ASSESSMENT OF SHEEPSHEAD IN LOUISIANA WATERS – 2010 REPORT

Executive Summary

- 2008 combined commercial and recreational harvest of 3,152,344 pounds is 1,651,129 pounds lower than 2004, the last year before the hurricanes of 2005, or about 66% of the 2004 harvest, but about 158,000 pounds above the 1981-2007 average harvest recorded for the species. Much of the recent drop is due to declines in commercial harvest, though recreational harvest also declined to near long-term average levels in 2006 and 2007 after several unusually strong harvest years. Recreational harvest increased substantially in 2008.

- The conservation standard for sheepshead is 30% spawning potential ratio (SPR). The results of Yield per Recruit (YPR) analysis indicate that if the natural mortality rate (M) is equal to 0.2 (the most conservative value within the range of estimates), the fishing mortality rate (F) in the years assessed (1999 - 2008) was below $F_{0.1}$ and well below F_{MAX}, with yield of 56% to 78% of maximum, and SPR at 47% to 63%. An M of 0.3 (the highest value examined) would indicate a more lightly fished stock with yield being 29% to 43% of maximum and with SPR being 69% to 82%.

- It should be noted that the method used in this assessment to determine the status of the stock is least precise in the most recent years of the fishery. As a cohort proceeds through the fishery, more information is available, making more accurate estimates possible. Sheepshead enter the fishery at age 1 and are fully recruited by age 8. It also takes several years of consistent harvest conditions before the VPA would accurately measure the impact of regulatory changes or other factors, since the method relies on the relative abundance of the age-classes in the fishery. In the case of sheepshead it would take 4 years of consistent harvest conditions assuming selectivities of age 5 and older is 100%.

- As a result of having several years of commercial trip ticket data, and collecting recreational fishery statistics data, the department was able to begin a program to representatively sample fishery dependent otoliths in 2002. The program uses trip ticket data and recreational survey data to weight sampling sites so that otolith collections reflect harvest from the fisheries for the species of interest. It is expected that this method of otolith sampling will improve stock assessments by providing more accurate annual catch-at-age data.

SUMMARY OF CHANGES FROM 2008 ASSESSMENT

There were no major changes in methods from the 2008 assessment. This report merely updates the analyses with new information on harvest, additional age information, updated age-length keys, and updated harvest at age. Two additional years of data are incorporated, including 2,024 commercial length samples, 508 recreational length samples, and 2,409 fishery-dependent age samples.

ASSESSMENT OF SHEEPSHEAD IN LOUISIANA WATERS
2010 REPORT

Harry Blanchet
Marine Fisheries Division
Louisiana Department of Wildlife and Fisheries

Table of Contents

Introduction 2
1 - Age and Growth 3
2 - Natural Mortality 4
3 - Disappearance Rates and Fishing Mortality 6
4 - Yield-per-Recruit 9
5 - Status of the Stock 10
Conservation Standards 10
Recent Regulatory History 10
Trends in Harvest and Abundance 10
Estimates of Yield and Spawning Potential 11
6 - Research and Data Needs 12
BIBLIOGRAPHY 13
Tables 15
Figures 21

Introduction

This assessment uses virtual population analysis (VPA), yield-per-recruit (YPR), and Spawning Potential Ratio (SPR) to estimate the impact of fishing on yield and spawning potential of sheepshead (*Archosargus probatocephalus*) stock in Louisiana waters. Estimated values using YPR and SPR are based on information regarding growth rate, spawning potential, and estimates of the natural mortality rate (M) and fishing mortality rate (F) on the stock. Virtual population analysis calculates F and stock size by age after recruitment to the fishery, based on the estimated numbers of each age class harvested annually. The spawning biomass of females is assumed to be the factor limiting the spawning potential of the stock; therefore, where possible, only data on female sheepshead are used. Yield-per-recruit and SPR analysis, as with many other generalized assessments, should be used only as a guide until a more comprehensive assessment can be conducted.

The definition of the unit stock must be considered in the development of a stock assessment. While a unit stock may be defined as that portion of the population which is genetically similar (e.g. Larkin, 1972), for our purpose in this stock assessment, the most applicable definition is one which considers the unit stock as that portion of the stock which is either dependent on Louisiana waters, or that is available to Louisiana fishermen, similar to the stock concept of Ricker (1975).

1 - Age and Growth

Ages of harvested fish were estimated using age-length keys (ALKs). Age data were collected from 1994 through 2008 from fishery-independent (n=2,209), commercial (n= 1,716) and recreational (n= 915) sources (Table 1) using sectioned otoliths. The oldest fish recorded were 4 fish aged at 23 years, captured in fishery-independent samples. The oldest fish sampled from fishery-dependent samples were age 14 from the recreational fishery, and age 17 from the commercial fishery.

Fish over age 15 were rare in the aged dataset, so fish of ages 15 and over were included in a 15+ age group. The length of sheepshead in the fishery-dependent samples were between 8 and 22 inches fork length, and between 4 and 22 inches for fishery-independent samples. Sex information was not available for many of the fish that were aged from fishery-dependent samples, especially from earlier years, so the ALK does not include sex information.

The largest fish aged was 17 years old, a 26 inch fish from the commercial fishery. This fish was not included in the analyses since it was pre-selected for size when sampled. When the ALK was applied to length measurements, fish over 22.99 inches fork length (FL) were combined into the 22-22.99 inch group, since there were no data to provide age distribution for sheepshead that large.

We considered the fishery-dependent age samples from the commercial fishery adequate to characterize that fishery, so the age-length key for the commercial harvest was derived from those samples alone.

Examination of the commercial age data indicated that there were larger proportions of fish sampled for each age in ages 5-13 in that dataset than were found in the recreational samples (see Figure 1). An ALK was developed for recreational fishery using the 915 sheepshead ages available from the recreational fishery alone. Annual age data was available from both the recreational and commercial fisheries, but we did not believe that we could justify using an annual ALK with the relatively low numbers of samples taken from those fisheries annually when considering the large number of age / length cells to be filled with this species, so decided to use a generalized ALK (across years). We added the age information from fishery-independent samples for the sheepshead <8 inches TL (14 age samples) to the recreational ALK, since there was little age information available directly from the recreational fishery. However, since there were very few of these small fish in recreational harvest length samples, the influence of this distribution is probably not significant to the overall age distribution for any given time period.

Sheepshead Aged by Fishery and Sex from 1994 through 2008
C=Commercial, FI=Fishery-Independent, R=Recreational Fisheries
F=Female, M=Male, U=Unknown Sex

Fishery	SEX	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	ALL
C	F	0	0	55	61	7	47	0	0	12	145	129	119	121	343	404	1,443
	M	0	0	41	44	2	33	0	0	11	105	105	85	83	233	305	1,047
	U	0	80	118	118	1	1	0	0	8	68	70	49	24	139	26	702
FI	F	2	19	132	217	306	209	197	142	6	0	0	0	0	0	0	1,230
	M	0	24	91	165	201	161	178	112	2	0	0	0	0	0	0	934
	U	0	0	9	12	8	7	4	5	0	0	0	0	0	0	0	45
R	F	0	0	0	0	0	0	0	0	56	84	97	177	146	256	278	1,094
	M	0	0	0	1	0	0	0	0	29	51	83	148	108	147	264	831
	U	0	0	0	0	0	0	1	0	1	2	2	2	1	3	11	23
UNK	F	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	ALL	2	123	446	618	525	458	381	259	125	455	486	580	483	1,121	1,288	7,350

Where available, fork lengths were used for analysis. Where these were not available, fork lengths were derived from total length, inverting the conversion for maximum total length to fork length provided by Joe O'Hop, Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission (pers. comm., 2006).

$$FL(mm) = (TL - 4.233) / 1.090$$

Weights were estimated from fork lengths, using the parameters reported by Beckman et al. (1991), then converted to pounds for this report. Their fork length - weight regression equation was:

$$\text{Female } W(gm) = 5.30 \times 10^{-5}\ FL(mm)^{2.85}$$

Von Bertalanffy growth parameters developed by Beckman *et al*. (1991) from fish harvested in Louisiana were used to calculate length and weight at age for female sheepshead for some analyses, including YPR and SPR. The equations are as follows:

$$\text{Female } L_t = 447(1-e^{-0.367\,(t+1.025)})$$

$$\text{Female } W_t = 2557(1-e^{-0.219\,(t+3.061)})^{2.85}$$

where, L_t = length at age t, W_t = weight at age t and t = age in years. As a note, the positive values for t_0 in these functions are probably due to the lack of young fish in the Beckman *et al*. samples. All of their fish came from recreational and commercial samples, and the youngest were about 2 years old. Based on the growth curve for females in the fishery, age (t) at length is calculated as:

$$t = 1.025 + \ln(1-L_t/447)/-0.367$$

2 - Natural Mortality

Natural mortality is one part of total mortality (Z) and is the mortality due to all causes other than fishing. These include predation, disease, spawning stress, starvation, and old age. Typically, natural mortality is estimated, as it is difficult to directly measure, especially on exploited fish stocks where natural mortality and fishing mortality occur simultaneously. No direct measure of natural mortality for sheepshead is available; therefore, several established

estimation procedures were used to derive an estimate. Four procedures are presented below and are taken from Sparre and Venema (1992). Modified versions of some of these procedures were provided by Gayanilo *et al*. (2005).

Pauly (1980) provides a method of estimating natural mortality from a set of parameters including the asymptotic length and growth rate of the fish, and the average water temperature of the environment. The growth parameters from the von Bertalanffy growth equation described in Section 1 and the mean annual water temperature, derived from readings from a set of four constant recorders located throughout the Barataria Bay system, were used in the calculation. The mean water temperature was 22.7^{o}C for the period 1989 - 1992 (pers. comm., M. Kasprzak, 4/13/92). These values were incorporated into the length-based function of Pauly (1980):

$$\ln(M) = -0.0152 - 0.279 * \ln(L\infty) + 0.6543 * \ln(K) + 0.463 * \ln(T)$$

where, ln(M) = natural log of natural mortality, $\ln(L\infty)$ = natural log of the asymptotic length, ln(K) = natural log of the growth coefficient and ln(T) = natural log of the mean annual temperature in degrees Celsius. A modified version of this is presented in Gayanilo and Pauly (1998). That function is

$$\ln(M)=-0.0066 - 0.279 * \ln(L\infty) + 0.6543 * \ln(K) + 0.463 * \ln(T)$$

Use of Louisiana data on growth and water temperature applied to Pauly's function results in a natural mortality estimate of M=0.75.

Alagaraja (1984) and Hoenig (1983) provide methods of estimating M based on the fishes lifespan or longevity, and with the assumption that M=Z. Longevity is also difficult to determine for exploited fish stocks, since the age distribution is usually truncated by fishing, but these methods are as useful as any in providing provisional estimates of natural mortality. The functions described by Alagaraja (1984) are:

$$M1\% = -\ln(0.01)/Tm$$
$$M0.1\% = -\ln(0.001)/Tm$$

where, M1% and M0.1% are the natural mortality rates corresponding to 99% and 99.9% mortality, respectively, given a fish's lifespan (Tm) in years. Sheepshead in Louisiana have been aged to 20- years-old (Beckman *et al.* 1991), and to 23 years (this report). If it is assumed that 99% or 99.9% of the fish die by age 20 then the corresponding natural mortality rates for M1% and M0.1% would be 0.23 and 0.35 respectively. For a maximum age of 23, the estimates are 0.20 and 0.30 respectively.

The function described by Hoenig (1983) is:

$$\ln(Z) = 1.46 - 1.01 * \ln(Tm)$$

where, when M=Z, longevity (Tm) can be defined as the maximum survival age. If we assume that the maximum age of sheepshead has been truncated due to fishing from 25 years to 20 or 23 years, the resulting estimate of natural mortality, given Tm=25, would be 0.2.

Another method of estimating M is described by Rikhter and Efanov (1976) and utilizes population age at sexual maturity. The function is:

$$M = 1.521/(Tm50\%^{0.720}) - 0.155$$

where Tm50% is the age at which 50% of the population is mature. Age 2 is reported as the age at more than 50% maturity for the sheepshead population resulting in an M estimate of 0.77. Render and Wilson (1992) report 95% maturity at age-2, so that the "massive maturity" age used in some versions of this function is the same as the 50% maturity age.

Beddington and Kirkwood (2005) reviewed several analyses developed by authors examining life history "optimization techniques" and extended those analyses to provide an estimate of:

$$M = 1.5 * K$$

where K is the von Bertalanffy growth coefficient.

In summary, the estimated rates of natural mortality for sheepshead in Louisiana using a variety of estimation procedures are as follows:

Estimates of Natural Mortality (M) (Author of function listed below, reported or modified in citation to right)	Sparre & Venema (1992)	Gayanilo et al. (2005)	Gayanilo & Pauly (1998)	
Rikhter and Efanov (1976)	0.77	0.77		
Hoenig (1983)	0.17		0.18	
Pauly (1980)	0.75	0.76		
Alagaraja (1984) M1% (23 yr max)	0.20			
Alagaraja (1984) M1% (20 yr max)	0.23			
Alagaraja (1984) M0.1% (23 yr max)	0.30			
Alagaraja (1984) M0.1% (20 yr max)	0.35			
Beddington & Kirkwood (2005)				0.55

3 - Disappearance Rates and Fishing Mortality

The disappearance rate (Z') from the fishery comprises the total mortality (natural + fishing) and some unknown rate of decreasing availability of the fish to the fishery. If the unknown rate of availability is small or nonexistent, then the disappearance rate will be a reasonable estimate of total mortality (Z). However, if a large portion of the disappearance rate is due to fish not being available to the fishery, then assuming Z'=Z will overestimate the impact of fishing.

Length frequency information was available from recreational and commercial fisheries for

the period from 1994-2008 (Table 2). Regulatory changes in the commercial fishery in 1995 and 1997 were evident in the selectivity patterns observed. Prior to 1995, gillnets and trammel nets fished in inshore waters of the state, taking primarily younger fish, were a significant contributor to commercial sheepshead landings. Restrictions limiting effort by these gears were implemented in August 1995 and by March 1997 all harvest by gill or trammel nets was banned. Currently, the predominant commercial gear is the otter trawl, taking primarily larger fish in offshore waters and large bays and sounds. It is evident that the commercial selectivity pattern in the most recent years has moved toward larger fish (Table 2).

An annual catch-at-age matrix was developed by applying the ALKs presented in Section 1 to the years where length frequency data for the commercial and recreational fishery was available (Table 3). Length frequency data were obtained from the Trip Interview Program (TIP), and Fisheries Information Network (FIN) sampling of the commercial fishery, and from the National Marine Fisheries Services (NMFS) Marine Recreational Fishery Statistics Survey (MRFSS) samples of the recreational fishery. The data from TIP and MRFSS surveys did not consistently distinguish between sexes. For purposes of the YPR and SPR analyses, we used the female growth and length / weight functions for all fish.

In assessments through 2004, the age at full recruitment was estimated to be 7, based on age assignments from the von Bertalanffy growth equation. In 2005, the growth curve was replaced by use of an ALK. Due to the use of an ALK, we estimated the age at full recruitment to be 5 in 2005 through 2008 assessments. In the current assessment, age at full recruitment is estimated to be age 8, due to additional ALK data (Figures 1 - 3). The new selectivities were utilized in the estimation of stock benchmarks and annual estimates of spawning potential ratio and yield per recruit. In the 2005 assessment, we compared a VPA analysis to a disappearance rate analysis of the catch at age. This year, as in the 2006 and 2008 assessments, the VPA is utilized as the basis of the assessment procedure, rather than the disappearance analysis used earlier. As a result, estimates of stock benchmark values (e.g. YPR at 30% SPR) differ slightly from those earlier reports. Also, annual estimates of SPR and YPR have changed because of these changes in analytical procedure, and the changes in estimated F at age from the new ALK.

Since additional information was incorporated into the recreational and commercial ALKs, there were changes in the estimates of harvest at age. The primary changes were that the estimates of younger (ages 1-3) and older (ages 8-15+) were increased, while the estimates of middle-aged (ages 4-7) fish were decreased, so that overall estimates of numbers of fish harvested per year increased slightly compared to the values used in the 2007 assessment.

A range of natural mortality rates were used in the assessment. After reviewing estimates of M in Section 2, we chose not to assume any method of estimating M was better than another, but rather to present results for the range of estimates. The range of M was from 0.20 - 0.77. We chose to use an M of 0.2 as the lowest estimate of M since it was the lowest estimate derived from the methods examined. Resulting disappearance rates using an M of 0.2 indicated SPR values well above 30%, so assessing the impact of an upper range of M was of little value in evaluating the status of the stock compared to the conservation standard. However, we did use an upper range of 0.3 to evaluate how a change in M impacted resulting yield and SPR.

Fishing mortality rates were calculated from the combined commercial and recreational

catch-at-age data by year for 1999 - 2008. Fishing mortality rates for ages 0-14 were derived directly from the VPA to be used in yield-per-recruit and SPR analyses. The indexed fishing mortality rate at age 8 (taken as fully recruited) was applied to all ages beyond age 14.

The estimates of harvest at age were evaluated using a VPA (Jones, 1984) to determine age-specific mortality rates by year. We used the Solver tool in MS © Excel to iteratively calculate $B_{(t)}$ such that $Q_{(t)} = B_{(t)}$ by varying F where:

$B_{(t)} = (Z_t*(EXP(-Z_t)))/(F_t*(1-EXP(-Z_t)))$,
$Q_{(t)} = V_{(t+1)}/(C_t*E_{(t+1)})$,
$C_{(t)}$ = catch at time (t),
$E_{(t)}$ = exploitation rate at time (t)= $U_t+(E_{(t+1)}*EXP(-(Z_t)))$ except for the oldest age, where $E=F/Z$,
$F_{(t)}$ = instantaneous fishing mortality rate at time (t),
$M_{(t)}$ = instantaneous natural mortality rate at time (t),
$S_{(t)}$ = survival rate at time (t) = $EXP(-(Z_t))$,
$U_{(t)}$ = utilization rate at time (t) = $(F_t/Z_t)*(1-S_t)$,
$V_{(t)}$=virtual population at time (t) = $V_{(t+1)}+C_t$, except for the oldest age, where $V_t=C_t$, and
$Z_{(t)}$= instantaneous total mortality rate (F_t+M_t).

The estimation procedure was constrained to F=>0.00001, precision of the solution set to 0.000001, convergence set to 0.0001, de-selecting the linear models option of Solver, using the quadratic estimation procedure, central derivatives, and the quasi-Newton search methods. This process was semi-automated through development of a macro to step through the annual estimation process. A range of terminal F was input manually, from 0.01 to 0.8 (Figure 3).

The results of this analysis were used to derive age-specific fishing mortality rates to be used in spawning potential calculations and yield-per-recruit analysis for comparison to estimates from the disappearance rate procedures used in this and prior assessments.

Examination of the estimates of F at age from various terminal F's in the VPA showed consistent patterns of selectivity across the range of terminal F's used for each year of input data (Figure 3). Sheepshead were estimated to be fully recruited to the fishery by age 8 in more recent years, based on inspection of the F at age for various years. Highest estimates of F were found for age-5 or age-8 sheepshead, with either a slight decline in F or an increase in F with older fish, depending on the year and M estimates. Another characteristic noted in the analysis was the relatively slow convergence of estimated F at age over the range of initial F considered. One reason for this is the relatively low values of F relative to M. Also, very low values of initial F resulted in substantially lower estimates of F over all ages.

Comparison of the results of this year's assessment with those from last year demonstrate the effects of additional information in the ALKs. The changes in the estimates of CAA noted earlier in this section resulted in slightly increased estimates of SPR for a given year than were found in the 2008 assessment. None of these changes were critical when measured against standard fishery benchmarks (F_{MAX} $F_{0.1}$, $F_{30\%}$, etc.). Also, the F at age estimates for the oldest fish (over 10 or 11 years old) tended to be high, relative to the last assessment. This is attributable to additional samples of older fish, resulting in assignment of more fish into these older year-classes.

The youngest year-classes were similarly affected, with estimates of harvest increasing for the very young fish. However, the estimates of F on these ages continued to be low, relative to F at full recruitment.

4 - Yield-per-Recruit

Yield-per-recruit and SPR analysis provide basic information on fish stock dynamics by estimating the impact of mortality on yield and the spawning potential of the stock. The results can be examined as to the sensitivity of natural and fishing mortality rates on yield and spawning potential.

The growth parameters described in Section 1, sexual maturity described in Section 2 and the age-specific selectivities described in Section 3 were incorporated into the yield-per-recruit and spawning potential analysis. Render and Wilson (1992) reported that 95% of the age-2, 100% of age-3, 96% of age-4, and all females over age-4 were mature. Their samples did not include any age-1 fish, so percent maturity at that age was not determined. For purposes of this assessment, we utilized a knife-edge maturity schedule for females at age-2. Mean weight for adult fish at each age was used as a surrogate of spawning potential, since we had no direct estimate of spawning potential at age. Natural mortality rates of 0.2 and 0.3 were used in the analysis because they are on the lower end of the range of estimates and would provide more conservative results. These rates are also used to describe the sensitivity of M on yield and spawning potential. The results are presented in Table 4, which contains estimates of F_{MAX} (fishing mortality rate that produces maximum yield), $F_{0.1}$ (fishing mortality rate representing 10% of the slope at the origin of a yield-per-recruit curve), $F_{20\%SPR}$ (fishing mortality that produces 20% SPR), $F_{30\%SPR}$ (fishing mortality that produces 30% SPR), and annual estimates of F based on the total mortality rates calculated in Section 3. Selectivities patterns of the overall fishery are recalculated with each additional year of data. Therefore, the results of this analysis will change each year depending on any change in selectivity patterns in the fishery.

In assessments before 2007, the status of the stock was based on disappearance rates calculated using a von Bertalanffy growth equation or an ALK. In the current analysis, the F at age was incorporated into the YPR analysis based on the results of the VPA for that year. Yield analyses are presented for the years 1999-2008. Age specific selectivities were based on F at age indexed to F at age 8. The yield analysis was carried out to age 20, but the VPA contained no information on F for fish older than age 14. Estimates of F at age 15+ carried no predictive power (these were the terminal years of the VPA). Therefore, fish ages 15 and older were assigned selectivities equal to the selectivities of age 8.

For the current YPR analysis, fishing mortality rates at age were selected as the average of the F at age from the $F_{terminal}$=0.1 to $F_{terminal}$=0.6. These rates were used in the analysis because they included a range of reasonable values, and the lowest terminal values were still near or above the F's estimated for slightly younger ages (Figure 3). Those age-specific mortality rates were applied to a yield per recruit model, using the von Bertalanffy parameters described in Section 1. Selectivities at age were assigned based on the annual estimated F profile for each value of M.

5 - Status of the Stock

Conservation Standards

Conservation standards are based on one of a number of biological measures of the dynamics of fish stocks, intended to protect the viability of that stock for future generations. These standards have historically been based on different measures of the dynamics of fish stocks, depending on the data available, the needs of fishery and of the resource.

Sufficient information is not available to directly estimate a conservation threshold for sheepshead in Louisiana. However, the conservation target of 30% SPR established by Act 1316 of the 1995 Regular Session of the Louisiana Legislature for black drum sheepshead, southern flounder and striped mullet appears to be adequate to maintain the sheepshead stock and prevent recruitment overfishing.

Recent Regulatory History

There are no size or creel limits for sheepshead taken recreationally. Commercial harvesters have a minimum size limit of 10 inches total length.

Rules for the commercial harvest of sheepshead changed on August 15, 1995 when Act 1316 of the 1995 Regular Legislative Session, the Marine Resources Conservation Act of 1995, became effective. This act outlawed the use of "set" gill nets or trammel nets in saltwater areas of Louisiana, and restricted sheepshead harvest by the use of "strike" nets to the period between the third Monday in October and March 1 of the following year. A "Restricted Species Permit" was required in order to harvest sheepshead, and several criteria were established in order to qualify for that permit. After March 1, 1997, all harvest by gill or trammel nets was banned, and legal commercial gear to harvest sheepshead is limited to trawls, set lines and hook and line. This set of regulations had the effect of reducing the harvest of sheepshead by this segment of the commercial fishing industry.

Trends in Harvest and Abundance

Fishery dependent commercial data prior to 1991 was obtained from NMFS's General Canvass Landing Program. From 1991 through 1998 it was collected by the Louisiana Department of Wildlife and Fisheries' (LDWF) Monthly Dealer Reports. From 1999 through present, LDWF's Commercial Reporting Requirement "Trip Tickets" program is utilized to gather this type of data. Recreational harvest data is obtained from the NMFS's Marine Recreational Fishing Statistics Survey (MRFSS), which had information from 1981 through 2008 available for this analysis. The MRFSS catch per unit effort (CPUE) and biological harvest information is

currently being collected by LDWF biologists.

Sheepshead were lightly exploited by the commercial fisheries until the early to mid-1980s when commercial harvest began to increase (Figure 4). Commercial landings have gone from 0.2 million pounds in the early1980s to 2.4 - 3.7 million pounds in the 1990s. Landings then generally declined from a high of 3.7 million pounds in 1993 to about 1.6 million pounds in 2002 and 2003, 1.5 million pounds in 2004, and 1.0 million pounds in 2005. Part of the decline in 2005, which continued into 2006 landings, is due to the effects of the passage of Hurricanes Katrina and Rita through south Louisiana, which damaged fishing vessels, gear, infrastructure, and logistics throughout the region. This most severely impacted the offshore trawl fishery, which operates in late fall until early spring. During that period in 2005-06, many Louisiana-based inshore, nearshore, and offshore marine commercial finfisheries showed substantial declines in effort and landings due to the impacts of these storms.

Recreational harvest estimates fluctuated from a low of 0.4 million pounds in 1981 to a high of 1.5 million pounds in 1997. This was followed by a decline, with a general increasing trend in 1999 through 2005, with 2004 being a record year with 3.3 million pounds of sheepshead being landed. Recreational harvests for the years examined (1981-2008), were equal to those of the commercial fishery until 1987 when the commercial fishery began to expand (Figure 4). In most recent years (2002-05), recreational harvest was again equal to or greater than the commercial harvest. However, total harvest was higher than was seen in the early 1980's. In 2006, recreational harvest was below the levels seen in other recent years. This is due, at least in part, to the fact that sheepshead is not a primary target species of recreational harvesters. In 2006, the harvests of spotted seatrout and red drum were very good, so that there was less recreational targeting or retention of sheepshead.

Mean catch-per-trip from the recreational fishery was calculated by selecting those trips that had sheepshead in their catch. The arithmetic average CPUE values were indexed to the long-term mean. The results are presented in Figure 5. The catch-per-unit-effort (CPUE) indices fluctuated with no indication of a long-term trend.

Catch-per-effort data from the Department's, fishery-independent trammel net (750' x 6' - 1 5/8" inner, 6" outer wall) samples were calculated as follows:

$$\text{Mean CPUE} = (\exp (\Sigma \ln (\text{catch} + 1) / N)) - 1$$

where catch is the total number caught in each set and, N is the number of samples taken annually. Trammel net data were used for the period 1986-2008. Trammel net samples are collected from October through March. In order to use the most recent data available to us in this report, trammel net CPUE was estimated for October-December only. This allowed the use of 2008 data through December. Trammel net CPUE fluctuated throughout the time period with no indication of a long-term trend (Figure 6).

Estimates of Yield and Spawning Potential

The results of the YPR and SPR are presented in Table 4. The results of YPR analysis

indicate that if M=0.2 (the value within the range of estimates that allows the lowest harvest rates within the conservation standard), the fishery in the years assessed (1999 - 2008) was operating near or below $F_{0.1}$ and well below $F_{MAX,}$ with yield of 69% to 77% of maximum, and SPR at 51% to 59%. An M of 0.3 (the highest value examined) would indicate a more lightly fished stock with yield being 35% to 44% of maximum and with SPR being 72% to 78% (Table 4).

6 - Research and Data Needs

Estimates of natural mortality used in the present assessment are generalized from other species, and may not accurately reflect natural mortality for this species in our area. This variation lessens the ability of the present assessment to provide an accurate estimate of the potential yield of the stock, and also reduces the confidence level of the present estimate of SPR. A more accurate estimate of natural mortality would improve both estimates.

Annual sex-specific age-length keys should continue to be developed to provide catch-at-age data necessary to conduct age-based population assessments. Due to the preliminary information on potential differential availability to recreational and commercial fisheries, efforts need to be made to collect adequate age samples from each fishery to independently characterize the age structure of these harvests. Interannual variation in cohort strength or changes in fishing patterns could create significant problems in future assessments, so that annual collections of this age information are required for accurate assessments. The department is in the process of collecting otoliths for development of annual age-length keys. When age data are sufficient, the Department intends to conduct more extensive analyses based on those collections, and to explore other statistical methods of evaluating the status of the sheepshead stock.

Sex-specific fishery dependent length frequency data is essential in adequately partitioning catch from the fishery. There can be significant improvement in the accuracy of this assessment if sex information is collected consistently from all harvest sectors.

Existing estimates of stock abundance or availability (CPUE in fishery-independent and fishery-dependent sampling programs) should be examined to determine if they can provide additional information to the assessment. Additional abundance indices should be derived, if possible, for this same purpose. Incorporating these indices into the assessment will require evaluating a suite of existing modeling tools, as well as comparing the results of those models to the existing assessment procedure to determine if additional robustness is added to the results.

The relationship between wetlands losses or modifications and the continuation of fishery production within the state has been discussed by many authors. However, this relationship is likely to be different for the various fishery species. Understanding of this relationship for sheepshead should be an ongoing priority.

In the presence of changing regulations, fishery-dependent information is not a reliable source of data necessary to assess the status of a fish stock. However, such data are necessary to measure the effects of fishing on that stock. Consistent fishery-dependent and fishery-independent data sources, in a comprehensive monitoring plan, are essential to understanding the status of

fishery stocks, and to identifying causes of changes in stock abundance. Present programs should be assessed for adequacy with respect to their ability to evaluate stock status, and modified or enhanced to optimize their capabilities.

BIBLIOGRAPHY

Alagaraja, D., 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. Indian J. Fish. 31:177-208.

Beckman, D. W., A. L. Stanley, J. H. Render, and C. A. Wilson. 1991. Age and growth-rate estimation of sheepshead *Archosargus probatocephalus* in Louisiana waters using otoliths. Fishery Bulletin, U.S. 89:1-8.

Beddington, R. J. and G. P. Kirkwood. 2005. The estimation of potential yield and stock status using life history parameters. Phil. Trans. of the R. Soc. B. 360: 163-170

Froese, R. and D. Pauly (editors). 2007. FishBase. World Wide Web electronic publication. www.fishbase.org, version (10/2007).

Gayanilo, F.C., P. Sparre and D. Pauly. 2005. FAO-ICLARM stock assessment tools II (FiSAT II) User's guide ISSN 1020-3249 Revised version. Worldfish Center, FAO, Rome.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish.Bull. NOAA/NMFS, 81(4):898-903.

Jones, R. 1984. Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and cohort analysis). FAO Fisheries Technical Paper 256. 118 pp.

Larkin, P.A. 1972. The stock concept and management of Pacific salmon. H.R. MacMillan lectures in fisheries. University of British Columbia Press, Vancouver. 231 pp.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. int. Explor. Mer 39(2)175-192.

Rikhter, V.A. and V.N. Efanov. 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res. Doc., 76/VI/8:12 pp.

Render, J. H. and C. A. Wilson. 1992. Reproductive biology of sheepshead in the Northern Gulf of Mexico. Trans. Am. Fish. Soc. 121:757-764.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. (191). 382 pp.

SAS, 1987. SAS/STAT guide for personal computers, Version 6 edition. SAS Inst., Cary, N.C. 1028 pp.

Sparre, P. and S.C. Venema. 1992. Introduction to tropical fish stock assessment, Part 1-Manual. FAO Fish.Tech.Pap., (306) Rev.1:376 pp.

Tables

Table 1. Age-length key used for assessment of sheepshead in Louisiana. Right-hand columns are total numbers of fish aged from each length increment in each of the fisheries. Fishery-independent samples were not utilized for the assessment, except at the smallest sizes, where ages from the pertinent fishery were not available or perceived to be adequate in size. R=Recreational fishery, C=Commercial fishery, and FI=Fishery-independent samples.

(a) Recreational fishery ALK (Fishery-independent ALK used for fish less than 8 inches FL)

		ages																									
Fishery	FL	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**sum**	**%**
R	**6**	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**0.1%**
R	**7**	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**	**0.2%**
R	**8**	0	24	23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**48**	**2.5%**
R	**9**	0	16	31	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**51**	**2.6%**
R	**10**	0	13	66	21	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**102**	**5.2%**
R	**11**	0	8	91	39	3	2	0	0	1	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	**148**	**7.6%**
R	**12**	0	2	85	100	10	5	1	0	1	1	1	1	0	1	0	2	0	0	0	0	0	0	0	0	**210**	**10.8%**
R	**13**	0	2	52	119	42	15	2	2	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	**238**	**12.2%**
R	**14**	0	0	22	106	74	43	11	6	1	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0	**267**	**13.7%**
R	**15**	0	0	8	63	88	80	40	17	4	7	3	2	1	2	2	0	0	0	0	0	0	0	0	0	**317**	**16.3%**
R	**16**	0	0	0	25	58	55	36	31	30	11	7	5	4	1	1	0	0	1	0	0	0	0	0	0	**265**	**13.6%**
R	**17**	0	0	4	13	28	26	21	17	22	9	5	8	7	3	6	2	0	0	0	0	0	0	0	0	**171**	**8.8%**
R	**18**	0	0	0	4	9	12	13	5	8	3	3	1	2	2	2	1	0	0	0	0	0	0	0	0	**65**	**3.3%**
R	**19**	0	0	0	1	3	5	5	8	3	4	1	1	1	0	1	0	0	0	1	0	0	0	0	0	**34**	**1.7%**
R	**20**	0	0	0	1	1	3	1	1	2	2	2	2	0	1	0	0	0	0	0	0	0	0	0	0	**16**	**0.8%**
R	**21**	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	**5**	**0.3%**
R	**22**	0	0	0	0	1	1	0	0	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	**6**	**0.3%**
R	**23**	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**0.1%**
total		**0**	**68**	**383**	**497**	**319**	**248**	**131**	**88**	**74**	**37**	**25**	**24**	**17**	**11**	**14**	**9**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1948**	
		0.0%	**3.5%**	**19.7%**	**25.5%**	**16.4%**	**12.7%**	**6.7%**	**4.5%**	**3.8%**	**1.9%**	**1.3%**	**1.2%**	**0.9%**	**0.6%**	**0.7%**	**0.5%**	**0.0%**	**0.1%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**		

(continued)

(b) Commercial ALK (note: 26" fish not used in further analysis)

		ages																									
Fishery	FL	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**sum**	**%**
C	**9**	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**	**0.1%**
C	**10**	0	0	3	3	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**	**0.4%**
C	**11**	0	0	6	17	20	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**46**	**1.4%**
C	**12**	0	0	18	46	36	16	2	0	2	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	**124**	**3.9%**
C	**13**	0	0	14	81	64	48	7	3	2	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**222**	**7.0%**
C	**14**	0	0	6	74	102	94	23	10	7	3	2	1	1	0	0	2	1	0	0	0	0	0	0	0	**326**	**10.2%**
C	**15**	0	0	2	33	124	166	72	66	43	28	14	3	6	1	2	2	5	0	0	0	0	0	0	0	**567**	**17.8%**
C	**16**	0	0	0	17	64	181	115	133	99	61	42	27	22	13	6	10	2	0	0	0	0	0	0	0	**792**	**24.8%**
C	**17**	0	0	0	5	19	82	92	99	129	86	57	41	34	14	11	9	4	1	0	0	0	0	0	0	**683**	**21.4%**
C	**18**	0	0	1	5	6	17	32	42	64	35	23	17	13	8	5	5	4	0	0	0	0	0	0	0	**277**	**8.7%**
C	**19**	0	0	0	3	6	6	10	15	14	15	2	7	5	5	4	3	1	0	0	0	0	0	0	0	**96**	**3.0%**
C	**20**	0	0	0	1	4	0	3	2	5	5	3	2	2	2	3	2	0	0	0	0	0	0	0	0	**34**	**1.1%**
C	**21**	0	0	0	0	0	0	0	0	0	0	0	4	1	1	0	0	0	0	0	0	0	0	0	0	**6**	**0.2%**
C	**22**	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**3**	**0.1%**
C	**26**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**	**0.0%**
total		**0**	**0**	**50**	**286**	**452**	**614**	**357**	**370**	**366**	**235**	**144**	**103**	**85**	**44**	**31**	**34**	**18**	**2**	**0**	**0**	**0**	**0**	**0**	**0**		
		0.0%	**0.0%**	**1.6%**	**9.0%**	**14.2%**	**19.2%**	**11.2%**	**11.6%**	**11.5%**	**7.4%**	**4.5%**	**3.2%**	**2.7%**	**1.4%**	**1.0%**	**1.1%**	**0.6%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**3192**	

(continued)

(c) Fishery-independent ALK

		ages																									
Fishery	FL	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**sum**	**%**
FI	**4**	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**	**0.1%**
FI	**5**	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**0.0%**
FI	**6**	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**	**0.2%**
FI	**7**	1	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**6**	**0.3%**
FI	**8**	1	7	47	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**57**	**2.6%**
FI	**9**	0	9	44	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**58**	**2.6%**
FI	**10**	0	15	38	22	7	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**86**	**3.9%**
FI	**11**	0	7	53	80	21	7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**173**	**7.8%**
FI	**12**	0	2	46	112	54	22	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**245**	**11.1%**
FI	**13**	0	0	22	107	116	51	14	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	**315**	**14.3%**
FI	**14**	0	1	17	75	129	63	23	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**316**	**14.3%**
FI	**15**	0	0	6	34	126	133	56	14	9	5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**384**	**17.4%**
FI	**16**	0	1	6	12	45	88	83	30	9	9	0	2	0	0	0	0	0	0	0	0	0	0	0	1	**286**	**12.9%**
FI	**17**	0	0	1	2	15	31	49	21	14	10	3	3	3	0	1	2	0	0	0	3	0	0	0	1	**159**	**7.2%**
FI	**18**	0	0	1	0	4	10	19	11	9	4	3	3	1	5	1	0	1	0	0	0	1	0	0	1	**74**	**3.3%**
FI	**19**	0	0	0	0	3	4	3	5	2	6	4	1	1	0	1	0	0	1	0	1	0	0	1	0	**33**	**1.5%**
FI	**20**	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**5**	**0.2%**
FI	**21**	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	**3**	**0.1%**
FI	**22**	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**0.0%**
total		**3**	**52**	**282**	**450**	**522**	**411**	**264**	**92**	**47**	**35**	**11**	**9**	**6**	**6**	**3**	**2**	**1**	**1**	**0**	**5**	**1**	**0**	**2**	**4**	**2209**	
		0.1%	**2.4%**	**12.8%**	**20.4%**	**23.6%**	**18.6%**	**12.0%**	**4.2%**	**2.1%**	**1.6%**	**0.5%**	**0.4%**	**0.3%**	**0.3%**	**0.1%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**	**0.2%**	**0.0%**	**0.0%**	**0.1%**	**0.2%**		

Table 2. Length frequency of recreationally and commercially harvested sheepshead from Louisiana waters

Recreational Length Frequencies by Year

FL (in.)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Overall %
5	0	3	0	0	0	0	0	0	0	0	0	0	0	0	2	0.2%
6	3	12	0	1	0	0	0	0	0	0	2	1	0	0	0	1.6%
7	4	2	6	5	0	1	0	1	0	0	0	6	0	0	0	2.4%
8	7	2	8	4	1	1	0	0	2	2	1	2	1	5	2	3.2%
9	15	11	15	9	0	4	1	5	6	4	11	13	20	6	2	6.3%
10	13	23	18	20	2	8	3	1	13	13	14	14	10	8	8	7.7%
11	42	44	27	24	18	13	6	7	33	35	13	27	16	10	19	12.1%
12	45	26	15	43	23	31	3	11	50	36	42	43	19	16	30	15.8%
13	35	61	55	62	35	30	5	17	40	52	53	40	32	25	29	18.7%
14	27	35	70	82	47	51	13	10	63	50	70	52	33	23	39	20.5%
15	22	38	49	63	62	51	10	14	72	55	82	75	50	30	39	21.7%
16	11	8	22	40	50	47	9	17	47	72	86	86	42	23	46	16.9%
17	6	12	13	18	38	31	11	20	28	77	46	49	21	34	40	12.0%
18	4	8	7	10	21	19	4	11	19	39	22	8	9	18	23	6.7%
19	1	4	2	5	6	7	4	8	9	18	14	10	7	13	9	4.1%
20	2	5	1	2	3	9	1	9	3	15	10	5	2	3	4	2.5%
21	0	1	3	0	0	0	1	3	1	2	1	2	3	1	1	1.0%
22	1	0	0	0	1	1	0	0	0	0	1	0	2	0	0	0.7%
23	2	0	0	0	0	1	0	1	0	0	2	0	0	0	0	0.7%
24	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0.6%
25	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.7%
Total	240	295	311	389	307	306	72	135	386	470	470	433	267	215	293	**Total** 4589

Commercial Length Frequencies by Year

FL (in)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	**Overall %**
8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1%
9	14	12	10	4	0	0	0	0	0	0	0	0	0	0	0	0.7%
10	17	42	44	5	3	0	0	0	0	0	0	0	0	2	0	2.0%
11	25	152	132	18	8	1	5	2	2	2	0	2	0	2	0	6.3%
12	67	247	210	65	30	4	15	7	1	13	13	11	3	10	13	12.2%
13	67	285	194	144	71	12	27	15	9	17	20	25	18	38	41	15.6%
14	52	291	138	186	99	24	65	36	26	58	40	34	23	70	77	18.4%
15	48	223	110	142	90	8	83	48	66	125	72	64	38	145	144	18.4%
16	28	136	100	91	36	2	62	28	63	109	109	64	63	283	235	13.8%
17	16	81	58	32	9	0	27	13	36	59	57	43	80	299	254	7.0%
18	12	53	35	13	1	0	13	7	24	20	5	8	28	216	96	3.3%
19	7	23	15	3	3	0	5	0	5	17	0	1	16	62	23	1.4%
20	1	9	7	3	0	0	1	1	2	13	1	2	4	10	4	0.7%
21	0	4	2	0	0	0	0	0	0	1	0	1	2	0	0	0.1%
22	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0.0%
Total	359	1558	1055	706	350	51	303	157	235	436	317	255	276	1137	887	**Total** 8082

Table 3. Estimates of total harvest at age of sheepshead in Louisiana waters using separate ALK's for recreational and commercial harvest.

using ALK's from recreational and commercial fish

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	1,352	4,874	1,274	1,244	1	117	1	268	1	1	833	1,669	1	1	159
1	27,740	54,022	31,343	22,763	3,489	4,824	5,888	6,951	11,221	11,273	22,356	26,504	16,626	9,067	12,547
2	204,529	255,491	215,613	179,558	93,754	101,115	73,653	56,701	113,781	119,760	160,969	144,836	86,738	48,928	106,580
3	459,176	516,381	467,505	458,869	319,643	438,617	204,989	154,907	197,261	219,516	325,622	239,685	121,667	81,559	187,958
4	422,138	461,590	425,627	434,193	351,957	485,450	252,178	184,846	175,644	214,854	292,614	208,365	98,531	78,033	160,918
5	329,432	345,424	290,164	390,119	322,703	428,121	274,002	203,533	187,498	225,601	289,703	199,547	94,051	90,674	166,116
6	102,751	122,435	104,048	144,583	124,506	127,579	129,805	96,295	103,755	129,872	156,861	106,055	54,780	61,545	102,192
7	84,821	96,988	81,555	112,256	93,499	81,264	115,763	84,093	89,782	110,019	128,277	86,374	45,101	58,229	86,581
8	78,369	86,245	72,386	89,698	73,706	60,888	97,620	72,217	80,141	101,740	109,234	74,163	41,355	58,501	83,790
9	47,810	53,138	43,210	53,783	42,812	34,045	59,753	44,075	48,292	60,230	63,346	41,987	24,074	36,030	48,223
10	28,792	33,179	27,177	32,721	24,999	19,756	35,632	27,832	29,892	37,256	40,557	26,077	15,092	21,742	30,616
11	17,912	24,500	20,233	20,837	15,728	10,776	24,028	18,653	22,259	31,574	31,786	21,870	13,034	17,322	24,379
12	17,534	20,137	17,621	18,787	14,978	10,694	21,279	14,980	17,682	23,854	24,260	16,562	9,604	14,100	19,711
13	8,081	10,718	9,522	8,419	6,712	3,850	11,279	9,547	9,979	14,975	13,768	9,288	6,400	8,104	11,269
14	6,179	8,090	7,283	7,717	7,125	3,987	9,583	6,981	8,739	14,309	13,082	8,973	5,869	7,372	10,906
15 +	20,798	24,017	20,153	19,977	16,028	16,995	19,892	15,809	15,488	20,802	17,772	15,216	9,341	10,307	16,072
Total	1,857,415	2,117,229	1,834,714	1,995,524	1,511,641	1,828,079	1,335,344	997,692	1,111,416	1,335,635	1,691,040	1,227,170	642,263	601,514	1,068,017

Table 4. Results of Yield per Recruit and SPR analysis for sheepshead. Values from the 2008 F profile are basis for estimates of the benchmarks provided. Estimates of the status for each year are based on the F profile for that year from the VPA. F ratio is the fishing mortality rate for fully-recruited ages; YPR is the yield per recruit in grams; SPR is the estimate of the spawning stock per recruit, in grams; %SPR is the SPR at the level of fishing in the first column, compared to the SPR for an unfished population; and % YPR is the ratio of the yield per recruit compared to the maximum possible yield.

M=0.2

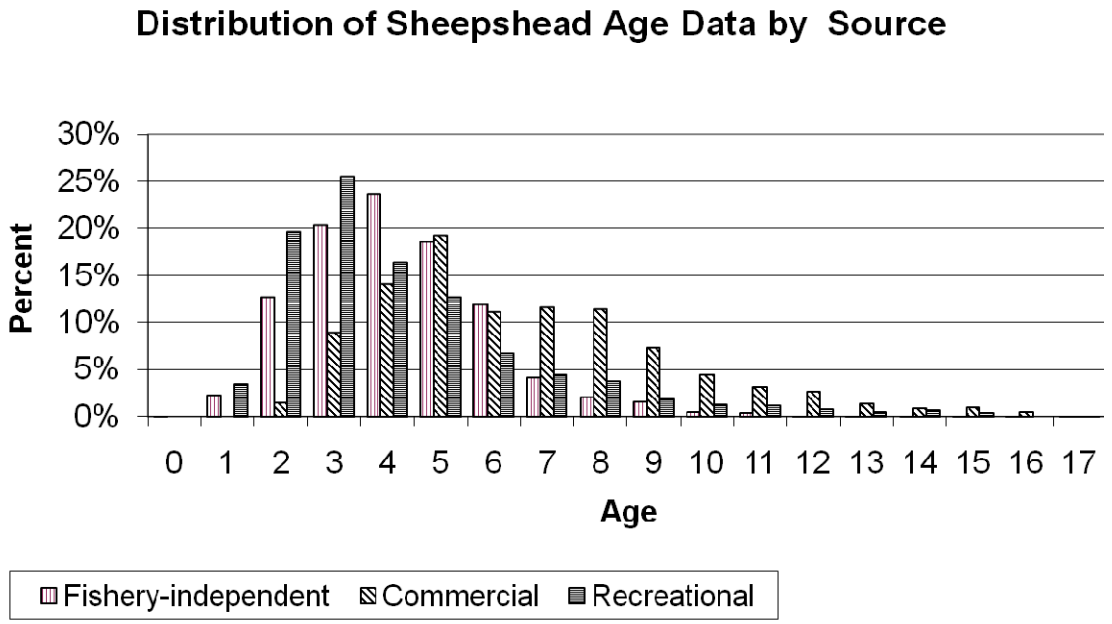
	F Ratio	YPR	SPR	%SPR	%YPR	
Fmax =	2.4301	516.8300	760	14.52%	100.00%	**Benchmarks based on 2008 F profile**
F0.1 =	0.3484	414.3571	2,460	47.02%	80.17%	
F20% =	1.5196	513.0240	1,046	20.00%	99.26%	
F30% =	0.7988	489.5101	1,569	30.00%	94.71%	
1999 =	0.2135	415.0065	2,433	46.50%	78.17%	**Estimates Based on VPA**
2000 =	0.2095	352.0768	3,047	58.24%	67.03%	
2001 =	0.2022	348.5619	3,067	58.63%	66.57%	
2002 =	0.2071	350.0571	3,019	57.72%	67.60%	
2003 =	0.1454	293.5641	3,462	66.18%	56.57%	
2004 =	0.2149	364.8990	2,892	55.28%	70.42%	
2005 =	0.2036	361.2627	2,879	55.03%	70.34%	
2006 =	0.1886	346.2075	2,990	57.16%	67.74%	
2007 =	0.2042	322.7140	3,290	62.89%	62.71%	
2008 =	0.2029	339.7213	3,107	59.39%	65.73%	

M=0.3

	F Ratio	YPR	SPR	%SPR	%YPR	
Fmax =	32.26	402.9061	72	2.73%	100.00%	**Benchmarks based on 2008 F profile**
F0.1 =	0.6241	278.1161	1,309	49.82%	69.03%	
F20% =	3.5200	377.7845	526	20.00%	93.76%	
F30% =	1.7747	351.7619	788	30.00%	87.31%	
1999 =	0.1256	181.6221	1,816	69.10%	43.77%	**Estimates Based on VPA**
2000 =	0.1297	131.7851	2,075	78.98%	32.25%	
2001 =	0.1243	129.1279	2,086	79.39%	32.16%	
2002 =	0.1252	134.6866	2,055	78.22%	33.55%	
2003 =	0.1202	123.1690	2,110	80.31%	30.31%	
2004 =	0.1362	143.1304	2,013	76.59%	35.80%	
2005 =	0.1254	139.5962	2,020	76.88%	35.32%	
2006 =	0.1151	128.6277	2,070	78.78%	32.42%	
2007 =	0.1286	113.6897	2,162	82.29%	28.62%	
2008 =	0.1261	124.2556	2,103	80.05%	30.84%	

Figures

Figure 1. Age frequency of sheepshead included in age-length keys from fishery-independent, commercial and recreational fisheries. Top figure shows percent in each age class for each fishery, bottom shows the same information on a logarithmic scale. Ages beyond 17 are not included in this graph, since they were rare in fishery-dependent samples.



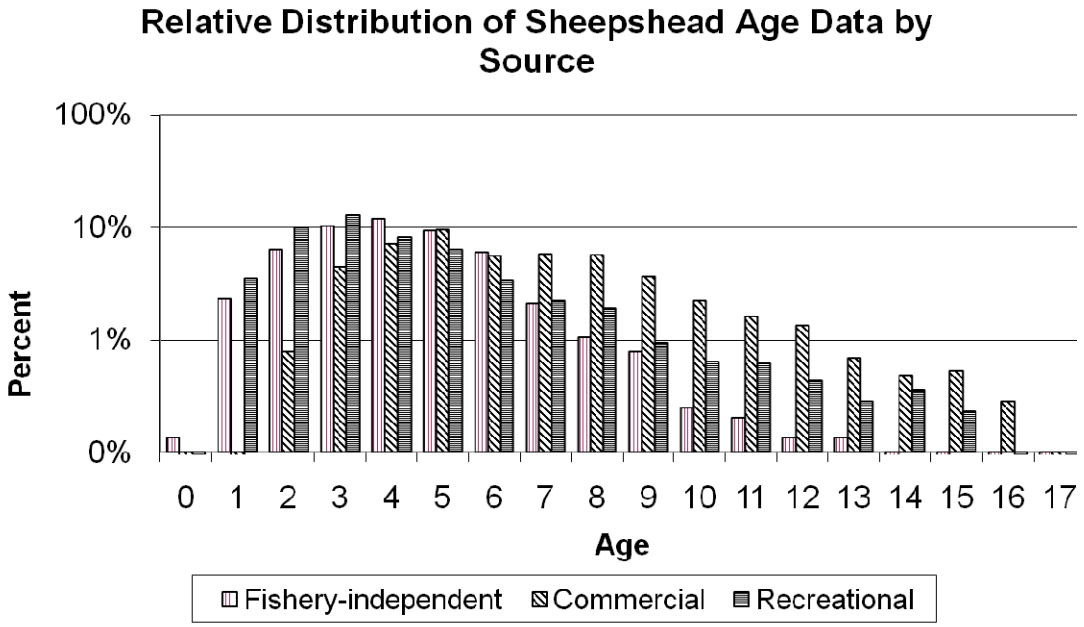


Figure 2. Overall age frequency of sheepshead harvest as estimated from length frequency information from commercial and recreational fisheries and age assignments from the ALKs as described in the text. The age distribution of each sector was calculated independently against the total for that sector and equals 100%.

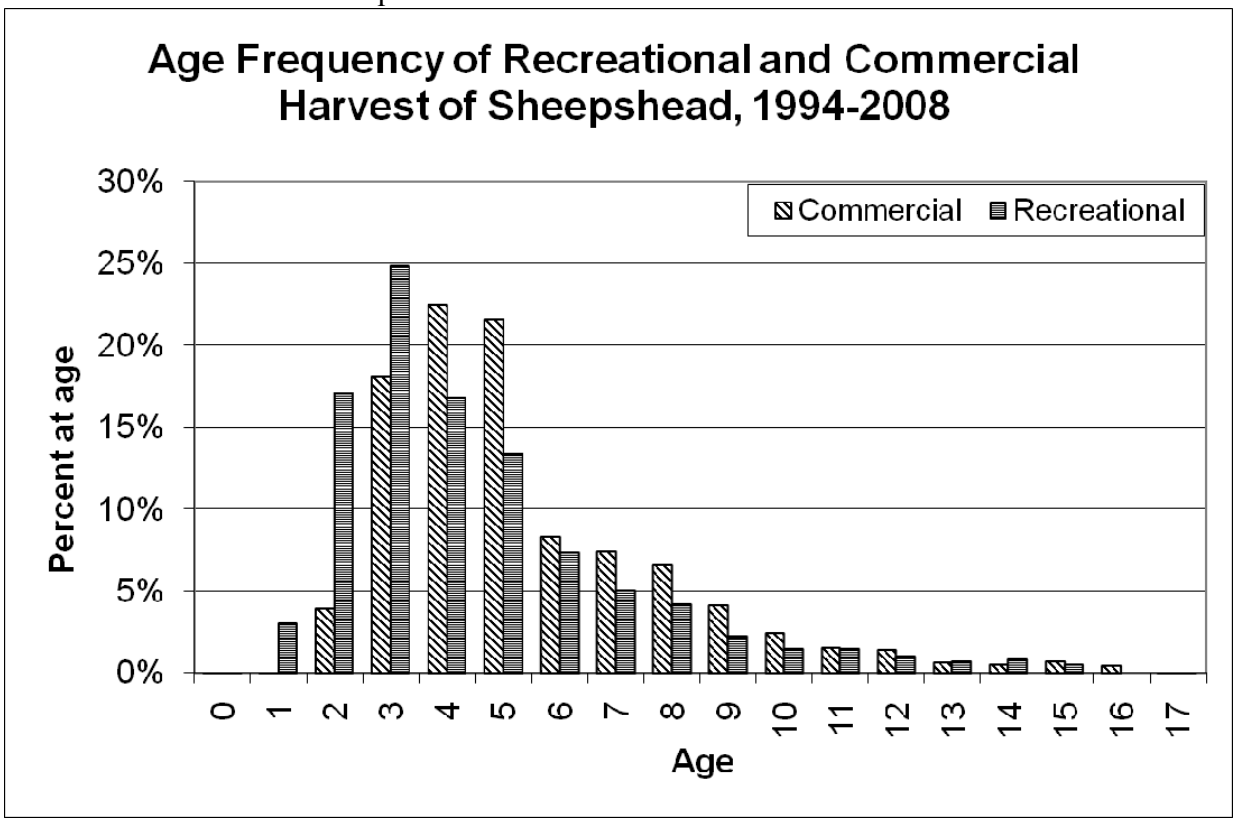
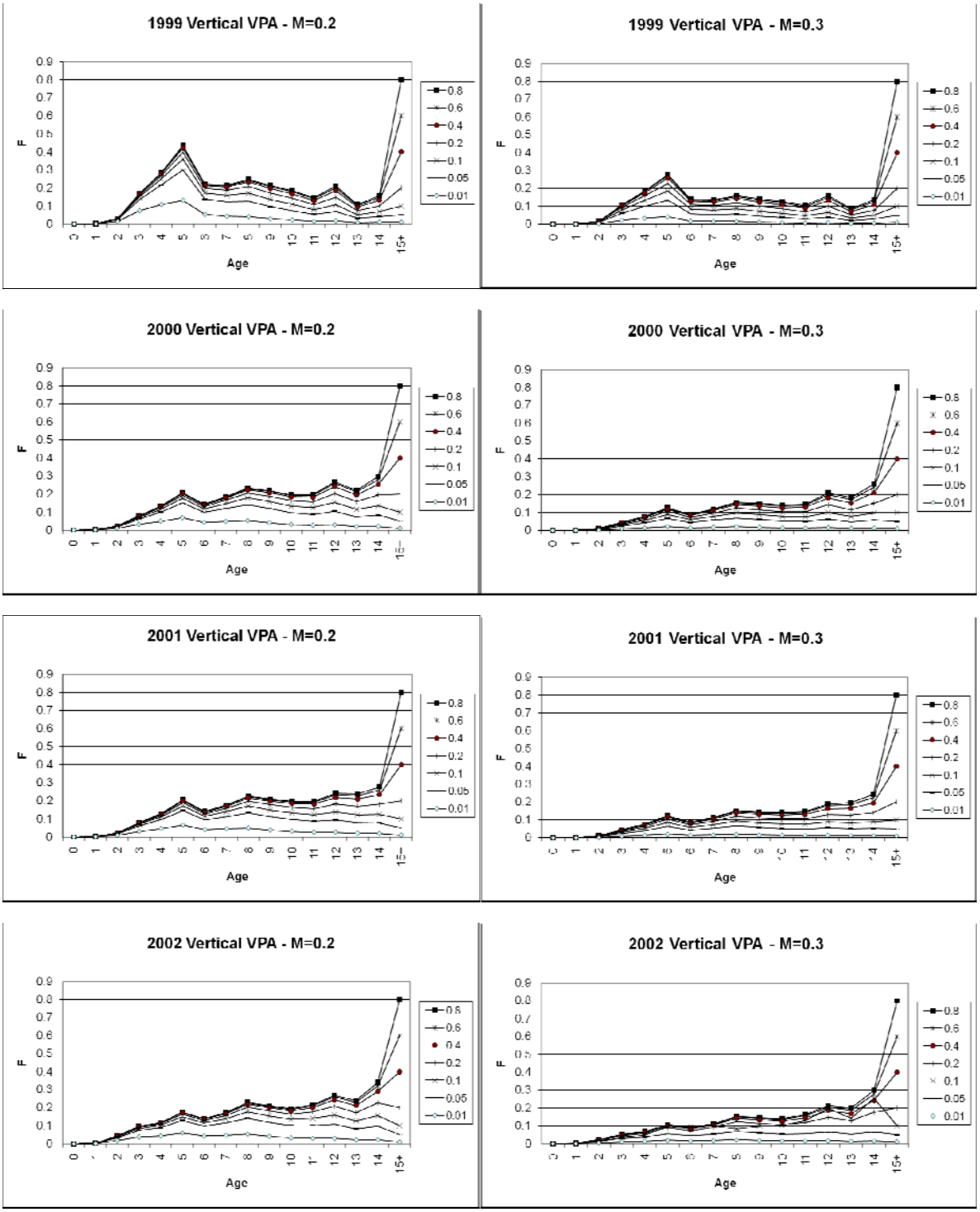
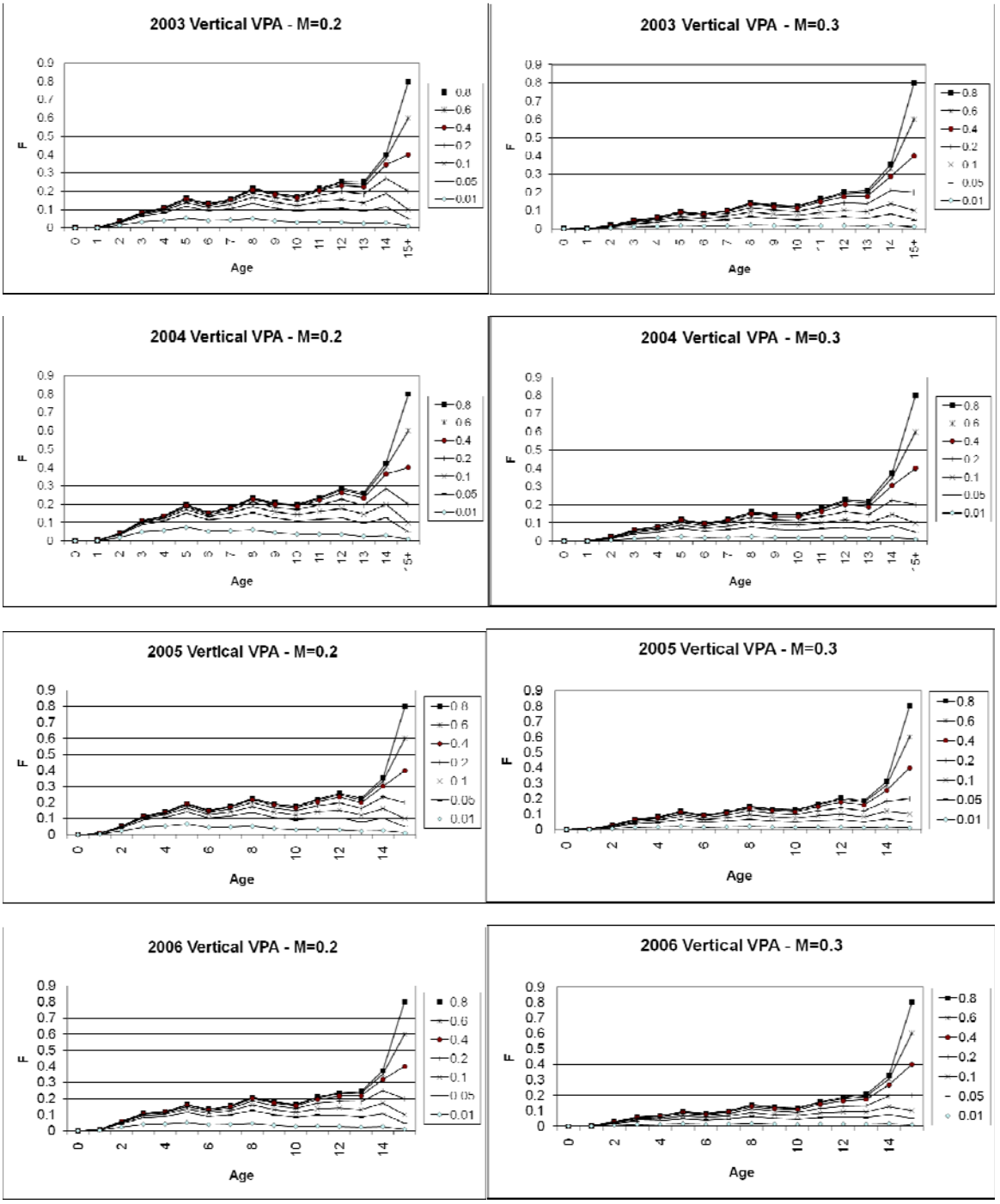


Figure 3. Estimates of F at age for Louisiana sheepshead from VPA using various terminal F's, for M=0.2 and M=0.3.



(continued)

Figure 3 Estimates of F at age for Louisiana sheepshead from VPA using various terminal F's, for M=0.2 and M=0.3.



(continued)

Figure 3(continued). Estimates of F at age for Louisiana sheepshead from VPA using various terminal F's, for M=0.2 and M=0.3.

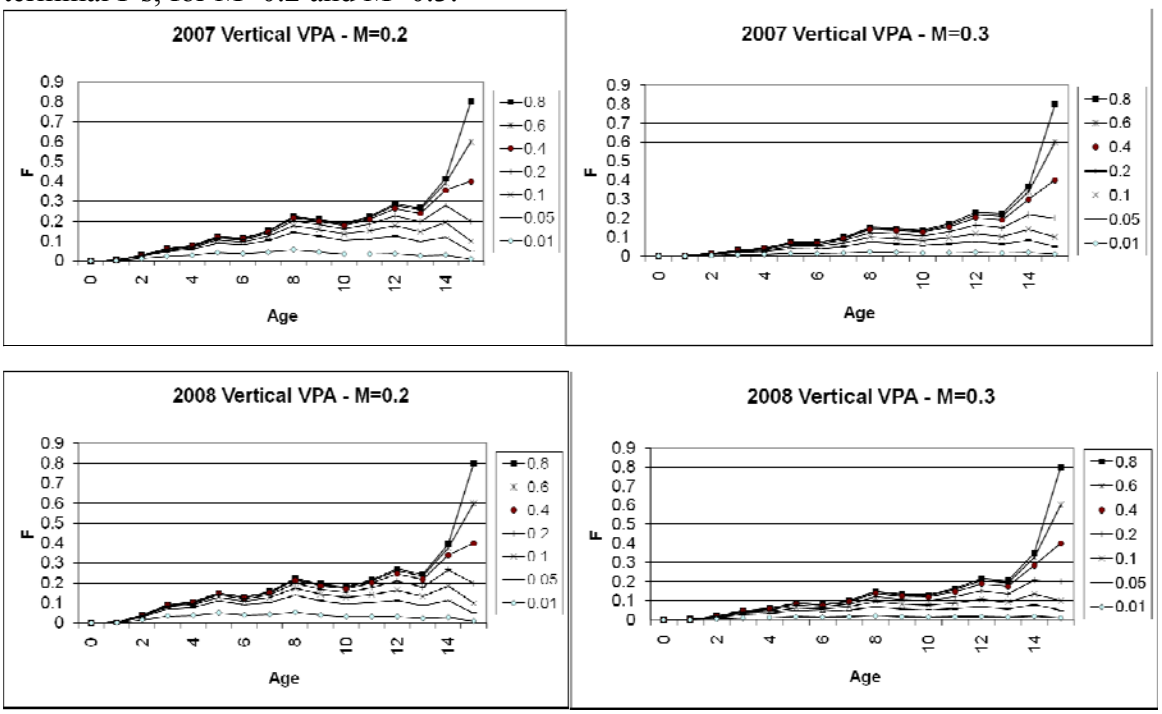


Figure 4. Recreational and commercial landings of sheepshead in Louisiana. Source of landings data described in text.

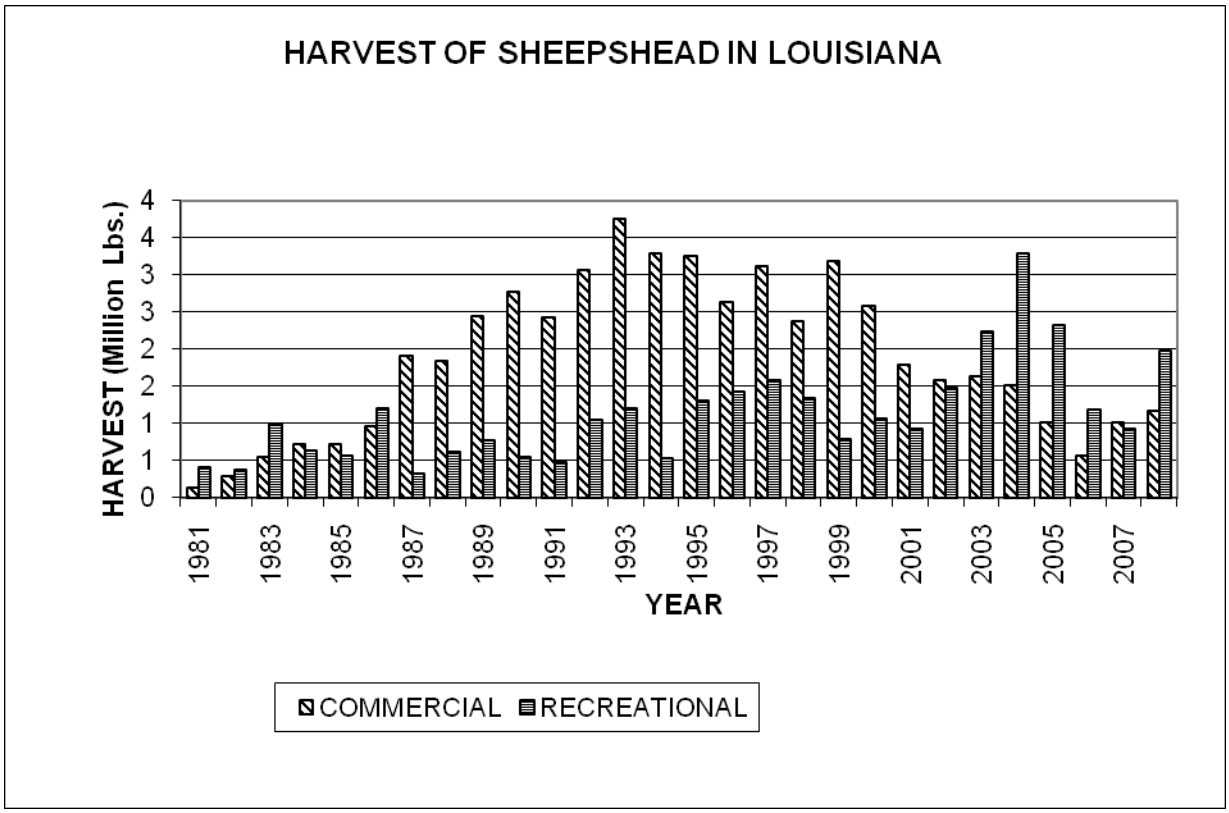


Figure 5. Standardized catch per effort for the recreational fishery for sheepshead in Louisiana. Derivation of estimates described in text.

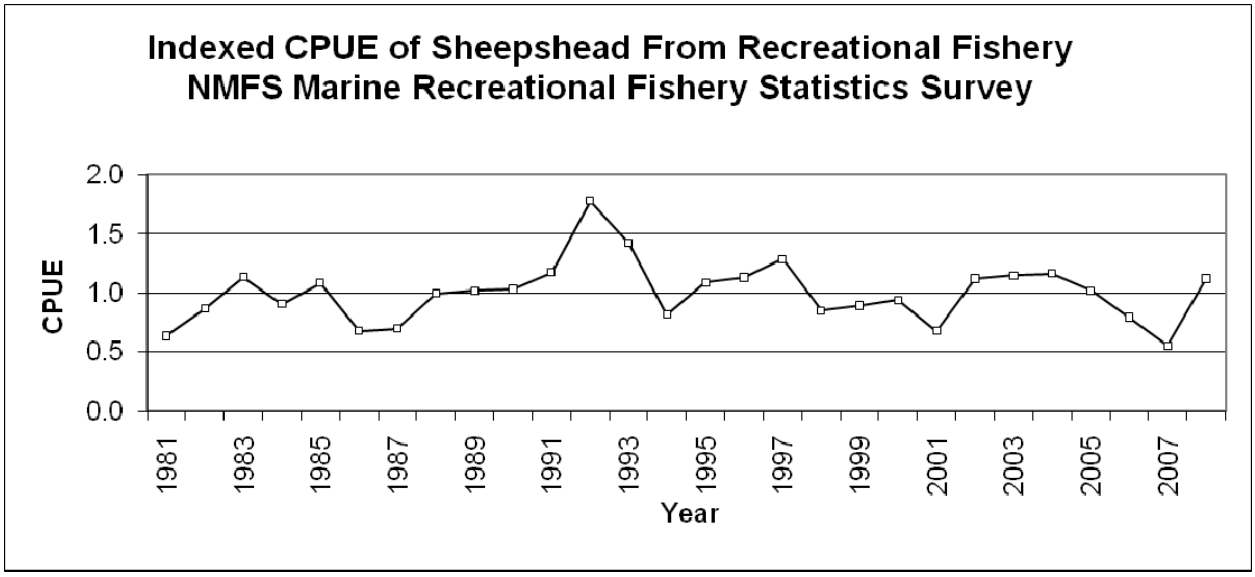
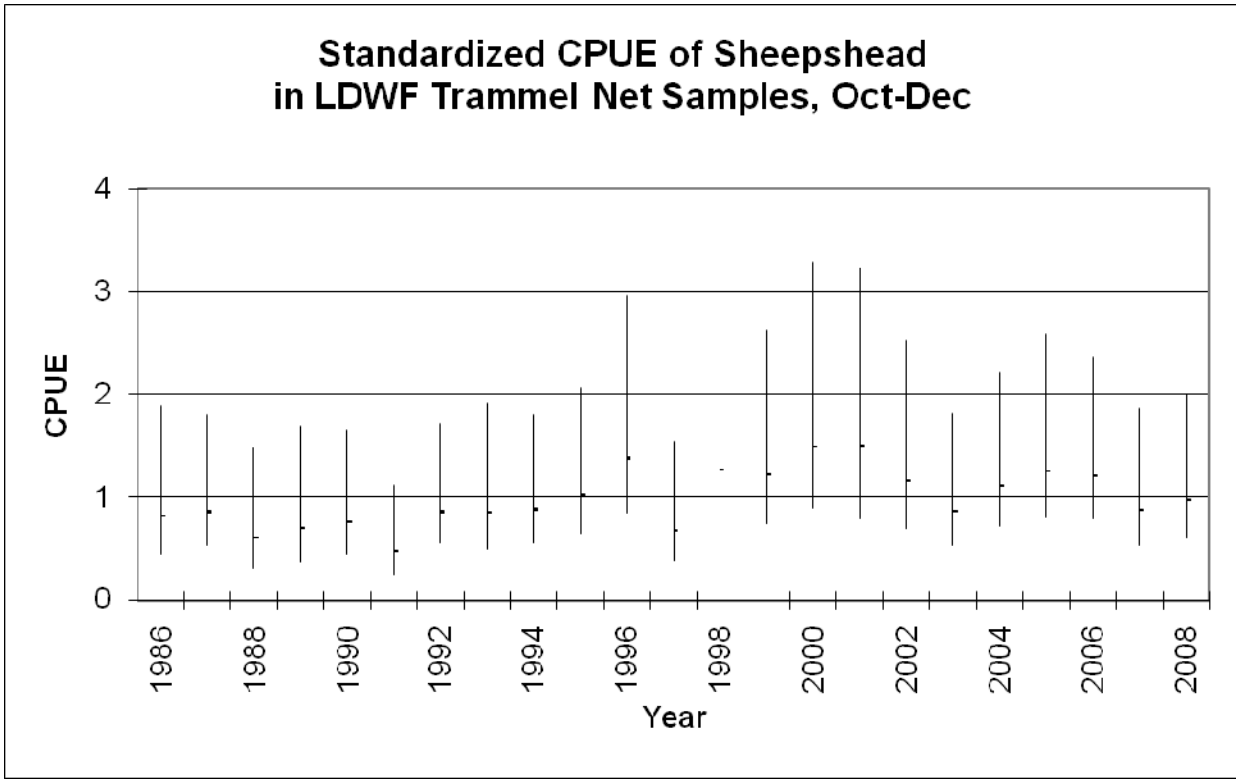



Figure 6. Standardized Catch per Unit Effort (CPUE) of sheepshead in LDWF fishery-independent trammel net samples, Oct-December of each year. Details of calculations of the CPUE index are described in text.