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VIRGINIA SALTWATER RECREATIONAL FISHING DEVELOPMENT FUND SUMMARY PROJECT APPLICATION*

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PRIORITY AREA OF CONCERN:

Research and Data Collection

PROJECT LOCATION:

Center for Quantitative Fisheries Ecology
Old Dominion University
Norfolk, VA 23508

DESCRIPTIVE TITLE OF PROJECT:

Sheepshead Population Dynamics in Chesapeake Bay, Virginia

PROJECT SUMMARY:

Recreational catch of sheepshead in Virginia, estimated by MRFSS, has been increasing in recent years. This increase has made local anglers such as the Coastal Conservation Association (CCA) concerned about sheepshead population status as the fishery develops. However, little is known about the Chesapeake Bay sheepshead population beyond minimal catch statistics. Moreover, the population in Chesapeake Bay may be a local stock governed by its unique vital rates. Therefore, specific data on population dynamics of sheepshead stock in Chesapeake Bay must be obtained to provide a scientific base for its management. We are proposing a three-year project to examine age composition, annual growth and mortality rates, and reproductive status of sheepshead in Chesapeake Bay, using this information to establish a baseline for stock assessment of this species in Chesapeake Bay. We present the third year's study here.

EXPECTED BENEFITS:

Fisheries management
Population characteristics of sheepshead in Chesapeake Bay will be evaluated and reported to VMRC as basic information for conducting initial stock assessment and for making management policies.

The results of this study will indicate the level of fishing that results in a sustainable exploitation of this stock, and whether this stock is separate from those in North Carolina, such that it can be managed independently by Virginia.

COSTS:

Year Three

VMRC Funding:	67,206
Recipient Funding:	9,140
Total Costs:	76,346

Detailed budget must be included with proposal.

Updated 6/1/05

***This form alone does not constitute a complete application, see application instructions or contact Sonya Davis at 757-247-8155 or sonya.davis@mrc.virginia.gov : Due dates are June 15 (Jul. – Nov. Cycle) and December 15 (Jan. – May Cycle)**

Sheepshead Population Dynamics in Chesapeake Bay, Virginia

Proposal for consideration by the Virginia Recreational Fishing Advisory Board

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Center for Quantitative Fisheries Ecology
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Statement of Problem

Recreational anglers have expressed interest in carefully developing a fishery for sheepshead (*Archosargus probatocephalus*) in Chesapeake Bay. Recreational catch of sheepshead in Virginia, estimated by the Marine Recreational Fisheries Statistics Survey (MRFSS 2007), increased from 1,583 to 20,319 fish from 1999 to 2005 (Figure 1). Although sheepshead is not a major fishery in Chesapeake Bay, this increase has raised concern about the population status of this species as the fishery develops.

The Coastal Conservation Association (CCA) has been the first to express concern about overfishing on sheepshead population in Chesapeake Bay. They believe that information on population dynamics of sheepshead should be collected and provided to fishery management before any negative impact of overfishing occurs on sheepshead in Chesapeake Bay (Personal communication with CCA).

All the previous studies on sheepshead were done from the South Atlantic Bight and Gulf of Mexico. To understand the population dynamics of sheepshead in Chesapeake Bay, we collected data from both recreational and commercial fisheries in 2006, under the first year of funding this project. The data collected in 2006 indicate some unique characteristics of this population, such as potential local spawning activity, older ages and larger weight at age than for southern populations. However as we expected, we were unable to obtain sufficient fish to assess reproductive status, an essential piece of information – despite great effort in public outreach on radio and with fishing clubs. With 2007 data collection (scheduled for the summer of 2007), we will provide some preliminary recommendations to the fisheries management as we promised. However, those two years data will not provided sufficient information to draw necessary scientific conclusions on which the fisheries management should be based –spawning stock characteristics. Initial evidence indicates that the population of sheepshead in Chesapeake Bay may be a local stock governed by its unique vital rates where fish exhibit subpopulation differences (Beckman et al. 1991; Matlock 1992; Render and Wilson 1992). Therefore, specific data on reproduction of the sheepshead stock in Chesapeake Bay must be obtained in the third year of this study to provide a scientific base for its management that we promised when we began this project.

Background

Previous studies of sheepshead have been conducted mainly in Florida and states in Gulf of Mexico, providing general information about the species. Beckman et al. (1991) found that annual rings formed once a year on sheepshead bones and could be used to age, and that females had faster growth and reached larger maximum size than males in Louisiana waters. Render and Wilson (1992) also reported that sheepshead were 50% mature by age 2, and all males and females were mature over age 3 and 4, respectively in Louisiana. Although it is reported that sheepshead are relatively long-lived species and reach ages in excess of 20 years (Beckman et al. 1991), the oldest sheepshead in Georgia was only 14 years based on otolith ageing (Music and Pafford 1984). Tremain (2004) reported that the movement of sheepshead only occurred between their spawning areas and surrounding waters in Florida. To date, there is no evidence that sheepshead migrate along the U. S. Atlantic coast. The best review of sheepshead biological characteristics and population dynamics was found in stock assessment reports documented by Florida Fish and Wildlife Conservation Commission (Murphy and MacDonald 2000). They confirmed that sheepshead did not migrate along the U. S. Atlantic coast and that their maturity and growth rates could be different among the regions.

Historically, an increasing demand for a fish species results in increased of management regulations on the species, concomitant with its decline in abundance. For example, Texas Parks and Wildlife Department imposed more regulations on use of gears, size, bag, and possession limits on sheepshead in response to dramatically increased fishing pressure during 1980s (Matlock 1992). Recently, sheepshead are becoming a more important fishery along the U. S. Atlantic coast, which requires more information on regional or local stocks in order to establish fishery management strategies on a regional scope. Unlike Florida, which has done long-term thorough stock assessments of sheepshead due to its importance there, both Georgia and South Carolina have only begun their initial stages of sheepshead stock assessment (Sedberry 2002; Georgia DNR 2004). Both states have started either monitoring or stock assessment programs for sheepshead.

However, no thorough studies have been conducted and little is known about sheepshead in Chesapeake Bay, although there is a potential that sheepshead may become more popular. Miller et al. (1996) listed sheepshead as a benthivore and nonresident species without any natural reproduction in Chesapeake Bay. However, they lacked information on population dynamics, and further we have uncovered evidence to indicate reproduction in the Bay region. For example, of 175 sheepshead collected in 2006 in this study, eight fish were found to be spawning in May and June (Please see the Preliminary Results section), indicating a possibility of sheepshead spawning activity in Chesapeake Bay.

Sheepshead in North Carolina is the closest population to that of Chesapeake Bay but knowledge is also limited there. For example, Schwartz (1990) was only able to use scales to age fish up to eight years and did not provide any information on older fish age composition in North Carolina. The Virginia Game Fish Tagging Program has trained anglers to tag a variety of fish species, including sheepshead. So far, the tagging program has not collected sufficient information to further our knowledge of sheepshead. For example, they had only one recapture each year of tagged sheepshead in 2000, 2001, and 2002, respectively (Lucy and Bain 2002). Our study in 2006 found that sheepshead in Chesapeake Bay were much older than those reported in South Atlantic and the Gulf of Mexico. For example, almost all the fish we collected were older than age 4 with the oldest age of 32 (Please see the Preliminary Results section). Therefore, our first year study strongly supports that to effectively manage this species, fisheries managers must first obtain detailed scientific information to identify the Chesapeake Bay sheepshead as a separate stock, to understand population dynamics of the stock, and then to conduct stock assessment for sheepshead fishery management.

Fish population characters such as age composition, growth and mortality rates, and reproduction status are primary information for recognition of putative stocks at the practical fisheries management level (Ihssen et al. 1981; Cadrin et al. 2005). Moreover, such data are necessary in a variety of stock assessment models such as ADAPT, FAST, MUTIFAN, which are used by fisheries scientists to establish effective management strategies. For example, the Atlantic States Marine Fisheries Commission (ASMFC) has been using ADAPT to conduct stock assessment of Atlantic striped bass (*Morone saxatilis*) for many years, providing fisheries managers with population dynamics information of this species. The population of this species has recovered from near depletion during 1980s, and which is considered as one of the most successful examples of fisheries management (Richards and Rago 1999). Therefore, collecting high quality information on age composition, growth and mortality rates, and reproduction status is the first and critical step to identify a fish stock and further to conduct assessment of the stock, especially a near-virgin stock.

Significance

By definition, a virgin stock is an unexploited standing stock (Gulland 1971), naturally regulated by density-dependent processes and characterized by a high proportion of old fish, slow individual growth rates, and low total mortality rates (Van den Avyle and Hayward 1999). Two signs may indicate that sheepshead in Chesapeake Bay is most likely to be very close to a virgin stock. First, exploitation in Chesapeake Bay is very low compared to other Atlantic regions. For example, the recreational catch is 5,783 (±4,580 SE) and 20,319 (±14,284 SE) fish in Maryland and Virginia in 2005, respectively, whereas the recreational catch is 75,954 (±18,837 SE), 54,317 (±13,742 SE), 122,286 (±26,658 SE), and 2,985,575 (±131,365 SE) fish in North Carolina, South Carolina, Georgia, and Florida in 2005, respectively (MRFSS 2007). Second, fishermen have been continuously reporting that they catch much larger sheepshead in Chesapeake Bay than other Atlantic regions. Our first year study also found that this population has older ages than its southern populations (Please see the Preliminary Results section). So either sheepshead grow larger here than elsewhere, or mortality is so low that fish get much older and larger here.

It is very unusual to find a near-virgin stock in Virginia in 2004, and it is also unusual for stakeholders to request the study of a fish stock before it is fully exploited--such as sheepshead stock in Chesapeake Bay. Taking this opportunity, we will be able to estimate natural mortality, and monitor and examine the response of sheepshead stock as fishing pressure increases in Chesapeake Bay, thus providing an exceptional benefit in managing this stock. The information from the project will benefit Virginia recreational anglers as follows.

1) Theoretically, when a virgin stock is open to exploitation for a certain time, population characters start to change. For example, the directed commercial fishery of sheepshead officially started in Chesapeake Bay in 2007, which could increase the exploitation rate dramatically. Our third year study will conclude our collection of reproductive data, and see if the sheepshead are responding to increased fishing mortality, and to test a variety of options for its management. For example, if age composition shift from a majority of older fish to younger fish, then will those remaining fish grow faster at younger ages?

2) This study will also contribute biological, ecological, and conservation knowledge on sheepshead in a broad geological range. It has been reported that sheepshead are widespread from Nova Scotia to Brazil (Robins and Ray 1986). However, we have not found any studies on sheepshead population north of North Carolina. Knowledge of this species in Virginia will provide information to conservation of this species and especially on the potential of connectivity between stocks.

Objectives

This study is the first to evaluate sheepshead population dynamics in the Chesapeake Bay and to determine whether there is evidence that it is a separate stock, governed by its own vital rates, separate from other Atlantic regions and to establish a baseline for stock assessment of this species in Chesapeake Bay. Our specific objectives are to: 1) examine age composition of the sheepshead population; 2) estimate their annual growth rates; 3) estimate annual mortality rates; and 4) evaluate their reproductive status in Chesapeake Bay. We have made good progress on objectives 1-3, but as we anticipated we need three years of data to accomplish objective 4, a critical piece of information.

The results of the project from the first two years will provide us with the preliminary knowledge of sheepshead population dynamics in Chesapeake Bay, such as length at age, population growth rate, mortality rate, and reproductive status in 2006 and 2007. This information could be used by the fisheries management to establish some preliminary policies. However, it is necessary and essential to continue the project for the third year and final year for three reasons. First, fish population growth, mortality, and reproduction activity vary with environmental conditions annually and even dramatically. A three-year study is necessary to show such variability, and provide less biased information for fishery management. Second, technically, reproductive status is difficult to determine because it requires that a large number of gravid females are caught and evaluated. Typically, we have seen only a few gravid females among 500 fish that we obtained in 2006. It is this problem that requires us to sample over three years – so that we will be able to determine the impact of fishing on the sheepshead's ability to replace itself through reproduction. Third, the directed commercial fishery of sheepshead officially started in 2007 in Chesapeake Bay. This could increase the exploitation rate of sheepshead dramatically. Our third year of study will monitor and examine potential impacts of the directed commercial fishery on this population. With the information above, we will be able to evaluate sheepshead management in the region to enhance recreational angling experiences.

Preliminary Results from Year One Sampling (Summer 2006)

The project officially started on May 1, 2006. We hired a master's student Mr. Scott Haga and trained him on field and lab work. Scott Hager conducted a pilot study on comparing ageing using sheepshead otoliths (ear stone), opercula and pelvic spines. He found that otoliths are the most appropriate hard parts to be used to age sheepshead, which is consistent with previous study (Schwartz 1990). In 2007-2008, we have recruited a Ph. D. graduate student and a part-time worker on this project. This will enhance the data collection and data analysis in the final year.

Our preliminary results are from the first year of study as the field season of the second year has not started when we prepared this proposal. In general, our first year study has indicated that there are unique characteristics of population dynamics for sheepshead in Chesapeake Bay (Liao et al. 2007). The majority of sheepshead collected in Chesapeake Bay were between 18 and 27 inches (Figure 2) and older than age 4 with a minimum of age 0 and a maximum of age 32 (Figure 3). Using the catch curve analysis (Quinn and Deriso 1999) and the linear regression model (Hoenig 1983), we estimated a total mortality (Z) of 0.11 and a natural mortality (M) of 0.14, respectively. The very close estimates of Z and M here indicated that the fishing mortality (F) might not make any significant impacts on the sheepshead population in Chesapeake Bay (and this is without a commercial fishery). In addition, we collected 7 age 0 fish (Figure 3) and 8 spawning fish (Figure 4), indicating a possibility of local reproduction of sheepshead in Chesapeake Bay. By examining the 8 spawning fish, we concluded that the sheepshead could spawn in May and June from age 5 (about 19.5 in. in total length) and up to age 13 (about 23 in. in total length) in Chesapeake Bay. However, due to the small sample size, these data on reproduction are *very* preliminary.

Preliminary Recommendations for Fisheries Management

Virginia Recreational Fisheries Advisory Board has asked for our recommendations on fisheries management of sheepshead in Chesapeake Bay by the end of the second year of the project, which will occur at the end of 2007. Although we have not obtained any data from the second year when we prepared this proposal, we would like to provide some management recommendations based on our preliminary information on the sheepshead population dynamics collected from the first year.

1) The minimum lengths could be set at 23 inches in the Chesapeake Bay Bridge and Tunnel areas in May and June pending further data collection and analysis. This allows sheepshead to spawn at least once at their life time, certainly a minimum precaution.

2) Sheepshead should be added to VMRC's monitoring program to obtain data on age composition and length frequency in catch annually. This will identify potential shifts of these two population parameters from older and larger to younger and smaller fish due to possibly increased exploitation rates from both recreational and commercial fisheries.

3) Sheepshead in Chesapeake Bay seem to be a near-virgin stock with many old, large fish and without significant fishing mortality. If a trophy-recreational fishery is to be maintained then exploitation must be carefully monitored and such stocks deplete quickly.

4) Again, our results are preliminary and based on small sample size.

Methods

Field work

Sheepshead have been predominantly caught by recreational anglers in the Chesapeake Bay with over eighty-four percent of the total landings in terms of weight from 2000 to 2005 (MRFSS 2007). Our first year sampling experience indicated that fish size varied spatially and between the recreational and commercial fisheries. To obtain a complete range of sizes, it will be necessary to sample sheepshead from both fisheries sectors. We have found that anglers will provide some of the samples needed for age and fecundity estimates, but this may have to be augmented by fishery-cooperative or fishery-independent sampling if gonads can't be obtained in "fresh" condition. Commercial sampling will provide a broader range of sizes to determine age and reproductive data than can be obtained solely from angling. If "fresh" gonads cannot be obtained from either fishery in sufficient numbers, then we will undertake fishery-independent sampling.

Recreational sampling:

During the past two years, we worked closely with the VA CCA, local marinas, angler's clubs, and anglers in person. Mr. Larry Snider from the VA CCA has volunteered the project coordinator between the VA CCA and ODU, enhancing communication between the recreational fishermen and us. We had a meeting with Mr. Tom Powers from the VA CCA, and discussed many details on how to promote the project, how to communicate with fishermen, and how to collect data, etc. We have placed coolers with ice at Long Bay Pointe Marina every day and at Little Creek Marina, Taylors Landing Marina, Bubba Marina, and Shore Dr. Marina on weekends along Shore Drive from Norfolk to Virginia Beach, Wallances Marina in Hampton. Recreational fishermen are encouraged to donate their sheepshead or sheepshead carcasses at each of these locations. We gave a presentation about this project to the Tidewater Anglers Association with very good feedback, and have scheduled the same presentation at the Tidewater Kayak Anglers Association on the 12th of July, 2007. We are working with five other anglers clubs to arrange presentations. We have also contacted many individual anglers personally who are known to specifically target sheepshead and they have been eager to participate in the project.

To promote collection of fish, we distributed project brochures to marinas and to anglers clubs. We developed a sheepshead research website where fishermen could check the ages, sex, and maturity of the fish they have donated (http://www.odu.edu/sci/cqfe/research/sheepshead%20project/sheepshead_project.htm). At the website, fishermen also can monitor the progress of the project so that they will know where and how to help the project in the future.

We will continue to sample sheepshead in this way during the third year of the project. The VMRC has imposed a bag limit of 4 fish per person for the recreational fishery and 500 pounds per day for the commercial fishery of sheepshead in 2007. These policies will require us to devote more effort to collect sheepshead from the recreational fishery sector in 2008 in order to obtain sufficient number of samples. Therefore, to encourage the donation of fish from anglers, we propose a sheepshead tournament in Virginia Beach area in late July of 2008. We anticipate that this will allow us to collect a variety of fish sizes and most of the reproductive organs we will need for fecundity estimates. If insufficient numbers of fish are collected by volunteers, then we will augment samples to reach the target of thirty fish bi-weekly. If the fish show signs of reproduction, we will sample more heavily during that period of time.

Commercial sampling

Because the directed commercial fishery of sheepshead in Chesapeake Bay started in 2007, we anticipate that the contribution of the commercial fishery to the total catch will increase in 2008. Also because the commercial fishery is less size selective compared to the recreational fishery, we will collect specific sizes of fish which we can't obtain from the recreational fishery while we focus on collecting majority of our samples from the recreational fishery. This will allow us to collect samples that represent the age and size composition of the population. We will use the help of the Virginia Marine Resources Commission (VMRC), which samples the commercial sector daily. VMRC employees will contact us anytime they intercept sheepshead. We will measure all the sheepshead we encounter, and we will then sub-sample randomly the commercial fish catch by purchasing boxes of fish (50 lbs. Box).

Fishery Independent Sampling

If the number of samples is insufficient from the commercial and recreational sector, charter boats will be used to collect sheepshead. Any charter boat captains with experience fishing for sheepshead will be contacted randomly for a full day of fishing on the bay. This will supplement the number of samples needed for this study.

Lab work

Once fish are collected they will be brought to the Center for Quantitative Fisheries Ecology (CQFE) at Old Dominion University (ODU) where they will be measured, weighed and the otoliths and gonads will be removed.

Otolith processing:

We will use a "bake and thin-section" technique to process sheepshead otoliths for age determination developed by the CQFE. The otolith will be secured to a microscope slide, and sectioned on a Buehler Isomet saw equipped with two Norton diamond wafering blades separated by a 0.4 mm stainless steel spacer, positioned so that the wafering blades straddles the focus. The otolith section will be placed into a ceramic "Coors" spot plate well and baked in a Thermolyne 1400 furnace at 400^{o}C. Baking time will be dependent on otolith size and gauged by color, with a light caramel color desired. The baked thin-section will be placed on a labeled glass slide and covered with a thin layer of Flo-texx mounting medium.

Gonad processing:

Histological sections of ovaries will follow the methods of Wells (1994) who examined the effect of different preservatives on the ability to discriminate amongst several different cellular structures. He found that preservation of ovaries in buffered formalin (5% vol:vol) minimally affected the ability of standard staining techniques, hematoxylin and eosin (H&E) to resolve intra-ovarian structures associated with spawning. Therefore in this study, ovaries will be preserved in formalin and histological sections will be stained with H&E for fecundity estimation. Each ovary will be cut in half and three replicate 1 cm^3 ovarian samples will be taken from each female, making sure that samples are taken from the tunica to the lumen to assure representative parts of gonadal material are sampled.

Data Analysis

Age determination:

Otoliths are read under a microscope using polarized light and an image analysis system. Procedures to establish quality assurance and reliability of age readings are incorporated into our laboratory protocols. We measure precision between age readings done by all readers so that we have consistency. Otoliths are read double-blind (with no knowledge of time or place of capture, or length of fish). A randomly selected subsample is read twice by the same reader and by another reader to test consistency among and between readers (Campana et al. 1995, DeVries and Frie 1996). We use a symmetry test (Bowker 1948) to measure precision and to observe tendencies to over- or underestimate age. Because it is also important to maintain consistency in age readings between years, we insert a sample of hard parts read in prior years among currently collected samples following double-blind procedures to test year-to-year consistency in ageing (Campana et al. 1995). We test for potential differences with repeated-measures ANOVA. Such vigilance keeps our age readings consistent and reliable from year to year.

Age composition and growth:

To evaluate growth, observed length-at-age data will be fitted to a von Bertalanffy Growth function (Ricker 1975), by non-linear least square regression (S-PLUS 1999):

$$Lt = L_{inf}(1-e)^{(-k(t-t0))}),$$

Lt = length at time t
L_{inf} = asymptotic mean length
t = time
t_o = theoretical age at 0 length
K = growth coefficient (instantaneous rate).

Likelihood ratio tests (Kimura 1980, Cerrato 1990) will be used to determine if differences exists between von Bertalanffy parameter estimates between sexes and years for mean fork length-at-age data:

$$\chi_k^2 = -N * Ln\left(\frac{RSS_\Omega}{RSS_w}\right)$$

Where k is the degrees of freedom (equals the number of constraints placed upon the fit), N is the total number of age groups from both curves combined, RSS_Ω is the total sum of squared residuals derived from fitting both curves separately and RSS_w is the total sum of squared residuals derived from fitting the curves with one hypothesized constraints ie. L_{inf} are the same, $t_0$are the same etc…

To determining the age distribution of the sheepshead population in the bay, we will use the large sample of fish we measured and the ages of the sub-samples and construct an age-length key. We can use the key to convert catch-at-size data into catch-at-age data. The keys specify the probability that fish of a given size belong to one of several age groups.

Mortality:
We will use the catch curve analysis (Quinn and Deriso 1999) to estimate the instantaneous rate of mortality. For this method, we simply plot the logarithms of frequency of occurrence against age. This results in a curve which has a steeply ascending left limb, a dome-shaped upper portion, and a long, descending right limb which is nearly straight. Assuming that fish increase in size by a constant amount from year to year, the slope of the right limb is equal to the negative of instantaneous total mortality (-Z). To estimate natural mortality, we will use two methods based on the longevity of sheepshead in the bay both described by Hewitt and Hoenig (2005). The first is based on a linear regression model (Hoenig 1983). He recommends using the predictive equation:

$$\ln(\widehat{M}) = 1.44 - 0.982 * \ln(t_{\max})$$

Where $\widehat{M}$ is estimate of natural mortality, and t_{max} is the maximum age observed.

The second method to estimate natural mortality consists of determining the value of M such that 100(P)% of the animals in the stock survive to the age t_{max} such that:

$$\hat{M} = \frac{-\ln(P)}{t_{\max}}$$

These two methods have been used extensively in work related to stock assessment for blue crab (*Callinectes sapidus*) (Hewitt and Hoenig 2005).

Reproduction Status:
It is straightforward to determine whether a fish is a batch or total spawner using histological samples of the gonads. Batch spawners show several developmental stages of oocytes at any given time. In the simplest case all developmental stages (excluding hydrated oocytes) of oocytes are present within one ovary. Similarly, group synchronous spawners would all have at least two distinct stages occurring simultaneously while asynchronous development is characterized by oocytes representing all stages of development and constant oocyte recruitment. The reproductive biology of Sheepshead was studied in the Gulf of Mexico (Render and Wilson 1992). The authors demonstrated that sheepshead in the Gulf of Mexico are batch spawners. We anticipate that Sheepshead in the Chesapeake Bay follow this pattern. If so, we must estimate both batch fecundity throughout the season and estimate the number of batches in a season.

Batch fecundity can be defined as the number of ripened oocytes in the ovary immediately prior to spawning (Bagenal 1978). Two methods will be used to estimate fecundity. For hydrated specimens, the hydrated oocyte method will be used (Hunter et al. 1985). In this method, a sub-sample of the gonad is weighed to the nearest 0.1mg. The number of hydrated oocytes is counted and the projection of batch fecundity is calculated by the product of the hydrated count and the weight of the gonads for both lobes. For specimens that are fully matured but not hydrated, an oocyte size-frequency distribution method will be employed (MacGregor 1957, Hunter et al. 1985). With this method the most advanced modal group of oocytes size classes is determined visually by constructing a size-frequency distribution of the oocytes. The total number of oocytes that constitute the most advanced mode is assumed the spawning batch. This method yields similar results as the hydrated method if highly advanced oocytes are used (Hunter and

Goldberg 1980; Laroche and Richardson 1980). Typically, determining the number of batches in a season is difficult. However, by sampling frequently over the course of the spawning season we can estimate the number of batches by examining the proportion of the population with post-ovulatory follicles present (evidence of recent spawning). The inverse of this proportion gives the average time between batches. For example, if 30% of the population has post-ovulatory follicles then the average interval between batches is 3 days. Thus, we can estimate the age-specific, batch fecundity and by summing over the spawning season and we can determine total fecundity for the population using characteristics from the sampled population.

Expected Results

Fisheries management

Population characters of sheepshead in Chesapeake Bay will be defined and reported to VMRC as basic information to conducting future stock assessment and to making management policies.

Outreach to Anglers

We will maintain a website for anglers to reference and will include on it our data and also reports specifically written to a general audience. We will also present our results to any anglers club who requests it.

Academic contributions

Two manuscripts will be submitted to peer-reviewed journals. One is about sheepshead growth and mortality in Chesapeake Bay, another is about sheepshead reproduction status in Chesapeake Bay.

Timeline for Year 2008-2009

Year 2008

<u>May to August</u>

1. Continue sampling to collect commercially harvested fish.
2. Continue to receive samples from recreational anglers.
3. Process ovary samples for batch fecundity estimation and histological preparation.
4. Process Sheepshead otoliths for age and growth analysis.
5. Ovarian samples are sent for histological preparation (first determinations of reproductive strategy).

<u>September to December</u>

1. Ageing using otoliths.
2. Preliminary fecundity estimates for sheepshead in the Chesapeake Bay.
3. Create a yield per recruit model to determine biological reference points and report the findings to the VMRC and the Recreational Board.

Year 2009

<u>January to April</u>

1. Process ovary samples for batch fecundity estimation and histological preparation.
2. Process Sheepshead otoliths for age and growth analysis.
3. Ovarian samples are sent for histological preparation (first determinations of reproductive strategy).
4. Ageing using otoliths.
5. Fecundity estimates for sheepshead in the Chesapeake Bay.
6. Create a yield per recruit and spawning stock biomass models to determine biological reference points and report the findings to the VMRC and the Recreational Board.

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Laboratory Facilities

In September 1997, the VMRC established The Age & Growth Laboratory at the CQFE at ODU to provide routine ageing of Virginia's marine finfish catch. The laboratory provides VMRC with the fundamental demographic data necessary for management. It is the mandate of this laboratory to help ensure Virginia's fish stocks remain a viable resource for future generations. To safeguard this resource, the Age & Growth Laboratory has established criteria that not only best suits the individual species, but also is consistent with other ageing facilities to allow for a coast-wide data exchange. Currently the lab is responsible for ageing 14 species of marine finfish. Bony structures presently being used to age fish include otoliths, scales, and opercula. However, we are examining additional hard (bony) structures, including pectoral fin rays, dorsal spines, anal spines, pelvic spines and vertebrae, for use as alternative ageing structures.

Budget for Year Three

	VMRC
PERSONEL:	
Salary of Jones (1 month)	**11,886**
Casual Employees	**21,630**
Fringe Benefits	**4,919**
	$38,435
GENERAL EXPENSES:	
Travel/Sample collection	**8,575**
Supplies for otoliths processing	**955**
Printing/Photocopying and Publication Charges	**1,000**
Telephone/Fax and Postage	**800**
	$11,330
SUBCONTRACT EXPENSES:	
Reproductive organ processing	**$4,000**
TOTAL DIRECT COSTS	**$53,765**
INDIRECT COSTS	**13,441**
TOTAL SPONSOR COST	**$67,206**
ODU Match	**9,140**
TOTAL PROJECT COSTS	**$76,346**

Budget justification

Personnel costs for the casual employees will be for sample collection, processing, and data analysis. Other Professional (Dr. Liao) will also oversee the project at no additional cost, coordinating sample collections and assisting with data analysis. Dr. Jones will be providing her expertise with population dynamics and statistical issues, and is requesting one month direct payment for each year.

We will subcontract the Department of Pathobiological Sciences at Louisiana State University to make histological slides for reproductive status analysis. The cost is $5 per slide plus shipping and handling fee. This will reduce the cost to half on making each slide but will increase the cost a little for paying our technicians and supplement to prepare reproductive organs in our lab. We are planning to hire charter boats to collect fish samples for us when sample sizes are insufficient from both recreational and commercial fisheries.

Travel costs consist of two parts. 1) Sample collection: We estimate traveling 5,000 miles per year around Chesapeake Bay to collect samples from recreational and commercial fisheries with a mileage compensation of $0.485 per mile. Total traveling miles have increased from 3,950 miles in 2007 to 5,000 miles in 2008 because Wallance's Marina in Hampton, VA is added in the list of our sample collection locations. 2) Meeting attendance: To update our knowledge of sheepshead population dynamics and related topics, we are requesting $750 to attend meetings during the second and third year of the project, respectively.

The remainder of funds goes to sample collection, processing supplies, publication costs, and information exchange with local communities and anglers organizations.

Figure 1. Annual total recreational catch of sheepshead (A+B1+B2, all modes and areas combined) in Virginia from 1999 to 2005 (MRFSS 2007). Catch is in number of fish. The vertical bar is standard error. The total catch has been increasing from 1999 to 2005 in general.

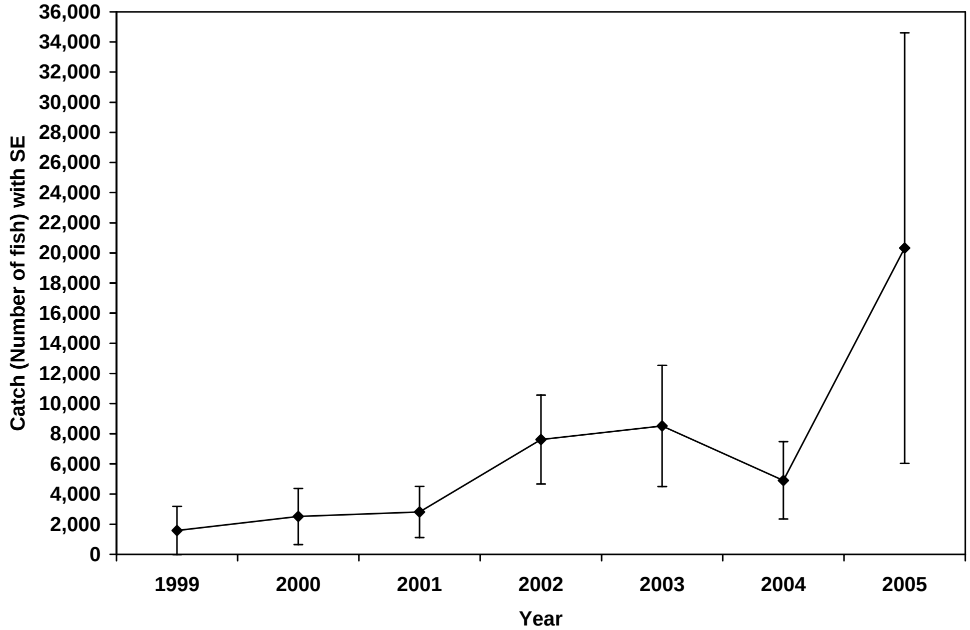

Figure 2. Length frequency of the samples collected from anglers in 2006 by ODU. There are no fish between 8 and 14 inches collected in 2006. Majority of fish collected are between 18 and 27 inches.

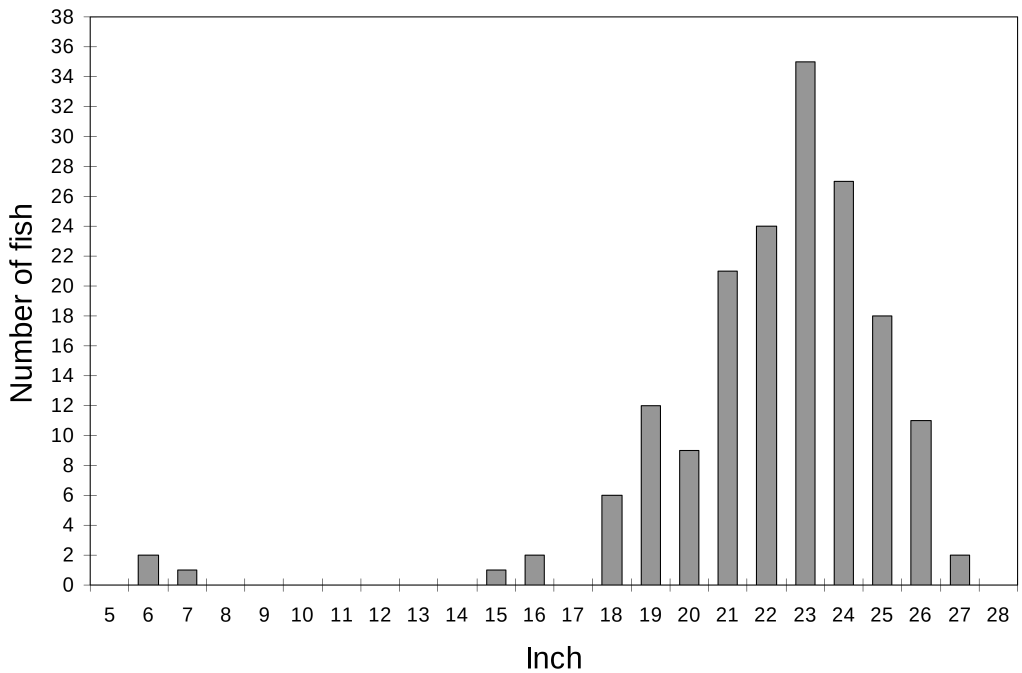

Figure 3. Age distribution of sheepshead collected from anglers in Chesapeake Bay in 2006 by ODU. Of 175 fish collected, 174 were aged with a minimum of age 0 and a maximum of age 32. There are no fish at age 2, 4, 26, 27, 28, and 29 collected in 2006.

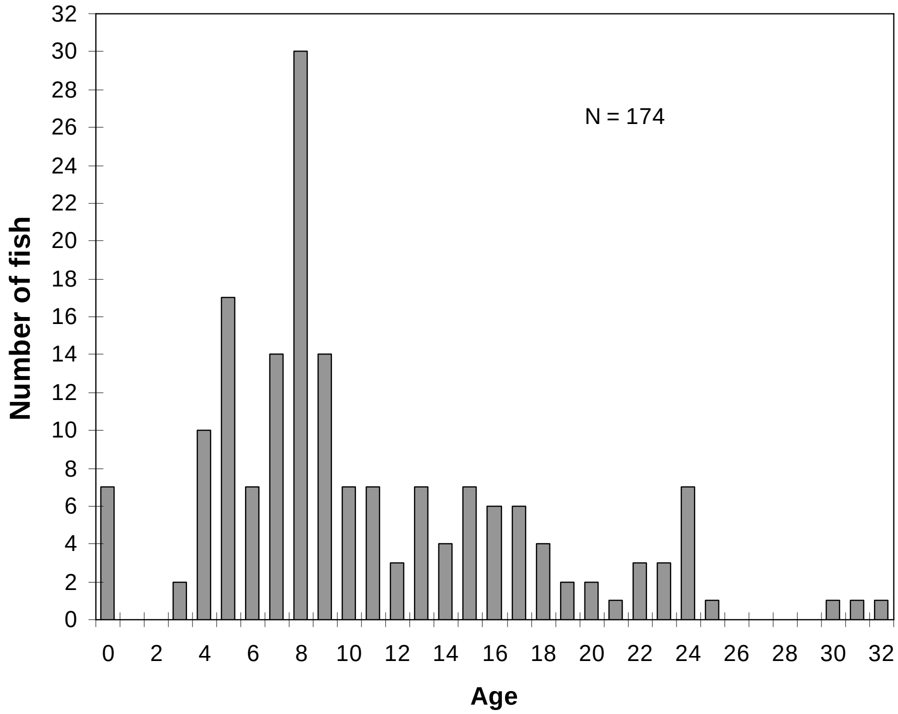

Figure 4. Macroscopic analysis on maturity of sheepshead collected in 2006 by ODU. The size of bubbles and the number in each bubble indicates the number of fish at different maturity stage and in different months.