that unless we saw that there was a benefit to be obtained out there by doing that. A real benefit. And in the case of the closed clam-shell bucket, I mentioned that it does not really reduce the production of mechanical dredges but it does cost money, because what you've got to do is to modify the equipment. The closed bucket modification, to my way of thinking, is not that expensive. All we're talking about is doing some welding of the bucket. In some cases the contractor may not have a bucket design that is amenable to that type of a modification. And we may be talking about forcing him to buy a new bucket or something like that.

We are talking about three dollars a cubic yard for a half million cubic yards. You could buy a bucket or two for that kind of money. So the percentage is relatively low for that type of a modification.

There are other modifications we can do for hydraulic dredging which also would affect dredging cost, such as controlling the rate of swing of a cutter head or the rate of rotation of the basket or the depth of burial of the cutter head. Those have an effect, but not as dramatic an effect as for mechanical dredging.

Q: (BY DR. RULIFSON). You said "a cost of three dollars a bucket." Is that just a number off the top of your head?

A: (BY DR. PALERMO). It's going to depend on a lot of things like distance from the disposal site and things like that. In general, mechanical dredging is more expensive than hydraulic pipeline dredging. The reason for that is we don't choose to do hydraulic pipeline dredging unless we have a disposal site that's within a reasonable pumping distance.

You have that, and usually the unit cost of removing a cubic yard is less with a hydraulic pipeline than for the mechanical.

A: (BY DR. HOMZIAK). If I could suggest, we do have a whole series of technical publications where all these subjects are covered in explicit detail.

A: (BY DR. PALERMO). I'll be glad to tell you about that. And I understand we're going to give some kind of a written summary here, in which I can give some additional information. If you ask for my card I'll be glad to send you a more detailed discussion of all this.

Overview of Dredging Operations (Environmental)

Mark LaSalle
U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, MS

I have the task this morning of addressing dredge-related environmental questions, and I will try to do it as best I can. There are a number of variables to consider. Before I start I want to emphasize a very important positive. The types of environmental and chemical alterations occurring around a dredge are for the most part related to the efficiency of the dredge. As Mike Palermo so well described, there are differences between the way different dredge types operate and each and every project will be slightly different.

Site specificity is very important to consider. In different areas, the degree of sediment suspension depends on, as Mike suggested, the type of dredge, and the way the dredge is handled. If the operator is not concerned about how fast he brings the bucket through the water, he can suspend a lot more sediments than if he takes his time with it. Cutter head speed is also a variable as is the type of sediment. All these variables have a lot to do with the quantity of sediment suspended, and the definition of the sediment field around that particular dredge. Lastly, the size and the configuration of the body of water you are working in has a lot to do with the things we are concerned about here.

What I am going to try to do briefly is to review what we know about the physical-chemical environment alterations around a dredge. These alterations are largely related to the suspended sediment field since sediment is what we are removing. Anything that is going to affect the environment or water quality is related to the concentration of that material placed into the water column, and whatever else is associated with it. In the case of chemical contaminants, the release of those will also be related to how much material you suspend in the water column. All of these variables, as I suggested before, are related to the efficiency of the dredging operation. If we were removing a cubic yard of material and could remove the entire cubic yard without contacting the water, we would have no problem. But dredges are not that efficient.

Three main concerns are usually associated with dredging: 1) the suspended solids field around the dredge; 2) dissolved oxygen reduction; and 3) chemical contaminant mobilization. Concerns about dredge-induced alterations are largely related to the quantities of suspended sediments. However, because of the anaerobic nature of dredged material, there is a concern about potential DO reduction. For the purposes of this discussion I will not address contaminated sediments and the problems with these, but I will briefly discuss the mechanisms associated with chemical scavenging by sediment compounds.

I will spend most of the time defining the suspended sediment field, again, remembering that all these fields will be site specific. I want to summarize the ranges of concentration of this material at the surface and the bottom of the water column and at distances out from the dredge. We can compare the types of dredges that Mike just discussed and their effects on this suspended solids field. If we look at suspended solid concentrations from the surface and the bottom related to these dredges, it becomes very obvious that bucket dredges suspend more material for obvious reasons. The bucket is bringing material from the bottom all the way up through the water column. Spilling of material out of the bucket and washing of material off the sides of the bucket contribute to suspension of a lot of this material into the water column. You will encounter a concentration in the range of up to 700 milligrams per liter in the upper water column, and eleven hundred milligrams per liter in the lower-water column. As opposed to the hopper and cutter head dredges, which are more efficient at the business end, bucket dredges work at the bottom. Therefore, you would expect to see higher concentrations at the bottom, and very little suspended sediment in the upper water column. Usually they are within 100-150 milligrams per liter at surface and up to 500 milligrams per liter at the bottom.

What I have described up to this point is vertical distribution of suspended sediments. What about horizontal? If we look at surface plume lengths (this is in meters) at the surface and at the bottom, again, we see that bucket dredging, because the suspended materials go all the way through the water column, is going to have a plume that extends a lot farther out, generally, at the surface. In the case of hopper dredging, it depends on the body of water, and the hydraulics of the system. Because the business end is on the bottom, you get plumes that can extend out several hundred meters to a thousand or so meters. Cutter head dredges, for the most part, are the cleaner of the operations. Plumes generally do not extend more than about 500 meters from the dredge.

This graph gives you a better idea of the spatial characteristics of the suspended sediment field around the three main types of dredges. You will notice, in the case of hopper dredges, we are talking only about hoppers without overflow.

This graph gives you more detailed data about both the vertical and horizontal distribution of that material around a hopper dredge with overflow. There is a big difference because, as you know, material is introduced not only at the business end of the dredge, but also at the top of the water column. Note the concentrations. These are at various depths in the water column. Concentrations can get as high as 1000 milligrams per liter in given areas. But remember, site specificity is very important to consider.

This next graphic provides a more detailed comparison of a clam shell bucket dredge and a cutterhead dredge. The isoline that we have listed here is a 50 milligram-per-liter line up to seven hundred feet away from the dredge. It is easy to see that there is a major difference (at fifty milligrams per liter) between the dredges. This is because the bucket is traversing the entire water column, as opposed to the cutterhead dredge where most of the activity occurs on the bottom. In this case, we are talking about concentrations as high as 130 milligrams per liter, as opposed to background concentrations in the upper-water column of 30, and at the surface as little as zero. The clam shell would tend to introduce a lot more material to the water column. But as this schematic would suggest, the concentration is not that high. Again, site specificity is very important, as is the type of sediment.

With another set of data you get an idea of the effect of tides on the plume. In this case a cutterhead dredge is dredging in a riverine coastal system. Again, we're talking the 50 milligram-per-liter isoline, but I would also point out the 100 milligram-per-liter isoline is approximately 10 feet off the bottom. The effect of a high velocity ebb tide, in this situation, is to increase the concentrations in the upper-water column. It is obvious, however, that a lot of material is restricted to the lower water column.

Another example of horizontal distribution away from the dredge was noted in a Savannah River project. It was obvious that a lot of this material, in the two hundred milligrams per liter range, was in the lower-water column. Generally, concentrations drop off exponentially away from the dredge. Within 1200 to 1600 feet of the dredge on the bottom you are near background levels as opposed to the middle and upper-water column where within shorter distances, you are back to near background concentration levels.

In order to evaluate a given dredging project's impact on the system, we have to understand what is naturally occurring in the estuary and put it in perspective. Not only must we understand what the dredge does, we must also consider other activities which produce similar concentrations of material in the water column. It has been suggested that dredges, regardless of the type of dredge, produce what is called a "near-field phenomenon." In other words, the dredge impacts a very restricted area, generally within 500 meters around a dredge, where impacts occur in terms of suspended sediments and dissolved oxygen reduction. Chemical mobilization can, depending upon the concentrations, affect a larger area. If a dredge operates in a small, restricted channel, it could cause greater problems than if it operates in a larger embayment. We have to understand the sediment field, and we can generally define it as largely restricted to within 500 meters of the dredge.

There are natural occurrences in estuaries, however, that can affect environmental alterations to the same degree as dredges. Storm surges, for instance, whether they are winter storms, or hurricanes, can elevate suspended sediment levels similar to or greater than that of a dredge. Storms can also occur at greater frequencies than dredging activities. Storm surges in the northeast, for instance, can occur on a cycle of 1-5 storms per year. A study in the northeast suggested that a single storm can introduce into the water, probably two and a half times the suspended-sediment concentrations that we see around a dredge. And it could suspend these levels baywide. So, in the perspective of the dredge, you are talking about a dredge that is operating in one spot in the estuary, whereas storms will affect the entire estuary, and much more frequently than dredging. A migratory fish does not know the difference. I am not trying to justify dredging with this statement, rather, I am pointing out that we have to consider the other types of phenomena that can happen in the system so that we can separate out what the dredge might be doing.

Another type of activity that introduces sediments in the water column, is shrimping. The shrimping industry is very large in this country. And shrimpers are typical of the types of people that are concerned with the effects of dredging. Shrimping does not only affect the amount of suspended material that is introduced into the water, but also impacts the bottom. One study along the gulf coast suggested that shrimping may produce suspended solids concentrations behind shrimp trawlers approaching 500-600 milligrams per liter, well within the range that dredges produce in the near field. It should be noted that shrimping is generally a baywide activity.

One activity that we need to understand is that the very vessels that use the channels that we are maintaining have an effect on suspended sediments as well. If you have a 40-foot channel, and a boat passes through drawing 30-35 feet of water, it produces a prop wash. Although we do not have good measurements on prop wash, it is going to suspend loose material on the bottom of the channel and it is going to do it every time the vessel passes regardless of whether it is one time a day or three times a day. Suspended sediments from prop wash will affect the organisms that we are concerned about, whether they are fish or shellfish.

Dissolved oxygen reduction, as I said earlier, is perceived to be a problem because dredging suspends anoxic sediments. Well, how do we get a handle on that? The obvious approach, earlier on, was to go out and measure the dissolved oxygen around a dredge. Well, a lot of probes were dropped into the water and except for the disposal end of the operations, very few measurements of significant dissolved oxygen reductions were measured. In the few good studies associated with a dredging operation, dissolved oxygen actually increases slightly, because of the turbulent activity around the dredge.

Without being totally satisfied with these findings, we tried to understand the cause and effect relationships between suspended anoxic sediments and oxygen demand. This approach requires estimating how much dissolved oxygen you would expect around a dredge given the amount of material being suspended, and a simple understanding of the causative agents. If we take that approach, we can estimate and predict the type of problem we may or may not have. To accomplish this, we have developed a very simple model which predicts the degree of dissolved oxygen reduction.

Basically, what we suggest is that oxygen reduction is related to the quantities of suspended solids that are introduced in the water column and the oxygen demand of this material. Oxygen demand can be estimated in several ways. We chose to look at volatile solids concentrations as related to BOD and residence time. In other words, how long is this material left in the water column, and how long is a given parcel of water going to be exposed to that oxygen-reducing material? This process can be related to flow rate and water-body dimensions.

I will discuss some simple calculations obtained from a project that's on-going in the New York District, Haverstow Bay. This is a fairly wide embayment with the dredging channel in the middle. We first estimate the quantities of volatile solids that are in the sediments that are being dredged, in this case 1.6% volatile solids. We take into account the quantities and materials being suspended as per our understanding of the suspended sediments fields around a typical dredge. We also assume that we are suspending maximal amounts. For a typical bucket-dredge operation 400 milligrams per liter are introduced within 100 feet, and 200 mg/l within 100 feet. Within the remaining 1500 feet, 100 milligrams per liter are introduced. We assume these

concentrations throughout the water column. Therefore, we are being conservative in our approach. We are also conservative in that we assume the plume extends completely around the dredge, which is not usually the case. Usually the field will be elongated depending upon the current characteristics and the environment at that particular site. After all the calculations were made, the model predicted that dredging reduced the dissolved oxygen in a given parcel of water by .016 milligrams per liter. Does that fit? Well, actually, when we have gone out and measured DO around the dredge, maximum DO reduction was about 0.2 mg/l. If we run through these calculations again, and assume an even higher concentration of more volatile solids (14%) we find that the dissolved oxygen in that parcel of water is reduced by 0.56, or half a milligram per liter. Dredging is simply not introducing a lot of suspended sediments into the water column. Most of it is a bottom phenomenon, well within 500 meters of the dredge, of concentrations within 500 milligrams per liter. I would reiterate, that site specificity is all important. In some situations the DO is much lower under normal, unaltered conditions.

Regarding chemically contaminated mobilization we are primarily concerned with heavy metals and chlorinated hydrocarbons. In soluble form they can be very problematic to living organisms. In other forms, however, they can be introduced via ingestion by organisms. I will simply talk to you about the fate of these materials that are released during the dredging activity. What happens to that material once it is released from the sediment?

One of the main processes that is occurring is metal scavenging by iron. Iron is a very important component of sediments in most estuaries and is in a reduced state in the bottom. The metals that may be there, and the other compounds, are free in the sediment, not necessarily associated with anything, except perhaps clay particles. When sediment is resuspended the metals and compounds are carried up into the water column and interactions occur rapidly. Iron is oxidized, becoming very reactive and tends to scavenge most of the metals and other compounds in the surrounding water column. Through sediment settling this material is transported back to the bottom. When we measure dissolved heavy metals around dredging, they are, in most cases, at very low or undetectable levels, largely because of this rapid process.

I am not going to address the effects of, or the amounts of, dissolved compounds in the water column. There could be very serious alterations and we probably will touch on some of the sublethal, as well as lethal, aspects of these contaminants later. However, for the most part, when we talk about Corps projects we are talking about sediments that in general are relatively clean.

Another group of chemicals of concern are chlorinated hydrocarbons. These compounds are scavenged by clay particles and/or organic matter. They are physically absorbed onto clay or organic particles because of electrostatic processes acting on them. Once scavenged by these particles, they fall back through the water column and return to the bottom. Here again we must mention the potential for ingestion of this material and the potential harm if there are high concentrations of these chemicals associated with sediments.

My presentation has been a brief summarization of environmental alterations associated with dredging and consequences that may affect fisheries. I want to reemphasize that each project is unique. Sediments will be suspended in the water column at different rates and different concentrations because of all the different variables acting on the system. We have to understand the

variability and place it in perspective with regard to the background of the system. If we are dealing with maintenance dredging in an existing channel, we have to keep in mind the impact of dredging along with other activities occurring in the system so that we can put them in perspective. A fish is not going to be able to tell the difference between a plume that is produced by you going out in the water and mucking up the bottom, or by a dredge. You have to keep in mind all the potential sources of disturbance, whether they're man-induced, or natural phenomena, that will affect the passage of fish through coastal systems.

If you want a more specific explanation, as Jurij suggested, we do have reports. Mike Palermo will be glad to fill you in on the physical aspects and specific data on the suspended solid concentrations around dredges.

Q: (BY MR. EARHART). What is the percentage of the material that the Corps dredges that's contaminated?

A: (BY DR. PALERMO). I can answer that question. Approximately 10% percent of the total volume that the Corps moves on an annual basis is deemed unacceptable for unrestricted open-water disposal areas. This does not mean it's heavily contaminated. It means it has flunked some set of criteria that would determine it to be acceptable for open-water disposal. So, really the fraction of materials which we deal with that are contaminated are only a small fraction of the total yardage we have every year.

Q: (BY MR. EAGER). Is there any way that the Corps has of manipulating the plume configuration downstream, and what the near-, mid-, and far-field effects are of those kinds of physical manipulations?

A: (BY DR. LASALLE). The only physical manipulation, and I'm sure Mike could talk about that in more detail, is that you can deploy a silk screen. Silk curtains can be deployed to reduce any perceived movement of that material at distances away from the dredging. In other words, you can deploy these things out to stop them, particularly at the surface and the mid depth.

Q: (BY MR. EAGER). What I'm thinking of is the width. Now, the plume will go down 1,500 feet. That's already a given. If you allow 15 straight down then you have a passage way around that, no problem or the problem is very much reduced for safe passage traversing the area. Is there a way to eliminate to the side? How far down do you have to stop for that? Anything ever done on that note?

A: (BY DR. LASALLE). Not that I'm not familiar with.

A: (BY DR. PALERMO). It's really related to hydraulics of the system. The silk screens are effective only in certain conditions, usually where there is low current or velocity. They do not do anything to remove turbidity from the water. All they do is force the turbidity down to the lower part of the water column. But they're only effective in doing that in low velocity environments. Less than a knot, I would say.

(FIVE-MINUTE RECESS)

Q: (BY DR. RULIFSON). At the coffee break we talked about potential effects of pH change as a result of dredging operations. For the record you might want to give your answer again.

A: (BY DR. LASALLE). What we know about pH is very limited. In the one study I am familiar with, no measurable effect or change in pH in the vicinity of the operating dredge was detected.

Q: (BY DR. RULIFSON). In the water column?

A: (BY DR. LASALLE). In the water column, at various depths. It wasn't an exhaustive study but in retrospect unless we're dealing with sediments that would have very high amounts of organic materials in them, that would be the potential problem. The introduction of high organic materials possibly could affect the pH, or anything else. I want to make another point about this, and it relates to his question but it also relates to the things I talked about relative to DO. Think about the quantity of material we're suspending, remembering that this is the sediment the dredge has not removed. We're introducing them in the water column and the dilution effect is very important. We have to consider that too because a lot of material settles out very rapidly and is simply diluted in the large scheme of things, even in a restricted channel. That bears on his question about pH. At this point, I don't know any other evidence to suggest that it alters pH drastically.

DR. MANDOCH: (Takes the podium.) At this time we are going to move some fish into the program. Bill Richkus, who is with us from Columbia, Maryland with Versar, Incorporated, is going to tell us about the management and biology of East Coast anadromous species.

Overview of Anadromous Fish Biology and Management

William Richkus
Versar, Inc.
Columbia, MD

I just attended a meeting in Dallas, and so I have been to fisheries meetings since last Saturday. I was also a little bit fuzzy on what I should talk to you about today. Given the range of the speakers later in the program, I thought I would provide background on the management of the anadromous fish, particularly the alosids and striped bass. This may be especially useful for those of you from the Corps who are not familiar with the parties that are players in this whole thing. Then, I thought I would give a very generalized overview of life history aspects of the alosids. I'll touch on striped bass. Later, I will give you an example of the kinds of management recommendations that are in the interstate plans, which will give you an indication of the relative concerns with regard to different aspects of the species biology, and concerns about the status of the stocks.

One thing that I think that everybody should be aware of, is that in a lot of individual states, my impression is that many of the water quality agencies tend to deal with dredging problems. And, in the management programs, it is invariably resource management agencies. In many states there is not very good communication between those groups. I think some of the problems the Corps runs into is that they are dealing with people from different segments of the state who do not have their own act together. And when you get into these interstate migratory species, you've got worse problems because the states can't get their act together.

So you all, especially at the district level, where you encompass different states, may encounter states that disagree, and government agencies within the states that disagree.

(Slide presentation.) Therefore, I have great empathy for your situation. Let me begin today with the alosids, starting with the background of management.

Alosids, as well as striped bass, migrate along the East Coast. Individual states have regulatory authority for fisheries within their own internal waters and out to the three-mile limit. When fish leave the state's waters and enter the coastal waters, the Atlantic States Marine Fisheries Commission (ASMFC) is responsible for overseeing management of those species. However, ASMFC is only an advisory body, and does not have regulatory authority. So, the way ASMFC works is that it establishes a management board for a particular species. In the case of alosids there are four species lumped together: American shad, hickory shad, blueback herring and the alewife.

There will be a management board which has on it, generally, administrators to make sure the states and the two federal agencies, Fish and Wildlife Service and National Marine Fisheries Service, cooperate.

That board is assisted by a Scientific and Statistical committee, an S and S committee, which has technical representatives from each of the states and the two federal agencies. The S and S committee is the group that deals with characterizing the species biology, identifying management problems, and coming up with the recommendations.

That material is compiled, approved by the board, and constitutes the ASMFC management plan. But as you can appreciate, the states are not bound by the plan. Basically, the plan establishes recommendations or suggestions which the states may or may not follow. In many cases, my impression is that the states do not follow them for various reasons, mainly political and social.

The only species for which there is an exception is striped bass. And in the case of striped bass it was such a politically hot issue that there was federal legislation passed called the Studds Bill, also referred to as the Striped Bass Conservation Act. The Studds Bill indirectly gives ASMFC regulatory authority. What it says is that the states have to follow ASMFC recommendations on striped bass or the federal government will impose a moratorium on striped bass harvesting.

The planning process for the alosids, on the other hand, went pretty smoothly because, number one, the species were not very controversial, and number two, the states did not have to follow anything that was said in the plan.

The striped bass is very, very different. Everybody pays a lot of attention to it because if the states do not follow what is in the plan, their authority gets taken over by the federal government. None of the states wants that.

The other management groups that come into play, which you should be aware of, are the Regional Fisheries Management Councils which were set up by the Magnusen Act (1976). They regulate fisheries between the three-mile limit and the 200-mile limit. For the species we are talking about today, their role is not that great except for the possibility that species like river herring, the alewife and blueback can be taken in offshore fisheries in the Fisheries Conservation Zone (FCZ).

Now, with regard to where we are in management is that in 1985, after about two-years' work, the interstate management plan for the anadromous alosids was released. I understand the Corps requested numerous copies. I don't know how many of you may have seen it. It is a large document, and covers the four species. It is a compendium of the status of information, up-to-date, hopefully, on species biology, status of the stocks, and includes all the recommendations. It was issued in 1985, although we really completed it in 1984. We have had a couple of meetings this past summer to up-date it, review the recommendations, and reassess what we have accomplished.

With regard to striped bass, there is an ASMFC management plan on striped bass which was issued in 1981. We are in the middle of redoing that plan. What has been accomplished so far is that there is a background document called the Source Document for Striped Bass, available from ASMFC. This was issued this past spring. We are in the middle of working on a revision on the management plan, but we are not going to get that far, I don't think, this year. We have a series of meetings this month and next month to develop a time schedule for revising the striped bass management plan in 1988. So, that is where the management process stands.

I also have some information from studies that we at Versar have done that relate to dredging. However, I think I will hold off until we get later into the program before talking about actual dredging effects, because many people are not familiar with our work. It was done for NOAA, and will probably be relevant to some of the issues that will come up later.

(Slides). These are the four species that are of concern: American shad, hickory shad, alewife and blueback herring. They are all shown in relative size. In terms of importance, American shad is probably the most important one. There is a substantial commercial fishery and recreational fishery for them.

Hickory shad are primarily a recreational species, although they fill a niche in commercial fisheries down south, particularly in North Carolina, because they appear earlier than American shad.

The river herrings are a major commercial species mainly in Maryland, Virginia, and North Carolina, and also up north, particularly in Maine. River herring is the term used for both alewife and blueback, because they are very difficult to distinguish. In many commercial landings the two are reported together, which causes some problems when you try to make species-specific decisions.

These are a series of summary slides, and I put them up here mainly as a focal point. This is an overview of the entire species biology, and of the material that I put together for this document. The speckled areas represent the range of the species. In the case of the American shad, they extend from St. John's River, Florida up into Canada. In the spring they enter their spawning waters to spawn. The bars on the map represent the period of spawning migration within different regions. You can see down south they start quite early. Some of the other speakers are going to get into this in more detail. But, generally, way down south it begins as early as February and extends into April. Dick Eager tells me it even covers a much greater period of time than February-April.

In the mid-Atlantic states, spawning migrations generally occur from April into June, maybe a little bit into July, and considerably later farther north.

From Chesapeake Bay north most spawning fish survive. They are not like salmon that die after spawning. South of the Chesapeake Bay the fish do die after spawning. So, there is no repeat spawning. Those that survive, move back out to the coastal waters, and together with the immature fish, those that are out in the ocean already, make a circuit up the east coast. They move up into the Gulf of Maine and into the Bay of Fundy in the summer, which is their foraging ground. Then they move down the coast and tend to overwinter, generally, in the mid-Atlantic Region. In the spring, again, they initiate the migration to their spawning grounds.

The habitats utilized by the species are represented in this lower part of the graph. And again, these are very general characterizations. But for shad, "J" is juvenile, "I" is immature, and "A" is adult.

The nursery grounds for the juveniles tend to be in the rivers, and tributaries of rivers extending into estuaries. Particularly in coastal areas like the Chesapeake Bay and in many of the major estuaries, there is a lot of spawning in the tidal fresh waters in the estuaries, as well as up in the riverine systems.

An interesting phenomenon in the Delaware River, which is somewhere in the middle here, is that the spawning grounds for the Delaware stock had been identified very far upstream, in totally riverine fresh waters. However, we are doing a survey of striped bass spawning in the tidal Delaware, and this spring we found tremendous numbers of shad larvae. So there is substantial spawning in tidal fresh waters in the Delaware as well as farther upstream.

In other systems, most of the spawning is way up in the rivers. The juveniles remain in the rivers and estuaries until the fall, then emigrate as temperatures drop. It is probably a fairly rapid migration, once initiated. They move out into the ocean and enter the migration route with the adults and the immatures. Mike Dadswell who, I guess, did not show up today, has a lot of information to show the pattern of movement through the Bay of Fundy.

It appears that different stocks are more or less segregated from each other even though the entire mass of east coast stocks makes this route. I will show a slide later from Mike Dadswell's data.

Hickory shad is an interesting species and was included in the plan. It is an important species for recreational fisheries, but a very low priority species for most of the states and commercial interests. As a result, very, very little work has been done on them. The species is in major trouble in Maryland. It could well be extinct in many of the former places where it occurred. However, the State of Maryland does not have any data to demonstrate that, or demonstrate that they are recovering, or anything else.

Hickory shad are a more southern species than the American shad and, probably have spawning populations from Maryland south. In Rhode Island last year, there were substantial numbers taken in recreational fisheries, and there are other reports of them being taken out on Cape Cod.

Hickory shad tend to migrate a bit earlier in than American shad. The more northern stocks make their spawning migrations later than the more southern stocks. Their distribution and pattern in the ocean is very poorly known and not well documented, as is their use of nursery areas, relative to shad. It appears that juveniles use estuaries more than the American shad do. The adults and immatures are out in the ocean. But again, we do not know where or when. So, it is a poorly described species. It has not come up as an issue in many cases mainly because the agencies tend not to know very much about their hickory shad stocks.

Blueback herring are the most ubiquitous of the stocks. They range from Canada to Florida and are very dominant in the southern part of their range, and very prominent in northern states like Massachusetts. They make a migration route similar to that of the American shad. Roger will discuss this. They spend the summer and fall in the north, over-winter in the mid-Atlantic states, and in the spring come south and probably enter their individual spawning areas.

All these species home to the streams in which they were spawned, which is typical of anadromous fish. Although, I think, with river herring there may be a lot of strains, and Joe Loesch believes that in the Chesapeake Bay there may be a lot of intermixing among tributary stocks.

Blueback herring, as you can see, are very early in their spawning runs to the south. They tend to be the earliest species in other areas. They appear from April to June in the south and from May to July the farther north you get.

Their use of habitat is similar to American shad. One point of distinction is that bluebacks enter very, very small streams. Certainly in the Chesapeake Bay they would be found in nearly all the small, very tiny estuaries, or tiny tributaries. But they also use tidal fresh water and are therefore ubiquitous. They can be found pretty much everywhere.

The juveniles stay in the river and estuaries, similar to shad. When the temperature starts dropping in the fall, they migrate out into coastal waters, and remain in the ocean.

Shad return to spawn at ages four, five, and six. For blueback herring perhaps three to five would be the primary ages. Males tend to mature earlier than females.

Alewife are very, very similar to blueback, but they have a somewhat more northern distribution. They are the dominant species in Canada and Maine. They tend to be later spawners than the blueback herring. A very interesting phenomenon up in New England is that their primary spawning grounds are in lakes and ponds. Local communities have fishways that go into small ponds.

When you get farther south, that situation tends not to exist with some major exceptions. Alewives spawn farther down tributaries in the bigger rivers than do the blueback herring. They use both fresh water and estuarine waters as nursery grounds, and again, migrate out into the ocean in the fall. They probably make the same migratory route as the blueback herring and the shad.

So you can see, all four of the species have fairly similar life styles. However, each divides the habitat in different ways, both in timing, and in specific subsections of the habitat. I feel sure that from a dredging perspective this period of migration is the primary factor of importance to the agencies. Certainly, juvenile downstream migration is another aspect of life history that could be affected. In some localized areas, there might be concern about dredging effects on spawning success.

While I have this last geographical slide up here, I will briefly discuss striped bass. The three primary stocks are in the Chesapeake Bay where they spawn in maybe seven major tributaries; second, the Albemarle Sound; and the Hudson River is the third. Striped bass also migrate in the spring to spawn. They do not use the upper parts of the tributaries and rivers. They occur in the tidal fresh water and very, very slightly brackish waters in estuarine areas.

They have a much more complex life history than the alosids. Age of maturity is variable. That is, a certain percentage of the year class will mature at one age, more will mature the next year, and more will mature another year. The age of maturity for females ranges from five to nine. And there is new data coming out this year which changes our prior views. When not spawning most striped bass remain in the ocean. They show a general northern

migration in the summer, and a southern migration in the fall. North Carolina is a major overwintering area. But you can find immature fish all along the east coast in different areas. Striped bass juveniles tend to remain in nursery areas for a much longer time than do the alosids, generally for at least two years. Again there is new data contradicting old information about how long males stay in estuarine waters. It used to be believed that they did not migrate. New data from Chesapeake suggests that they migrate the same as females.

The complexity of their life history poses much greater management problems for striped bass than for the alosids. With regard to dredging, I think the primary concerns would be with spawning and potential dredging effects on spawning. Because their migrations are less discrete than the alosids, they tend to be in much, much larger waters. And in terms of nursery areas, they utilize virtually an entire estuarine area and are not restricted to relatively narrow portions of riverine sections or habitat.

This is total American shad landings of the east coast (slide). And if you have seen material on landings, nearly all the anadromous species have a pattern of total commercial landings that declines. It is a low point right now.

This record goes back to 1930 and there are obviously a lot of fluctuations. One of the problems you have with using landings data as an indicator of fish abundance is that the amount harvested is also a function of how many fisherman were out there and how intensively they were fishing. Effort changes. That information is, as a time series, pretty difficult to get and is of questionable quality. So, in most cases we have used total landings as a gross indicator of fish abundance. In the case of shad, landings for the 1950's and '60's stayed relatively level with a slight decline, about the beginning of the '70's, where they began declining precipitously. But the decline is different by region. In New England, the landings are fairly low for American shad. In fact, almost all of these landings through this whole time period are from the Connecticut River. There are some ocean landings in other states, but nearly all the New England shad are of Connecticut River origin.

Historically, in the mid-Atlantic there were tremendous landings from both the Delaware and Hudson River. You are all familiar, I am sure, with the Delaware's water quality problems, and the oxygen block in the river that knocked that run down to virtually nothing. The Hudson has sustained a very good shad run.

But another factor comes into play in landings data and that is the market. Shad is a very seasonal species. People eat shad in the spring and then that is it. They are all done for the year. What happens with the Hudson is that people down south catch the fish early, flood the markets, and even though the Hudson has tremendous numbers of shad, they are not worth fishing for, because the price is too low. Most of the landings in here (slide) have been from the Hudson. These graphs only go up to 1980. With the recovery of the Delaware, which has been remarkable, Delaware landings have increased. This curve continues going up, but you have a market factor that keeps landings down.

The Chesapeake Bay is the major contributor to the overall coastal pattern of landings that shows the decline. In the Chesapeake Bay landings, we're bouncing along pretty good until about 1970 and then they just crashed. This has been the major impetus for ASMFC having undertaken an interstate management program.

Somebody mentioned earlier the linkage between anthropogenic to environmental change, and responses of stocks. This has been a subject of God knows how many millions of dollars of research, not just on shad but all the anadromous species. The linkage still is not there. I mean, you just can not say why that happened. But it did happen. And the Maryland stocks, particularly, remain very depressed. They have not recovered.

When you get into the south Atlantic region, shad is not a major species. The primary source of shad in commercial landings for the region is North Carolina. The stocks throughout the south remain fairly depressed.

There is a lot of new information being developed by a subcommittee of ASMFC investigating fishing exploitation rates. There is no question that many of the stocks may have been overfished. But that is not the sole reason for the decline, and it is probable that environmental factors may be keeping stocks from recovering even though the fishing problem may have been alleviated. But that is not a hard fact.

These (slide) are the original series of the lengths of river that shad used; and this is the length of river currently available to them (slide). You can see in most of these rivers that dam construction has reduced their total habitat substantially. Fortunately, there are now numerous restoration programs that are attempting to reestablish fish passage. So, a lot of this original habitat is being reopened in many states. One of the major restoration projects is in the Susquehanna, which used to support extremely large runs, and now has a dwindling population.

So, there are steps being taken to get fish into new habitats, which then raises some questions and problems with preserving new habitats that are not now occupied.

This is a slide from Mike Dadswell's work. The point here is to illustrate that fish that utilize the Bay of Fundy are from the entire East Coast. Mike Dadswell tagged shad in the Bay of Fundy. The fisheries concern is that there is an organization proposing development of tidal hydropower in the Bay. Since we have stocks from the entire east coast, from St. Johns all the way up, using that area, the construction of tidal hydropower in the Bay of Fundy could pose a threat to shad stocks throughout the entire coast. This illustrates the similarity of behavior of all these stocks when they are in the ocean.

Jumping to river herring, Paul Perra, from ASMFC, stole my east coast graph, but it is very similar to the one for shad. One of the primary factors in the 1970's that probably drove river herring down was an upsurge of foreign fishing in the FCZ, devastating river herring stocks. Tremendous landings were made. If you totalled the foreign landings with America's landings you would have graphic columns that go way up here (slide). And then classic overfishing was followed by a crash in catches. The fishery was eliminated in the early 1970's, but the stocks have not recovered. Obviously something else is going on.

To give you a regional perspective on river herring, these are the landings for New England (slide). These landings are a result of changes in the nature of the fishery in Massachusetts during this period of time. A fish-reduction plant opened, but menhaden declined. Therefore, people fished for river herring. If you ignore this one situation, most of the river herring landings in New England come from Maine. Maine has just had a very sustained production of river herring even though the stock was under intensive pressure up until the last three or four years. Recently, Maine landings have crashed, and it is distressing that we really do not know why.

This graph represents mid-Atlantic river herring landings, which are near zero. This is a very interesting phenomenon because there are tremendous amounts of river herring in mid-Atlantic states, but there is no market. No fishery. Nobody cares about them. Therefore, very few fishery statistics are being collected except when the agencies incidentally observe herring when they study other species.

The picture changes when you get into the Chesapeake. This graph is a combination of Virginia and Maryland landings. Tremendous catches. The two states account for the majority of landings along the entire East Coast. This area showed dramatic decline in 1970. The problem in interpreting landings is that once the fish reach low abundance, fishermen have to catch a lot of them to make any money. So fishermen lose interest in going after them. Also, processing plants need lots of fish for production. Therefore, once population levels drop low, a lot of the fishermen stop fishing, and the landings go down lower even though the stocks may not be quite that depressed.

However, in Maryland it certainly looks like the stocks are as bad as those data would suggest. And again, it is very difficult to understand exactly why. Why haven't the stocks recovered given that the fishing pressure has declined dramatically?

In the south, we encounter an interesting phenomenon. The decline in the 70's certainly occurred, but landings remained relatively high. They are almost totally from North Carolina. There is really no substantial river herring harvest in South Carolina or Georgia. In North Carolina, according to word-of-mouth reports the stocks have recovered dramatically. Tremendous numbers were caught in '85 and '86. Numbers would have gone up higher, I understand, except that the market was flooded so the fishermen were not catching them. Thus, there seems to be something happening in North Carolina for the good, but in the Chesapeake the situation still does not look favorable.

This is sort of an update from the time the plan was produced, just as an overview of the status of the stocks. Now for hickory shad, we have no new information from the time we prepared the plan. There are no current studies and the species is low-priority. People in the states have a lot of other fishery problems to focus on. There is not too much attention to hickory shad. So, we really don't know what is happening.

The stocks of river herring in North Carolina have recovered dramatically. However, stocks in Virginia and Maryland have remained depressed. They may be stable at low levels, but still are not showing substantial recovery.

River herring stocks in Maine have declined dramatically and we do not know the cause. The other stocks, from information available, seem to be holding their own and doing satisfactorily.

For American shad, the stocks in Maryland have remained severely depressed. Stocks in Virginia and farther south are low but stable. Most of the stocks to the north have been doing okay, particularly the Delaware River stocks, and the recovery there after the water pollution problems had been addressed has been tremendous.

One discouraging aspect, and I guess one Mark Gibson might talk about today, is in the Pawtucket River, which is newly restored. The shad run this year was much lower than expected. Again, we are trying to determine the cause.

Now, I do not want to discuss in detail all the management recommendations. But I do wish to run through them to give you an idea of the kinds of things that were of concern and what has been accomplished in the last couple of years. Management recommendations were placed in eight categories. Each category addressed certain aspects and then there were subrecommendations within them.

The concern here is with harvesting river herring in the FCZ. Even though there is not a directed foreign fishery for river herring, there are tremendous numbers of mackerel in the same area. Foreign and American fishermen are very interested in catching mackerel. Therefore, there was a major concern that foreign fishing for mackerel might take river herring as a bycatch. This would add pressure on these stocks, particularly on depressed stocks in the Chesapeake Bay. The resolution of this problem was that the Fishery Management Council put restrictions on these foreign fisheries when they fish south of the mouth of the Chesapeake Bay, which is where Chesapeake stocks would occur. Restrictions include a very tight limitation on bycatch. Also, the National Marine Fisheries Service is monitoring the situation to be sure problems do not arise. So this problem appears to be addressed.

There is still the potential that if these fisheries expand rapidly there is a lot of money to be made. This could pose a problem. This is an example of where the stock is suffering from a lot of different impacts.

A second set of recommendations dealt with Territorial Sea harvests. A concern here is that the early fish tend to bring the good price at the market. Fishermen down south have the first opportunity to catch shad. They discovered that if they go out in the ocean and catch shad, they can send them off to New York and make a lot of money. So in South Carolina, and Bill McCord's going to be talking about this, they started fishing ocean shad and the fishery has expanded.

The states up north began wondering whose fish they were catching. Because if they were catching, say, Chesapeake Bay fish which are quite depressed, that could be another factor keeping that stock from recovering.

Therefore a recommendation was made to begin coastal tagging. That is what Bill will be talking about today.

Fishermen in North Carolina and Virginia have seen the opportunities. Ocean fishing for shad and their participation could pose a future problem. Let me discuss briefly, harvest in internal waters, those within the state. There was a feeling that many stocks had been overfished, and that may be a problem. Remember that ASMFC cannot tell states what to do. However, the committee did recommend certain exploitation rates for the states, based on the percentage of fish that are harvested each year. The rates differed depending on the status of stocks. For depressed stocks, it was recommended that there be a moratorium--no fishing. For stocks that were down but not severely depressed, a twenty-five percent (25%) exploitation, and for stable stocks, a forty percent (40%) exploitation rate was recommended. Several states did not know what their exploitation rates were, so they were encouraged to initiate studies to find out.

Future problems could arise if exploitation rates are unknown. The fishery could change and we would not know it until the stocks collapsed and nobody would know why.

The next topic relates to dredging. They suggested that water quality standards and criteria be established to protect anadromous alosids. That is easy to say, but the issue here is that management agencies generally are not the water quality agencies. They are a sister agency, and usually can only make recommendations. A lot of times water quality agencies do not listen to their resource agencies. Maryland is a perfect case. Maryland developed great water quality standards for anadromous fish. However, I think they just got sent over to the Office of Environmental Programs and sat there.

A second major area of concern has been acid deposition and acid rain effects, because it has been shown that anadromous alosids and striped bass are very sensitive to pH. The concern is that in the future there is going to be continued development in anadromous fish watersheds, and that is going to pose a stress to all anadromous species.

Water flow requirement is another environmental factor. This mainly relates to hydroelectric plants, but also to potential water use. Most of the states already do what has been recommended. The concept is to ensure that flow requirements from hydroelectric dams are sufficient to protect the anadromous alosids. Water use is really not a major issue on the East Coast compared to situations out west.

It is very important that the agencies review all proposed projects to ensure that the species involved are protected. That is generally an ongoing process and certainly nearly all the agencies, all the agencies that I am aware of, do this quite well.

This whole set of recommendations (slide) deals with restoration because it was perceived that there is a lot of unexploited, or unused habitat. If alosids or striped bass were re-established into those habitats, then you could enhance the total east coast stocks. That is basically what restoration is intended to do.

There is concern about downstream alosid migration in that they might get killed going through turbines. So that was a specific area of concern. Nearly all states, or many of the states, have restoration programs, either comprehensive for the entire state, or specific for individual rivers.

In the middle-Atlantic states where river herring are not of great importance, there are some restoration programs going on but there is more habitat that could be used. However, there is no value in the species, per se, so the programs are not moving ahead very fast.

Finally, let me discuss recommendations on research. The focus here was the need to exchange valuable data. This has worked very well.

We also developed a list of priorities for research needs which has been followed. I will mention that dredging is not included. It was suggested that NMFS monitor what is going on in the offshore fishery to ensure that river herring are not affected. Coastal tagging studies and coastal harvest statistics were also assigned high priority. The highest priority, from the perspective of the committee, is to monitor the exploitation rates, because that is the most important aspect to fishery management.

From a management perspective, it is perceived that there is a lack of very important information concerning the basic fisheries and about the exploitation rates for the various species. There is a lot of uncertainty about what is acceptable in terms of an exploitation rate. And exploitation rates must always be viewed within the context of the other factors that are controlling the reproductive success of the species. All these species' reproductive success is strongly affected by natural environmental factors. What happens is that anthropogenic factors, dredging or just general pollution, are additive to the natural factors. Partitioning these out has been a very difficult problem and it has not been addressed very well, primarily because it is so complex. That is going to always be a problem. Trying specifically to identify dredging effects within the context of all the other anthropogenic effects is, I think, a challenge and a very difficult one.

I guess that about sums up what I wanted to say. However, I think the idea of looking at partitioning out the effects of anthropogenic factors and then looking at dredging as a subset is a good topic for today's discussion.

We have studied historical data going back to the 1800's to explore the effects of various anthropogenic environmental changes on resource stocks in five estuaries along the east coast. Dredging was one of those. This is a correlational kind of analysis with some interesting results, but only correlational. So these data would only be useful for identifying potential relationships, not for coming up with any hard conclusions.

I will stop there. Any questions?

Q: (BY DR. MANOOCH). I have one question. Not necessarily pertaining to this group, but as far as my agency is concerned, would it be beneficial to have a species breakout of blueback and alewife in terms of statistics for any of your analyses?

A: (BY DR. RICHKUS). I think it would be so difficult--

Q: (BY DR. MANOOCH). You think it would be difficult?

A: (BY DR. RICHKUS). Yeah. That it just wouldn't be feasible.

Q: (BY DR. MANOOCH). We run into the same thing with snappers and groupers. The people who collect those statistics told us it would be difficult, but we are attempting to do that. But for herrings you must use the peritoneum to distinguish?

A: (BY DR. RICHKUS). And you're dealing with a pretty diverse group of fishermen.

A: (BY DR. LOESCH). That's easy enough to do at the state level. I think it's difficult for the Feds. But at the state level, we break them out by species because we take landings by two-week periods. We have subsamples in every period. And so, we have species, and sex, and age.

A: (BY DR. RICHKUS). But I mean, for example, Maryland doesn't go out, in other words, fishermen report data. So, you have to depend on individual fishermen.

A: (BY DR. LOESCH). Kennedy does this, is what I'm getting at.

Q: (BY DR. CHRISTOFFERS). What organization did you say you were with?

A: (BY DR. RICHKUS). I'm with a company called Versar. And it used to be Martin-Marietta Environmental Systems. We got sold in April. And we do a lot of contract work with the Maryland Department of Natural Resources. And this work is being done under contract to the Atlantic States Marine Fisheries Commission. It's kind of a unique position. I'm at least a neutral observer. Everybody trusts me because I'm not a member of a state or a federal agency.

Q: (BY MR. EAGER). I'd just like to point out one thing. We have been involved a little bit in that offshore mackerel effort that you referred to. And the preliminary information that I have is that the bycatches have been almost nothing compared to the actual tons of mackerel that they've been taking.

DR. MANOOCH: Doug Clark from Vicksburg, Mississippi will be next on our program.

Problem Statement by the Corps of Engineers

Douglas Clarke
U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, MS

I am a member of the Coastal Ecology group at Waterways, and happen to be the only fisheries person that we have on staff. Although I do not have any pretense on being an anadromous fish expert, I was designated to state the Corps side, the problem in trying to address research needs in regards to what is happening between dredging and the potential effects on anadromous fish.

What I would like to do today is take what has been said about dredging and fish and tie the two together, discuss where we are headed with this meeting, and what we expect to accomplish.

The question of whether dredging impacts migrating anadromous fish seems simplistic, but is hard to monitor in the field. It just doesn't turn out. Today, I will try to mention what the Corps concerns are, and then give you some brief ideas of our past experiences with monitoring and the scientific studies that the Corps has initiated in trying to approach these problems.

(Slide presentation.) "Why can't we just get out in the field and demonstrate that during an operational dredging activity fish either get by that activity or they do not?" On the surface that seems like a very simple thing to try to do. If you were going to set up your known hypothesis and were going to test fish going by the dredge and so forth, there would, basically, be three alternatives. If you have upstream migrating anadromous fish, and they are confronted with physical alterations that are entailed by dredging, what would they do? Either their behavior could be neutral to the existence of the turbidity plume, and essentially, would just swim on by and have no effect on their movement towards spawning grounds, or they might display avoidance response. The worse case would be where the plume forms a complete barrier to fish movement beyond that point.

If you look at any dredging operation in cross-section, a lot would have to do with the site-specific details of the dredging operation (types of sediments, bottom topography, etc.). What are your target species? Are they confined in their upstream movement to the channel areas, the deeper channel areas, or where? If the dredging operation suspended-sediment plume is largely confined to the bottom of the channel, are fish going to be able to move out of the channel into shallow areas and get around the dredge, or is the plume going to be an effective block to their upstream migration?

This slide compares the types of problems that we are investigating. Is the dredging going to be in a small tributary where there might be complete cross-sectional blockage entailing the turbidity plume? Or, is it in a large waterway? Many large-scale projects involve waterways a mile and a half or two miles wide. Is it conceivable that the dredging plume could completely block the passage of an upstream migrating fish?

You then must consider the methodology you are going to use to look at these problems. Suppose you select gill nets. How do you get your net samples out there, confining them to the plume if you are looking at fish catches in the plume versus those outside of the plume. This is a very difficult thing. How do you know what the vertical extent of the plume is, etc.? Methodology is a key issue, one with which the Corps is very much concerned. Can statistically defensible data be collected that proves dredging is, or is not, having an effect on migrating anadromous fish? And, are we talking about some specific percentage of fish moving by the dredge? What percentage are we willing to allow to move by the dredge? How much of a change and an alteration in this pathway are we going to allow before we say that it is having an effect on the total resource? Total by population, or the dredge itself? We just alluded to the fact that it is going to be difficult to evaluate dredging in the total scheme of anthropogenic impacts on the resource.

One way to begin might be to look at what factors influence fish migration and how these may be impacted by dredging. What factors influence fish migration? There might be more, but basically those things that involve sensory cues that fish key in on for their migratory orientation. Value things, like chemical information, mechanical stimuli, temperature, electrical and magnetic stimuli, and then the theory that the fish are just randomly searching for their home and spawning grounds. There is a lot of information available on different species and migration cues, mechanical stimuli and chemical orientation. Some work was done by Dodson, and mid '70's data especially show that these were two important stimuli in shad orientation. And so, if we keep up with what dredging entails, maybe then we can focus on what we need to look at, what parameters we need to measure, etc.

Again, electrical, mechanical, and magnetic stimuli have been inferred in migrations of migrating fish, such as eels. I am not aware of any information that has keyed that into alosids, in particular. I do not have information that dredging would offset these patterns. Temperature in monitoring programs, is measured on a conventional basis. But then again, I can not really conceive of any particular set of conditions where a dredge would have a drastic effect on lowering or altering temperature in moving water bodies. And I think that is mainly what we are talking about in this case. Mechanical stimuli, the imposition of a dredge on a water body, might have some near-field effects on flow. If, in fact, it is an important effect, that might be something you want to investigate. But it is hard to conceive of a situation where just near-field changes in flow patterns would have a barrier-type effect.

There is some anecdotal information on chemical stimuli. Maybe that is something that we need to consider. In "An Overview of Dredging Impacts," a publication put out by Darnell a few years ago, the idea came up that dredging resuspends sediments. Clay particles have the capability to absorb organic molecules. Would the presence of a turbidity plume essentially mask those sensory cues that the fish need in their upstream migration to get back to their native spawning grounds?

What role does light play? Fish are known to orient against gradients of light in their movements. And, when we consider turbidity, perhaps that is one of the more important parameters.

Okay, that is all the slides I have. I will now shift to an overhead. Going from that last slide to the fact there is an influence in migration, to what we consider as being actually involved in a dredging operation that might have impact, four basic categories come to mind:

1. Suspended sediment and fish tolerances. This is the topic that we probably have the most information on. Most work has been done, at least in the laboratories, in determining what the exact tolerances are of a given species to a total suspended sediment load.

2. Dissolved oxygen depletion. That has already been brought up in reference to dredging operations. I am not going to say too much about it other than to refer most questions to Mark. He knows more about DO depletion than I. Except that, in looking at the literature, I do not see anything that really proves or disproves a behavioral-blockage effect on anadromous fish, even though there is DO depletion.

3. The latitude avoidance response. Again, this is basically a behavioral trait when the fish first encounter a turbidity plume. Again, a lot of the concerns that I see raised in relation to avoidance-type behavior are anecdotal. Some of the people I talked to have said, "Well, a lot of surveys we have done have shown that in spring when you get a freshet coming down the river system, that the shad move back down stream," and so forth, "and spend some time." That is probably due to elevated turbidity. I have not seen any evidence that suggested this is not also correlated with increased current speed during a freshet. There might be an energy-conservation effort by fish as they drop down stream until they can make their upstream migration at less energy expense.

4. And finally, a category of masking sensory cues. That is one that I mentioned with the absorption of clay particles. Just how important are these chemical cues for the fish in getting by the dredging operation?

Some of the problems in the past have been, again, differences in interpretation of what little information there is available.

We have a number of source documents that I might point out. Probably the best that I am aware of is put out by the National Marine Fisheries Service under contract with the Profiles Research and Consulting Group. I will be glad to provide the reference later on. It was put out by the Northeast Fisheries Center and is quite an exhaustive review of the literature. It is mainly keyed to the northeast species. But, it has a lot of relevant information coastwide. We are mainly dealing with scarce literature. That is the problem and we place a lot on the Corps as far as getting the information out concerning the Dredging Material Research Program. But it does filter out.

This is a document compiled by the New Jersey Department of Environment Protection. Do we have anybody here from that agency? It is a very good source document and Richard Cannon did a very good job of examining the available literature and relating it to dredging. The title is, "A Review of Potential Environmental Effects of Dredging In New Jersey's Tidal Waters With Recommendations On Seasonal Restrictions." There have been several others. I think we have done our own in house documentation, and published in the American Society of Civil Engineering Symposium. We can get you reprints. But, there are caveats to be aware of. If you examine the literature, there is not much that really pertains to fish movement in relation to dredging.

Here are two examples of very generalized statements. First, from the Profile of Research and Consulting Group document: "Interruption of spawning migrations for freshwater spawning areas, due to zones of high turbidity, may have significant effects on anadromous species. Suspended solids are known to interfere with upstream migration of some species." Second, from Radkey and Turner, in 1967 demonstrated that "upstream migration of prereproductive striped bass was greater when suspended solids were low, and that 350 parts per

million is a critical level that blocks migration. And even lower concentrations of suspended solids were required for spawning." That sounds pretty definitive. A specific concentration is given that blocks migration.

There is also this statement in the New Jersey document: "Radkey and Turner demonstrated that upstream migration of prereproductive striped bass was greater when suspended solids was low. They suggest 300 milligrams per liter is a critical level that blocked migration even though a lower concentration was required for spawning."

If you look at the citation and then go back to the original document a note in the Transactions of the American Fisheries Society. I forget what year, '67, I think: "High concentration of total dissolved solids blocked spawning migrations of striped bass in the Joaquin River in California." The critical thing here is that there has been a misuse of total suspended solids and total dissolved solids. They were not measuring gravimetric distributions of suspended sediment, or optical distributions of suspended sediment, rather dissolved solids. Therefore, in this case, the fish were moving upstream and osmotically facing a reverse of the migration, if you would. They were approaching the 35 milligrams per liter, indicating a return to sea water. This is probably the only key reference that I have seen so far that really pertains to fish movement upstream in relation to turbidity.

There were some others, older ones, that go back to the '40's, that involve references to blockage of salmonids. Again, the older references, and I can give you these later on, largely are based on anecdotal comments. I am not saying that this is wrong, rather that we have to be careful of what we say.

I would like to give you some examples from the Corps' experience in trying to set up monitoring programs. I can tell you that this has been an exercise in futility, consternation and frustration. But what I have done is gather information from the Philadelphia District, who, I believe, has probably gotten more involved with anadromous fish issues than any of the other Corps districts on the east coast, actually addressing the issues in the field.

This list was put together by the Philadelphia District as to what species become involved when seasonal restrictions on dredging issues are brought. This is a prioritized list, and we see that anadromous fish are important when it comes to imposing restrictions on dredging. The American shad, the river herring, and striped bass are all included.

Now, this is a map of the Philadelphia District for those who are not familiar with how the Corps is set up. Districts are based on river drainage and geographical boundaries, rather than state boundaries, etc. That in itself can cause some problems. In the Philadelphia District, the main river system that we are concerned with, as it pertains to anadromous fish, is the Delaware. It bisects the District boundaries. There are several states involved here, which impacts coordination. Politics definitely has an impact on what we try to establish in terms of an agreeable option program. When you've got more than one set of state issues, along with all of the federal resource agencies involved, it can get quite complicated.

What I would like to do is to discuss three projects, and non-projects as it were, involving the monitoring of upstream migration of American shad in the Delaware River. Chronologically we can go through this, starting up in the section of the river just below Trenton where a study was done back in the mid '70's by Martin-Marietta.

(To Dr. Richkus.) I don't know, were you there?

DR. RICHKUS: I was out there on the boat.

DR. CLARKE: Okay. Then the study was at least proposed in the Philadelphia/Camden area. I believe that was three years ago. And then one that is currently under way in the Wilmington Harbor area. If you can, remember those three stretches of river.

The Martin-Marietta study was, as far as I am aware, the first attempt at using hydroacoustic techniques for the assessment of upstream fish migration in the vicinity of an operating dredge. This was in 1975, I think. Following is a condensed summary based on progress reports.

There were three main objectives. One was to measure the turbidity in a ten mile stretch of the river and relate that to dredge-induced turbidity. "Could the plume be detected around that dredge?" Second, was to determine what fish densities were in that river segment, and if the distribution pattern could be explained or correlated with the observed turbidity measurements. Third, was to measure the dissolved oxygen, temperature, and conductivity, etc., to determine the possible effects of dredging on these parameters. Basically, the methodology included a toad transmissometer which recorded turbidity in percent transmittance and simultaneous hydroacoustic assessment. I do not know if everybody here is familiar with hydroacoustics, but they were able to utilize studies that filter out nontarget species. Essentially, they looked at signals that had a high probability of being shad. They were in the right size range, and cyclic-strength determinations, etc. The studies started out in a ten-mile river segment. Basic ground proofing was conducted to ensure that shad were in the system. The preliminary results lead to the inference that none of the changes in the measurable parameters such as the dissolved oxygen, temperature, or so forth, could really be related to the dredge, which was located in a central area. Any changes that occurred were in a linear-to-downstream manner, and really could not be construed as to be associated with the dredge. Later surveys keyed in on a smaller stretch of the river. I believe it is about two river miles. More intensive studies were performed around the dredge.

However, this precedent-setting study was doomed from the start. A contributing factor was that the dredge was a hydraulic dredge. And, hopefully after the presentation this morning, you know that the hydraulic dredge is not the worse case scenario. It was not a bucket dredge with appreciable turbidity fluids. It was a suction-dredging operation with a pipeline. Most of the measurements taken did not really detect a significant turbidity plume. And so, you are already in a position of saying, "Well, if there's no suspended sediments there, why would you expect a change in the behavior of the fish?"

DR. RICHKUS: Just one point. They were also dredging up sand that was so pure that they were putting it on the dredge and selling it commercially.

DR. CLARKE: Right, this was not filthy material. And so, again, you know, hindsight, the 20/20 business, it's something to consider tomorrow in the working groups. If we are looking for an ideal set of circumstances to test whether dredgings have any effect, we might look for a filthier environment to work in.

Basically what was shown was that the distribution of fish could not be related to the presence of the dredge.

This (slide), again, is a breakdown using markers in the river system as landmarks. This was the only circumstance that I could see where data were taken when the dredge was not in operation versus when it was in operation. And first of all you see a general pattern of very low fish density up to where the dredge would be located, and then high densities upstream of the dredge. Something is happening in relation to the dredge, probably accounted for in a number of ways. One might be that the bottom topography was important. The location of the dredge happened to be where a change in depth of the channel occurred. So upstream from that point, the channel was about 40 feet. From there on the channel was much shallower in that particular stretch of river. Therefore there was a different volume of water. And, there were a number of other factors that could probably contribute to the observed distributions of fish, irrespective of whether the dredge was there or not.

Now, I will show you a slide of both the turbidity measurement and the fish distribution data for one survey. There was no significant increase in optical turbidity versus background. The variations seen in fish distribution were just as great at areas removed from the dredge as they were in the immediate vicinity of the dredge. Therefore, for various reasons, nothing conclusive, I believe, came out of that particular monitoring effort. It was actually a poor choice for determining impactors.

DR. RICHKUS: Again, to interject, I think that's the point that was made earlier about the scheduling. That was the study that, as you know, in procurement process took a long time, went from RP, and then to proposals. So, the money was there and the date came up, and there was supposed to be a hopper dredge operating somewhere down, much further down. And that was somehow cancelled. And this was the only dredge operating.

DR. CLARKE: Well, the district biologists, and we've got a number of them here, know about pulling your hair out when the contracting people change everything around on you. You've got the schedule set for dredging and they change it, not only the schedule, but the type of dredge and so forth. And the logistics are a tremendous problem when you're out there trying to do a controlled-experimental approach. And then all of these tangential things are added.

The second dredging experience in relation to anadromous fish in the district, was one down in the Philadelphia/Camden area. Bill Richkus made mention of a phenomenon that's now known, I believe, as the "Philadelphia/Camden oxygen sag phenomenon." This happens seasonally where water quality surveys detect a very drastic lowering of dissolved oxygen in that particular stretch of the river.

This was only three to four years ago, I believe, when the study was conceived. But most of the agencies wanted to look at fish movement through that heavily industrialized area already experiencing the oxygen sag phenomenon. A lot of planning went into it. And I would have to say that when we got to the review, we really had some second thoughts about whether this was going to be a productive exercise or not for a number of reasons. When several states are involved, personalities tend to complicate things, too. Committee decision may be driven by the stronger personalities and politics gets involved also.

The review panel proposed a study that involved fish monitoring by sonic tagging, hydroacoustics, radio tagging, and conventional techniques. Everybody on the committee had their own favorite methods. We have found that, generally, there is an aversion to trying unconventional techniques. An example would be hydroacoustics. Most people perceive it as "high tech magic" more than anything else. You note reluctance from people who have been around for a while that there is no data that you could ever obtain that will mean anything if it has not been caught in a gill net.

In addition to the logistics, money must be considered. That's something else we need to consider when we're thinking about what we can do tomorrow. The district requested an estimate of how much a good quality survey would cost. I believe the ballpark figure was something like two hundred thousand dollars (\$200,000). When cost is factored in, added on to all the other things, labor intensive aspects such as day/night monitoring, costs increased dramatically. The figure that I recall is something like three quarters of a million dollars (\$750,000) for a monitoring program. And that, essentially, was the crux of the matter. We did not have that much money available either in the research component of the Corps or through the district. We could not get a consensus from the various interested parties as to where we could back off of this basic plan, and put our efforts to get the most return for the investment. Therefore, this was a nonstudy because of the inability to settle disagreements between the parties involved as to just what they wanted to accomplish and how they wanted to go about it. We had very real concerns about just what types of information would be obtained because of the setting of this study.

Let me read, in part, the letter that was sent out to the review agencies from the Chief of Planning in Philadelphia: "Of the various reviews, it is concurred to use the American shad as the primary target species, and to site the study in the main stream of the Delaware River in an area that is filthy in nature. More pertinent were the concerns raised that the project was trying to study too many variables and that the hypotheses to be tested should be better defined." I remember I added some of these comments myself. The comment also was made that the data returned from a particular method should be evaluated with respect to the cost to obtain the data, because employing the number of methods proposed might not be a cost effective solution to the problems.

"In addition, simultaneous employment of the suggested methodologies could compromise the results of the respective techniques." The opinion was also voiced that the use of a worst case situation as a test environment may be inappropriate. If the results of the study are to be applied to the entire river or a major portion of the river, it may be more prudent to test a more representative section of the river. In addition, siting a study at a worst case situation might also complicate the analysis of the results to the extent that determining cause and effect is not possible. That was my basic concern in this particular proposed study, there are really only two results. If you get out and monitor, either the fish were affected in their upstream migration or they were not.

If they were not affected, good. The Corps has clear sailing. There is nothing we can do, because this is the worst case scenario. From now on we can dredge anywhere and not expect anything to happen.

However, the other side of the coin was that if fish were impaired or impeded in their upstream migration, then what do you attribute it to? Was it the oxygen-sag phenomenon? There was also the question of toxic substances there (with the heavily industrialized area). Or, was it due to the dredging? And I do not think that the study plan as it was proposed, even with the high cost, Cadillac approach, really would have been able to assess that. So, basically the decision was made that nobody could agree on where to back off and the whole study just fizzled out.

One more quick example is in the Wilmington area near the Delaware Bay, a very tidally influenced area. The project involved the creation of a containment area adjacent to the shoreline of the river, right at the confluence with the Christina River. And again, there are not many conclusions resulting from this study. This (slide) is the one that is underway. This is the section of the river where the Delaware Memorial Bridge is located. New Jersey is on this side of the shoreline, and Delaware and Pennsylvania are above. The study site is actually in this river reach, right here. The dredging is going to occur here in the broader areas, creating a diked containment area for future maintenance drilling.

The telemetry approach will be used. Remote receivers that transect downstream and upstream of the dredging project site will be employed. There is one on each side of the river. The distance between the transects is about seven river miles. The concept is to capture and tag adult shad, during their migration, and release them south of south transect. Fish would be detected as they moved past the south transect, and then, hopefully, again, depending whether or not they were affected by the dredging operation, detection would be made upstream of the dredge.

Specifically I think the release will involve eighteen tagged adult shad. And of these, ten have to be detected within five days of release at the southern transect. Therefore, ten shad will be in the study area. And then you have, I believe, five days following that to detect at least five of the ten fish passing by the northern transect.

John Forren is here. He's a biologist from the Philadelphia District and he might know more about the rationale for the monitoring system if you have specific questions later.

But I think what we would like to do, during the course of the next day, is, perhaps, get a better feel for just what we are going to be able to derive from these types of studies.

This (slide) again, is a monitoring plan that was arrived at to allow the district to go ahead with the dredging. If a certain number of fish have not reached that south transect, the dredging operation shuts down. If they do sample fish beyond there, and five fish make it to the north transect, the dredging is allowed to proceed. If not, the dredging shuts down again. If they do sample fish beyond there, and five fish make it to the north transect, the dredging is allowed to proceed. If not, the dredging shuts down again.

After a set time period, there is a new release of shad. This sequence repeats at least three times before all dredging is shut down for that entire season.

Therefore, our question might be, "Is a study like this going to be expandable, refinable to the point where we can tie in those data to whether the dredge is really having an effect or not?" My concern with telemetry studies is sample size. How much do we have to do before we can statistically defend that something is happening in that river research that is attributable to the dredge? The objectives of the program are really twofold. From the district's point of view, "Let's get our dredging done." But from the research end of the view, "Is this really the ideal way that we want to answer the question?" That is what I would like to explore in the next day or so.

We also have a representative here from the Aquatic Habitat Group, in Waterways, Dick Kasul, a member of our hydroacoustics team.

We have also done a tidal study in this same river reach. And we are going to make recommendations for next year from the district to do hydroacoustic surveys, both moving transects such as we used in the Martin-Marietta study, and fixed aspects of the studies. We might actually be able to work at fish movements within the turbidity plume. I think I am out of time, but I have provided you with some concerns that we need to discuss tomorrow. The Corps really has a sincere desire to go about things in the right way. And we have been frustrated in the past.

If we can tie something together so we have a study plan ready when the appropriate dredging project comes up, then I think we would all come out ahead in the long run. We are all interested in the answer to these questions, but I think everybody would agree right now that the jury is still out.

Q: (BY DR. RULIFSON). I have two things. The first one is, you only had eighteen shad. And I think a number of radio telemetry studies have indicated that a change in the behavior of upstream migrating adults results from tagging. You may get downstream migrants. You tag them and release them, and they go back downstream. So, to say that you are going to set your requirement, particular requirement of whether or not you are going to start or stop dredging operations, you know, if there's a question as to whether or not the radio tag itself is causing the downstream migration.

A: (BY DR. CLARKE). I think that was supposed to be handled by the fact that they had a particular period of time, in the release south of the south transect. They had a given period of time to reach that, to cross that transect. And if you get ten fish by, then the assumption would be made that their behavior is normal. I have a concern myself about handling it that way, which is one of the reasons why we notified the district and said, "We'd like to at least try hydroacoustics again." That was really one of the concerns.

A: (BY DR. HOMZIAK). I'd like to interject a quick comment. One of the main reasons why we're here is because many of the decisions made in terms of monitoring plans are based on political and turf-fighting types of issues. And one of the reasons we're trying to get a technical basis for these kinds of decisions is to evaluate the fact of "Why is eighteen fish the magic number? Why aren't ten fish the magic number?" We're trying to get to a statistically balanced sample size to be able to refer back to the meeting that we've had here, and the opinions of the "experts."

We've gathered to tell the politicians that "This is an invalid approach. You can't make us do this." It's not going to be anything except an exercise in spending money to achieve your goals that are not compatible with the goals of either the resource management agencies or the Corps of Engineers for the good of the species. It may be good for their political stature, but

not good for the management efforts that we're trying to put into it. So, our purpose is to go beyond those numbers.

Q: (BY DR. RULIFSON). Could you discuss whether any studies have been done on the noise level or the activity levels of various dredge types?

A: (BY DR. CLARKE). I don't think so. Other than everybody would say that a dredge is noisy.

A: (BY DR. PALERMO). If you're in the engine room it's really noisy. I know underwater that sound travels worse, and fish probably get agitated by that, too. But no studies have ever been done that I'm aware of.

Q: (BY DR. RULIFSON). So, acoustic studies or radio type studies, that may well be the dredge type rather than the plume itself?

A: (BY DR. CLARKE). Un-huh (yes). I don't know whether you would expect that a bucket dredge would be quieter than a hydraulic dredge as far as in-the-water noise levels or not. I'm not sure about that.

A: (BY MR. KASUL). If I may comment on that as well. I worked with the hydroacoustics people at WES. Much of the noise that's generated by the dredge, I think, is probably relatively low-frequency noise. The hydroacoustic systems that we deal with have very, very high frequencies and are sensitive only to those high frequencies. So, noise that's generated at lower frequencies will not be seen by the acoustics equipment. It's all relatively transparent to much of the kinds of fairly low-frequency noises that we would expect to see generated.

Q: (BY MS. DORE). I just wanted to add something about my experience with radio telemetry. Fish tagged with radio telemetry at Canandaigua Dam have been known and found in the Delaware River. So, not only will you have a drop-back, you'll probably have some kinds of mortality, but you'll have the fish leaving the river system altogether.

DR. CLARKE: Well that's another concern about doing a study in the tidal portion of the river, where the behavior is known. When the fish first hit the fresh, saline wedge they meander there. They're known to be younger in this area. So, you could have an up and down effect in that river stretch, very easily, that you couldn't account for and apply it to some observable cause-and-effect relationship.

Q: (BY MR. EAGER). This probably needs to go under the workshop area, where it's more anecdotal. I think I observed the fish that I released in very heavy flows. I don't get the drop back effect, either in t-bar tagging or radio tagging on the fish. They just home in on that flow and stay there.

A: (BY DR. CLARKE). Well, I think, perhaps tomorrow we can come up with an ideal dredging situation that both of us can live with. It may never ever occur in nature, but we can start from there.

Q: (BY DR. RICHKUS). One other complicated factor, and it's an open question as to how far up you are, but of course there are an awful lot of shad in the Delaware Bay that aren't Delaware fish. And it is not very clear how far these other stocks move up. But if you're anywhere in tidal waters you have a good chance that if they're catching them south of your south point, where they're available, they might be tagging Hudson River fish.

A: (BY DR. CLARKE). Yeah. One final caveat that I'd like to add here is that in that river stretch, again, it's a wide river system, and it might be, there's a constriction of the Delaware River Memorial Bridge, but the river system opens up, and it may be a mile, mile and a half, wide at some points there. And as it just so happens, there is another natural channel, not as deep, but on the New Jersey side. And from talking to the contractors who've gone through the telemetry, and commercial fishermen, most of the gill-net catches are on the New Jersey shore. And there might not be that significant a segment of the upstream migrating shad that actually uses the navigational canal. They might be just following the eastern shoreline. In which case, again, you're not even getting near the dredging operation.

DR. MANOOCH: Let's move on to our next speaker.

Review Of Fishery Management Concerns
Pertaining To Dredging

Edward Christoffers
National Marine Fisheries Service
Northeast Region
Habitat Conservation Branch
Oxford, MD

The speakers from the Waterways Experiment Station and other previous speakers have pretty well covered all of the problems that we in the Northeast see in terms of trying to establish, set, and enforce reasonable, seasonal restrictions for the protection of fishery resources in general. The DO issues, turbidity, optical problems for shad, specifically, and the release of toxics, or nutrients that can cause problems have been discussed. From the last of Doug's presentation it is obvious that the development of a study which will satisfy all of us, especially the resource agencies, from a statistical validity standpoint, is going to be extremely difficult to design.

Bill alluded to the fact that trying to differentiate naturally occurring events from those generated by man, specifically dredging, is difficult.

We have heard Mark mention that storm events cause more problems, more turbidity on a wider spread basis than dredging does, and that is in fact, true. However, we haven't yet figured out how to regulate nature. We can do something about what happens with dredging. When we do have sensitive life history stages we like to take the opportunity to protect that resource. From that standpoint I don't apologize for the positions that our agency, the National Marine Fisheries Service (NMFS), has taken in the past.

Twelve years ago, when I came to the Chesapeake Bay area, there were comments like: "You won't dredge during this time," and "You don't do this," and "You don't do that." It was all, I think, based on data, albeit skimpy data. And we took those positions because our mission is to ensure that the fishery resources get a fair shake and that those resources are conserved for not only our generation but for future generations.

I would like to point out examples of how provision of data similar to that which this workshop is trying to devise a study to acquire, has resulted in our changing various time-of-year requirements. I will address fishery resources in general, not just anadromous fish.

Studies that were done by VIMS in the Hampton Roads area have resulted in NMFS shifting priorities in terms of shellfish beds. Anything within five hundred meters of the dredge was considered to be at risk, and outside of that area we had generally few problems. I should point out that this was turbidity generated by the dredge. When we get into overboard disposal, we are talking a whole new ball game. When you evaluate a dredging project from a time-of-year-restriction standpoint, I don't think you can really partition activities. The type of equipment you use and your disposal method have a great deal to do with the turbidities and the potential problems that are generated. A second area

had to do with blue crabs overwintering in lower Chesapeake Bay, and the dredging of the Baltimore/Norfolk Channels. A recent study by benthic ecologists at VIMS shows that there is an extremely small percentage of the overall population confined to the slopes of those channels. Upon review of that document, NMFS made the decision that it was not resource justified to continue restrictions which would have closed down the dredging for the Baltimore deepening over the entire winter.

The third area where we have made some shifts involves anadromous fisheries in the James River. The James is a major spawning area for anadromous fish. We have a number of substantial tributaries to the James which also support anadromous species. What we have been able to do there with the cooperation of the Norfolk District is to develop a sequential schedule. There were three separate shoals that were being dredged. One was in the upper part of the river above Hopewell near Dutch Gap. This is within the spawning area for striped bass and other anadromous species. Young fish also occur there during certain times of the year. The second shoal was around Windmill Point which is just below Hopewell. It starts just a little bit below the spawning area and just involves the nurseries. The third shoal was further down around Dancing Point which is basically in the nursery zone. We asked the Corps to dredge the lower-most shoal first, in the spring. The rationale being that the river was wide enough there that the upstream migrating fish could navigate past the dredge without any particular problem. We asked that they do the uppermost shoal next because that schedule would put them there after the primary spawning period and the eggs and larvae would have been carried downstream. We naturally left the middle shoal for last since the fish would be through the area and juveniles would be able to maneuver around any potential problems.

I should point out that the Windmill Point area and the Swan Point area are both overboard disposal and the Dutch Gap area utilized a confined site, which makes a real difference in terms of setting time-of-year restrictions.

One fact that should be noted based on what I have read, is that the larval phase of striped bass appear to be closely associated with the bottom. I think there was a reference earlier today to this. Within three different districts in the North Atlantic Division, the Norfolk, Baltimore, and Philadelphia, there have been substantial differences in the application of, or reasons given for, time-of-year restrictions. One was, in the case of Philadelphia, the optical problem. In the case of Baltimore, their discussion revolved around entrainment. And in Norfolk it seemed to be more physical damage. I am not sure exactly which State or Federal agency applied the various restrictions but the office that I am in charge of deals with all three Districts. In the Baltimore area my assumption is that the restrictions were based on conditions in the C and D canal and the upper Chesapeake Bay. There is a substantial amount of striped bass spawning in this river. In the confines of C and D there would be, I think, a real concern for actual physical entrainment. In terms of the James, I think the same point holds true. If it was the upper part of the James, depending on where the fish are distributed, you have the larvae on the bottom, where the dredge would be operating. And when you work with a suction dredge there is a real possibility to entrain organisms.

I would like to point out one error that was made. Our Branch in the Northeast Region, not the Fisheries Center, was the group who funded the Profiles Report. I think that it is an example of our interest in trying to get to the bottom of this problem. Our purpose was to resolve some of the problems that have been addressed here. There were differences between districts and

within our own field offices, and we funded that effort to try and pull together the available information. And for any of you who would like a copy, we have a few. They are photocopies. But if you will give me a business card afterwards, I will be happy to see that what we do have gets mailed to you.

Other than that, I really do not have much more to say. However, I think that Mark's comment earlier, relative to each project being an individual entity is extremely important. You have to look at the type of equipment that is being used and the type of disposal. You have to look at the sediments, whether we are dredging fine particles or sand, and you must look at whether the sediments are contaminated. Also, you have to look at what life history stage of what resource is within the area that you are proposing to dredge.

In our office we deal with several Corps districts. We have dredging meetings with each District where we try, in advance, to coordinate the scheduling. I know that this does not always eliminate problems and we have on many occasions given additional time, at the end of windows when there's been a mechanical or physical problem that has prevented the dredge from operating, allowing the project to continue rather than having the district absorb substantial mobilization and demobilization costs. In short, we try to be flexible when the risk to living resources is minimal.

I think that is really about it.

DR. HOMZIAK: In terms of the strategy session, we have kind of used that as an accordion plan to either expand or contract depending on lengths of time. Having gone to a number of scientific meetings and technical presentations we have all seen people getting excited about what they do and how to present it, and slides start going and the figures start flying and somebody's tapping watches and waving flags, and the guy's going on too long.

So, we did not know how much of that or how little of that we were going to have. So, the primary function of this was to try to summarize our position, kind of what we have gone through this morning. And the notes that I had made were to mention several things.

I would like to solicit any comments concerning the actual making of the problem statements. If you have any comments to those, and for any expansion of the agenda, or whatever thoughts you may have on it, now is a good time to go on record.

In terms of the problem statements that were brought up by the Corps, everything from pathology to methods, to anything that you think was not touched but should be brought into the agenda and should be brought up at this point so everyone could hear of that concern and have a chance to comment on it.

Strategy Session

William Richkus
Versar, Inc.
Columbia, MD

There's one thing that comes into play recently that really hasn't been considered, and that is cumulative and/or synergistic effects. This is becoming a very, very major issue. If you look at anything individually, you see barely trace kinds of effects, and by themselves they are not significant. However, when you view them within the context of an entire watershed or entire region, they accumulatively have a major effect. We haven't touched on that. I don't think it's come up as a specific issue with regard to dredging, but I have the feeling that we're going to be facing that substantially in the future. It is even more difficult than trying to partition anthropogenic effects from anything else. It's almost another dimension, but it's probably something we should at least kick around, and maybe try to anticipate the kinds of things that might come up in the concurrent, cumulative, and synergistic aspects.

DR. HOMZIAK: You said the magic word in terms of how do you structure this particular reading in this planning session: "anticipation." In other words, the point should be made that if we can't deal with the problem with the pieces that we have today, we should keep in mind the midterm and the long-term view of how the things that we can design today can be used or be useful in a longer-term study.

In my introduction, I deleted a couple of pages. But as an ecologist by training, I was considering the fact that, when you are dealing with sublethal effects, for example, and you start having cumulative effects, or change susceptibility to disease, or changes in reproductive potential or reproductive success, these add up. So you don't have the effect on the individual level, or at the immediate time that you are actually measuring. You are seeing this in the reflection, in terms of mortality rates, and in terms of population changes, or age structure shifts, or whatever.

These are not simple areas to address, but every journey started with the first step. Make sure that our steps are in the right direction. Ten years from now we could be able to use data to start addressing some of these issues. You can't do it all at once. You've got to start somewhere.

MS. DORE: I almost hate to bring it up, but the response to the public is a real concern. Being a fisheries manager, I have to manage these fisheries for the user groups. And sometimes there are very politically-motivated, emotional issues centered around dredging projects in relation to the fish that they want to look out for. I don't know how you want to figure that in or whether you want to exclude it.

DR. HOMZIAK: Well, we are attempting to figure it in. I mentioned that survey we had done on the Corps districts and divisions, and it is one of the things that has come up. Let's see how best to describe this. It has surfaced as a seasonal restrictions concern. And someone, let's say, from the Great Lakes/Buffalo District, in particular, has said, "We have a seasonal restriction because of anadromous fish." So you ask questions, "Just what are the concerns?" And what it all boils down to is that the fishermen on the lake don't want to see a dredge operating while they have a fishing experience with their sons. It's an important concern. How to address this? Well, I can't

give you any solutions, but a suggestion would be to perhaps think of being able to coordinate these research efforts. And as these plans develop we need to bring them into touch with the interstate management plans which find their way into management commissions and the press releases. And the other points of contact are being made to illustrate the fact that we are attempting to cover maintaining this fishery.

That's the idea. But there are obviously many other approaches involved, but that's a very good concern. PR is something that technical people tend to sometimes forget. But it's when those fishermen go out in a boat, boy, I'll tell you, you sure pay attention to them.

DR. RULIFSON: I also want to make sure that we consider the eggs, larvae, and juveniles. A lot of the information presented as possible strategies for discussing dredging never consider egg and larval sampling or juvenile sampling. It was trawls, radio tagging, and so forth. And I think that a lot of people don't understand that once the adult fish go to the spawning grounds and do their thing, they think that everything's fine and dandy and that we can go ahead and do whatever we want to. But there is certainly a lag period there in which we have to consider these other life stages.

DR. HOMZIAK: We have made an effort. Chuck Manooch and I, and others, have worked on this, to bring in the fact that these are equally important life stages.

You have three life stage components: eggs and larvae, juveniles and adults. We thought that because of the commercial and recreational importance, it's all weighted towards the adults. We have to admit that. That's sort of the easiest and most straightforward thing to do on a relatively complex set of problems. But in order to address the environmental concerns that are raised, we have to look at all three life stages.

While our past experiences have been largely made up of existing data that deal primarily with adults, we really need to start going off into new territory. If you've got upstream-migrating adults it's fine, but if channel blockage occurs and the downstream-migrating juveniles do not get by, you still have problems. We recognize that and we are trying to get the adult section pinned down now. The eggs, larvae, and juveniles sections are still in tomorrow's plans.

We really have a problem with methodology there. We would like to be able to try to get the expertise available, whatever experiences have been, what's been heard of, or whatever, to assist us.

MR. STROUD: In addition to the juveniles of anadromous species in North Carolina, we have a problem with juvenile nonanadromous, commercially important species that go up into some of these same areas, especially in the Cape Fear system. We find, for instance, flounder up above Wilmington, and the Wilmington Harbor is a most important dredging area. We have designated primary nursery areas, and have a two-stage moratorium. One, on anadromous species, and one for both penaeid shrimps and juvenile nonanadromous species. They overlap to a certain extent, but we can go from February through October 1st in the Cape Fear River, for instance, if the species are there.

DR. HOMZIAK: We're attempting to focus the group on alosids, although we will share our--

MR. STROUD: I realize that is a primary focus for this.

DR. HOMZIAK: That's true.

MR. STROUD: There are other considerations.

DR. HOMZIAK: ... that would fall under the site-specific category. But I appreciate your bringing that up for the simple fact that you have to recognize that none of these situations involve single species. Although it's convenient from management terms to deal with one species and one set of stocks, you have to look at it holistically, a holistic type of approach. If you're going to evaluate a dredging effect, you can't simply look at one species.

Hopefully when we start focusing on these, you can also pay some attention on a site-specific basis to other problems that arise as well.

MR. STROUD: And I think the results of the study will be applicable to the species that we're dealing with.

DR. MANDOCH: I think the methodologies that we develop, or are trying to develop here, could be applied to a much broader scale.

DR. HOMZIAK: Another set of comments, something to bring up in our talks before the audience--we've covered basically the presentations by Doug Clarke, and the fishery management concerns that were brought up in management strategies. Any other comments that we could have integrated with this, we'd appreciate at this time. I'd also like to solicit any views by the Corps of Engineers, or field office concerns, that need to be aired to let the rest of the audience know, give the specific areas that have been covered or have been touched on. Anyone from districts?

MR. FORREN: I just wanted to comment on the monitoring program that we have set up for Wilmington Harbor. There was a concern expressed about the small sample size. That's something we wrestled with for quite some time. As a matter of fact, this thing's been under way for three years. Just the study. The dredging project actually started after the spring run this year. And the eighteen fish is a small sample size but we felt that it would still favor the resource.

We are constrained by costs. During periods of the dredging shutdown, it would cost the Corps fifty thousand dollars (\$50,000) a week. So, we didn't want to exceed that threshold. I mean, the cost of the study has a certain cost, and we didn't want to exceed the cost of the shut-down.

DR. RICHKUS: I think that the concern was that you were putting yourself at more risk with eighteen fish. At least that's the way I was perceiving it.

MR. FORREN: Well, we had a choice there. We either abided by the dredging window, we would shut down for three months, and that would have a heavy toll in terms of cost of the project. So, we could either shut down for the dredging window or set this monitoring program up so that we could at least, from the Corps' perspective, buy some time in the dredging project.

DR. HOMZIAK: To follow up that comment, it's important to consider the interaction of economics versus the amount of data generated or the usefulness and utility of the data that are being obtained from a particular study. Research can get to be a very expensive hobby. But it has to be directed, in this case, toward solving particular problems. And you also have to consider that there is a trade off between the amount of money spent on a dredging project and the amount of research that project will support. In other words, the

Corps would like to get by with the least amount of investment in research as possible. They like to have all the answers up front. Given that they don't have the answers, how much would it cost? Well, we've gotten into a problem. I'm saying this in all candor. Often, because it's cheaper to go and agree to a seasonal restriction request that we may feel is outrageous, but it's just plain cheaper not to go out and fight against it. Just do what needs to be done and give them the report and get out of it. That is not getting us anywhere in terms of solving the problem. We're just postponing the problem from year to year.

What we're trying to do here is to break out of that mold. We're trying to get a bonafide technical opinion that will allow us to say, "Well, we have reason to believe that things may be different. We would like to invest our money or efforts into getting an answer for this." But the cost for that particular answer can't be so outrageous as to not be justified by the size of the project. Therefore, a scale effect has got to be put into play. We have to keep that in mind.

DR. CHRISTOFFERS: I would like to make a comment on that. Something that is of concern to me, is this constantly comes up in terms of how much it costs and that it's got to be relative to the scope of the project. But we are not talking about something that is going to probably apply to only one project. We're talking about providing a plan for research that is going to be fairly broadly applied. And from my perspective, as a custodian of a natural resource, it better be accurate and statistically valid or I don't want any part of it. I'm not going to hang my hat on an ill conceived study whose design is constrained because you have only two hundred thousand dollars (\$200,000) in the budget. Now, I agree with you a hundred percent that we should not invest in high-tech wizardry at extreme expense if it isn't going to provide a solid foundation upon which to make decisions in the future. But I can't buy at all the fact that we should sit around and constrain ourselves, initially anyway, on a cost figure. If we have to do this over several seasons or at several different sites, I think we should come up with what we think we need and then go out and find the dollars to do the job.

MR. FORREN: I'd just like to say that when I said that cost is the constraint here, I really should have said that what we were interested in was avoiding the problem that this Philadelphia/Camden project encountered. You get a group of people together and try to set up a comprehensive study, and end up with nothing because people just can't agree on how that kind of study should be conducted.

What we were interested in on the Wilmington-Harbor Project was to set up a monitoring program to result in a construction shutdown should we feel that the shad were somehow impeded in their migration. We were not interested in why or how those shad might be affected behaviorly in their migration. If the construction shutdown was met, then we shut down, regardless of reason. The reason that we set up a minimum number for the south transect was because an earlier concern was stated about how these fish might behave with a sonic telemetry tag in their gut. If that minimum number was not detected at the south transect, then we'd shut down because in essence we don't have a monitoring program.

So we were not, are did not want to get bogged down with all these problems and concerns stated in this Philadelphia/Camden project. We just wanted to set up a monitoring program that would result in a shutdown if the shad did not make it past the predisposal site.

DR. CHRISTOFFERS: I am not condemning anybody's efforts in the past. This comment has absolutely nothing to do with that. It has to do explicitly with our effort, in that we should be looking at devising what we think we need and we shouldn't be trying to hang it on the budget of any individual Corps projects, because it has much broader applicability than that.

DR. HOMZIAK: That's a very good point and I'm glad you brought it up simply as it was more of a conscious thing to keep in the back of one's mind. The agreement that we have to have here is to recognize that there are, to some degree, financial limitations, and that in turn should be a driving force in establishing an economical and efficient study format. If the study is good, I would be willing to gamble that the funds would be available to resolve these issues.

The illustration I brought up was, because of certain constraints in terms of immediate projects and immediate needs, oftentimes the restrictions are essentially unchallenged and left in place because it's economically less expensive to go out and try to find the answers. Ours is an effort to come up with a reasonable study plan. If the study is, in the terms that Dr. Christoffers used, statistically valid and unambiguously answers the questions that are posed, then the funding will probably be there for it.

MR. EAGER: There's a tendency at most governmental levels to try and standardize every thing (data, application, acquisition) and to utilize standardized data very broadly. That eliminates future individual projects or a fishery biologist or ecologist input. It takes the project out of his hands and it seems to dilute the individual project's eccentricities out of the standardized formula. I would caution the Corps against efforts to remove biologists from looking at an individual project on a project-by-project basis just because you now would have one magical study. I really would like to look project by project by qualified people rather than having a cook-book solution.

DR. LASALLE: I think you're right, and agree with what you're saying. To ease that concern, I don't believe that is what the Corps intends. What we are trying to do in this issue, and a number of other issues, is not necessarily to say, "Look, we're going to do one big study and this can solve all the problems." That's absolutely not the way we feel. That's why we stress site specificity. We're looking to as many different situations as possible so that at least the approach is consistent and "valid." That's really what we're here for, to get a consensus on the approach on this issue, and then apply it to as many different places as possible.

But I share your concern that it shouldn't be one thing, and have it applied to all different areas. And I speak from the context of being an estuarine ecologist understanding the variability of the system we're working. You can't blanketly apply one study to take the place of all them.

MR. HALL: From our experiences in the Savannah Harbor, I'd like to emphasize site specificity, also. I also support Dr. Richkus's comments with reference to cumulative effects or mainly seasonal validity. Most of the references to validity deal with laboratory studies of acute effects on early life history forms. It's a little more than acute, it's chronic, and we need to look at the chronic aspects.

This may not be the place and time to bring up this issue since the Corps was not involved in agitation dredging, but there may be other people in the room that do have to deal with private agitation dredging using I-beams. It might be worthwhile in some discussion groups to at least discuss it as just for the strategy purpose.

DR. HOMZIAK: The point's well taken that in addition to the dredging types that we normally deal with, there is federally-funded dredging. There is also permitted dredging where the Corps representatives on the regulatory side would be involved with understanding of issues. We plan to bring that up.

MR. HARDY: The private permitted dredging especially in causeways in Georgia is a very big problem cumulatively speaking, because, now, granted most of the dredging done, the majority of it, is done by Corps money and by Corps dredges and by Corps contract. But if you start dragging those I-beams up and down the Savannah River, in and out of every little boat slip and every little estuary here and there, you get a real cumulative effect over, say, a ten year period of time. That's dredging, and that affects the fisheries. I'd like to reiterate that probably should be discussed even though the Corps isn't paying for it. That's Corps dredging.

DR. HOMZIAK: It would fall in the category, as you said, the cumulative effects. And that would be the appropriate thing.

In addition to the previous comments, I have one last thing to include this morning. There have been recent efforts made by the Corps both on the district and division level and on the laboratory level, to deal with the problems of contentious issues, which are issues that cause conflicts for a variety of reasons. The development and implementation of monitoring plans and study designs is often cause for contention that has been developed over many years or misunderstandings and at times have severed our relationships. I've been involved with one in the Pacific northwest that if you'd have given the people knives it would have been a bloody Sunday.

We are also establishing and developing a set of guidelines to attempt to provide information to the Corps districts who are actually involved in doing the dredging which this information feeds into. We support wholeheartedly the efforts made by people at the Baltimore District, for example, to go through methods of arbitration or expert opinion to bring about resolution of contentious issues.

Finally, we're also involved in a methodology that we are beginning to accept that's called the "AEAM Approach," the Adaptive Environmental Assessment and Management developed in British Columbia, which involves a third-party group of people allowing voices and opinions to be stated. They essentially defuse the political aspects and past adversarial history, where you come together to a common ground. So, in issues that would be contentious, they should not be a focus of this workshop.

We are trying to get together to focus research efforts through cooperative work. The past history and existing contentious issues are to be addressed and solved in a different arena. Any other comments?

DR. RICHKUS: Let me just take a minute to run through this other dredging project. This seems like a good time to do it before lunch.

(Slide presentation). Just as background on this, this is a NOAA report. And if you want to write it down it's "NOAA Technical Memorandum, NOSOMA 31." And you can come get the title from me. It is a project we did that was initially funded by the Office of Marine Pollution Assessment, OMPA, which doesn't exist anymore, the way things go, they were acquired by some other division of NOAA. The intent of this program was to take historical data, going back to eighteen hundred, and try to establish whether there were any statistically significant relationships between a variety of anthropogenic

factors and aquatic resources in five major estuaries: Narragansett Bay, Potomac River, Delaware Bay, Hudson River and New York Bight. It didn't include the whole bight, but rather inshore areas.

We did this work initially with Carnegie-Mellon. This project went on for about three years. Carnegie-Mellon University initiated the development of these historical times series of data. They covered a variety of aspects. We identified things like human development in a water shed, pollution, sewage input into the water shed, time series of different inputs of different constituents of pollutants based on things like the amount of metal plating factories that had a certain type of constituent in their effluent. This information was used to give an estimated time series of annual loadings into the estuary of different types of constituents.

One of the factors included was dredging. These are NOAA data developed for the Delaware and the Hudson. It gives you an indication of what dredging has been like over that period from 1880 to 1980, a hundred years. Obviously a lot of their data are what you might call "soft" data which means people would say it's useless data. Our group developed a statistical approach called "categorical time series regression" that acknowledges that the numerical values may not be meaningful, but that perhaps at least the highs and the lows are meaningful. All these times series were split by a median value and converted into a series of pluses and minuses. The categorical regression approach takes those plus and minus series and does what amounts to a stepwise regression and ties into these series and goes through the process of assessing how much variation in the individual fish stocks can be attributed to these various time series.

Besides the anthropogenic aspects, there were the natural environmental factors like river flow and temperature, that were also included in the analysis.

They also focused on stock effects, a stock-recruitment relationship, and zeroed in very specifically on spawning periods, because that was the time when one would expect the stock to be most sensitive to environment and anthropogenic change.

The results are purely correlative, and are not causative. The intention of this study was to identify factors that might be amenable to further study based on historical record. However, as in all correlative studies, you always get interesting results. The reason I present it today is that for American shad, the bottom line of this was that "the volume of dredged materials within the spawning reach of shad was positively associated with stock size in the Connecticut River and weakly associated, but positively, with stock size in the Hudson River." And dredging didn't enter into the regression significantly in the other stocks. This analysis shows that there is some positive effect between dredging and stock size. What specifically caused the correlation? Maybe the channel opened up and the shad could move up easier or dredging improved water circulation. But it's just an interesting aspect of this whole issue. This analysis has not received wide distribution because the document is recent.

With regard to striped bass there was no detectable influence of dredging, for the historical time periods analyzed.

This slide shows all the major shad spawning streams and the kind of dredging operations that have gone on over the years.

This slide shows the total volume of material dredged. I'm not exactly sure of the source, but you can see there are really substantial differences in the amount of dredging over time.

This (slide) is the Delaware River and it has been subdivided into the upper portion and lower portion. I'm not exactly sure where ninety miles is, but the intention is to separate out the spawning area from the estuarine area. And you can see that there is a lot more variation from year to year in the lower portion. This probably would be in the tidal-estuarine area more than in the upstream area.

This (slide) is the Connecticut River showing a tremendous upsurge in dredging in the 1940's. The shad stock in the Connecticut has improved in the latter portion of this period, and that may be why dredging came in as a positive factor.

This slide is of the upper portion of the Hudson River showing tremendous year-to-year variability, which I can not explain. It was surprising to me.

Those are the only sides I have. I presented them to give you a feel for the kind of annual variability that you can get with dredging. This report is available now from NOAA. So, if anybody wants a copy of it, just ask me.

DR. CHRISTOFFERS: I may just give you a solution or an anecdote that comes to mind immediately. Right after, about 1957 I guess it was, they started lifting a lot of fish out of the riverine estuary. That certainly had a very positive effect on the stock size.

DR. RICHKUS: Well, as I say, correlative studies are always interesting to create hypotheses and to discuss.

MS. DORE: I also want to say that on the Connecticut River, it could have to do with the management of the types of gear used to collect shad. Drift gill nets are the only gear that are allowed to be used. They have eliminated all the other types of gear. Therefore, that adds a lot of selectivity into those calculations.

(LUNCH RECESS)

DR. MANOOCH: Next on our program is Bill McCord who is with the South Carolina Wildlife and Marine Resources Department, Charleston. Bill and Glen Ulrich have been involved in research on alosids there. He is going to discuss some of the tagging work that they have been doing off the coast.

John W. McCord

South Carolina Wildlife and Marine Resources Department
Charleston, SC

I work with the Marine Division of the Department. We also have a Fresh Water Division. They have conducted research on blueback herring, primarily in the Santee/Cooper Lake system. Some of the people here with the Corps are probably familiar with the redirection project that has been going on there. That project has opened up some interesting possibilities, because there is now a fish-passage facility on a redirection canal that leads into the Santee/Cooper Lakes which were created in the late 1940's. The Santee River was blocked at about river mile 65, and at that time there was absolutely no provision for upstream passage of shad in the Santee River. It is the largest river system in South Carolina and supports annual migration of alosids.

Historically, the river spanned 378 miles and the shad were able to migrate as far as they desired. The redirection canal and fish passage enable the fish once again to migrate far upriver and has opened the lakes to passage of blueback herring, a forage for striped bass.

American shad have also migrated into the lakes, and there is definite evidence there that they are successfully reproducing in this system. The State of South Carolina is conducting haul seine surveys in the lakes and have gotten quite a few juvenile American shad. In fact, I think they've gotten more juvenile American shad than they have blueback herring this year. They estimated that about twenty-five thousand American shad had gone through the fish-passage facility. Prior to this, herrings and shads had been passing into the lakes through the navigational locks at Penobscot Dam and Cooper River.

Since 1979 the Marine Division has been working primarily on American shad commercial fisheries in South Carolina and inventorying all river systems in the state, monitoring the commercial fisheries and collecting some basic life history information on age as well as catch/unit effort data.

As we collected information on blueback herring, American shad and hickory shad, we found that gill nets, both stake and anchor, are used in most of the river systems, but haul seines and hoop nets are used in the Santee/Cooper system where about two hundred to three hundred thousand pounds are caught annually.

Our Fresh Water Division has been doing some work on the Santee/Cooper system connected with redirection and passage of bluebacks into the lakes as forage. That work has been funded primarily by the Corps of Engineers. In 1986 we started tagging shad in the ocean, as Bill Richkus stated earlier. One of the major goals of the Atlantic States Marine Fisheries Commission's Management Plan is to determine what stocks of shad are being taken by coastal fisheries. A migration pattern for American shad has recently been suggested where they move

in from over-wintering grounds offshore of North Carolina. Southern stocks probably run south of there, and the northern stocks probably run up the coast as water temperatures moderate in spring. There were some indications that most shad may be moving southwards, but we did not know that, so that was the reason we undertook this tagging operation.

Gill net fishermen began moving out into the ocean to take advantage of the capability to catch shad earlier in the season, like Bill Richkus suggested, when the prices were higher and also the fishermen could fish basically an unlimited amount of netting. They fish up to three thousand yards of gill net and their catches could be quite substantial. They also fished for Atlantic sturgeon in the same area.

South Carolina has made some management changes in this fishery, not based on shad but because of incidental catches of sea birds and other creatures in the nets. Only drift gill nets are allowed. This has reduced the effectiveness of the fishery, but it is still landing about sixty to seventy-five percent of the landings in South Carolina, which have been around three hundred and fifty to four hundred thousand pounds for the past several years. This fishery alone accounts for about two hundred thousand pounds or so annually.

We began our operations to determine the feasibility of tagging shad in coastal waters and to ascertain which riverine stocks were impacted by this fishery. The primary sampling site in 1986 was near the Winyah Bay jetties, which are located near Georgetown. This was an ideal sampling location because it was in the center of the commercial fishery, which operated about forty kilometers on either side of this site. The area was easily accessible and the jetties offered some protection, and concentrated fish. The major drawback was that we were near a very large river system, and we anticipated that a lot of tagged fish would enter the mouth of the Winyah Bay system into the Waccamaw and Pee Dee rivers which empty into Winyah Bay.

In 1987 we decided to try to avoid this problem by moving our operations to Murrells Inlet which is an open beach area. It does not have any direct fresh water input and is about forty kilometers north of Winyah Bay. However, we didn't catch very many fish there so we moved back to Winyah Bay for the remainder of our tagging operations.

Fishermen use five and a half inch stretch mesh gill nets, and fish two to three hundred yards of net depending on the availability of fish and weather conditions. We fished from a seventeen and a half foot Georgetown-style commercial boat. The nets were hauled about every thirty minutes or as often as possible depending on weather conditions and the availability of fish.

In 1986 the fish were caught and placed in a rectangular tank and we exchanged the water by bucket as necessary, which did not turn out to be a good technique. So, in 1987 we put in a flow-through system with bilge pumps, one inboard and one overboard to hold the fish. Before tagging we moved the fish out about eight hundred meters from the netting site so they would not be subjected to immediate recapture. This procedure worked pretty well, as I recall. We recaptured one fish the first year and one the second year, and both were released in good condition.

Before tagging we sexed the fish and recorded lengths, in the event we got recaptures in subsequent years. Shad were tagged with 4FT1 dart tags. The general condition of each fish was observed upon release to see if it was able to maintain its equilibrium and swim off normally or whether it sank to the bottom.

Instead of having a real tight sampling schedule, we went whenever the weather was good, because a lot of times it wasn't too good and we went several times when the weather left a little bit to be desired.

In 1986 we made thirteen tagging trips in Winyah Bay. There was another trip made in January to Murrells Inlet. These trips were made from January through about the middle of April. We tagged four hundred and eighty-five fish at the Winyah Bay site and only four at Murrells Inlet. We got no recaptures from Murrells Inlet.

In '87 we made five trips to Murrells Inlet and on two of these trips we did not catch any shad and tagged only ten shad at that location. That is why we switched back to Winyah Bay. We encountered prevailing easterly winds in the spring of 1987 which made it very difficult to work. We were not able to get in near as much effort as we had hoped so we tagged only a hundred and twenty-five shad which was far below what we had hoped. After our experiences in '86 we thought we were going to have a good year in '87 and were therefore disappointed with the results.

Gill net bycatches were primarily Atlantic menhaden, spider crabs and blue crabs. We did catch some other anadromous species, a few hickory shad, blueback herring, and juvenile Atlantic sturgeon and one adult female shortnose sturgeon. Other important bycatch species were small sharks, spiny dogfish, smooth dogfish and juvenile sandbar sharks.

Pretagging mortalities in 1986 were relatively high on the first tagging day and on all trips in April. April was when the sharks started showing up in large numbers. The high mortality on the first date was due to an unexpectedly large catch of shad and we were unprepared to handle a lot of fish. We had three hundred yards of net out, and the weather was real nasty. By the time we got finished fishing the net, some of the fish had been caught for over an hour. So we had some pretty high mortalities. Then in April the sharks were real abundant. We caught seventy-five sharks in a matter of about four or five hours of fishing. The water temperature was a little higher, so there was a lot more stress which produced higher mortality rates.

In 1987, after refining our handling procedures with the flow-through system, we experienced much lower mortality rates. However, we also caught fewer fish.

This (slide) is a schematic diagram of the tag returns. All returns in 1986 came from South Carolina and Georgia except one recovered in the ocean just on or about the North Carolina-South Carolina state line. You can see from this that the majority of fish were taken in the Winyah Bay, Waccamaw, Pee Dee River system. I think about 68% of the tag returns came from this system, which was what we expected. However, we did have a pretty good distribution of tags from south of the tagging sites.

Eighty percent of the tag returns came from South Carolina, and 9% of the returns came from the Altamaha River in Georgia. We have a total of a 120 tag returns out of 489 fish tagged (24.5%).

If we look at the tag returns over time, we see that all the fish tagged through the 27th of March were available to all fisheries in South Carolina and Georgia. Fish tagged from the 31st of March to the 7th of April were only available to South Carolina fisheries in the Savannah River area.

If you look at the average distance traveled and days out, you notice a decreasing trend in numbers. That is because the fish that we caught earlier in the season tended to be going to farther areas, or returned from far off. This is consistent with the way shad move in the rivers farther south earlier in the season. They then move progressively later in the season as they migrate north.

Tag returns in 1987 were very similar to 1986. We had a 31% return rate out of a 125 fish. We got 39 returns. All returns came from South Carolina and Georgia. We did not recover any from north of the tagging site; all were south.

This slide shows returns by location. We had 64% within the Waccamaw-Pee Dee drainage, and about 68% were from South Carolina rivers. If you look at the tag returns by time period you can see the same general trend of decrease in distance traveled through time. Fish tagged from the 6th of April through the 13th of April were not available to Georgia fisheries.

Days-at-large, distance traveled, and the distance-per-day were very similar for both years. The fastest travel we documented was for a fish tagged on the 10th of March, 1986 at Winyah Bay and recaptured four days later in the Altamaha River, which is roughly 300 kilometers from the point of tagging.

In 1986, all but three returns came from commercial gill nets. One was recaptured by fishermen near Charleston and was released in good condition. We had one that was caught on a broken-back Rebel lure by a large-mouth bass fisherman in the Ogeechee River about a month after the commercial season had ended. And, we had one that was caught on a shad dart in the Pee Dee River by a recreational shad fisherman.

Basically, we determined that we could tag fish in nearshore ocean waters. We found that most of the fish were going through South Carolina rivers, moving south of the tagging site, and the mortality rate was quite high for tagged fish. However, we were not able to tag continuously over the period, so it is hard to say what the actual mortality rate was on fish moving through that area because we were fishing below a lot of the effort. We only had probably 5% of the tag returns from ocean fishermen, and there has been a recent development of ocean fisheries, as Bill Richkus pointed out, in Virginia and North Carolina. There is much concern about what those fisheries may be taking. There is a possibility that fish being taken, especially in Virginia, may be moving northward instead of southward if the net catches of these migratory patterns are indeed true. Much remains to be learned from tagging shad, and we plan to tag this year. North Carolina is also trying to initiate some tagging projects in 1989. That is all I have. Are there questions or comments?

MS. DORE: I have a comment on survey design, but I can tell you later. Your method is very similar to the way we are collecting shad and tagging them on the Susquehanna River.

Q: (BY DR. MANOOCH). Did you have any trouble with floating, dead fish afterwards?

A: (BY MR. MCCORD). Most of the fish were in remarkably good condition after we released them, especially in 1987 when we caught a lot fewer fish. The primary objective was to get out as many tags as we could so we could get stock identification data. So, we just looked to see if the fish swam off when we released them. We had about 7% of the fish over both years that sank out of sight without swimming off.

We also checked each tag individually to make sure it was well secured. We do not think we had much tag loss. There had to be some post-tagging mortality, but it was probably minimal.

We do have a real problem with commercial fishermen. They don't like to cooperate with wildlife agencies. But we know that there was a lot of talk around Georgetown, which is the center of the commercial fishing industry in South Carolina, especially for shad, about people who had caught large numbers of shad in the ocean and did not return their tags. We anticipated that. Therefore, the actual catch rate on fish that we tagged and released may have been as high as 50%. I wouldn't be suprised if it was.

Q: (BY MR. FORREN). How long were the shad held in those holding tanks?

A: (BY MR. MCCORD). Oh, it was--generally we try to fish the nets every 30 minutes--so it was, hopefully, no longer than 30 minutes. We checked the net, removed the shad, placed them in a flow-through system that worked real well, and took them directly offshore about 800 meters or so, tagged and released them. We didn't hold them for a very long period of time. The fish were in real good shape. With the flow-through system we could have held them a lot longer probably, especially with the low catch rates.

If we had caught 50-60 fish in a net, which we had done several times on one 30-minute period in 1986, we might have had more problems. But in 1987 we never had more than 15 fish or so in the tank at any one trip.

Q: (BY DR. CHRISTOFFERS). Have you guys given any consideration to using a circular tank as opposed to the square one?

A: (BY MR. MCCORD). The first one was square, which didn't work real well. The fish concentrated in the corners. However, I don't think it really introduced any great amount of stress because the fish weren't in there very long, and they were already stressed when we put them in anyway. We did change the water pretty routinely, by bucket. The tank we used last year is rounded, it's an oval-shaped tank, so the fish can swim around.

Q: (BY DR. CHRISTOFFERS). That was one of the key issues, I think, in the major shad transport when they went away from the traditional, square transport vehicles to the round-shaped--

A: (BY MR. MCCORD). They definitely preferred the rounded corners.

Q: (BY DR. CHRISTOFFERS). And the current in the tanks, through water jets, that made a significant difference?

A: (BY MR. MCCORD). This system worked real well and the fish seemed to do a lot better.

Q: (BY MS. DORE). That was the suggestion I was going to make. We went from the square tanks, to the oblong, still with no success. When we went to the circular with the bilge pump in it, we found that to be very successful.

A: (BY MR. MCCORD). We thought about that, as a matter of fact. The first year we tried to go out with a shrimp trawler and let it be stationed by the jetties. We had an eight-foot circular tank with a stand pipe in it and all this stuff. We had a great design. We were going to go out and tag thousands of shad. And we got out there and it was blowing 25 miles to the northeast. We had to run all the way back to Charleston and go back up the next day. You might do that three or four days in a row. And you get a whole two weeks of blowing and it was all shot. And you had all this travel back and forth with a shrimp trawler.

Q: (BY MS. DORE). What we were using was like a 30, I think it was about 35-inch diameter culture tank. It worked very well.

A: (BY MR. MCCORD). Space is a problem though. We try to get on fairly small vessels, so that's one reason we went to this tank. But it seemed to work real well at least for relatively small numbers of fish.

DR. MANOOCH: The next speaker is Richard Eager who is with the U.S. Fish and Wildlife Service in South Carolina.

Richard Eager

U.S. Fish and Wildlife Service
Wadmalaw Island, SC

The Corps of Engineers, in South Carolina and Georgia, and the Fish and Wildlife Service, started a cooperative program evaluating the passing of shad through the New Savannah Bluff Lock and Dam, at river mile 187 on the Savannah River. The Corps constructed the New Savannah Bluff Lock and Dam about 50 years ago. In 1950 the 81st Congress authorized a dredging project by the Corps to deepen the existing five foot channel to nine feet (and nine feet wide).

Declines in commercial traffic to near zero in recent years, and actually zero in 1986, continually delayed plans to further deepen the channel. Operation of the lock was contractually turned over to the City of Augusta in May, 1987. The City of Augusta had been concerned that the closure of the facility might curtail port development plans.

Dredging operations downstream principally in the port city of Savannah, had been extensive and ongoing since 1874. American shad was an important fish to commercial and sport fisheries along the Savannah River. The stocks have declined since 1970 at an alarming rate. The concern over shad population declines, from my perspective, seems to have been raised in the northeast but has recently received the attention of the more southern states because the value of their fishery was finally realized. For example, a recreational fishery has developed relatively recently at the New Savannah Bluff Lock and Dam. During the peak of the shad season, as many as 8 to 10 boats and 200 bank fishermen fish the immediate area, within 300-400 yards of the New Savannah Bluff Lock and Dam.

Catches of 30 shad per boat in the three to six pound range were not uncommon. The largest American shad caught, a new State of Georgia record, eight and a quarter pounds, was caught here last year.

Fishermen have developed a basket technique to assist them in landing fish from the wall. They will drop a basket down, maneuver the fish onto the basket and haul the basket up this 30-foot wall. I've seen a 15 pound striped bass being brought up that way. Fish as large as 26 pounds have been reported, striped bass, being brought up there in just that manner.

The dam represents a 15 foot impasse to upstream migration by American shad, blueback herring, shortnose and Atlantic sturgeons, when the river flows are less than 16,000 cubic feet per second. Above these flows, the dam gates are raised fully open, and the river below rises sufficiently, so that the migrating shad have no restrictions to their passage. The Corps of Engineers fish-speed data show that American shad have a burst speed able to traverse anything that is less than 14 feet per second flow.

There appears to be an inverse relationship between the amount of water in cubic foot per second versus the velocity. In other words, as the CFS increases, the flow in feet per second decreases below these dams. Anything less than 16,000 CFS during the period of migration and you have problems. It is hard for a fisherman to stand there and look at 15,000 CFS going down the river and think it was a low-water year. However, the fish can't traverse in such a low-water year by our definition.

Passage to the spawning grounds above the New Savannah Bluff Lock and Dam may significantly increase the number of fish returning in four to five years and being caught by fishermen.

Development on prime spawning and nursery areas above the Savannah Bluff Lock and Dam has been minimal. There is very little development, either homes or industry, along the upper areas of the Savannah River.

Preventing loss of this suitable area demands determination of environmental parameters that may impact early life history stages. The area is a prime spawning and nursery site. It is a very beautiful area with very clean water. There are numerous pools and riffles and I think there are 13 or 14 major shoals with several nice, large pools. The area is almost impossible to get to by boat. You would have to launch, take out, and launch between the shoals. You can see why developing this area would have a negative impact.

The average discharge of Clark Hill, or Stevens Creek, the reservoir below Clark Hill that would feed all the water into these spawning and nursery habitats, is 5,000-6,000 CFS during the period of juvenile development. Since the Augusta canal could take 8,000 CFS, it could literally take all but the 500 CSF leakage that occurs around that facility.

The goal of the joint-cooperative study was to determine American shad passage in low-water years, which again, is anything less than 16,000 CFS, through the New Savannah Bluff Lock and Dam by the lockage process. An alternate regime would be to pass the American shad through the dam. That proved basically impossible in low-water years. Other goals were to enumerate the passage of; to determine a minimum number of shad needed to add significantly to the stock; monitor spawning; determine the specific spawning sites; establish nursery areas and quantify their parameters; estimate run-to-sea time; and quantify the area's contributions to the stock that might be in the ocean.

This (slide) was made April 26th, 1986, and shows two females which were taken below New Savannah Bluff Lock and Dam. This is a picture of good condition shad roe in 1987, early in the season. This, in contrast to the other one, is later in the season, June 5th, 1986. I did not think these fish would spawn at all. Fish looked pretty bad by June. On March 20th, 1986 the water temperature was 57°F. In 1987, the first female was creel on April 10th, several weeks later. It was a cool spring and the water temperature was 54°F. The peak of the shad run in 1987 was sometime after May 1st, because only 38% of the fishermen's creel was made of roeshad on that date.

Tagging of American shad in 1987 was conducted on April 19th and 20th, and only 42 of 272 fish tagged, 15%, were females. Males preceded females for both years by as much as two weeks. The cool waters of the Savannah River allows the shad extended periods of time over which to spawn.

Fish were in good body condition on June 5th, although the eggs look pretty bad. Those fish did spawn, however. In 1987, only emaciated males were found by July 16th.

Twenty-eight tests were conducted in an eight-day effort, at the New Savannah Bluff Lock and Dam in 1986. Fifteen different combinations of gate openings, valve openings, test-time durations, and river flows across the dam were evaluated. Empirically, the most efficient of the several successful

attracting flows was obtained by leaving the land wall open and opening the valves from the flooding valves from the river wall. The attracting flow is 360 cubic feet per second, or a 1.6 foot per second velocity. Passing flows, which are when you close the lock, raise the water, and open the upper gates, were 260 cubic feet per second. Water moved through the lock at only .19 feet per second since it was now so deep. I have a handout that goes a little bit more into detail than I might need to talk about here.

It was uncertain how many of the passage combinations worked at passing shad upstream because of the difficulty in recapturing fish exiting the lock. We do know that the fish required 20 minutes to completely exit the lock. So, a complete cycle could be done in an hour, and probably seven or eight lockages could be done in a day.

The number of fish that locked through was estimated at about 1,000. No effort to actually count the fish was made in 1986, but in 1987 they were successful in counting the emigrants with a Bendix fish counter. It actually counts air bladders with sonar.

We found that the southern American shad seem to be bottom-oriented, not surface-oriented as we reported in the northeast. Maybe that is because most of the locations in the northeast, maybe in Connecticut, involved little creeks where the fish have no choice but to be surface oriented. In our area, the shad have a lot of water. It is 30 feet deep at the dam and they seem to be bottom oriented. The only fish I caught in nets were on the bottom. And, they were all on the river wall side.

Electrofishing in 1987 was productive at River Mile 203.1 and 206.6. The river is very difficult to sample because of all those shallow water shoals. Our electrofishing rig is a Coffelt VVP 15, which is not the best unit to use in soft water. Actually the VVP 2E was 45% more effective than the VVP 15. The boat is a negative, the electrodes are all positives.

Attempts to move the fish through the dam were completely unsuccessful. You would have to manage flow so that it's less than a three-foot head drop. Then fish could move through. That kind of a waterflow would take 16,000 CFS in this particular system for about twenty-four hours in order to raise the river down below the lock. Then when we opened up the gates we could move the fish, I think fish have been passing through the locks easily enough. Unless we just happen to encounter a flood situation and then we could manipulate the gates and pass, probably, many more fish than we do by the lock method.

Growth was monitored over a 112 day period, August 22nd through December 10th. The mean time between samples was 10 to 26 days. The smallest specimen was 53 millimeters, and the largest was 116 millimeters. All specimens were taken by electrofishing at the two sites. The principal site for collections was below the shoal at 203.1. It is characterized as a long shelf with a pool below the last shoal, and the uppermost four miles are accessible to the locked shad. It has sand bottom with aquatic vegetation, mostly coontail and Potamogeton, pondweed, clumped throughout the area. Currents were moderate with depths from six inches to three feet. Depth was dependent upon the amount of discharge. That went from one foot to five feet deep.

The graph data show that as the shad approach 90 millimeters total length, they seem to move out of the collection area site. The slopes of these lines are .34 and .28. The slope for the Susquehanna River was .87. North Carolina researchers had data that show the same size fish for about the same dates. They concluded that that was excellent growth. So, the growth here probably is not unreasonable. I can't explain the high growth rate in the Susquehanna River except that maybe the Savannah River is cooler. Southern rivers below dams are cooler than northern, undamed rivers in summer. And the Savannah River is a lot softer than the Susquehanna and is almost a first-order stream since it flows behind a major blockage, and there are very few tributaries into this area.

It appears that the fish move out of the nursery area into deeper water and move out of my sampling area and that may explain why I obtained a negative growth rate. The average size would decrease. Therefore, in sampling be careful not to sample a single-type habitat. If you sample in only those areas where you can collect, you will probably wind up with erroneous data as fish move or change food habits.

The outmigration in 1986 was really a lot longer than suspected. Bill Richkus said that "When shad go, they go." Well, that may be up north. The reason they left I can not tell you. The temperatures were about the same throughout the whole period.

We monitored for 44 days, thirteen of which were only monitored partially with the side scan, Bendix-Sonar counter, immediately above the New Savannah Bluff Lock and Dam. All the fish had to go through a one and a half to two and a half foot area below the dam gates. The total number of fish counted was 46,313. That was for half of the river, a 120-foot area that we counted. I cleaned up the data and removed anything that was less than 10 fish per sampling period, which was an hour, per gate. I threw those out. I still retained 95.7% of the fish, which would indicate that everything was some discrete larger group. When I adjusted that against the five largest groups that had been through, I still retained 86.9% of the fish, 40,213, for 18 of the most concentrated, individual hours counted.

For the 18 hours, 35,726 fish, or 77.1% of the fish, were totally counted. You have to double this figure to include the South Carolina side, because we counted the Georgia half of the river only.

When I first looked at fish passage I was convinced that shad didn't know daylight from dark. However, about 80% percent of the fish left between 11:00 p.m. and 6:00 a.m. And then there was another group that left between 3:00 and 7:00 p.m.

Evidently the spawning was quite successful above the New Savannah Bluff Lock and Dam in 1986. That is interesting because lower river inflows to the area were experienced that year than any other year on record. Because of the drought in 1986 the Corps of Engineers twice reduced the minimum flow released through the Clark Hill Dam down to something like 3,300-3,600 CFS as a daily average. 1987 looks pretty good. I think we have been successful in passing fish through and we may be successful in contributing to the stock.

DR. MANOOCH: Next on our program is Mary Ellen Dore who is with the Maryland Department of Natural Resources in Annapolis.

Mary Ellen Dore
Maryland Department of Natural Resources
Annapolis, MD

I am Mary Ellen Dore with the Maryland Department of Natural Resources. And my involvement in this whole picture is that when a project comes in for dredging, I am usually one of those people who put a time-of-year restriction on it. There are reasons why we impose time-of-year restrictions. You just heard a couple of talks about the adult migrations and the problems encountered in the physical barriers with the fish. But a lot of the restrictions are imposed based on the larval and juveniles stages, particularly the young larval stages. There has been very recent research about what happens once the egg has been laid in the water. A lot of the eggs of anadromous fish--herrings or shad--are either surface floating or they are demersal. They are somewhere in the water column flowing along. Some are adhesive, meaning they stick together or they collect detritus to them, and hang in a certain area of the water column. And some are not buoyant at all and occur along the bottom. With increased turbidity in the water and being of an adhesive nature, these eggs will collect detritus, silts, and fine sediments that are in the water, and will sink. They will be buried. You have lost a year class or a segment of the year class.

Another problem is that once these eggs hatch, larval fish feed on their yolk sacks. They have not begun actively feeding, they are ichthyoplanktonic. They just float along in the water column, whether it be in the surface layers or somewhere in the midwater column. They begin feeding passively. Research has shown that these fish will accidentally encounter a particle that is the proper size for their mouths and ingest it. If they are successful, they get that burst of energy and want to be rewarded again. They keep feeding. The incidence of phytoplankton blooms and zooplankton abundance has to coincide with larval fish, otherwise there is no feeding success. Once a larva has exhausted its yolk sack and has not encountered food, even if food organisms become abundant, that larva will not feed. This failure to feed has been demonstrated for American shad and other fishes. These are some of the reasons why we impose time restrictions.

Another reason we impose them are water temperatures. Spawning activities, hatching, larval development, and metamorphosis into juvenile stages, are all keyed to certain water temperatures. A wide temperature range for most anadromous fish is 10° to 24°C. It varies with species, but is usually around 20°C.

The task that we have today and tomorrow was unclear to me when I first arrived. I knew we were talking about anadromous fish, adults. I did not know quite how the other life history stages were going to fit into the picture. I am beginning to understand that a lot of the focus seems to be keyed on the adults and passing of those adults past a dredging project. Be advised that a lot of these areas where you are going to encounter adults are also going to be areas where spawning takes place. For instance, any dredging projects that occur in the upper reaches of the Chesapeake Bay, Susquahanna River, the C and D Canal, and the Potomac River will involve all life stages. There are wide reaches in those systems where anadromous fish, shad, herrings, and striped bass all spawn.

That's all I have to say. Thank you.

DR. MANOOCH: We have an open place on our program, so we have extended invitations to our two North Carolina fishery agencies, the North Carolina Wildlife Resources Commission and the North Carolina Division of Marine Fisheries. Mike Street from the Division of Marine Fisheries will be here this evening. We also have with us today a gentleman from the North Carolina Wildlife Resources Commission, Kent Nelson. His agency is not directly involved in dredging activities and anadromous fish even though they have worked with the N.C. Department of Transportation on bridge construction and stream flows. He is very familiar with anadromous fish populations in North Carolina and some of the sampling techniques. We hope he will join us in discussions tomorrow.

Next on the program is Joe Loesch with the Virginia Institute of Marine Science at Gloucester Point.

Joseph G. Loesch
Virginia Institute of Marine Science
School of Marine Sciences
College of William and Mary
Gloucester Point, VA

I think you will find there is some redundancy in the presentations by the biologists today since we did not consult before the meeting. But we'll be kind and call it reinforcement, rather than redundancy.

I am going to speak about the anadromous program at the Virginia Institute of Marine Science, and somewhat about the distribution of the anadromous fishes in Virginia. Bill Richkus covered most of the basic biology and distribution of the alosids.

The anadromous program at VIMS is divided into three categories: a general monitoring category, a research category, and a restoration category. The projects complement one another, and all augment the data base necessary for our intended goals.

We have monitoring programs for the striped bass and alosid stocks. The alosids are the American shad, blueback herring and the alewife. We also monitor the juveniles and determine their relative abundance in order to get a juvenile index of abundance. The objectives of monitoring the adult stocks are to collect the basic, but essential, data such as species composition, sex ratios, age structure, spawning history, and length and weight at age. The object of monitoring the juveniles is to obtain relative abundance. These indexes are generally sensitive to at least large changes in year-class strengths. We can determine good and poor year classes. If the juvenile index can also be shown to be reasonably related to, and to vary directly with, the spawning stock size over a large range in stock sizes, the index can then be used as a surrogate variable for actual recruitment, which would not be until several years later.

The research projects presently ongoing are the striped bass brood-stock study, in the Pamunkey River and the striped bass mark-capture study in the James River. I will be starting another tagging study of striped bass, possibly next week in the Rappahannock River. We are waiting for water temperatures to go down a bit.

In the spring I hope to start an evaluation of a new fish ladder in the Chickahominy River, a tributary to the James River, where I will be tagging either American shad or river herring. This is one of those sites that had an old fish ladder built back in the '30's that never really worked.

The brood-stock study is a cooperative effort with other agencies: Virginia Game and Inland Fisheries Commission, U.S. Fish and Wildlife Service and the Virginia Marine Resources Commission. Essentially we are removing the adults from the stream and the Game and Inland Fisheries is to spawn them out. The fish will be grown to a size that can be marked with an internal binary code, and, subsequently, the young can be returned to their natal stream. The object is to see if hatchery fish can noticeably supplement a wild stock.

The objectives of mark and recapture are to evaluate exploitation and mortality under present management regulations, assess coastal migration patterns and the assess degree of fidelity to the river of capture in subsequent spawning seasons. I believe Bill Richkus mentioned this morning that I'm not a believer in the parent-stream theory. It is not quite that clear cut. North of Virginia there are a lot of systems that empty directly into the ocean, and I think there is a lot of stream influence drawing the fish back. They probably have a high degree of stream fidelity. It's just that there is no evidence, no real good evidence yet in Chesapeake Bay for homing. Where fish come into a very large bay it is possible that in any given year one stream could be more attractive than another, either physically or chemically. I guess I'm just taking the Doubting Thomas position. I want to see the evidence first.

The data that we gather in the monitoring and research programs will be made available to others through reports and scientific journals.

With the restoration projects we are looking at fish-passage facilities. Ed Christoffers talked somewhat about the James River and dams there. In the Chickahominy we will be evaluating the success of the fish ladder presently under construction. The objective is to see if fish stocks can be enhanced or re-established. The emphasis of my program is on the development of anadromous stock assessment models that will give our fishery administrators quantitative tools to assist in the formulation of management decisions.

I did not realize that Bill was going to present life histories, however, I have some brief summaries.

The striped bass is a member of the temperate-water basses. I think everybody knows it's one of our most prized anadromous fish on the Atlantic coast, and certainly one that people get most hysterical about. As Bill mentioned, they range along the coast from the Saint Lawrence River in Canada down to Saint Johns in northern Florida. They are also present in coastal streams. The species is also present on the west coast due to stocking efforts in 1879 and 1882. On the east coast, tributaries of the Chesapeake Bay and the Hudson River are considered to be the chief striped bass spawning grounds. Most spawning in the Chesapeake Bay takes place from about mid-April to mid-June with the peak of spawning when water temperature is about 15-18°C. The young striped bass remain at least two years in estuarine waters, and tend to congregate in the deeper holes of the bay during the winter. Males at about age two or three may participate in the spawning runs upstream, but the females at that age will tend to stay downstream or enter the coastal waters. There are both commercial and recreational striped bass fisheries in Virginia.

The American shad on the east coast ranges from the Saint Lawrence River, Canada to the Saint Johns River in Florida. It also occurs along the west coast because of several introductions of shad eggs between 1873 and 1886. In the Chesapeake Bay shad ascend the rivers to fresh water from about mid-February to mid-May. Spawning is temperature related, so it can vary by a month in some years. In fact, we will get male shad coming into the James River in December, but they are not ready to spawn.

American shad are main-stream spawners. Unlike the alewife, they will not venture into little creeks. They generally spawn over sand or gravel, where the water temperatures range from about 14-21°C. The juveniles remain in tidal fresh water in the spring, later move down into the estuary, and most of them eventually go to sea at the end of their first year, i.e., the year they were spawned. Some remain over winter in deep holes. They will return as

adults to their natal river, at least in northern systems, generally at about age four or five. Quite often we see mostly six year olds in our sampling but that is, in part, because of gill net selectivity. The adults are prey for large piscivores and the juveniles are important as prey within the tidal freshwater and in the estuaries.

I think Bill mentioned today that the alewife and blueback are look-alikes, and they certainly are. As he mentioned, they are collectively referred to in the states as river herring, although the landings are reported just as alewife. In Canada, they are collectively referred to as alewife or gaspereau and landings are also reported as alewife. This collective reference stems from the similarity in appearance and similarity in times of spawning. Often, the spawning grounds are close together or overlap. Commercial uses of the species are also similar. They are used primarily as bait, pet food and fish meal. In Canada a substantial portion of the catch is salted and exported for human consumption. There are small local markets for smoked, canned, salted, and fresh products. As you can see from this overhead, there is a sympatric distribution. The alewife occurs from Labrador and Newfoundland to South Carolina, while the blueback herring ranges from Nova Scotia to the Saint Johns River, Florida.

I don't think we want to discuss how we distinguish the two physically, but primarily it is based on peritoneum color, and on eye diameter.

The onset of spawning for river herring, like the other anadromous species, is related to water temperature. Therefore, spawning is progressively later as one goes from south to north. As I mentioned before, there can be quite a variation in the time of spawning depending upon river temperature from year to year.

An important spawning aspect, and it may figure into dredging considerations, is that in the sympatric distribution there's a tendency for the alewife to spawn in lentic conditions, slow streams and lakes or ponds. The blueback herring, in contrast, will stay in the faster flowing water. Southward, in lower North Carolina or upper South Carolina, where alewives are rare, and below that where there are no alewives, blueback herrings change spawning habitat selection. While they still spawn in main streams, they show a preference for flooded rice paddies and cypress swamps where there is no competition with alewives for space. This behavior suggests a clinal spawning pattern for the bluebacks. It ranges from partitioning the stream with the alewife to spreading out to other sites in the absence of the alewife. Spawning has been well studied, in North Carolina, South Carolina, and to a lesser degree, in the north. However, in my own region there has been very little work, because we work farther down in the rivers and we work with commercial fisheries, not inland on the smaller streams.

Anadromous fishes may return to their native stream, but they will readily inhabit other areas when the hydrology is proper and access is made available. Examples are the introduction of shad and striped bass on the west coast, rapid population growth of alewives in the Great Lakes a number of years ago, and the recent re-establishment of shad and river herring runs in New England areas.

There is another spawning migration aspect of river herring reported in the literature, and that is that blueback herring will not go as far up river as alewives. This premise is false and developed primarily because the very early studies of the two species were in New England where coastal streams end in head ponds. The alewife spawn in the ponds, but bluebacks stay below in the faster flowing water. If you look at the major rivers, the old work done in the Santee/Cooper area, in Chesapeake Bay, and in the Connecticut River, you find bluebacks going farther up river than alewives. Species distribution could be a concern when dredging is considered. In the Chesapeake Bay tributaries the young are distributed throughout the tidal fresh water in the spring. With a saline encroachment when the fresh water flow is less, the tidal nursery grounds are moved farther upstream. I found in Virginia, that the juvenile alewife and shad tend to move down into the estuary a lot sooner than juvenile blueback herring. The blueback stay until August, sometimes September. In the estuary, I have taken large numbers of blueback juveniles in October.

Another consideration is that the species exhibit negative phototrophic behavior in the water column. When determining distribution and relative abundance, the findings will be influenced by the choice of gear and the time of sampling. I've found in Virginia waters, and it has been reported for the adults offshore, that the alewives are deeper in the water column than the blueback herring, and both exhibit a diel periodicity.

Juvenile river herring are prey for most piscivores in fresh water and the estuaries. They are the dominant pelagic prey species, particularly the blueback, until mid-summer when a large influx of menhaden occurs. The adults are fed upon by striped bass, bluefish, and most large predators in the ocean. In the estuaries, striped bass feed heavily on river herring in the spring.

Bill gave you a picture of what the coast-wide landings look like, and I want to show what they have been in recent years for Virginia. This (slide) shows the landings. We do have effort and catch-per-unit of effort, but they reveal similar trends. Dramatic decrease in landings cannot be attributed to the kinds of changes in effort that we have observed. Effort did not always go down. Sometimes it went up. This is for the striped bass (slide). We see pretty much the same period of decline as for the American shad. In around '75, '76, '77 it dropped off. Landings for river herrings reflect the picture Bill showed for the entire east coast, particularly, Maryland and Virginia. Here the decline is very dramatic. You see steps (slide). As Bill mentioned, in the late '60's there were very high landings by foreign fleets. However, there was also a very heavy harvest in the Chesapeake Bay at that time. Landings dropped to another level later on. In 1972 we had tropical storm Agnes pass through. It was estimated that the Susquehanna river deposited more sediment in Chesapeake Bay in the first ten days after the storm than it had done in the previous 25 to 30 years. The storm occurred in June and decimated the 1972 young-of-the-year.

And so, as we go along (in the slide) at this level, a reduced level, and then encounter still another drop.

When fishery administrators or biologists look at catch trends like this, and then someone proposes something that they perceive could be detrimental to the stocks, to the spawning grounds, or what have you, they can get a little uptight about it.

Roger Rulifson
East Carolina University
Institute for Coastal and Marine Resources
Greenville, NC

About four different times today I wished that I could have rearranged the order of my slides and talked about different aspects of what people have already discussed. I have a wide range of interests, and so you will see a lot of this in these slides today which cover the work that I am doing.

I have done fisheries work all the way from the Gulf of St. Lawrence to the Gulf of Mexico, ranging from ocean tagging of adults to looking at eggs and larvae of anadromous fish in freshwater systems. I have done much of this work for federal and state agencies, and also with private industry: hydropower and nuclear facilities, fossil fuel plants and tidal power. I am not coming from any one slant or the other. I would just like to share with you some observations I have made on high suspended sediments systems, and how that might influence anadromous fish.

We are here today to talk about dredging, and what effects dredging might have on anadromous fish migration. I want to show these slides because I took them a long time ago and I have never had the opportunity to use them.

This is in the Cape Fear River and involves the use of a hydraulic dredge in conjunction with the Brunswick Steam and Electric Plant. Carolina Power and Light Company wanted to build a water intake canal which would run from the dredged ship channel below Sunny Point, through a marsh system, and into some upland areas to the nuclear power plant. The intake canal created new habitat. We saw this when the pumps were first turned on. The power plant intake canal extends for several miles and dead ends at the intake screens of the nuclear power plant.

When the pumps were first turned on we saw an extraordinary species diversity. We saw everything from cutlassfish to flounders and crabs and shrimp. Species diversity was observed for the next couple of months. What had happened was that, as this new dredge habitat was explored by various species, suddenly the pumps were turned on and everything got sucked right in. After a while when things started to stabilize, the species diversity went down and stabilized at a lower level. At the present time this situation has been altered by the construction of a diversion screen at the head of the intake canal.

The point is that when you dredge, you create new habitat. One of the problems is, what do you do with the dredge spoil? I found in Canada that the Canadians can it and sell it for souvenirs. (Displaying can.) It says, "Souvenir of Atlantic Canada. Home of the highest tides in the world. A super gift for mud slingers. Ideal for designer mud flaps. A great mud facial but it falls off when the tide comes in. A gift from your muddled friends from the biggest mud puddle in North America. Future home of tidal electric power." I'll put this up here as Exhibit A. And the Corps, maybe, can make some money on some of their dredge spoil.

We do know that in dredging, the flow pattern of the water circulation is going to be altered. We are going to change benthic habitats and so forth. In the case of the Brunswick Steam Electric Plant, we have the Cape Fear River coming along here (slide) and Snow's Marsh. The cut was made, bisecting Snow's

Marsh, going through a tidal creek system called Walden Creek, and along this upland region to the Brunswick Stream Electric Plant. What happened there is that the sediment characteristics changed over time. This area was very sandy but there were some fine silt clay particles that dominated all along this area. And that became a very big attractant for penaeid shrimps. That was one of the problems caused as a result of dredging. The fine silt clay particles settled out in this very nice stratified water system created by the canal. Also, we can see problems with changing organic matter of the sediments, and of course, this will change to some extent the fauna and flora that will live in the area. Not only were the particles very fine along here, but they were also relatively high in organic content, a very nice attractant for penaeid shrimps.

I would like to talk now about anadromous fish and some of the life-history patterns of these fish. Very little information has been published about anadromous fish in the southeastern United States. That has been a major problem in trying to come up with management plans or any type of interstate, interjurisdictional management strategies. Therefore, in 1980 the Fish and Wildlife Service contracted me to write an Anadromous Species Management Plan for the Southeast. The management plan includes seven coastal states: North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana. We tried to identify all the literature: old proposals that never got funded, gray literature, and memorabilia, throughout Region 4, and derive life-history strategies. That has been presented in this 1982 document by Rulifson, Huish and Thoesen, and it is available from the U.S. Fish and Wildlife Service, Region 4, Atlanta, Georgia. The plan covers different aspects, including suspended sediments and its effects on eggs and larvae of certain species. So, you might want to obtain it. It is a good source document and covers everything up to 1980. A summary paper detailing potential causes for decline of anadromous stocks was published in *Estuarine Comparisons*, a 1982 book edited by Vic Kennedy.

One of the things that we did for this report was question a number of state and federal agency personnel in the seven-state region about what anadromous fish species were present in their systems and what they thought was causing the decline of these anadromous stocks. It turns out that in the seven-state area, there are 10 species or races of anadromous fishes, most of which are clupeids or alosids.

There are two races of striped bass (Morone saxatilis), the Atlantic race of striped bass in the South Atlantic states, and the Gulf striped bass along the Gulf of Mexico.

There are three sturgeons: The Atlantic sturgeon, Acipenser oxyrinchus, the Gulf coast sturgeon which is a sub-species, Acipenser oxyrinchus desotoi, and the shortnose sturgeon, an endangered species, Acipenser brevirostrum.

As far as clupeids go we have six: American shad (Alosa sapidissima), hickory shad (A. mediocris), blueback herring (A. aestivalis), and alewife (A. pseudoharengus) all in the South Atlantic coastal area. There are two species along the Gulf coast: the Alabama shad (A. alabamae) and the skipjack herring (A. chrysochloris). So, we are talking more here than just bluebacks and alewives, but a whole host of anadromous stocks.

This (slide) is the way the species are distributed by state. North Carolina has seven, South Carolina has seven and Georgia has nine. Florida has 10 because there are two coasts, the Gulf and the South Atlantic. Alabama has six, Mississippi has three, and Louisiana has five.

Anadromous fishes are important in our southern region, especially in North Carolina, South Carolina, and Georgia, as far as the commercial finfish fisheries go. In North Carolina we can see that we have a percent of total landings, and percent dockside value on the "y" axis. Year is indicated on the "x" axis. In North Carolina anadromous species make up 5 to 10% of all the landings of finfishes in North Carolina with a dockside value approaching 20%. So, even though the landings are not real great, the value is, and most of this is due to striped bass.

In South Carolina, landings approached 5% for a very long period of time, and then we get this sudden blip in the mid-1960's, and it tails off in the mid-1970's. That is as far as the data went, with a dockside value ranging between 10-30%.

In Georgia, landings contribute 20 to 60% of the total finfish landed, with dockside value ranging anywhere from 40 to 70%. Therefore, anadromous species are definitely important to this three-state region.

Now, as I stated earlier, the state and federal agency personnel surveyed were asked to write down factors they felt were contributing to the problem of the stock decline of anadromous species. Far down on the list is "channelization." Thirty-two and a half percent (32.5%) of South Atlantic sounds, estuaries, and tributaries that contain anadromous species were thought to have a channelization problem. And farther down the list we see "dredge-and-fill projects," 22.5% of all those estuaries, sounds, and tributaries that have anadromous species. So, it was considered a problem in one-fifth to one-third of the South Atlantic area.

Here are some of the other things that were examined. "Turbidity," for instance. Turbidity seems to affect 17.5% of the systems. You must remember these are all opinions, hopefully based on good observations through a number of years of working out in the field.

Along the Gulf Coast states, we see that channelization is the prime candidate for contributing to stock decline. Thirty percent (30%) of those river systems seem to be affected by channelization, and 12.12% by dredge-and-fill projects. Three percent (3%) are affected by turbidity. So, turbidity, channelization and dredge-and-fill projects are problems. This is not to say that dredging affects migrations, but there seems to be a problem with these activities, and the result is in these areas.

Turbidity and high suspended-sediment loads are not something new to anadromous species. This (slide) is a nice-sized female striped bass being captured by electrofishing in the Staunton River which is part of the Roanoke River system up in Virginia. I would say that the suspended natural sediment load there was quite high. This is the striped bass hatchery facility. They are doing a natural spawn here: injecting the fish with gonadotropin and letting them spawn in circular tanks. They use the natural waters of the river which are also high in suspended sediments. However, we are not sure what effects turbidity and high-suspended sediments have on the eggs and the larvae. This (slide) happens to be a deformed larva taken several years ago from the Roanoke River. It is not uncommon to see deformed larvae in the Roanoke River system. This condition could have been caused by sudden temperature shock. It could have been caused by a sudden drop in pH, or it could have been caused by other factors.

The Management Plan document cites several reports on what levels of suspended solids are adequate for a successful egg hatching. For instance, for alewives, anything less than 100 milligrams per liter seems to be satisfactory for having good survival rate and hatching of alewife eggs, for bluebacks, less than 100 milligrams per liter. Shad is less than 100 milligrams per liter, but larvae exposed to 0.1 milligrams per liter over 96 hours showed substantially reduced survival. It appears that the difference between eggs and larvae is quite great. We see this for other aspects as well, for subtle changes in the water quality.

The striped bass has been designated as a sensitive species to suspended sediments. And if I may digress for a moment, survival of yolk-sac striped bass larvae exposed to suspended-sediment concentrations of 500 and 1,000 milligrams per liter for 48 to 96 hours was significantly reduced. Larvae exposed to suspended natural sediments from the Chesapeake and Delaware Canal for 24 to 48 hour periods exhibited LC50 values of 4.85 grams per liter and 2.8 grams per liter, respectively. Now, those are natural suspended sediments.

DR. LASALLE: Is that grams or liters?

DR. RULIFSON: Well, this says grams. I could have mistyped this as we were writing it. But the reference for this is Auld and Schubel (1978) (Estuarine and Coastal Marine Science 6:153-164), and, let's see, "Striped bass were, therefore, classified as a sensitive species to suspended sediments," Morgan et al. 1973. I can give you that reference later if you'd like (Final report. U.S. Army COE Contract DACW61-71-C-0062). Anyway, the point is that striped bass appear to be sensitive to suspended sediments.

Let me switch now to the Bay of Fundy in Canada. The reason I would like to discuss this is because there are a number of studies going on right now in the upper Bay of Fundy concerning tidal power. This area has one of the largest tidal amplitudes in the world. Because of that, and because of the characteristics of the bottom, waters are very high in suspended sediments. The tides are about 45 feet on the average. We get large striped bass migrating through the system, like this (slide), all the way down to young-of-the-year. This is about a 50 pound female striped bass. The area that we have been studying is the site for tidal hydropower development. Tidal power, again, would go through this area.

There are a couple of things that I would like you to notice about these two embayments: Minas Basin and its upper counterpart, Cobequid Bay. Let me also mention that the Shubenacadie River is the main fresh water input into the system with several other smaller ones throughout the area. Minas Basin, the outer part, is a very deep basin. It has clear water and it is highly saline. It approaches the salinity of the Northwest Atlantic Ocean. It is quite cool with slight vertical mixing. Cobequid Bay on the other hand is quite shallow. In fact, a third of it goes dry at every low tide so it has extensive mud flats that extend for miles. It is highly turbid because of the tremendous amount of water going over fine silt-clay particle sediments. It is quite brackish, anywhere from 5 to 15 parts per thousand. It is warm because at low tide these mud flats heat up and then the cold water rushes in over the top and warms quickly. There is intense vertical mixing that goes on in this region.

Now, since 1983 we have been studying the migration patterns of alewives, bluebacks, and striped bass in this region. This (slide) is some data from 1985. In 1985 we monitored the catches of the commercial fishing weirs in the two bays and we came up with this pattern. It appears that Cobequid Bay, which is the upper embayment, traditionally has more of the smaller striped bass, and Minas Basin has the larger striped bass. There are several reasons why this might be so, but one of the things that I hypothesize is that it is because so much water is lost at low tide. It is more efficient for smaller striped bass to go in with the tides and come back, being able to drift, than it is for the large striped bass, which may stand a greater chance of being caught in too shallow water.

We just came out with a publication in the 1987 Transactions of the American Fisheries Society (116:119-122), which discusses the food habits of striped bass in the upper Bay of Fundy. We compared these two basins. It appears that as far as the different food items go, the Crangon, a certain type of epipelagic shrimp, occurs in 83% of all the striped bass stomachs examined, for a mean percent volume of 62.5%. The second most important group would be fish; 43.6% of all stripers had fish in their stomach, comprising 25% of the mean percent volume.

This does not look too unsurprising considering we examined mostly smaller fish. And it has been documented throughout the years that striped bass as they get older, go from an invertebrate or benthic-type feeding strategy to being piscivorous. If we look at the percentage of volume made up of Crangon and fish over the size classes of striped bass examined, we see that Crangon makes up 100% of the diet of the smallest striped bass. It diminishes to approximately 20% of striped bass that are 480 to 520 millimeters in size. This (slide) would be five to seven pound striped bass. Not the biggest one, certainly, that we have caught.

On the other hand, fish are never found in the smallest young-of-the-year stomachs. The percent-by-volume composition increases substantially as the length class increases. However, if we look at percent occurrence, we see that even though the large striped bass consume mostly fish, there is still a substantial portion that had Crangon in their stomachs. This is not documented in the literature for any other system. This means that the larger striped bass are still depending on Crangon or invertebrates for a major portion of their diet. Why is this? Why is this system different from other systems? We believe that the striped bass in Minas Basin under these clear, slight vertical-mixing conditions are using a visual-feeding strategy and are eating fish. And, under the reduced-visibility conditions of Cobequid Bay, these fish are reverting to more of a tactile type of feeding strategy where they are going up into the shallow creeks. As they do, they are following the tide as it pushes in, and they are eating anything that is there. Because a lot of mixing goes on, they are getting the Crangon and polychaete worms and other things that are being stirred up by the tides.

So, to conclude that portion of the talk, then, I would say that suspended sediments do affect the feeding strategies of striped bass as documented in the upper Bay of Fundy. And indeed, Mike Daswell who could not be with us today--incidentally, Mike has changed jobs. He is no longer working for the Canadian government. He is now a full-time professor, like myself, at Acadia University. Hopefully, this will allow him to pursue some of these fish-related projects that he has been so keen on the past few years. He sends his regrets.

I can answer most questions you have about his work because we have been working together for a number of years. One of his graduate students, Daphne Themelis, did a feeding study of American shad in Cobequid Bay, Minas Basin and other portions of the lower Bay of Fundy. She compared day versus night, seasonality, and so forth. And what it came down to was that the American shad, as it passes through these very turbid portions of the Upper Bay of Fundy, seem not to feed. This is something that Mike did not realize at first. We all figured that they were going up there on a feeding heyday as there was so much food available. We thought that they would swim through there consuming everything and then come back out, all fat and happy, lots of fat deposition, and so forth. That is not the case. Almost without exception, the shad that were caught in Cobequid Bay, that highly-sedimented area, had nothing in their stomachs. So, it appears then that shad are affected too by highly suspended sediments.

Keith Stone, another graduate student at Acadia University did a similar study on river herring feeding in Cobequid Bay and Minas Basin. He found some significant differences in the food composition. I can't remember whether or not that was attributed to turbidity. These studies have been on going in the upper bay--well, mine, since 1983.

Now, let us talk a little about migration. Mike Dadswell has looked at American shad migration and it turns out that this Bay of Fundy area is ocean. Don't forget that, it is ocean. All the tagging that we have done in this area is ocean tagging.

What has happened, apparently, is that a lot of stocks of fish, different fish species, get trapped up in here and it acts like a huge weir entrapping the fish for a certain period of time, and then they manage to get back out. This has created maximum opportunity for tagging studies because what you are doing is tagging in the ocean from a number of various stocks, letting them go wherever they want to go to spawn, and going to the maximum catch/effort that you could possibly want, which is concentrated in the river systems.

Heretofore, various state agencies have tagged in the river systems. Many times anadromous fish species are most easily caught during the spring spawning run, and, therefore, they are recaptured on spawning grounds. Therefore, it is a very short turn-around time between mark and recapture. You do not know where the fish are coming from, only that they got here. We tagged them, and now we are allowing them to go back to their natal spawning grounds. We have gotten fish out two or three years later coming back to their natal streams to spawn. So, we have growth data and so forth on a lot of these fish.

What Mike Dadswell found out about American shad was covered by Bill Richkus. I would like to talk about the inner Bay of Fundy. The circulation paths are clockwise like this (slide), and so the fish seem to move in a counter-clockwise position coming in on this side, going around within the Upper Bay of Fundy and the Nova Scotia side, coming out, going through here, and then exiting back out the Bay of Fundy system to overwinter. There seem to be several overwintering areas for American shad along the eastern seaboard. I hypothesize a similar strategy for blueback herring and alewife. It appears that a lot of blueback herring stocks that enter this bay are probably of U.S. origin. We have gotten blueback herring tagged here that were recaptured in the Roanoke River, North Carolina a year later on the spawning grounds. Alewives seem to be more of a local origin. This whole area is, for the most part, alewife dominated, for a major portion of the year. This information was presented in the 1987 Transactions of the American Fisheries Society article mentioned earlier.

There are several river systems in New Brunswick and Nova Scotia that are worth looking at concerning turbidity and fish migration up the rivers. I am going to address the Gulf of Saint Lawrence areas, specifically the Richibucto River and the Miramichi. Then I will compare those with the Shubenacadie/Stewiacke River system, which is completely tidally dominated, and very high in suspended sediments. This one has very low tidal influence, very clear waters. It is the Richibucto River. Most of the commercial fishermen there are French, which makes it very interesting to go out with them. You can see the river waters are quite clear. It is beautiful when you are in a clear estuary and able to see the bottom and all the fish swimming around. It is just incredible. The striped bass and river herring spawn in this river system in the spring. They all rush up in a big bunch and spawn within a several week period. There is no dredging going on in this (slides) area.

This is the Miramichi River in New Brunswick. Again, very clear water, although this water has a tannin or a tea-colored tint to it. Not much dredging going on in this particular area. The striped bass seem to go up very quickly and spawn, as do the river herring. The Shubenacadie River in Nova Scotia is one of the few rivers in the world that has a tidal bore. The tidal bore comes in, I couldn't find my slides, but you can see it coming in right here. It comes in as a small wave. This happens to be a neap tide. During spring tides, the tidal bore will be a wall of water half a foot to a foot deep. I had a whole sequence of slides to show you how it formed a huge whirlpool in this area. The area is very highly sedimented. It contains a lot of silt-clay particles. In the tagging studies that I have done, a large portion of the striped bass returns have come from this river system. Evidently, what goes on in this river system, as far as upstream migration goes, is that the striped bass follow the tide back and forth in these highly sedimented waters. And they drift around waiting for the water temperatures to warm up. The water temperatures in these shallow areas, again, increase dramatically between the two tides. The water temperatures might be 15°C on an outgoing tide. And it might be 10°C when the fish first come in. So, within a six-hour period the water temperature can warm up five or six degrees which makes it difficult for the striped bass to figure out when is exactly the right time to spawn. But again, the mud flats situation, the very high loads of suspended sediments, all contribute to the heating of the water system on a quick order. Striped bass stay in the system and just move around, then spawn just at the head of tide where the water has dropped its sediment load and has become very clear. Then the eggs and larvae hatch out at some point in the Shubenacadie River system, we are not sure where. The young eventually migrate back down into Cobequid Bay and utilize that as a nursery area during the fall.

Let me now move closer to home in the Roanoke River. The Roanoke River is dominated by discharge from the Roanoke Rapids Dam. The entire length of the river in North Carolina is dominated by a reservoir impoundment system. In the Roanoke we see great increases and decreases in water height over the spawning grounds due to hydroelectric generation. This was discussed in a paper presented at the Symposium on Coastal Water Resources in Wilmington, N.C., May 22-25, 1988.

The Roanoke River system is characterized by high, very fine silt-clay particles that get resuspended during hydropower generation. A colleague of mine, John Bray, and I are working on the aluminum chemistry of the Roanoke River. This work was presented in another paper at same the symposium in Wilmington in May, 1988. This is something that has not been mentioned yet but should be considered. The coastal plain of North Carolina is typified by fine silt clays that contain high levels of aluminum, a natural phenomenon. We believe that as

the pH of the water becomes slightly acid--we do have slightly-acid waters here in North Carolina--that resuspension of silt-clay particles with aluminum is causing a change in the aluminum chemistry. The change would be toward monomeric aluminum. Monomeric aluminum is the one to be concerned about because it has been shown to be very toxic to larval fish, specifically blueback herring and striped bass.

Therefore, we have designed a program whereby we are attempting to look at monomeric aluminum in natural waters in the Tar River, and hopefully in the Roanoke River pretty soon, using the fluoride electrode, and monitoring the fluoride activity in absorbing aluminum as it spins off of these small particles under acidified conditions.

These are some of the data that we have obtained (slide), which probably will not mean anything to most of you. I would like to mention briefly some of the rivers that have been mentioned as having problems with turbidity within the seven-state region which includes North Carolina. These include the Chowan River, Roanoke, and other Albemarle tributaries, Tar River, Neuse River, New River, Cape Fear River, and the Northeast Cape Fear River. Surveyed individuals in South Carolina did not mention any rivers. The Georgia people mentioned the Savannah, Ogeechee, Altamaha, Satilla and Saint Marys Rivers as being affected by turbidity. In Florida, the Saint Marys, Saint Johns and Apalachicola (although there may be more) were mentioned. None in Alabama and Mississippi were listed. Louisiana listed the following rivers: Pearl, Bayou Lacombe, Tchefuncte, Tangipahoa, Tickfaw, Amite, Mississippi, Mermentau and Atchafalaya. My point is that we need to examine the details of turbidity and its effects on migration before we get caught up in accusing each other of doing too many different things and thereby hanging ourselves.

With that I will leave you and answer any questions that you might have regarding either my studies or Dr. Dadswell's studies.

Q: (BY DR. LASALLE). I've got two questions. The interesting thing about the really high tidal river you saw, the tidal bore up there in Nova Scotia. What kind of success did you get with striped bass spawning in that area? Is it a good spawning site or isn't it?

A: (BY DR. RULIFSON). That's one of the few rivers left that still has a good run of striped bass. And the exploitation rate must be incredible because that's where the majority of my tags are coming from.

In fact, that's one of the few rivers where Stripers Unlimited is looking to get eggs from. They say it's not polluted so they are trying to get eggs from there and ship some of the larvae back to the States to stock in our river systems here.

Q: (BY DR. LASALLE). Is there any manmade activity there? Dams or anything on that river at all?

A: (BY DR. RULIFSON). There are some bridges. The headwater is Shubenacadie Grand Lake near Halifax on the Atlantic side. The Shubenacadie goes for quite a long ways and meanders a lot. It's really strange. It's characterized by its extensive mud flats and very shallow water with big pools at low tide. I think that striped bass probably hide in these big pools at the very lowest points in the water. Then at high tide, of course, there's quite a good water depth for them.

Q: (BY DR. LASALLE). One more question. What did you mean by turbidity problems? What is the definition of turbidity problems that you were using?

A: (BY DR. RULIFSON). I use that term loosely. Turbidity problems may be caused by a number of things. It could be due to channelization, due to dredge-and-fill projects or it could be due to turbidity level alone. Activities that would produce turbidity.

Q: (BY DR. PALERMO). I know that studies have shown differences in specific gravity between some of the Chesapeake Bay eggs and Roanoke eggs. Is there anything similar for the Shubenacadie? Since I would think they would be more like the Chesapeake, do they just stay afloat for another tidal period in the pools?

A: (BY DR. RULIFSON). I don't know. I don't think that has ever been examined. Canadians, up to the time of my study, have not put much research effort into their own striped bass populations. They have concentrated on Atlantic salmon and trout. Now they are interested in striped bass because all the U.S. fishermen are going up there to fish for them.

Q: (BY MR. FORREN). In the Upper Bay of Fundy, how is the cause and effect relationship between high turbidity levels and the empty stomachs you found in shad established?

A: (BY DR. RULIFSON). What is the cause and effect relationship?

Q: (BY MR. FORREN). Well, you mentioned that turbidity was responsible for the lack of stomach contents.

A: (BY DR. RULIFSON). Okay. Shad are pretty much thought of as visual, or sight, feeders unlike Atlantic menhaden, which are a close relative, in the same family. But the Atlantic menhaden flares its gills and filters the water and is not really thought of as a visual feeder. It is more of a filter feeder. American shad, on the other hand, commonly have lots of fish in their stomachs indicating they are probably a visual feeder. Because of the high turbidity loads, the American shad is under constraints to feed by other means. I don't think they are very good filter feeders. Would you agree with that, Joe?

A: (BY DR. LOESCH). I really don't have any experience with that, Roger. They're certainly not as efficient as Brevoortia.

Dr. RULIFSON: Also, in the Bay of Fundy, the effects of turbidity on shad level in the water column is really great. In the Upper Bay of Fundy, because the slack-water period is only about 15 minutes, there's very little time for the suspended sediment load to settle out, so it doesn't.

Therefore, you might go from a secchi depth reading of 20 centimeters to 50 centimeters, and then the whole process starts over again. The sediments are resuspended. There's no real way to test the hypothesis that they could feed better if there was no turbidity in this area. But what Dadswell and his colleagues have done is use very deep gill nets that have color-coded mesh. They have looked at where the shad were caught in relation to day time versus night time, and according to turbidity levels. And they have found that under these very high-turbid conditions, the shad stayed up in the water column (Canadian Journal of Fisheries and Aquatic Sciences 40 (Suppl. 1): 322-330).

Dr. HOMZIAK: I have a couple of comments to make. I guess it would be a clarification rather than a question. In the first part of your talk when you were dealing with the document that you had prepared on the causes and concerns, a couple of the categories that you pointed out were dredge and fill, and channelization. Those activities sort of fall into the dredging scenario by default rather than anything else. Channelization is where you take the basic crooked stream and straighten it out. Which, we are really not interested or involved in any way.

And dredge and fill is, in terms of what was used, was more of an archaic practice that has generally been condemned in the sense that it's impossible or nearly impossible to dispose of material. So, that's essentially out of the way. Therefore, pretty much half of that dredge and fill really doesn't apply anymore in the sense that fill isn't really being, well it's being done, but it's really pretty limited. The areas of concern are pretty much limited to the dredging site. I was just trying to make a definition that those kind of all fit into, just barely ride into, the areas of the gill net.

Dr. RULIFSON: I'd like to comment on that, too. There's really no way to quantify this, saying it's because we're channelizing or we're deepening a harbor or we're deepening navigable waters or whatever. I can't say that specifically from this document. Certainly, those things were considered and when people filled out their questionnaires, it wasn't directed specifically to those things that we want to look at today.

Dr. PALERMO: I want to make a comment on his comment. There are at least two instances of which I'm aware in North Carolina where there is open water disposal. Oregon Inlet maintenance with the side casters, and that of bank disposal on the Cape Fear River maintenance.

Dr. HOMZIAK: I was speaking in terms of, specifically, dredge and fill operations. Basically you're coming up with a traveling bulkhead?

Dr. RULIFSON: I didn't create any test lines behind it.

Dr. HOMZIAK: That is specifically known as dredge-and-fill, my terminology, here. Open water disposal is commonly practiced in a lot of areas.

Dr. PALERMO: I'm in agreement with that. I'm specifically addressing the term "dredge and fill."

Dr. HOMZIAK: But relative to anadromous fish, total bank disposal in the Cape Fear system is of concern. We have been able to work fine with the Corps as far as getting it so that it's not during spawning season.

Q: (BY MS. DORE). Again, how could I get a copy of that document?

A: (BY Dr. RULIFSON). I can give you the address. It is U.S. Fish and Wildlife Service, Fisheries Resources, Region 4, 75 Spring Street SW, Atlanta, GA 30303.

DR. RICHKUS: I was just going to comment, you know, the old characterizations of striped bass spawning grounds, I'd characterize them as being turbid. And that was a heyday. That's when stocks were doing fine. The other thing I find amusing is that in our new striped bass document, we also have striped bass migrations blocked by Ratkey and Turner's 350. And it's even converted, it's not even double-suspended solids, it's already turbidity. So, I'm glad I caught that. But I looked at the reference, and it's clearly in the title of the article that it's total-dissolved solids.

DR. CHRISTOFFERS: You mentioned some numbers in terms of turbidity and shad. I've got a paper that was being put together as part of the Chesapeake Bay Program, which talks about hatching of shad not being particularly affected at around 1,000 milligrams per liter. But larval shad are being affected at around 100 units at 0.1 milligrams per liter. We seem to be having some conflicts in terms of numbers of guess. What is the source of those numbers?

DR. RULIFSON: Could be units, too. It could have been micrograms per liter.

DR. LASALLE: You do get a lot of that problem. You know, reporters may leave the "m" off of milligrams. You've got to be real careful. We've seen that problem quite a bit. Or they won't convert it, or they use all sorts of different units.

Q: (BY MR. HALL). What we're saying is that larvae are apparently more sensitive than eggs, right?

A: (BY DR. RULIFSON). That seems to be the overriding thing. And somebody mentioned earlier, I think Mary Ellen mentioned earlier, that some of these species have eggs that are slightly adhesive, especially sturgeon. And if you have high suspended sediment loads it just suffocates them, either by making them sink to the bottom or by covering them with sediment and suffocating them under a blanket of sediment. So, those would be things to consider tomorrow when we get into our little discussion groups.

MR. EAGER: Just in light of that, too, there's a paper somewhere along the line that says something like "60% of the American shad eggs are on the bottom." And that's where your highest load of silt is from the dredging operations. So, this is something to be aware of. If you're dredging where the eggs are, you're right at the interface there.

DR. RULIFSON: I'd like to make a comment. One thing that I would really like, an input from the Corps, is what kind of units can we measure turbidity in. Should we measure it in JTU's (Jackson Turbidity Units)? Should we measure it in secchi-visibility depths, or measure it in percent of radiants? Exactly what would be helpful for you?

DR. CLARKE: My personal experience with that has been that the gravimetric measurements are probably the only ones that you can look at across the board with direct comparisons. You can't transpose directly from a depolarimetric unit or a percent-transmission unit and convert that to milligrams per liter. You have to have a tremendous data set within the same system, depending on what the suspended sediments consist of, to make any direct correlation between optical measurements and then gravimetric. To me the comparisons on a gravimetric scale among systems are more valid than those taken by other readings.

DR. LASALLE: It's confusing because you've got different ways of measuring. Gravimetric is pretty much consistent across the board, or at least it's less variable in terms of its measurement.

DR. HOMZIAK: One addition to that is that Mike Palermo was here. He had to leave. The best way for the Corps to be looking at this engineering viewpoint would be going through some gravimetric method and the appropriate measure would be to relate the physical measurements that are being taken by the engineers. In other words, be able to relate them to public-biological groups who could use their research.

DR. CLARKE: I have one more piece of information that might be relevant. It's always going to be a mixed bag in how you look at the information. But the idea of the critical period in larval development where they are feeding also, there's information out there. Jordan Fuller who's now with the National Marine Fisheries Service in Hawaii did a study on the Pacific herring and shad, herring and alewife, I believe. He found enhanced feeding by larvae in turbid water. What the situation there is that the visual field of the larvae is so short that turbid backgrounds enhance the detection capability of the item that it's feeding on. So again, it's a mixed bag. There's probably beneficial and detrimental aspects of it depending on the shift from one life history stage to another.

DR. LASALLE: I think this is a good place to put this point in, too. I can understand a lot of these concerns and I'm not trying to discredit any of them, but I want to emphasize one thing and I probably should have emphasized earlier this morning. That is, you have to consider scale here, too. And it goes along with the site specificity that I mentioned. If the dredge is in any kind of a--or anything is producing turbidity. If it constitutes a small portion of the water body, it's going to be a less problematic thing than if it's affected the smaller portion of the water body. And we also need to take note not only in terms of spacial extent of the scale but in also time, duration. I believe that's probably a concern we need to remember.

MS. DORE: Just suppose that if you're putting a dredge in a fairly large water body, and you're working with a severely depressed stock of fish, you'd have to take that into consideration as well. You have to maximize the amount of habitat available for the spawning and hope for survival of the species.

MR. EAGER: More than that, Mary Ellen. If you had a zone that all these larval fish or eggs would drift through and die in that short zone, it doesn't matter that it's a short zone and 90% of your river is good. They're all dead anyway. So, you have to be careful that you're not taking up the whole width of a very small section. It's the whole width, or it's a very significant portion. Same thing with entrainment or impingement studies. If you're taking the whole river through, but you're taking it through for five minutes, you're only killing them five minutes out of twenty-four hours. So you're not really killing them for a very long time, but they're still dead.

DR. HOMZIAK: I appreciate the viewpoint, but I would also like to point out that to remove a lot of these viewpoints from the realm of speculation is the purpose of us being here. We need to pin some of these numbers down, or these ideas, or views, or hypotheses down to a method by which we can get a handle on. Because if we're dealing with things that we know, we'll respect that. And we'll make every effort to run and maintain, like we mentioned the disposal on the top, or the bank type of disposal. We need to be able to work together on it. But in terms of strict-speculation table, it may be just as good. I recognize the fact that they're going to be just as dead. And I don't want them to be dead anymore than you do.

DR. MANOOCH: As a courtesy to our last speaker who has waited all day, let us continue with this part of our program. If time permits we can return to this discussion later today. Two people have come in to join us. Mike Street, with the North Carolina Division of Marine Fisheries in Morehead City, and Bill Cole, with the Fish and Wildlife Service also in Morehead City.

Mark Gibson is the last person on the program. He is with the Rhode Island Fish and Wildlife Department in Kingston, Rhode Island.

Mark Gibson
Rhode Island Fish and Wildlife Department
Kingston, RI

Since I have the honor of being the last speaker, I'll be the most controversial.

We have heard a lot about what dredging is, what it does, how it's done, and some of the possible impacts on anadromous fish. Basically, I have come to the conclusion, at least I have from the literature reviews, and listening to all this today, that we really don't know very much about it at all. There are very little data.

The title of my presentation is "Disparity Between Observed and Expected Stock Dynamics in American Shad Exposed to Dredge Operations." This all came about rather by accident. The Division of Fish and Wildlife in Rhode Island is involved in an extensive, ambitious restoration project for anadromous fish in the Pawcatuck River. We successfully restored the alewife, and have restored a small population, at this point, of American shad. We have also had returns of Atlantic salmon. So, we have been quite successful. In the past we have always recommended the usual dredge windows where we don't want anything to take place after March 31st, which is when the alewife first begins migrating. And we have not had real strong evidence for it, obviously, because of what we have seen today.

What happened in 1987 was that through a permitting error--I should back up and say, the Pawcatuck River forms part of the boundary between the states of Rhode Island and Connecticut. Because of an error in the permitting process, two dredge operations were allowed to proceed up until June 1st, past the usual March 31st cessation. And coincidentally, we had a very poor return of shad as well as alewives and Atlantic salmon.

I am only going to address shad today. We've heard plenty about anadromous fish life histories, and I won't go over those. My strategy is going to be to show you a general slide on what happened, beginning several hundred years ago when New England rivers were dammed and interruption occurred to fish spawning and migration. And, of course, the species were exhumated from the river. I will give just a general development of the restoration, how it began and some of the results. Then I will try to implicate dredging as a reason, at least a partial reason, for reduced returns of the species. It is sort of an indirect method since I cannot develop a cause and effect relationship, between dredging and the reduced return because of a lack of data.

It happened entirely accidentally. We were not aware of it until it was too late. So, we were not able to set up an intention-type study. What I'll try to do is to eliminate other sources of variation in the run for which we have good data and try to work back and increase the probability that dredging was partially at fault.

This (slide) is a map that was developed for a striped bass presentation, but it serves the purpose. The arrow is a little out of place. The Pawcatuck River is right down in here, and forms part of the boundary of the states of Connecticut and Rhode Island. The important portion of this slide is

that it is very close to the Connecticut River. The assumption that I'm going to make is that conditions in the ocean during shad oceanic migration periods are very similar for Connecticut River and Pawcatuck River fish. When these shad are moving north of the mid-Atlantic overwintering ground, they cross around Long Island, into Long Island Sound, and there is where they break apart and head to their respective natal rivers. Therefore, I assume that any mortality incurred outside of the natal river fisheries is essentially the same for Pawcatuck River and Connecticut shad.

This (slide) is a little better map. It shows the river. There are a couple of dams down there. We have fishways on the river and also on the Connecticut River. You see how close they are. The major difference is in size, but the river mouths are very close. Fish were trapped inside where, essentially, we counted all the fish that come upstream in the fishways. I'll show you slides of that later on. It was located about here.

The two dredge sites were right down here (slide). They were marina expansions that involved removal of about 50,000 cubic yards by clam shell dredge. They were about four miles downstream. They occurred where the river is quite small, maybe 200 feet across. As I said, the dredge was a clam shell operation. There were no covers on the buckets or anything like that. They just plunged it in, dropped it on a barge, let sediments spill over and build up the barge height to overflow, and let it all go right into the stream.

We happened upon it by accident. We were doing some other survey work in the river and weren't looking for a dredge plume, but it was very apparent to us when we came upon it. We were not prepared to make any measurements on it. We took a few secchi disk transparencies and that sort of thing, but I don't think they amounted to very much. It was basically qualitative observations on the extent of the dredge plume. On several occasions we noticed that the plume crossed just about the entire river's cross-section. So, I think we have probably the worse possible conditions that could exist. And given the type and nature of the dredging, the type of equipment, the size of the river, and the timing, it was a very poor situation.

To begin anadromous fish restorations, first of all you have to build some fishways to get the fish upstream. This (slide) was the first fishway we built on this system. It is called Potter Hill Fishway. This is a shot of the construction, and you can see the river in the background. You can note the size of river we are talking about. It's quite small. It's not even a river by most people's standards. It would be a stream or a brook. Mean annual discharge is probably about 800 cubic feet per second with flood periods maybe up to 2,000 cubic feet per second.

This is a slide looking up to the right of the fishway and you can just see the entrance to the fishway. We put a board upstream from the fishway to improve the attraction water flow. This is another slide of the attraction water coming out with the shad entering. Shad and alewife are migrating. This is a shot of another fishway, essentially the same type. This one we finished off fairly nicely to improve the aesthetics so that people with property right next to it don't object as much.

When you don't have any shad, you have to go looking for them. This (slide) is how we transported shad back from the Connecticut River for restoration purposes. We talked already about the necessity of a circular tank. We

found that out pretty fast. Shad don't do too well unless you put them in a circular tank and a jet current along the side to obtain a circular flow. We ran up and down the highways for a number of years beginning, I think back in 1964, to transport fish. We could usually take about a hundred shad. We don't really need to do this anymore since we've established our own returns. Hopefully we won't have to go back and start doing it again.

Here we are loading shad at the Kennedy Falls Hydroelectric Station on the Connecticut River. Fish are bucketed out of the fishway and dumped into the tanks and then off we go. They are discharged into the Pawcatuck River at different stocking sites.

Shad successfully reproduced, and we have a juvenile sampling program where we have a number of stations. We take haul samples through the late summer and fall to estimate abundance and year-class strength of the juveniles.

This (slide) is the top of the fishway that I showed you, under construction. This is the holding pool and all the fish have to come up through this fishway where we can put in flashboards, hold down the flow, and we can handle and sample any fish that are in there. Therefore, we have very good estimates of the shad population size. Just about every fish is handled individually. At some point, when the run grows in size, obviously this practice won't work and we'll have to utilize some kind of subsampling routine. We'll have to let all the fish pass through. We may even have to build another fishway on the other side of the dam if the capacity isn't sufficient. Here we have one of our biologists measuring shad and inserting radio tags to collect biological data on the population. We do a little telemetry work to see where the fish go after we pass them up over the fishway.

That was the basic outline of our restoration project. Now, I will get into a little of the results. This (slide) is the size of the watersheds for some of the major shad runs on the east coast. And you can see the relative size of the Pawcatuck compared to the Connecticut River with a million and some shad, and Delaware with 600,000. I don't know what the Susquehanna has had historically, probably close to two million shad. The Hudson River has a very large population.

And what we have done with these kinds of data is try, through empirical models, to develop an estimate of the maximum population size that we might expect in the Pawcatuck River, based on some measure of carrying capacity of the system, such as watershed, square miles, river length, discharge, etc.

I don't have a slide for shad, but this is one I developed for alewives. What I did essentially, was look at data on the alewife populations and the average stock size versus spawning acreage which is available to the adults. It worked out to be a pretty decent relationship and one from which I could make some predictions on alewife population size. I've done the same thing for shad, but I don't have a slide. It turns out that we can expect about 25,000 to 30,000 shad in the Pawcatuck River. The largest return we have had is 4,200 shad. This past spring we were quite disappointed. We only got a return of 718.

This (slide) is some of the trends in population size for the Pawcatuck River shad beginning in 1978. From just a handful of shad, we rose up to 4,000, 3,000 shad and then it plummeted off again. It looked like we were doing pretty well with a logistic type population growth which has been observed in other anadromous alosids. Examples are alewives in the Atlantic River in New Hampshire, and the blueback herring in the Connecticut River. There are a number of examples where populations are falling.

This (slide) is a population trajectory. We had a substantial drop off in 1987 and were confused by it, and as yet have been unable to explain why the decline occurred.

We also have some stock and recruitment data for the population and we have had a number of recruits produced, a number of females transplanted, and a number of naturally returning females.

We also have data on June flows which have been shown to be strongly correlated with year class strength in American shad in the Connecticut River. This flow is particularly significant. We got a very large flow which resulted in a very poor year-class production in both the Pawcatuck and the Connecticut Rivers.

This (slide) is the way our stock-recruitment relationship looks at this point. These are relationships between female spawning stock size and the number of recruits produced. It is fairly evident that the number of females at this point, when the population is very low, is very important to the population growth. Ordinarily, if you were to look at this type of relationship--and this is unadjusted for environmental factors--and were to fit a relationship here, the deviations from this line would be correlated to the June flows. It is interesting because the low population sizes and the influence of environmental effects are much less on this stock than they are in the Connecticut River. In the Connecticut River system environmental factors have a major impact. That is a dominant cause for year-class variations--river hydrographic conditions during the spawning period. This is not the case on the Pawcatuck River despite the fact that the environmental conditions are very similar because the rivers are very close. Therefore, it seems that when populations are very low, relative to their carrying capacity, density dependent effects in conjunction with density independent effects are not as important. That is a hypothesis that has been expressed before.

This is simply a slide of shad on cumulative passage rates. The time scale starts at May 1 and proceeds through the end of the shad migration. It shows that much of the shad run in any year is far upstream well before June 1st, which is when the dredging was terminated. Upstream migration of shad, at least in the Pawcatuck, is controlled very strongly by temperature and by river flow. There are very specific conditions under which shad enter the fishway (certain temperatures and certain water levels).

These are some of the relationships that I'll be using to develop estimates of what the cohorts should have been in 1987 as opposed to what they were observed to be. What I have done is plot ages by abundance (abundance of fish of a particular age). In this case, we have the numbers of age-three shad and the x's numbers of age for shad the following year. I've done this for a number of year classes. This is fours versus fives the following year. This is fives versus sixes the following year; and sixes versus sevens. Actually, the x-value is not just age six. In this case, I will be predicting age sevens on the basis of sixes-in-year "n" minus 1, fives-in-the-year "n" minus 2, and so on. In other words, the year-representation of that cohort. In all cases I was able to fit a significant relationship for prediction purposes.

What I am trying to do is, through the use of some prediction models or time-series models, estimate what I thought, based on our understanding of stock dynamics, the return should have been. Then compare that to what it was. As far

as the overall population size, I used three different models to predict that time trend, excluding 1987 data. I used a simple linear projection, an exponential prediction of the population size in the first order of moving-average model.

These are some of the regression statistics; there were various components, standard error of the estimate, and so on. The important thing is that the actual value of 718 is far below either projection, and also below even 95% confidence intervals, despite the fact that they're very wide on that population size. And since any run of shad is composed, at least in Rhode Island, of fish of a number of ages--three, four, five, six, seven, and even some eights--there is a possibility our poor returning this year could have been due to the 1982-year-class, which would be age-five fish, and which we know was weak. So, I made individual predictions on the individual year class components of the 1987 run based on power functions of the graphs that I showed earlier. However, the same thing happened. The actual values fall outside or well below all of the point estimates, and, also, in three out of four cases below even the 95% confidence intervals on the estimates.

I also looked at non-natal riverine mortality for the Connecticut River shad, which I showed in the earlier slide. I would assume that this mortality rate would also apply to the Pawcatuck River shad. And that is mortality that occurs outside of the river. It is not due to sport or commercial fisheries.

What happens with the Connecticut River shad is that there is a large step increase that occurs right here, due to the operation of the passage of fish in both the Kennedy Falls and the hydroelectric generating station. Thereafter, the mortality rate dropped off. There's no significant trend through here in mortality rates.

So, I concluded that it was unlikely that Pawcatuck River shad experienced an unusually high rate of mortality in 1986.

This is also Rhode Island shad landings. Shad aren't heavily fished in Rhode Island. We don't allow any to be captured in the Pawcatuck River, but there are some caught incidentally in the floating trap fishery in the coastal waters. These are the landings since 1981 for American shad. You can also see, again, that there is not much of a trend. Also, there was no large catch made in 1986, and, in fact, it fell off quite a bit in 1985. This suggested that mortality wasn't the cause of the reduced returns in the river.

This is the slide that I always show at the end of a shad presentation. It's what our ultimate goal is, looking to establish a recreational sport fishery for American shad.

This is all I have. Are there any questions?

DR. RICHKUS: You didn't state your conclusion.

MR. GIBSON: You're right I haven't. Well, it's a very difficult conclusion to make because, as I said, it's tenuous and circumstantial evidence, at best. But it's the best that I have. I'd like to say that dredging had something to do with it, because I've tried to eliminate all other sources of variation that I have data to evaluate. But it still doesn't get me to that point. So, I can't make that conclusion. I can just suggest that, at this point I would say that time windows on dredging restrictions for projects in small river systems certainly should stand.

DR. HOMZIAK: There is, also, a sort of lesson to be kept in mind. It's the equipment type used. And you had mentioned specifically the cross-section of the river, it's a small river. And you're using bucket dredges and an open bucket. You're putting as much of a load on the system as you are going to get, and you're going to combine that with an overflow.

DR. GIBSON: It's a worst-case scenario, there's no doubt about that.

Q: (BY MR. STREET). Are you suggesting that the fish just turned around and left the river without spawning? Is that your thought?

A: (BY DR. GIBSON). That would be the only mechanism I could think of. Because of the sediment plume they perhaps spawned below it after it settled out.

A: (BY DR. GIBSON). We're measuring our juvenile production right now, and have been. Up to the point when I left, it hadn't been very good. It's not conclusive because the majority of our catches are taken in late September and October at our sampling stations. So, it's yet to be evaluated. I can also look at some of these year classes that appear to be missing right now and see if they appear in renewed strength next year. That's another way I could evaluate it.

Q: (BY MS. DORE). When did you start stocking the Pawcatuck River?

A: (BY DR. GIBSON). The adult-shad transplants?

Q: (BY MS. DORE). Yes.

A: (BY DR. GIBSON). From the Connecticut River?

Q: (BY MS. DORE). Right.

A: (BY DR. GIBSON). We began that, I think, back in 1974.

Q: (BY DR. HOMZIAK). Any speculation as to why '82 was a bad year for the association with the high river discharge? Do you think that's an overflow function?

A: (BY DR. GIBSON). Yeah. That's been pretty well evaluated in the Connecticut River. Year-class strength of shad seems to be inversely correlated to water temperature, water discharge and rainfall. And I guess they have evidence that shows that the larval feeding success is poor in periods of high discharge. I guess the zooplankton isn't as continuously distributed as it ordinarily is, and it's dispersed throughout the river. Shad larvae may be physically injured by the high flows. There was an exceptional storm event for the 1982 year class. We had six to eight inches of rain in a period of about two hours, and the river flooded and the fish were in the streets. It was a very poor year for shad.

Q: (BY MR. MCCORD). Did the turbidity increase during those storm periods? I mean, has that had some role in the breakdown of the production of zooplankters. Is that not part of it?

A: (BY DR. GIBSON). I really don't know.

Q: (BY MR. MCCORD). If you get highly turbid waters, obviously, you wouldn't have phytoplankton, and you wouldn't want zooplankters, so it would break down at some point.

A: (BY DR. GIBSON). I don't know. I really don't know.

Q: (BY MR. EAGER). You said that your shad population is predictable by spawning data. Do you have the formula for that?

A: (BY DR. GIBSON). Predictable by what?

Q: (BY MR. EAGER). By the amount of spawning area.

A: (BY DR. GIBSON). Oh, for shad?

Q: (BY MR. EAGER). Yeah, shad.

A: (BY DR. GIBSON). Yeah, I don't have it with me, but I can certainly provide that for those types of relationships. However, they are only empirical relationships to get you in the ball park. That's going to be, obviously, over the Susquehanna River, where historically it's the same, but much larger population of shad due to its own carrying capacity. It's the inherent size of the carrying capacity, for the juvenile production area.

Q: (BY DR. RICHKUS). I just have a question about that dredging operation. They would have had to have the Corps of Engineers permit wouldn't they?

A: (BY DR. HOMZIAK). Yeah. That would be a curious thing to try to track down.

DR. MANOOCH: Please be thinking this evening about what committee you want to serve on. I'm sure there are more people here leaning towards the adult phase, but you have heard that the eggs and larvae are very important. So, think about a committee. We also need a spokesperson for each committee.

THE WORKSHOP WAS ADJOURNED

FOR THE DAY

DR. MANOOCH: Mike Street is going to talk about the North Carolina Division of Marine Fisheries Program.

Mike Street
NC Division of Marine Fisheries
Morehead City, NC

My name is Mike Street, and I am Chief of Research for the North Carolina Division of Marine Fisheries, part of the North Carolina Department of Natural Resources and Community Development.

When we talk about fisheries management, a lot of people have various views on what it means. Mostly views are limited. Management means enforcement or regulation, but it actually means far more than that. It is all activities concerning maintenance and improvement of the fisheries and utilization of the fishery stock. That includes research, monitoring, development of management regulations, and enforcement.

In North Carolina we have a pretty good fisheries management system in that the authority for regulation is within the Marine Fisheries Commission, a 15 member body appointed by the Governor, with requirements for diversified expertise in various fields. The Division of Marine Fisheries conducts research, monitoring, collection of statistics, enforcement, and in general works for the Commission. And there is a unique authority whereby the Commission can delegate to the Director of the Division of Marine Fisheries the authority to take management actions for fisheries affected by variable conditions. And this applies to all fisheries. Fisheries, by the way, includes the fish and the pursuit of the fish by people. So, we have a system whereby this authority is delegated to the Division of Marine Fisheries in many, many fisheries.

For example, we open and close our shrimp fisheries based on the data we get from field sampling. When the shrimp reach an appropriate size we open an area or close an area, perhaps two or three times during the season.

This system is an extremely flexible management system and a very responsive management system. We have managed it so finely that we've had situations where we have two species of shrimp in a given area, one at harvestable size, one juvenile size, and we open it with an interval in hours.

I believe it was midnight to 4:00 am. We had it open so shrimpers could harvest pink shrimp, a nocturnal species, and leave the brown shrimp alone, which are more of a day-time species. It worked very nicely. So, we have the ability in fisheries management to fine tune pretty closely depending on the species and our knowledge of the species' need.

The Division of Marine Fisheries is also a review agency for habitat alteration permits. This includes Coastal Area Management Act permits, Corps of Engineer permits, FONSI, EIS, NPDES, and everything else. In my role, I serve as the coordinator of our habitat alteration review system. The permits go out to various field offices where people have the responsibility to review them. I then coordinate the reviews, take care of recommendations for denial, and so forth.

Just a little bit of general history. Anadromous fish have been important in North Carolina since colonial times. Salted river herring were a medium of exchange in the colonies instead of money. Since 1971 landings of anadromous fish have generally decreased because of decreases in their abundance and harvest, as well as increases in the harvest of other edible species such as flounder, croaker, spot, etc. Total landings of edible finfish in North Carolina in the last 15 years have gone up, peaking in the early '80's, and since have declined.

The anadromous fisheries research conducted by the Division of Marine Fisheries is funded by a combination of state funds and grants from the National Marine Fisheries Service and the U.S. Fish and Wildlife Service under the Anadromous Fisheries Conservation Act. We began our work about 18 or 19 years ago and it continues today. We have a large data base on anadromous fisheries in North Carolina.

We began our work in the ocean around 1968, tagging striped bass. The work moved inshore in 1971 according to a plan that we developed, and gradually covered the entire coastal area. In 1981 federal funds were greatly reduced, and we halted work on anadromous fishes in all areas except the Albemarle Sound area in northeastern North Carolina. The objectives of our work were to determine spawning areas, nursery areas, and population parameters of adults (size, age, sex composition) based on fisheries dependent sampling. That is, we determined those parameters by sampling at the fish houses. And we also determined migrations.

This (slide) is the goal of our management program. You will note that we try to maintain the stock's habitat. If you don't have good habitat, you don't have any stock, and that applies to recreational and commercial fisheries.

These (slide) are the species, the seven species in North Carolina. No shortnose sturgeon were seen in North Carolina for about 90 years, but this spring we found one in the Cape Fear River. The sturgeon fishery is a very minor fishery. There are directed fisheries for American shad, river herring, blueback herring, alewife and striped bass.

We know very little about sturgeons. We just don't encounter them in our sampling. We sampled all the rivers and sounds for spawning areas and nursery areas and just found an occasional juvenile Atlantic sturgeon. We have tagged a couple of hundred Atlantic sturgeon off the coast and got returns both to the south and as far north as, I believe, Nantucket and Martha's Vineyard off Massachusetts. But we know really very little about sturgeons.

We know considerably more about American shad and have sampled all the major rivers: the Cape Fear system, the Neuse River, Pamlico, Tar--the name changes at the bridge right here, but I don't know why--the Albemarle Sound, the Roanoke River, Chowan River, various tributaries and the Pamlico Sound. There is the New River right here (slide), and the White Oak River. Camp Lejeune is at the New River. That is a Marine Base for those who don't know.

American shad are generally distributed throughout the coastal area. The reason that there is a discontinuous distribution for American shad and all the other species in this area is we just never caught any in the ocean. However, they have got to be there because they migrate along the coast and go up the rivers. But we didn't find them in the sampling that we have done. There are American shad runs in all of the major coastal systems. They go

farther upstream in the Cape Fear. They are locked upstream in the Cape Fear River by the Corps of Engineers' navigation locks. They spawn in the vicinity of each of those locks. The green on this slide is the nursery area. The gray is spawning areas. Spawning and nursery areas are well defined. The one thing this slide cannot show is that there are a number of tributaries that also serve as spawning habitats. Particularly, on the Neuse River and Tar River there are some tributaries and there are a couple on the Northeast Cape Fear. The Cape Fear, in such areas as the Black/South River system, comes up in this area. We have documented these areas in a series of federal-aid reports. We are in the process of preparing a fairly comprehensive American shad report now. It is about two-thirds ready, and summarizes all the work we have done over the years.

American shad spawn at ages four, five, and six in North Carolina, younger fish to the south in the Cape Fear system, and older fish in the north in the Albemarle Sound system. Very few shad spawn more than once in the Cape Fear and further south. Spawning repetition increases as you go north. We have had some years where up to 50% of shad in the Albemarle Sound are repeat spawners. Some years it is as low as 10%. It varies. You can tell this from the annual spawning checks on scales. Shad runs in the Cape Fear River begin as early as January, and continue in the Albemarle system into June. Critical spawning period in the more southern areas is through May and in the Roanoke it's through June. We have the nursery area documented except for the Albemarle Sound. We have not found enough juvenile American shad up there to document the nursery areas. We still look because we do sample throughout the area, but we rarely find more than 20 or 25 juveniles in the Albemarle Sound in any year. However, we will find that much in a single sample in the Tar, Neuse, or Cape Fear. We don't know why. Obviously, they are there because they keep coming back to the area. And we have documented spawning. We just have not been able to locate the nursery areas. In the fall the shad descend to the eastern area and nearshore ocean where we have taken juveniles.

Hickory shad is a poorly known species in most areas. A little bit is known about it in Georgia and Maryland. There has probably been more work done in North Carolina than anywhere else. The species is of minor commercial importance. However, it does have some recreational significance. They are caught primarily in Contetnea Creek, a tributary of the Neuse River in this area (slide). The Town of Grifton has an annual shad festival built around hickory shad, not American shad. There are several weeks of activities. We have documented spawning areas and distribution. Only one nursery area has been found and that is in the Neuse. There are, of course, other areas but the difficulty in documenting nursery areas for hickory shad is that they apparently leave the estuarine areas at a very early size/age, probably in June of most years. We just don't pick them up in our samples. They begin spawning as early as age two, principally ages three to five years. Frequently, 50% or more have spawned before. They spawn early. Generally spawning is over by early May. They peak in March and April.

River herring is a collective term for two species, the blueback herring at the top (slide), alewife on the bottom. This (slide) is the southern edge of the range for alewife. They may get down farther, but we've never been able to really document how far south into South Carolina they go. I don't know whether they even get to the Santee system. It may end at the Winyah Bay complex.

These are important species in North Carolina commercially, recreationally, and socially. A lot of people dip herring recreationally off of small bridges and in the spawning areas of creeks. Some people recreationally

pull haul seines in coastal rivers for river herring in the spring and fry them on the bank and have a big party. There are two processing plants for river herring still operating. One company owns both. They cut the roe and can it, fillet the fish, and pack them in various packaging. Herrings are even salted, packed in wine, and a number of other ways. They are distributed commercially throughout the coastal area. Virtually everywhere in the spring you will find river herring in our coastal streams.

We have documented spawning and nursery areas. The Albemarle Sound area is the principal habitat in North Carolina. The processing plants are located in the upper Chowan, right in here. However, fisheries have declined drastically over the years.

A couple of interesting situations. These (slide) are two natural lakes: Lake Phelps and Lake Mattamuskeet. A series of four canals connects Lake Mattamuskeet with the Pamlico Sound. Only the alewife is found in Lake Mattamuskeet and they spawn in the lake. It is a Fish and Wildlife Service National Wildlife Refuge.

The Wildlife Resources Commission built a fish ladder to allow fish passage into Lake Phelps for blueback and alewife. Historically, people had just dipped them up and thrown them in the lake. They would spawn and come out through the water-control gates in the fall. The lake has been at extremely low levels because of droughts, and there is not enough water to operate the fish ladder at present. There may be this spring, I'm not sure.

Alewife enter the coastal area earlier than blueback herring. They generally finish spawning in very early April, while blueback herring will spawn into May.

About 70 to 85% of the annual harvest in North Carolina is blueback herring. The principal ages of spawning fish are three to four for males, and four, five, and six for females. Some years you see very high percentages of repeat spawners, 30 to 40%, and some years it's much lower.

Striped bass are the most glamorous of the coastal anadromous fishes. We have documented them in all these systems (slide). You noticed earlier that we had spawning even in these small streams for river herring. Striped bass are fairly restricted to larger waters. We have spawning in all of the systems. Right here, Meherrin River, a small stream, runs up to Emporia, Virginia at Interstate 95. There is, just above there, an impassable dam on the river. We have documented river herring spawning up there. One year we caught several striped bass eggs in the Meherrin. Some years there is not enough water in the river for striped bass to get up. Therefore, it is probably a very small spawning, intermittent-spawning stock.

The major spawning area, by far, for striped bass in North Carolina is the Roanoke River. The spawning generally begins in early April in the Cape Fear system and extends as late as June in the Roanoke River.

The majority of males mature at age two. Females in North Carolina, about half of them, are sexually mature and spawning by age four, and virtually all by age six. Striped bass in North Carolina mature earlier and at smaller sizes than in the Chesapeake Bay and farther north. Our stock is different.

The juveniles remain in fresh or low salinity water at least until sexual maturity and initial spawning in North Carolina.

The relationship between spawning stocks in North Carolina and the Atlantic migratory stock on the coast is not well defined. I will get into that a little bit more, but in the late '60's and early '70's we tagged striped bass off the coast from just above Cape Lookout up to southern Virginia. We tagged about 1,700 over the three years. We got returns from the northern Pamlico Sound, Albemarle Sound, Chesapeake Bay, off Delaware Bay, along the Jersey coast, New York Harbor, all along Long Island Sound, the James River, Narragansett Bay, all around Cape Cod and up into Maine.

This demonstrated to us that coastal North Carolina serves as a wintering ground for the Atlantic migratory stock of striped bass, which originates principally in the Chesapeake Bay. We got returns from spawning streams in Chesapeake Bay, but none from spawning streams in North Carolina. We tagged fish from ages two to about 15, weighing less than a pound to 60 pounds. The principal return area for big striped bass, 10 kilograms or more, was Cape Cod and the North Carolina fishery. That was the principal harvest area.

The unknown here and the question for striped bass management along the coast is, what is the relationship of the Albemarle Sound/Roanoke River stock to the Atlantic migratory stock? We documented some interchange between the ocean and Albemarle Sound. The spawning stocks south of Albemarle Sound are endemic. They do not leave North Carolina. There is a possibility that Albemarle Sound fish maybe endemic also. I'll get into that a little bit more later.

These are specific tagging results (slide) on striped bass in more detail and also more confusing. We have tagged in the Wilmington area in the Cape Fear system. We have returns from within this system. We tagged them just below New Bern in the Neuse River, and have gotten them back in the Neuse River. We tagged them in the upper estuary of the Pamlico River and have gotten them back up on the spawning grounds in the Tar River.

Analyses of returns get confusing. There has been something on the order of 20,000 striped bass tagged in northeastern North Carolina since 1937, with something over 5,600 returns from fish tagged, by a lot of people. The first tagging took place in the western Albemarle Sound, by Merriman in 1937. All his returns came from the western Albemarle Sound. He also tagged fish in extreme eastern Albemarle Sound and returns came from the same area. Bill Hassler, at N.C. State University, tagged over 10,000 striped bass in the lower Roanoke River from 1955 through 1983. His returns came from the spawning grounds of the Roanoke River, in Albemarle Sound, and a few in the Pamlico Sound. There were no returns from the ocean.

The National Marine Fisheries Service, in the '50's tagged over 5,000 striped bass all over Albemarle Sound. They got back 1,500 or something like that, from the northern Pamlico Sound, Albemarle Sound, and upper Roanoke River, none of them out in the ocean. The National Marine Fisheries Service at Beaufort tagged striped bass along the beach off Nags Head and got returns on up the coast. Merriman, in '37, tagged a few fish on the beach. He got returns up the coast. And as I said, we tagged fish in the ocean. We got returns all the way up to Maine, as well as inside.

Tagging along the coast north of North Carolina has resulted in fish tags being caught back inside Albemarle Sound and northern Pamlico, but never on the Roanoke River spawning grounds.

In the early '70's we tagged almost 500 striped bass right here (slide), in the Croatan Sound during the winter. It is a wintering area. We wanted to see if these fish would go outside. All returns were from the northern Pamlico Sound and Albemarle Sound. So far, I know of no certified returns of fish tagged inside Albemarle Sound or on Roanoke River spawning grounds having come back from north along the coast. They have been caught and returned from markets up there, but they have all been traced back to commercial catches in the Albemarle Sound.

The question of whether the North Carolina striped bass contribute to the migratory stock is still not completely answered, because there have been returns from fish tagged up the coast coming back in. My personal belief is that the contribution is negligible, if at all, and would occur only during years when there was a dominant year class, that is, very, very successful reproduction in the Albemarle Sound. The last dominant year class in the Albemarle Sound was 1967.

We have also tagged river herring, alewife, and blueback. In the Scuppernon River we tagged about 11,000 over two years to obtain population estimates just as they run into the river, here (slide). We estimated three million fish. We also tagged river herring here (slide). We got returns all around Albemarle Sound and spawning rivers, and even the next year in some of the spawning rivers. We also got a return of one off Georges Bank by an East German or Polish trawler, and off northern Jersey. I think that was an East German trawler off Georges and a Polish trawler off northern New Jersey.

Our data complement some of the things that Roger Rulifson was saying about migration in his talk yesterday. We provided a lot of the funding for Roger's work in Canada.

We have tagged hickory shad in the Neuse River, in the lower Neuse. All the returns have come from the Neuse River. We have tagged shad in all the rivers. The returns have all been local.

Since 1980 we have worked with the U.S. Fish and Wildlife Service, Edenton Hatchery, Edenton, North Carolina (National Fish Hatchery), stocking phase II striped bass from coastal North Carolina in all the major coastal systems. We tag a portion of each stocking group to get an idea of utilization and migration. Phase II striped bass are four to 10 inches long. What "phase II" means is they've been raised, put in ponds and grown for about six to eight weeks up to about two to three inches in size. Then the ponds are harvested and the fish are restocked at lower stocking rates and grown out into the winter. So that is the second phase of growth. The excess fish from phase I are stocked at that size. However, that size cannot handle an external tag. We wanted to get returns from fishermen, so we stock only phase II. And another reason we stock phase II in the Albemarle Sound is that we do annual assessments of juvenile reproduction, of natural reproduction, in the Albemarle Sound. So, if we were to stock phase I without any detectible tag on top of the natural population, we wouldn't be able to get an idea of success or failure of natural reproduction. The third reason is that the Albemarle Sound is a highly eutrophic area. We have had major fish kills, so we stock in the winter after the problem period is over.

Over the years we have stocked about 922,000 phase II striped bass along the coastal area. Thirty-nine thousand been tagged. We have gotten about 4,000 returns. Most recaptures have been in the area of stocking. The fish have been taken by all fishing gear, commercial and recreational. Our goal was to contribute to the fisheries, therefore, the stocking has contributed to the fisheries.

The other objective was to see if we could augment spawning stocks. We have gotten tagged fish back from the spawning grounds in the Tar River and Roanoke River. So, both objectives have been achieved and the program is continuing.

As I said earlier, landings of anadromous fishes have declined drastically in North Carolina. You don't have to worry about the specific numbers here (slide). You note a 10 year period of high striped bass landings in excess of a million pounds for this period. River herring landings, you see, peaked in the late '60's and declined drastically. They came back a little less than 11.5 million pounds in '85. It was about 3.5 million or less in '87, the worst on record. The shad, hickory shad, steadily declined. One reason for the low landings of striped bass is the harvest restrictions. There is a limited season, etc. In general the stocks of all anadromous fishes have declined as indicated by landings, and we have catch-per-effort for river herring and there is a definite decline there.

The reasons for the decline are the real concern. We have an index of juvenile abundance for striped bass. This (slide) is from Bill Hassler's data. This is catch-per-effort, a very simple index. This has been obtained since 1955. Same gear, same areas. There are three dominant year classes, the last one in 1967. A number of pretty good year classes, and then, since then, very poor. Recent year indices are less than 1.0. The long-term average is about 6.5, but we have a very, very serious problem. Basically, we suspect reproductive failure has occurred in the Albemarle/Roanoke system.

I mentioned fish kills earlier. These (slide) were too good year-classes in a row, 1975 and 1976. This year class showed up in the fishery. This year class never appeared in the fishery, however, they did show up in the fall of '76 in massive fish kills. Small striped bass turned belly up in the west Albemarle Sound and Chowan River. Massive algae blooms occurred and the decomposition of the plant material caused mortality to fish. In fact, we found in examining scales of striped bass from the '76-year class and later on, checks on the scales which indicate stress.

There are a number of things always cited for decline of anadromous fish. Dams are one. Dams are a concern in the Cape Fear and Roanoke. However, in the Cape Fear attempts are made to lock the fish upstream in the spring by the Corps of Engineers. But, we don't have evidence to suggest successful striped bass spawning up the Cape Fear. They spawn below lock and dam one. Obviously, they used to go considerably further up the river. But we have evidence of shad and herring spawning up the river.

The main concern with the dams in the Roanoke River is the water release schedule. Flows are regulated by peaking-power generation. The water is turned on and off and you get drastic flow changes in just a very short period, a few hours. Again, I don't know that anybody's documented the effects of that, but we feel there is a significant effect.

Overfishing is another possibility. There are insufficient data to determine anything relative to overfishing on shad. But on river herring we think we have good documentation of overfishing by foreign vessels. These (slide) are landings in North Carolina and Virginia, and in foreign fisheries from the mid-'60's to the present. Virginia landings of river herring used to greatly exceed North Carolina's. In the late '60's to early '70's, foreigners--Russians, West Germans, East Germans, Poles, Bulgarians--made tremendous catches in the ocean.

If this slide had gone farther back you would have seen "total landings" like this in this area for a number of years. The foreign fleet hit them real hard here, and they just crashed after that. In 1976 the Fisheries Conservation and Management Act went into effect. Prior to that enactment, we had negotiated bilateral treaties with Poland, Rumania, and the Soviet Union. Their catches had already been going down because of lack of fish and new restrictions. With the Fishery Conservation and Management Act in force, foreign fishermen could not fish directly for herring. They have a 100 metric ton allowable bycatch in some other fisheries, and they have always been under that.

Virginia's landings have not shown signs of recovery. North Carolina's landings, like I said, came up 11 million pounds in '85, and down in '87. I'm not sure why. Fishermen say it was high water. We will find out this spring if we have a new downward trend in landings. The interesting thing here is that after foreign fishing was prohibited in '76, there was no recovery in the stocks. I'm not really sure why in Chesapeake Bay. But in the Albemarle Sound and Chowan River, the principal spawning and nursery area, the eutrophic conditions may have been the problem. We have recorded dissolved oxygens in the range of two in spawning areas, during the spawning season. It's a highly stressed area.

Also, there may have been a change in the forage base available to river herring as well as striped bass. Roger has done some work on that. A change in the plankton community might have occurred from a green dominated to a blue-green dominated community. There's a number of potential possibilities for stock declines. I have already mentioned our concerns with the power generation situation and with possible growth overfishing of striped bass. I don't think they are yet subject to recruitment overfishing. Past channelization of creeks and swamps has had an effect where herring can no longer spawn in swamps. A current problem we have and one that relates to dredging, is the bridge replacement program in the North Carolina Department of Transportation. Most of the river herring spawning areas are on the creeks, the upper tributaries. And there were a lot of old bridges built in the '30's that are now in the process of being replaced.

This (slide) is what some of these bridges look like. There's some sampling we did. We would hang gill nets off these small bridges, and we would always catch river herring. Fishermen use dip nets and dip off these bridges and catch fish. These bridges take a lot of time and money to build, and this is what they're replacing them with. Culverts. And we don't think river herring like to go through something like this. Particularly culverts that are 50 and 60 feet long. Just pipe culverts. We think culverts have a negative effect on upstream migration of river herring. We are going to sample some of these areas after the culverts have been installed. If we don't find fish, then that is the change that is taking place. DOT says this is quick and easy. We suggested they use big concrete box culverts and they say, "No, this is simple and cheap." The idea is to replace as many as they can as fast as they can, even during spawning season. We have a problem with this. Any questions?

Q: (BY MR. EAGER). Well, the one question I have is on your spawning sequence. Do you have the alewife followed by the hickory, followed by the blueback, followed by the American shad in the same streams?

A: (BY MR. STREET). Yes. Now, you have several species spawning in secession. Yes, and in some of these streams, say, like Contetnea Creek, Fishing Creek on the Tar, Tranter's Creek on the Tar, Black, South River system, a number of those that are big enough to have shad. Usually your first species in there will be alewife or hickory shad, then blueback and American almost together. Several species will spawn in the same stream, but possibly different portions of the stream. The herring go out to the swamps if they can get to them, whereas the American shad and hickory shad will spawn in the main stream.

Q: (BY MR. EAGER). And your nursery areas are documented by using what catching technique?

A: (BY MR. STREET). Mostly seines.

Q: (BY MR. EAGER). Beach seine or trawl?

A: (BY MR. STREET). No, beach seine is our major gear. We're also using trawls. We develop an index of abundance on river herring every year in the Albemarle and it's by seine. We have used the same seine at the same places since about 1974.

Q: (BY MR. EAGER). Are you using a 20 foot?

A: (BY MR. STREET). A 60 foot beach seine with quarter-inch bar and an eighth-inch bag.

Q: (BY MR. EAGER). And two horses to haul it?

A: (BY MR. STREET). Two people can do a 60 foot seine. A hundred foot would require more. But two people can handle a 60 footer.

Q: (BY MR. HALL). Mike, you mentioned a possible problem with the peak in hydropower facilities on the Roanoke River. But those dams have been there for a long time and including times when the fisheries were in their peak.

A: (BY MR. STREET). That's right, I agree.

Q: (BY MR. HALL). So, what are your comments on that?

A: (BY MR. STREET). I think it's a combination of factors. I think that's a part of the factor. Hydropower operation basically determines the area of spawning. When there's not much water coming through fish can't go as far up into the rapids. When there's a lot of water coming through the dams the fish have to get up into the rapids. There is some evidence, I honestly can't cite it, but Hassler has said, and some other folks have stated, that the further up spawning is, the more successful, whereas, spawning downstream, potentially, is less successful. I guess that's from a fertilization viewpoint. Hassler did some analyses of his data through 1980 for us, and more analyses need to be done. He indicated that high flow and low flow are equally detrimental as far as spawning success of striped bass in the Roanoke River, and that moderate flow will generally result in the best reproduction. There are several factors. You must consider the available spawning area but at the same time high flow can also wash the eggs out into the swamps in the middle and lower river areas, and they will be lost and will not develop because they settle to the bottom and die.

High flow also has the potential for washing larvae through the lower river delta area, and out into Albemarle Sound before they start feeding and where food is scarce for initial feeding, and, also, prevent development of a good plankton-prey community in the lower delta area. Roger Rulifson has done a lot on this relationship.

Q: (BY MR. HALL). It would seem then, that the primary purpose of most of these dams that you're talking about up there is flood control. And the purpose of a flood-control project is to even out the flows so that you don't get a situation like at John S. Kerr this year. They had the highest water on record. Now, had that dam not been there, that would have all gone down stream. And so, it does even it out, some. Now, I'm not justifying or saying that the dams don't have any impact at all.

Q: (BY DR. MANOOCH). I've been on the Kerr Reservoir-Roanoke River system for twenty-seven of my forty-four years, as a child and young man at Kerr Reservoir and as an adult on the River. The basic problem with the Kerr Reservoir and the Roanoke River is that the philosophy has changed. Flood control is no longer the first priority. In fact there has been little of the development in the Basin that the Corps anticipated. The first priority in the Kerr Reservoir appears to be recreation.

A: (BY MR. STREET). The peaking power at Roanoke Rapids is the major fluctuation affecting the immediate spawning grounds.

A: (BY MR. PAYONK). Well, the way the reservoir is operated is that there is a Rule Curve, and Max Grimes--do you know Max Grimes?

Q: (BY DR. MANOOCH). Yes.

A: (BY MR. PAYONK). Max Grimes operates the dam according to that curve, and he is not going to let anyone tell him how to do it, because he has experienced that if you start deviating from your plan, from your Rule Curve, you get in trouble. I mean, because you'd have downstream effects and upstream effects. You'd have people downstream hollering that there's not enough water. And the people upstream are hollering that there's too much water. So, he goes by the Rule Curve.

Q: (BY DR. MANOOCH). Did you know that the State of North Carolina is involved in litigation over this issue?

A: (BY MR. PAYONK). Oh, I know. Yeah, I know that.

Q: (BY DR. MANOOCH). Okay. You're going to see a lot of this coming out in the near future, the aspects I just referred to. In other words, flow releases and impacts on downstreams resources.

A: (BY MR. STREET). The Rule Curve needs to be evaluated. It may need some adjustments.

There's an attraction theory, that attraction flows are needed. And that is in the Rule Curve to get striped bass up to the spawning grounds.

There have been years of high water in the late seventies and early eighties. There were three or four straight years when the Roanoke River valley was under water. They were very wet years. The flood plain was under water for eight, nine months of the year. Those years were unsuccessful spawning years. In the beginning the Corps prevented floods, absolutely, major floods. Now we wonder.

A: (BY MR. PAYONK). There are many factors that go into play, many resources that have to be considered in addition to fisheries resources. When you start flooding people's homes, those things have to be considered, and will be considered in operations.

A: (BY MR. STREET). There's plenty of land that's spread around to everybody. I mean, allowing development in the flood plain, this sort of thing. It's all in the area. Nothing can be separated out. It may well be possible to re-evaluate the Rule Curve and come up with some improvements in it.

We have worked with Union Camp in the Upper Chowan, which has a very large discharge, just above the North Carolina/Virginia border. In low-water years, their discharge can be eighty percent of the Chowan flow. But we've worked with them so that they can discharge earlier in the winter than they previously have. So that by the time the anadromous fish come in the late winter or early spring, their discharge for the year is over. So, one reflects on this kind of thing. But there are some real problems there.

Q: (BY DR. CHRISTOFFERS). On your juvenile striped bass index, when you have a long time series of data taken at an individual point, do you do anything to monitor the water quality and the habitat of those points to see whether or not you've had shifts in habitat character that may account for the fish leaving the area?

A: (BY MR. STREET). Well, those--okay, those data are from Bill Hassler. And he doesn't, to my knowledge, take any environmental data. We, however, sample those same areas every other week from him. He's out there every other week, and we do the in-between weeks. And we do have salinity-temperature data. We also sample other areas of Albemarle Sound for striped bass, because if you have a dominant year class they're going to be spread all over the place.

Q: (BY DR. CHRISTOFFERS). I was looking more at the carrying capacity objective. If you're looking for a sandy, cobble-type bottom which is preferred by the younger fish, and if the bottom is silted in, in that way the habitat is no longer as attractive.

A: (BY MR. STREET). Most of these areas are right or about the break where it starts to drop off. And it's principally sandy bottom.

Q: (BY MR. COLE). Well, something happened at your Commission group meeting yesterday that I think might be of interest to this particular group. The State of North Carolina is currently allowing mechanical clam harvesting, which has been internally viewed in the state as almost dredging. It is a dredging operation. I thought maybe you might want to give some time to discussing this. This is a classic management case of fishery activities, dredging, you know, it's the same thing.

A: (BY MR. STREET). This is my personal view on mechanical harvest of shellfish.

Q: (BY MR. COLE). You might explain to them how you got in this mess.

A: (BY MR. STREET). Okay. Do you want to take the time? Five minutes?

DR. HOMZIAK: Well, if I can, as sponsor in this, this is an important series of considerations because one of our charges is to acquaint effects that are similar to suspended sediment load, with those similar to those created by dredging and dredging-type operations. Clam kicking, bull racking, scallop dredges, shrimp dredges are sources of sediment loads into the water. Anything along those lines is entirely welcome. You can spend however much time you want on that.

A: (BY MR. STREET). Okay. Mechanical clam harvesting in North Carolina is done with hydraulic clam dredges. Everybody knows what they are? It's a push-escalator dredge approximately three feet wide. It digs about six inches into the bottom. The clams are washed up by water pressure onto a belt, and they come to the surface. This has been going on in North Carolina for probably 20 years. There are about 20 rigs in North Carolina.

Kicking is washing clams from the bottom using a propeller wash. Clams are caught in a very heavily weighted trawl that drags very close behind the boat.

Then there's outboard kicking where you just do the same thing and let the water clear and go back and pick them up.

Stick raking, this is where you have a rake on a small skiff, kind of tied to the front of the boat, or the back of the boat with an outboard motor. And you just kind of drag it along using the boat for power. It's a bull rake pulled with the engine power. We've had people go out and just use a little portable pump to wash clams out. We've had people harvest clams using a plow behind a mule. I'm serious. The kicking, using outboard washes as the predominant, mechanical type began, probably 30 years ago, in Core Sound, which is eastern Pamlico Sound. It's Carteret County above Cape Lookout. From Cape Lookout to near Ocracoke Inlet. And they'd start, using a small boat. They would put a stake in the ground, tie onto it, and just go around and around.

In the mid-seventies, they began to get a bigger boats. 1976, '77, and '78 were extremely cold winters. The northern clam areas, particularly Long Island Sound, were frozen with very heavy ice. All of a sudden clam prices went through the ceiling. In North Carolina people said "We've got to get a lot of clams that winter." We had no regulations, no restrictions. They kicked up grass beds, oyster rocks, and everywhere else.

Clam landings just went up drastically. Over a two or three year period we began to regulate it. For the last several years we managed a clam fishery using our proclamation authority that I described earlier. The administrative orders were in effect in 48 hours with a written public notice.

We determined the areas where kicking and all mechanical harvestors come under the same regulation. We used to separate them. The dredgers took us to court. We could not prove that dredging had any more or less effect than kicking. They are the same. That was an out of court settlement two years ago.

The areas that we opened to mechanical dredging, the legally opened areas, are mostly clean sand or sand and shell bottom areas. Water depth varies from approximately two feet to eighteen or twenty feet in some areas of the New River. We do not open grass beds, open oyster beds, or open muddy bottoms, primary or secondary nursery areas, to clam kicking or to the mechanical harvest of clams. Violations do occur. Our people do the best they can with it. But there are some areas where very honestly this is the best method to harvest these clams. In open water areas, where you've got winds to be concerned about, you can't sit there and tong them very easily.

This is strictly a winter fishery, open in December. Under our revised regulation this year the director can open and close the areas between December 1st and March 31st. So, it's a cold water fishery, when biological activity is generally at its lowest ebb for shellfish and finfish. In the areas we open, I personally think the mechanical harvest is a very good method in those areas. I don't think it has a significant environmental effect in those areas. In fact, there are a number of areas, lower New River, for example, just below Highway 172 bridge, that we've opened, closed and reopened. It rotates, every other year. The area is clammed by several large hydraulic dredges. And it comes back every time. I think we've been through five cycles. And Core Sound rebounded, although they say it's getting a little tougher to get clams. There is a one-inch minimum size, and our enforcement agency has been pretty tough about administering the regulation.

In the areas that we opened, and under the conditions that we impose, I don't think that there's any significant negative environmental effects.

In some areas there were initially very hard sand bottoms with clam populations, mostly large chowder clams. These bottoms, having been worked, actually may be more productive now. There are more clams per unit area. Maybe the same biomass, just distributed differently. Instead of just a few large ones, a good number of smaller ones.

Q: (BY DR. RULIFSON). How many acres total in the state, Mike?

A: (BY MR. STREET). There's something like 25,000-26,000 acres of 2.2, 2.3 million estuarine area that are open for mechanical clamming. We opened a number of areas of the intercoastal waterway channel to this gear. Dredges only, because of the depth of the water.

Q: (BY DR. HOMZIAK). I just had a question about the technical detail on the permitting. When you say that you're trying to limit off of nursery areas, I know that the department has made very little effort to identify which are the nursery areas for the variety of species. But the sand bottom, clean sand bottom, is there a standard established for, you know, the percent of silt clay or something like that?

A: (BY MR. STREET). No, it's not based on bottom-sediment sampling. It's just, "This is a clear, sand bottom. There's no seagrass in it. No scallops. No oysters" And we generally try--one of the ripoffs we've had in management is that we would try to follow the outlines of the--you know, "keep them off the grass." And our lines would frequently--kind of like--there were stakes in it.

This year we're going to make a real effort to make them straight. And if that costs them some clean sand bottoms, then it's going to cost them. But they knock our stakes down an awful lot, little things like that.

It's a very real enforcement problem because clams are so lucrative. They hit twenty cents each this last season. It's about a seven and a half million dollar fishery for fishermen.

It's on permits, but not limited entry. Just so we know who they are. We have catch-effort data. But probably only around two hundred or so of the permits are utilized.

And then within those 25,000 acres or so, the productive areas are far less than the total area available.

DR. HOMIZAK: Thanks. I appreciate your taking the time to tell us about that.

(THE MEETING WAS RECESSED
AND THE WORK GROUPS WERE BEGUN)

WORK-GROUPS GENERAL SUMMARY

Mark LaSalle
Waterways Experiment Station
Vicksburg, MS

Introduction

Based on discussions of available information on dredge-induced environmental alterations and their potential impact on anadromous fishes (e.g., shad, river herring and striped bass), the working group was charged with identifying data gaps and making recommendations on designing studies to address these issues. To accomplish these tasks, participants in the working group were divided between two subsections: one dealing with adult and juvenile fishes, and a second dealing with eggs and larvae. Synopses of the general conclusions of these subsections are provided below.

Fish Eggs and Larvae Subsection

Members of this subsection took the approach of listing and discussing specific environmental alterations of concern as they related to fish eggs and larvae. Information on both the known or perceived tolerances/nontolerances of species of concern and the probable magnitudes of dredge-induced alterations were considered. The importance of site-specific conditions was emphasized. Each environmental alteration was ranked as either a low, moderate or high concern. Ranking reflected a combination of the availability of pertinent information and no information on a given topic and did not necessarily relate to the amount of information. Due to time constraints, no attempt was made to recommend approaches to studying these issues.

Concern/issues falling within each rank category are listed below along with a brief statement of justification for the assigned rank.

High Concerns

- a) Entrainment - given that eggs and larvae of most anadromous fish species are passively carried by currents, they would be unable to avoid potential entrainment by a hydraulic dredge.
- b) pH alteration - a site-specific concern particularly relevant to areas characterized by low pH waters and by sediments with high organic content (e.g. hydrogen sulfide, tannic acids) which, if sufficient quantities were suspended, could alter the pH enough (as little as 1/2 a pH unit) to affect development and affect tolerance/susceptibility to chemicals present in the system.
- c) Chemical mobilization - in cases where sediments are known to be contaminated by chemical pollutants, concern is for both potential acute as well as sublethal effects.
- d) Particle adhesion to eggs - totally adhesive or semi-adhesive eggs may be susceptible to damage by elevated concentrations of suspended sediments which could adhere to surface membranes. As a consequence to increased density, eggs would sink to the bottom, which might lead to smothering or burial.

e) Food source depletion or impairment - concern for the direct effect (entrainment, turbidity induced reductions) of dredge operation on zooplankton swarms that serve as a major food source for newly hatched fry. Because the spatial distribution of zooplankton swarms is believed to be patchy, the elimination of a given swarm at a critical time could reduce a food source leading to mortality of young fishes.

f) Ingestion of particles by larvae - suspended sediment particles of the appropriate size (closely matching that of zooplankton prey) could be ingested in place of the target food, thereby affecting growth of larvae. This represents a potentially more serious problem in times of low zooplankton abundance.

Moderate Concerns

a) Burial of eggs - burial and subsequent smothering of eggs may be a problem, but generally only within a limited area around the dredge.

b) Change in hydrodynamics - potential changes in water circulation within the body of water being affected, if real, may alter the transport of eggs or larvae.

Low Concerns

a) Dissolved oxygen reduction - reduction in dissolved oxygen is generally not appreciable, in part due to the dilution with unaffected water passing by and because most areas will have dissolved oxygen levels at or above the 4 ppm level considered to be the minimum for a healthy population.

b) Temperature alteration - temperature would not likely be affected by introduction of sediments into the water column.

c) Light reduction or attenuation - the affected area around an operating dredge would, in most cases, represent only a small porportion of the area available for primary production and would be affected for only a short period of time.

In addition to these general conclusions, the members of the subsection expressed the need for consideration of site-specific conditions and synergistic effects of more than one concurrent alteration.

Adult and Juvenile Fishes Subsection

Members of this subsection concentrated their discussions on the effects of turbidity on adult and juvenile fishes using the general categories of a) adult migration and passage, b) juvenile migration and passage, and c) juveniles on nursery grounds. Discussion of each category included the most effective types of studies (lab and/or field) for evaluating the effects of a given environmental alteration.

Adult Migration and Passage

Laboratory studies. A good first step approach to evaluating turbidity effects on adults as well as juvenile migration would be the use of laboratory based turbidity avoidance studies. The sum of both artificial and natural substrate at varying concentrations could provide gross information (positive or negative response or no response) upon which more elaborate tests could be based. The use of artificial substrate would allow the evaluation of turbidity alone, avoiding any complication due to unknown compounds that may be present in natural sediments. Natural sediments, however, could be used for comparative purposes.

Field studies. Field studies should be designed to evaluate the consequences of a dredging operation over the entire period of migration of the stock. This would allow for evaluation during different environmental conditions and stock levels. An experimental approach, controlling for dredge operation (dredge-on/dredge-off), would provide comparative information for any given time period. Parameters such as turbidity and dissolved oxygen levels should be monitored for each experimental condition and used in conjunction with estimates of fish abundance to evaluate the effect of the alteration(s). The use of multiple methods of fish monitoring was recommended to increase the ability to detect fish presence/absence (e.g., acoustics, tracking, netting).

Juvenile migration and passage

Juveniles are inherently less important to a given stock because the loss of a single juvenile is not equivalent to the loss of a single reproductive adult. It is recognized that juveniles will suffer greater mortality from a number of sources. Blockage of upstream migration of adults to spawning habitats is potentially more detrimental to a stock than blockage of downstream migration of juveniles. Laboratory studies on turbidity effects should concentrate more on tolerance and stress-related impacts rather than on behavior-related problems. Field studies on plume avoidance could be attempted for downstream migration using stationary acoustic monitoring techniques. The use of sonic tracking was discussed and was determined to be not feasible because of inherent difficulties in handling of equipment and fish and logistics.

Juvenile on nursery grounds

In the case of dredge-related impacts to nursery grounds, scale is an important consideration. Site-specific information on the relative proportion of a given site which would be affected must be considered. It is recognized that juveniles, unlike larvae, are mobile and can avoid any affected areas. Laboratory studies on the effects of sediment and/or constituents within it could focus on stress related phenomena. Feeding response was considered a low concern because of the mobility of juveniles.

WORK-GROUP SUMMARY
(Eggs, Larvae and Juveniles)

Roger Rulifson
East Carolina University
Institute for Coastal and Marine Resources
Greenville, NC

Our group worked on eggs and larvae. I think the consensus was that there are two sides of the fence and it's very difficult to try and stand in the middle, but we tried. We came to the conclusion that there are three tiers. The first tier is: if there's a problem with dredging during a window in which anadromous species are on spawning grounds (dictating that there be no dredging), the Corps might have to come in and say we've got to dredge, so what can we do?

So then we move to tier two, which would involve making judgment values based on technical information as to whether or not dredging can be done. If so, can it be done in a part of a river system without affecting the rest of the system?

The third tier, of course, would be political, where the decision might perhaps be made on an emergency basis, or at the very highest levels of government which might not even consider technical information.

We identified several categories and I will go through those. Maybe not in the right sequence, but you'll at least get a flavor of our discussion.

First, the item of entrainment using hydraulic dredges or whatever type of equipment. Entrainment was thought to be a high priority item for site specific problems. Most of the things that we talked about were site specific. In other words, if you are dredging in a stream that is very narrow, you are under physical constraints, meaning that some of these items will take a very high priority. If you are dredging in an area that is quite wide, a mile or two wide, then a lot of these items become very low on a priority list. Is that correct, Jurij?

DR. HOMZIAK: Yes.

DR. RULFISON: Feel free to interject at any time. I may throw in a personal opinion or something which was not discussed.

DR. HOMZIAK: My quick explanation of the tiers, what we had basically: Tier I was that there is no conflict, no overlap of issues. In other words, we need to identify where we're working, where the working areas are, and where the important nursery and egg-laying areas are. That's the first tier. If there is no overlap, there's no problem. It leaves our jurisdiction.

Tier 2, there is an overlap. That's when we need the technical data to make a decision on where the problems could occur.

Tier 3 is beyond the technical data and is in the political arena, and the technical information is not going to help much anyway.

DR. RULIFSON: Very eloquently said.

Entrainment was considered a high-priority item simply because the eggs and the larvae are pretty much unable to avoid the area, and so they would drift. They could drift right through the plume area and become entrained in the hydraulic dredge or with the cutters, and so forth.

Burial of the eggs is considered a medium priority. I think most of us felt that burial would occur within a very limited area. If this was in a small stream in which the entire stream was blocked by the plume, of course this would be a very high priority item. If the eggs were coming downstream and passing through this area, chances are rather good that they would be buried.

In other words if we expanded this scenario to a river one mile, two miles, or five miles wide, the chances of burial would be very slim, just immediately within the plume area.

Next, pH. pH was considered a high-priority item, if we're looking at a site-specific basis. A lot of the areas that are dredged are very sandy, but there are a number of areas that may have high organic content. The areas may have a lot of hydrogen sulfide-type sediments involved, or tannic acids and so forth, so pH may be at the lower limit of the stressful region. We could have a situation where we have a shift of half the pH unit, which may be critical for these two life stages.

Dissolved oxygen was considered very low on the priority list. Some of the dredging studies that have been done indicate that dissolved oxygen is not changed appreciably in the area of dredging. With the dilution factor, and the fact that most areas are going to have four milligrams and above of dissolved oxygen, which is considered the lower limit for a healthy fish population, then this will not be a problem. There may be certain instances in which dissolved oxygen becomes a major issue under very stressful conditions, and those have to be considered on a case-by-case basis.

Temperature too, is a very low priority item. Of course, in a case where you have sudden shifts in the temperature not caused by the dredge under natural conditions, we may ask that dredging be suspended because of the additional stress to the system.

Chemical mobilization was considered a high priority item, although certain Corps members felt that 95% of all sediments that are dredged have no pollutants or toxics in them. Again, this aspect needs to be defined further and some of the mobilization chemistry needs to be discussed and researched.

DR. HOMZIAK: Roger, I guess, in addition to what you're saying is that we again stressed the idea of site specificity. First of all, in relation to the earlier question of pH. If there is going to be pH shift, the possibility of any kind of contaminant or some kind of contaminant, or even natural substance mobilization was important.

Two, if we're dealing with an already depleted population that is down in the lower range of its numbers, it would be perhaps more sensitive to even natural mortality from things resulting from chemical mobilization or contaminant shifts.

And finally, the idea, rather than endorsing immediate research to the issue, we recognize the fact that a significant amount of research in the area is already going on. We would be tracking that research to see how it applies to the questions that we have in hand, and then act on it and re-evaluate it as it's going along to see if we need to actually get involved in the research in this area.

DR. RULIFSON: The hydrological conditions, and the way that the water circulation patterns may be changed, was considered a medium priority. Do I need to say any more about that?

Particle adhesion by the eggs was considered high. The reason we considered it high was because a number of anadromous species have eggs that are semi-adhesive or totally adhesive. Because of the nature of the fine silt-clay particles being able to travel long distances and the fact that it only takes a few minutes for these particles to adhere to eggs, we felt that this was a very high priority item. A high adhesion rate could sink the eggs and put them on the bottom where they would eventually smother. Or, if the sedimentation was high enough, it could eventually bury the eggs.

Food source, zooplankton. No one knows what effects high-suspended sediments have on zooplankton. It may be that zooplankton are affected similarly to eggs or larvae. In other words, if the zooplankton community passed through a plume within a several hour period, it might cause a demise of the zooplankton population. Because of the very nature of fish larvae and their requirement for eating very soon after hatching, a several-hour window of no feeding because a complete zooplankton population was wiped out in a certain area, and the fact that larval fish and zooplankton there a very patchy distribution, we thought this was a very high priority.

Light reduction or light attenuation, we believe, has a low priority. In the case of phytoplankton production, we're only talking, perhaps, several hours at the most, for phytoplankton passing through a plume. We're also talking about a very small area in relation to the total productivity of the system. We felt this was a very low priority.

Ingestion of particles by fish larvae. We felt this was a high priority. My work on the Roanoke River indicates that in times of low zooplankton distribution, the ingestion of particles by fish larvae is a real problem. If the larvae were subjected to high levels of particles relative to zooplankton, a point made yesterday by Mary Ellen Dore, the fish are going to try and be rewarded for every feeding strike they make. If it happens to be a food particle that they eat, fine. If it happens to be a sediment particle that they eat, fine. They won't be able to tell the difference as long as it's the right size.

Those are all the different categories. Does anyone have any question or more comments on these?

DR. HOMZIAK: One comment. Several of the items were not simultaneous. The one depended on the other. A specific case was the research on zooplankton. Given that suspended sediment fields involved did not cause direct mortality then we would need to perhaps look at, go back to, the sublethal effects. Once we got beyond the lethal or chronic effects, then we started looking at the sublethal effects. So it was not that both ranked high in priority, but they were not temporarily occurring at the same time. One would come before the other.

DR. RULIFSON: Also, some of these are synergistic effects. And realizing that, we didn't really take them into consideration. For instance, pH and chemical mobilization go hand in hand. And so, even those were discussed, we all decided to take them separately.

MS. DORE: Yes, I have one other thing to add. One of the things we came up with in this group was to map out what we have in terms of a spawning area. Where we now, in our own jurisdictions, know where the eggs and larvae are for a number of these species.

DR. HOMZIAK: Let me just fill that in. I've got the notes on it. What we recommended were, first of all, to map the areas in terms of temporally and spatially mapping both the spawning and nursery areas where the eggs and larvae occur. So, in a fashion, it will be consistent among regions and states and such. We would all have the same basic plans to work from. Where the interaction between dredging and these areas would occur. That's the first step. It would put us back to tier one. We recommended that the areas be identified with the same criteria. So, where in one state it's identified the same way as another state. We're trying to fit this into the management plans that are currently being developed for anadromous fishes along the east coast. If this could follow somewhere when they're planning their spawning and nursery areas.

The second recommendation was a compilation of literature of the known physical parameters and their effects on egg and larval biology and ecology, so we could all work from a common data base as opposed to some parties knowing some information and other parties knowing other information.

We would all need to be on a common ground to be able to address the issues specifically. Those are the recommendations that we came up with, of certain "medium" activities.

DR. RICHKUS: My only comment there is that I know many, many states have spawning and nursery areas mapped out. I mean, that's a generic thing that people have done for years. And on the literature, I can't believe that somewhere the Corps doesn't have summaries of literature on the dredging effects on eggs and larvae.

DR. HOMZIAK: While that is true, we do not have some of these other facts. But the kinds of lists that we developed, take for example Roger's work with the chemical immobilization and pH, the facts brought out by Mike Street about the effects, specific things, black water streams and things of that sort, in our area, and we had not considered at times, we need to be able to compile the information that we have both in published and gray literature.

DR. RICHKUS: But I guess there are things that, just as an example, in the Chesapeake Bay there was an exercise gone through to establish water quality criteria for resource species. And one element of that was to go through the literature, update all the literature on the effects of all these different constituents on eggs and larvae. That's just one of many documents. I'm always cautious of redoing stuff that's been done before.

DR. HOMZIAK: Sure. We don't need to re-invent the wheel.

DR. LASALLE: A very big problem, and what we've already suggested, if it's a piece of gray literature, it's very difficult to even know about it.

DR. RICHKUS: Also, if it's gray literature, it may not be worth worrying about. You wind up with compendiums of information, two-thirds of which is actually bad.

DR. LASALLE: The idea, though, is that we all have to be made aware of the literature, even if it's only gray literature.

DR. RICHKUS: I question that. It may be better that you don't know that it's out there.

MR. STREET: Not necessarily. In mapping of nurseries, for example, in our agency, most of what we do is gray literature. Federal aid reports where we have mapped the spawning and nursery areas. And we have listed them.

DR. RICHKUS: I have less of a problem with the mapping than I do with any kind of study that was done by somebody that supposedly represents the effect of an contaminant on something that wasn't peer reviewed. And we all know of loads of them where the results are just not correct. They're just not acceptable.

DR. LOESCH: On his point of mapping, also, you have to be careful of where it was done, or just once, because in Virginia we will see the nursery area and the spawning grounds change by 10 to 15 miles in the Mattaponi and Pamunkey, depending upon whether you've got a wet season or a dry season or spring.

DR. RULIFSON: Yes, that point was brought out. It's not a consistent thing, but changes year to year.

DR. LOESCH: It's dynamic all right. It would be wrong to consider it static.

DR. LASALLE: Can I make one last point relative to just what you were saying? Whether it's gray literature or not, there's one thing we as scientists forget quite often. We take one study and say "Hey, here it is." And repetition is very much needed regardless of what issue you're discussing. All we can get is repetition.

Let me make just one further point on the gray literature. That there have been studies conducted where they have looked at what are the chances of any particular study being--

MR. KASUL: Good or bad.

DR. LASALLE: --put in the literature. And very often, the studies that don't show significant effects don't end up in the literature, while those that do, do end up. So, you end up with a publication bias which can mislead you about the general results.

DR. RICHKUS: But my impression of gray literature is, invariably, it shows up to support the point that somebody is trying to make whether it's a negative result or a positive result. And without that peer review--I mean, even with the peer review, you wind up with published literature that's controversial.

DR. HOMZIAK: There's a mechanical solution to the problem area, and that's that the identification in a review of peer review versus--a point could be substantiated by peer-review literature or have no substantiation of peer-review literature. And there are other risks associated with them. And you use this at your own risk.

WORK-GROUP SUMMARY (Adults)

William Richkus
Versar, Inc.
Columbia, MD

Okay, for adults and juveniles we identified three categories, three phenomena: Adult migration and passage, juvenile migration and passage, and juveniles on the nursery ground, in terms of concern about the dredging effects. For adults migratory passage, we discussed a lot of different aspects of it. We discussed the Delaware River study as it's playing now. I think we viewed that as kind of the last-resort approach that one might use when there is an issue that can't be resolved and all you want to do is monitor whether something is happening or not. And then, if something's happening, that triggers off an action, such as the cessation of dredging. However, you don't learn anything from that study because you don't have mechanisms. You haven't identified what's going on and why it's going on. The information is not transferable. So the approach, unless you instituted it as a monitoring approach for dredging operations everywhere, is not a productive way of resolving dredging and migration issues.

We discussed what you might do in order to try to get at these issues and resolve them. One, sort of a light bulb went on when Dick said, "What about laboratory studies?" And we all decided since nobody has demonstrated that any of the alosids respond to turbidity, you could do a very simple laboratory avoidance study. And you could do it in a variety of ways. You can use artificial substrate, artificial sediment, and create different turbidity levels and merely see if there's avoidance, using natural river water. This was viewed as sort of a field experimental study where you pump water through some type of avoidance chamber, and expose them to natural sediments, and artificial sediments. The intent is just to document that there's a response to turbidity. That answers one question which is unresolved right now from existing information based on what we've discussed today and yesterday.

There was a lot of debate about using artificial sediments which would give you a response to turbidity, versus natural sediments which would give you a response to turbidity together with whatever other constituents were in the sediments and so forth. The conclusion was there should be some types of studies done with both. The intent here was not to get into an extremely precise characterization of what constituents were causing the response, but more or less to give a simple basic set of information that allows you to say that, yes, these fish do avoid turbidity and perhaps some other major constituents.

That information is not sufficient to resolve the issues. That's viewed as a backup set of information which is transferable, or perhaps might be transferable. In addition, you'd have to do field studies. The concept here would be to use an experimental approach where you had a dredge operation in a location that could pose a problem. You would have a study that extended over the entire period of migration of the stocks, so we had different environmental conditions and also different stock levels.

It would be a situation where you controlled the operation of the dredge. So you'd have periods "dredge on," and "dredge off." You would monitor the water quality and other environmental imports caused by the dredge. Just simply mapping out turbidity plumes, oxygen levels, and so forth, to document the affected area.

And then, for monitoring fish movements, you'd consider using multiple methods. Acoustics with some type of minimal ground truthing to identify what you're looking at would be useful for looking at avoidance and route of migration. Tracking would give you information, much more specific information, on exactly what the fish were encountering and what it was doing.

The measureable factors were the degree of movement or blockage, whether fish got past the dredge or didn't, the rate of movement past the dredge because there's concern about delay during migration to spawning, and the route or avoidance. In other words, there might not be a delay, or there might be a delay because the fish have to take an alternative route. That's basically where we stood with the adult migration.

With juvenile migration, we had a lot of discussion on this. I think the consensus was that juveniles are inherently less important than adults because adults, a single spawning adult, is one spawning unit. Juveniles going out are obviously going to suffer a lot of mortality. So, if you lose a percentage of juveniles it's less important than losing a percentage of adults.

Laboratory studies with juveniles, we felt were important, to look not so much at behavior in response to perturbations, but actual stress and mortality effects. That might be more likely to be a concern. We had a lot of discussion on whether juveniles coming downstream can avoid the plume. At first we were saying they couldn't because they're just following the current down and all of a sudden they're in it. It's a little different than coming upstream. But then it was pointed out that in tidal systems, obviously, the plume is dispersed. And also they can visually detect the plumes. So, we kind of dropped that idea.

Tracking studies, such as sonic tracking, would be very difficult for juveniles, particularly alosids. It's possible, but difficult. Probably just not feasible. Not worth doing. You can monitor movement if you're in a system where there aren't too many other species around. Conceivably something like stationary acoustic monitoring could be used just to track net passage past the plume, look at rate of passage and total passage, whether there was blockage or not. Overall the general aspect of juvenile migration was considered a lower priority than adult migration.

Finally, juveniles on the nursery ground. The major concern there would be some type of environmental alteration that affected the survivability--that had affected a portion of the nursery ground. So, the scale of size of the perturbed area would make a big difference as to whether it's important or not. If it's a dredging operation in a very, very large extended nursery area, it's probably a low concern. If it's a perturbed area in a rather small nursery area, it becomes important. The concern here would be primarily with the effects--the stress and mortality effects of sediments and the related constituents, which could be looked at through laboratory studies.

Feeding response was a concern, but juvenile fish, generally, especially in the fall when they're large, are very mobile. They cover a lot of territory. If the dredge effects are in a fairly small, confined area, feeding effects may not be important. And, also, they'd be difficult to establish. The fish could have fed somewhere else and be in the plume when you catch them, or be in the plume with an empty stomach because there wasn't any food somewhere else. So, feeding studies were considered a low priority.

And that's about where we stood.

CLOSING SUMMARY

Charles S. Manooch, III
National Marine Fisheries Service
Beaufort, NC 28516

I had the pleasure of opening the meeting at 0800 on the 18th, and welcomed everyone to Raleigh and thanked all of you for taking time to participate in this meeting.

If you will remember, you were challenged to work during these two days to develop recommendations for studying effects of an operating dredge on anadromous fish movements in the vicinity of the dredge. This is an area about which very little or limited information is available.

The attendees were asked to serve as an unbiased jury of experts, and to make recommendations based on fact or an attempt to ascertain facts.

Jurij Homziak discussed some of the problems confronting the Corps of Engineers in the field, their funding and costs, hazardous conditions, and water flows that impacted the effectiveness of dredging operations. He discussed the differences in the mission of the Corps of Engineers compared to state and federal conservation agencies or groups. Mission emphasis has often lead to confrontation. Jurij mentioned that there is often reason to question the quality and the variability of data that is presented in response to a dredging proposal. Jurij then reviewed and discussed the directions and objectives, in detail, of this workshop.

Mike Palermo explained the physical aspects of the major types of dredging, or the different techniques. He emphasized that the dredging types and spoil deposition requirements must match up. In other words, a certain type of dredge may require a particular method of disposal. It is this match-up situation that may be unfamiliar to many biologists. He explained that different dredge types have different advantages over others. In one situation, one type of dredge is advantageous, and in a different situation another dredge is more advantageous. An interesting point to me was that three major dredge types are used in 99.9% or so of the operations.

Mark LaSalle discussed variability inherent in natural riverine, estuarine, and coastal systems. In other words, sediment characteristics, basic basin configuration, flow, etc. He discussed physiochemical problems associated with dredging such as suspended sediments, dissolved oxygen reduction, and chemical releases. He talked about background turbidity and the importance of recording that at various sites, and also discussed the near-field phenomenon. He emphasized that other activities in estuarine areas such as shrimp trawling, some clam kicking which was brought up today, and storm surges raise suspended sediment levels in estuarine systems. He touched on the fate of heavy metals and chlorinated hydrocarbons in estuarine waters.

Bill Richkus provided an overview of anadromous fish biology and management. He referred to the complexity of fish, water quality and people, and reminded us that in some states fishery resource managers and the water quality people don't always see eye to eye, and do not always cooperate on some issues.

He brought the group up to date on the regulations and the regulatory roles of the Atlantic States Fishery Management Commission and the Fishery Management Councils. He referred to the management plans for alosids that were developed in 1985, and for striped bass, which were developed, I believe, in 1981. He reviewed landing statistics which showed the decline, in many instances drastic declines in recent years, for most species of anadromous fish. And of course these declines could be associated with or impacted by fishery actions, both domestic and foreign and also water quality and habitat degradation.

Doug Clarke stated the Corps of Engineers' problems and concerns, and reviewed several case histories in the northeast pertaining to fish movement in the vicinity of an operating dredge. Theoretically, fish have several alternatives when they come to a dredge. They can go straight through the plume, they can move slightly to one side or another, or they can turn around and go back. One question is, "What percentage of this variation would be acceptable to fishery managers or concerned parties?"

He discussed the problem of reliably sampling the various life stages. He mentioned factors influencing migration such as light, temperature, or chemical composition of the water. Case histories or case studies in the Delaware River were not very useful because of the suspended sediment type, and the type of dredge used.

Ed Christoffers reviewed fish management concerns stressing that each situation is different regarding species involved, life history stages, potential entrainment problems, types of sediments, and types of dredging operations. The difficulty, of course, is that these systems are very complex. Dredging involves the changing of the physical and chemical environment visited by the migrating anadromous fish.

At that time Jurij Homziak elaborated a bit, discussing what we would doing today, the 19th. He asked the group to be thinking about the group approach in subcommittee discussions, and to think about our responsibilities in those areas.

Bill Richkus took the opportunity to look at some historical data that dealt with dredging activities through the years in terms of volumes of materials that have been dredged.

Next on our program were invited experience presentations by individuals from throughout the federal service and state governmental agencies.

First to speak was Bill McCord. He explained efforts by the State of South Carolina to tag adult American shad in coastal waters.

Rich Eager followed with a discussion of Fish and Wildlife Service activities with American shad on the Savannah River in the vicinity of the New Savannah Bluff Lock and Dam.

Mary Ellen Dore, who is with the Maryland Department of Natural Resources, referred to her own work. It pertained to the review of dredging applications. She cautioned those in attendance not to concentrate too much on adult stages, but to be very mindful of the juveniles, the eggs and larvae, and particularly the adults on the spawning ground.

Joe Loesch, from the Virginia Institute of Marine Science, reviewed alosid and striped bass biology in the Chesapeake Bay area. He told of the work that VIMS researchers are doing regarding restoration projects and their actual research endeavors. Most of Joe's research is directed at anadromous fish stock assessments. Models are being used by managers to formulate some of the plans.

Roger Rulifson, professor at East Carolina University, discussed his research with the targeted species in the Albemarle Sound in North Carolina and also in the Bay of Fundy, Canada. He emphasized suspended sediment problems, the organic matter content percentage, and the influence of turbidity on the distribution of shad in the water column.

Mark Gibson explained his work with the Rhode Island Department of Fisheries and Wildlife in the Pawcatuck River in Connecticut, an American shad restoration study site. He hypothesized that dredging activities there had disrupted the upstream migrations of shad. He will be doing more work on this in the future.

He was able to predict what returns of fish should have been and reported what they actually were. In most instances, or all instances, returns were lower than predicted. He suggested that the time window concept for dredging operations on small rivers like the Pawcatuck should be retained.

That evening the group enjoyed a meeting session that was sponsored by the North Carolina Wildlife Federation.

On Saturday morning Mike Street was the final speaker for the experience papers session. He outlined anadromous fish work of the North Carolina Division of Marine Fisheries explaining some of their problems such as exploitation by fishermen, water quality, and particularly the eutrophication problems in the western end of Albemarle Sound. He also discussed some of the difficulties in dealing with another state agency, the Department of Transportation, and some of the new work of that Department on bridges and their practice of placing culverts as opposed to bridging these areas.

Mike addressed the topic, and there was lively discussion, of mechanical clam kicking in North Carolina. This activity has caused turbidities in estuarine areas, and of course, has torn up some sea grass beds.

Work sessions followed with the two groups, the eggs and larvae subcommittee meeting in one area of the room, and the adults and juvenile subcommittee in the other.

I don't believe it is necessary to summarize subcommittee reports as they have just been recorded.

DR. HOMIZAK: Thanks for participating and taking the time to discuss the issues. I can assure you that I will be following through on a lot of these recommendations and getting some of the stuff off the ground. We are trying to get some of these issues resolved. We're trying to put it in the place where it really belongs, on a technical grounds level.

I want to emphasize the fact that we do recognize that there's a need for dredging windows. We also recognize the fact that these need to be based on technical grounds. And we all, basically state agencies and national agencies, and whatever, need to work together to establish the fact that these-- what the grounds for these kinds of operations, exist.

You have to understand the fact that dredging will continue. And we also recognize the fact that there are fisheries problems, and endangered fisheries, and problematic fisheries that need to be protected. One side can't do it all. We've got to work together and we'll wind up solving these problems.

That's all I have to say. I appreciate your coming.

(THE MEETING WAS CONCLUDED)

LIST OF PARTICIPANTS

C. Robert Stroud, Jr.
7225 Wrightsville Avenue
Wilmington, NC 28403

Richard L. Kasul
Waterways Experiment Station
P.O. Box 631
Vicksburg, MS 39180

Douglas Clarke
Waterways Experiment Station
P.O. Box 631
Vicksburg, MS 39180

Mary Ellen Dore
MD Department of Natural Resources
Tawes Office Building
Annapolis, MD 21401

William Richkus
Versar, Inc.
9200 Rumsey Road
Columbia, MD 21045

Jurij Homziak
Waterways Experiment Station
P.O. Box 631
Vicksburg, MS 39180

Mark Gibson
RI Fish and Wildlife
Box 218
W. Kingston, RI 02892

John Forren
US Army Corps of Engineers
2nd and Chestnut
Philadelphia, PA 19106

Joseph Loesch
Virginia Institute of Marine Science
Gloucester Point, VA 23062

Richard Eager
US Fish and Wildlife Service
P.O. Box 69
Wadmalaw Island, SC 29487

Carl Hall
GA Department of Natural Resources
Game and Fish Division
Rt. 2, Box 219 R
Richmond Hill, GA 31324

Randall P. Cheek
National Marine Fisheries Service
Habitat Conservation Division
Beaufort, NC 28516

Edward W. Christoffers
National Marine Fisheries Service
Habitat Conservation Bureau
Oxford, MD 21654

Larry Hardy
National Marine Fisheries Service
Habitat Conservation Division
Beaufort, NC 28516

Ron Sechler
National Marine Fisheries Service
Habitat Conservation Division
Beaufort, NC 28516

John W. McCord
SC Wildlife and Marine Resources Division
Charleston, SC 29412

Roger Rulifson
East Carolina University
Institute of Coastal and Marine Research
Greenville, NC 27858

Kent Nelson
NC Wildlife Resources Commission
803 Drexel Lane
Winterville, NC 28590

Phil Payonk
US Army Corps of Engineers
Wilmington District
Wilmington, NC 28405

David Rackley
US Fish and Wildlife Service
P.O. Box 25034
Raleigh, NC 27611

Charles S. Manooch, III
National Marine Fisheries Service
Beaufort, NC 28516

Len Houston
US Army Corps of Engineers
26 Federal Plaza
New York, NY

Tom Patin
Waterways Experiment Station
P.O. Box 631
Vicksburg, MS 39180

Mike Street
NC Division of Marine Fisheries
Morehead City, NC 28557

Bill Cole
U.S. Fish and Wildlife Service
Morehead City, NC 28557

Mike Palermo
Waterways Experiment Station
P.O. Box 631
Vicksburg, MS 39180

Glenn Earhart
US Army Corps of Engineers
P.O. Box 1715
Baltimore, MD 21203

Mark LaSalle
Waterways Experiment Station
P.O. Box 631
Vicksburg, MS 39180