Atlantic Menhaden Technical Committee
June 29, 2005
Manchester, New Hampshire

Technical Committee Meeting Summary

Meeting Participants:

Behzad Mahmoudi (Chair)
Matt Cieri
Jason McNamee
Alexei Sharov (Vice-Chair)
Brian Cheuvront
Douglas Vaughan
Gary Nelson
Ellen Cosby
Clif Tipton
Peter Himchak
Joseph Smith
Bob Beal (Staff)

Guests:

Derek Orner
Amy Kenney
Jeff Kaelin
Pete Jensen
Toby Gascon
Jim Price
Buffy Baumann
Steve Meyers
Bill Goldsborough
A.C. Carpenter
Niels Moore
Shaun Gehan
Niaz Dorry

The Atlantic Menhaden Technical Committee met on June 29, 2005 in Manchester New Hampshire to discuss a number of issues (see attached agenda).

<u>Menhaden Research Program</u>

This first issue addressed by the Technical Committee was the research priorities to examine the possibility of localized depletion of Atlantic menhaden in the Chesapeake Bay. The Committee reviewed the research needs that were developed at the June 30, 2004 meeting. The Committee reiterated that the prioritized research needs are:

A. Determine menhaden abundance in Chesapeake Bay
B. Determine estimates of removal of menhaden by predators
C. Exchange of menhaden between bay and coastal systems
D. Larval Studies (determining recruitment to the Bay)

The Committee determined that social and economic data should be collected from the commercial and recreational fisheries. A summary of the social and economic research needs is attached as Appendix A. (Brian Cheuvront will develop list) There was agreement that the biological needs should take priority but the socio-economic needs are important to a complete understanding of the impacts of the menhaden fishery.

Derek Orner from the NOAA Chesapeake Bay Office reviewed the priorities, timeline, and technical review process for the competitive grant process for funding research in the Chesapeake Bay. A summary of the projects that will likely be funded through the federal grant process was presented.

Bob Beal presented an update on the funding of menhaden research projects through the increased Atlantic Costal Fisheries Cooperative Management Act (AFCFCMA) appropriation for FY 2005. The intent is for the ASMFC to fund the LIDAR study as proposed by representatives from Maryland, Virginia, and the US Fish and Wildlife Service. The ASMFC will also fund the project entitled "Do Environmental Conditions in Nursery Habitat Contribute to a Mismatch in Growth and Production of Young Atlantic Menhaden (*Brevoortia tyrannus*) and Striped Bass (*Morone saxatilis*)?" This project will be completed through a joint effort by the University of Delaware and the University of Maryland, Eastern Shore.

The Committee compared the projects that will be funded with the research priorities identified above. Overall, the research priorities are at least being partially addressed. The Committee agreed that the pending projects would considerably increase the available data needed to examine the possibility of localized depletion. The Committee identified and prioritized the following items as needed to fully address the research priorities:

1. Additional coastwide diet composition studies of predators to determine the consumption rate, by age, of menhaden. The Committee agreed that if funding was not available to do a coordinated coastwide study, a piece-meal approach using existing state surveys would be an acceptable approach.

2. In-season exchange rates of menhaden between Chesapeake Bay and Atlantic Ocean.

3. Determination of larval influx along the Coast (addressed by current studies for Chesapeake Bay)

4. Determine survivorship of pre-juvenile menhaden

The Committee agreed that a workshop should be held in about 2 years to review the data generated from the newly funded research projects and determine what are the appropriate next steps for menhaden research and management.

LIDAR Study

The Committee reviewed the LIDAR study proposed by representatives from Maryland, Virginia, and the US Fish and Wildlife Service. The study was designed to address research Priority A listed above.

Clif Tipton (USFWS) and Alexei Sharov (MDDNR) presented a summary of the project. The presentation included details on the hydroacoustic and LIDAR portions of the study.

Toby Gascon, Director of Government Affairs for Omega Protein, presented a summary of the efforts for remote sensing technology in the Gulf of Mexico to locate schools of menhaden. In the 1970's, the LANDSAT I and II satellite sensors were able to determine areas in the Gulf that were "high probability" for containing schools of menhaden. These "high probability" areas were only accurate for about 24 hours before conditions had substantially changed. Due to this short duration of "high probability" areas this technology was not pursued by the commercial industry.

Omega Protein also explored the use of LIDAR in the Gulf of Mexico to locate schools of menhaden. A summary of the exploratory use is attached as Appendix B. Included in this memo from Omega Protein are a number of questions regarding the current LIDAR proposal. These questions were addressed by Alexei Sharov and Clif Tipton (Appendix C).

Based on the presentations, the Committee discussed the current proposal. The Committee determined that the proposed LIDAR study was appropriate for a pilot study to determine if LIDAR and hydroacoustic sensing equipment can be used to assess menhaden populations. The Committee agreed that the study should be funded and the feasibility portion of the project completed in 2005 if possible.

The Committee requested that the proposal be amended to include recording of environmental variables (surface temperature, air temperature, sea state, etc.). The Committee determined that sea surface conditions should not affect the LIDAR survey given that state of current technology. Concern was also raised that the number of "no-fly" zones over Chesapeake Bay may have an impact on the coverage that may be possible with the use of LIDAR. The Committee agreed that, if successful, the LIDAR will survey adult menhaden populations and in conjunction with larval and juvenile studies could provide a complete survey of all ages of menhaden. The Committee also agreed that it would be beneficial if an active or retired menhaden spotter pilot could be on the LIDAR plane to assist in identifying menhaden schools.

The future years of the LIDAR and Hydroacoustic study should be designed to have a statistically valid survey design to develop an index of abundance. Most likely the survey will have to be conducted on a monthly basis. The long-term funding of this study will have to be considered if the pilot program is successful.

Potomac River Fisheries Commission Landing Presentation

A.C. Carpenter presented a summary of landings and effort data from the Potomac River since 1964. Additional effort data has recently been located and entered into the database. The data allow for two different catch-per-unit-effort indices to be developed. The first is based on pounds landed per license and is suitable from 1964 to 1993, and the second is a pounds per net-day and is suitable from 1976 to present.

This long time series of data allowed the PRFC to make two conclusions; the low Maryland juvenile index and CPUE values have been seen before in the late 1960's and early 1970's, and the CPUE has remained relatively stable for the past 16 years (since 1989), as have the Potomac River landings.

The Technical Committee agreed that these new analyses have merit and should be further reviewed in preparation for the next (2006) stock assessment.

Update of 2005 Fishery

Landings through May 31st are 7,701 mt. Landings are down 55% through May 31st relative to 2004, however they are up 34% from the previous five-year average. Historically, the fishery through the end of May has only represented a small portion of the annual harvest. The catches in early June have been good; bait market is a bit soft with the reduced crab catch.

No landings from the reduction fishery have occurred in North Carolina in 2005.

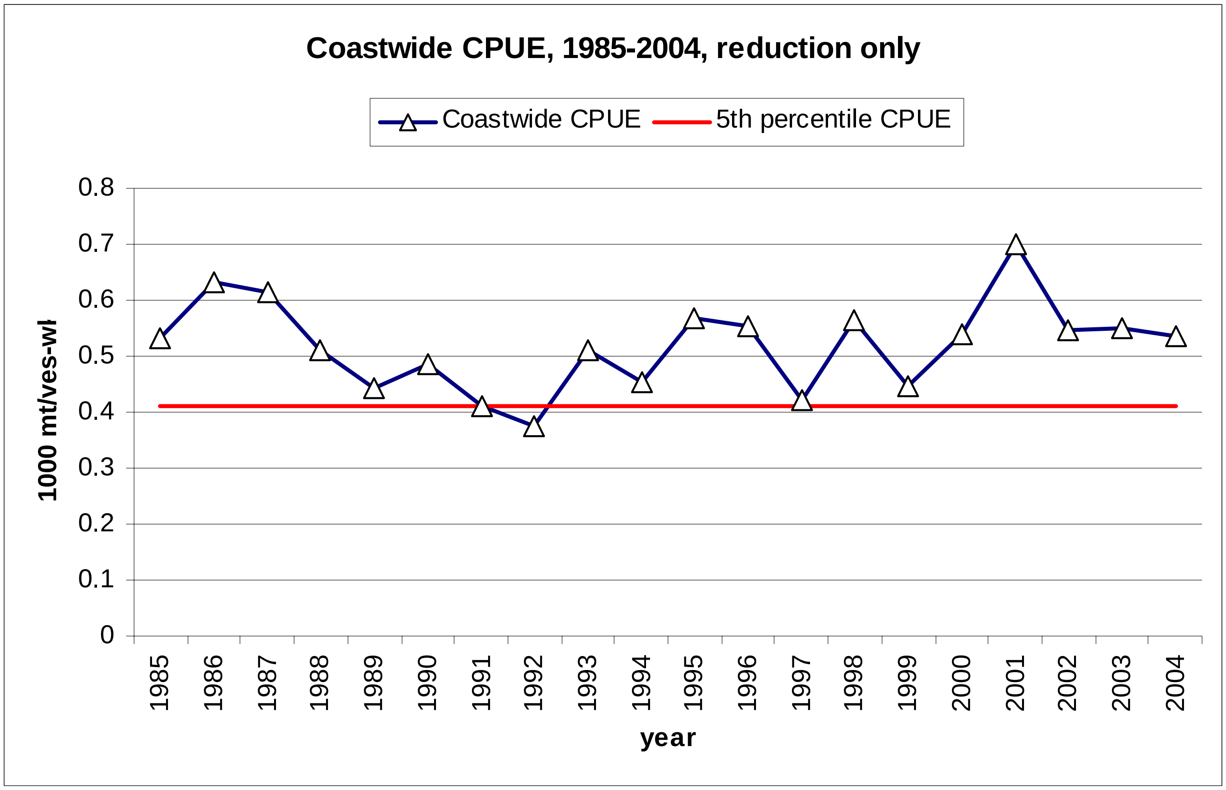
State Menhaden Indices

The Committee reviewed the North Carolina seine index, the Virginia beach seine survey for juvenile menhaden, and the Rhode Island seine survey (Appendix D). The Virginia index value was similar to levels since 1993, however, considerably lower than levels in since the late 1960's when the survey was initiated. The North Carolina survey and the Rhode Island surveys in general produce "noisy" index numbers. The Committee agreed that the 2004 indices from these surveys were comparable to previous years and did not signal a significant change in the menhaden population.

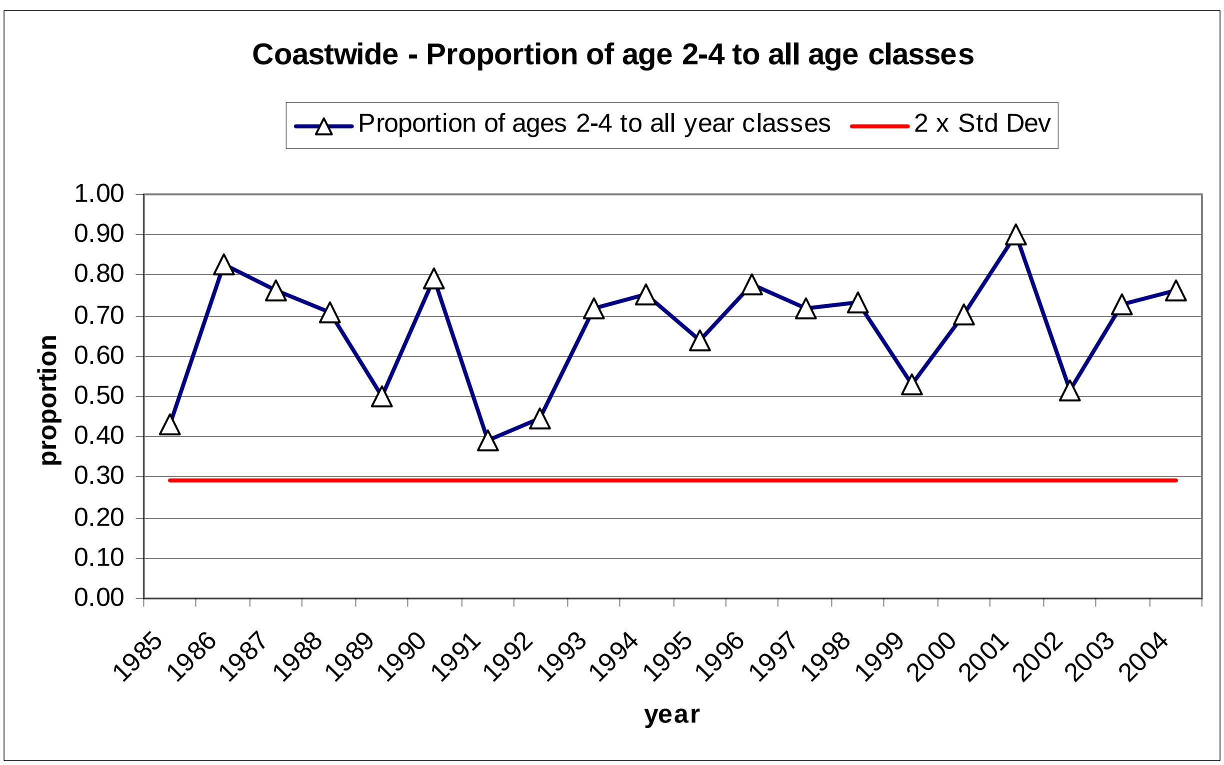
Stock Assessment Triggers

The Committee reviewed the two triggers that are included in Addendum I to determine if a stock assessment update is necessary in 2005.

The first trigger is met if "the CPUE index falls below the 5th percentile for the past 20 years". The CPUE index was above the 5th percentile for the twenty-year period 1985-2004. See the following figure for details.



The second is met if "the ratio of ages 2-4 to the total catch of all ages falls below the second standard deviation unit over the last 20 years". The Committee agreed that the ratio is above the second standard deviation. See the following figure for details.



Based on the fact that neither of the triggers had been met and there is no compelling information in the available state surveys, the Committee agreed that a stock assessment was not required in 2005. The next scheduled stock assessment will take place in 2006.

Appendix A.

Localized Depletion of Menhaden in the Chesapeake Bay:
Social and Economic Studies

Brian Cheuvront, Ph.D. and Peter Schuhmann, Ph.D. of the ASMFC Menhaden TC suggested the following research priorities to examine the possible social and economic outcomes localized depletion of Atlantic Menhaden (*Brevoortia tyrannus*) in the Chesapeake Bay. These research recommendations are contingent upon the biological determination of the existence of a localized depletion in Chesapeake Bay.

A. Economic and social impact of depleted stock in Chesapeake Bay on recreational and commercial fishing interests.

Surveys measuring economic and social constructs with commercial and recreational fishing interests in the Chesapeake Bay. Research participants to be interviewed include the processing industry, commercial menhaden bait fishery, fishermen who rely on menhaden for bait (e.g. crab pot fishermen), recreational fishermen who target species such as striped bass that utilize menhaden as a forage species, and charter boat operators.

Social research constructs include social and historical importance of the fishery, conflicts between user groups, perception of the existence of a localized depletion, etc. Economic research constructs include the economic value of the fishery in terms of jobs, incomes, and direct and indirect effects on local and regional economies from the commercial fishery. Non-market values (economic value above expenditure, e.g. recreation benefits) associated with a viable stock will also be an important component of total economic value, and can be assessed using the travel cost method. For more information on economic values associated with natural resources, and methods used to derive them, see Freeman (1993).

The entire project could be completed in 12 – 18 months.

Cost Estimate: $75,000 - $100,000

B. Determine non-fishing social and economic impacts of depleted menhaden stocks in the Chesapeake Bay.

A localized depletion of menhaden in the Chesapeake Bay has social and economic impacts beyond fishing interests. Many other sectors of society and the economy depend on a healthy bay. These sectors include tourism and coastal development, among others. A systematic analysis of the longer-range impacts needs to be assessed.

A mail or phone survey of indirect (or passive) users of the resource and households that have no direct association with the resource can be constructed to assess economic and social impacts of depletion. Using non-market valuation techniques such as the contingent valuation method would allow for the derivation of economic value of the fishery to passive users and non-users as well as measures of non-harvest social value.

Cost Estimate: $20,000 - $40,000

C. Social and economic benefits of recovered menhaden stocks in the Chesapeake Bay.

Society in and around the Chesapeake Bay would be impacted by a recovery of menhaden in the Chesapeake Bay. Research needs to be done to determine what those benefits might be in terms of economic and social gains to both the fishing and non-fishing sectors. The expected net returns from a stock recovery effort might be an impetus to fishery managers to take whatever steps are necessary to recover the stock.

This project would require an interdisciplinary approach. The social and economic constructs derived in parts A and B would be combined with biological estimates of the time path of menhaden stock recovery and the associated effects on commercial fishing effort, growth of other (predator) species and corresponding recreational effort. A dynamic model of stock growth and user group interaction would have to be developed, calibrated and applied to the status quo as well as different management options for stock recovery. See Schuhmann and Easley (2000) for an example of such a model.

Cost Estimate: As this work will require significant input from biologists, we cannot accurately forecast a cost estimate. The social and economic constructs required would be products of parts A and B above. Time to complete the required additional modeling effort by the investigators would likely be less than one year.

<u>References</u>

Freeman, A. Myrick III, The Measurement of Environmental and Resource Values: Theory and Methods, Resources for the Future, 1993.

Schuhmann, P.W. and J.E. Easley Jr. "Modeling Recreational Catch and Dynamic Stock Adjustments: An Application to Commercial-Recreational Allocation", *Land Economics*, 76(3): 430-447 (2000).

Appendix B.

Summary of LIDAR Efforts By Omega Protein

MEMO

To: Members of the Atlantic Menhaden Technical Committee

Cc: Jack Travelstead, Chairman, Menhaden Management Board
Vince O' Shea, Executive Director, ASMFC
Bob Beal, ISFMP Policy Director

From: Toby M. Gascon, Director of Government Affairs, Omega Protein Inc.

Date: June 13, 2005

Re: LIDAR

First, I would like to thank and commend the Atlantic States Marine Fisheries Commission for following up on the Menhaden Management Board's May 2004 request that ASMFC organize and conduct a technical committee meeting and workshop in 2004 to develop complete plans, implementation schedules, and budget to implement the research priorities for Atlantic menhaden in Chesapeake Bay presented to the Atlantic Menhaden Management Board, and to identify further stock-wide monitoring and research needs to complement such a Bay-specific program.

As you are aware, the menhaden reduction industry has been subject to numerous restrictions over the past decade. As a result of these restrictions, we are only allowed to fish in very limited areas and only during a limited season, which in the Gulf of Mexico runs from late April through October and from May into November or December (depending on the state) on the Atlantic coast. We do not fish on weekends and we do not fish on major holidays, so we are restricted to a set number of fishing days every year. This is, of course, where our interest in LIDAR technology originated. Rising costs have always been a major problem for the menhaden industry, resulting in a significant reduction in the overall fleet. Because of the menhaden regulatory regime, a day lost to weather is a day that cannot be recovered, yet the clock continues to run on operating costs in this capital intensive business. For these reason, Omega Protein became very interested in exploring whether LIDAR technology would enable us to fish on some days when it is too cloudy for our spotter aircraft, which presently rely on visual identification, to operate effectively.

As a result, the industry conducted several trials with LIDAR as this technology appeared very promising, Industry viewed this technology as a means to fully utilize our fleet even when those factors which are uncontrollable, such as weather, prevented us from operating. Unfortunately, while this concept looked very good on paper, the actual application was very cumbersome, came with significant safety concerns, and did not produce accurate or consistent data. For these reasons, the company decided to discontinue trials for application of LIDAR .

Attached, I have provided a brief summary (Attachment A) of the Industry's experiences and findings (Attachment B) with this technology. I have also provided a list of technical questions (Attachment C) which, from industry's perspective, could begin to provide us with a better understanding of the proposed study and its' purpose.

Finally, I am in the process of securing the employee who was the principal investigator for these trials to travel to Manchester to attend the Technical Committee meeting. If successful, he will be available to answer any questions the members may have, and discuss these matters in detail with the Technical Committee.

Attachment A

Summary of the Menhaden Industry's Trial Application of LIDAR

In 1993 Omega Protein (then Zapata) began investigating the possibility of utilizing airborne LIDAR systems (Light Detection and Ranging) as a tool for locating of menhaden schools, specifically schools lying deep beneath the surface, beyond the range of the human eye.

The investigation leads to a variety of sources, including NASA. However, we ultimately came to work with a U.S. Department of Defense contractor from Tucson, AZ. This contractor was/is a large producer of military helicopters and a leader in the development of laser and LIDAR applications. At the time, the "Magic Lantern" technology was successfully utilized during the Persian Gulf War for the detection of underwater mines. Once the technology became unclassified, defense contractors became very interested in developing civilian applications for this technology and they were willing to work with Omega (Zapata) to test the equipment.

After much laser and aircraft engineering, aircraft modification and test flying with the contractor and FAA, we successfully adapted a 4 watt laser system into the baggage compartment of a Cessna 182. This was completed during the summer and winter of 1993/1994. The aircraft successfully mapped the bottom of several shallow, clear lakes in the Arizona area.

Following the development stage, the plan was to try out the aircraft during the 1994 Gulf fishing season. In April of 1994 slow development and cost concerns resulted in Omega (Zapata) management deciding to cancel the LIDAR project. Following the project being discontinued by Omega (Zapata), another menhaden company immediately picked-up the LIDAR equipped Cessna-182 and flew numerous times during the 1994 Gulf season.

<u>Attachment B</u>

LIDAR Trial Summary Findings

1. *The LIDAR equipment was complicated to operate and interpret by a pilot alone. It ultimately required a back seat LIDAR operator working in close coordination with the pilot.*
2. The minimum expectation was to achieve a "look" that would go 20' into the water by a ¼ mile wide swath. The 4 watt laser had very limited ability to penetrate the turbid Gulf Waters – in either direct or shadow modes. The higher you fly, the wider, but weaker, the lasers scan becomes. In order to obtain reasonable water penetration, the aircraft had to fly very low and very slow (about 200 feet and 80 knots). At low altitude, the effective scan width (swath) was only about 50 feet. This was simply not enough viewing area to make an effective search mechanism. Even at very slow airspeeds, it became apparent you could miss significant pieces of data with the blink of an eye.
3. Banking or turbulent flight became a problem with the LIDAR return, indicating the need for some type of gyro stabilized beam (always looking directly down).
4. At low altitudes, a direct look into the 4 watt laser will cause eye damage.
5. The promise of species identification (by the unique signature nature of the backscattered light) was never achieved.
6. The LIDAR equipment, power supplies, displays, etc completely "filled-up" the Cessna 182. It was simply too much equipment for a typical spotter aircraft. Everyone came to the conclusion that the proper platform for this application of LIDAR was a large helicopter – exactly what was used in the Persian Gulf War.
7. To achieve adequate scan width and water penetration required much more laser power – If possible at all, it would be up in the million dollar range. Further, such equipment required a very large helicopter of fixed wing airplane to house it.

   After those trials, it was concluded that LIDAR was not a practical or cost effective search tool for the menhaden industry. Omega Protein did revisit the issue in 1999, but at that point the project did not move forward again.

<u>Attachment C</u>

QUESTIONS RELATED TO THE PROPOSED PROJECT,
"EVALUATING THE USE OF AIRBORNE LIGHT DETECTION AND RANGING (LIDAR) AND HYDROACOUSTICS FOR ESTIMATING THE ABUNDANCE AND DISTRIBUTION OF ATLANTIC MENHADEN IN CHESAPEAKE BAY"
June 10, 2005

1. How powerful (in watts) is the LIDAR laser? Does the LIDAR laser present any potential threats to the health of humans and/or fish and wildlife? If yes, how so? What specific actions does the project propose to avoid any potential threats to the health of humans and/or fish and wildlife? If any, will these actions potentially alter the results of the surveying process? If yes, how so?
2. Who has determined that major impacts to humans, animals, and their environments are not likely to occur in conjunction with this project?
3. What is the expected penetration depth of the LIDAR laser relative to the natural distribution of menhaden within the water column? How might temporal and geographical variation in water turbidity due to storms, increased/decrease riverine flows, tides, varying water salt content, etc. affect the laser penetration depth? What affect, if any, might changes and differences in water turbidity have on the consistency and reliability of a LIDAR-based survey process? How does the project propose to measure changes and geographical differences in water turbidity to ensure that LIDAR-derived abundance estimates accurately reflect the actual standing menhaden abundance and biomass?
4. What age menhaden is the project intended to survey? What are the minimum and maximum size menhaden that the project will include in estimates of abundance and biomass?
5. Does this project purport to be able to estimate abundance in the Chesapeake Bay by the end of the second year? If so, what would such estimate represent: a snapshot of abundance at a particular time or total annual abundance? If it is a snapshot, what period would that picture cover, and can the technology cover the bay quickly enough to ensure that Bay-wide estimates are not confounded by menhaden migration? Either way, how would such estimates be used to determine either 'appropriate' or comparative historical levels of menhaden abundance in the Bay (i.e., whether the Bay is depleted in some sense compared to a baseline of 'normal' abundance)?
6. Will the surveys conducted during the second year of the project estimate menhaden abundance in both the Bay and its adjacent river systems, or the Bay-proper area only? If Bay-only, what are the ramifications of omitting the substantial riverine areas located along the Bay?
7. According to the project summary, both LIDAR and hydro acoustic measurements can survey a large area quickly. What is the width of a single transect (swath) within the LIDAR laser-based survey area? Does hydro acoustic sampling require locating specific menhaden schools? What is the best current estimate of the amount of time it will take to survey the entire Bay hydro acoustically?

8. The project proposes to calibrate LIDAR for detection of menhaden by measuring menhaden reflectivity to green laser light in controlled aquaria conditions. What size menhaden will the project test under these conditions? How will the project ensure that these lab conditions produce reflectivity measurements that accurately reflect those associated with large schools of wild menhaden?
9. The project proposes to calibrate hydro acoustic sonar by taking field-based target strength measurements of menhaden captured by purse seine. However, the project summary appears silent in regards to establishing a protocol to ensure a systematic sampling of a wide age- and size-range of menhaden. As purse seine operations normally target larger, age 2+ fish, and as it appears that the project currently proposes to only sample five menhaden schools, how will the project produce measurements of a range of varying-size menhaden?
10. The project states, "[c]omposite information from the two techniques [LIDAR and hydroacoustics] could be used to produce fine-scale quantitative maps illustrating the movement and biomass of adult menhaden in Chesapeake Bay" [Emphasis added]. As juvenile menhaden constitute the largest proportion of the total menhaden stock, by what method does the project propose to measure the movement, abundance and biomass of juveniles?
11. The project proposes to compare LIDAR and hydro acoustic estimates of menhaden school biomass to commercial catch. Does the project assume that the commercial vessel engaged in the project will take the entire school surveyed by the LIDAR and acoustic methods? If yes, how will the project ensure that the entire school of surveyed menhaden is actually captured by the commercial vessel? If no, how will the project correlate the survey estimates to actual, existent commercial catch and, hence, resultant menhaden abundance and biomass?
12. What is the intent of conducting nighttime flights with the LIDAR system? Can the system provide abundance estimates of non-schooling menhaden? How would hydroacoustic sampling confirm these nighttime estimates? What about the safety issue related to the use of a high-powered laser at night? How will the project ensure that the laser will not strike boaters and others in darkness?
13. Should an industry vessel not be available to compare LIDAR and hydro acoustic estimates of menhaden school biomass to commercial catch, how will the project convert these research data into abundance and biomass estimates?
14. The project proposal appears to indicate that LIDAR measurements will be coupled with hydroacoustic measurements "to the extent possible "during the second year of the project. This appears to suggest that the two surveying methods may not be conducted simultaneously. If so, how would the project estimate menhaden school density, and hence abundance and biomass, without hydro acoustic measurements, for example?
15. During the second year of the project, it appears that the project proposes to conduct LIDAR surveys for three days each month. Is it the intent of the project to conduct these three survey days consecutively, or to space them apart? If the survey days are conducted consecutively, will this snapshot provide adequate data to make meaningful inferences about the seasonal movement and distribution of the menhaden resource? What is the minimum amount of survey data necessary –

during any given month – to make meaningful inferences about the seasonal movement and distribution of the menhaden resource?

16. Will the project answer the question of whether ‘localized depletion’ is occurring within the Chesapeake Bay? If yes, how? If not, why not?

Appendix C.

Responses to Questions from Omega Protein Regarding the Proposed LIDAR Study

QUESTIONS RELATED TO THE PROPOSED PROJECT,
"EVALUTATING THE USE OF AIRBORNE LIGHT DETECTION AND RANGING (LIDAR) AND HYDOACOUSTICS FOR ESTIMATING THE ABUNDANCE NAD DISTRIBUTION OF ATLANTIC MENHADEN IN CHESAPEAKE BAY"
June 29, 2005

1. Q. How powerful (in watts) is the LIDAR laser? Does the LIDAR laser present any potential threats to the health of humans and/or fish and wildlife? If yes, how so? What specific actions does the project propose to avoid any potential threats to the health of humans and/or fish and wildlife? If any, will these actions potentially alter the results of the surveying process? If yes, how so?

   A. The NOAA Fish Lidar transmits an average power of 3 W. The laser satisfies the ANSI standards for laser exposure in the workplace. We have shown that these limits are also safe for a wide variety of marine mammals. The same argument says that our laser is safe for any animal with a visual acuity similar to or worse than humans. Our normal survey procedures are safe.

2. Q. Who has determined that major impacts to humans, animals, and their environments are not likely to occur in conjunction with this project?

   A. Laser safety has been evaluated by James Churnside, who has written several papers on the topics of laser safety in the environment.

3. Q. What is the expected penetration depth of the LIDAR laser relative to the natural distribution of menhaden within the water column? How might temporal and geographical variation in water turbidity due to storms, increased/decrease riverine flows, tides, varying water salt content, etc. affect the laser penetration depth? What affect, if any, might changes and differences in water turbidity have on the consistency and reliability of a LIDAR-based survey process? How does the project propose to measure changes and geographical differences in water turbidity to ensure that LIDAR-derived abundance estimates accurately reflect the actual standing menhaden abundance and biomass?

   A. Our typical penetration depth for coastal waters is 20 – 30 m, reduced from over 50 m in open ocean waters. This, of course, varies with turbidity. Each lidar pulse provides a measurement of the attenuation coefficient of the water and the penetration depth, so we always know the measurement volume. Except for the very narrow deep channel running through the middle of the bay, nearly all waters in the bay are less than 20 m deep. We expect full laser beam penetration down to the bottom for most of the area. The LIDAR measures the actual depth of light penetration for each data point, thus accounting for difference and variability in turbidity, salinity and other factors affecting signal attenuation. If the school of fish is located within the LIDAR penetration depth limits, given *current conditions, LIDAR should yeld a reliable estimates of school parameters. However, this is a pilot study intended to explore the strength and limitations of LIIDAR and hydroacoustics. We will make appropriate adjustments as we wll learn those limitations.*

4. Q. What age menhaden is the project intended to survey? What are the minimum and maximum size menhaden that the project will include in the estimates of abundance and biomass?

   A. This pilot study was designed to work cooperatively with the industry in Chesapeake Bay and therefore target age 1+) menhaden. Given the short study period and complex logistics we felt that a coordinated effort between a purse seine vessel, research vessel, spotter aircraft, and research aircraft on five schools (as a minimum) would provide sufficient data for a pilot evaluation of the technologies. As a protocol to provide menhaden abundance and distribution information is refined then other sizes/ages of menhaden may be included.

5. Q. Does this project purport to be able to estimate abundance in the Chesapeake Bay by the end of the second year? If so, what would such an estimate represent: a snapshot of abundance at a particular time or total annual abundance? If it is a snapshot, what period would that picture cover, and can technology cover the bay quickly enough to ensure that Bay-wide estimates are not confounded by menhaden migration? Either way, how would such estimates be used to determine either 'appropriate' or comparative historical levels of menhaden abundance in the Bay (i.e., whether the Bay is depleted in some sense compared to a baseline of 'normal' abundance)?

   A. Development of a reliable methodology for menhaden population abundance estimation is an ultimate goal of this research. However, the first year is the pilot phase of the study intended to evaluate LIDAR technology appropriateness. By the end of the second year, this project may produce an experimental estimate of abundance. Several years of refinement and validation of the technique should be done before these estimates are used for stock management. At this stage we plan to conduct monthly survey during the second year, which may provide a snapshot of menhaden abundance and distribution in the Chesapeake Bay. The spatial scale of inference is not possible to gage at this time, but the temporal scale will be on the order of weeks or months during the fishing season.

6. Q. Will the surveys conducted during the second year of the project estimate menhaden abundance in both the Bay and its adjacent river systems, or the Bay-proper area only? If Bay-only, what are the ramifications of omitting the substantial riverine area located along the bay?

   A. It is our intention to sample in all areas occupied by menhaden schools. The extent to which we will be able to survey the Bay area will depend on the outcome *of the pilot study. In any event, a probability based survey design will be employed, as a census of the population is not possible.*

7. Q. According to the project summary, both LIDAR and hydro acoustic measurements scan survey a large area quickly. What is the width of a single transect (swath) within the LIDAR laser-based survey area? Does hydro acoustic sampling require location specific menhaden schools? What is the best current estimate of the amount of time it will take to survey the entire Bay hydro acoustically?

   A. *The swath width of the lidar is 5 m. The operation is like a scientific echo sounder – line transects are used to statistically sample the area, with the transect spacing designed to provide the desired survey accuracy based on the patchiness of the fish. Initially, hydroacoustics will be directed from the air to determine the schools size and biomass. The need for hyfroacoustics transects for the purpose of population size estimation will be determined during the pilot study. The amount of time necessary to complete the survey will depend on a number of factors, including a number and length of transects, number of participating vessels, vessel speed, etc.*

8. Q. The project proposes to calibrate LIDAR for detection of menhaden by measuring menhaden reflectivity to green laser light in controlled aquaria conditions. What size menhaden will the project test under these conditions? How will the project ensure that these lab condition produce reflectivity measurements that accurately reflect those associated with large schools of wild menhaden?

   A. *We will be using menhaden captured in the Bay by poundnets or seinenets, so their size will be representative of Bay population sizew structure. The prupose of initial calibration experiments in fish tank is to ifentify menhaden specific optical 'signature'. LIDAR based measurements of schools size in the field will be verified through comparison with biomass estimates obtained for the same schools as they are caught and landed.*

9. Q. The project proposes to calibrate the hydro acoustic sonar by taking field-based target measurements of menhaden captured by purse seine. However, the project summary appears silent in regards to establishing a protocol to ensure a systematic sampling of a wide age- and size-range of menhaden. As purse seine operations normally target larger, age 2+ fish, and as it appears that the project currently proposes to only sample five menhaden schools, how will the project produce measurements of a range of varying-size menhaden?

   A. This is a pilot project that is designed to test LIDAR and Sonar technology feasibility in general. It has to be discovered yet if there is any significant effect of fish size (age) on estimates of school abundance and biomass. Our ability to do so will depend on the size range of fish caught by the fishing fleet participating in the study. We expect to cover at least ages 1-3, which dominate in menhaden catch in Chesapeake Bay.

10. Q. The project states, "[*c*]*omposite information from the two techniques* [LIDAR and hydro acoustics] *could be used to produce fine-scale quantitative maps illustrating the movement and biomass of* <u>*adult menhaden*</u> *in Chesapeake Bay"* [Emphasis added]. As juvenile menhaden constitute the largest proportion of the total menhaden stock, by what method does the project propose to measure the movement, abundance, and biomass of juveniles?

    A. At this time the pilot study will not be targeting young of the year menhaden. The project emphasis is on exploitable population in the Bay (ages 1+). If the study will prove LIDAR technology successful in principal, adjustments could be made to the protocol after additional experiments to produce recruitment estimates.

11. Q. The project proposes to compare LIDAR and hydro acoustic estimates of menhaden school biomass to commercial catch. Does the project assume that the commercial vessel engaged in the project will take the entire school surveyed by the LIDAR and acoustic methods? If yes, how will the project ensure that the entire school of surveyed menhaden is actually captured by the commercial vessel? If no, how will the project correlate the survey estimates to actual, existent commercial catch and, hence, resultant menhaden abundance and biomass?

    A. The project does assume that the commercial vessel captures the entire school of fish. We believe that it is usually the case for a reduction fishery. In case the school is not taken completely, a video or photo snapshots of the school from the air would allow to estimate what fraction of the school is actually taken (based on the surface area of the entire school and the one encircled by the net). It is also our hope that LIDAR and or acoustics will show us the l size, shape and depth of the school before and after interaction with fishing vessel.

12. Q. What is the intent of conduction nighttime flights with the LIDAR system? CAN the system provide abundance estimates of non-schooling menhaden? How would hydro acoustic sampling confirm these nighttime estimates? What about the safety issued related to the user of high-powered laser at night? How will the project ensure that the laser will not strike boaters and others in darkness?

    A. There are several reasons for investigating nighttime operation as well as daytime. The lidar has a better signal-to-noise ratio at night, when there is not sunlight reaching the receiver. If a significant number of fish are deeper than the lidar penetration depth during the day, they will likely come closer to the surface at night. If daytime schools are so dense that the lidar will not see the fish at the bottom, they will likely spread out at night so the lidar can see all the way through. The laser is still safe at night. It can be seen by boaters, however, so we typically block the beam with a remotely operated shutter controlled from the cockpit.

13. Q. Should an industry vessel not be available to compare LIDAR and hydro acoustic estimates of menhaden school biomass to commercial catch, how will the project convert these research data in abundance and biomass estimates?

A. The industry cooperation is critical for successful completion of the study. Worldwide experience shows that when fishermen and science work together, they make significant progress in every area: getting new knowledge about fsh stocks, improving mutual understanding, building trust, improving management.
If the industry will refuse to cooperate, we will consider other options, including contracting fishing vessels and using information on school size frequency distribution in the Bay.

14. Q. The project proposal appears to indicate that LIDAR measurements will be coupled with hydro acoustic measurement "*to the extent possible*" during the second year of the project. This appears to suggest that two surveying methods may not be conducted simultaneously. If so, how would the project estimate menhaden school density, and hence abundance and biomass, without hydro acoustic measurements, for example?

A. We expect that both methods will be able to produce estimates of schools size (surfacxe area projections), depth and shape (3D image). Whenever both methods could be used, they will serve for a verification of each other's results. However, The airborn LIDAR is expected to survey more schools than rsearch vessel with sonar. In that case hydroacoustic method could provide supplemental information on school size variability, by sampling schools independently.

15. Q. During the second year of the project, it appears that the project proposes to conduct LIDAR surveys for three days each month. Is it the intent of the project to conduct these three survey days consecutively, or to space them apart? If the survey days are conducted consecutively, will this snapshot provide adequate data to make meaningful inferences about the seasonal movement and distribution of the menhaden resource? What is the minimum amount of survey data necessary-during any given month- to make meaningful inferences about the seasonal movement and distribution of the menhaden resource?

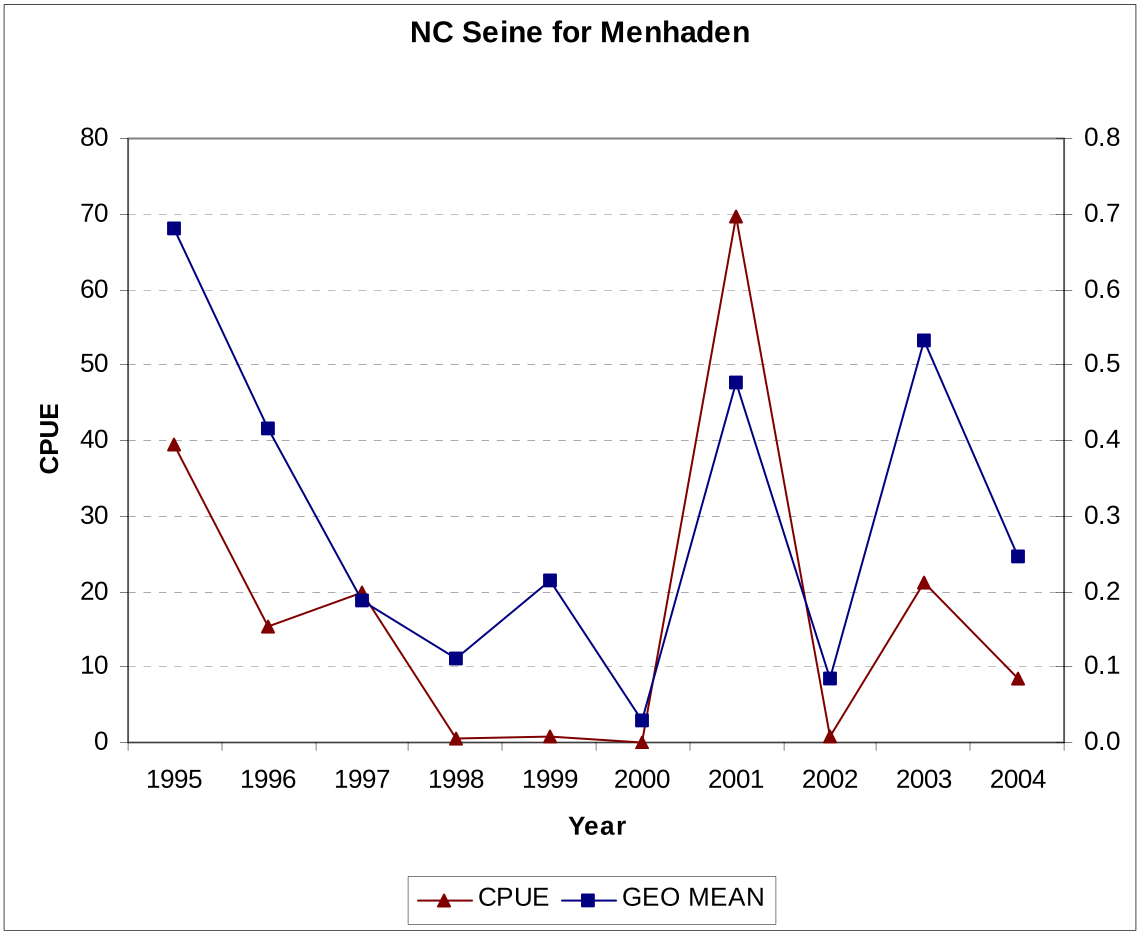
A. If the project continues into the second year, we propose to conduct monthly surveys to produce snapshots of population abundance in the Bay. In an ideal setting the fights should be conducted in as shorter time as possible. In real life that might be affected by weather or other events, but efforts will be made to do the survey as quickly as possible. Actual number of days necessary for Bay coverage will be estimated based I=on the results of the pilot study.

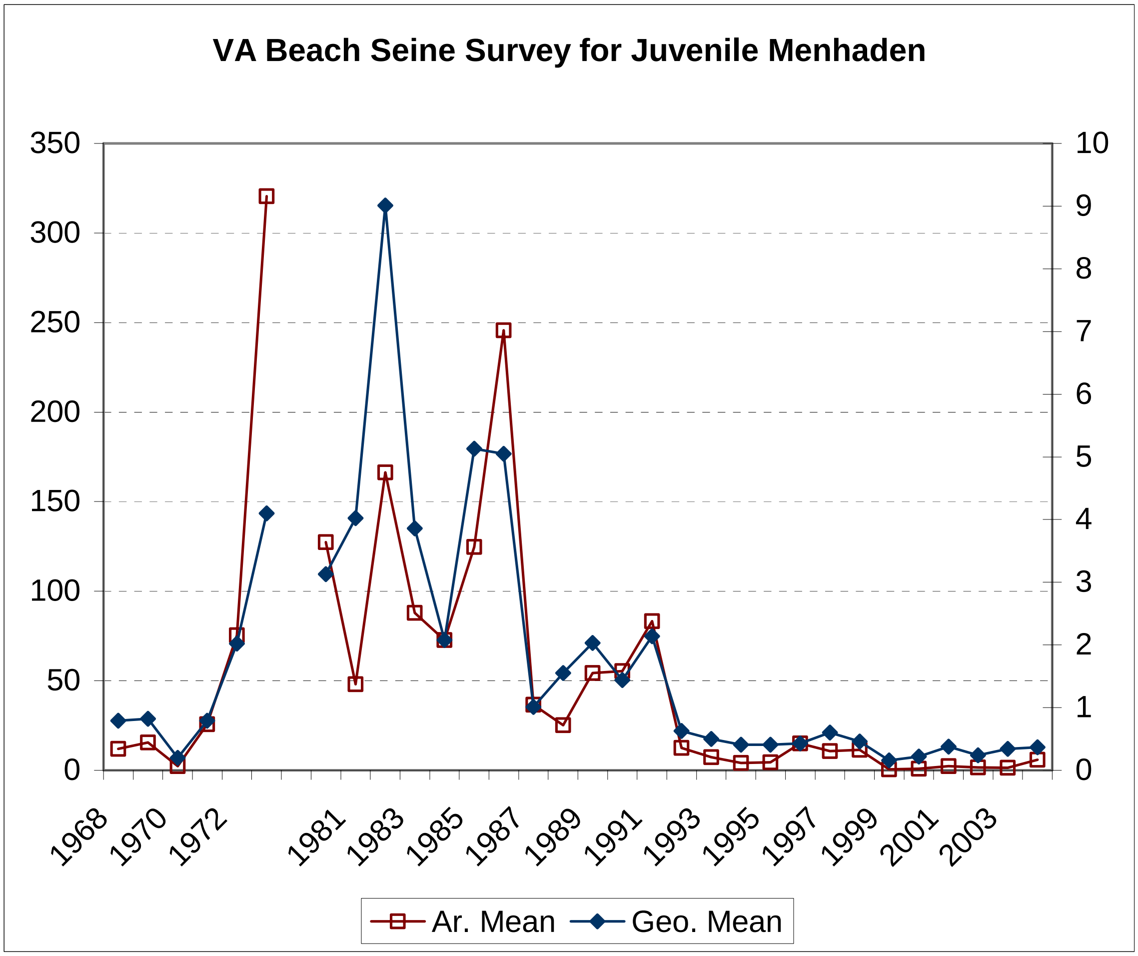
16. Q. Will the project answer the question of whether 'localized depletion' is occurring within the Chesapeake Bay? If yes, how? It not, why?

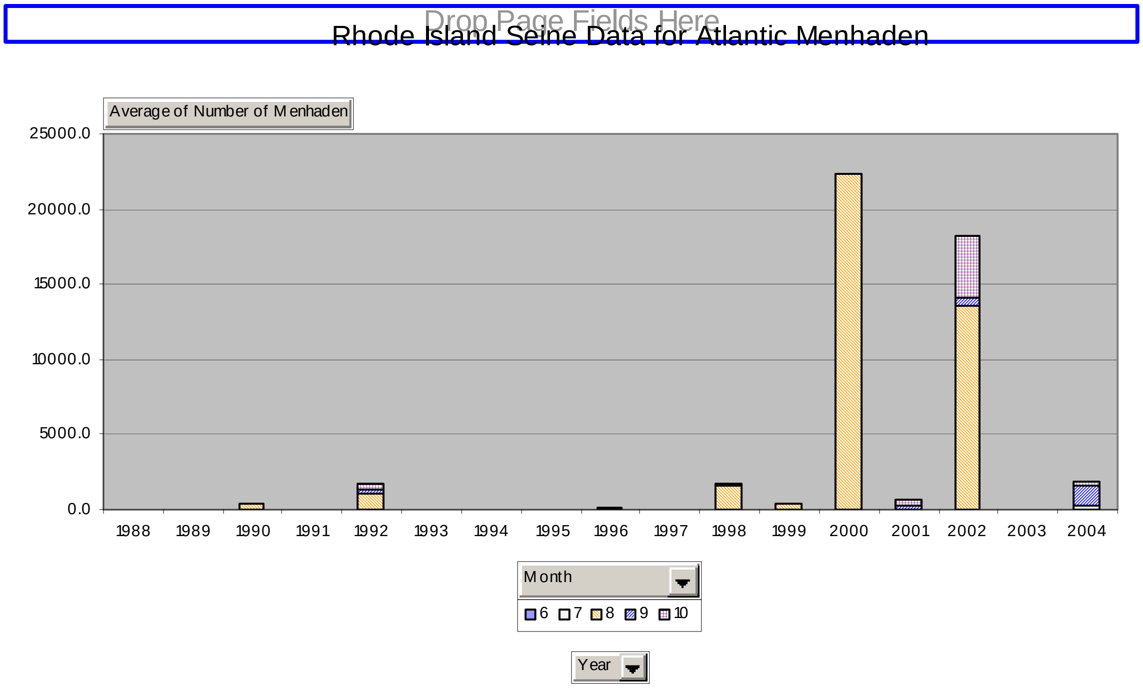
A. The goal of this project is to test LIDAR and sonar applicability to estimation of absolute abundance of menhaden population. If the results are successful, the estimation methodology will be developed and estimates of abundance and biomass produced. Those estimates will be made available to the ASMFC and others involved in menhaden research and management and used appropriately.

Appendix D.

North Carolina, Virginia, and Rhode Island Menhaden Surveys


NC Seine for Menhaden
CPUE
80
70
60
50
40
30
20
10
0
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Year
CPUE
GEO MEAN


VA Beach Seine Survey for Juvenile Menhaden
350
300
250
200
150
100
50
0
10
9
8
7
6
5
4
3
2
1
0
1968
1970
1972
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
Ar. Mean
Geo. Mean


Drop Page Fields Here
Rhode Island Seine Data for Atlantic Menhaden
Average of Number of Menhaden
25000.0
20000.0
15000.0
10000.0
5000.0
0.0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Month
6
7
8
9
10
Year