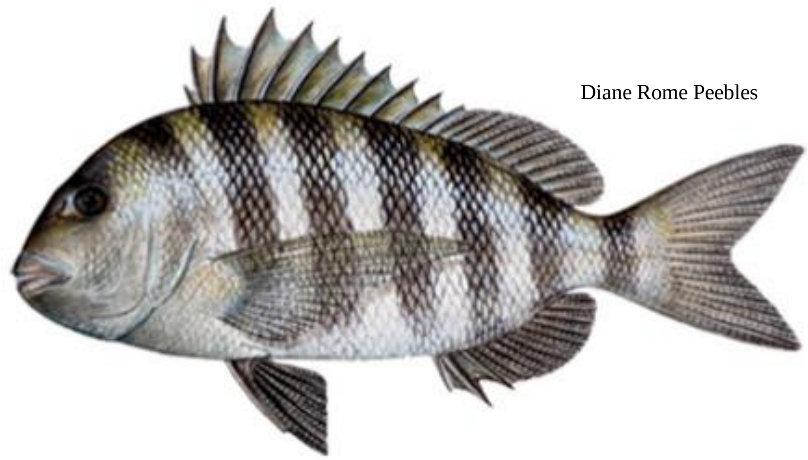

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An Assessment of the Status of Sheepshead in Florida Waters Through 2015

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Executive Summary

Since 2000, the stocks of Sheepshead (*Archosargus probatocephalus*) off Florida's east and west coasts have been assessed in 2000, 2006 and 2011. This report provides outputs and results of an update of the 2011 Sheepshead stock assessment.

For stock assessment purposes, Sheepshead inhabiting waters on the Atlantic and Gulf coasts of Florida were considered separate management units, and assessments were conducted separately for each coast. However, an area-specific model may better reflect the genetic stock structures identified recently (Fig. 2.1), but the lack of age data for northwest Florida prevents the application of an age-based modeling approach, therefore precluding comparison between different age/length-based assessment methodologies.

Available data on the species included abundance indices, recorded landings, estimated commercial and recreational discards, and samples of annual size compositions and age compositions from fishery-dependent and fishery-independent sources. Three abundance indices were developed: one from the Marine Recreational Information Program (MRFSS/MRIP, 1991–2015), and two from the FWRI Fishery-Independent Monitoring program (FIM, 1996/97–2015). Landings data were available from (and aggregated across) all recreational and commercial fisheries. The 2011 assessment included landing data for the period 1982–2009; this assessment for the period 1982–2015.

Stock Synthesis, version 3 (SS3), was used as the primary assessment model. In addition, continuity runs of the Age-Structured Assessment Program (ASAP) were performed, because ASAP was the basis of the 2011 Sheepshead stock assessment. This may help investigate results under a different set of model assumptions. SS3 is a new type

of assessment model for Sheepshead. ASAP model configurations were analogous to ASAP models in 2011, except that the 1982–1996, fishery-dependent age compositions on the Atlantic coast and the 1982–1992, fishery-dependent age compositions on the Gulf coast were treated as missing, because they were developed with average age-length keys. ASAP also included the FIM haul-seine catch rates at age to guide the estimation of the age structure of the populations.

Results from base runs of SS3 suggested that:

1. On the Atlantic coast, the commercial fishing mortality F (calculated across all ages) was 0.02–0.05 year^{-1} during 1982–2015. On the Gulf coast, it was 0.12 year^{-1} from 1992 through 1994. The recreational F increased from 0.18 year^{-1} in 1982 to 0.28 year^{-1} in 1994 on the Atlantic coast, and from 0.1 year^{-1} in 1982 to 0.47 year^{-1} in 1992 on the Gulf coasts.
2. Since 1996, the commercial F on the Atlantic and Gulf coasts, respectively, has averaged at 0.03 and 0.06 year^{-1}. The recreational F has averaged at 0.14 year^{-1} on the Atlantic coast and 0.26 year^{-1} on the Gulf coast.
3. Age-0 recruits on both coasts of Florida remained on the same order of magnitude, but the recruitment was highly variable until the early 1990's especially on the Gulf coast.
4. Total biomass and spawning biomass (SSB) of Sheepshead on the Atlantic coast were 4,497 and 3,250 mt, respectively, in 1982, then declined to 3,647 and 2,634 mt in 1996. Since 1996, the total biomass and SSB have remained relatively stable, averaging 3,734 mt annually and, 2,734 mt annually, respectively.
5. Total biomass and SSB on the Gulf coast were 5,910 and 4,585 mt in 1982, then declined to 2,597 and 1,820 mt in 1996. However, total biomass and SSB were slightly higher in recent years (1998–2015), averaging 3,234 and 2,289 mt, respectively.
6. There are no overfishing, overfished and depleted definitions for Sheepshead in Florida, and there are no control rules for determining the status of Sheepshead in Florida. However, a (purely) hypothetical Spawning Potential Ratio (SPR) of 30% and a (purely) hypothetical spawning depleted level of 30% were employed to gauge the plausible Sheepshead stocks status on each coast of Florida, considering that: (i) the ratios of F to $F_{30\%} > 1$ indicated overfishing; (ii) the ratio of current F (geometric mean of F across 2013–2015) to $F_{30\%}$ indicated whether overfishing was or was not occurring; (iii) overfished conditions occurred when the ratios of annual SSB to the SSB at $F_{30\%}$ were greater than 1; and (iv) the stocks may be currently overfished if the ratios of current SSB (geometric mean of SSBs during 2013–2015) to the SSB at $F_{30\%}$ is less than one. The static spawning potential ratios and the transitional spawning potential ratios were also developed and compared with an SPR target of 30%, while the ratio SSB/SSB unfished was compared with a depletion target of 30%.
7. The results from the previous analyses suggested that: (i) overfishing of Sheepshead may have occured on the Atlantic coast in 1994 only and on the Gulf coast in 1988, 1989 and during 1992–1994; (ii) overfishing may not be currently occurring on both coasts of Florida; (iii) the Sheepshead stock on Florida's Atlantic coast may have never been overfished; and (iv) Gulf coast Sheepshead may have been overfished during 1994–2001, but is not currently overfished.

ASAP model results were generally consistent with SS3 model results on both coasts of Florida.

The overfishing and overfished definitions and the development of harvest control rules were amongst the recommendations of this stock assessment.

1 Introduction

1.1 Management Unit Definition

The management unit used in this assessment includes all Sheepshead found in waters within and adjacent to the state of Florida including inland, state, and federal waters.

1.2 Regulatory History

Sheepshead harvest was not directly regulated in Florida until 1996. In 1996, Sheepshead was designated a restricted species. Effective January 1, 1996, a 12-inch fork length (FL) minimum-size limit for all harvesters and a 10-fish recreational bag limit were established. At the same time, commercial fishing was restricted to the use of hook-and-line, cast net, beach and haul-seine gears, with a 50-pound bycatch allowance for harvest by non-conforming gears. These regulations were amended in 1997, 1998, 2006, and 2013. In 1997, the recreational bag limit was increased to 15 fish per person and commercial spearfishing was allowed. In 2006, the 12-inch minimum-size limit was defined in terms of total length (TL) instead of fork length, effectively decreasing the minimum-size limit.

1.3 Assessment History

The status of Sheepshead in Florida waters has previously been assessed five times (Muller and Murphy 1994; Murphy *et al.* 1997; Murphy and MacDonald 2000; Munyandorero *et al.* 2006 2011). The first assessment mainly relied upon life history information from other states, and was conducted before the enactment of the 1996 implementation of regulations directed at Sheepshead. The other four assessments incorporated biological characteristics specific to Sheepshead in Florida waters.

The 2011 stock assessment (Munyandorero *et al.* 2011) indicated that the estimated abundance of Sheepshead ages-0 and older during 1982–2009 varied similarly on both coasts: it increased until the mid-1990s, declined and leveled off since 1996, but Atlantic coast abundance was always smaller than Gulf coast abundance. Results also showed lower fishing mortality rates during 1996 through 2009 when compared to estimated fishing mortalities for the early 1990s. The fishing mortality rates on each coast in 2009 were well below the fishing mortality producing the maximum yield per-recruit (YPR), F_{MAX}, and even below the fishing mortality at which the marginal increase in the YPR is 10% of the marginal increase in the YPR when there is no fishing, $F_{0.1}$. Atlantic coast and Gulf coast stocks of Sheepshead in Florida appeared abundant enough to produce adequate supplies of new recruits but the Gulf coast population showed overfished and overfishing signals. It was concluded that additional data were necessary to provide a more precise assessment of Sheepshead, namely: (1) direct samples from landings for age composition; (2) direct observations of discards from all fisheries and estimates of related size and age; (3) estimates of release mortality and; (4) coast-specific sex-ratio and maturity-at-age.

The temporal window for this new assessment update is the period 1982–2015. This report therefore incorporates thirteen years of pre-regulation fishery data, twenty years of post-regulation fishery data and Florida-specific, life-history data into an evaluation of the status of the Sheepshead populations on the Atlantic and Gulf coasts of Florida.

2 Life History

2.1 Stock Structure

Two subspecies, reportedly distinguishable by meristic characters (number and size of body bars, number of gill rakers on the lower limb of the first gill arch, number of lateral line scales, number of dorsal fin spines and rays), were thought to occur in Florida waters (Caldwell 1965). The purported northern form, *Archosargus probatocephalus probatocephalus* ranges from Nova Scotia south along the U.S. Atlantic coast and into the Gulf of Mexico to Cedar Key, Florida; and also occurs along the South American coasts to Rio de Janeiro, Brazil. *Archosargus p. oviceps* ranges from about St. Marks, Florida, to Campeche Bank, Mexico, and is associated more with mud bottoms than is the northern form (Randall *et al.* 1978, Jennings 1985).

A 2008 assessment of Sheepshead stock structure along Florida's Atlantic coast and in the Northern Gulf of Mexico confirmed the existence of subspecies according to divergent morphology (Anderson *et al.* 2008). Subspecies designation according to molecular genetic data, however, has been mixed. Anderson *et al.* (2008) found little divergence between the subspecies using both familial- (sparid) microsatellite markers and mitochondrial DNA (mtDNA) control region haplotypes and thus described the population as a single panmictic group. A recent analysis of mtDNA control region haplotypes divided the populations between Gulf and Atlantic but left a wide margin of the location of the genetic break between Apalachicola (Florida Gulf coast) and Indian River (Florida Atlantic coast). However Sheepshead-specific microsatellite markers (Seyoum *et al.* 2016, in press) revealed three separate genetic stocks. The first genetic break occurred near the phenotypic boundary between the two purported subspecies (Apalachee Bay, FL), while the second break occurred in south Florida (between Miami and Palm Beach, FL), an area known to act as a geographic impediment to gene flow between populations in estuary dependent fishes. These genetic breaks divided the Sheepshead populations into three clusters; the western Gulf, the eastern Gulf and the Atlantic (Figure 2.1; Seyoum *et al*. 2016, in press).

For stock assessment purposes, Sheepshead inhabiting waters on the Atlantic coast of Florida and those on Florida's Gulf of Mexico coast are considered separate management units, and assessments were conducted separately for each coast. Although an area-specific model may better reflect the genetic stock structures (Seyoum *et al.* 2016, in press), the lack of age data for northwest Florida prevents the application of an age-based modeling approach such as ASAP, therefore precluding comparison between different assessment methodologies (i.e., SS3).

2.2 Age and Growth

Comparisons between readings from otolith sections and scales from the same fish indicated that scale-based ages either were unreliable or underestimated the true age (Dutka-Gianelli and Murie 2001). Age determination for Sheepshead has since then been thought to be reliable when based on annuli seen in thin-sections taken from sagittae (Beckman *et al.* 1991; Dutka-Gianelli and Murie 2001; Wenner and Archambault, 2006;

McDonough et al. 2011; Liao *et al.* 2009, 2014; Winner *et al.* 2017). Age validation was examined using distinct annual patterns in marginal increment distances or recaptures of tagged or chemically marked fish. Annulus deposition in adult Sheepshead occurs during April–May in Louisiana and Mississippi waters (Beckman *et al.* 1991, Brown-Peterson *et al.* 2005), March–May in northwest Florida (Dutka-Gianelli and Murie 2001), and May–June in in South Carolina and Tampa Bay (FL) (McDonough et al. 2011; Winner *et al.*, 2017). The ages validated in most studies ranged from 1 to 6 years.

Longevity (t_{max}), aging methods, and maximum sizes (length, L_{max}; weight, W_{max}) for Sheepshead have been reported from various locations along the Atlantic and Gulf of Mexico coasts (Table 2.1). Previously, ages of Sheepshead sampled from Florida inshore waters ranged from 0 to 16 years, with a median age of three years; typical maximum ages appeared to be 13 years for males and 16 years for females (FWC-FWRI unpublished data). Likewise, the majority of Sheepshead collected from Cedar Key to Keaton Beach (Northwest FL) were 3 to 6 years old, with maximum ages ranging between 14 and 12 years for males and females, respectively (Dutka-Gianelli and Murie 2001). Coast-wide age data used in this study revealed that, in recent years, older Sheepshead in Florida waters have been observed on the Atlantic coast (t_{max} = 25 years for males; 23 years for females) and on the Gulf coast (t_{max} = 20 years for males; 17 years for females).

In Louisiana waters, larger Sheepshead possibly older than 20 years have been observed but not aged (Beckman *et al.* 1991), and in South Carolina waters, t_{max} = 26 years (Wenner 1996 *in* Dutka-Gianelli and Murie 2001). Schwartz (1990) determined a maximum age of 8 years for Sheepshead in NC using scales, which he suggested was an underestimation by one or two years caused by difficulties in reading scales. The observed maximum length and weight for Sheepshead has generally been at about 23 inches FL (25 inches TL) and 18 pounds, respectively (Table 2.1). A possible outlier to the length data exists for Florida (Florida Museum of Natural History - Ichthyology) where the maximum observed length reported was nearly 30 inches FL (33 inches TL).

Growth studies of Sheepshead have been conducted in the South Atlantic Bight, eastern Gulf of Mexico, and Chesapeake Bay. In Louisiana waters, Sheepshead grow rapidly during their first 6–8 years of life with females generally being larger at a given age (Beckman *et al.* 1991). In Tampa Bay, both males and females experience relatively rapid growth through age-6, followed thereafter by a marked decrease in growth rate (Winner *et al.* 2017). Sheepshead in northwest Florida grow quickly in length until 4–5 years, ages beyond which growth rate is reduced (Dutka-Gianelli and Murie 2001). In South Carolina waters, growth rate slows considerably after 5 years (Wenner and Archambault 2006; McDonough *et al.* 2011). Sheepshead in Chesapeake Bay: 1) grow very rapidly before 5 years-of-age, slowly by age 10; and 2) exhibit larger sizes at age than those of Sheepshead of any other region (Liao *et al* 2009). Reduction in growth rate generally coincides with sexual maturity; i.e., 2 or 3 years of age for males and 3 or 4 years of age for females (Render and Wilson 1992; Wenner and Archambault 2006; McDonough et al. 2011, note: sexual maturity reached at age-1 in SC).

Larval and early juvenile growth rates for Sheepshead in Tampa Bay, Florida, were about 0.20 mm d^{-1} (Parsons and Peters 1989). Springer and Woodburn (1960) reported that the average total lengths for young-of-the-year (YOY) Sheepshead in Tampa Bay were 21, 29, and 42 mm in June, July, and August, suggesting a slightly faster growth rate of about 0.35 mm d^{-1}.

While age was not a good predictor of weight or length and vice-versa, some studies were conducted to fit sex-specific and/or combined von Bertalanffy growth (VonB) equations using length- and weight-at-age data (Table 2.2; Beckman *et al.* 1991; Matlock, 1992; Dutka-Gianelli and Murie 2001; Liao *et al.* 2009; McDonough *et al.* 2011). The L_∞ parameter of the VonB model for combined sexes of Sheepshead from various Texas' bays may have been an underestimate (Matlock 1992). VonB models were significantly different for males and females in Louisiana waters (Beckman *et al.* 1991), in Tampa Bay (Winner *et al.* 2017), and in Chesapeake Bay (Liao *et al* 2009) where, except in Tampa Bay, females exhibited a faster growth rate and achieved larger maximum sizes. For South Carolina and the northwest Florida region, Dutka-Gianelli and Murie (2001) and McDonough *et al.* (2011) found no significant sex and subspecies-specific growth patterns in both length-at-age and weight-at-age. Tampa Bay sheepshead are typically smaller at a given age than those in more northern climates and not as long lived (Winner *et al.* 2017).

Coast-specific samples of length-age data for Florida available for this assessment are presented in Figure 2.2. As shown, fishery dependent data sources (i.e., BIOSTAT) do not sample all available lengths compared to fishery independent sources (i.e., FIM), particularly lengths less than 25 cm TL. This is partly due to the minimum-size limit. Therefore, only fishery independent sources were used to determine mean size-at-age.

VonB analysis indicated the following (Figures 2.3-2.4): 1) the mean size-at-age for male and female Sheepshead are comparable; 2) on average, Sheepshead reach about 25 cm TL between ages 1 and 2, 30 cm TL between ages 2 and 3, and 33.5 cm between ages 3 and 4; and 3) through age 2, the mean size-at-age for Sheepshead was slightly larger on the Atlantic coast than on the Gulf coast; thereafter, Gulf coast Sheepshead were slightly larger at age. A comparison of L_∞ parameter values in Table 2.1 shows L_∞ is smallest for the Florida Atlantic coast, followed by Louisiana and Florida Gulf coast. L_∞ values are larger and about equal for Northwest Florida, Georgia, and South Carolina, and are largest for Chesapeake Bay.

For this stock assessment, growth between males and females was assumed to be similar, but coast-specific growth parameters were used. Evidence for differences between males and females has often been weak or conflicting among various studies. Munyandorero *et al.* (2006) summarized various relations between weight and length and between different length measurements which are found in the literature. Table 2.2 updates the weight-length relationships and length-length conversions for Florida's Gulf and Atlantic coasts using length-weight data accumulated over 1993-2015. For this analysis, biological samples include both fishery independent and fishery dependent sources (FIM and BIOSTAT, respectively) and were recovered by multiple gear types (hook and line, cast net, gill net, seines, trawls, etc.).

2.3 Reproduction

Sheepshead spawn during the late winter/spring in the mid-Atlantic, South Atlantic, and Gulf of Mexico (Jennings 1985; Wenner and Archambault 2006; McDonough et al. 2011). Spawning off Louisiana occurred from late February through late April (Render and Wilson 1992). In Florida waters, mean gonadosomatic index (GSI) values are elevated from January–March, with a peak occurring in February (FWC-FWRI unpublished data). In nearshore reefs off Georgia, spawning occurred primarily in April (Music and Pafford 1984). In coastal South Carolina, spawning takes place during February–early May in nearshore ocean waters such as areas around artificial reefs, and each year females are seen with evidence that they have spawned at least once in April to early May (Wenner and Archambault 2006; McDonough *et al.* 2011). Most recent literature suggests that spawning occurs in nearshore continental shelf waters although there is some evidence of spawning within estuaries (Render and Wilson 1992). Within Tampa Bay, a small number of female Sheepshead have been collected with hydrated oocytes or post-ovulatory follicles, indicative of imminent or recent spawning (T. MacDonald, FWC-FWRI unpublished data). Sheepshead containing post-ovulatory follicles or in advanced stages of maturity have been more commonly collected from offshore waters (Music and Pafford 1984; Render and Wilson 1992). The best temperature for spawning is around 70^0 F in waters with ocean level salinity: fertilized eggs are 0.03 in diameter, float near the surface, and larvae hatch in 28-40 hours after spawning in waters of around $75\text{-}76^0$ F (Smith 1907; Wenner and Archambault 2006). The recruitment window (i.e., period of high occurrence of YOY) appears to be April–July (FWC-FWRI unpublished data).

Sheepshead are batch-spawners (Render and Wilson 1992; Wenner and Archambault 2006; Liao *et al.* 2009; McDonough et al. 2011). That is, they show multiple oocyte developmental stages whereby they produce a batch of ripe eggs, spawn them, recover and feed, develop another batch of eggs and spawn them, and so forth. In general, older and larger females spawn earlier and more frequently during the season, produce bigger batches of eggs and, therefore, contribute more eggs than younger, smaller females (Wenner and Archambault 2006). Batch fecundities for Sheepshead found in South Carolina waters were estimated for individuals that were 282–603 mm FL long and 2–18 years old, and ranged from 18,400 to 738,500 eggs (mean +/- SD = 235,700 +/- 161,947 oocytes/ovary; McDonough *et al.* 2011). In Georgia, fecundities for Sheepshead 428–591 mm FL and 4–14 years old ranged from 296,000 to 963,000 eggs (Music and Pafford 1984). However, it is unclear whether only the oocytes available for the next batch were counted in this study.

The spawning frequency of Sheepshead range from once per day to once every 20 days (Render and Wilson 1992; McDonough *et al.* 2011). McDonough *et al.* (2011) found batch fecundity was significantly related to both TL and age, but low r^2 values indicated a poor predictive relationship. This is expected given uncertainties about their total seasonal fecundity and their wide range of batch fecundities (Render and Wilson 1992).

Age and length at maturity appear to vary from location to location. In general, female Sheepshead begin to mature at about age 2 (Tucker 1987; Render and Wilson 1992; T. MacDonald, FWC-FWRI unpublished data). However, the proportion of females that are mature at age 2 and subsequent age classes appears lower in Florida and Georgia than in Louisiana. Nearly all males older than age 2 and nearly all females older than age 1 were mature in samples taken from Louisiana waters (Render and Wilson 1992). This early maturity was attributed to their sample locations, which were all offshore using purse seiners, i.e., it was a biased sample of say 2-yr-olds with only mature fish of that age found in offshore waters (M.D. Murphy, personal communication). In Georgia, the smallest female showing developing ovaries was age 3 (282 mm FL) and the smallest male was age 4 (393 mm FL, Music and Pafford 1984). In South Carolina waters, sexual maturation occurred in 50% of both males and females at approximately 250 mm FL and at age 1. Sheepshead reached 100% maturity by age 5 and 400 mm FL (McDonough *et al.* 2011). In Florida, the length at 50% maturity for males is 276 mm FL; from which the proportion of mature males increases gradually to 100% at 551 mm FL and larger. Some females begin to mature at 354 mm FL and all females are mature when they are 551 mm FL and larger. Female Sheepshead are mature between age 1 and age 2 and all are mature in their fifth year (T. MacDonald, FWC-FWRI unpublished data). In Chesapeake Bay, the age at 50% maturity for female Sheepshead is 1.01 years and the length at 50% maturity is 252 mm FL; all females are mature by age 4 and at 350 mm FL. Age and length at 50% maturity for males are 1.47 years and 278 mm FL, respectively; like females, all males are mature by age 4 but at 325 mm FL (Liao *et al.* 2009).

The sex-ratio and maturity at age of Sheepshead have been rarely investigated. However, in Liao *et al.*'s (2009) collection of Chesapeake 345 Sheepshead, the sex-ratio was 1 male: 1.45 females. Similarly, in Tampa Bay, the sex-ratio was estimated at 1 male: 1.65 females, and significantly different from a 1:1 ratio (T. MacDonald, FWC-FWRI unpublished data). Alternatively, McDonough *et al.* (2011) found sex ratios were not significantly different from 1:1. The proportions of mature females at each age were predicted by logistic regression as follows for age 2 and older fish: 0.02 for age 2; 0.15 for age 3; 0.60 for age 4; 0.93 for age 5; 0.99 for age 6; and 1 for ages 7 onwards (all age-0 and age-1 fish were immature; T. MacDonald, FWC-FWRI unpublished data). This maturity vector was used in this assessment to characterize the maturity schedule for both Atlantic and Gulf coast populations of Sheepshead off Florida

2.4 Natural Mortality

In this stock assessment, coast-specific values of age-independent natural mortality (M year^{-1}) are based on recommendations in Then *et al.* (2015). This study updates Hoenig's (1983) and Pauly's (1980) regression methods and relates total longevity (t_{max}) and von Bertalanffy growth parameters (L_∞, K) to M according to the relationships. Values of M at age were then estimated using Lorenzen's (2005) method. This approach relies on the relationship between age and length and is scaled to a "target" natural mortality rate. Based on the combined coast-specific age-and-growth information developed for this assessment (Tables 2.1 and 2.2), the estimated age-specific natural mortality rates for ages 0–14 were scaled to the age-independent M values (Figure 2.5).

3 Habitat Requirements and Biological Interactions

Larval Sheepshead occur in nearshore waters and within estuaries (Jennings 1985, Parsons and Peters 1989). The smallest pelagic larvae (6 mm) have been collected at the surface over sandy bottom (Hildebrand and Cable 1938, Springer and Woodburn 1960) or near seawalls within the estuary (Parsons and Peters 1989). The pelagic larval stage appears to last for 30–40 days and ends when the larvae metamorphose to juveniles at about 8 mm standard length (Parsons and Peters 1989; Tucker and Alshuth 1997).

Juvenile Sheepshead are most abundant in grass flats or over mud bottoms (Springer and Woodburn 1960, Odum and Heald 1972, Jennings 1985). In late summer, when juveniles are about 40 mm long, they begin leaving these areas and congregate with adults around stone jetties, breakwaters, piers, wrecks, and bulkheads (Jennings 1985). Juveniles tolerate the saltiness of the oceans and waters with very low salinities (Wenner and Archambault 2006). In Tampa Bay, juvenile Sheepshead have been collected in salinities and temperatures ranging from 5–35‰ and 12.8–32.5^{0}C, respectively (Springer and Woodburn 1960). Juvenile Sheepshead were considered estuarine-dependent transients of a regularly-flooded saltmarsh cordgrass habitat near Beaufort, NC (Hettler, Jr. 1989).

Pre-recruits and adults frequent structures with topographic relief in nearshore and estuarine areas. They frequent oyster bars, muddy shallow waters, piers, breakwaters, seawalls, and artificial reefs and wrecks often running far up rivers. They also form large feeding aggregations at times (Johnson 1978).

In Florida, Sheepshead are not true migratory species, but move in schools to offshore spawning grounds with the onset of cool weather. They return to inshore waters in the spring after spawning. In Georgia, 37% of tagged Sheepshead recoveries were made close to the tag-release site (Music and Pafford 1984). The greatest distances traveled occurred during the spring but were never farther than 100 km and tagged and recaptured Sheepshead spent a maximum of 413 days at large (Woodward *et al.* 2000). Sheepshead emigrating from Georgia estuaries generally moved to nearshore reefs located close to the mouth of the estuary where they were tagged. The depth range for Sheepshead is up to 15 m (http://www.FishBase.org), but high concentrations have been found at depths of 7–12 m near oil platforms in the northern Gulf of Mexico (Jennings 1985). In Georgia waters, Woodward *et al*. (2000) found that Sheepshead form spawning aggregations on nearshore reefs in the winter and spring, potentially exposing them to high fishing pressure.

Food habits of larval Sheepshead have not been studied but the diet of juvenile Sheepshead less than 50-mm long consists mainly of invertebrates including ostracods, gammarids, copepods, and polychaetes (Hildebrand and Cable 1938; Springer and Woodburn 1960; Castillo-Rivera *et al.* 2007). In general, juveniles feed on soft-bodied organisms that occur in association with sea-grasses. At about 50-mm long, juvenile Sheepshead begin to feed on hard-shelled organisms, i.e., mollusks, echinoderms, and barnacles (Jennings 1985; Sedberry 1987).

Overall, Sheepshead are omnivorous grazers, feeding on whatever is available seasonally and spatially in their habitats, thereby showing adaptations towards maximizing the use of trophic resources (Overstreet and Heard 1982; Wenner and Archambault 2006; Castillo-Rivera *et al.* 2007). Their trophic level was estimated at 3.53 (http://www.FishBase.org). Fish collected from two North Carolina jetties consumed more than twice as much algae as invertebrates (Ogburn 1984). Based on the amount of algae found in the stomachs of Sheepshead and the low *p*H of gastric secretions (2.0), Ogburn (1984) believed that algae was an important source of nutrients for both juvenile and adult Sheepshead. Bryozoans were important in the diets of juvenile and adult Sheepshead collected in the South Atlantic Bight (Sedberry 1987). Bivalves, echinoderms, and ascidians were important in the diets of Sheepshead larger than 350 mm standard length (Sedberry 1987). In South Carolina and Georgia, adult Sheepshead feed on bryozoans, oysters, barnacles, small crabs, decapod shrimp, and mussels (Music and Pafford 1984; Wenner and Archambault 2006). Feeding activity was greatest in Georgia waters during the spring, summer, and fall and dropped dramatically during the winter. In a tropical estuary of Veracruz, Mexico, the diet of Sheepshead was similar during day and night, but feeding intensity was greatest during daylight hours (Castillo-Rivera *et al.* 2007)

Sharks and other large piscivorous fishes feed on Sheepshead, and a known predator, investigated in the Indian River lagoon system on the central east coast of Florida, is the bull shark, *Carcharhinus leucas* (Snelson *et al.* 1984).

4 Fishery Description

4.1 Brief Overview of Fisheries

The fisheries of Sheepshead in Florida are characterized by the use of a mixture of gears, especially for the commercial fishery, and landings made from throughout estuarine and nearshore waters. Since at least 1982 when the first reliable recreational catch estimates became available, most landings were made with hook-and-lines. The recreational fishery on each coast of Florida represented at least 66% of the annual total landings (Table 4.1; Figure 4.1). The combined recreational and commercial landings of Sheepshead in Florida averaged about 3.83 million pounds (of which 2.4 million pounds were landed on the Gulf coast) during 1982–1995, and 2.6 million pounds (1.7 million pounds on the Gulf coast) since 1996. They amounted to 2.26 million pounds in 2015.

4.2 Current Status

The fisheries of Sheepshead in Florida are considered small compared to other Florida-based fisheries for more highly targeted fishes. This is perhaps the reason why there have been no determination of the status of this fishery in terms of economic or social importance, and, apart from the trends, no predefined management goals in terms of biological reference points the assessment estimates could be judged against.

5 Data Sources

5.1 Commercial fishery

Commercial harvest information was obtained from the FWC's Marine Fisheries Information System (or trip ticket program) and from the Fisheries Statistics Division of the National Marine Fisheries Service (NMFS) for the years 1978–2015. These data included annual landings from monthly dealer reports collected by the NMFS during 1978–1985 and FWC trip ticket records compiled from 1986 through May 2016.

The NMFS-developed Trip Interview Program (TIP) provided lengths data sampled from the commercial landings. These data were available for the periods 1992–2015 on the Atlantic coast and 1991–2015 on the Gulf coast. Only TIP data available in the FWC-FWRI-maintained database were queried for this assessment.

5.1.1 Data Collection Methods

5.1.1.1 Surveys

A full description of landings statistics collected and of the sampling intensity is presented in the 2011 Sheepshead stock assessment (Munyandorero *et al.* 2011). In short, landings of Sheepshead were reported to the NMFS prior to 1986, but were based on a subset of dealers (including large wholesale dealers) operating in Florida. Since 1986, information on what is landed and by who in Florida's commercial fisheries came from the FWC's trip-ticket program. This program greatly expanded the coverage of the fishery by including all wholesale dealers and each transaction where marine resource products are purchased from a licensed commercial fisher.

5.1.1.2 Biological Sampling

Biological samples from the Sheepshead commercial fisheries were weight and length measurements of fish intercepted at fish houses during 1992–2015 on the Atlantic coast and during 1991–2015 on the Gulf coast. Since 2007, otoliths have also been collected through a variety of fishery-dependent projects. However, while Sheepshead are included on the list of species to be sampled, they are sampled “as available” because of their low priority and because of the small amounts that are generally landed.

5.1.1.3 Age Composition

Sheepshead commercial landings-at-age were estimated by converting the available length frequencies of Sheepshead in the landings to ages using age-length keys (ALKs) constructed from Sheepshead length and age data collected by various FWC sampling projects, especially the FWC’s fishery independent monitoring program (FIM) using haul seines. Assumptions underlying the commercial age-composition of Sheepshead, the aging methods and the convention adopted for assigning ages are in Munyandorero *et al.* (2011).

5.1.1.4 Development of Estimates

The number of Sheepshead commercially landed and the related data on fishing effort were derived for five gear categories. The gear categories identified were cast nets, entangling nets (i.e., gill nets and trammel nets), hook-and-lines, “others” (i.e., a mosaic of gears that were individually associated with sporadic landings, poor biological samples or both; they included spears, trawls, haul seines, purse seines and long lines) and the unknown gear category.

The number of Sheepshead landed were converted from landings in weight (Table 5.1; Figure 5.1) in conjunction with annual length frequencies obtained from TIP samples (Figure 5.2) and annual length (inch)-weight (g) relationships based on pairs of length-weight data compiled from various sources (Table 5.2). For each length bin within a gear category, the conversion was performed as follows:

(1) Estimation of mean weight by applying length-weight relationships.
(2) Estimation of (i) the sampled weight by multiplying the number of fish sampled with mean weight and (ii) the proportion of sampled weight frequencies.
(3) Estimation of annual landings in weight by multiplying the proportion of sampled weight with total landings weight.
(4) Estimation of annual landings in number by dividing annual landings weight by mean weight.

Similar to the 2011 stock assessment, 40 fish were considered to be a minimum sample size requirement to conduct the previous estimations (Table 5.3). Otherwise, some pooling of samples was required when few or no Sheepshead were available. The pooling scheme was as follows: (i) if less than 40 fish were sampled in consecutive years, they were aggregated and, if their sum exceeded 40, the resulting length distribution was employed for each of those years; (ii) if less than 40 fish were sampled in a single year or if the distribution in (i) above totaled less than 40, they were pooled with the distribution(s) of adjacent year(s) having the required sample size(s). For the unknown gear category in particular, the estimations during 1982–1996, 1997–2003, and since 2003 were based on a single length frequency created by pooling, respectively, (i) samples available during

1991–1994 for all gear types; (ii) the cast net, hook-and-line and "others" gear samples across 1997–2003; and (iii) the samples labeled "unknown" since 2004.

The TIP program recorded lengths as standard, fork or total lengths. All length types were converted to total lengths (TL) using the appropriate length-length relations (Table 2.2). There were no data in 1999 and prior to 1997 on the Atlantic coast and prior to 1994 on the Gulf coast to estimate the weight-length relationships (Table 2.2). In those cases, the overall, coast-specific weight-length relationship was applied.

The number of Sheepshead landed by age during 1982–2015 was estimated by applying age-length keys (ALKs) to estimated length frequencies. ALKs were developed from Sheepshead age-length pairs available from various sources (Table 5.4; Figures 5.3 and 5.4). The conventions and assumptions made were those detailed in the 2011 stock assessment (Munyandorero *et al.* 2011). For example:

(1) Ages of Sheepshead were incremented on January 1 each year to align ages with other calendar-based statistics. This meant that Sheepshead labeled as age-1 for the modeling exercise were approximately 9–21 months of age based on peak spawning in April;
(2) Only ALKs with at least 70 age-length data pairs were retained;
(3) An Atlantic coast mean ALK for application to length frequencies for all years from 1982 through 1996 was obtained by averaging the 1997 and 1998 ALKs;
(4) A 1999 ALK for the Gulf coast was obtained by averaging the 1998 and 2000 ALKs;
(5) When no data were available, fish less than 6 inches FL were assumed age-0;
(6) All Gulf coast Sheepshead 25, 26, and 28 inches FL were evenly distributed across ages 8-15, 9-16, and 11-18, respectively, on the basis of the observed distribution of ages in adjacent size classes and on expected lengths at age predicted by growth curves.

The commercial catch rates (CPUE, i.e., reported landings in pounds per-directed trip) were standardized for the predominant gear types in the fisheries (cast nets and hook-and-lines). A directed trip was considered to be one that retained at least one of the species frequently caught with Sheepshead based on a cluster analysis using the Bray-Curtis similarity index (Figure 5.5).

The distribution of pounds landed per-trip necessitated the use of a two-part model – a quasibinomial sub-model of the proportion positive trips and a lognormal sub-model of the pounds of Sheepshead caught in a successful trip. A quasibinomial sub-model was preferred over a binomial sub-model because it inflates the reported standard errors when there is over-dispersion. At minimum, year was a covariate used in the GLM standardization. Other potential factors included region (NE, SE/SW, Central, NW), month, gear, and time fished. The model selection procedure was two-fold. First, forward model selection was performed to remove factors that did not result in a net decrease of AIC of at least two. Then, the number of factors were further reduced if the reduction in mean deviance of the model was less than 0.5% for each selected factor. AIC is undefined for 'quasi' models, therefore model selection was performed using a binomial sub-model.

The distribution of the least-squares means for the year effect were simulated using 500 randomly generated residuals from the mean; each residual was a random normal deviate times the standard error for its least-squares mean. These estimates were back-transformed to pounds and the distribution was described in terms of percentiles and a median.

5.1.1.5 Commercial landings: Trends and Regional, Gear and Length Comps

Across-gear commercial landings weight of Sheepshead on both coasts of Florida peaked at 0.87–1 million pounds between 1990 and 1994; they declined to less than 400,000 pounds and varied without trend since 1996 (Figure 4.1; Tables 4.1 and 5.1). The sharp decline in statewide commercial landings observed after 1995 coincided with the implementation of the entangling net restrictions enacted in July 1995 and a 12 inches minimum-size limit and possession limit enacted in January 1996. This decline occurred on both coasts. The commercial landings of Sheepshead on the Atlantic coast were highest during 1982–1994 when they averaged 311,450 pounds annually; they averaged 153,800 pounds during 1996–2015. On the Gulf coast, the commercial landings of Sheepshead increased gradually to peaks in the late-1980s–early-1990s, averaging 382,200 pounds annually during 1982–1994. Their annual average was 166,150 pounds during 1996–2015.

Between 1986 and 1995, entangling nets were among the dominant commercial fishing gears used to capture Sheepshead in Florida: they averaged 43% and 64% of total commercial landings weight and 45% and 71% of total commercial landings numbers on the Atlantic and Gulf coasts, respectively (Tables 5.1 and 5.5; Figures 5.1 and 5.6). These are minimum percentages because some entangling gear landings were likely included in landings of the ‘unknown’ gear category during these years. The unknown gear category landings prior to 1986 also probably comprised entangling gear landings. During 1996–2015, the Sheepshead landings were made using a variety of gears, but gear-specific landings declined —drastically for entangling nets— or varied without trend excepted “other” gears landings that trended up.

Commercial landings of Sheepshead in Florida were made throughout almost all coastal counties during 2015 (Figure 5.7). The counties that showed the greatest amounts (> 10,000 pounds) were Duval County and east-central counties, and, along the Gulf coast, Charlotte, Lee, Manatee, Hillsborough, Pinellas, Dixie, Franklin, Gulf and Escambia counties. Significant landings also occurred in St. Johns and Taylor counties.

The length distributions of Sheepshead commercial landings shifted abruptly on both coasts since 1997 (Figure 5.8). They peaked at 8 inches FL through 1995 and at 11 or more inches thereafter. Two aspects should be noted. First, the distributions through 1992 were assumed to be similar to that of 1993. Second, the bubbles of Figure 5.8 are proportional to total landings: landings were lowest and nearly constant since 1997; during 1982–1994, they were highest and varied without trend on the Atlantic coast, but showed a peak in the late-1980s–early-1990s on the Gulf coast.

5.1.1.6 Commercial Discard/Bycatch

There are no monitoring programs to estimate the regulatory discards of Sheepshead from commercial fishing gears. To adhere to the 12-inch TL minimum size, Sheepshead discards could be substantial. Nonetheless, discard data are fragmentary and were documented in the 2011 stock assessment. In this assessment, commercial discard amounts were assumed to have a profile similar to that in the recreational fishery (described below). Therefore, year-specific ratios of fish recreationally released alive (Type B2) to the estimated numbers of Sheepshead recreationally landed (Type A+B1) were applied to the commercial landings in numbers to infer the commercial discards (Table 5.6)

5.1.1.7 Length Compositions of Commercial Discards

There have been no length samples of commercial discards. The length compositions of commercial discards and the corresponding dead fraction were developed similarly as for the recreational discards (see Section 5.2.2.2 below). The period 1992–1995 was considered as a reference period about the directed catch samples for lengths across all gear-types.

5.1.1.8 Commercial Fishing Effort

Effective fishing effort (i.e., a measure of fishing activity accounting for differences in fishing power and efficiency) is one of the fishery indicators appropriate to evaluate the impact of exploitation on fishery resources. Unfortunately, this type of effort is difficult to define and quantify in mixed fisheries, as are for Sheepshead in Florida. At best, measures of nominal fishing effort may be available and can be used as indicators of fishing pressure. Here, indicators of fishing pressure were the number of Saltwater Product License holders (SPL; Table 5.7) and the number of trips (Table 5.8) that landed Sheepshead.

The number of SPL holders that landed Sheepshead on the Atlantic coast averaged 1,225 during 1986–1995 and 774 thereafter. SPL holders using cast nets and hook-and-lines represented between 40 and 57% prior to 1996 and, since then, between 75 and 86%. On the Gulf coast, the number of SPL-holders reporting Sheepshead landings fell from an annual average of 2,082 to 938 between the periods of 1986–1995 and 1996–2015. During these periods, respectively, SPLs operating with cast nets and hook-and-lines were on average 35% and 72%.

The trends of the total number of trips and the relative composition of cast net and hook-and-line trips that reported Sheepshead (Table 5.8) were very similar to those of SPL holders. Likewise, the reported total commercial landings were linearly and significantly related to the total number of fishing trips [*F*-test: $F_{(1, 28)} = 297.31$, $p < 0.001$, $r^2 = 0.91$ on the Atlantic coast; $F_{(1, 28)} = 192.55$, $p < 0.001$ $r^2 = 0.87$ on the Gulf coast].

5.1.1.9 Commercial Catch Rates (CPUE)

During the estimation of the standardized commercial CPUE, significant factors of the binomial sub-model for the Atlantic coast included year and region, while year, region, and gear were significant for the Gulf coast (Table 5.9). The lognormal sub-model included year, region, month, and gear for the Atlantic coast and all factors were selected for the Gulf coast.

The Atlantic coast standardized CPUE averaged 8 pounds per-trip during 1991–2015 with a decreasing trend from 2005; the lowest value of 5 pounds per trip occurring in 2014–2015 (Figure 5.9; Table 5.10). The Gulf coast standardized CPUE showed a steep declining trend from 1992–1998 before leveling off to a mean of 3.5 pounds per-trip with a peak of 4.6 pounds per-trip occurring in 2010 (Figure 5.9; Table 5.10).

5.1.1.10 Commercial Catch-at-Age

The commercial landings in numbers of Sheepshead mostly were individuals of age-1 through age-5 (average: 78% on the Atlantic coast; 80% on the Gulf coast; Figure 5.10; Table 5.11). There has been a shift since 1997 to more representation of age-3 to age-5 fish (57–62% on average). On the Atlantic coast prior to 1996, the commercial landings of ages 1 to 5 contributed an average of 93% whereas these age groups contributed an annual average of 66% since 1997. On the Gulf coast, contributions of ages-1 to age-5 Sheepshead in commercial landings declined from 91% during 1982–1996 to 71% thereafter. Less than 1% of age-1 Sheepshead have been landed in most years since 1997, whereas they contributed about 10–19% during 1982–1995. Occasional but significant landings of age-6 to age-8 Sheepshead have also been observed on both coasts Florida since 1997.

A similar age composition should be noted for the period 1982–1985. This age composition has been caused by both an average ALK and a constant length structure (for the unknown gear category) made of available length frequencies sampled from various gear types in the early 1990s. The same average ALK was also applied each year across 1986–1996 on the Atlantic coast and across 1986–1992 on the Gulf coast, but along with constant or year-specific length compositions within gear types.

5.2 Recreational fishery

Recreational landings and releases were obtained from the Beaufort Headboat survey and the Marine Recreational Information Program (MRIP) which was formerly called the Marine Recreational Fisheries Statistical Survey (MRFSS). Sheepshead have been infrequently observed in headboat anglers catches in Florida (i.e., 187 fish weighing 262 pounds on the Atlantic coast and 384 fish weighing 459 pounds on the Gulf coast during 1983–2015); so headboat landings were excluded from analyses. The MRFSS/MRIP was therefore considered the sole source of Sheepshead landings (data downloaded from http://www.st.nmfs.noaa.gov/recreational-fisheries/index in June 2016).

While recreational landings are available from 1981, they are presented below for the period 1982–2015. This is because the sampled and intercepted trips were complete from 1982 through 2015.

5.2.1 Data Collection Methods

5.2.1.1 Surveys

The MRFSS/MRIP survey began in 1979. The first two years have been considered a sampling pilot study because the change in the survey's estimation methodology in 1994 precluded the calculation of estimates in the first two years. MRFSS/MRIP therefore uses March, 1981 as the start of the program. FWC/FWRI personnel began conducting the creel survey interviews for MRFSS/MRIP in 1998.

MRFSS/MRIP estimates of total catch, releases and landings have been made in two stages. During the first stage, data were collected on a per trip basis through angler interviews. Interviews included questions about what kinds and how many fish were caught, angler demographics, and other trip characteristics. Angler interviews were chosen and made within strata, defined by coast, year, two-month period (wave), fishing mode (shore, private/rental boat, charter/guide boat), and fished area (inshore waters including bridges/beaches and man-made structures, state territorial waters and federal offshore waters). Fish seen during angler interviews were identified, measured for midline length (FL for Sheepshead) and weighed.

During the second stage, estimates of the number of trips per stratum were made using telephone survey data. Since 2000 on the Gulf coast and 2001 on the Atlantic coast, there has been a more narrowly directed phone survey to determine the fishing effort expended by the for-hire segment of the recreational fishery.

Since 2004, MRIP implemented new estimation procedures that required more night and early morning interviews that has resulted in fewer interviews conducted in recent years. NMFS/MRIP subsequently recommended use of MRIP estimates where possible. For this reason, an Ad Hoc Recalibration Working Group was convened to develop a ratio method for adjusting NMFS/MRIP data prior to 2004 (NOAA 2012).

5.2.1.2 Sampling intensity

The total number of recreational trip interviews conducted during 1982–1991varied between 2,747 and 4,431 on the Atlantic coast and between 2,129 and 8,139 on the Gulf coast (Figure 5.11). Since 1992, the number of trips interviews on each coast of Florida has increased significantly, but leveled off at about 13,500 until 2007 before declining on the Atlantic coast and at about 19,000 on the Gulf coast during 1998–2015.

5.2.1.3 Biases

Other than possible biases in the early (1981–2003) MRFSS/MRIP surveys (e.g., no sampling at night), there are no obvious biases to the recreational data. Since 2004, MRIP may have reduced bias by conducting night and early morning interviews.

5.2.1.4 Biological Sampling

On the Atlantic coast the number of Sheepshead measured for length each year has not changed, averaging 239 individuals each year during 1982–2015 (Figure 5.12). On the Gulf coast the number of Sheepshead measured for length before 1992 was similar to that on the Atlantic coast, but has averaged 590 fish measured each year since 1992. Weight is also measured for most of the Sheepshead sampled for length.

5.2.2 Development of Estimates

5.2.2.1 Length Compositions of Recreational Landings (Type A + B1)

Similar to the 2011 stock assessment, the length compositions of the recreational landings were estimated using Sheepshead lengths measured from the creel survey (Type A individuals). Length data were aggregated into 2 cm length bins ranging from 2 to 62 (Atlantic coast) and 2 to 72 (Gulf coast) cm TL and were weighted by the estimated landings within a MRFSS strata (wave x mode fishing x area fished). Matrices of landing-at-length for type A+B1 fish were constructed for each region (NE, SE, SW and NW) of Florida based on the length frequency of the Type A landing.

Because the numbers of Sheepshead measured in certain MRFSS strata was relatively low, some MRFSS strata were pooled to provide for more robust sample length frequencies to apply to strata-estimated landings. The pooling procedure included collapsing the different boat-based modes of fishing to a single mode, collapsing all area fished modes occurring in the ocean to one mode, and collapsing the 2-month waves into ‘cold’ (November–April) and ‘warm’ (May–October) periods. Pooling occurred hierarchically when the observed length sample was below 40. At the first level when 40 Sheepshead lengths were not available, lengths from the different fishing modes were combined. If less than 40 Sheepshead lengths resulted from the pooling, then pooling occurred sequentially: 1) across areas fished, 2) across seasons, and 3) within management period (before and from 1996).

The previous estimation method employed landings obtained with the MRFSS old methodology. The annual totals of the resulting length frequencies did not match the adjusted MRFSS/MRIP landings. Therefore, annual ratios "adjusted MRFSS/MRIP landings/total of MRFSS old-method landings by length" were calculated to raise those length frequencies of recreational landings during 1982–2003. The recreational landings length compositions for the period 2004–2015 was directly based on landings obtained with the MRFSS/MRIP new methodology.

5.2.2.2 Length Compositions of Recreational Releases (Type B2)

The MRFSS/MRIP provides estimates of the number of Sheepshead caught and then released alive (Type B2). A portion of these fish die after release. Of the various data sources containing length samples of fish released alive (i.e., MRFSS type 3 records; "Angler Action" of the Snook Foundation data set; and the Volunteer Angler Logbooks), MRFSS type 3 records included sizes of only nine individuals during 2005–2009 on both coasts of Florida (Table 5.12), and the "Angler Action" of the Snook Foundation data set included only 35 sizes of Sheepshead released alive during 2012–2015 (Table 5.13). In the latter data set, about 71% of releases measured less than 30-cm TL, suggesting that the majority of individuals released are below the 12-inch TL size limit, but the sample size is small to warrant the validity of this observation.

In the absence of reliable length data for the recreational discards, an estimation protocol similar to that used in the 2011 stock assessment was applied. This protocol involved a number of assumptions: (1) only smaller or illegal Sheepshead have been released alive; and (2) their size structure was below the size limit as mirrored by the creel samples for sizes (in other words, the length data were right-censored at 11 inches FL). The period 1991–1995 was considered as a reference period about the MRFSS samples for lengths. The corresponding length frequencies were pooled and the resulting distribution was assumed to reflect annual size structures of released Sheepshead. As the size limit for Sheepshead is 12-inch total length (TL) and the catch-at-length for various fishery sectors were developed in FL, it was necessary to estimate a FL size limit equivalent to the 12 inches TL size limit. Exploration of the conversion of FL-TL indicated that 11 inches FL could be a reasonable size cut-off to set a size limit equivalent to 12- inch TL size limit.

Deaths of Sheepshead resulting from catch and release (i.e., percentage of fish caught and released alive that subsequently die) are unknown. For Wenner and Archambault (2006), a few fish may die because Sheepshead are "though", including when they are handled after being caught by an angler. Like in the 2011 stock assessment, it was assumed that 1% of Sheepshead released alive die, but a sensitivity analysis of the-catch-and-release angling mortality of 5.5% was conducted.

5.2.2.3 Age Compositions

Very few individuals of Sheepshead landed by the recreational fishery in Florida have been sampled for ageing structures on the Atlantic coast, but relatively large age samples have been collected on the Gulf coast since 2007 (Table 5.4). No Sheepshead released alive have been sampled for aging structures. Regardless, the number of Sheepshead recreationally landed and released alive by age group during 1982–2015 was calculated from the estimated annual length frequencies of the landings and released alive using the ALKs developed for the commercial landings (see Sections 5.1.1.3 and 5.1.1.4 for conventions adopted and assumptions made).

5.2.2.4 Recreational Catch Rates (CPUE)

In the early MRFSS/MRIP survey, the sampling protocols were changed in 1991 to link together ancillary interviews to the primary interview conducted for the same trip. In addition, 1991 was the first full year after the extensive training of samplers for this survey program had been implemented which improved the quality of the survey data. Therefore, as in the 2011 stock assessment, the recreational catch rates only use data drawn from 1991 through 2015 to take advantage of the improvements in the survey design (ability to link all angler interviews for a boat-based fishing trip) and data quality.

In the 2011 stock assessment, recreational catch rates were calculated using fishing trips which either caught or had sought (i.e., targeted) Sheepshead. This assessment employs cluster analyses to identify which MRFSS/MRIP interviews (for shore, charter boat and private/rental fishing mode trips) had the potential to catch Sheepshead (the shore fishing mode included man-made and beach/bank fishing modes). Rare species (occurring in <1% of all trips) and those not identified to species were excluded from the cluster analysis. The Sheepshead cluster on the Atlantic coast included southern flounder, spotted seatrout, red drum and black drum while the Sheepshead cluster on the Gulf coast included sand seatrout, southern kingfish, and black drum (Figure 5.13). The selection criterion was to consider all trips that caught any species in the cluster as Sheepshead trips; therefore, that cluster was retained for MRFSS/MRIP index standardization.

The standardization of the recreational CPUE used a delta-lognormal modeling approach (Lo *et al* 1992) to account for various sources of uncertainty in all recreational trips that caught any species of the Sheepshead cluster. This approaches relied on two generalized linear models (GLIMs). The first GLIM assumed a binomial distribution (logit link) to estimate the probability that a trip caught Sheepshead for the proportion of positive trips. The second GLIM assumed a lognormal distribution (identity link) of the number of Sheepshead caught (i.e., both harvested and released) on successful (positive) trips. Potential variables were year, wave (the two-month time period), the number of anglers on a trip, hours fished, area fished ("ocean" or "inland"), the mode of fishing (shore, charter, private/rental boat), and avidity (the number of fishing trips that the angler made in the previous two-months). Variables were evaluated for inclusion in the GLIMs through a forward step-wise process, and were included in the final model if they were statistically significant and they reduced the null mean deviance by at least 0.5%.

The final model was run and annual adjusted (or "least-squares") means were computed with the set of variables selected. The annual mean catch per-trip values were calculated through 10,000 Monte Carlo simulations on the least-squares mean probability of catching a Sheepshead multiplied by the mean number of Sheepshead caught per-trip in that year. Random variation was added to each outcome by multiplying the standard error of the proportion positive by a random, normal deviate and by multiplying the standard error of the total number of Sheepshead caught per-trip by a different random deviate. After the random deviates were added to the respective least-square means, the terms were back-transformed to their original scales and multiplied together. The index was the median of the outcomes by year, and the coefficient of variation (CV) was the ratio of the standard deviation to the mean of the outcomes by year.

5.2.3 Estimated Recreational Landings

Estimates of recreational landings (Type A+B1), released alive (Type B2) and total catch (Type A+B1+B2) do not match those estimates made for earlier assessments because NMFS/MRIP recommended that the new MRIP methods and estimates be used to adjust the estimates for the years prior to 2004, using the procedures developed by the Ad Hoc Recalibration Working Group (NOAA 2012). The MRIP adjustment factors were calculated using 2004–2015 data. The patterns of estimates made with the MRFSS old method and with the MRFSS/MRIP new method were generally similar, but the magnitude of the landings, releases and catches were different in most years (Figure 5.14).

The numbers of Sheepshead kept by anglers on the Atlantic coast peaked at 1.02 million fish in 1987 and at 1.09 million fish in 1994; they varied at lower levels since 1997, with multiple peak-years at less than 574,000 fish (Table 5.14, Figure 5.15). On the Gulf coast, Sheepshead landings peaked in 1983 and in the late-1980s–early 1990s at amounts ranging between 843,000 and 2 million fish. Since 1996, recreational landings of Sheepshead varied without trend between 455,000 fish in 2010 and 1.05 million fish in 2005. In 2015, the estimated Sheepshead landings were highest (> 100,000 fish) for all coastal counties except for the southeast counties and Monroe County (Figure 5.16).

Estimates of the number of Sheepshead killed by anglers (i.e.., harvest = landings + live release deaths, assuming a 1% release mortality) during 1982–2015 trended similarly as the landings from each coast of Florida (Table 5.14; Figure 5.17). Except in 1983, 1985 and 1989, estimated kills on the Atlantic coast were more than 500,000 fish each year during 1982–1995, and exceeded 1 million fish in 1987 and 1994. Since 1996, the number of Sheepshead killed varied between 205,000 and 580,000. On the Gulf coast, there were also multiple peak-years when more than 1 million fish were killed each year across 1982–1995. The annual kills during 1996–2015 have been less than 1 million fish except in 2005.

Most Sheepshead landed by recreational fishermen in 2015 were 10–16 inches FL long on both coasts of Florida. There was a substantial reduction in landings of small Sheepshead (size < 10 inches FL) beginning in 1996 (Figure 5.18), which generally reflected the compliance with the 12-inch TL minimum size. Beginning in 1996, the landings of Sheepshead at least 11 inches FL (i.e., about 12 inches TL) long averaged 90% annually on the Atlantic coast and 87% on the Gulf coast. The recreational landings of Sheepshead in the early 1990’s noticeably peaked at less than 12 inches FL.

There was a general shift to older age Sheepshead in the recreational fishery landings beginning in 1997. On the Atlantic coast prior to 1996, Sheepshead of ages 2–5 averaged 79% of landings. Since 1996 about 66% of the landings were ages 2–5 with a decrease in the proportion of age-1fish in the landings and a general increase in the number of age-6 and older Sheepshead in the landings (Figure 5.19; Table 5.15). On the Gulf coast the proportion of the total landings that were ages 2–5 has not changed significantly over time but the contribution of age-4 through age-7 Sheepshead has increased.

5.2.4 Estimated Recreational Discards/Bycatch

Anglers in Florida often released less than 40% of Sheepshead they caught prior to 1997 on the Atlantic coast and prior to 1994 on the Gulf coast (Table 5.14, Figure 5.15). Since then, the number of Sheepshead released alive averaged 56% and 62% of the total catch on the Atlantic and Gulf coast, respectively. Much of this can be attributed to the increased minimum size limit implemented in 1996 though releases were already increasing before 1996. On the Atlantic coast, the number of Sheepshead released alive averaged about 76,825 fish during 1982–1990, then increased slowly to a peak of 321,559 releases in 1995. Since then annual number released alive have averaged 388,436 fish. On the Gulf coast, the number of releases was highly variable during the 1980's, ranging from 229,200 to 1,366,850 individuals. During the 1990's prior to the implementation of the size limit, the annual number of Sheepshead released alive averaged 874,000 individuals. Since 1996 the number of Gulf coast releases of Sheepshead has averaged 1,180,589 fish.

The estimated lengths of Sheepshead released alive ranged between 6 and 10 inches FL, with a peaks at 9 or 10 inches 1996. They simply reflect the assumptions made on the sizes of released fish. The corresponding age composition mostly included age-1 through age-5, generally peaking at age-2 (Figure 5.21; Table 5.16).

5.2.5 Estimated Recreational Catch Rates (CPUE)

The number of directed trips in the recreational fishery was estimated for all members of the Sheepshead cluster (Table 5.14; Figure 5.22). On the Atlantic coast, fishing effort trended up from 379,316 trips in 1982 to 3.1 million trips in 2007. It declined thereafter, ranging between 1.4 and 2 million trips. During 1982–1993, the directed trips on the Gulf coast were of the same magnitude as those trips on the Atlantic coast, but leveled off since 1994 (average: 1 million trips annually). The statewide number of directed trips trended similarly as the number of directed trips on the Atlantic coast (Figure 5.22).

Based on MRFSS/MRIP intercepted trips, the binomial sub-model on proportion positive trips (PPT) and the lognormal sub-model on the total number of fish caught per successful trip on the Atlantic coast were: PPT = Wave + Year + number of anglers + Area and log(number of fish/trip) = Fishing mode + wave + Year + Hours fished. On the Gulf coast, the retained sub-models were: PPT = Wave + Area + Year and log(number of fish/trip) = Wave + Fishing mode + Year + Hours fished + Area + Avidity + number of anglers. With the retained factors, the GLIM reduced the mean deviance of the proportion positive trips by 8.5% on the Atlantic coast and by 10.7% on the Gulf coast; it reduced the mean deviance of the recreational positive trips model by 5.5% on the Atlantic coast and by 11.5% on the Gulf coast (Table 5.17).

The standardized recreational CPUE of Sheepshead (Figure 5.23; Table 5.18) indicated that, on the Atlantic coast, the total number (Type A1+B1+B2) of Sheepshead per angler-trip declined steadily during 1991–2000, from 1.2 to 0.5 individuals; after a slight increase in 2001, the CPUE declined again until 2007 before showing a noisy but generally increasing trend. On the Gulf coast, the recreational CPUE trended up during 1991–2005, varying between 1.2 and 2.1 fish. It declined during 2006–2008 to about 1 fish but rebounded thereafter with values ranging between 1.4 and 1.7 individuals.

5.3 Fishery-Independent Survey Data

Fishery-independent data came from the FWC's Fishery Independent Monitoring (FIM) program. Only records based on a stratified random survey were considered for Apalachicola Bay, near Cedar Key, Tampa Bay, Sarasota Bay, Charlotte Harbor, the southern and northern Indian River Lagoon, and the St. Johns River area.

5.3.1 Data Collection Methods

5.3.1.1 Survey Methods

From 1996/1997, the FWC's FIM program used a stratified random design to collect data on animal populations. Strata were primarily defined by depth, shore type (overhanging or not), and bottom vegetation (seagrass or not). This program also collects length, weight, sex, and material for age determination while monitoring abundance of young-of-the-year (YOY; ≤ 40 mm SL, age-0) and larger fishes.

YOY Sheepshead indices were based on collections made using a 21.3-m center-bag seines deployed during April through July, considered to be recruitment window. Most YOY data on the Atlantic coast were made in the northern Indian River Lagoon during 1998–2015. On the Gulf coast the YOY survey has been consistently conducted since 1996/1997 in portions of Charlotte Harbor and Tampa Bay.

Post-YOY Sheepshead (individuals ≥ 100 mm SL, assumed to be age-1+ old) data were collected since 1997 in 183-m haul seines in the Indian River Lagoon from the Banana River south to Jupiter Inlet and since 2001 in the St. Johns River. Gulf coast post-YOY Sheepshead data were collected using 183-m haul seines from 1996 in Tampa Bay and Charlotte Harbor, 2009 in Sarasota Bay, 1997 in Cedar Key, and 1998 in Apalachicola Bay.

5.3.1.2 Sampling Intensity

During the recruitment window (April–July), between 379 and 1,413 bag-seine sets have been made on the Atlantic coast, and between 1,332 and 2,412 sets on the Gulf coast (Table 5.19). Beginning in 1996/1997, the 183-m haul seine sets have ranged between 395 and 614 on the Atlantic coast and between 312 and 924 on the Gulf coast. The numbers of Sheepshead captured varied considerably for the YOY surveys. On the Atlantic coast, age-1+ Sheepshead collected using the 183-m haul seine survey generally were of the same magnitude until 2010, dropped substantially in 2011, and increased sharply since 2012. On the Gulf coast, age-1+ Sheepshead sampled with the 183-m haul seine trended up over time.

The previous time series of sampling intensity on the Atlantic coast related to the Indian River Lagoon prior to 2001, and included data collected from the St. Johns River area since 2001. The number of sets made in the St. Johns River area averaged 47% and 32% of the coast wide total number of sets for the 21.3-m bag seines and the 183-m haul seine, respectively, but a few number of Sheepshead have been collected each year by those surveys, averaging about 6% annually.

The Gulf coast time series of sampling intensity also include collections made in Sarasota Bay since 2009. Overall, the southwest sampling areas (Tampa Bay–Charlotte Harbor) represented the bulk of sets made (average: 65% for the 21.3-m bag seine surveys and 58% for the 183-m haul seine surveys) and Sheepshead captured (average: 91% for the 21.3-m bag seine surveys and 81% for the 183-m haul seine surveys).

5.3.1.3 Biases

The stratified random sampling design should reduce the variance of the catch rate and should be unbiased if sampling is representative of the abundance of Sheepshead in an area. Attempts were made to eliminate any known bias induced by changes in the survey design by utilizing only strata that have been consistently sampled over time.

5.3.1.4 Biological Sampling

Up to 20 Sheepshead-per-size-class captured during sampling were measured for standard length (SL) and all were counted within each size class. When more than 20 individuals of Sheepshead were encountered then length frequencies of the 20 fish were expanded to the total number caught to estimate the sample catch length frequency. All Sheepshead used in the analysis of the YOY catch rates were less than or equal to 40 mm SL and were assumed to be age-0. In the haul seine sets, if five or fewer Sheepshead were captured they were retained and brought back to the lab where weights and lengths were measured, sex was determined and sagittae were removed for age determination. The numbers of Sheepshead sampled for ages from the haul seine surveys were the main source of Sheepshead used in the year-specific ALKs during 1997–2015 on the Atlantic coast and during 1993–2015 on the Gulf coast (Table 5.4).

Estimated annual length frequencies for Sheepshead caught in the 183-m haul seines showed a wide size range with most of the catch ranging from 3 through 18 inches FL (Table 5.20).

5.3.1.5 Ageing methods

Sheepshead sampled from the FIM program collections had sagittae (otoliths) removed, cleaned, and stored dry. Age determinations were made based on the number of annuli recognized on otolith sections viewed under reflected light. The ages of Sheepshead in the haul seine catch were estimated using ALKs applied to length-frequency information that had been expanded to the entire sample of Sheepshead. Ages of Sheepshead were by convention incremented on January 1 each year to align ages with other calendar-based statistics. This meant that Sheepshead labeled as age 1 for the modeling exercise were approximately 9–21 months of age based on peak spawning in early April.

5.3.1.6 Development of Estimates

YOY abundance indices of Sheepshead were developed using data from the FIM 21.3-m seines deployed during the recruitment window (April–July) in various sampling bays/rivers. Calculations for the northwest (collections from near Cedar Key and Apalachicola Bay) and northeast (collections from the St. Johns River area) Florida proved problematic, because few or no Sheepshead were captured and many strata surveyed were empty. Similarly, data from the 183-m haul seine deployments in various rivers/bays were used to develop abundance indices of age-1+ old Sheepshead. Abundance indices based on the 183-m haul seine surveys also served to derive age-specific indices for Sheepshead.

Standardized catch rates were estimated using a delta lognormal modeling approach (Lo *et al.* 1992) to account for various sources of uncertainty in the observed number of YOY Sheepshead per 21.3-m seine set and in the observed number of age-1+ old Sheepshead per 183-m haul seine set. With this modeling approach, one model estimated the probability that a set of 21.3-m seines and a set of 183-m haul seine would catch individuals assuming a binomial (presence/absence) distribution (logit link). The other model was based on non-zero catches (or successful sets) to estimate the number of individuals per 21.3-m seine set and per 183-m haul seine set assuming a lognormal distribution (identity link).

Potential variables utilized in the index development were subdivided into category effects to reduce the number of empty strata about the catch-rate response. The factors created were year, month, bay/river, bottom vegetation type (submerged aquatic vegetation, other), bottom sediment type (mud, sand), temperature, salinity, and shore type (emergent vegetation, terrestrial managed, other). The year-specific marginal means estimates and standard errors of the above two sub-models (binomial for presence/absence, lognormal for positive catches) were used to generate distributions of (linear) estimates for each sub-model from 10,000 Monte Carlo simulations. These distributions were first back-transformed and then multiplied to provide an estimate of the year-specific mean catch rate and its variability. Analyses were based on only main effects and were done using the SAS version 9.3, whereby only factors that explained more than 0.5% of the residual deviance (a measure of variability)/degree-of-freedom were retained in the models.

The factor bottom sediment type caused the lognormal sub-model not to converge when analyzing YOY Sheepshead data; so this factor was dropped from analyses. All candidate factors were considered for the development (without major problems) of the age-1+ Sheepshead data.

To develop age-specific indices, the total number-at-age of Sheepshead caught each year was divided by the total number of sets made using the 183-m haul seine surveys. The breakdown of age-specific indices was made possible by using estimates of the age composition of Sheepshead in aggregate samples. These age composition estimates were made by applying ALKs (pertaining to haul seine collections only) to length frequencies of captured Sheepshead.

5.3.2 Catch Rates (Numbers)

The sub-model on proportion positive sets (PPS) and lognormal sub-model on catch per successful set were as follows for the YOY abundance index: PPS = Bay + Salinity + Year + Shore and log(CPUE) = Salinity + Bay + Year on the Atlantic coast; PPS = Bay + Month + Bottom Vegetation + Year + Shore and log(CPUE) = Bottom Vegetation + Year + Bay + Month + Salinity + Temperature on the Gulf coast. With the retained factors (Table 5.21), the GLIM reduced the mean deviance of the proportion positive 21.3-m seine sets by 18% on the Atlantic coast and by 15.35% on the Gulf coast; it reduced the mean deviance of the 21.3-m seine positive sets model by 8.35% on the Atlantic coast and by 12.45% on the Gulf coast. For the age-1+ abundance index, PPS = Year + Bay + Month + Salinity and log(CPUE) = Bay + Year + Salinity + Temperature on the Atlantic coast; PPS = Bay + Salinity + Month + Year and log(CPUE) = Year + Bay + Month on the Gulf coast. The GLIM reduced the mean deviance of the proportion positive haul seine sets by 13.3% on the Atlantic coast and by 6.2%% on the Gulf coast; it reduced the mean deviance of the haul seine positive sets model by 8.5% on the Atlantic coast and by 7% on the Gulf coast (Table 5.22).

The indices of abundance of YOY Sheepshead varied without obvious long-term trend, but showed periodic highs (presumably strong year-classes) in 1999–2001, 2004/2005, 2009 and 2013 on the Atlantic coast and in 2000, 2004, 2008, and 2014 on the Gulf coast (Figure 5.24, Table 5.23). The age-1+ index of abundance of Sheepshead was also variable with periodic highs and lows generally trending down on the Atlantic coast until 2011; on the Gulf coast, that index trended steadily up from 1996 through 2003–2005 after which period it also showed periodic highs and lows (Figure 5.25).

Catch rates at age of Sheepshead captured in the haul seines were highest for ages 2–6 on both coasts of Florida (Table 5.24). On the Atlantic coast, the age-0 index peaked similarly as the YOY index in 1999–2001, 2004, 2009 and 2012/13. The 1999–2001 strong year-classes can be seen in the high catch rates for age-2 Sheepshead in 2002, age-3 Sheepshead in 2003, age-4 Sheepshead in 2004, and age-5 Sheepshead in 2005, and so on. Similar patterns can be seen in the 2004, 2007, 2009, 2012 and 2013 year-classes.

Age-0 index on the Gulf coast indicates strong year-classes in 1997, 1999, 2000, 2003, 2008, 2009, and 2014. The 1997, 1999, 2008, 2009 and 2014 year-classes also show peaks in abundance at older ages in subsequent years. The YOY index from the 23.1-m seines and the age-0 index developed from the haul seines suggest that 1997, 2001, 2003, 2008, and 2014 were good years in terms of Sheepshead recruitment on the Gulf coast.

5.3.3 Length/Weight/Catch-at-age

The generated YOY index (Table 5.23) represented age-0 Sheepshead. The estimated catch-at-age of Sheepshead caught by the haul-seine surveys was mostly age-0 through age-7 (Table 5.25 – note that the total number of age frequencies is smaller than the total number of length frequencies in Table 5.20; this is because individuals caught in some length bins, especially beyond 17-inches FL, had no corresponding ages in ALKs developed for haul seine collections). Given the different levels of effort used to capture Sheepshead each year (e.g., Table 5.19), these age frequencies reflected relative abundance among ages within each year only. Length-at-age, as used as an intermediate step to estimate ages, were given as part of ALKs (see Section 5.1.1.4).

6 Assessment

6.1 Trend in Abundance

A key assumption underlying stock assessments is that the abundance of a resource is reflected in catch rates. Fishery-independent indices and, whenever possible, indices by specific ages, should preferably be used (The National Research Council 1998). For this Sheepshead stock assessment, the catch rates used to tune the model are from FWC's FIM program's stratified-random 21.3-m beach seines for YOY Sheepshead and 183-m haul seine for all ages and, where necessary, by age of Sheepshead (Sections 5.3.2 and 5.3.3), as well as total catch rates from the recreational fishery (Section 5.2.5).

Note that the only biomass index developed in this assessment is the standardized commercial catch rates of Sheepshead (weight per-trip). However, commercial catch rates are commonly considered not to be reliable indices of stock abundance due to changes in regulations that affected the amount and sizes of Sheepshead that could be legally landed. Such catch rates can also be market-driven.

6.2 Comparison of Abundance Indices

The YOY index developed using the 21.3-m bag seine data and the catch rates for age-0 pertaining to the haul seine collections show consistent trends (Figure 6.1). In contrast, the age-1+ index based on FIM haul seine collections and the MRFSS/MRIP catch rates depict differently the Sheepshead populations in Florida; they are even uncorrelated especially on the Atlantic coast where they diverge in most years (Figure 6.2). This is perhaps because these indices are rooted in different sampling schemes and because their selectivity patterns link them differently to the corresponding age groups in the populations. In such situations where an index data set can possibly be unrepresentative and can propagate uncertainty in the assessment results, there may be need to create alternative assessment models, in each of which both indices are included or one index is omitted (Francis, 2011). This assessment strategy is meant to indicate (to managers) that one of these models is likely correct but we do not know which one.

The MRFSS/MRIP catch rates were assumed to be unrepresentative of the Sheepshead populations. An alternative to running an assessment model with or without the MRFSS/MRIP catch rates would be to link their selectivity to the corresponding fishery. The FIM-based haul seine index was considered representative because it comes from scientific surveys and because the haul seine samples were the basis of age-0 catch rates that appeared consistent with the YOY index.

6.3 Assessment Models

Three assessment models were used: (1) the catch curve analyses; (2) the Age-Structured Assessment Program (ASAP, version 3.0.17, also referred to as ASAP3); and (3) the Stock Synthesis (version 3, SS3) Program. ASAP3 and SS3 are programmed in ADMB and are available at NMFS's Northeast Fisheries Science Center's Assessment Toolbox (http://nft.nefsc.noaa.gov/). The catch curve analyses were performed using the numbers of fish caught by age by the FIM haul seines to get a rough idea of the levels of total mortality rates. SS3 model was the primary assessment model, whereas ASAP was used for continuity and comparison purposes. This section describes the SS3 model and related results while the description and results from the catch curve analyses and ASAP model are provided in Appendices 16.1–16.5.

6.3.1 Stock Synthesis (SS) Model Description

6.3.1.1 Overview

Stock synthesis is an integrated, statistical catch-at-age model that allows for multiple fisheries/fleets, discards, and tuning indices (Methot and Wetzel 2013). In this assessment the SS version 3.24s (Methot and Taylor 2011) is employed as primary assessment tool, because it has been rigorously tested in previous assessments and is now commonly used (Methot and Wetzel 2013).

The main value in using SS over statistical or error-free catch-at-age models (e.g., ASAP) is that SS can be constructed using relatively unprocessed input data and model predictions dynamically integrate many of the important process driving the distribution and abundance of marine fishes (e.g., mortality, recruitment and growth). Since many of these processes tend to be highly correlated with one another (e.g., natural mortality and steepness), modeling these processes simultaneously provides a more robust prediction of stock status. This is because integrating these processes allows for enhanced accounting of uncertainties in the input data and variables.

Similar to statistical catch-at-age models, SS is comprised of three subcomponents: (1) a population subcomponent that estimates the numbers/biomass at age using natural mortality, growth, fecundity, etc.; (2) an observational sub-component that consists of observed (measured) quantities such as indices of relative abundance or proportion at length/age; and (3) a statistical sub-component that uses likelihoods to quantify the fit of the observations to the recreated population (Methot and Wetzel 2013).

6.3.1.2 SS Model Configuration and Equations

SS was employed as a length-based (length in cm TL), age-structured population model. The available literature on Sheepshead indicates genetic variability between the Atlantic and Gulf coasts (Section 3.1). However, little is known about migration patterns or cross-breeding between these two genetic stocks of Sheepshead. Thus, similar to previous assessments, two separate SS models were developed, one for the Atlantic coast and another for Gulf of Mexico, assuming no emigration or immigration between stocks. Model configurations were consistent between the two coasts, though some input data (e.g., growth parameters, L_{max}, Age_{max} and timeframes of abundance indices; see Tables 6.1 and 6.2) vary between the Atlantic and Gulf of Mexico SS models.

SS models were initiated in 1982. Data collection for the commercial and recreational fisheries, as well as the FIM survey data were assumed to be continuous throughout the year, thus a seasonal component to the removals and biological predictions was not modeled. Currently, little is known regarding discard mortality or released alive proportions for the commercial fishery. Therefore, the models were set up so that all commercial landings were assumed to be total catch/retained catch (in metric tons). For the recreational fishery, we have modeled the landings as the harvest (i.e., retained catch in thousands of numbers) and included the B2s (released alive) as total discards (in thousands of numbers). We assumed a 1% discard mortality on the recreational B2s and a 5.5% discard mortality was used for a sensitivity run.

6.3.1.3 Life History Parameters

The natural mortality rate (*M*) was solved for in order to derive age-specific mortality based on Lorenzen (2005). Age-3 was used to constrain the Lorenzen curve because age-3 is the age at which the von Bertanlanffy curve begins to level-off (Figure 2.5). *M* at age 3 for the Atlantic and Gulf model was initialized at 0.33 and 0.32, respectively (based on the Lorenzen curve), with an upper bound set to 0.35 and a lower bound set to 0.1. A symmetrical beta prior (i.e., a smooth U-shaped prior) was used to constrain the *M* estimate within realistic bounds, using a standard deviation (SD) of 10.

Growth was modeled using a three parameter von Bertalanffy equation, which requires three initial parameter estimates (L_{min}, L_{max}, and *K*). The length at recruitment (age-0) is equal to the lower limit of the first population length bin, which was 2 cm (TL). After reaching A_{min} (age 0.5), fish grow according to the von Bertalanffy equation. In SS, the initial L_{min} value corresponds to the length-at-age used to force the Lorenzen curve (i.e., age-3). For the Atlantic model, the L_{min} was initialized at 17 cm, and for the Gulf of Mexico model the L_{min} was initialized at 14 cm. The initial L_{max} value was set equal to the approximate length where the von Bertalanffy curve asymptotes (Figures 2.3 and 2.4) for both regions. *K* was initialized at 0.23 for the Atlantic model and 0.26 in the Gulf of Mexico model. These 3 parameters were solved for, but were constrained using a symmetrical beta prior type. Two additional parameters are used to describe the variability in size-at-age; these parameters represent the CV_{young} (length at A_{min}) and CV_{old} (length at A_{max}; age max = 25 in the Atlantic model and age 20 in the Gulf of Mexico model). These two parameters were also solved for without any prior-type assumptions.

A one-gender model was used in SS model configurations, assuming that the sex-ratio at birth is 50% females. A length-logistic maturity option was applied, where the first mature age was set to age 2 (see Section 2.2). The length at 50% mature was initialized at

31 cm in the Atlantic model and 32 cm in the Gulf model, with a fixed slope set to -0.11 in both models (Liao *et al*. 2009).

6.3.1.4 Stock-Recruitment Parameters

To facilitate the estimation of the Beverton–Holt stock–recruitment steepness (*h*) in both SS models (and ASAP models), an empirical distribution of *h* was constructed. This distribution results from the combination of a meta-analytic allometry between maximum recruit survival rates (α) and asymptotic lengths (L_∞) with female Sheepshead's unexploited spawning biomass per-recruit (Φ_0, Figure 6.3). The following steps were involved in its construction. Each trio of available von Bertalanffy growth parameters and each pair of available weight-length scales and exponents of Sheepshead were treated as valid, but all data-points of those parameter sets were considered to be characterizing scientific uncertainty. Because those growth parameters were linearly and significantly related, they were jointly simulated as multivariate normal distributions (1,000 iterations) given their empirical mean vectors and covariance matrices. The α–L_∞ relationship then served to infer empirical values of α for each Sheepshead's drawn L_∞ value, provided this value fell within the range of the relationship in question. Monte Carlo simulations were finally used to propagate the uncertainty in growth parameters into constant natural mortality ($M = 4.118K^{0.73}L_\infty^{-0.33}$; Then *et al.* 2015), natural mortality-at-age ($M_{\text{age}} = \frac{\text{M}}{\text{K}}\log\left[1 + \frac{\text{L}_\infty}{\text{L}_{\text{age}}}(\text{e}^{\text{K}} - 1)\right]$), Φ_0 (calculated using standard techniques), $\alpha\Phi_0$ and h [$h = \alpha\Phi_0/(4 + \alpha\Phi_0)$].

A Beverton–Holt stock–recruitment relationship was used, whereby three parameters in both SS models were estimated ($\text{Ln}(\text{R}_0)$, h, and sigma R). R_0 is the unexploited equilibrium recruitment, which was initialized in log-space at 15.42 (i.e., about 5 million numbers of recruits), and was solved for using bounds of 5 to 20 (with no prior-type assumptions). The parameter h was initialized at 0.72, and was bounded between 0.57–0.92 (Figure 6.3) with a symmetrical beta prior type and a SD of 10 (to keep it within these bounds). Sigma R was initialized at 0.6, bounded between 0.2–1.2, with no assigned prior type.

6.3.1.5 Initial Conditions

The starting year of both SS models is 1982. Removals of Sheepshead are known to have occurred in the Southeastern US since the late 1930s, and thus the stocks on both coasts were not assumed to be at equilibrium at model start. Given the moderate to low precision for the recreational fishery data, which makes up the majority of the catch since recreational statistics have been collected, attempts at a historical reconstruction for Sheepshead were considered unreliable. The equilibrium catch estimates were assumed to be 50% of the 1982 catch estimates for both the commercial and recreational fisheries.

The 1982 *F* estimates for the commercial and recreational fisheries were initialized according to the upper limit of the 1982–1996 *F* values from the 2011 Sheepshead assessment. For the commercial fishery, the initial *F* estimates were solved for by bounding the initial input between 0.0018 and 0.3 for the Atlantic model and between 0.0013 and 0.1 for the Gulf model, with no assigned prior type. For the recreational fishery, the initial *F* was bounded between 0.1 and 0.62, with a symmetrical beta prior type (and SD = 1). Based on observational landings in 1982, these *F* estimates are assumed to be of an appropriate magnitude at SS model initialization.

6.3.1.6 Length and Age Comps

Landings input data are, (1) the annual commercial landings (metric tons), (2) the annual recreational landings (Type A+B1 in thousands of numbers), (3) the annual recreational released discards (Type B2 in thousands of numbers) and, (4) the recreational discard mortality rates (percent dead). Inputs for abundance indices are, (1) the recreational CPUE (number of fish caught per angler-trip), (2) the FIM young-of-the year (YOY; number of fish caught per seine set), and (3) the FIM haul seine age-1+ (number of fish caught per set). Length frequencies by year of landings were available from both the commercial and recreational fisheries, as well as from the FIM haul seine survey, and were converted to proportions at length before inputting into the SS models. Note that: (1) the length compositions pertained to biological samples, and (2) the landings of the commercial fishery were treated as retained catch, as the related discards and release proportions are unavailable. In base model runs, the proportion of dead discards from the recreational fishery is assumed to be 1% of the total discards. Effective sample size (*Nsamp*) is used to help predictions of proportions based on the multinomial likelihood for the landing and index compositions. Due to large sample sizes (*Nsamp* > 200) associated with the annual length frequency data, we use the square root of the actual sample size, which keeps sample sizes below 200 for all years.

In addition to the length compositions, age composition inputs for the Atlantic SS model include, (1) the commercial length-at-age compositions (LAA), (2) the recreational LAA (Type A+B1), and (3) the FIM haul seine survey LAA. For the Gulf coast, commercial LAA data was not available. Thus, in the Gulf of Mexico SS model LAA data is only from the recreational fishery and the FIM haul seine survey. Fishery-related input data for both SS models are summarized in Tables 6.1 and 6.2.

6.3.1.7 Selectivity Blocks and Functions

Two selectivity blocks (1982–1995 and 1996–2015) were assigned in SS models. These distinct blocks are used to represent the enactment and implementation of management regulations directed at Sheepshead in 1996 for the recreational fishery, and include the change in recreational discards (based on the implemented, 12” TL minimum size limit). The selectivity for the FIM YOY index in both SS models was set up so that the expected survey abundance was equal to the age-0 recruitment (i.e., no length/age composition data is input, nor is a selectivity function applied).

Because SS is primarily a length-based model, selectivity by fleet (commercial and recreational) and for the FIM haul seine survey was applied as a length-based, simple logistic function. Furthermore, the fact that there is high variability in the length-at-age data for Sheepshead (Figure 2.4), a simple logistic function was assumed to be most appropriate for representing the selectivity of the commercial fishery. The implementation of the entangling net ban changed the gear type from entangling nets to cast nets, in 1995. However, since there are no data on discard mortality from the commercial fishery, only the selectivity parameters change during this time period in the SS models.

The recreational fishing fleet was assigned discards. Thus, the length-based, single-logistic selectivity pattern has associated with it both retention and discard parameters. A length-based, logistic function is used for retention and discard mortality, and the associated input parameters for each are the inflection point, slope, asymptotic retention and the male offset (for 2 sex models). The recreational fleet’s selectivity and retention parameters changed according to the block pattern described above, from 1996–2015 (to reflect the implementation of the 12” minimum size limit).

For the FIM haul seine survey a simple logistic selectivity function was assigned, because this gear type can select all lengths of Sheepshead, as indicated by the observed cumulative proportions.

All selectivity parameters for each fleet/survey were solved for, with the exception of the discard mortality parameters for the recreational fleet. In some instances, a symmetrical beta prior type was used to keep parameter estimates within bounds. Input values used to initialize the selectivity for the commercial, recreational and FIM survey include the initial inflection point and the 95% width for the logistic function, the upper and lower bounds and any prior type or SDs (Tables 6.1 and 6.2).

6.3.1.8 Assumed Error in the Fishery-Dependent Input Data

The commercial landings were assumed to have a constant standard error (log-space) of 0.11 (the average CV of catch across all years), while the recreational landings were assumed to have a constant error equal to 0.19 (the average CV of catch across all years). A log-normal error type was used for the recreational CPUE and indices of abundance from FIM YOY and FIM haul seine surveys, where the standard error was derived from the annual index CVs by assuming $SD = \sqrt{(Ln(CV^2 + 1))}$. As such, the log values for the model tuning indices were assumed to be linearly related to abundance.

6.3.1.9 Parameters Estimated in SS Models

A total of 59 parameters were estimated in base model runs, in both the Atlantic and Gulf of Mexico SS models (Tables 6.1 and 6.2). Since the recommended SS ‘hybrid’ *F* mode was used, year-specific continuous *F* rates were not estimated, which greatly reduced the total number of parameters necessary. Use of the continuous *F* option tended to produce similar model estimates during preliminary model runs. The estimated parameters consisted of six major groups: (1) natural mortality (*M*), (2) growth parameters (L_{min}, L_{max}, *K*, $CV_{\_young}$, $CV_{\_old}$), (3) stock–recruitment parameters (Ln(R0), *h*, sigma R); (4) recruitment deviations (1982–2015); (5) initial *F*s for 1982; and (6) length-based selectivity parameters for the logistic functions. Parameter bounds were selected to be sufficiently wide to avoid truncating the searching procedure during maximum likelihood estimation. The soft bounds option in SS was utilized when running the assessment model. This option creates a weak symmetric beta penalty on selectivity parameters to move parameters away from the bounds (Methot 2011).

6.3.1.10 Model Convergence

Model convergence was assessed using a jitter analysis, where the initial values used for minimization were randomly adjusted with the intention of causing the search to traverse a broader region of the likelihood surface. Starting values of all estimated parameters were randomly perturbed by 10% and 50 trials were run.

6.3.1.11 Uncertainty in Model Results

Uncertainty in parameter estimates and derived quantities resulting from uncertainty in data inputs was investigated using a parametric bootstrap approach. Bootstrapping is a technique used to estimate confidence intervals for model parameters or other quantities of interest. To conduct the bootstrap analysis, a built-in option within SS was used to create bootstrapped data-sets. This feature performs a parametric bootstrap using the error assumptions and sample sizes from the input data to generate new observations about the fitted model expectations. The model was refit to 300 bootstrapped data-sets and the distribution of the parameter estimates were used to represent the uncertainty in the parameters and derived quantities of interest.

6.3.1.12 Sensitivity Runs

Three sensitivity analyses were made, keeping the basic input data of the base run:

- Dropping the MRFSS/MRIP CPUE;
- Using Lorenzen M-at-age scaled to Pauly's nonlinear estimator (Then *et al*. 2015);
- Using an assumed 5.5% release mortality that was estimated for Portuguese sparids (Veiga *et al.* 2011).

6.3.1.13 Retrospective Analyses

The base model and sensitivity runs were subject to a retrospective analysis that removed successive years of data from the model for 5 years.

6.3.1.14 Projections

No projections were made.

6.3.2 SS3 Model Results

6.3.2.1 Measures of overall model fit

6.3.2.1.1 Landings

A constant standard error of 0.11 (log-space) for the commercial landings data and 0.19 (log-space) for the recreational landings led to precise fits to both sources of observational landings data (Figures 6.4 and 6.5).

6.3.2.1.2 Indices of Abundance

For each coast of Florida, the SS model was fit to one fishery-dependent index of abundance, the recreational CPUE, and two fishery-independent indices of abundance, the FIM haul seine age-1+ catch rates and the FIM YOY catch rates (Figures 6.6–6.11). Overall the base model predicted the observed index values fairly well.

6.3.2.1.3 Length Composition

The models were fit to length observations from the commercial and recreational fisheries, as well as the FIM haul seine survey. The model performed fairly well at predicting yearly length compositions, and even better when averaged across all years for each of the data sources (Figures 6.12–6.15), without any large residual patterns evident (plots not shown to preserve space, but available upon request).

6.3.2.1.4 Conditional Age-at-Length

Age observations were included in the model as conditional age-at-length in order to avoid double-counting the observations, since all age observations had corresponding length measurements used in the length composition data. Given the variability in the length-at-age for young (ages 1–5) Sheepshead (Figures 2.3 and 2.4), the model fits to the observed ages were poor. While conditional age-at-length is often used to improve estimates of the growth function, the growth parameters (e.g., *K*) in both models needed symmetrical beta prior-types in order to keep the parameter estimates within realistic ranges. Model fits to the age-at-length data are available upon request, but are not shown to preserve space.

6.3.2.2 Parameter Estimates

A list of all model parameters for each coast include estimated parameter values, initial parameter estimates, prior types (if applicable), prior values, and whether the parameter was fixed or estimated (Tables 6.1 and 6.2). Of the 59 active parameters in both the Atlantic and Gulf coast base models, 51 parameters were estimated. The models were more stable if parameters had the ability to vary during model runs.

6.3.2.3 Fishery Selectivity

The estimated selectivity patterns indicate that smaller fish were selected during the early time period (pre-1996) by the commercial and the recreational fleet (AB1 + B2), with larger fish being selected by both fleets in recent years due to the implementation of the 12” size limit (Figure 6.16 and 6.17). To reflect the changes in the retained catch caused by the implementation of the 12” size limit in 1996, we used a special block pattern that allowed us to have time-varying retention (Figures 6.16 and 6.17). These estimated selectivity and retention patterns, combined with estimated growth parameters, allowed the model to fit the observed length composition data well (Figures 6.12–6.15).

6.3.2.4 Recruitment

The predicted number of unfished (virgin) age-0 recruits in 1980 is 6.306 million in the Atlantic and 6.915 million in the Gulf base models. The estimated age-0 recruits remain on the same order of magnitude for all assessed years (Table 6.3 and 6.4, Figures 6.18 and 6.19). Mean recruitment across the entire time series was 5.636 million fish on the Atlantic coast and 8.184 million fish on the Gulf coast.

Although age-0 recruits are on average of the same magnitude across the time series, the recruitment was highly variable during the 1980s–early 1990s on the Gulf coast, but since about 1992 has been less variable with deviations from the predicted stock–recruit function around a mean of zero to +/− 0.4 (Figure 6.19). On the Atlantic coast, deviations were around a mean of zero in all years, except in the early 1980s, and in 2010 and 2012 (when deviations approached − 1.3, − 0.5 and 0.5, respectively (Figure 6.18).

6.3.2.5 Stock Biomass

In the Atlantic base model, total biomass and spawning biomass (SSB, sexes combined) were estimated to be 4,497 and 3,250 mt respectively in 1982 (Table 6.3), then declined steadily to 3,647 and 2,634 mt in 1996, when the 12” minimum size limit was enacted and its implementation became effective. Since 1996, the total biomass and SSB have remained relatively stable, averaging 3,734 mt annually and, 2,734 mt annually, respectively. In the Gulf base model, total biomass and SSB were estimated to be 5,910 and 4,585 mt in 1982 (Table 6.4). Both then declined, steadily to 2,597 and 1,820 mt up to 1996. However, total biomass and SSB estimates are slightly higher in recent years (1998–2015), averaging 3,234 and 2,289 mt, respectively.

6.3.2.6 Fishing Mortality

The fishing mortality rates estimated by the SS3 base models (Tables 6.3 and 6.4, Figures 6.20 and 6.21) andicate that the estimated commercial full F (F estimated across all ages) was low (between 0.02–0.05 year^{-1}) throughout the entire time series, on the Atlantic coast. In the Gulf coast model, the commercial F was 0.12 year^{-1} in 1992 and remained at this magnitude through 1994 (Table 6.4). For the recreational fishery, the full F (across all ages) increased from 0.18 (year^{-1}) and 0.10 (year^{-1}) in 1982 up to 0.28 year^{-1} in 1994 and 0.47 year^{-1} in 1992 on the Atlantic and Gulf coasts, respectively. Since the size limit regulation was implemented, the full F for the commercial fishery on the Atlantic and Gulf coasts has averaged at 0.03 and 0.06 (year^{-1}), respectively. The full F for the recreational fishery has averaged at 0.14 and 0.26 (year^{-1}), on the Atlantic and Gulf coasts (Tables 6.3 and 6.4). The summary, instantaneous fishing mortality rates for the most vulnerable age-groups (ages 1–6) were of the same magnitude and varied similarly as the commercial and recreational full F (Tables 6.3 and 6.4, Figures 6.20 and 6.21).

6.3.2.7 Parameter Uncertainty

The jitter analysis indicated that the base models converged on a global solution, as deviations from the derived base model parameters were deemed negligible (Figure 6.22 and 6.23). While this test cannot prove convergence of the two assessment models, it did suggest strong evidence to the support of our initial estimates for these two regions. Figures 6.24 and 6.25 present the derived density plots for parameter and reference point estimates from the bootstrap analysis, which are used to represent the uncertainty in the parameters and derived quantities of interest.

6.3.2.8 Sensitivity Analyses

Inputs with underlying assumptions and with different values have the potential to affect a model results. The effects of inputs tested are given in Sections 6.3.2.8.1–6.3.2.8.4.

6.3.2.8.1 Sensitivity of Base Model to a Release Mortality of 5.5%

Base models were insensitive to whether the discard mortality was 1% or 5.5% (Figure 6.26 and 6.27).

6.3.2.8.2 Sensitivity of Base Model to Equilibrium Catch Value

Base models were insensitive to whether the equilibrium catch value (a required, input estimate needed in the SS3 data file) was set to 50% or 75% of the 1982 catch estimate (Figures 6.26 and 6.27).

6.3.2.8.3 Sensitivity of Base Model to Pauly's Estimator of Natural Mortality

Base models were insensitive to M-at-age scaled using Pauly's nonlinear estimator of M (Figures 6.26 and 6.27).

6.3.2.8.4 Sensitivity of Base Model to Dropping the MRFSS/MRIP CPUE

Compared with SS3 base models, the model runs without the MRFSS/MRIP CPUE on the Atlantic coast produced slightly different estimates of SSB from 1995–2015 (Figure 6.26). This resulted in a slightly higher SSB in 2015- though, compared to the base model estimate, it is a relatively small difference in SSB (Figure 6.26). On the Gulf coast, the F

rate was slightly higher from 1995–2000, which causes the number of recruits and SSB to be smaller in 1995, and the SPR ratio to be higher during this period (Figure 6.27).

In response to those sequences of lower and higher parameter estimates when removing the MRFSS/MRIP CPUE, the estimated SSB was more optimistic than the base model estimates, for both coasts (Figures 6.26 and 6.27). Therefore, using the base model configurations is more precautionary.

6.3.2.9 Retrospective Analysis

No retrospective pattern was observed, for either the Atlantic or Gulf coast base model configurations (Figure 6.28 and 6.29).

6.3.2.10 Projection of Estimates

No projections were made.

7 Stock Status

7.1 Overfishing and Overfished/Depleted Definitions

There are no overfishing, overfished and depleted definitions for Sheepshead in Florida, and there are no control rules for determining the status of Sheepshead in Florida.

7.2 Analyzing the Possible Stock Status

In spite of the lack of pre-defined management reference points for Sheepshead in Florida, a (purely) hypothetical SPR of 30% and a (purely) hypothetical depleted level of 30% were employed to gauge the plausible Sheepshead stocks status on each coast of Florida. These SPRs and depleted levels were set as targets in SS3 model runs.The SPR of 30% was investigated because the related SSB is commonly used as threshold for overfished conditions and because the corresponding F level ($F_{30\%}$) is commonly advocated as an F_{MSY} proxy, F_{MSY} being an overfishing threshold.

Given these considerations, the ratios of annual F to $F_{30\%}$ ($F_t/F_{30\%}$) greater than one was assumed to be indicative of overfishing. In particular, given current F (F_{cur}) calculated as a geometric mean of F for the years 2013 throrough 2015, the ratio $F_{\mathrm{cur}}/F_{30\%}$ may suggest whether overfishing is or is not occurring.

The Sheepshead stocks were assumed to be overfished if the ratios of annual SSB to the SSB at $F_{30\%}$ (SSB_t/SSB@$F_{30\%}$) were less than one. The stocks may be currently overfished if the ratios of current SSB (geometric mean of SSBs during 2013–2015) to the SSB at $F_{30\%}$ is less than one. The static spawning potential ratios (sSPR) and the transitional spawning potential ratios (tSPR) were also developed and compared with a SPR target of 30%, while the ratio SSB/SSB unfished was compared with a depletion target of 30%.

Note that the sSPR is an indicator of the relative changes in fishing rates and not an indicator of the SSB size, while the tSPR indicates how close the age structure of a stock is to being rebuilt (GMFMC 1996). According to the GMFMC (1996), the tSPR can be used as a measure of overfished conditions in terms of wheter or not the age structure is distorted due to historical fishing patterns.

7.3 Possible Overshing Status

Table 7.1 summarizes the reference points obtained from SS3 base model runs. The trajectories of the *F* ratios (Figure 7.1, Table 7.2) indicate that overfishing of Sheepshead may have occured on the Atlantic coast in 1994 only and on the Gulf coast in 1988, 1989 and during 1992–994. The sSPR values convey a similar message (Figure 7.2, Table 7.3).

$F_{30\%}$ was estimated to be 0.14 year^{-1} on the Atlantic coast and 0.13 year^{-1} on the Gulf coast. The estimates of current *F* (F_{cur}) on the most vulnerable ages (ages 1–6) were 0.05 year^{-1} and 0.06 year^{-1}, respectively, leading to the ratios $F_{cur}/F_{30\%}$ = 0.36 on the Atlantic coast and $F_{cur}/F_{30\%}$ = 0.46 on the Gulf coast. These ratios are less than one. Therefore, overfishing may not be currently occuring on both coasts of Florida.

7.4 Possible Overfished Status

SS3 base model results suggest that the Sheepshead stock on Florida's Atlantic coast may have never been overfished (Figure 7.1; current SSB = 2,835 mt, SSB at $F_{30\%}$ = 1,467 mt and the SSB ratio = 1.93). These results concur with the tSPR (Figure 7.2, Table 7.3) and the spawning depletion, which always exceeded 30% (Figure 7.3). The tSPR and the spawning depletion were lowest during the early 1990's but trended up since 1996. The tSPR increase since 1996 suggests an expansion of the age structure for Sheepshead.

On the Gulf coast, Sheepshead may have been overfished during 1994–2001 (Figure 7.1, Table 7.2); they may not be currently overfished (current SSB = 2,638 mt, SSB at $F_{30\%}$ = 1,658 mt and the SSB ratio = 1.59). The trajectories of the tSPR (Figure 7.2, Table 7.3) and spawning depletion (Figure 7.3) are consistent with the previous results. The tSPR exceeded 30%SPR since 1998, when it started increasing steadily. The ratio $SSB_t/SSB@F_{30\%}$ and the spawning depletion exceeded, respectively, one and the depletion target of 30% since2002. Since then, these ratios trended up.

8 Comparison of Model Results

SS3, the Catch Curve Analysis (CCA) and ASAP differ greatly in complexity and, in particular, in input requirements and how they handle the processes modeled. For example, the CCA relies on very restrictive assumptions (e.g., constant recruitment, error-free age composition and equal vulnerability to fishing for ages above a prespecified age group). ASAP and SS3, on the other hand, are able to capture the temporal changes in the selectivity by blocks of periods and for the strucures of interest (by age for ASAP and by length for SS3), while allowing flexibility in the modeling of variable recruitments.

8.1 Total mortality

The CCA typically helps estimating total mortality (*Z*). It is appropriate to compare its results with *Z* inferred from ASAP and SS3 results. For ASAP, *Z* was the sum of constant *M* and the unweighted fishing mortality (*F*); for SS3, *Z* = commercial *F* + recreational *F* + the estimated *M*. On the Atlantic coast, the CCA produced *Z* values lower than those from ASAP and SS3, except in 1997 and 1998. The CCA-based *Z* in most years were rather similar to constant *M* and are deemed unrealistic. On the Gulf coast, the CCA-based *Z* were comparable with *Z* estimated with ASAP and SS3 since 2002 (Figure 8.1).

8.2 Fisheries Performance

Perhaps that the ratios $F_t/F_{30\%}$, $F_{cur}/F_{30\%}$, sSPR, tSPR, $SSB_t/SSB@F_{30\%}$, current SSB relative to SSB at $F_{30\%}$ and the spwaning depletion are the best indicators for comparing SS3 and ASAP model results in terms of the sheepsehead fisheries performance. First note that the ratios $F_{cur}/F_{30\%}$ and current $SSB/SSB@F_{30\%}$ (Sections 7.3 and 7.4 as well Section 16.5 in Appendix) inferred from both models suggest that Sheepshead are currently neither overfished nor undergoing overfishing on both coasts of Florida.

ASAP- and SS3-based F ratios on the Atlantic coast and ASAP- and SS3-based biomass ratios and spawning depletions on the Gulf coast generally were comparable and conveyed similar historical status of the Sheepshead stocks (Figure 8.2). Unlike the $F_t/F_{30\%}$ ratios based on the Gulf ASAP model, such ratios from the SS3 model indicated that the Shepshead stock was undergoing overfishing during the late 1980's–mid-1990's. Finally, the sSPR and tSPR from SS3 models were far more optimistic than those estimates from ASAP models on both coasts of Florida, and so were the biomass ratios and spawning depletions on the Atlantic coast.

9 Research Recommendations

9.1 Fisheries-Dependent Priorities

- Develop and implement an observer program to identify the magnitude and the size/age compositions of discards and quantify the release mortality for all commercial gear types.
- Develop and implement an observer program to quantify the magnitude of the recreational release mortality.
- Conduct field studies on size/age selectivity by gear type necessary to the assessment models.
- Continue length and age collections by gear type, especially in the commercial sector.

9.2 Life History Priorities

- Determine the patterns and triggers of inshore-offshore migrations.
- Determine any migration patterns or cross-breeding between the two genetic stocks of Sheepshead in Florida.
- Estimate/update information on spawning periodicity, fecundity, sex-ratio and maturity-at-age as these parameters largely affect the levels of the SSB.

9.3 Management Priorities

- Provide overfishing and overfished definitions and develop harvest control rules.

10 Minority Report

This assessment was not peer-reviewed within a framework that required consensus or minority reports. Members of the FWRI stock assessment group reviewed early summaries of the data and model runs, suggesting potential changes.

11 Description of Opinions

Not Applicable.

12 Justification of Why Not Adopted

Not Applicable.

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14 Tables

Table 2.1 Von Bertalanffy growth parameters, maximum observed fork length (L_{max}) and weight (W_{max}), longevity (t_{max}) and aging for Sheepshead in studies by various authors.

Location	Sex	L_∞ W_∞	K (yr^{-1})	t_0 (yr)	Lmax (mm)	Wmax (g)	Tmax (yr)	Aging Method	Source
Texas	Combined	437 mm	0.358		505			Mark-recapture	Matlock (1992)
Louisiana	Males	419 mm 1900 g	0.417 0.28	-0.901 -2.657	500		20	Otoliths	Beckman et al. (1991)
	Females	447 mm 2557 g	0.367 0.219	1.025 -3.061	500		20	Otoliths	Beckman et al. (1991)
Mississippi	Males	456 mm	0.409	-1.829	472[1]		6	Otoliths	Brown-Peterson et al. (2005)
	Females	424 mm	0.633	-0.759	502[1]		6	Otoliths	Brown-Peterson et al. (2005)
Northwest Florida	Combined	490.4 mm 2731.2 g	0.26 0.25	-0.42 -0.53	522		14	Otoliths	Dutka-Gianelli & Murie (2001)
	Males	509.2 mm 2934.9 g	0.23 0.23	-0.52 -0.53			14	Otoliths	Dutka-Gianelli & Murie (2001)
	Females	475.7 mm 2523.9 g	0.28 0.28	-0.46 -0.52			12	Otoliths	Dutka-Gianelli & Murie (2001)
Florida: Gulf coast	Combined	451 mm	0.242	-1.17			16	Otoliths	Murphy & MacDonald (2000)
	Males						14	Otoliths	Munyandorero et al. (2006)
	Females						14	Otoliths	Munyandorero et al. (2006)
	Combined	440.8 mm	0.252	-1.396	613	10880	20	Otoliths	This report
	Males	427 mm	0.253	-1.598	541	10880	20	Otoliths	This report
	Females	451.2 mm	0.24	-1.516	613	8056	17	Otoliths	This report
Florida: Tampa Bay	Combined	418.7	0.273	-0.981	524			Otoliths	Winner et al. (2017)
	Males	422.5 mm	0.255	-1.115			15	Otoliths	Winner et al. (2017)
	Females	419.1 mm	0.272	-1.099			15	Otoliths	Winner et al. (2017)
Florida: Atlantic	Combined	381 mm	0.39	-1.13				Otoliths	Murphy & MacDonald (2000)
	Males						18	Otoliths	Munyandorero et al. (2006)
	Females						16	Otoliths	Munyandorero et al. (2006)

	Combined	421.7 mm	0.232	-2.019	555	4573	25	Otoliths	This report

Table 2.1 Continued.

Location	Sex	L_∞ w_∞	K (yr^{-1})	t_o (yr)	Lmax (mm)	Wmax (g)	Tmax (yr)	Aging Method	Source
	Males	425.4 mm	0.223	-2.045	545	4126	25	Otoliths	This report
	Females	422.1 mm	0.229	-2.142	555	4573	23	Otoliths	This report
Florida (statewide)	Combined				760	9600			Florida Museum of Natural History - Ichthyology Department
	Combined	427.2 mm	0.254	-1.58	613	10880	25	Otoliths	This report
	Males	425.4 mm	0.242	-1.77	545	10880	25	Otoliths	This report
	Females	428.9 mm	0.255	-1.62	613	8056	23	Otoliths	This report
Georgia	Combined	498 mm	0.218		580		18	Otoliths	Fortuna et al. (Unpublished) *in* McDonough et al. (2011)
	Males	495 mm	0.233		580		18	Otoliths	Fortuna et al. (Unpublished) *in* McDonough et al. (2011)
	Females	502 mm	0.212		580		18	Otoliths	Fortuna et al. (Unpublished) *in* McDonough et al. (2011)
South Carolina	Combined	498 mm 3778 g	0.297 0.165	-1.1 0.548	603		23	Otoliths	McDonough et al. (2011)
	Males	499 mm	0.299		567		19	Otoliths	McDonough et al. (2011)
	Females	498 mm	0.297		603		23	Otoliths	McDonough et al. (2011)
	Combined	505 mm	0.29	-1.109	560		26	Otoliths	Wenner (1996) *in* Dutka-Gianelli & Murie (2001)
North Carolina	Combined				671 [1]	8370	8	Scales	Schwartz (1990)
Chesapeake Bay	Males	537 mm	0.31	-0.77	594		35	Otoliths	Liao et al. (2009)
	Females	556 mm	0.28	-0.9	623		35	Otoliths	Liao et al. (2009)
	Females						40	Otoliths	Liao et al. (2014)

[1] Data were reported as total length and were converted to FL

Table 2.2 Coefficients of weight-length (W-L) relations ($W=aL^b$) and length-length conversions (e.g., TL = a + bSL) for Sheepshead off Florida's Atlantic and Gulf coasts. Weight, standard length (SL), total length (TL), and fork length (FL) were compiled from multiple data sources (i.e., FIM and BIOSTAT).

weight, grams vs FL, mm					**SE**	
	a	**b**	**MSE**	**n**	**a**	**b**
Atlantic	0.000028	2.9812	22230	6728	0.000002	0.009499
Gulf	0.000039	2.9196	35204	9860	0.000002	0.010546
Male	0.000029	2.9755	22895	8955	0.000001	0.008265
Female	0.000045	2.8928	31349	5326	0.000004	0.014259
Combined	0.000036	2.9356	29194	18079	0.000002	0.007021

weight, grams vs TL, mm					**SE**	
	a	**b**	**MSE**	**n**	**a**	**b**
Atlantic	0.000019	2.9990	15500	6190	0.000001	0.008202
Gulf	0.000030	2.9225	36270	9697	0.000002	0.010830
Male	0.000022	2.9775	23685	9029	0.000001	0.008409
Female	0.000030	2.9163	29980	5382	0.000003	0.013883
Combined	0.000025	2.9525	26988	17551	0.000001	0.006868

weight, grams vs SL, mm					**SE**	
	a	**b**	**MSE**	**n**	**a**	**b**
Atlantic	0.000065	2.9105	16298	5894	0.000003	0.008399
Gulf	0.000105	2.8162	36172	9412	0.000007	0.010555
Male	0.000078	2.8731	24343	8680	0.000004	0.008410
Female	0.000118	2.7969	32973	5157	0.000010	0.014267
Combined	0.000091	2.8450	28402	16982	0.000004	0.006936

FL vs TL, mm					**SE**	
	a	**b**	**MSE**	**n**	**a**	**b**
Atlantic	2.1416	0.9038	37.25	6135	0.3242	0.0009
Gulf	0.1668	0.9163	51.69	10016	0.3121	0.0009
Female	1.3608	0.9085	40.12	9142	0.2985	0.0008
Male	0.2397	0.9127	39.98	5495	0.3899	0.0011
Combined	0.6689	0.9123	45.38	17641	0.2061	0.0006

FL vs SL, mm					**SE**	
	a	**b**	**MSE**	**n**	**a**	**b**
Atlantic	8.9471	1.1238	34.19	5827	0.3121	0.0012
Gulf	10.4348	1.1157	49.95	9699	0.3017	0.0011
Female	11.2387	1.1137	41.75	8776	0.3022	0.0011
Male	10.5831	1.1167	39.93	5259	0.3857	0.0014
Combined	9.0256	1.1209	45.72	17018	0.2047	0.0007

TL vs SL, mm					**SE**	
	a	**b**	**MSE**	**n**	**a**	**b**
Atlantic	8.8330	1.2370	56.14	5946	0.3929	0.0014
Gulf	13.3626	1.2095	90.80	9828	0.4037	0.0014
Female	12.6918	1.2187	74.06	8895	0.4001	0.0014
Male	12.9024	1.2167	61.93	5356	0.4766	0.0017
Combined	10.5249	1.2228	80.30	17439	0.2648	0.0010

Table 4.1. Annual commercial landings (pounds), recreational landings (adjusted Type A+B1; pounds), and combined landings (pounds) of Sheepshead on the Atlantic, Gulf, and both coasts of Florida during the period 1978–2015. The assessment used the 1982–2015-time series when landings of both fisheries were available.

	Commercial			Recreational			Combined		
	Gulf	Atlantic	Statewide	Gulf	Atlantic	Statewide	Gulf	Atlantic	Statewide
1978	225,559	165,614	391,173				225,559	165,614	391,173
1979	196,954	214,414	411,368				196,954	214,414	411,368
1980	260,289	148,973	409,262				260,289	148,973	409,262
1981	291,766	265,622	557,388				291,766	265,622	557,388
1982	172,162	364,023	536,185	1,238,048	1,226,117	2,464,166	1,410,210	1,590,140	3,000,351
1983	213,390	237,709	451,099	2,048,035	498,875	2,546,909	2,261,425	736,584	2,998,008
1984	169,502	234,175	403,677	2,085,864	1,487,680	3,573,544	2,255,366	1,721,855	3,977,221
1985	249,574	257,996	507,570	2,310,433	511,421	2,821,854	2,560,007	769,417	3,329,424
1986	293,363	284,965	578,328	840,811	900,636	1,741,447	1,134,174	1,185,601	2,319,775
1987	336,449	317,224	653,673	957,760	1,458,162	2,415,922	1,294,209	1,775,386	3,069,595
1988	384,575	292,438	677,013	2,891,181	942,929	3,834,110	3,275,756	1,235,367	4,511,123
1989	392,795	253,617	646,412	2,892,695	523,236	3,415,931	3,285,490	776,853	4,062,343
1990	419,237	356,278	775,515	1,391,785	760,010	2,151,795	1,811,022	1,116,288	2,927,310
1991	471,625	398,527	870,152	1,561,852	1,263,119	2,824,971	2,033,477	1,661,646	3,695,123
1992	640,207	402,517	1,042,724	3,261,636	1,160,457	4,422,093	3,901,843	1,562,974	5,464,817
1993	581,460	309,078	890,538	2,847,234	1,330,920	4,178,154	3,428,694	1,639,998	5,068,692
1994	644,103	340,875	984,978	1,568,188	2,061,430	3,629,618	2,212,291	2,402,305	4,614,596
1995	424,492	254,760	679,252	2,514,559	1,503,624	4,018,182	2,939,051	1,758,384	4,697,434
1996	148,081	153,340	301,421	1,633,233	914,743	2,547,976	1,781,314	1,068,083	2,849,397
1997	184,929	159,857	344,786	1,382,793	626,103	2,008,896	1,567,722	785,960	2,353,682
1998	157,262	146,398	303,660	1,614,470	613,100	2,227,570	1,771,732	759,498	2,531,230
1999	178,417	126,048	304,465	2,169,882	752,968	2,922,850	2,348,299	879,016	3,227,315
2000	183,691	210,503	394,194	1,616,249	835,588	2,451,837	1,799,940	1,046,091	2,846,031
2001	185,262	155,404	340,666	1,877,523	1,004,414	2,881,937	2,062,785	1,159,818	3,222,603
2002	153,942	147,191	301,133	1,517,136	662,396	2,179,531	1,671,078	809,587	2,480,664
2003	194,963	140,110	335,073	1,667,167	772,856	2,440,023	1,862,130	912,966	2,775,096
2004	162,850	123,709	286,559	1,522,286	490,471	2,012,756	1,685,136	614,180	2,299,315
2005	154,420	172,150	326,570	2,429,729	1,065,427	3,495,156	2,584,149	1,237,577	3,821,726
2006	135,971	164,507	300,478	1,547,690	645,407	2,193,096	1,683,661	809,914	2,493,574
2007	114,533	160,037	274,570	1,401,792	587,813	1,989,606	1,516,325	747,850	2,264,176
2008	93,282	173,449	266,731	1,224,424	528,011	1,752,435	1,317,706	701,460	2,019,166
2009	137,860	174,345	312,205	1,514,365	513,637	2,028,001	1,652,225	687,982	2,340,206
2010	194,554	145,466	340,020	911,857	822,061	1,733,918	1,106,411	967,527	2,073,938
2011	150,656	112,898	263,554	1,327,029	805,562	2,132,591	1,477,685	918,460	2,396,145
2012	159,699	130,265	289,964	1,376,186	624,221	2,000,406	1,535,885	754,486	2,290,370
2013	180,281	180,296	360,577	1,083,963	536,825	1,620,788	1,264,244	717,121	1,981,365
2014	199,602	167,569	367,171	1,952,491	1,262,612	3,215,103	2,152,093	1,430,181	3,582,274
2015	252,746	131,550	384,296	1,215,246	656,174	1,871,420	1,467,992	787,724	2,255,716

Table 5.1. Commercial landings (pounds) of Sheepshead by gear category on the Atlantic coast of Florida, 1978–2015.

	Cast nets	Entangling nets	Hook_and_lines	Others	unknown	Total
1978					165,614	165,614
1979					214,414	214,414
1980					148,973	148,973
1981					265,622	265,622
1982					364,023	364,023
1983					237,709	237,709
1984					234,175	234,175
1985					257,996	257,996
1986	66,232	70,359	108,083	13,958	26,333	284,965
1987	64,611	125,892	81,525	17,896	27,300	317,224
1988	38,924	123,892	65,812	8,586	55,224	292,438
1989	55,058	90,877	56,395	16,185	35,102	253,617
1990	90,306	151,209	67,235	12,625	34,903	356,278
1991	92,501	169,298	56,227	8,029	72,472	398,527
1992	106,062	218,759	58,729	14,156	4,811	402,517
1993	79,225	159,978	59,014	10,810	51	309,078
1994	54,437	205,816	66,708	13,910	4	340,875
1995	50,859	79,036	109,875	14,990		254,760
1996	88,082	893	60,311	4,054		153,340
1997	90,382	1,192	59,914	8,369		159,857
1998	67,976	1,507	63,268	13,647		146,398
1999	58,307	949	53,612	11,281	1,899	126,048
2000	97,335	308	69,798	39,387	3,675	210,503
2001	64,804	107	52,017	36,802	1,674	155,404
2002	66,831	162	49,646	30,547	5	147,191
2003	67,147	95	55,702	17,166		140,110
2004	56,512	2,403	46,006	18,788		123,709
2005	90,251	895	47,850	33,154		172,150
2006	64,320	44	50,076	50,067		164,507
2007	70,993	1,758	39,098	48,188		160,037
2008	89,142	92	44,058	40,156	1	173,449
2009	87,682	81	42,228	44,351	3	174,345
2010	65,380	91	40,121	39,874		145,466
2011	53,280	25	30,508	29,085		112,898
2012	63,731	6	38,444	28,084		130,265
2013	55,620	23	47,252	77,401		180,296
2014	45,028	23	35,639	86,879		167,569
2015	37,189	32	40,308	54,021		131,550

Table 5.1 (Cont.) Commercial landings (pounds) of Sheepshead by gear category on the Gulf coast of Florida, 1978–2015.

	Cast nets	Entangling nets	Hook_and_lines	Others	unknown	Total
1978					225,559	225,559
1979					196,954	196,954
1980					260,289	260,289
1981					291,766	291,766
1982					172,162	172,162
1983					213,390	213,390
1984					169,502	169,502
1985	30		662	93	248,789	249,574
1986	38,753	166,151	40,376	14,010	34,073	293,363
1987	40,723	195,434	40,202	15,288	44,802	336,449
1988	47,811	199,917	46,856	13,656	76,335	384,575
1989	70,299	200,701	57,038	16,604	48,153	392,795
1990	95,909	196,208	63,462	19,759	43,899	419,237
1991	89,975	314,379	44,227	15,157	7,887	471,625
1992	70,687	517,082	39,615	11,097	1,726	640,207
1993	61,375	480,418	24,851	10,812	4,004	581,460
1994	79,951	527,923	24,683	11,546		644,103
1995	118,484	251,860	37,752	16,396		424,492
1996	119,045	480	20,669	7,713	174	148,081
1997	127,980	554	42,632	13,742	21	184,929
1998	99,523	1,167	28,863	27,709		157,262
1999	118,698	251	21,663	35,691	2,114	178,417
2000	124,616	864	22,752	33,525	1,934	183,691
2001	131,729	140	24,550	27,526	1,317	185,262
2002	109,554	390	18,696	25,302		153,942
2003	139,205	130	19,662	35,966		194,963
2004	84,515	95	15,221	63,019		162,850
2005	106,068	139	11,020	37,193		154,420
2006	106,598	295	9,712	19,366		135,971
2007	87,781	2	11,597	15,153		114,533
2008	71,384	29	7,207	14,461	201	93,282
2009	87,417	68	11,281	39,094		137,860
2010	123,024	187	13,589	57,754		194,554
2011	83,404		13,830	53,422		150,656
2012	82,483		22,299	54,917		159,699
2013	101,872	20	20,261	58,128		180,281
2014	90,391	32	20,785	88,394		199,602
2015	101,645	26	18,369	132,706		252,746

Table 5.2 Estimated scales (a) and exponents (b) of the overall and year-specific weight (g)–fork length (inch) relationships for both sexes of Sheepshead sampled on the Atlantic and Gulf coast of Florida (the standard errors and mean squared errors of these parameters are also included; there were no estimates for 1999 on both coasts).

Coast	year	a	SE_a	b	SE_b	n	MSE
Atlantic	Overall	0.6751287	0.0180258	2.85499	0.00989	6724	25844.6
	1997	0.6405991	0.0626366	2.88026	0.03655	319	14303.4
	1998	0.4942744	0.0707017	2.97702	0.05516	267	13961.2
	2000	0.5484385	0.0709382	2.93861	0.04929	245	12135.4
	2001	0.6535691	0.0964844	2.85421	0.05461	279	28700.2
	2002	0.6677148	0.0538604	2.86323	0.02988	361	11307.4
	2003	1.3779638	0.1905068	2.57994	0.05109	373	41815.3
	2004	0.7816534	0.0740863	2.80174	0.0349	354	18459.9
	2005	0.5754932	0.055158	2.91586	0.03605	349	11267.6
	2006	0.4927841	0.0458547	2.98275	0.0341	297	14769.2
	2007	0.4113999	0.0404098	3.04995	0.03584	317	17519.5
	2008	0.4225028	0.038568	3.03666	0.03374	323	13556
	2009	0.6380425	0.0529793	2.88056	0.03077	281	10872.1
	2010	0.6342065	0.0413164	2.88108	0.02401	296	7407.66
	2011	0.6480533	0.0546549	2.87629	0.03081	314	14073
	2012	0.8669916	0.1312522	2.76074	0.05515	400	59678.8
	2013	0.5884561	0.0723782	2.90489	0.04565	616	55885
	2014	1.2075889	0.1253046	2.61174	0.03881	655	36415.3
	2015	0.4526916	0.0264268	3.01497	0.02158	567	10591.5
Gulf	Overall	0.7523392	0.0219456	2.79514	0.01076	9856	39159.5
	1994	0.9701398	0.099953	2.69487	0.03795	229	11018.8
	1995	0.9377037	0.0917586	2.73211	0.03787	358	8658.14
	1996	0.6637145	0.0578378	2.85146	0.03343	457	9541.19
	1997	0.551969	0.0616326	2.91213	0.04085	320	19870.8
	1998	0.3053896	0.0385022	3.1447	0.04589	155	12151.6
	2000	0.5155316	0.0493242	2.93962	0.03461	309	16161.5
	2001	0.8589257	0.2124814	2.75744	0.0896	419	153916
	2002	0.7776976	0.1204838	2.77737	0.05699	485	60331.1
	2003	0.8279787	0.0908755	2.74723	0.0402	427	22832.1
	2004	0.8728395	0.0800855	2.7397	0.03326	449	24939.7
	2005	0.7433372	0.0633992	2.79856	0.03171	495	12981
	2006	0.6954023	0.0776715	2.8286	0.04169	479	20758.4
	2007	0.637569	0.0595644	2.85849	0.03468	457	14917.7
	2008	0.5734572	0.045106	2.90046	0.02866	466	15744.5
	2009	0.6297608	0.0520103	2.85822	0.03084	523	13691.3
	2010	0.7325615	0.0746371	2.80637	0.0381	502	20972
	2011	0.9493228	0.1547519	2.71844	0.05977	560	77236.8
	2012	0.6980258	0.05878	2.81465	0.03107	590	17213.5
	2013	1.0044614	0.2453375	2.68521	0.09019	611	177380
	2014	0.8152681	0.0709433	2.75042	0.0322	672	20202.8
	2015	0.7858783	0.0558468	2.77813	0.0263	889	20401.6

Table 5.3 Sample sizes (N) of lengths taken from the Atlantic commercial fishery that were used to estimate gear-specific length frequencies and total number of Sheepshead landed each year (shaded fields: N < 40 fish; empty cells: no samples were available; those situations required some pooling).

	Cast net	Entangling nets	Hook_and_lines	Others	unknown	Total
1992		1428	2			1430
1993	3	667	18	20		708
1994	2	477	29	9		517
1995	78	153	33	2		266
1996	551	44	14	43		652
1997	928		157	529		1614
1998	195		153	77		425
1999	126		500	130		756
2000	252		122	517		891
2001	109		235	313		657
2002	141		53	58		252
2003	121		284	89		494
2004	81		41	146	2	270
2005	44		39	77	14	174
2006	127		27	99	8	261
2007	71		63	91		225
2008	51		87	178		316
2009	67		39	24	79	209
2010	209		27	240	1	477
2011	76		94	91	4	265
2012	53		46	122	6	227
2013	240		117	211	11	579
2014	101		113	136	28	378
2015	118	1	136	138	6	399

Table 5.3 (Cont.) Sample sizes (N) of lengths taken from the Gulf commercial fishery that were used to estimate gear-specific length frequencies and total number of Sheepshead landed each year (shaded fields: N < 40 fish; empty cells: no samples were available; those situations required some pooling).

	Cast net	Entangling nets	Hook_and_lines	Others	unknown	Total
1991		1020				1020
1992		1563	58	16		1637
1993	16	407				423
1994	29	403		3		435
1995		48	7			55
1996	29	16	12			57
1997	143		109	50		302
1998	105	17		94		216
1999	14	3	17	18		52
2000	100	97	13	98		308
2001	120		27	292		439
2002	275			337		612
2003	4	30	72	212		318
2004	25	7	18	51		101
2005	46			65	5	116
2006	49			61	24	134
2007	2		6	4		12
2008	38		15	7		60
2009			50			50
2010	66		163	14	21	264
2011			125	18	55	198
2012	7		15	29	28	79
2013	52			34	26	112
2014	73		1	22		96
2015	23		40	35	34	132

Table 5.4 Sources and sample sizes of age-length data pairs used to develop age-length keys of Sheepshead off Florida’ s coasts (under FIM surveys, the “other” category includes trawls, bag seines, gillnets and trammel nets).

	Atlantic							**Gulf**						
	FIM			FDM				FIM			FDM			
Year	Haul Seine	Other	Unknown	Recreational	Commercial	Unknown	Totals	Haul Seine	Other	Unknown	Recreational	Commercial	Unknown	Totals
1993	0	0	20	0	0	0	20	0	76	30	0	0	0	106
1994	0	4	6	0	0	0	10	0	56	220	0	0	0	276
1995	0	1	36	0	0	0	37	0	153	210	0	0	0	363
1996	0	42	24	0	0	0	66	169	97	202	0	0	0	468
1997	342	1	5	0	0	0	348	277	36	10	0	0	0	323
1998	264	3	0	0	0	0	267	144	11	0	0	0	0	155
1999	44	0	26	0	0	0	70	0	0	0	0	0	0	0
2000	239	0	6	0	0	0	245	281	20	9	0	0	0	310
2001	258	0	8	0	0	0	266	341	7	0	0	0	0	348
2002	325	0	0	0	0	0	325	357	7	0	0	0	0	364
2003	337	0	0	0	0	0	337	360	3	0	0	0	0	363
2004	312	0	0	1	0	0	313	372	6	0	0	0	0	378
2005	331	0	0	0	0	0	331	438	0	0	0	0	0	438
2006	273	0	0	0	0	0	273	436	0	0	0	0	0	436
2007	300	1	0	13	0	0	314	393	0	6	43	0	0	442
2008	315	0	0	0	0	0	315	390	0	7	108	0	0	505
2009	275	0	0	0	0	0	275	398	1	7	157	0	0	563
2010	289	0	0	0	0	0	289	331	1	5	201	0	0	538
2011	294	0	0	0	0	0	294	264	8	3	336	0	0	611
2012	303	0	0	0	0	0	303	344	8	2	190	0	0	544
2013	300	6	0	0	49	0	355	394	7	4	173	0	8	586
2014	334	5	0	0	96	0	435	366	6	7	256	0	0	635
2015	214	0	0	0	0	0	214	320	2	5	22	0	0	349
Totals	5349	63	131	14	145	0	5702	6375	505	727	1486	0	8	9101

Table 5.5 Estimated numbers of Sheepshead landed by gear category on the Atlantic coast of Florida during 1982–2015.

	Cast nets	Entangling nets	Hook_and_lines	Others	unknown	Total
1982					328,796	328,796
1983					214,706	214,706
1984					211,514	211,514
1985					233,029	233,029
1986	52,846	65,206	79,267	8,021	23,785	229,126
1987	51,553	116,672	59,790	10,284	24,658	262,957
1988	31,057	114,819	48,266	4,934	49,880	248,956
1989	43,931	84,222	41,360	9,301	31,705	210,518
1990	72,055	140,135	49,310	7,255	31,525	300,280
1991	73,806	156,899	41,236	4,614	65,459	342,015
1992	84,627	202,738	43,071	8,135	4,345	342,916
1993	63,213	133,123	43,280	6,212	46	245,874
1994	43,435	189,198	48,923	7,994	4	289,553
1995	41,381	42,896	80,581	8,614		173,472
1996	47,533	441	44,232	2,330		94,535
1997	51,235	589	29,607	4,770		86,200
1998	36,968	744	29,877	7,876		75,465
1999	29,283	469	20,635	4,164	745	55,295
2000	48,763	152	26,708	14,108	1,442	91,173
2001	30,696	53	21,417	17,547	657	70,370
2002	26,772	80	22,140	11,318	2	60,312
2003	28,549	47	19,454	5,844		53,894
2004	24,197	1,187	19,570	7,331		52,284
2005	34,802	442	17,237	13,355		65,836
2006	29,008	22	17,630	19,294		65,955
2007	30,503	868	13,998	18,056		63,426
2008	29,435	45	18,465	16,639		64,585
2009	43,127	40	19,344	17,644	1	80,156
2010	30,975	45	18,466	17,084		66,570
2011	28,290	12	10,675	13,407		52,384
2012	31,230	3	13,612	10,997		55,842
2013	28,229	11	18,708	28,917		75,866
2014	25,625	11	13,744	33,309		72,689
2015	22,275	16	18,092	23,515		63,898

Table 5.5 (Cont.) Estimated numbers of Sheepshead landed by gear category on the Gulf coast of Florida during 1982–2015.

	Cast nets	Entangling nets	Hook_and_lines	Others	unknown	Total
1982					134,173	134,173
1983					166,304	166,304
1984					132,100	132,100
1985					193,892	193,892
1986	27,019	153,255	14,668	6,521	26,555	228,017
1987	28,392	180,265	14,605	7,115	34,916	265,294
1988	33,334	184,401	17,022	6,356	59,491	300,603
1989	49,012	185,124	20,721	7,728	37,528	300,113
1990	66,868	180,979	23,055	9,196	34,212	314,311
1991	62,730	289,979	16,067	7,054	6,147	381,977
1992	49,283	426,648	14,392	5,165	1,345	496,833
1993	42,791	423,142	9,028	5,032	3,120	483,113
1994	55,509	325,032	9,125	5,407		395,073
1995	77,563	141,542	13,053	7,212		239,370
1996	81,735	245	7,306	3,515	136	92,937
1997	47,889	292	11,830	6,608	8	66,626
1998	36,789	612	7,996	8,682		54,080
1999	35,867	131	6,399	14,742	779	57,917
2000	54,023	434	6,582	18,234	712	79,986
2001	53,810	63	7,048	13,741	485	75,147
2002	48,650	184	5,611	14,606		69,051
2003	62,536	62	6,040	18,705		87,343
2004	36,729	44	5,175	35,557		77,504
2005	44,351	65	3,748	17,559		65,722
2006	40,725	138	3,253	8,740		52,856
2007	24,428	1	3,906	7,259		35,593
2008	19,663	14	2,407	6,909	74	29,067
2009	24,646	32	4,474	18,973		48,126
2010	55,082	87	7,952	27,557		90,679
2011	38,558		6,554	24,695		69,807
2012	40,395		11,325	26,917		78,636
2013	52,024	9	9,961	27,674		89,669
2014	32,665	15	10,654	43,803		87,136
2015	37,131	12	9,093	63,500		109,737

Table 5.6 Estimated numbers of Sheepshead released alive and total catch made by the commercial fishery on the Atlantic and Gulf coasts of Florida during 1982–2015 (the ratios of released alive to reported landings in the recreational fishery were applied to commercial landings).

	Atlantic Ratio B2/A+B1	Commercial Landings (#)	Discards (#)	Total Catch	Gulf Ratio B2/A+B1	Commercial Landings (#)	Discards (#)	Total Catch
1982	0.16	328,796	52,103	380,899	0.62	134,173	83,632	217,805
1983	0.04	214,706	8,875	223,581	0.54	166,304	89,933	256,237
1984	0.01	211,514	3,169	214,683	1.45	132,100	190,982	323,082
1985	0.18	233,029	42,213	275,243	0.24	193,892	46,267	240,158
1986	0.06	229,126	14,244	243,370	0.58	228,017	131,766	359,783
1987	0.03	262,957	8,555	271,512	0.58	265,294	153,945	419,239
1988	0.17	248,956	42,946	291,902	0.38	300,603	114,286	414,889
1989	0.81	210,518	170,257	380,775	0.14	300,113	41,491	341,604
1990	0.13	300,280	40,090	340,370	0.45	314,311	141,640	455,951
1991	0.22	342,015	74,107	416,122	0.91	381,977	348,720	730,697
1992	0.23	342,916	80,479	423,395	0.59	496,833	292,710	789,543
1993	0.17	245,874	42,093	287,968	0.57	483,113	275,729	758,842
1994	0.20	289,553	59,185	348,739	0.76	395,073	301,579	696,652
1995	0.39	173,472	67,886	241,358	0.80	239,370	192,340	431,710
1996	0.64	94,535	60,614	155,149	1.16	92,937	107,787	200,723
1997	0.93	86,200	80,086	166,285	1.34	66,626	89,253	155,879
1998	1.34	75,465	101,456	176,921	1.79	54,080	96,995	151,075
1999	1.13	55,295	62,234	117,529	1.45	57,917	83,899	141,816
2000	0.92	91,173	84,230	175,403	2.00	79,986	160,139	240,125
2001	1.24	70,370	87,418	157,788	1.48	75,147	111,129	186,276
2002	1.37	60,312	82,741	143,053	1.87	69,051	128,984	198,035
2003	1.11	53,894	60,040	113,933	2.06	87,343	179,815	267,158
2004	1.25	52,284	65,122	117,406	1.97	77,504	153,062	230,566
2005	0.74	65,836	48,895	114,730	1.77	65,722	116,174	181,896
2006	1.29	65,955	84,787	150,742	1.51	52,856	79,927	132,783
2007	1.20	63,426	76,285	139,711	1.51	35,593	53,874	89,467
2008	1.96	64,585	126,528	191,113	1.54	29,067	44,659	73,726
2009	1.56	80,156	124,781	204,937	1.19	48,126	57,099	105,225
2010	0.96	66,570	63,595	130,165	2.74	90,679	248,182	338,860
2011	1.24	52,384	65,208	117,592	2.10	69,807	146,726	216,533
2012	1.78	55,842	99,538	155,380	1.87	78,636	147,361	225,998
2013	1.87	75,866	141,689	217,556	2.07	89,669	185,394	275,063
2014	1.23	72,689	89,218	161,907	1.72	87,136	149,512	236,649
2015	1.84	63,898	117,790	181,688	1.53	109,737	168,065	277,802

Table 5.7 The number of saltwater products license (SPLs) holders who reported the commercial landings of Sheepshead by gear type on the Atlantic coast of Florida during 1986–2015 (the SPL counts in 1986 were incomplete and the 2015 data were preliminary).

	Cast nets	Entangling nets	Hook_and_lines	Others	unknown	Total
1986	78	120	81	39	37	355
1987	200	269	266	139	208	1,082
1988	194	254	266	124	304	1,142
1989	273	257	297	160	182	1,169
1990	361	278	319	130	153	1,241
1991	393	473	318	166	136	1,486
1992	334	597	320	165	32	1,448
1993	291	617	327	183	3	1,421
1994	281	680	321	193	1	1,476
1995	411	414	409	196		1,430
1996	454	32	282	90		858
1997	417	43	299	124		883
1998	349	45	321	140		855
1999	315	32	277	145	41	810
2000	345	17	266	139	40	807
2001	307	13	254	127	25	726
2002	311	13	253	131	1	709
2003	317	8	256	128		709
2004	296	10	271	106		683
2005	270	12	261	104		647
2006	307	8	271	136		722
2007	265	25	271	152		713
2008	293	10	325	123	1	752
2009	292	10	330	138	1	771
2010	297	10	333	132		772
2011	297	12	355	132		796
2012	314	5	384	197		900
2013	267	7	379	201		854
2014	260	8	377	192		837
2015	232	4	271	161		668

Table 5.7 (cont.) The number of saltwater products license (SPLs) holders who reported the commercial landings of Sheepshead by gear type on the Gulf coast of Florida during 1986–2015 (the SPL counts in 1986 were incomplete and the 2015 data were preliminary).

	Cast nets	Entangling nets	Hook_and_lines	Others	unknown	Total
1986	80	356	108	63	98	705
1987	217	680	344	152	373	1,766
1988	242	743	380	169	657	2,191
1989	382	930	528	190	373	2,403
1990	450	822	461	184	285	2,202
1991	478	1,339	363	163	114	2,457
1992	425	1,439	298	158	8	2,328
1993	527	1,464	181	154	2	2,328
1994	463	1,447	227	152		2,289
1995	804	865	283	201		2,153
1996	734	26	210	116	4	1,090
1997	781	25	211	248	5	1,270
1998	581	35	148	304		1,068
1999	608	17	159	311	33	1,128
2000	629	28	150	265	22	1,094
2001	566	13	145	218	17	959
2002	511	6	131	248		896
2003	490	9	143	273		915
2004	492	4	111	245		852
2005	422	5	81	173		681
2006	452	3	66	153		674
2007	402	1	76	154		633
2008	398	4	69	221	1	693
2009	433	2	79	232		746
2010	470	2	78	247		797
2011	511		90	242		843
2012	598		126	275		999
2013	693	2	141	357		1,193
2014	602	7	162	364		1,135
2015	587	4	149	352		1,092

Table 5.8 The number of fishing trips taken by SPL holders where Sheepshead were caught and landed on the Atlantic coast of Florida during 1985–2015 (the 2015 data were preliminary).

	Cast nets	Entangling nets	Hook_and_lines	Others	unknown	Total
1985					5,782	5,782
1986	1,601	2,667	1,689	505	547	7,009
1987	1,671	3,179	1,709	485	670	7,714
1988	1,603	2,899	1,633	377	1,348	7,860
1989	1,993	3,118	1,527	558	830	8,026
1990	2,821	3,275	1,787	374	863	9,120
1991	2,670	3,956	1,743	428	1,344	10,141
1992	2,986	5,563	1,306	535	83	10,473
1993	2,103	5,173	1,556	615	3	9,450
1994	1,829	5,776	1,448	824	1	9,878
1995	2,616	2,338	1,971	708		7,633
1996	3,881	51	1,329	193		5,454
1997	3,601	74	1,311	327		5,313
1998	3,198	67	1,393	554		5,212
1999	2,992	46	1,269	607	66	4,980
2000	2,929	20	1,353	642	57	5,001
2001	2,854	14	1,215	586	29	4,698
2002	3,064	24	1,088	577	1	4,754
2003	3,430	8	1,081	616		5,135
2004	2,860	26	1,192	440		4,518
2005	2,672	23	1,128	623		4,446
2006	2,823	9	1,114	730		4,676
2007	2,866	41	1,178	673		4,758
2008	3,566	11	1,387	567	1	5,532
2009	3,331	17	1,234	634	1	5,217
2010	2,624	17	1,097	536		4,274
2011	2,678	15	1,161	610		4,464
2012	2,521	5	1,470	894		4,890
2013	2,188	7	1,401	1,092		4,688
2014	2,111	10	1,287	1,221		4,629
2015	1,936	5	1,222	935		4,098

Table 5.8 (Cont.) The number of fishing trips taken by SPL holders where Sheepshead were caught and landed on the Gulf coast of Florida during 1985–2015 (the 2015 data were preliminary).

	Cast nets	Entangling nets	Hook_and_lines	Others	unknown	Total
1985					13,671	13,671
1986	1,951	11,168	2,015	682	1,608	17,424
1987	2,223	11,500	1,830	539	2,078	18,170
1988	2,240	11,754	1,885	611	3,570	20,060
1989	3,522	12,253	2,762	736	2,086	21,359
1990	4,484	11,815	3,202	1,012	2,228	22,741
1991	3,638	16,955	1,797	593	428	23,411
1992	2,561	21,031	945	421	16	24,974
1993	2,496	21,922	552	397	7	25,374
1994	2,521	19,767	514	571		23,373
1995	3,868	6,996	745	699		12,308
1996	5,858	44	548	282	4	6,736
1997	6,395	38	605	961	5	8,004
1998	6,039	65	353	1,583		8,040
1999	5,989	26	380	1,699	40	8,134
2000	5,688	70	390	1,408	27	7,583
2001	5,348	20	383	1,209	23	6,983
2002	4,585	14	336	1,157		6,092
2003	3,971	12	317	1,601		5,901
2004	3,254	4	232	2,327		5,817
2005	3,269	9	174	1,653		5,105
2006	3,767	3	177	704		4,651
2007	3,057	1	175	677		3,910
2008	3,222	7	161	1,002	1	4,393
2009	3,307	5	223	1,144		4,679
2010	3,414	3	187	1,590		5,194
2011	3,825		220	1,260		5,305
2012	3,929		376	1,587		5,892
2013	4,296	4	393	2,322		7,015
2014	4,033	8	403	2,350		6,794
2015	3,802	4	361	2,929		7,096

Table 5.9 Linear regression statistics for the generalized linear models (factors were included if they reduced the mean deviance by at least 0.5%) on proportion positive commercial hook and line and cast net (binomial sub-models) and on positive (lognormal sub-models) on the Atlantic and Gulf coasts of Florida (Prob. chi square < 0.0001).

Source	DF	Deviance	Dev/DF	Δ mean dev	% change	Cum %	Δ AIC	chi_df
Atlantic - Binomial sub-model								
year	660873	537551	0.8134					
year region	660872	528733	0.8001	0.0133	1.6402	1.640	8817.77	1
year region month	660861	526555	0.7968	0.0033	0.4036	2.044	2178.24	11
year region month days_fished_cat	660853	526048	0.7960	0.0008	0.0931	2.137	506.75	8
Atlantic - lognormal submodel								
year	93410	185736	1.9884					
year region	93409	171362	1.8345	0.1539	7.7378	7.738	7523.81	1
year region month	93398	169528	1.8151	0.0194	0.9766	8.714	983.30	11
year region month gear	93397	167491	1.7933	0.0218	1.0962	9.811	1127.76	1
year region month gear days_fished_cat	93389	167167	1.7900	0.0033	0.1668	9.977	164.96	8
Gulf - Binomial sub-model								
year	547650	519149	0.9480					
year region	547648	515072	0.9405	0.0074	0.7850	0.785	4073.04	2
year region gear	547647	510260	0.9317	0.0088	0.9268	1.712	4810.41	1
year region gear month	547636	507739	0.9271	0.0046	0.4837	2.195	2499.10	11
year region gear month days_fished_cat	547628	507216	0.9262	0.0009	0.0993	2.295	506.67	8
Gulf - lognormal submodel								
year	100006	180183	1.8017					
year month	99995	167330	1.6734	0.1283	7.1233	7.123	7381.07	11
year month gear	99994	163046	1.6306	0.0428	2.3768	9.500	2592.23	1
year month gear days_fished_cat	99986	161501	1.6152	0.0153	0.8507	10.351	936.72	8
year month gear days_fished_cat region	99984	161200	1.6123	0.0030	0.1649	10.516	182.18	2

Table 5.10 Standardized total catch rates (median) of Sheepshead on the Atlantic and Gulf coasts of Florida during 1991–2015 for the commercial cast net and hook and line gear types (various statistics for those catch rate estimates are also shown).

Atlantic

Year	Mean	CV	2.5th	25th	Median	75th	97.5th	Total trips	Positive trips	Obs mean	Obs SE
1991	10.92	0.05	9.77	10.56	10.92	11.30	12.18	2173	653	8.70	27.99
1992	8.13	0.06	7.12	7.77	8.11	8.49	9.19	5407	1338	6.60	27.81
1993	7.53	0.06	6.66	7.20	7.52	7.84	8.47	9259	2077	4.92	21.27
1994	7.44	0.06	6.63	7.13	7.43	7.72	8.32	11082	2442	4.65	21.53
1995	8.00	0.06	7.12	7.69	8.00	8.30	8.89	15733	4310	5.52	24.87
1996	6.82	0.06	6.08	6.56	6.81	7.08	7.62	21442	5155	3.63	18.68
1997	8.02	0.06	7.16	7.71	8.00	8.32	8.96	19696	4853	4.32	20.99
1998	7.69	0.06	6.83	7.39	7.68	7.99	8.63	19030	4535	3.95	19.70
1999	6.73	0.06	6.00	6.46	6.72	6.98	7.50	17080	4255	3.45	19.45
2000	8.27	0.06	7.36	7.93	8.25	8.60	9.23	17159	4256	4.90	25.81
2001	9.09	0.06	8.11	8.74	9.07	9.42	10.14	15215	4058	3.99	19.38
2002	8.73	0.06	7.78	8.37	8.71	9.07	9.74	16166	4144	3.68	19.10
2003	9.02	0.06	8.05	8.67	9.01	9.36	10.09	15655	4498	3.66	19.22
2004	9.05	0.06	8.09	8.70	9.04	9.38	10.10	13920	4042	3.61	18.88
2005	9.42	0.06	8.39	9.05	9.41	9.77	10.50	13283	3753	4.09	21.65
2006	8.25	0.06	7.35	7.92	8.23	8.55	9.22	13872	3917	3.80	21.55
2007	8.76	0.06	7.83	8.42	8.75	9.08	9.79	14204	4030	3.49	18.58
2008	8.12	0.06	7.24	7.80	8.10	8.42	9.05	16579	4933	3.44	19.87
2009	7.20	0.06	6.42	6.91	7.19	7.46	8.00	17065	4539	3.26	19.76
2010	7.49	0.06	6.69	7.19	7.49	7.77	8.33	15758	3701	3.37	19.33
2011	7.47	0.06	6.66	7.17	7.46	7.75	8.36	14526	3828	2.99	17.39
2012	7.47	0.06	6.67	7.19	7.46	7.76	8.33	15991	3982	3.48	19.35
2013	7.10	0.06	6.31	6.81	7.09	7.37	7.93	15553	3582	3.66	19.77
2014	5.41	0.06	4.81	5.19	5.40	5.61	6.05	15995	3391	2.66	16.10
2015	5.21	0.06	4.62	4.99	5.20	5.41	5.85	15300	3163	2.61	15.69

Gulf

Year	Mean	CV	2.5th	25th	Median	75th	97.5th	Total trips	Positive trips	Obs mean	Obs SE
1991	5.92	0.11	4.73	5.46	5.89	6.39	7.16	1319	400	9.76	29.63
1992	8.61	0.08	7.28	8.09	8.61	9.07	10.10	3097	1227	13.70	35.49
1993	6.22	0.08	5.25	5.87	6.19	6.56	7.31	3338	1129	7.88	25.09
1994	6.73	0.08	5.72	6.35	6.71	7.07	7.89	3220	1057	9.85	32.30
1995	5.67	0.08	4.88	5.37	5.66	5.96	6.57	10202	3601	6.19	22.21
1996	3.99	0.08	3.43	3.78	3.98	4.19	4.60	20856	6336	3.88	16.69
1997	3.58	0.08	3.08	3.38	3.57	3.75	4.13	23463	6895	3.98	18.80
1998	3.25	0.08	2.78	3.08	3.25	3.42	3.76	20834	6322	3.31	16.91
1999	3.67	0.08	3.14	3.48	3.66	3.86	4.26	20680	6346	3.91	17.97
2000	3.66	0.08	3.14	3.47	3.65	3.84	4.24	20223	6052	4.00	18.86
2001	4.07	0.08	3.50	3.86	4.06	4.28	4.71	19183	5697	4.52	21.40
2002	3.81	0.08	3.27	3.61	3.80	4.00	4.41	17623	4892	4.24	19.95
2003	4.16	0.08	3.58	3.94	4.16	4.38	4.84	16463	4225	4.84	22.96
2004	3.61	0.08	3.08	3.42	3.60	3.80	4.21	14651	3468	4.02	20.37
2005	3.87	0.08	3.31	3.66	3.86	4.07	4.51	12997	3404	4.36	20.68
2006	3.06	0.08	2.60	2.89	3.04	3.22	3.56	16963	3904	3.66	19.75
2007	3.15	0.08	2.70	2.98	3.15	3.31	3.67	13580	3187	3.66	18.92
2008	2.96	0.08	2.54	2.79	2.95	3.11	3.46	14156	3358	3.25	17.34
2009	3.00	0.08	2.57	2.84	2.99	3.15	3.49	15097	3506	3.86	20.08
2010	4.60	0.08	3.94	4.35	4.59	4.83	5.34	12757	3552	5.83	25.80
2011	2.94	0.08	2.51	2.78	2.93	3.09	3.43	17002	4014	3.61	19.04
2012	3.30	0.08	2.82	3.13	3.29	3.47	3.83	16018	4278	3.99	19.48
2013	2.94	0.08	2.52	2.78	2.93	3.09	3.41	18400	4648	3.69	18.78
2014	3.22	0.08	2.75	3.05	3.21	3.38	3.76	17311	4409	3.84	19.05
2015	3.38	0.08	2.89	3.19	3.38	3.56	3.93	14964	4124	4.41	21.79

Table 5.11 Estimated age proportions (January 1 birthdate) of Sheepshead caught by the commercial fishery and landed on the Atlantic coast of Florida during 1982–2015.

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+
1982	0.0004	0.1938	0.3387	0.2106	0.1278	0.0674	0.0227	0.0168	0.0087	0.0056	0.0075
1983	0.0004	0.1938	0.3387	0.2106	0.1278	0.0674	0.0227	0.0168	0.0087	0.0056	0.0075
1984	0.0004	0.1938	0.3387	0.2106	0.1278	0.0674	0.0227	0.0168	0.0087	0.0056	0.0075
1985	0.0004	0.1938	0.3387	0.2106	0.1278	0.0674	0.0227	0.0168	0.0087	0.0056	0.0075
1986	0.0030	0.1816	0.3141	0.2118	0.1324	0.0773	0.0282	0.0229	0.0114	0.0070	0.0103
1987	0.0027	0.1840	0.3205	0.2122	0.1310	0.0746	0.0268	0.0213	0.0107	0.0066	0.0094
1988	0.0019	0.1882	0.3263	0.2109	0.1292	0.0726	0.0257	0.0199	0.0101	0.0064	0.0087
1989	0.0029	0.1834	0.3208	0.2128	0.1313	0.0744	0.0267	0.0212	0.0107	0.0066	0.0093
1990	0.0033	0.1853	0.3243	0.2124	0.1295	0.0728	0.0262	0.0207	0.0103	0.0064	0.0088
1991	0.0030	0.1875	0.3282	0.2119	0.1284	0.0712	0.0255	0.0198	0.0099	0.0062	0.0084
1992	0.0034	0.1862	0.3264	0.2125	0.1287	0.0719	0.0259	0.0202	0.0101	0.0063	0.0084
1993	0.0031	0.1769	0.3141	0.2143	0.1364	0.0769	0.0272	0.0220	0.0111	0.0066	0.0114
1994	0.0018	0.1820	0.3223	0.2149	0.1335	0.0725	0.0267	0.0212	0.0104	0.0062	0.0084
1995	0.0031	0.1482	0.2756	0.2235	0.1495	0.0945	0.0340	0.0305	0.0156	0.0083	0.0172
1996	0.0000	0.0956	0.2145	0.2575	0.1844	0.1165	0.0464	0.0382	0.0196	0.0106	0.0168
1997	0.0000	0.0226	0.1428	0.3624	0.2183	0.0792	0.0683	0.0559	0.0242	0.0079	0.0184
1998	0.0000	0.0141	0.1436	0.2417	0.2374	0.2112	0.0474	0.0355	0.0228	0.0175	0.0289
1999	0.0000	0.0018	0.1203	0.1799	0.2327	0.1801	0.0430	0.1342	0.0110	0.0774	0.0196
2000	0.0000	0.0128	0.0794	0.2171	0.2629	0.0826	0.1450	0.0640	0.0188	0.0374	0.0799
2001	0.0000	0.0174	0.1286	0.1796	0.1704	0.1423	0.1018	0.0798	0.0808	0.0315	0.0678
2002	0.0000	0.0034	0.1154	0.2588	0.1946	0.1372	0.1375	0.0391	0.0297	0.0289	0.0554
2003	0.0000	0.0001	0.0536	0.2272	0.2263	0.1364	0.0824	0.1296	0.0499	0.0366	0.0579
2004	0.0000	0.0000	0.0651	0.1910	0.3339	0.1487	0.0793	0.0556	0.0538	0.0109	0.0616
2005	0.0000	0.0082	0.0015	0.1524	0.2242	0.2147	0.1416	0.0738	0.0198	0.0676	0.0961
2006	0.0000	0.0002	0.1136	0.0433	0.1499	0.2280	0.2334	0.0545	0.0536	0.0224	0.1010
2007	0.0000	0.0039	0.0570	0.2188	0.0850	0.1097	0.1493	0.1911	0.0727	0.0314	0.0812
2008	0.0000	0.0139	0.0624	0.1813	0.2849	0.0268	0.0554	0.1054	0.1326	0.0498	0.0875
2009	0.0000	0.0049	0.1851	0.1926	0.2124	0.1626	0.0345	0.0298	0.0577	0.0286	0.0917
2010	0.0000	0.0003	0.0672	0.2593	0.2037	0.1439	0.1324	0.0275	0.0299	0.0152	0.1206
2011	0.0000	0.0001	0.0879	0.1344	0.2999	0.2022	0.0863	0.0940	0.0033	0.0136	0.0784
2012	0.0000	0.0000	0.0314	0.2754	0.1235	0.2507	0.0727	0.0801	0.0493	0.0129	0.1041
2013	0.0000	0.0121	0.0251	0.1074	0.2498	0.1276	0.1449	0.0863	0.0820	0.0640	0.1008
2014	0.0000	0.0079	0.0692	0.0795	0.1907	0.2764	0.0905	0.0547	0.0388	0.0172	0.1752
2015	0.0000	0.0179	0.1482	0.1857	0.1414	0.2027	0.1850	0.0293	0.0268	0.0198	0.0431

Table 5.11 (Cont.) Estimated age proportions (January 1 birthdate) of Sheepshead caught by the commercial fishery and landed on the Gulf coast of Florida during 1982–2015.

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+
1982	0.0020	0.1370	0.2861	0.3012	0.1526	0.0473	0.0203	0.0148	0.0135	0.0117	0.0135
1983	0.0020	0.1370	0.2861	0.3012	0.1526	0.0473	0.0203	0.0148	0.0135	0.0117	0.0135
1984	0.0020	0.1370	0.2861	0.3012	0.1526	0.0473	0.0203	0.0148	0.0135	0.0117	0.0135
1985	0.0020	0.1370	0.2861	0.3012	0.1526	0.0473	0.0203	0.0148	0.0135	0.0117	0.0135
1986	0.0045	0.1905	0.2606	0.2646	0.1463	0.0488	0.0210	0.0152	0.0165	0.0158	0.0163
1987	0.0044	0.1926	0.2635	0.2647	0.1452	0.0480	0.0206	0.0147	0.0158	0.0150	0.0156
1988	0.0043	0.1865	0.2641	0.2678	0.1462	0.0483	0.0207	0.0149	0.0160	0.0152	0.0158
1989	0.0049	0.1840	0.2574	0.2676	0.1485	0.0499	0.0214	0.0156	0.0170	0.0165	0.0171
1990	0.0053	0.1781	0.2527	0.2702	0.1513	0.0513	0.0221	0.0160	0.0176	0.0173	0.0181
1991	0.0052	0.2015	0.2644	0.2622	0.1428	0.0469	0.0199	0.0137	0.0147	0.0138	0.0148
1992	0.0019	0.1506	0.2863	0.2856	0.1484	0.0488	0.0218	0.0160	0.0136	0.0122	0.0147
1993	0.0012	0.1015	0.3243	0.4116	0.0755	0.0069	0.0185	0.0127	0.0131	0.0159	0.0189
1994	0.0080	0.0773	0.1030	0.4071	0.2637	0.0384	0.0261	0.0191	0.0432	0.0040	0.0101
1995	0.0044	0.0580	0.2786	0.1940	0.2319	0.1479	0.0246	0.0153	0.0048	0.0212	0.0192
1996	0.0000	0.1383	0.2082	0.2357	0.1276	0.1391	0.0911	0.0223	0.0166	0.0058	0.0153
1997	0.0050	0.0033	0.0321	0.1857	0.3523	0.1441	0.1604	0.0705	0.0197	0.0126	0.0143
1998	0.0000	0.0000	0.0315	0.2417	0.2301	0.2201	0.0689	0.1072	0.0674	0.0102	0.0229
1999	0.0000	0.0177	0.1165	0.2873	0.1823	0.1356	0.0618	0.0930	0.0366	0.0130	0.0563
2000	0.0000	0.0477	0.2196	0.3545	0.1508	0.0603	0.0640	0.0487	0.0131	0.0139	0.0275
2001	0.0000	0.0014	0.1184	0.2344	0.4131	0.1175	0.0289	0.0118	0.0244	0.0131	0.0369
2002	0.0000	0.0017	0.0860	0.3144	0.2704	0.2035	0.0543	0.0259	0.0222	0.0154	0.0062
2003	0.0000	0.0016	0.0704	0.2969	0.3196	0.1421	0.1275	0.0125	0.0057	0.0065	0.0172
2004	0.0000	0.0120	0.0513	0.2726	0.3443	0.1576	0.0707	0.0751	0.0057	0.0040	0.0066
2005	0.0000	0.0200	0.0407	0.1650	0.2777	0.2697	0.0925	0.0538	0.0485	0.0186	0.0135
2006	0.0000	0.0070	0.1133	0.1695	0.1903	0.1828	0.1892	0.0727	0.0164	0.0481	0.0107
2007	0.0000	0.0042	0.0498	0.1602	0.1827	0.1367	0.1443	0.1769	0.0303	0.0272	0.0877
2008	0.0005	0.0090	0.0225	0.1219	0.2241	0.1559	0.1030	0.1644	0.0676	0.0383	0.0929
2009	0.0000	0.0030	0.1888	0.1075	0.1955	0.1589	0.0968	0.0660	0.0599	0.0563	0.0672
2010	0.0000	0.0010	0.0715	0.2709	0.2072	0.1227	0.1108	0.1124	0.0299	0.0191	0.0545
2011	0.0000	0.0006	0.0291	0.1908	0.2127	0.1649	0.1697	0.0928	0.0578	0.0159	0.0659
2012	0.0001	0.0062	0.0210	0.1867	0.2713	0.1747	0.0739	0.1181	0.0524	0.0510	0.0446
2013	0.0000	0.0021	0.0733	0.2217	0.1519	0.2221	0.1385	0.0578	0.0565	0.0210	0.0552
2014	0.0000	0.0028	0.0367	0.2516	0.2673	0.1118	0.1410	0.1120	0.0212	0.0151	0.0405
2015	0.0000	0.0069	0.0414	0.2372	0.2786	0.1043	0.1274	0.1024	0.0491	0.0215	0.0313

Table 5.12 Lengths of Sheepshead released alive obtained from MRFSS type 3 records.

YEAR	Coast	FL (mm)	FL (inches)
2006	Gulf	375	15
2008	Atlantic	364	14
2005	Gulf	395	16
2005	Gulf	402	16
2007	Atlantic	339	13
2007	Gulf	340	13
2007	Gulf	324	13
2009	Atlantic	274	11
2009	Atlantic	325	13

Table 5.13 Lengths of Sheepshead released alive obtained from the "Angler Action" of the Snook Foundation data set

	Year				
FL (cm)	2012	2013	2014	2015	Total
20	1	0	0	0	1
22	1	2	5	3	11
24	0	1	5	2	8
26	1	2	0	2	5
28	0	0	0	1	1
30	0	0	0	2	2
32	0	3	0	0	3
34	0	1	0	0	1
40	0	2	0	0	2
48	0	1	0	0	1
Total	3	12	10	10	35

Table 5.14 Estimated total numbers of Sheepshead landed, caught and released alive by anglers, percent released alive, numbers of fish that died after being released alive (assuming 1% release mortality), total harvest (landings plus those that died after being released alive), and estimated number of trips directed at Sheepshead on the Atlantic coast of Florida during 1982–2015.

year	Landings	Released	Total catch	Percent Released	Dead releases	Total harvest	Directed Trips
1982	782,079	123,933	906,012	13.68	1,239	783,318	379,316
1983	456,077	18,853	474,930	3.97	189	456,266	390,341
1984	949,306	14,224	963,530	1.48	142	949,448	602,398
1985	309,963	56,150	366,113	15.34	562	310,525	422,169
1986	653,968	40,656	694,624	5.85	407	654,375	820,561
1987	1,018,627	33,138	1,051,765	3.15	331	1,018,958	723,111
1988	537,800	92,772	630,572	14.71	928	538,728	435,158
1989	299,445	242,177	541,622	44.71	2,422	301,867	593,135
1990	520,725	69,521	590,246	11.78	695	521,420	499,518
1991	757,298	164,090	921,388	17.81	1,641	758,939	1,302,720
1992	731,667	171,714	903,381	19.01	1,717	733,384	1,203,891
1993	795,946	136,265	932,211	14.62	1,363	797,309	1,219,756
1994	1,092,901	223,391	1,316,292	16.97	2,234	1,095,135	1,612,655
1995	821,695	321,559	1,143,254	28.13	3,216	824,911	1,534,280
1996	413,846	265,347	679,193	39.07	2,653	416,499	1,298,801
1997	322,236	299,380	621,616	48.16	2,994	325,230	1,492,275
1998	258,505	347,540	606,045	57.35	3,475	261,980	1,375,469
1999	345,071	388,371	733,442	52.95	3,884	348,955	1,351,011
2000	348,689	322,135	670,824	48.02	3,221	351,910	1,762,994
2001	427,651	531,253	958,904	55.40	5,313	432,964	1,841,744
2002	265,951	364,856	630,807	57.84	3,649	269,600	1,488,969
2003	324,883	361,935	686,818	52.70	3,619	328,502	1,640,968
2004	202,471	252,184	454,655	55.47	2,522	204,993	1,639,803
2005	389,701	289,422	679,123	42.62	2,894	392,595	2,182,669
2006	243,547	313,089	556,636	56.25	3,131	246,678	2,045,673
2007	254,966	306,660	561,626	54.60	3,067	258,033	3,067,362
2008	237,344	464,977	702,321	66.21	4,650	241,994	1,899,326
2009	227,154	353,617	580,771	60.89	3,536	230,690	1,441,941
2010	351,792	336,071	687,863	48.86	3,361	355,153	1,692,754
2011	287,117	357,403	644,520	55.45	3,574	290,691	1,685,791
2012	266,675	475,351	742,026	64.06	4,754	271,429	2,004,141
2013	253,005	471,937	724,942	65.10	4,719	257,724	1,510,420
2014	573,355	703,726	1,277,081	55.10	7,037	580,392	1,623,253
2015	305,663	563,468	869,131	64.83	5,635	311,298	1,521,945

Table 5.14 (Cont.) Estimated total numbers of Sheepshead landed, caught and released alive by anglers, percent released alive, numbers of fish that died after being released alive (assuming 1% release mortality), total harvest (landings plus those that died after being released alive), and estimated number of trips directed at Sheepshead on the Gulf coast of Florida during 1982–2015.

year	Landings	Released	Total catch	Percent Released	Dead releases	Total harvest	Directed Trips
1982	703,167	438,293	1,141,460	38.40	4,383	707,550	326,674
1983	1,195,067	646,260	1,841,327	35.10	6,463	1,201,530	453,806
1984	945,435	1,366,850	2,312,285	59.11	13,669	959,104	832,195
1985	977,420	233,233	1,210,653	19.27	2,332	979,752	415,344
1986	502,292	290,264	792,556	36.62	2,903	505,195	921,735
1987	595,369	345,482	940,851	36.72	3,455	598,824	522,161
1988	1,635,146	621,662	2,256,808	27.55	6,217	1,641,363	740,327
1989	1,657,891	229,206	1,887,097	12.15	2,292	1,660,183	801,658
1990	887,881	400,113	1,287,994	31.06	4,001	891,882	698,803
1991	843,303	769,880	1,613,183	47.72	7,699	851,002	1,431,662
1992	2,098,074	1,236,086	3,334,160	37.07	12,361	2,110,435	1,287,439
1993	1,940,182	1,107,328	3,047,510	36.34	11,073	1,951,255	1,219,408
1994	955,617	729,470	1,685,087	43.29	7,295	962,912	1,004,968
1995	1,245,674	1,000,931	2,246,605	44.55	10,009	1,255,683	1,054,070
1996	714,992	829,237	1,544,229	53.70	8,292	723,284	896,339
1997	656,749	879,788	1,536,537	57.26	8,798	665,547	810,956
1998	700,243	1,255,929	1,956,172	64.20	12,559	712,802	925,104
1999	887,626	1,285,824	2,173,450	59.16	12,858	900,484	1,085,399
2000	723,137	1,447,792	2,170,929	66.69	14,478	737,615	1,225,052
2001	742,846	1,098,528	1,841,374	59.66	10,985	753,831	1,155,175
2002	684,931	1,279,419	1,964,350	65.13	12,794	697,725	1,069,281
2003	757,890	1,560,283	2,318,173	67.31	15,603	773,493	1,104,286
2004	708,614	1,399,433	2,108,047	66.39	13,994	722,608	1,064,471
2005	1,050,108	1,856,219	2,906,327	63.87	18,562	1,068,670	1,065,799
2006	623,318	942,557	1,565,875	60.19	9,426	632,744	962,720
2007	590,627	893,971	1,484,598	60.22	8,940	599,567	1,130,616
2008	556,779	855,456	1,412,235	60.57	8,555	565,334	1,023,188
2009	681,263	808,285	1,489,548	54.26	8,083	689,346	1,002,400
2010	455,074	1,245,509	1,700,583	73.24	12,455	467,529	906,635
2011	606,810	1,275,448	1,882,258	67.76	12,754	619,564	1,069,663
2012	628,124	1,177,079	1,805,203	65.20	11,771	639,895	1,158,299
2013	524,242	1,083,886	1,608,128	67.40	10,839	535,081	909,626
2014	894,581	1,534,955	2,429,536	63.18	15,350	909,931	864,017
2015	589,074	902,181	1,491,255	60.50	9,022	598,096	597,310

Table 5.15 Estimated age proportions (January 1 birthdate) of Sheepshead caught by anglers and landed (Type A + B1 fish) on the Atlantic coast of Florida during 1982–2015.

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+
1982	0.0226	0.0750	0.1906	0.2523	0.1833	0.1341	0.0453	0.0413	0.0186	0.0114	0.0255
1983	0.0241	0.0602	0.1847	0.2619	0.1978	0.1334	0.0409	0.0381	0.0193	0.0113	0.0283
1984	0.0006	0.0470	0.1539	0.2646	0.2159	0.1510	0.0543	0.0473	0.0248	0.0129	0.0276
1985	0.0096	0.0607	0.1795	0.2606	0.2165	0.1426	0.0439	0.0370	0.0182	0.0110	0.0205
1986	0.0000	0.0711	0.2087	0.2724	0.1936	0.1219	0.0371	0.0375	0.0186	0.0107	0.0283
1987	0.0000	0.0606	0.1886	0.2780	0.2157	0.1249	0.0395	0.0351	0.0191	0.0087	0.0298
1988	0.0000	0.0527	0.1681	0.2732	0.2171	0.1468	0.0400	0.0419	0.0191	0.0115	0.0296
1989	0.0000	0.0601	0.1670	0.2553	0.2045	0.1447	0.0459	0.0492	0.0240	0.0140	0.0354
1990	0.0000	0.0739	0.2163	0.2875	0.1975	0.1120	0.0371	0.0331	0.0177	0.0115	0.0133
1991	0.0000	0.0512	0.1865	0.2767	0.2139	0.1436	0.0450	0.0393	0.0154	0.0079	0.0205
1992	0.0000	0.0838	0.2161	0.2666	0.2025	0.1126	0.0408	0.0345	0.0171	0.0090	0.0171
1993	0.0000	0.1147	0.2473	0.2525	0.1781	0.1011	0.0329	0.0266	0.0174	0.0103	0.0190
1994	0.0000	0.0486	0.1608	0.2716	0.2141	0.1440	0.0479	0.0413	0.0243	0.0136	0.0336
1995	0.0000	0.0799	0.1816	0.2603	0.1927	0.1283	0.0461	0.0485	0.0218	0.0124	0.0283
1996	0.0000	0.0301	0.1085	0.2616	0.2405	0.1611	0.0658	0.0609	0.0278	0.0121	0.0316
1997	0.0000	0.0155	0.1140	0.3408	0.2250	0.1145	0.0702	0.0644	0.0272	0.0048	0.0235
1998	0.0000	0.0061	0.0777	0.1838	0.2867	0.2548	0.0392	0.0312	0.0408	0.0344	0.0452
1999	0.0000	0.0049	0.1237	0.1824	0.2256	0.1778	0.0459	0.1280	0.0111	0.0729	0.0277
2000	0.0000	0.0124	0.0904	0.2148	0.2279	0.0815	0.1347	0.0635	0.0201	0.0567	0.0979
2001	0.0000	0.0172	0.1222	0.1641	0.1645	0.1486	0.1003	0.0773	0.0880	0.0429	0.0749
2002	0.0000	0.0220	0.1662	0.2261	0.1488	0.1214	0.1141	0.0325	0.0373	0.0247	0.1069
2003	0.0000	0.0002	0.0862	0.2909	0.2127	0.1279	0.0641	0.1064	0.0393	0.0265	0.0457
2004	0.0000	0.0000	0.0657	0.1867	0.3097	0.1507	0.0837	0.0635	0.0572	0.0158	0.0670
2005	0.0000	0.0234	0.0120	0.1523	0.2212	0.1916	0.1253	0.0643	0.0179	0.0779	0.1141
2006	0.0000	0.0034	0.1516	0.0534	0.1327	0.2125	0.2032	0.0500	0.0621	0.0138	0.1173
2007	0.0000	0.0084	0.0707	0.2555	0.0837	0.0956	0.1453	0.1742	0.0648	0.0255	0.0763
2008	0.0000	0.0270	0.0866	0.2081	0.2646	0.0262	0.0509	0.0909	0.1174	0.0526	0.0758
2009	0.0000	0.0103	0.1636	0.1863	0.2033	0.1638	0.0408	0.0321	0.0642	0.0409	0.0947
2010	0.0000	0.0051	0.0510	0.2315	0.1863	0.1403	0.1463	0.0327	0.0375	0.0193	0.1500
2011	0.0000	0.0000	0.0490	0.0949	0.2406	0.2442	0.0765	0.1020	0.0133	0.0267	0.1528
2012	0.0000	0.0011	0.0353	0.2622	0.1169	0.2444	0.0778	0.0796	0.0503	0.0098	0.1226
2013	0.0000	0.0099	0.0324	0.1255	0.2622	0.1277	0.1424	0.0837	0.0832	0.0536	0.0794
2014	0.0000	0.0297	0.0954	0.0870	0.2073	0.2473	0.1011	0.0493	0.0342	0.0159	0.1327
2015	0.0000	0.0102	0.1304	0.1590	0.1502	0.2051	0.1970	0.0425	0.0474	0.0260	0.0322

Table 5.15 (Cont.) Estimated age proportions (January 1 birthdate) of Sheepshead caught by anglers and landed (Type A + B1 fish) on the Gulf coast of Florida during 1982–2015.

					Age						
Year	0	1	2	3	4	5	6	7	8	9	10+
1982	0.0020	0.1370	0.2861	0.3012	0.1526	0.0473	0.0203	0.0148	0.0135	0.0117	0.0135
1983	0.0020	0.1370	0.2861	0.3012	0.1526	0.0473	0.0203	0.0148	0.0135	0.0117	0.0135
1984	0.0020	0.1370	0.2861	0.3012	0.1526	0.0473	0.0203	0.0148	0.0135	0.0117	0.0135
1985	0.0020	0.1370	0.2861	0.3012	0.1526	0.0473	0.0203	0.0148	0.0135	0.0117	0.0135
1986	0.0045	0.1905	0.2606	0.2646	0.1463	0.0488	0.0210	0.0152	0.0165	0.0158	0.0163
1987	0.0044	0.1926	0.2635	0.2647	0.1452	0.0480	0.0206	0.0147	0.0158	0.0150	0.0156
1988	0.0043	0.1865	0.2641	0.2678	0.1462	0.0483	0.0207	0.0149	0.0160	0.0152	0.0158
1989	0.0049	0.1840	0.2574	0.2676	0.1485	0.0499	0.0214	0.0156	0.0170	0.0165	0.0171
1990	0.0053	0.1781	0.2527	0.2702	0.1513	0.0513	0.0221	0.0160	0.0176	0.0173	0.0181
1991	0.0052	0.2015	0.2644	0.2622	0.1428	0.0469	0.0199	0.0137	0.0147	0.0138	0.0148
1992	0.0019	0.1506	0.2863	0.2856	0.1484	0.0488	0.0218	0.0160	0.0136	0.0122	0.0147
1993	0.0012	0.1015	0.3243	0.4116	0.0755	0.0069	0.0185	0.0127	0.0131	0.0159	0.0189
1994	0.0080	0.0773	0.1030	0.4071	0.2637	0.0384	0.0261	0.0191	0.0432	0.0040	0.0101
1995	0.0044	0.0580	0.2786	0.1940	0.2319	0.1479	0.0246	0.0153	0.0048	0.0212	0.0192
1996	0.0000	0.1383	0.2082	0.2357	0.1276	0.1391	0.0911	0.0223	0.0166	0.0058	0.0153
1997	0.0050	0.0033	0.0321	0.1857	0.3523	0.1441	0.1604	0.0705	0.0197	0.0126	0.0143
1998	0.0000	0.0000	0.0315	0.2417	0.2301	0.2201	0.0689	0.1072	0.0674	0.0102	0.0229
1999	0.0000	0.0177	0.1165	0.2873	0.1823	0.1356	0.0618	0.0930	0.0366	0.0130	0.0563
2000	0.0000	0.0477	0.2196	0.3545	0.1508	0.0603	0.0640	0.0487	0.0131	0.0139	0.0275
2001	0.0000	0.0014	0.1184	0.2344	0.4131	0.1175	0.0289	0.0118	0.0244	0.0131	0.0369
2002	0.0000	0.0017	0.0860	0.3144	0.2704	0.2035	0.0543	0.0259	0.0222	0.0154	0.0062
2003	0.0000	0.0016	0.0704	0.2969	0.3196	0.1421	0.1275	0.0125	0.0057	0.0065	0.0172
2004	0.0000	0.0120	0.0513	0.2726	0.3443	0.1576	0.0707	0.0751	0.0057	0.0040	0.0066
2005	0.0000	0.0200	0.0407	0.1650	0.2777	0.2697	0.0925	0.0538	0.0485	0.0186	0.0135
2006	0.0000	0.0070	0.1133	0.1695	0.1903	0.1828	0.1892	0.0727	0.0164	0.0481	0.0107
2007	0.0000	0.0042	0.0498	0.1602	0.1827	0.1367	0.1443	0.1769	0.0303	0.0272	0.0877
2008	0.0005	0.0090	0.0225	0.1219	0.2241	0.1559	0.1030	0.1644	0.0676	0.0383	0.0929
2009	0.0000	0.0030	0.1888	0.1075	0.1955	0.1589	0.0968	0.0660	0.0599	0.0563	0.0672
2010	0.0000	0.0010	0.0715	0.2709	0.2072	0.1227	0.1108	0.1124	0.0299	0.0191	0.0545
2011	0.0000	0.0006	0.0291	0.1908	0.2127	0.1649	0.1697	0.0928	0.0578	0.0159	0.0659
2012	0.0001	0.0062	0.0210	0.1867	0.2713	0.1747	0.0739	0.1181	0.0524	0.0510	0.0446
2013	0.0000	0.0021	0.0733	0.2217	0.1519	0.2221	0.1385	0.0578	0.0565	0.0210	0.0552
2014	0.0000	0.0028	0.0367	0.2516	0.2673	0.1118	0.1410	0.1120	0.0212	0.0151	0.0405
2015	0.0000	0.0069	0.0414	0.2372	0.2786	0.1043	0.1274	0.1024	0.0491	0.0215	0.0313

Table 5.16 Estimated age proportions (January 1 birthdate) of Sheepshead released alive by anglers (Type B2 fish) on the Atlantic coast of Florida during 1982–2015 (note: age proportions during 1982–1996 are similar because they were based on a same average age-length key).

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+
1996	0.0000	0.1864	0.3875	0.2598	0.1177	0.0390	0.0070	0.0000	0.0000	0.0025	0.0000
1997	0.0000	0.1773	0.3488	0.3359	0.1182	0.0149	0.0000	0.0000	0.0000	0.0050	0.0000
1998	0.0000	0.1956	0.4262	0.1838	0.1171	0.0632	0.0140	0.0000	0.0000	0.0000	0.0000
1999	0.0000	0.0903	0.6530	0.2176	0.0000	0.0391	0.0000	0.0000	0.0000	0.0000	0.0000
2000	0.0000	0.2306	0.5849	0.1561	0.0094	0.0094	0.0094	0.0000	0.0000	0.0000	0.0000
2001	0.0000	0.2338	0.4959	0.1771	0.0547	0.0182	0.0111	0.0000	0.0000	0.0091	0.0000
2002	0.0000	0.1613	0.5516	0.2350	0.0326	0.0098	0.0000	0.0000	0.0098	0.0000	0.0000
2003	0.0000	0.0424	0.5387	0.3756	0.0364	0.0070	0.0000	0.0000	0.0000	0.0000	0.0000
2004	0.0070	0.0655	0.3944	0.2007	0.3023	0.0151	0.0151	0.0000	0.0000	0.0000	0.0000
2005	0.0291	0.5930	0.1991	0.1368	0.0316	0.0105	0.0000	0.0000	0.0000	0.0000	0.0000
2006	0.0000	0.1115	0.8175	0.0238	0.0377	0.0094	0.0000	0.0000	0.0000	0.0000	0.0000
2007	0.0000	0.0845	0.3324	0.4763	0.0498	0.0144	0.0000	0.0000	0.0072	0.0000	0.0354
2008	0.0058	0.1686	0.3816	0.3002	0.1068	0.0078	0.0000	0.0000	0.0078	0.0000	0.0214
2009	0.0102	0.2394	0.4785	0.1802	0.0717	0.0200	0.0000	0.0000	0.0000	0.0000	0.0000
2010	0.0000	0.2177	0.2837	0.3799	0.0504	0.0611	0.0072	0.0000	0.0000	0.0000	0.0000
2011	0.0000	0.0458	0.5514	0.2716	0.0806	0.0507	0.0000	0.0000	0.0000	0.0000	0.0000
2012	0.0122	0.0162	0.3084	0.5657	0.0890	0.0086	0.0000	0.0000	0.0000	0.0000	0.0000
2013	0.0070	0.1457	0.1996	0.3532	0.2438	0.0152	0.0253	0.0051	0.0051	0.0000	0.0000
2014	0.0000	0.1487	0.3524	0.1506	0.2427	0.0931	0.0124	0.0000	0.0000	0.0000	0.0000
2015	0.0000	0.2137	0.3889	0.2523	0.0391	0.0865	0.0195	0.0000	0.0000	0.0000	0.0000

Table 5.16 (Cont.) Estimated age proportions (January 1 birthdate) of Sheepshead released alive by anglers (Type B2 fish) on the Gulf coast of Florida during 1982–2015 (note: age proportions during 1982–1992 are similar because they were based on a same average age-length key).

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+
1992	0.0000	0.1534	0.4145	0.3338	0.0915	0.0067	0.0000	0.0000	0.0000	0.0000	0.0000
1993	0.0000	0.1480	0.4291	0.3908	0.0321	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1994	0.0000	0.1052	0.2686	0.4668	0.1530	0.0063	0.0000	0.0000	0.0000	0.0000	0.0000
1995	0.0000	0.2071	0.5459	0.1438	0.0895	0.0138	0.0000	0.0000	0.0000	0.0000	0.0000
1996	0.0000	0.1454	0.4734	0.3134	0.0353	0.0196	0.0059	0.0000	0.0071	0.0000	0.0000
1997	0.0080	0.2261	0.4051	0.2568	0.0698	0.0228	0.0000	0.0114	0.0000	0.0000	0.0000
1998	0.0000	0.0794	0.5920	0.2845	0.0000	0.0441	0.0000	0.0000	0.0000	0.0000	0.0000
1999	0.0018	0.1859	0.5267	0.2339	0.0297	0.0221	0.0000	0.0000	0.0000	0.0000	0.0000
2000	0.0036	0.2925	0.4613	0.1833	0.0593	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2001	0.0000	0.1520	0.4785	0.2276	0.0932	0.0365	0.0122	0.0000	0.0000	0.0000	0.0000
2002	0.0080	0.1516	0.5557	0.1558	0.0993	0.0174	0.0122	0.0000	0.0000	0.0000	0.0000
2003	0.0000	0.1621	0.4299	0.2608	0.0946	0.0425	0.0101	0.0000	0.0000	0.0000	0.0000
2004	0.0119	0.1786	0.2944	0.3107	0.1661	0.0000	0.0098	0.0186	0.0000	0.0000	0.0098
2005	0.0000	0.2032	0.4117	0.1773	0.1272	0.0232	0.0267	0.0230	0.0000	0.0000	0.0077
2006	0.0000	0.2288	0.6374	0.1235	0.0000	0.0104	0.0000	0.0000	0.0000	0.0000	0.0000
2007	0.0000	0.1092	0.5423	0.3152	0.0334	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2008	0.0065	0.2028	0.3740	0.2716	0.1052	0.0200	0.0000	0.0069	0.0065	0.0000	0.0065
2009	0.0000	0.1032	0.5176	0.1857	0.1489	0.0303	0.0143	0.0000	0.0000	0.0000	0.0000
2010	0.0000	0.0519	0.4382	0.3610	0.0440	0.0806	0.0122	0.0122	0.0000	0.0000	0.0000
2011	0.0000	0.0169	0.3357	0.3846	0.0878	0.0662	0.0943	0.0072	0.0000	0.0072	0.0000
2012	0.0042	0.1329	0.1079	0.3321	0.3382	0.0544	0.0000	0.0304	0.0000	0.0000	0.0000
2013	0.0000	0.0540	0.3478	0.2087	0.2141	0.1350	0.0079	0.0230	0.0057	0.0039	0.0000
2014	0.0000	0.0588	0.4399	0.2771	0.0690	0.0869	0.0435	0.0248	0.0000	0.0000	0.0000
2015	0.0000	0.1453	0.2174	0.3524	0.1934	0.0491	0.0212	0.0141	0.0071	0.0000	0.0000

Table 5.17 Linear regression statistics for the generalized linear model (factors were included if they reduced the mean deviance by at least 0.5%) on proportion positive trips (binomial sub-model) and on positive trips (lognormal sub-models) for MRFSS/MRIP index of Sheepshead on the Atlantic and Gulf coasts of Florida (Prob. chi square < 0.0001).

Source	DF	Deviance	Dev/DF	Δ mean dev	% change	Cum %	chisq	chi_df
Atlantic - Binomial sub-model								
Null	28484	29029.6	1.0192					
wave	28479	27590.3	0.9688	0.0504	4.941	4.941	1439.22	5
wave Year	28455	27057.7	0.9509	0.0179	1.756	6.698	532.63	24
wave Year num_angl	28449	26716.9	0.9391	0.0118	1.156	7.853	340.80	6
wave Year num_angl area	28447	26531.7	0.9327	0.0064	0.632	8.486	185.19	2
Atlantic - lognormal submodel								
Null	5887	5488.94	0.9324					
mode_fx	5885	5358.92	0.9106	0.0218	2.336	2.336	141.15	2
mode_fx wave	5880	5267.57	0.8958	0.0148	1.583	3.919	101.23	5
mode_fx wave Year	5856	5197.02	0.8875	0.0084	0.898	4.817	79.39	24
mode_fx wave Year hr_fished	5850	5153	0.8809	0.0066	0.709	5.527	50.09	6
Gulf - Binomial sub-model								
Null	15316	19311.3	1.2609					
wave	15311	17962.4	1.1732	0.0877	6.955	6.955	1348.91	5
wave area	15309	17378.4	1.1352	0.0380	3.014	9.968	584.05	2
wave area Year	15285	17213.3	1.1262	0.0090	0.715	10.684	165.11	24
Gulf - lognormal submodel								
Null	10342	11486.6	1.1107					
wave	10337	10779.9	1.0428	0.0678	6.107	6.107	656.77	5
wave mode_fx	10335	10579.6	1.0237	0.0192	1.727	7.834	194.03	2
wave mode_fx Year	10311	10447.2	1.0132	0.0105	0.941	8.775	130.19	24
wave mode_fx Year hr_fished	10305	10342.8	1.0037	0.0095	0.860	9.635	103.94	6
wave mode_fx Year hr_fished area avidity	10297	10178.2	0.9885	0.0075	0.678	11.004	81.44	2
wave mode_fx Year hr_fished area avidity	10297	10178.2	0.9885	0.0075	0.678	11.004	84.49	6
wave mode_fx Year hr_fished area avidity num_an	10291	10112	0.9826	0.0059	0.527	11.531	67.43	6

Table 5.18 MRFSS/MRIP standardized total catch rates (median) of Sheepshead on the Atlantic and Gulf coasts of Florida during 1991–2015 (various statistics for those catch rate estimates are also shown)

Atlantic

	Mean	cv	2.5th	25th	Median	75th	97.5th	n prop	n positive	obsmea	obs SE
1991	1.20	0.1325	0.92	1.09	1.19	1.30	1.55	388	119	1.62	0.25
1992	1.20	0.1053	0.96	1.11	1.19	1.28	1.46	659	240	1.76	0.21
1993	1.06	0.1018	0.86	0.98	1.05	1.13	1.28	852	268	1.55	0.35
1994	0.97	0.0986	0.79	0.90	0.96	1.03	1.17	1183	353	1.38	0.14
1995	0.86	0.1000	0.70	0.80	0.86	0.92	1.04	1082	308	1.27	0.16
1996	0.79	0.1081	0.64	0.73	0.79	0.85	0.97	916	226	0.96	0.11
1997	0.70	0.1108	0.56	0.65	0.70	0.75	0.87	935	220	0.74	0.08
1998	0.72	0.1045	0.58	0.67	0.71	0.76	0.88	1057	289	0.88	0.08
1999	0.62	0.0994	0.51	0.57	0.61	0.66	0.75	1583	376	0.86	0.08
2000	0.52	0.1085	0.42	0.48	0.51	0.55	0.63	1494	264	0.73	0.08
2001	0.70	0.0992	0.57	0.65	0.69	0.74	0.84	1640	354	0.89	0.08
2002	0.54	0.1089	0.43	0.50	0.54	0.58	0.67	1498	276	0.66	0.06
2003	0.58	0.1121	0.46	0.53	0.58	0.62	0.72	1235	245	0.97	0.12
2004	0.46	0.1174	0.36	0.42	0.46	0.50	0.58	1313	212	0.54	0.05
2005	0.45	0.1198	0.35	0.42	0.45	0.49	0.57	1426	205	0.57	0.06
2006	0.40	0.1145	0.31	0.37	0.39	0.43	0.49	1598	249	0.56	0.07
2007	0.37	0.1270	0.29	0.34	0.37	0.40	0.47	1335	184	0.54	0.07
2008	0.58	0.1164	0.46	0.53	0.58	0.62	0.72	1195	213	0.82	0.09
2009	0.53	0.1218	0.41	0.48	0.52	0.57	0.66	1023	184	0.72	0.09
2010	0.78	0.1100	0.62	0.72	0.77	0.83	0.95	1163	239	0.94	0.09
2011	0.63	0.1200	0.49	0.57	0.62	0.67	0.79	1054	190	0.99	0.12
2012	0.50	0.1220	0.39	0.46	0.50	0.54	0.63	1233	191	0.88	0.12
2013	0.49	0.1422	0.37	0.44	0.49	0.53	0.64	653	113	0.91	0.16
2014	0.65	0.1148	0.52	0.60	0.65	0.70	0.81	923	193	1.00	0.14
2015	0.71	0.1211	0.55	0.65	0.71	0.77	0.89	1047	177	0.94	0.12

Gulf

	Mean	cv	2.5th	25th	Median	75th	97.5th	n prop	n positive	obsmea	obs SE
1991	1.21	0.1236	0.94	1.10	1.20	1.30	1.52	304	149	2.37	0.35
1992	2.10	0.0778	1.80	1.99	2.10	2.21	2.44	749	507	4.52	0.33
1993	2.37	0.0764	2.03	2.24	2.36	2.48	2.74	683	508	4.24	0.30
1994	1.50	0.0845	1.27	1.41	1.49	1.58	1.77	814	444	2.43	0.21
1995	1.77	0.0819	1.50	1.67	1.76	1.86	2.07	764	457	3.30	0.40
1996	1.74	0.0808	1.48	1.64	1.73	1.83	2.03	658	426	2.91	0.21
1997	1.56	0.0861	1.31	1.47	1.55	1.64	1.83	563	363	2.92	0.27
1998	1.70	0.0784	1.45	1.61	1.70	1.79	1.98	770	519	3.54	0.30
1999	1.87	0.0729	1.61	1.77	1.86	1.96	2.14	890	637	4.83	0.30
2000	1.72	0.0861	1.45	1.62	1.71	1.82	2.02	538	350	4.33	0.37
2001	1.69	0.0841	1.43	1.59	1.69	1.79	1.99	564	365	3.78	0.29
2002	1.71	0.0803	1.45	1.61	1.70	1.79	1.99	622	420	3.97	0.29
2003	1.79	0.0811	1.52	1.69	1.79	1.89	2.09	553	400	4.18	0.30
2004	1.96	0.0790	1.68	1.86	1.96	2.06	2.29	569	424	4.78	0.37
2005	2.02	0.0786	1.73	1.91	2.01	2.12	2.35	603	441	4.82	0.33
2006	1.57	0.0830	1.33	1.48	1.56	1.65	1.83	566	398	3.83	0.30
2007	1.11	0.0931	0.92	1.04	1.11	1.18	1.33	501	303	2.92	0.28
2008	1.11	0.0896	0.92	1.04	1.10	1.17	1.31	527	333	2.71	0.24
2009	1.42	0.0856	1.20	1.33	1.41	1.49	1.67	548	378	3.87	0.32
2010	1.69	0.0823	1.44	1.60	1.69	1.78	1.98	585	414	4.29	0.30
2011	1.68	0.0766	1.44	1.59	1.68	1.77	1.95	762	541	3.71	0.23
2012	1.41	0.0817	1.20	1.33	1.41	1.49	1.65	679	457	3.25	0.25
2013	1.53	0.0878	1.28	1.43	1.52	1.61	1.80	444	323	4.11	0.42
2014	1.73	0.0783	1.48	1.64	1.73	1.82	2.01	570	428	3.59	0.25
2015	1.61	0.0852	1.35	1.51	1.60	1.70	1.89	491	358	3.92	0.30

Table 5.19 Numbers of hauls made and numbers of Sheepshead captured from various sampling areas by the FWC's Fishery-Independent monitoring programs stratified random surveys using 21.3-m bag seines and 183-m haul seines, 1996–2015. For the 21.3 m bag seine collections, young-of-the-year individuals were less than or equal to 40 mm SL and were subset over the presumed recruitment window of April–July. Age-1+ individuals captured using the 183-haul seine were assumed to be >= 100 mm SL and were collected throughout the year.

	Atlantic				**Gulf**			
	21.3-m bag seine		183-m haul seine		21.3-m bag seine		183-m haul seine	
	Collections	No. fish	Collections	No. fish	Collections	No. fish	Collections	No. fish
1996	422	45			1,544	215	312	435
1997	431	34	395	1,466	1,680	577	539	562
1998	379	108	434	2,260	1,332	161	727	802
1999	380	169	420	1,529	1,404	294	924	1,164
2000	380	290	420	1,515	1,446	512	919	995
2001	705	322	548	1,363	1,771	252	852	1,107
2002	839	149	614	1,789	1,776	160	852	973
2003	839	63	613	1,855	1,854	259	864	1,169
2004	912	489	614	1,845	2,304	471	924	1,567
2005	1,039	303	610	1,974	2,412	333	924	1,308
2006	1,123	215	612	1,370	2,412	108	924	1,031
2007	1,413	626	614	1,460	2,411	352	924	1,229
2008	1,412	562	592	1,375	2,172	964	924	1,736
2009	1,412	552	564	1,291	2,280	714	912	1,256
2010	1,172	295	564	1,435	2,201	178	888	1,661
2011	1,091	264	564	1,032	2,201	333	888	1,212
2012	1,064	240	564	1,892	2,201	407	888	1,278
2013	1,064	383	564	3,027	2,208	424	888	1,930
2014	1,057	170	564	2,430	2,208	886	888	1,706
2015	1,064	160	564	2,904	2,225	301	888	1,847

Table 5.20 Fork lengths (inches) of Sheepshead captured using the 183-m haul seine deployed during the Fishery-Independent Monitoring program's stratified random sampling survey conducted during 1997–2015 along the Atlantic coast of Florida.

	Year																		
Inch_FL	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0	0	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	4	0
2	0	1	4	10	1	5	5	13	9	1	31	23	5	9	0	0	37	12	2
3	21	4	20	83	28	14	10	141	25	12	175	26	46	22	14	18	108	31	31
4	46	12	30	110	110	32	15	111	37	18	67	39	81	35	44	121	37	29	32
5	28	39	41	64	104	38	19	40	54	34	54	45	82	56	48	165	96	46	49
6	30	33	41	56	93	47	13	26	57	33	59	47	99	95	43	199	180	94	90
7	53	30	41	48	116	92	37	25	114	51	93	77	81	146	78	145	273	236	208
8	97	59	50	86	115	131	74	47	171	76	83	93	74	123	103	88	330	258	287
9	159	101	82	99	120	172	126	81	183	70	98	97	80	111	99	126	276	198	306
10	165	174	89	114	101	182	198	115	126	97	106	108	114	77	94	139	229	233	338
11	216	282	129	128	102	164	212	179	146	130	136	105	110	119	96	179	230	229	360
12	144	282	162	160	124	169	198	226	181	169	157	131	116	130	93	176	220	208	282
13	159	277	170	159	117	200	233	212	186	159	169	133	107	125	103	176	204	182	196
14	134	279	182	187	92	180	221	222	162	125	162	159	113	119	103	166	212	149	160
15	94	247	202	173	88	128	187	185	130	88	127	122	99	90	76	103	107	110	92
16	44	116	151	105	81	114	125	127	111	58	80	95	72	45	41	60	67	64	55
17	25	79	93	60	69	82	88	90	82	42	52	34	52	35	31	40	42	48	49
18	23	42	72	41	33	35	54	40	59	27	32	25	29	17	10	31	23	38	20
19	14	22	29	22	16	26	36	27	23	12	33	14	20	14	13	24	17	11	11
20	6	14	21	13	13	6	23	11	19	17	11	12	17	6	8	4	4	16	5
21	9	4	6	5	6	7	6	2	6	8	8	0	7	8	5	3	3	7	3
22	3	1	0	2	2	3	3	3	3	3	3	2	4	2	1	0	2	1	0
23	0	1	2	1	2	5	2	2	1	1	1	2	2	1	1	0	1	0	1
24	0	1	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,470	2,100	1,618	1,728	1,533	1,833	1,885	1,926	1,885	1,231	1,738	1,389	1,411	1,386	1,104	1,963	2,698	2,205	2,578

Table 5.20 (con't) Fork lengths (inches) of Sheepshead captured using the 183-m haul seine deployed during the Fishery-Independent Monitoring program's stratified random sampling survey conducted during 1996–2015 along the Gulf coast of Florida.

	Year																			
Inch_FL	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0
1	2	3	0	2	0	0	0	0	0	2	1	0	1	0	0	0	9	1	13	5
2	2	1	4	13	8	1	3	9	20	9	1	0	46	2	4	46	58	53	171	52
3	12	13	28	43	62	27	46	93	43	64	60	31	106	83	62	4	1	0	0	48
4	15	33	38	76	36	33	51	81	67	69	62	48	121	137	77	86	79	75	88	50
5	28	40	23	38	42	20	27	40	43	55	54	25	86	77	47	66	68	75	53	0
6	23	32	29	31	51	20	24	32	14	53	41	32	105	75	63	52	88	107	45	58
7	4	21	32	48	74	53	26	28	27	42	43	43	86	92	98	46	92	113	50	95
8	21	21	54	60	56	73	36	51	56	73	58	87	104	89	144	82	89	200	104	99
9	32	32	61	106	57	76	63	84	100	94	64	103	149	112	162	83	106	215	184	159
10	50	43	64	89	75	105	73	94	152	109	100	127	160	110	151	109	130	205	205	206
11	58	52	62	96	90	117	110	130	186	149	126	147	200	125	183	94	141	194	226	246
12	49	44	76	86	82	102	71	129	164	141	111	94	154	114	162	96	119	183	213	207
13	48	40	68	95	78	89	98	127	176	141	105	114	155	103	137	88	115	169	157	154
14	43	62	87	90	83	81	102	116	153	107	96	88	122	90	109	85	93	123	152	162
15	32	50	72	73	83	95	84	95	128	104	87	113	118	81	103	90	85	90	92	105
16	24	39	49	63	55	84	58	65	86	87	66	77	91	47	71	41	62	53	58	63
17	17	22	32	42	51	70	38	62	67	64	57	55	58	37	44	32	36	31	31	49
18	10	21	19	27	24	42	27	34	42	46	21	35	32	30	23	22	19	21	12	27
19	1	19	31	29	32	31	23	24	25	29	13	14	27	10	10	15	17	12	7	10
20	0	18	19	13	22	22	15	15	16	18	4	12	12	2	5	1	6	3	3	5
21	0	9	9	11	12	16	5	5	5	4	2	4	4	1	4	3	4	2	1	4
22	1	2	3	2	4	9	6	1	5	2	0	2	1	2	0	3	0	0	1	0
23	0	3	3	1	6	6	4	1	1	0	0	0	1	0	0	0	0	0	1	2
24	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	472	620	863	1,135	1,086	1,172	992	1,316	1,576	1,462	1,172	1,251	1,939	1,419	1,659	1,145	1,421	1,926	1,867	1,806

Table 5.21 Linear regression statistics for the generalized linear models (factors were included if they reduced the mean deviance by at least 0.5%) on proportion positive 21.3-m seine sets (binomial sub-models) and on positive 21.3-m seine sets (lognormal sub-models) for the young-of-the-year index of Sheepshead on the Atlantic and Gulf coasts of Florida (Prob. chi square < 0.0001).

Source	DF	Deviance	Dev/DF	Δ mean dev	% change	Cum %	chisq	chi_df
Atlantic - Binomial sub-model								
Null	5509	4783.01	0.8682					
bay	5508	4106.56	0.7456	0.1227	14.127	14.13	676.44	1
bay sal_cat	5495	3996.82	0.7274	0.0182	2.097	16.22	109.74	13
bay sal_cat year	5478	3939.39	0.7191	0.0082	0.948	17.17	57.43	17
bay sal_cat year shore_cat	5474	3896.5	0.7118	0.0073	0.842	18.01	42.89	4
Atlantic - lognormal submodel								
Null	862	763.1	0.89					
sal_cat	849	727.78	0.86	0.0280	3.168	3.17	40.90	13
sal_cat bay	848	704.59	0.83	0.0263	2.975	6.14	27.94	1
sal_cat bay year	831	674.22	0.81	0.0195	2.208	8.35	38.02	17
Gulf - Binomial sub-model								
Null	13271	9335.39	0.70					
bay	13267	8665.13	0.65	0.0503	7.152	7.15	670.26	4
bay month	13264	8362.67	0.63	0.0227	3.221	10.37	302.46	3
bay month bveg_cat	13263	8157.85	0.62	0.0154	2.189	12.56	204.82	1
bay month bveg_cat year	13244	7971.61	0.60	0.0132	1.874	14.43	186.24	19
bay month bveg_cat year shore_cat	13240	7884.26	0.60	0.0064	0.912	15.35	87.35	4
Gulf - lognormal submodel								
Null	1492	1231.23	0.83					
bveg_cat	1491	1191.33	0.80	0.0262	3.176	3.18	49.19	1
bveg_cat year	1472	1135.73	0.77	0.0275	3.327	6.50	71.35	19
bveg_cat year bay	1468	1094.84	0.75	0.0258	3.121	9.62	54.75	4
bveg_cat year bay month	1465	1081.33	0.74	0.0077	0.932	10.56	18.53	3
bveg_cat year bay month sal_cat	1452	1058.33	0.73	0.0092	1.119	11.67	32.10	13
bveg_cat year bay month sal_cat temp_cat	1446	1044.68	0.72	0.0064	0.777	12.45	19.38	6

Table 5.22 Linear regression statistics for the generalized linear models (factors were included if they reduced the mean deviance by at least 0.5%) on proportion positive haul seine sets (binomial sub-models) and on positive haul seine sets (lognormal sub-models) for the age-1+ index of Sheepshead on the Atlantic and Gulf coasts of Florida (Prob. chi square < 0.0001).

Source	DF	Deviance	Dev/DF	Δ mean dev	% change	Cum %	chisq	chi_df
Atlantic - Binomial sub-model								
Null	10400	14389.6	1.3836					
bay	10398	12848	1.2356	0.1480	10.697	10.697	1541.69	2
bay month	10387	12626.6	1.2156	0.0200	1.446	12.142	221.35	11
bay month sal_cat	10374	12488.1	1.2038	0.0118	0.855	12.997	138.53	13
bay month sal_cat year	10356	12427	1.2000	0.0038	0.275	13.272	61.06	18
Atlantic - lognormal submodel								
Null	5475	6042.12	1.10					
bay	5473	5732.57	1.05	0.0562	5.089	5.089	287.99	2
bay year	5455	5619.74	1.03	0.0172	1.561	6.650	108.85	18
bay year sal_cat	5442	5543.43	1.02	0.0116	1.048	7.697	74.87	13
bay year sal_cat temp_cat	5433	5485.92	1.01	0.0089	0.806	8.503	57.11	9
Gulf - Binomial sub-model								
Null	16823	21550.7	1.28					
bay	16819	20701.8	1.23	0.0502	3.916	3.916	848.92	4
bay sal_cat	16806	20517	1.22	0.0100	0.784	4.700	184.79	13
bay sal_cat month	16795	20331.2	1.21	0.0103	0.801	5.502	185.87	11
bay sal_cat month year	16776	20157.4	1.20	0.0090	0.701	6.203	173.72	19
Gulf - lognormal submodel								
Null	5705	5468.13	0.96					
bay	5701	5175.09	0.91	0.0507	5.293	5.293	314.29	4
bay month	5690	5090.65	0.89	0.0131	1.365	6.658	93.87	11
bay month year	5671	5055.13	0.89	0.0033	0.341	6.999	39.95	19

Table 5.23 Standardized catch rates (medians) of young-of-the-year Sheepshead (≤ 40-mm SL) captured by 23.1-m bag seines during the FWC fishery Independent Monitoring program each April–July period on the Atlantic and Gulf coasts of Florida. Various statistics for those catch rate estimates are also shown.

Atlantic

	Mean	CV	2.5th	25th	Median	75th	97.5th	n prop	n positive	Obs mean	Obs SE
1998	0.016	0.473	0.006	0.0109	0.0147	0.020	0.035	112	23	0.714	0.274
1999	0.036	0.380	0.016	0.027	0.034	0.043	0.070	112	23	1.179	0.470
2000	0.036	0.361	0.017	0.027	0.034	0.043	0.067	112	28	1.348	0.398
2001	0.032	0.331	0.016	0.024	0.030	0.037	0.057	235	43	0.860	0.261
2002	0.027	0.342	0.013	0.021	0.026	0.032	0.049	265	28	0.392	0.108
2003	0.008	1.124	0.001	0.003	0.006	0.009	0.027	262	17	0.122	0.042
2004	0.058	0.283	0.033	0.047	0.056	0.068	0.097	296	59	1.348	0.396
2005	0.051	0.307	0.027	0.040	0.049	0.060	0.088	322	65	0.612	0.113
2006	0.026	0.346	0.012	0.020	0.024	0.030	0.048	358	48	0.397	0.080
2007	0.051	0.269	0.029	0.041	0.049	0.059	0.082	456	81	1.086	0.303
2008	0.041	0.276	0.023	0.033	0.039	0.047	0.067	456	78	0.853	0.326
2009	0.049	0.271	0.028	0.040	0.048	0.057	0.081	456	100	0.912	0.150
2010	0.039	0.299	0.021	0.031	0.038	0.046	0.066	376	65	0.521	0.096
2011	0.016	0.398	0.007	0.011	0.015	0.019	0.032	339	36	0.478	0.258
2012	0.018	0.380	0.008	0.013	0.017	0.021	0.034	340	38	0.341	0.087
2013	0.034	0.321	0.017	0.027	0.033	0.040	0.060	340	54	0.621	0.164
2014	0.018	0.422	0.007	0.013	0.017	0.022	0.037	333	40	0.243	0.053
2015	0.022	0.366	0.010	0.016	0.021	0.026	0.042	340	37	0.344	0.087

Gulf

	Mean	CV	2.5th	25th	Median	75th	97.5th	n prop	n positive	Obs mean	Obs SE
1996	0.009	0.403	0.004	0.007	0.008	0.011	0.018	504	41	0.234	0.088
1997	0.047	0.259	0.028	0.038	0.045	0.054	0.075	551	87	0.833	0.182
1998	0.018	0.368	0.008	0.013	0.017	0.021	0.034	443	43	0.251	0.060
1999	0.037	0.294	0.020	0.030	0.036	0.043	0.063	468	60	0.393	0.081
2000	0.055	0.284	0.031	0.044	0.053	0.064	0.092	474	71	0.882	0.338
2001	0.027	0.330	0.014	0.021	0.026	0.032	0.049	592	52	0.248	0.045
2002	0.017	0.389	0.007	0.012	0.016	0.020	0.033	592	43	0.142	0.029
2003	0.032	0.299	0.017	0.025	0.031	0.037	0.054	587	53	0.296	0.063
2004	0.044	0.257	0.026	0.036	0.043	0.050	0.070	768	94	0.469	0.090
2005	0.019	0.308	0.010	0.015	0.018	0.022	0.033	804	68	0.286	0.078
2006	0.006	0.754	0.001	0.003	0.005	0.007	0.018	802	39	0.071	0.014
2007	0.035	0.276	0.020	0.028	0.033	0.040	0.056	803	80	0.298	0.055
2008	0.093	0.240	0.057	0.077	0.090	0.105	0.143	698	134	1.062	0.191
2009	0.040	0.259	0.023	0.033	0.039	0.046	0.063	772	113	0.635	0.186
2010	0.009	0.411	0.004	0.007	0.009	0.011	0.018	735	50	0.152	0.035
2011	0.028	0.269	0.017	0.023	0.027	0.033	0.046	734	81	0.330	0.068
2012	0.035	0.276	0.020	0.028	0.034	0.041	0.058	734	100	0.392	0.066
2013	0.029	0.273	0.017	0.023	0.028	0.034	0.047	736	102	0.399	0.063
2014	0.057	0.246	0.034	0.047	0.056	0.066	0.090	734	114	0.939	0.230
2015	0.012	0.335	0.006	0.009	0.012	0.015	0.022	741	68	0.227	0.062

Table 5.24 Indices of abundance for Sheepshead on the Atlantic coast of Florida. The MRFSS indices were considered valid for Sheepshead ages 2 through 6. The gray color indicates the strongest year-classes (age-0) and their progressions across ages and years.

	Age-specific and age-aggregated FIM Haul Seine catch rates (number of fish at age per haul-seine set)											Age-aggregated		Combined early YOY (median #		MRFSS index (median # per	
Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10+	CPUE (median)	CV	per set)	CV	trip scaled to mean)	CV
1991																1.764	0.133
1992																1.764	0.105
1993																1.553	0.102
1994																1.424	0.099
1995																1.266	0.100
1996																1.167	0.108
1997	0.241	0.391	0.546	1.092	0.592	0.276	0.190	0.206	0.053	0.019	0.068	1.599	0.092			1.035	0.111
1998	0.129	0.122	0.668	0.867	1.141	1.082	0.157	0.115	0.184	0.128	0.147	1.909	0.085	0.015	0.473	1.055	0.104
1999	0.326	0.137	0.434	0.376	0.651	0.440	0.185	0.450	0.043	0.427	0.074	1.664	0.084	0.034	0.380	0.910	0.099
2000	0.636	0.441	0.437	0.471	0.526	0.186	0.358	0.230	0.054	0.247	0.325	1.905	0.083	0.034	0.361	0.760	0.109
2001	0.443	0.393	0.549	0.251	0.209	0.226	0.159	0.110	0.158	0.094	0.185	1.316	0.084	0.030	0.331	1.027	0.099
2002	0.145	0.293	0.678	0.542	0.305	0.270	0.247	0.070	0.090	0.062	0.259	1.766	0.077	0.026	0.342	0.795	0.109
2003	0.101	0.045	0.459	0.737	0.473	0.301	0.165	0.348	0.115	0.105	0.170	2.120	0.073	0.006	1.124	0.853	0.112
2004	0.547	0.028	0.244	0.428	0.736	0.337	0.214	0.167	0.119	0.044	0.265	1.933	0.073	0.056	0.283	0.681	0.117
2005	0.225	0.605	0.185	0.385	0.433	0.392	0.239	0.132	0.034	0.134	0.272	1.888	0.073	0.049	0.307	0.667	0.120
2006	0.160	0.136	0.454	0.082	0.197	0.297	0.305	0.069	0.080	0.022	0.169	1.216	0.087	0.024	0.346	0.584	0.114
2007	0.534	0.130	0.392	0.529	0.145	0.159	0.234	0.270	0.136	0.083	0.199	1.579	0.079	0.049	0.269	0.544	0.127
2008	0.244	0.263	0.332	0.369	0.442	0.044	0.068	0.148	0.191	0.090	0.149	1.512	0.081	0.039	0.276	0.857	0.116
2009	0.417	0.133	0.590	0.299	0.280	0.214	0.050	0.035	0.114	0.062	0.283	1.581	0.082	0.048	0.271	0.772	0.122
2010	0.218	0.499	0.287	0.417	0.261	0.196	0.203	0.043	0.047	0.030	0.235	1.391	0.081	0.038	0.299	1.142	0.110
2011	0.188	0.069	0.529	0.212	0.299	0.287	0.082	0.103	0.009	0.023	0.153	1.053	0.085	0.015	0.398	0.922	0.120
2012	0.791	0.063	0.511	0.734	0.235	0.473	0.148	0.148	0.099	0.023	0.250	1.666	0.084	0.017	0.380	0.736	0.122
2013	0.680	0.903	0.469	0.626	0.778	0.279	0.318	0.202	0.181	0.125	0.217	2.395	0.079	0.033	0.321	0.718	0.142
2014	0.216	0.747	0.695	0.328	0.562	0.602	0.181	0.120	0.067	0.022	0.323	1.837	0.080	0.017	0.422	0.958	0.115
2015	0.202	0.721	1.129	0.672	0.402	0.606	0.452	0.095	0.096	0.053	0.131	2.375	0.078	0.021	0.366	1.045	0.121

Table 5.24 (Cont.) Indices of abundance for Sheepshead on the Gulf coast of Florida. The MRFSS indices were considered valid for Sheepshead ages 2 through 6. The gray color indicates the strongest year-classes (age-0) and their progressions across ages and years.

	FIM Haul Seine catch rates at age and pooled (number of fish at age per haul-seine set)													**Combined early YOY** (median # per set)		**MRFSS index** (median # per trip scaled to mean)	
Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10+	Age-aggregated CPUE (median)	CV		CV		CV
1991																0.722	0.124
1992																1.265	0.078
1993																1.425	0.076
1994																0.902	0.084
1995																1.062	0.082
1996	0.173	0.108	0.209	0.294	0.177	0.207	0.182	0.038	0.035	0.007	0.046	0.716	0.135	0.008	0.403	1.045	0.081
1997	0.226	0.060	0.104	0.150	0.232	0.075	0.105	0.045	0.013	0.035	0.024	0.766	0.103	0.045	0.259	0.936	0.086
1998	0.096	0.096	0.202	0.187	0.163	0.197	0.051	0.070	0.063	0.007	0.035	0.893	0.089	0.017	0.368	1.023	0.078
1999	0.167	0.133	0.226	0.232	0.139	0.120	0.052	0.074	0.033	0.008	0.040	1.027	0.079	0.036	0.294	1.125	0.073
2000	0.165	0.189	0.198	0.231	0.114	0.053	0.056	0.081	0.016	0.009	0.032	0.897	0.081	0.053	0.284	1.035	0.086
2001	0.001	0.174	0.263	0.227	0.355	0.118	0.036	0.025	0.058	0.045	0.056	0.978	0.080	0.026	0.330	1.019	0.084
2002	0.163	0.038	0.185	0.220	0.209	0.174	0.048	0.029	0.025	0.031	0.027	0.985	0.081	0.016	0.389	1.028	0.080
2003	0.247	0.093	0.176	0.302	0.293	0.157	0.152	0.028	0.007	0.008	0.052	1.231	0.075	0.031	0.299	1.079	0.081
2004	0.148	0.120	0.123	0.364	0.394	0.220	0.128	0.134	0.017	0.014	0.032	1.271	0.075	0.043	0.257	1.182	0.079
2005	0.215	0.134	0.173	0.188	0.269	0.271	0.101	0.081	0.089	0.018	0.016	1.258	0.075	0.018	0.308	1.216	0.079
2006	0.193	0.117	0.260	0.180	0.114	0.131	0.127	0.054	0.024	0.038	0.017	0.983	0.081	0.005	0.754	0.943	0.083
2007	0.113	0.062	0.261	0.329	0.201	0.098	0.075	0.098	0.023	0.020	0.041	0.877	0.083	0.033	0.276	0.669	0.093
2008	0.393	0.269	0.256	0.366	0.313	0.172	0.101	0.108	0.044	0.022	0.049	1.304	0.070	0.090	0.240	0.667	0.090
2009	0.328	0.158	0.295	0.183	0.226	0.139	0.064	0.033	0.049	0.033	0.034	1.080	0.072	0.039	0.259	0.851	0.086
2010	0.214	0.087	0.377	0.401	0.341	0.190	0.116	0.057	0.034	0.006	0.023	1.301	0.072	0.009	0.411	1.017	0.082
2011	0.229	0.009	0.198	0.259	0.201	0.104	0.138	0.055	0.016	0.009	0.039	0.888	0.081	0.027	0.269	1.012	0.077
2012	0.252	0.188	0.082	0.272	0.351	0.152	0.075	0.095	0.033	0.048	0.006	1.087	0.071	0.034	0.276	0.850	0.082
2013	0.230	0.200	0.541	0.214	0.309	0.261	0.122	0.086	0.087	0.018	0.058	1.484	0.064	0.028	0.273	0.917	0.088
2014	0.366	0.057	0.313	0.452	0.133	0.263	0.257	0.127	0.049	0.039	0.039	1.497	0.065	0.056	0.246	1.042	0.078
2015	0.175	0.185	0.176	0.491	0.440	0.119	0.178	0.126	0.040	0.017	0.044	1.365	0.065	0.012	0.335	0.968	0.085

Table 5.25 Estimated age-frequencies for Sheepshead caught by the FWC's FIM program 183-m haul-seine gear during 1997–2015 on Florida's Atlantic coast and during 1996–2015 on Florida's Gulf coast.

Atlantic

Age (yr)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0		95	56	137	267	243	89	62	336	137	98	328	145	235	123	106	446	384	122	114
1		154	53	58	185	215	180	28	17	369	83	80	156	75	282	39	35	509	421	407
2		216	290	182	184	301	416	281	150	113	278	241	196	333	162	299	288	265	392	637
3		432	376	158	198	137	333	452	263	235	50	325	218	169	235	120	414	353	185	379
4		234	495	273	221	115	187	290	452	264	120	89	262	158	147	169	132	439	317	227
5		109	470	185	78	124	166	185	207	239	182	97	26	121	110	162	267	157	340	342
6		75	68	78	150	87	151	101	131	146	187	144	40	28	115	46	84	179	102	255
7		81	50	189	96	60	43	213	102	80	42	166	88	20	24	58	84	114	68	54
8		21	80	18	23	87	55	71	73	21	49	83	113	65	27	5	56	102	38	54
9		8	55	179	104	51	38	64	27	82	14	51	53	35	17	13	13	70	13	30
10+		27	64	31	136	101	159	104	162	166	103	122	88	160	133	86	141	123	182	74
Totals		1,452	2,057	1,488	1,642	1,523	1,818	1,851	1,921	1,852	1,207	1,726	1,385	1,397	1,375	1,102	1,960	2695	2180	2571
Sets		395	434	420	420	548	614	613	614	610	612	614	592	564	564	564	564	564	564	564

Gulf

Age (yr)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0	54	122	70	154	152	1	139	213	137	199	178	104	363	299	190	203	224	204	325	155
1	34	33	70	123	173	148	33	80	111	124	108	57	248	144	78	8	167	177	51	164
2	65	56	147	209	182	224	157	152	113	160	241	242	236	269	335	176	73	481	278	156
3	92	81	136	214	213	194	188	261	336	173	166	304	338	167	356	230	242	190	401	436
4	55	125	118	129	105	302	178	253	364	248	105	185	290	206	303	178	312	274	118	390
5	65	41	143	111	49	100	149	136	204	250	121	90	159	127	168	93	135	231	233	106
6	57	56	37	48	51	31	41	132	118	94	117	70	93	59	103	122	67	108	229	158
7	12	24	51	69	75	22	25	24	124	75	50	90	100	30	50	49	84	76	113	112
8	11	7	46	31	15	49	21	6	16	82	22	21	41	45	30	14	29	77	44	36
9	2	19	5	7	8	39	27	7	13	17	35	18	20	30	6	8	42	16	34	16
10+	14	13	25	37	29	48	23	45	30	15	15	38	45	31	20	35	5	52	35	39
Totals	461	576	848	1,131	1,051	1,157	980	1,309	1,565	1,438	1,157	1,219	1,933	1,406	1,640	1,117	1,381	1,887	1,861	1,768
Sets	312	539	727	924	919	852	852	864	924	924	924	924	924	912	888	888	888	888	888	888

Table 6.1 List of SS parameters for the Atlantic base model configuration. The list includes fixed and estimated parameter values and their associated initial estimates from the base model run, any prior types and standard deviations that were used, and whther the parameter was estimated, fixed or NA (not applicable).

Label	Predicted Estimated Value	Initial Value	Prior type	Prior Prior Value	Prior SD	Status
NatM_p_1_Fem_GP_1	0.307647	0.33	Sym_Beta	0.33	10	Estimated
L_at_Amin_Fem_GP_1	12.8423	17	Sym_Beta	17	1	Estimated
L_at_Amax_Fem_GP_1	44.7595	46	Sym_Beta	46	10	Estimated
VonBert_K_Fem_GP_1	0.23567	0.23	Sym_Beta	0.23	1	Estimated
CV_young_Fem_GP_1	0.230721	0.17	No_prior	--	--	Estimated
CV_old_Fem_GP_1	0.120193	0.14	No_prior	--	--	Estimated
Wtlen_1_Fem	2.00E-05	2.00E-05	No_prior	--	--	Fixed
Wtlen_2_Fem	2.99905	2.99905	No_prior	--	--	Fixed
Mat50%_Fem	25.1134	31	Sym_Beta	31.4436	10	Estimated
Mat_slope_Fem	-0.14995	-0.1132	Sym_Beta	-0.1132	10	Estimated
Eggs_scalar_Fem	1	1	No_prior	--	--	Fixed
Eggs_exp_wt_Fem	1	1	No_prior	--	--	Fixed
RecrDist_GP_1	0	0	No_prior	--	--	Fixed
RecrDist_Area_1	0	0	No_prior	--	--	Fixed
RecrDist_Seas_1	0	0	No_prior	--	--	Fixed
CohortGrowDev	1	1	No_prior	--	--	Fixed
SR_LN(R0)	8.74928	15.42	No_prior	--	--	Estimated
SR_BH_steep	0.729974	0.72	Sym_Beta	0.72	10	Estimated
SR_sigmaR	0.418976	0.6	No_prior	--	--	Estimated
SR_envlink	0.1	0.1	No_prior	--	--	--
SR_R1_offset	0	0	No_prior	--	--	--
SR_autocorr	0	0	No_prior	--	--	--
Main_RecrDev_1982	0.74309	--	--	--	--	--
Main_RecrDev_1983	0.278957	--	--	--	--	--
Main_RecrDev_1984	0.747274	--	--	--	--	--
Main_RecrDev_1985	0.248711	--	--	--	--	--

Main_RecrDev_1986	-0.1337	--	--	--	--	--
Main_RecrDev_1987	0.067264	--	--	--	--	--
Main_RecrDev_1988	0.064984	--	--	--	--	--
Main_RecrDev_1989	0.08024	--	--	--	--	--
Main_RecrDev_1990	0.366896	--	--	--	--	--
Main_RecrDev_1991	-0.013	--	--	--	--	--
Main_RecrDev_1992	-0.01311	--	--	--	--	--
Main_RecrDev_1993	0.338438	--	--	--	--	--
Main_RecrDev_1994	0.300527	--	--	--	--	--
Main_RecrDev_1995	-0.17643	--	--	--	--	--
Main_RecrDev_1996	0.043907	--	--	--	--	--
Main_RecrDev_1997	-0.42457	--	--	--	--	--
Main_RecrDev_1998	-0.27597	--	--	--	--	--
Main_RecrDev_1999	-0.07848	--	--	--	--	--
Main_RecrDev_2000	0.365456	--	--	--	--	--
Main_RecrDev_2001	-0.02544	--	--	--	--	--
Main_RecrDev_2002	-0.52994	--	--	--	--	--
Main_RecrDev_2003	-1.30503	--	--	--	--	--
Main_RecrDev_2004	0.091083	--	--	--	--	--
Main_RecrDev_2005	-0.20007	--	--	--	--	--
Main_RecrDev_2006	-0.31234	--	--	--	--	--
Main_RecrDev_2007	0.154069	--	--	--	--	--
Main_RecrDev_2008	-0.39576	--	--	--	--	--
Main_RecrDev_2009	0.373178	--	--	--	--	--
Main_RecrDev_2010	-0.16046	--	--	--	--	--
Main_RecrDev_2011	-0.81748	--	--	--	--	--
Main_RecrDev_2012	0.024908	--	--	--	--	--
Main_RecrDev_2013	0.531866	--	--	--	--	--
Main_RecrDev_2014	0.159674	--	--	--	--	--
Main_RecrDev_2015	-0.11874	--	--	--	--	--
InitF_1Commercial	0.020961	0.17	No_prior		--	--
InitF_2Recreational	0.130133	0.39	Sym_Beta	0.39	1	Estimated
SizeSel_1P_1_Commercial	23.3063	28	Sym_Beta	28	1	Estimated
SizeSel_1P_2_Commercial	2.99218	3.6	Sym_Beta	3.6	1	Estimated

SizeSel_2P_1_Recreational	21.8521	23.14	Sym_Beta	23.14	20	Estimated
SizeSel_2P_2_Recreational	6.02803	5.46	Sym_Beta	5.46	10	Estimated
Retain_2P_1_Recreational	22.6223	30.85	Sym_Beta	30.85	20	Estimated
Retain_2P_2_Recreational	2.50099	0.18	Sym_Beta	0.18	10	Estimated
Retain_2P_3_Recreational	1	1	No_prior	--	--	--
Retain_2P_4_Recreational	0	0	No_prior	--	--	--
DiscMort_2P_1_Recreational	20	20	No_prior	--	--	--
DiscMort_2P_2_Recreational	1.00E+06	1.00E+06	No_prior	--	--	--
DiscMort_2P_3_Recreational	-0.98	-0.98	No_prior	--	--	--
DiscMort_2P_4_Recreational	0	0	No_prior	--	--	--
SizeSel_4P_1_FIM_HaulSeine	26.7153	27.76	Sym_Beta	27.76	1	Estimated
SizeSel_4P_2_FIM_HaulSeine	18.9015	6.1	Sym_Beta	6.1	1	Estimated
SizeSel_1P_1_Commercial_BLK1repl_1996	33.9137	37	Sym_Beta	37	1	Estimated
SizeSel_1P_2_Commercial_BLK1repl_1996	4.04723	3	Sym_Beta	3	1	Estimated
Retain_2P_1_Recreational_BLK1repl_1996	30.8283	33.45	Sym_Beta	33.45	10	Estimated
Retain_2P_2_Recreational_BLK1repl_1996	2.68113	0.26	Sym_Beta	0.26	10	Estimated

Table 6.2 List of SS parameters for the Gulf base model configuration. The list includes fixed and estimated parameter values and their associated initial estimates from the base model run, any prior types and standard deviations that were used, and whther the parameter was estimated, fixed or NA (not applicable).

Label	Predicted Estimated Value	Initial Value	Prior type	Prior Prior Value	Prior SD	Status
NatM_p_1_Fem_GP_1	0.299142	0.32	Sym_Beta	0.33	20	Estimated
L_at_Amin_Fem_GP_1	10.304	14	Sym_Beta	17	1	Estimated
L_at_Amax_Fem_GP_1	44.0018	47	Sym_Beta	46	20	Estimated
VonBert_K_Fem_GP_1	0.258517	0.26	Sym_Beta	0.23	1	Estimated
CV_young_Fem_GP_1	0.245856	0.17	No_prior	--	--	Estimated
CV_old_Fem_GP_1	0.17397	0.14	No_prior	--	--	Estimated
Wtlen_1_Fem	2.00E-05	2.00E-05	No_prior	--	--	Fixed
Wtlen_2_Fem	2.92161	2.92161	No_prior	--	--	Fixed
Mat50%_Fem	24.9323	32	Sym_Beta	31.4436	10	Estimated
Mat_slope_Fem	-0.15005	-0.1132	Sym_Beta	-0.1132	10	Estimated
Eggs_scalar_Fem	1	1	No_prior	--	--	Fixed
Eggs_exp_wt_Fem	1	1	No_prior	--	--	Fixed
RecrDist_GP_1	0	0	No_prior	--	--	Fixed
RecrDist_Area_1	0	0	No_prior	--	--	Fixed
RecrDist_Seas_1	0	0	No_prior	--	--	Fixed
CohortGrowDev	1	1	No_prior	--	--	Fixed
SR_LN(R0)	9.13815	15.4249	No_prior	--	--	Estimated
SR_BH_steep	0.759249	0.72	Sym_Beta	0.72	10	Estimated
SR_sigmaR	0.305218	0.6	No_prior	--	--	Estimated
SR_envlink	0.1	0.1	No_prior	--	--	--
SR_R1_offset	0	0	No_prior	--	--	--
SR_autocorr	0	0	No_prior	--	--	--
Main_RecrDev_1982	0.186246	--	--	--	--	--
Main_RecrDev_1983	0.383718	--	--	--	--	--
Main_RecrDev_1984	-0.06648	--	--	--	--	--
Main_RecrDev_1985	0.012218	--	--	--	--	--

Main_RecrDev_1986	0.413423	--	--	--	--	--
Main_RecrDev_1987	-0.46363	--	--	--	--	--
Main_RecrDev_1988	-0.39147	--	--	--	--	--
Main_RecrDev_1989	-0.38873	--	--	--	--	--
Main_RecrDev_1990	0.498985	--	--	--	--	--
Main_RecrDev_1991	0.683408	--	--	--	--	--
Main_RecrDev_1992	-0.15934	--	--	--	--	--
Main_RecrDev_1993	0.270709	--	--	--	--	--
Main_RecrDev_1994	0.004764	--	--	--	--	--
Main_RecrDev_1995	-0.40127	--	--	--	--	--
Main_RecrDev_1996	-0.38027	--	--	--	--	--
Main_RecrDev_1997	0.356839	--	--	--	--	--
Main_RecrDev_1998	0.031135	--	--	--	--	--
Main_RecrDev_1999	0.146242	--	--	--	--	--
Main_RecrDev_2000	0.290033	--	--	--	--	--
Main_RecrDev_2001	0.083441	--	--	--	--	--
Main_RecrDev_2002	-0.3414	--	--	--	--	--
Main_RecrDev_2003	-0.16754	--	--	--	--	--
Main_RecrDev_2004	0.052797	--	--	--	--	--
Main_RecrDev_2005	-0.08008	--	--	--	--	--
Main_RecrDev_2006	-0.33288	--	--	--	--	--
Main_RecrDev_2007	0.116742	--	--	--	--	--
Main_RecrDev_2008	0.056497	--	--	--	--	--
Main_RecrDev_2009	-0.27385	--	--	--	--	--
Main_RecrDev_2010	-0.20809	--	--	--	--	--
Main_RecrDev_2011	0.253487	--	--	--	--	--
Main_RecrDev_2012	0.219778	--	--	--	--	--
Main_RecrDev_2013	-0.41866	--	--	--	--	--
Main_RecrDev_2014	0.433687	--	--	--	--	--
Main_RecrDev_2015	-0.42047	--	--	--	--	--
InitF_1Commercial	0.00764	0.042	No_prior	--	--	--
InitF_2Recreational	0.081315	0.252	Sym_Beta	0.39	10	Estimated
SizeSel_1P_1_Commercial	24.5447	29.02	Sym_Beta	28	1	Estimated
SizeSel_1P_2_Commercial	5.1463	4.36	Sym_Beta	3.6	1	Estimated

SizeSel_2P_1_Recreational	18.1406	28.33	Sym_Beta	23.14	20	Estimated
SizeSel_2P_2_Recreational	5.72578	4.27	Sym_Beta	5.46	20	Estimated
Retain_2P_1_Recreational	24.1841	28	Sym_Beta	30.85	20	Estimated
Retain_2P_2_Recreational	5.965	0.23	Sym_Beta	0.18	20	Estimated
Retain_2P_3_Recreational	1	1	No_prior	--	--	--
Retain_2P_4_Recreational	0	0	No_prior	--	--	--
DiscMort_2P_1_Recreational	20	20	No_prior	--	--	--
DiscMort_2P_2_Recreational	1.00E+06	1.00E+06	No_prior	--	--	--
DiscMort_2P_3_Recreational	-0.98	-0.98	No_prior	--	--	--
DiscMort_2P_4_Recreational	0	0	No_prior	--	--	--
SizeSel_4P_1_FIM_HaulSeine	27.7407	26.97	Sym_Beta	27.76	1	Estimated
SizeSel_4P_2_FIM_HaulSeine	19.0089	6.5	Sym_Beta	6.1	1	Estimated
SizeSel_1P_1_Commercial_BLK1repl_1996	36.4564	38.86	Sym_Beta	37	1	Estimated
SizeSel_1P_2_Commercial_BLK1repl_1996	5.04757	3.07	Sym_Beta	3	1	Estimated
Retain_2P_1_Recreational_BLK1repl_1996	29.2368	32.97	Sym_Beta	33.45	1	Estimated
Retain_2P_2_Recreational_BLK1repl_1996	1.51013	0.31	Sym_Beta	0.26	1	Estimated

Table 6.3 Time series of total biomass (mt), SSB (mt), recruits (numbers), $SPR_{30\%}$, summary instantaneous *F* for ages 1–6 (most vulnerable), *F* from commercial and *F* from recreational fisheries on all ages, estimated by the Atlantic base model.

Year	Total biomass (mt)	Spawning biomass (mt)	Age-0 recruits	*SPR*	*F* ages 1-6	*F* Commercial	*F* recreational
1982	4,497	3,250	11,140	0.41	0.12	0.04	0.18
1983	4,567	3,081	6,940	0.56	0.06	0.03	0.09
1984	4,890	3,401	11,271	0.42	0.11	0.03	0.18
1985	5,094	3,412	6,850	0.66	0.04	0.03	0.05
1986	5,567	3,920	4,773	0.54	0.07	0.03	0.11
1987	5,560	4,101	5,872	0.42	0.13	0.03	0.18
1988	5,142	3,827	5,801	0.53	0.08	0.03	0.11
1989	5,006	3,748	5,872	0.65	0.05	0.03	0.06
1990	5,043	3,787	7,834	0.52	0.08	0.04	0.11
1991	4,969	3,633	5,325	0.43	0.10	0.04	0.16
1992	4,660	3,429	5,276	0.42	0.11	0.05	0.16
1993	4,356	3,207	7,416	0.40	0.12	0.04	0.19
1994	4,152	2,953	7,038	0.31	0.16	0.05	0.28
1995	3,818	2,634	4,275	0.38	0.12	0.04	0.21
1996	3,647	2,588	5,309	0.52	0.06	0.04	0.19
1997	3,723	2,651	3,339	0.58	0.05	0.04	0.14
1998	3,746	2,771	3,908	0.63	0.04	0.03	0.11
1999	3,763	2,825	4,779	0.58	0.06	0.03	0.15
2000	3,711	2,764	7,418	0.55	0.06	0.04	0.16
2001	3,787	2,683	4,989	0.51	0.05	0.03	0.20
2002	3,802	2,711	3,019	0.62	0.04	0.03	0.12
2003	3,853	2,863	1,405	0.59	0.05	0.03	0.14
2004	3,663	2,862	5,675	0.69	0.04	0.02	0.09
2005	3,684	2,782	4,219	0.53	0.06	0.03	0.18
2006	3,498	2,618	3,727	0.61	0.04	0.04	0.12
2007	3,456	2,589	5,928	0.60	0.04	0.04	0.13
2008	3,528	2,554	3,411	0.62	0.03	0.04	0.12
2009	3,549	2,631	7,404	0.63	0.04	0.04	0.11
2010	3,763	2,660	4,352	0.56	0.05	0.03	0.16
2011	3,814	2,757	2,272	0.62	0.04	0.02	0.13
2012	3,783	2,865	5,313	0.64	0.05	0.03	0.11
2013	3,813	2,842	8,807	0.63	0.04	0.04	0.11
2014	4,057	2,848	6,073	0.46	0.06	0.03	0.26
2015	4,033	2,815	4,587	0.61	0.04	0.03	0.13

Table 6.4 Time series of total biomass (mt), SSB (mt), recruits (numbers), $SPR_{30\%}$, summary instantaneous *F* for ages 1–6 (most vulnerable), *F* from commercial and *F* from recreational fisheries on all ages, estimated by the Gulf base model.

Year	Total biomass (mt)	Spawning biomass (mt)	Age-0 recruits	*SPR*	*F* ages 1-6	*F* Commercial	*F* recreational
1982	5,910	4,585	10,284	0.59	0.09	0.02	0.10
1983	5,818	4,479	12,495	0.45	0.15	0.02	0.18
1984	5,531	4,157	7,894	0.51	0.06	0.02	0.10
1985	5,414	4,103	8,526	0.48	0.09	0.02	0.18
1986	5,211	3,966	12,679	0.61	0.07	0.02	0.15
1987	5,342	4,000	5,280	0.57	0.08	0.02	0.15
1988	5,291	4,068	5,688	0.33	0.05	0.03	0.08
1989	4,495	3,488	5,585	0.28	0.06	0.03	0.09
1990	3,606	2,783	13,085	0.36	0.16	0.04	0.28
1991	3,386	2,416	15,326	0.36	0.20	0.05	0.35
1992	3,534	2,329	6,550	0.20	0.14	0.06	0.22
1993	3,137	2,088	9,838	0.20	0.11	0.08	0.21
1994	2,819	1,854	7,335	0.29	0.21	0.12	0.47
1995	2,801	1,891	4,911	0.26	0.25	0.12	0.47
1996	2,597	1,820	4,968	0.38	0.16	0.13	0.25
1997	2,558	1,834	10,403	0.39	0.19	0.09	0.34
1998	2,630	1,791	7,467	0.37	0.11	0.06	0.31
1999	2,723	1,840	8,435	0.33	0.11	0.08	0.29
2000	2,776	1,854	9,756	0.39	0.08	0.07	0.33
2001	2,996	1,994	8,073	0.40	0.11	0.08	0.40
2002	3,194	2,173	5,381	0.44	0.08	0.08	0.30
2003	3,324	2,369	6,519	0.43	0.08	0.07	0.29
2004	3,308	2,404	8,149	0.44	0.07	0.06	0.24
2005	3,304	2,386	7,125	0.34	0.09	0.06	0.25
2006	3,076	2,191	5,436	0.45	0.09	0.05	0.24
2007	3,092	2,241	8,564	0.47	0.12	0.05	0.39
2008	3,174	2,271	8,086	0.49	0.07	0.05	0.24
2009	3,309	2,359	5,856	0.44	0.07	0.04	0.22
2010	3,314	2,400	6,276	0.53	0.06	0.03	0.20
2011	3,408	2,507	10,042	0.48	0.07	0.04	0.24
2012	3,483	2,500	9,704	0.47	0.06	0.06	0.15
2013	3,613	2,550	5,144	0.52	0.07	0.04	0.20
2014	3,742	2,730	12,216	0.41	0.06	0.05	0.21
2015	3,744	2,637	5,167	0.49	0.05	0.05	0.17

Table 7.1 Derived reference points from the Atlantic and Gulf coast base model configurations.

Reference Point[1]	Atlantic Base	Gulf Base
SSB unfished (mt)	6,416	6,916
Total B unfished (mt)	7,998	8,465
R_0 (millions)	6,306	9,303
SSB at *SSB*30% (mt)	1,925	2,075
SPR at *SSB*30%	0.36	0.36
$F_{SSB30\%}$	0.11	0.10
Yield at *SSB*30% (mt)	722	792
SSB at *SPR*30% (mt)	1,467	1,658
$F_{SPR30\%}$	0.14	0.13
Yield at *SPR*30% (mt)	732	809
$SSB_{current}$ (mt)	2,835	2,638
$F_{current}$ (ages 1-6)	0.05	0.06
$SPR_{current}$	0.56	0.52
Bratio ($SSB_{current}/SSB_{SPR30\%}$)	1.93	1.59
Fratio ($F_{current}/F_{SPR30\%}$)	0.36	0.46

[1] *SSB* is mature biomass; R_0 is unfished recruitment; SSB30% is SSB at 30% unfished SSB, SPR is spawning potential ratio; $F_{SPR30\%}$ is F that produces 30% *SPR*; *current* = geometric mean.

Table 7.2 Derived *F* ratios ($F/F_{30\%}$) and B ratios (SSB/SSB@$F_{30\%}$) from the Atlantic and Gulf coast base model configurations.

	Atlantic		**Gulf**	
Year	*F* Ratio	B Ratio	*F* Ratio	B Ratio
1982	0.82	2.22	0.41	2.21
1983	0.39	2.10	0.66	2.16
1984	0.76	2.32	0.50	2.00
1985	0.28	2.33	0.61	1.98
1986	0.53	2.67	0.38	1.91
1987	0.91	2.80	0.40	1.93
1988	0.56	2.61	1.16	1.96
1989	0.35	2.55	1.45	1.68
1990	0.57	2.58	1.00	1.34
1991	0.72	2.48	0.75	1.16
1992	0.79	2.34	1.47	1.12
1993	0.88	2.19	1.82	1.01
1994	1.12	2.01	1.13	0.89
1995	0.85	1.80	1.35	0.91
1996	0.43	1.76	0.77	0.88
1997	0.34	1.81	0.76	0.88
1998	0.31	1.89	0.59	0.86
1999	0.41	1.93	0.76	0.89
2000	0.41	1.88	0.60	0.89
2001	0.37	1.83	0.56	0.96
2002	0.26	1.85	0.53	1.05
2003	0.36	1.95	0.67	1.14
2004	0.30	1.95	0.62	1.16
2005	0.45	1.90	0.85	1.15
2006	0.30	1.78	0.52	1.06
2007	0.30	1.77	0.52	1.08
2008	0.25	1.74	0.43	1.09
2009	0.27	1.79	0.52	1.14
2010	0.33	1.81	0.40	1.16
2011	0.28	1.88	0.51	1.21
2012	0.33	1.95	0.45	1.20
2013	0.30	1.94	0.36	1.23
2014	0.45	1.94	0.68	1.32
2015	0.26	1.92	0.39	1.27

Table 7.3 Estimated static and transitional spawning potential ratios (sSPR and tSPR) for Sheepshead on the Atlantic and Gulf coasts of Florida during 1982–2014.

	Atlantic		Gulf	
	sSPR	tSPR	sSPR	tSPR
1982	0.40	0.38	0.62	0.58
1983	0.57	0.39	0.48	0.57
1984	0.42	0.41	0.54	0.55
1985	0.67	0.42	0.51	0.53
1986	0.54	0.45	0.64	0.53
1987	0.41	0.46	0.60	0.54
1988	0.54	0.45	0.35	0.52
1989	0.66	0.47	0.29	0.45
1990	0.52	0.49	0.37	0.39
1991	0.42	0.49	0.37	0.37
1992	0.42	0.46	0.20	0.34
1993	0.40	0.44	0.20	0.28
1994	0.30	0.41	0.29	0.24
1995	0.37	0.37	0.27	0.25
1996	0.53	0.37	0.40	0.25
1997	0.59	0.39	0.41	0.28
1998	0.64	0.43	0.39	0.31
1999	0.59	0.47	0.35	0.33
2000	0.56	0.49	0.41	0.33
2001	0.52	0.50	0.42	0.35
2002	0.63	0.50	0.47	0.37
2003	0.60	0.52	0.45	0.39
2004	0.70	0.54	0.47	0.40
2005	0.54	0.56	0.36	0.40
2006	0.62	0.55	0.48	0.39
2007	0.61	0.56	0.50	0.41
2008	0.63	0.56	0.52	0.43
2009	0.64	0.57	0.47	0.44
2010	0.57	0.57	0.56	0.45
2011	0.63	0.57	0.51	0.47
2012	0.65	0.57	0.50	0.47
2013	0.64	0.58	0.55	0.48
2014	0.46	0.57	0.44	0.48

15 Figures

Figure 2.1. Map of 13 sampling areas at which sheepshead (*Archosargus probatocephalus*) were collected for the study of genetic population structure using 15 species specific microsatellite DNA loci: 1=Corpus Christi; 2=Fort Walton; 3=Apalachicola; 4=Steinhatchee; 5 = Cedar Key; 6=Tampa Bay; 7=Charlotte Harbor; 8=Florida Bay; 9=Indian River; 10=St. Johns River; 11=St. Simmons and Cumberland Islands; 12=Charleston; 13= Morehead City. Specimens were collected from 1999 to 2001. The boundaries of the three sheepshead clusters identified are indicated by different color shades. Arrows indicate regions of genetic break between the western and eastern Gulf (I) and between the eastern Gulf and the Atlantic (II).

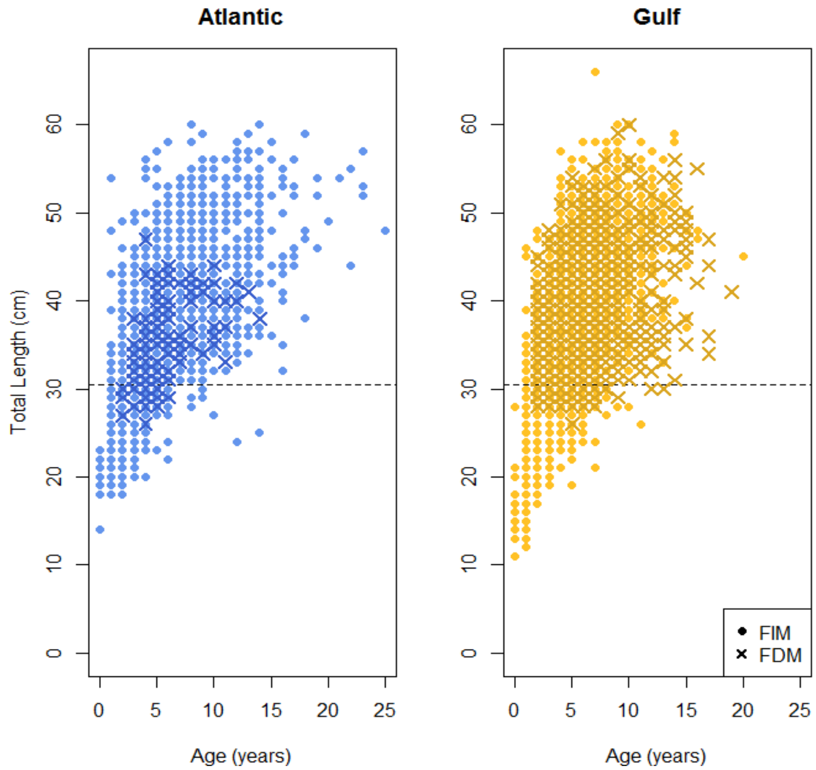


Figure 2.2. Total length (cm) versus age (years) by coast and data source.

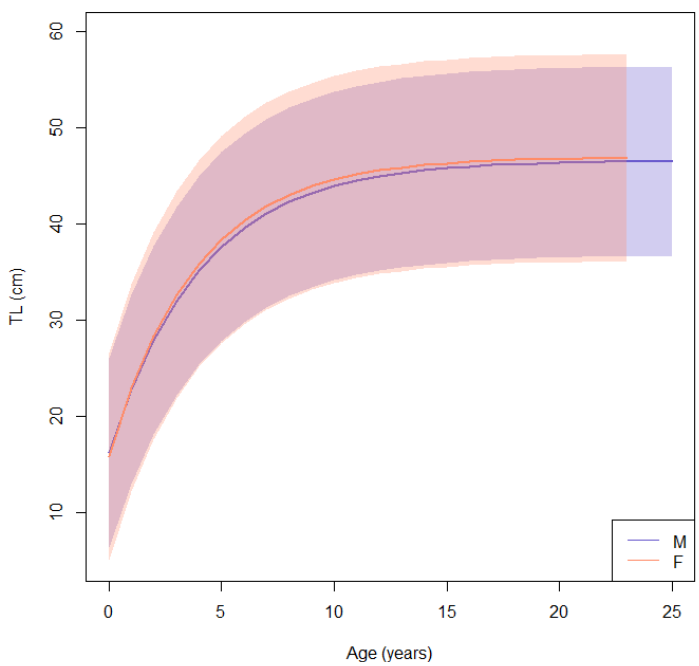


Figure 2.3. Predicted von Bertalanffy growth of Sheepshead by sex. Shaded regions depict 95% confidence intervals.

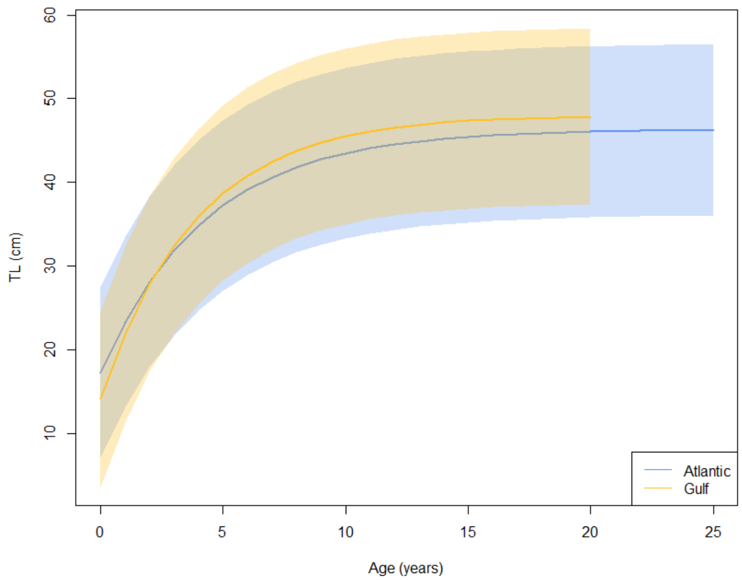


Figure 2.4. Predicted von Bertalanffy growth of Sheepshead by coast. Shaded regions depict 95% confidence intervals.

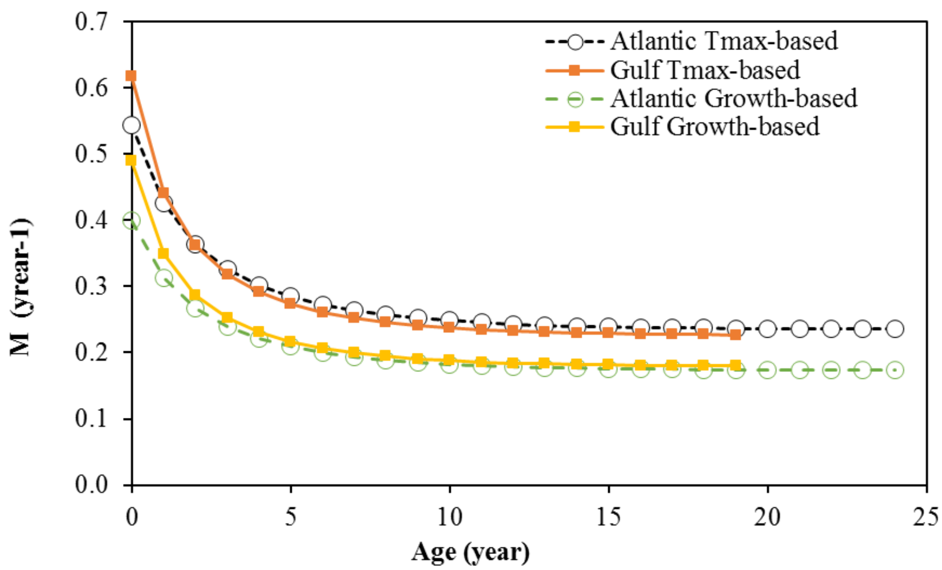


Figure 2.5. Age-specific natural mortality rates for Sheepshead off Florida's Atlantic and Gulf coast.

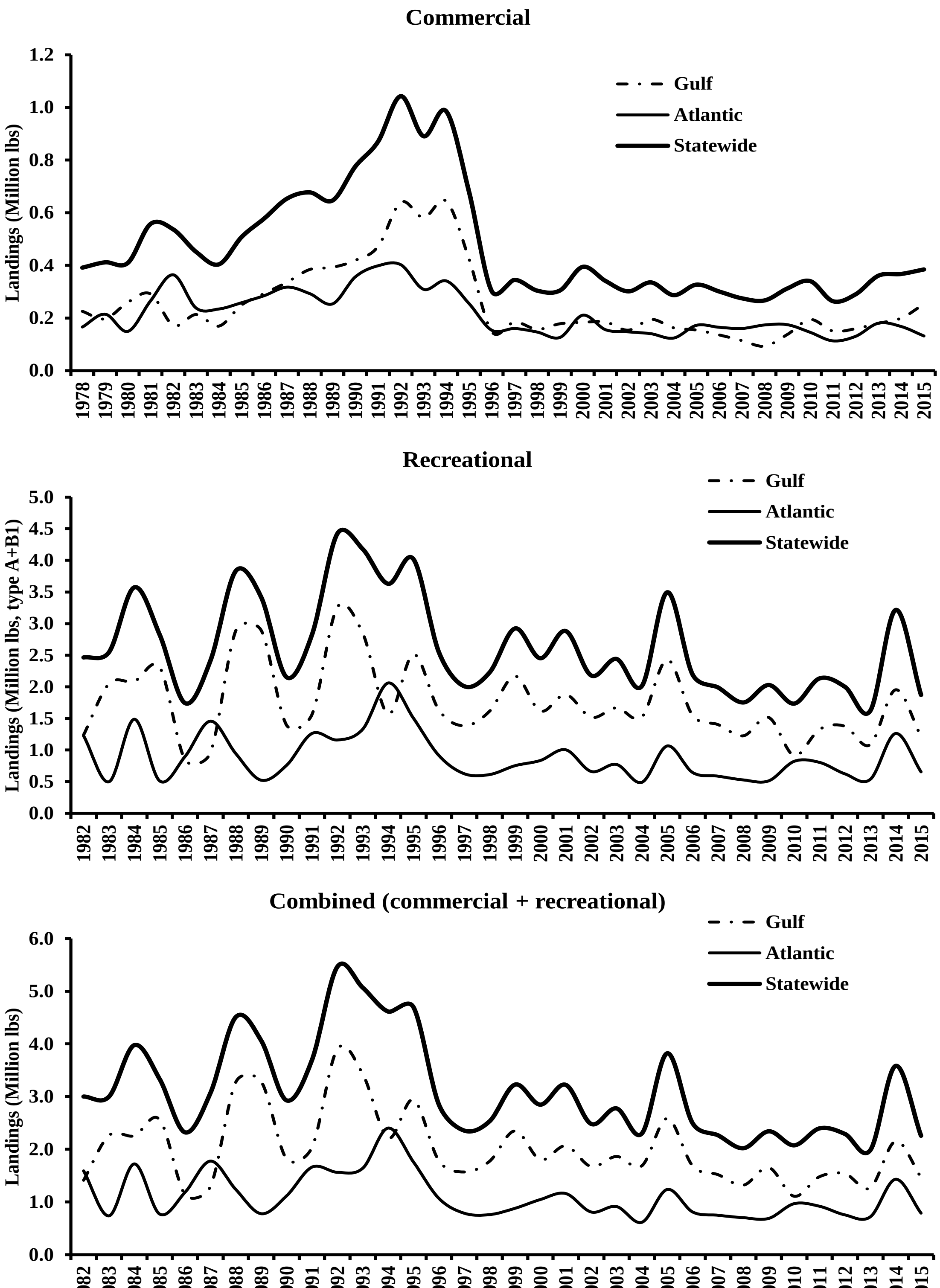
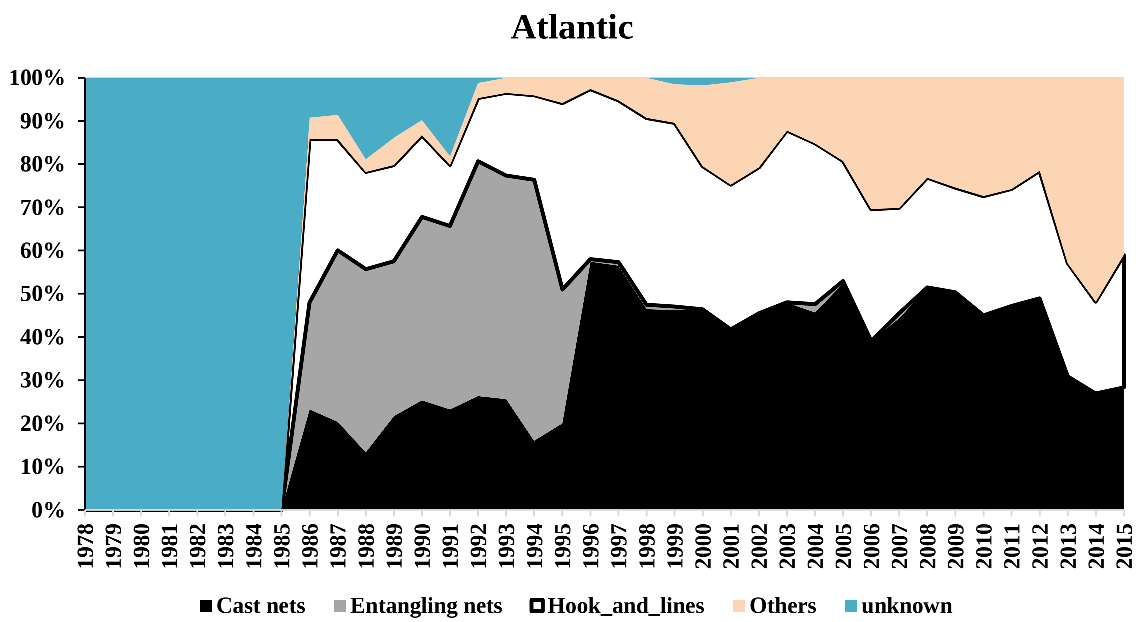


Figure 4.1 Coast-specific and statewide commercial, recreational (adjusted Type A+B1) and combined landings (pounds) of Sheepshead in Florida during 1978–2015.



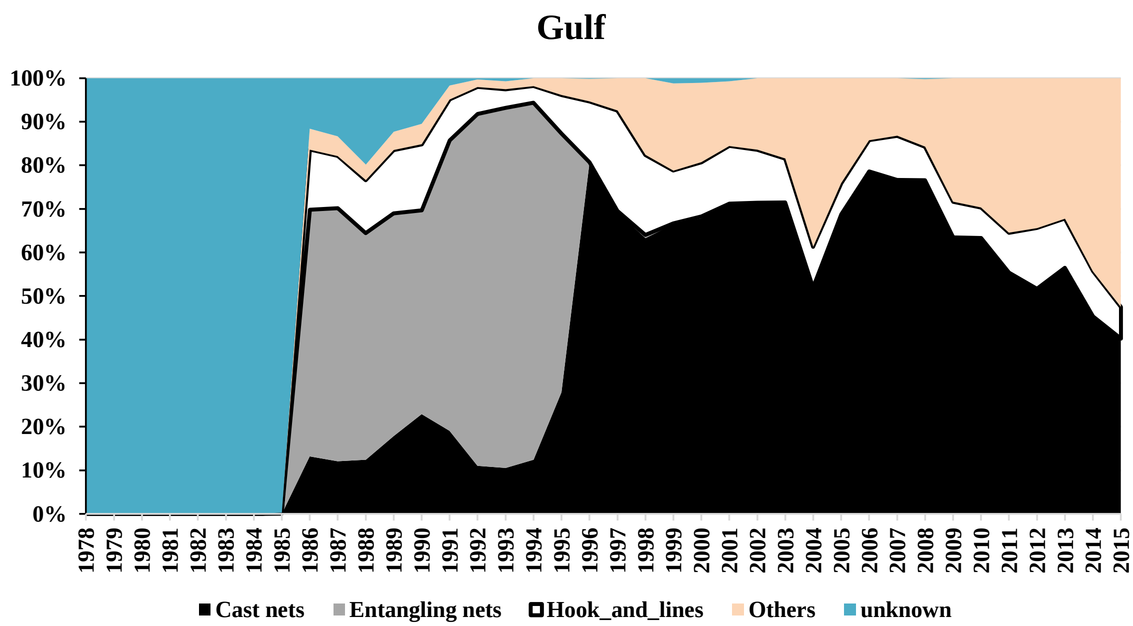


Figure 5.1 Percentages of commercial landings (pounds) of Sheepshead by gear category on the Atlantic and Gulf coasts of Florida during 1978–2015.

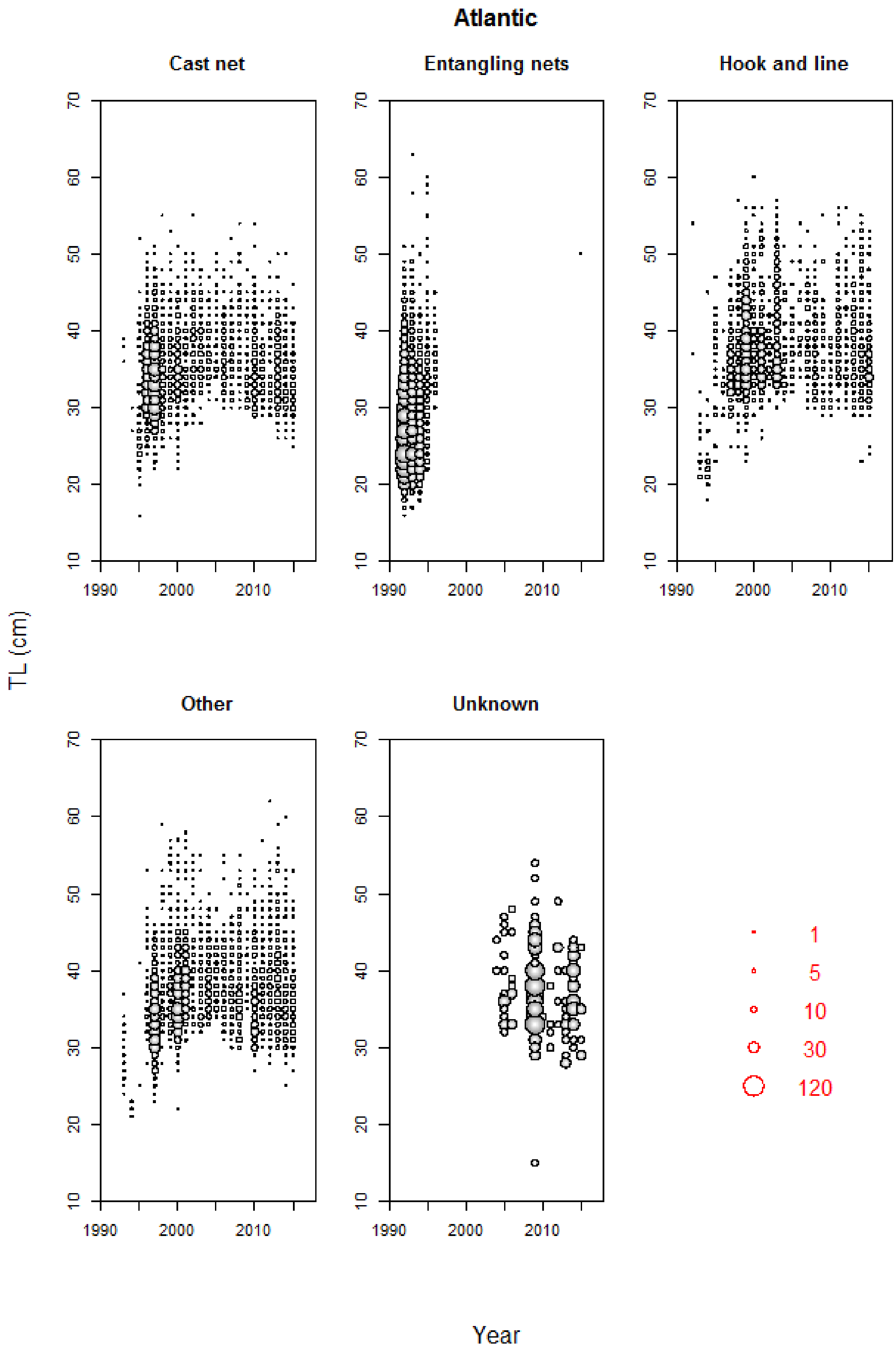


Figure 5.2 Total length frequencies of Sheepshead biological samples from the commercial fishery on Florida's Atlantic coast by gear-type during 1992–2015 (see Table 5.3 for annual sample sizes).

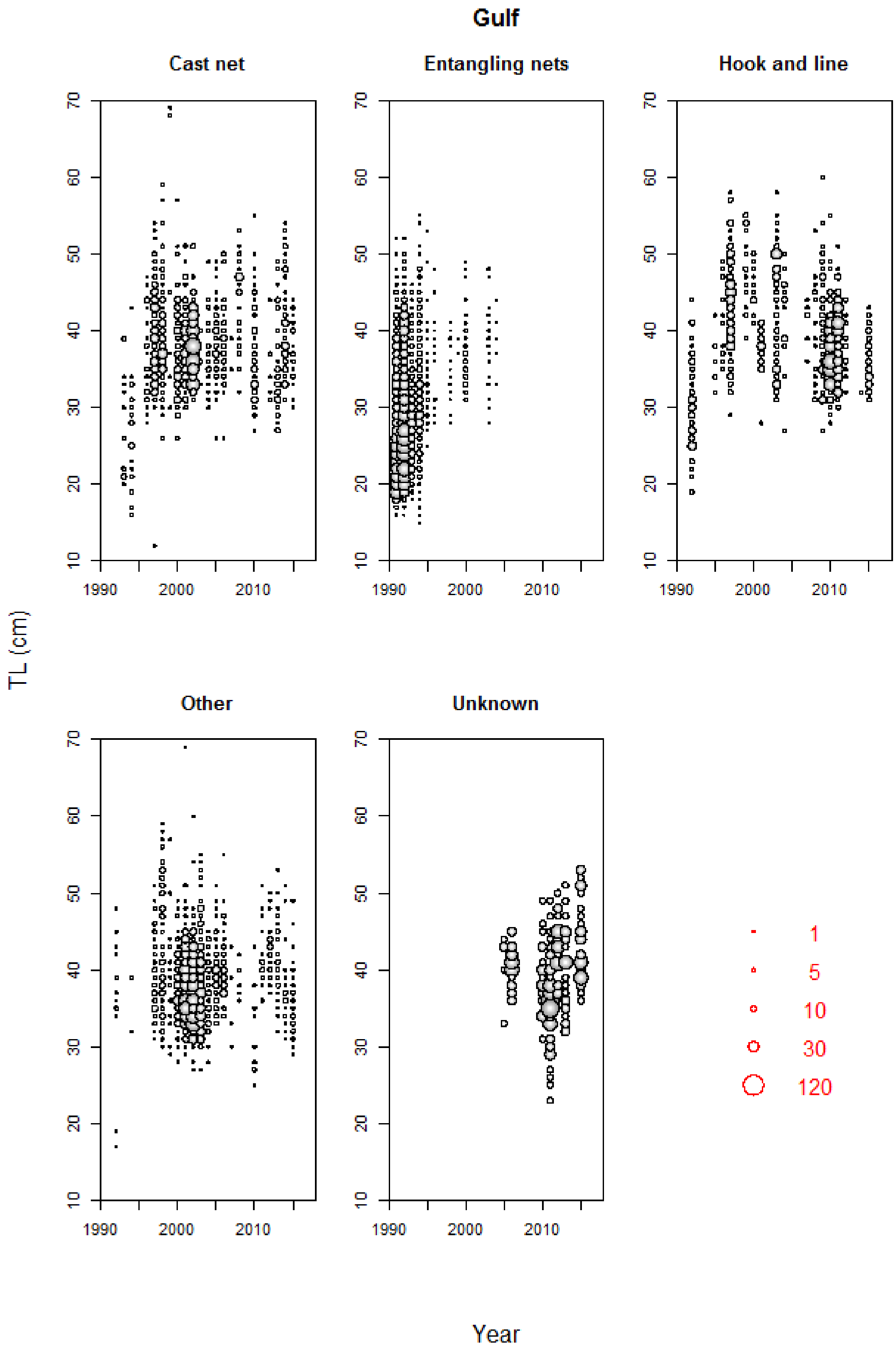
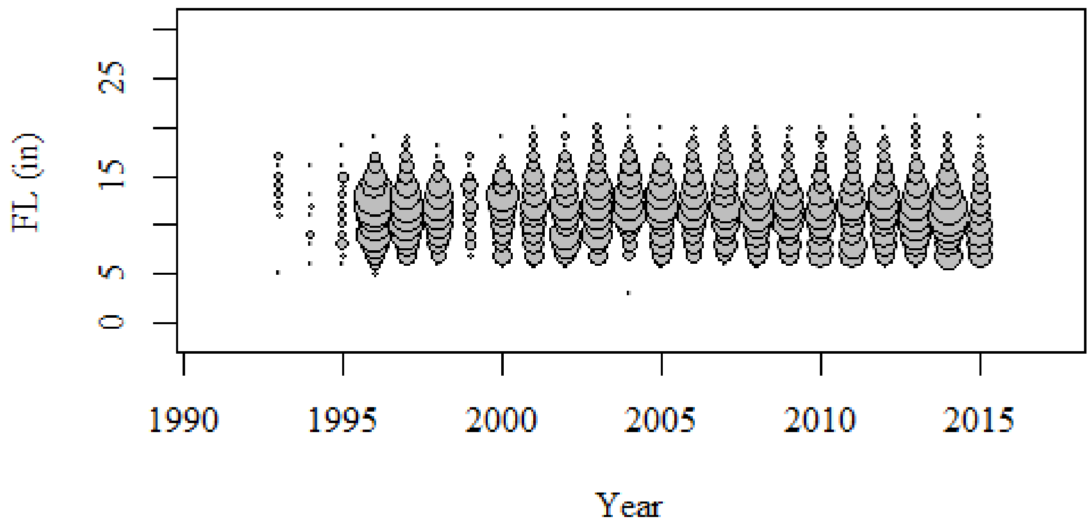


Figure 5.2 (Cont.) Total length frequencies of Sheepshead biological samples from the commercial fishery on Florida's Gulf coast by gear-type during 1991–2015 (see Table 5.3 for annual sample sizes).



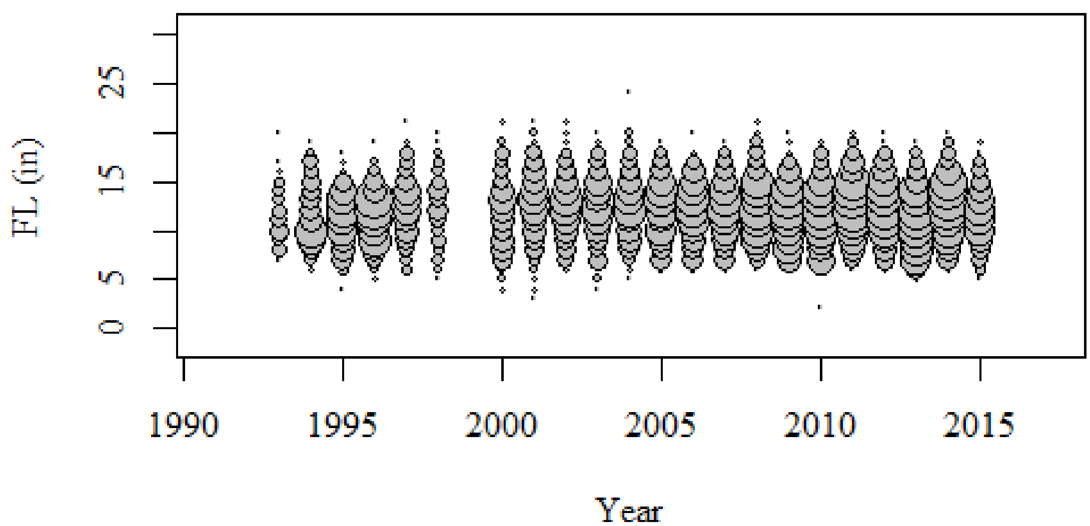


Figure 5.3 Fork length (FL, inch) frequencies of Sheepshead biological samples included in the annual age-length keys for the Atlantic (top) and Gulf (bottom) coasts of Florida (see Table 5.4 for annual total sample sizes).

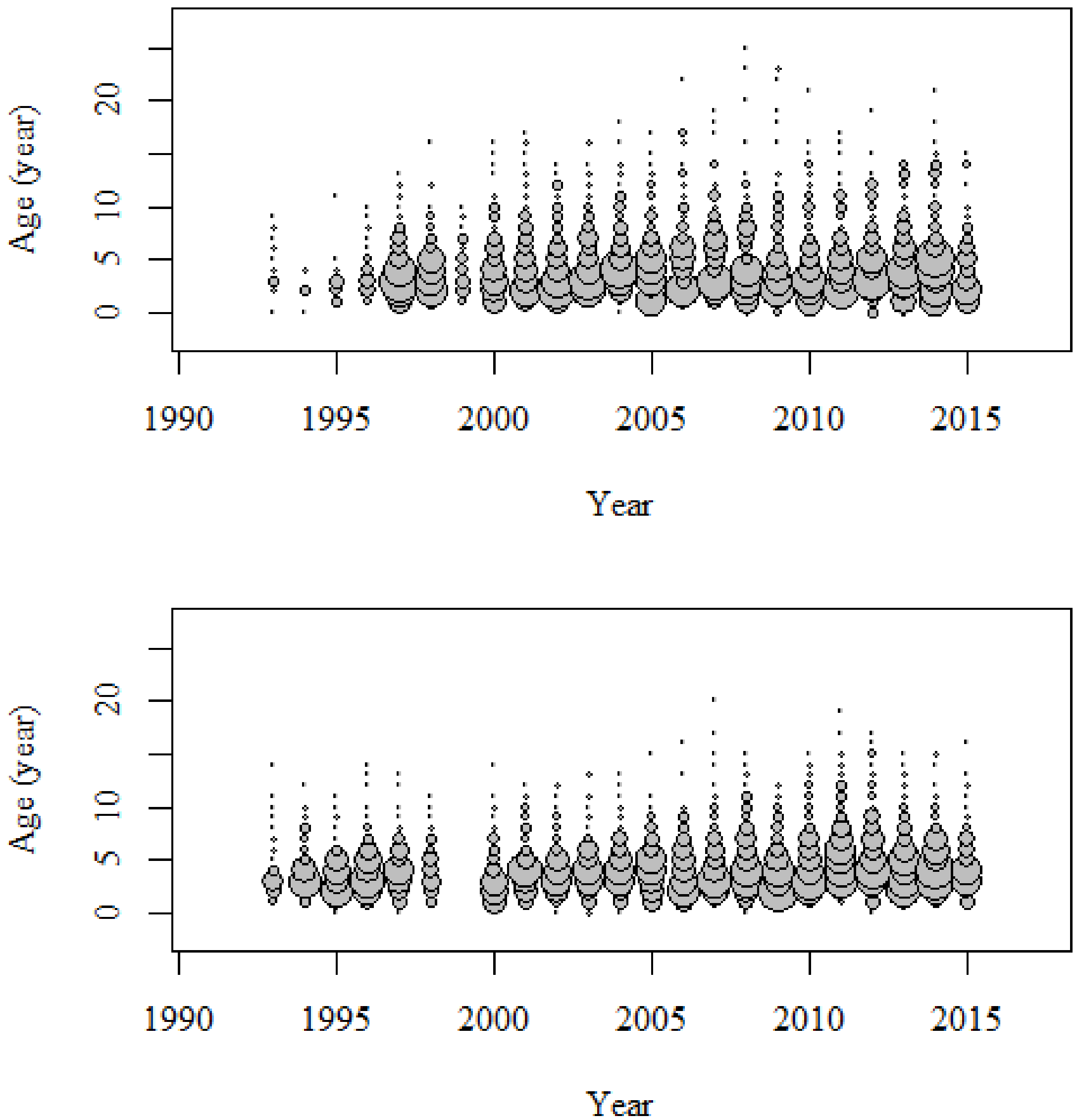
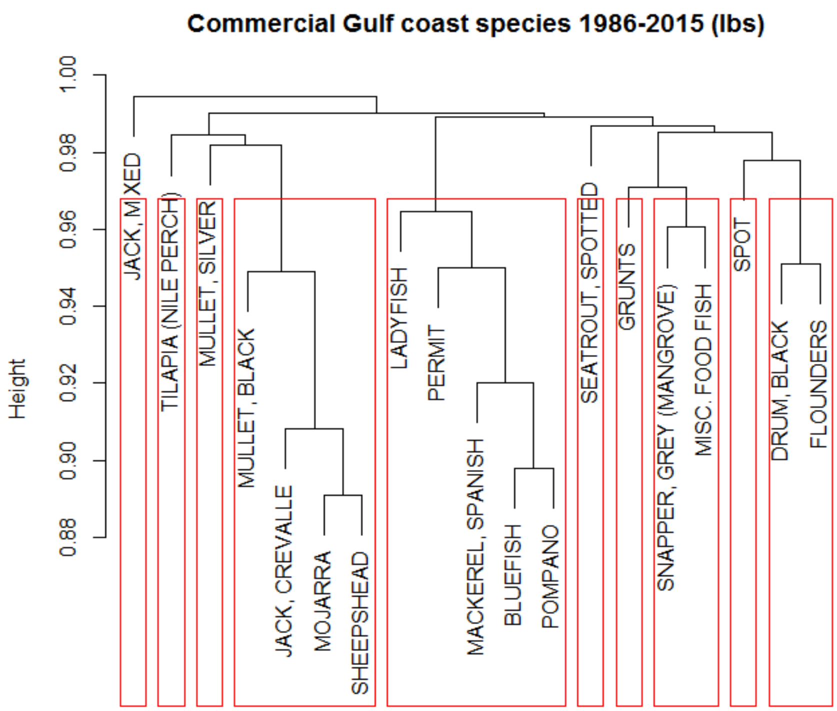


Figure 5.4 Distributions of age groups of Sheepshead sampled and included in the annual age-length keys for the Atlantic (top) and Gulf (bottom) coasts of Florida (see Table 5.4 for annual total sample sizes).



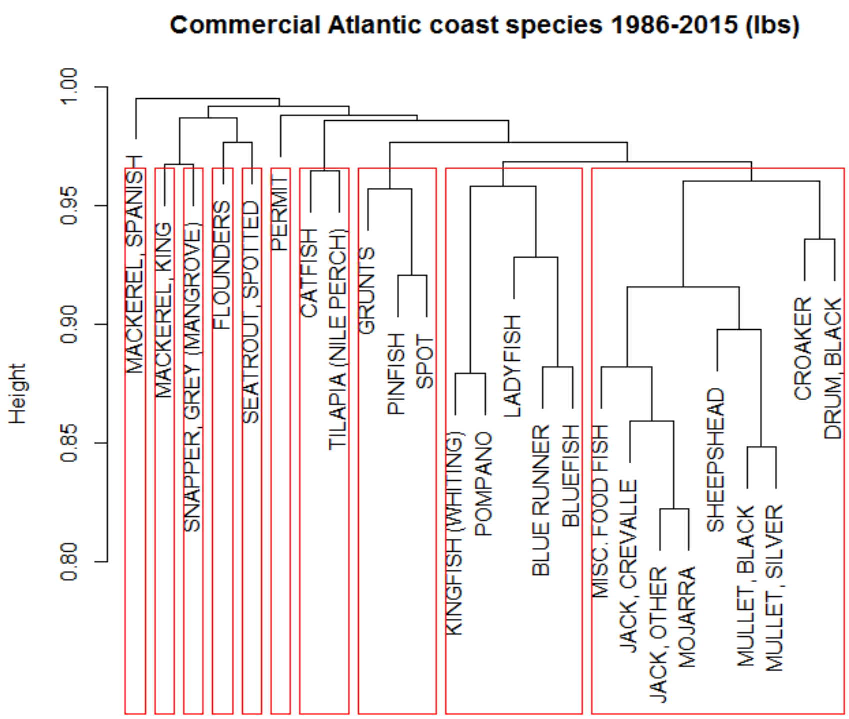
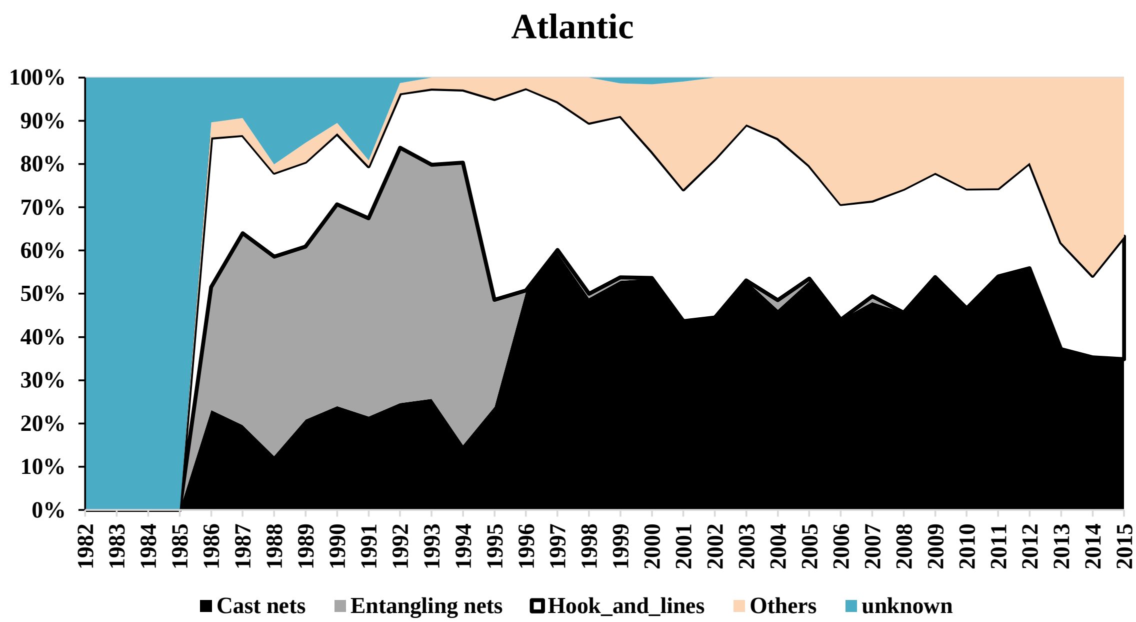


Figure 5.5 Cluster analysis of the commercial hook and line and cast net (1986–2015) catch data by species and coast.



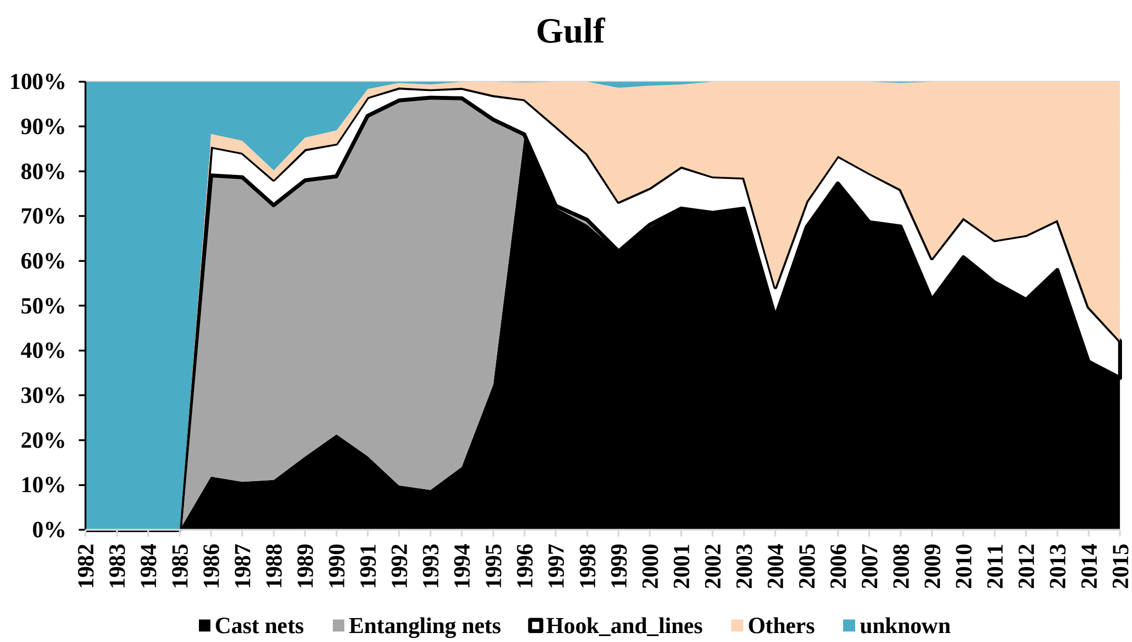


Figure 5.6 Percentages of commercial landings in numbers of Sheepshead by gear category on the Atlantic and Gulf coasts of Florida during 1982–2015.

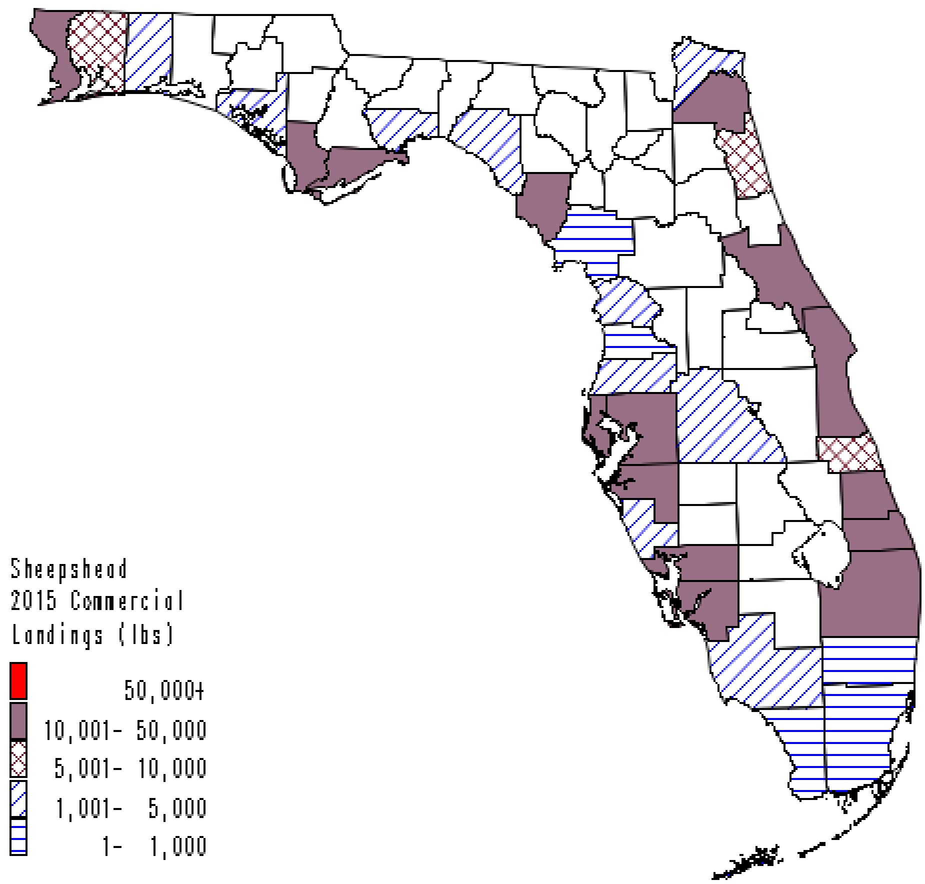
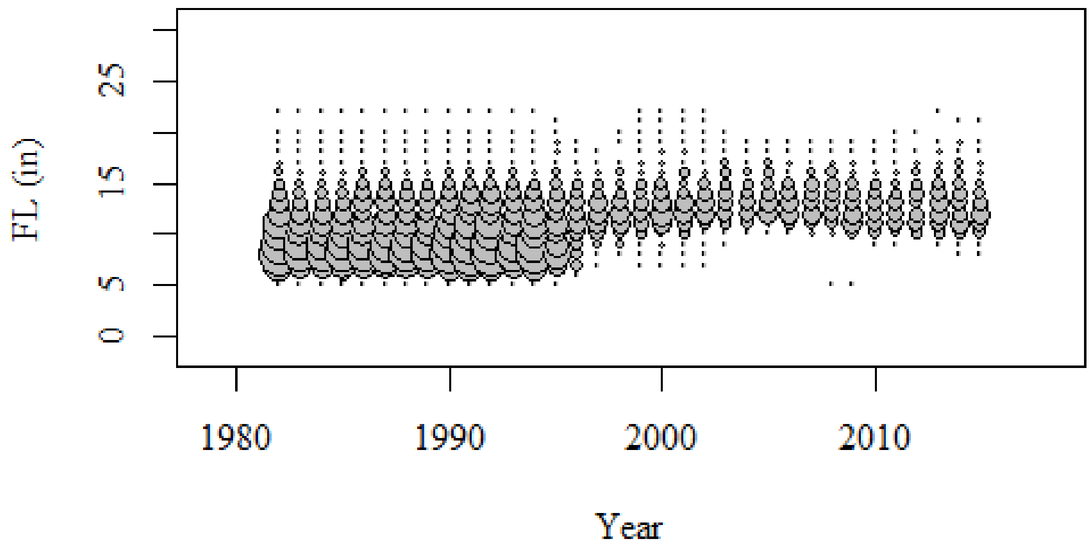


Figure 5.7 Distribution of commercial landings of Sheepshead by county in Florida during 2015.



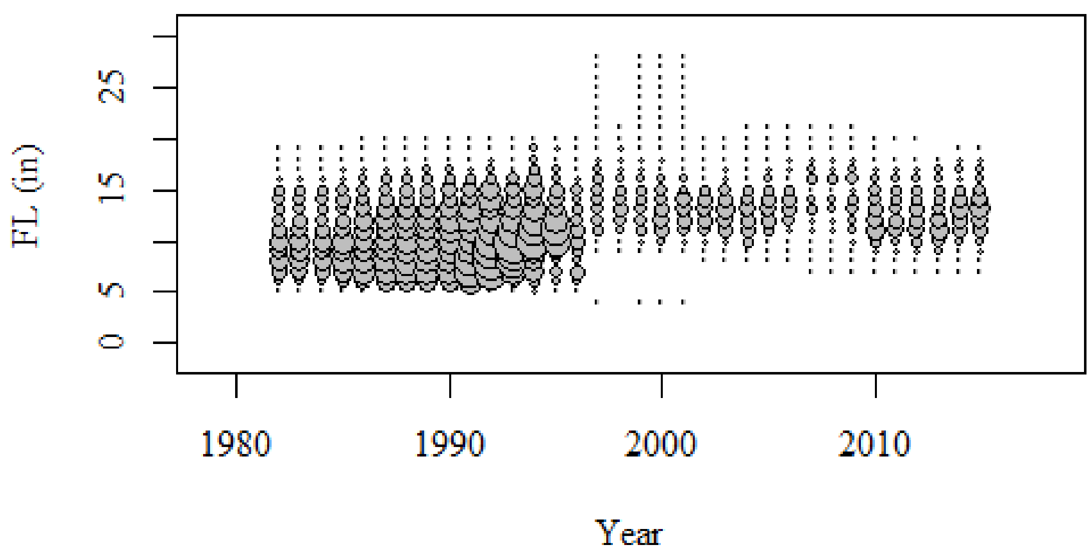
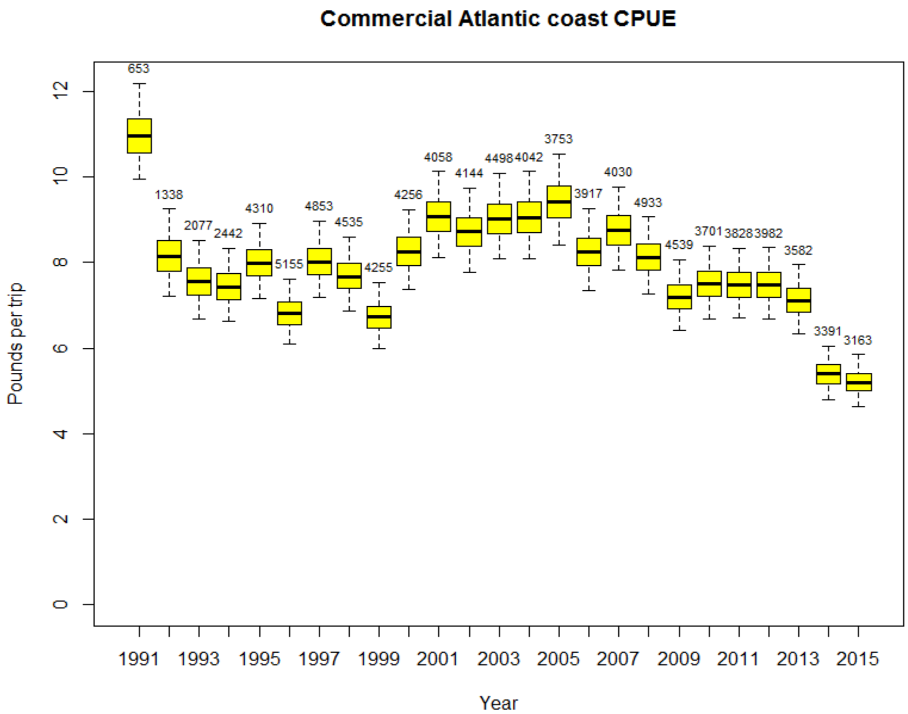


Figure 5.8 Estimated length frequencies (inches FL) of Sheepshead caught and landed by the commercial fishery (Table 5.1) on the Atlantic (top) and Gulf (bottom) coasts of Florida during 1982–2015.



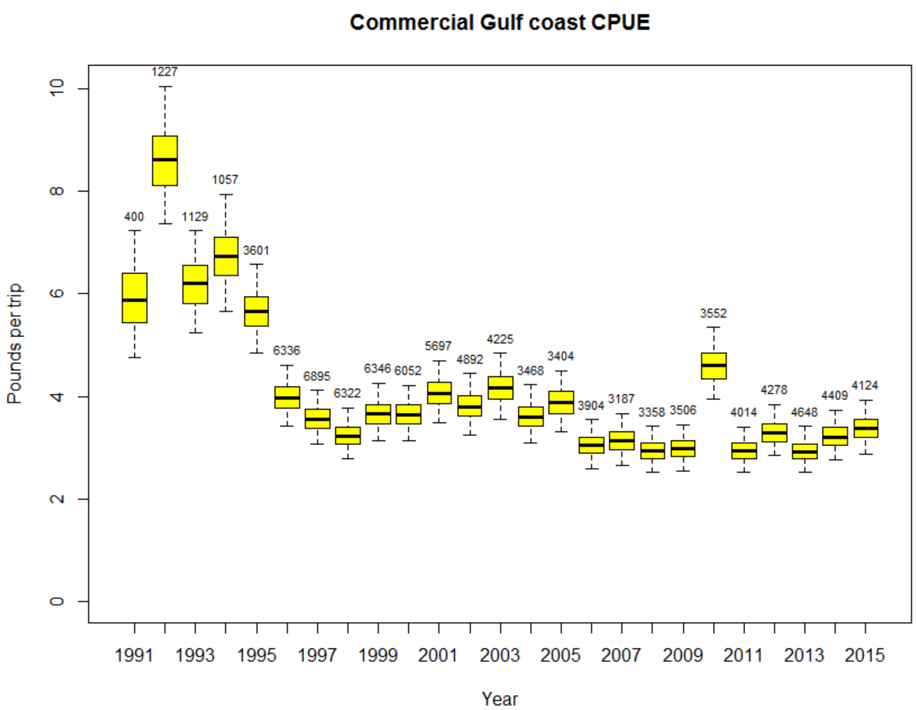


Figure 5.9 Standardized catch rate of Sheepshead on the Atlantic (top) and Gulf (bottom**)** coasts of Florida during 1991–2015 for commercial cast net and hook and line gear types. The black dash represents the median, the box represents the 25th–75th percentiles and the vertical whiskers extend from the 2.5th–97.5th percentiles. Numbers of positive trips are shown above the upper whisker.

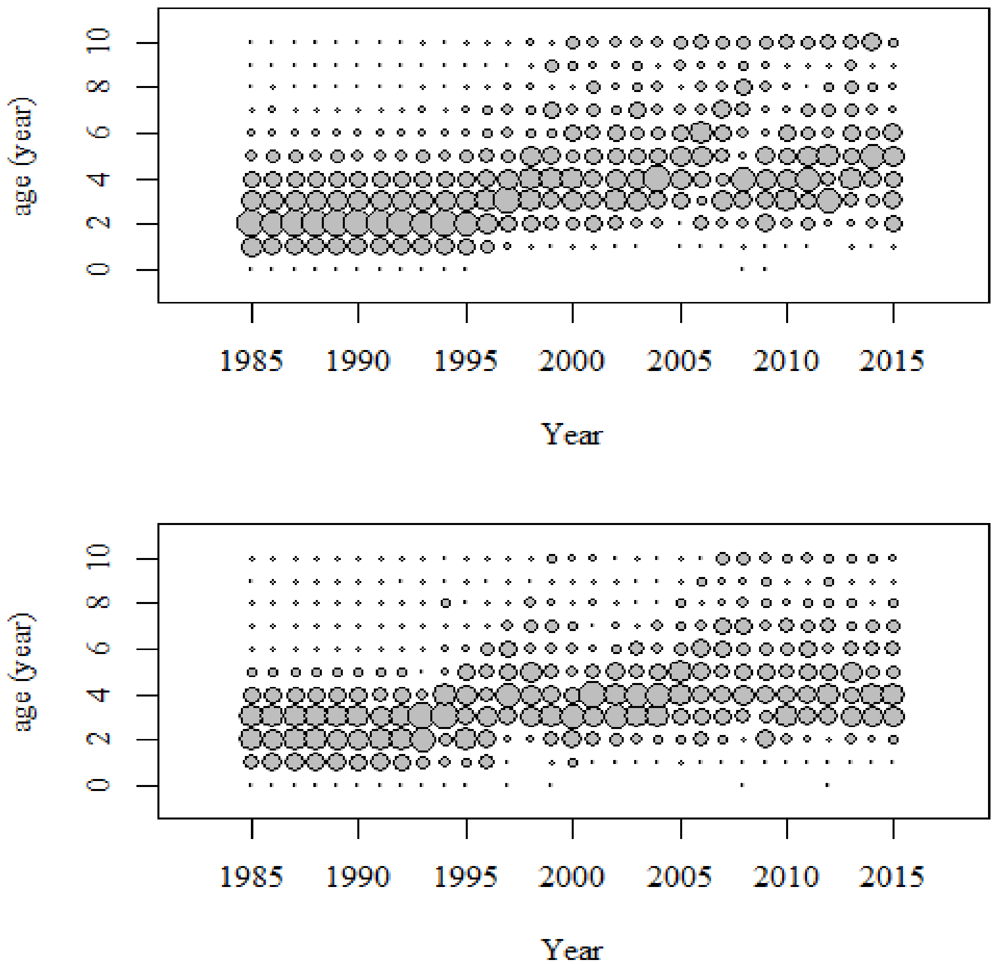


Figure 5.10 Estimated age proportions (January 1 birthdate) of Sheepshead caught by the commercial fishery and landed on the Atlantic (top) and Gulf (bottom) coasts of Florida during 1985–2015 (the age composition during 1982–1984 was similar to that of 1985).

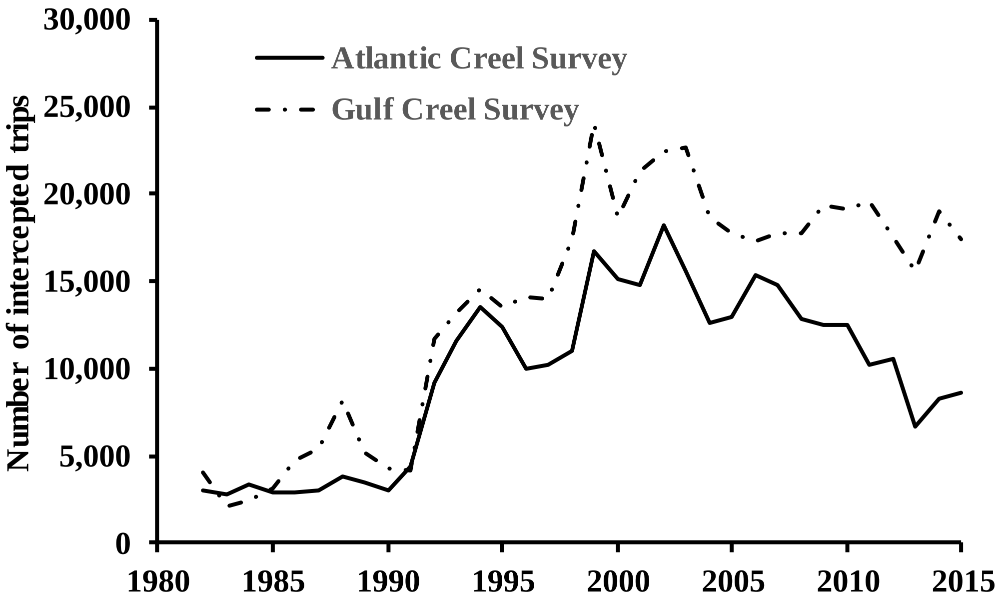


Figure 5.11 Number of recreational intercepts conducted by MRFSS/MRIP samplers on Florida's coasts for Sheepshead during 1982–2015.

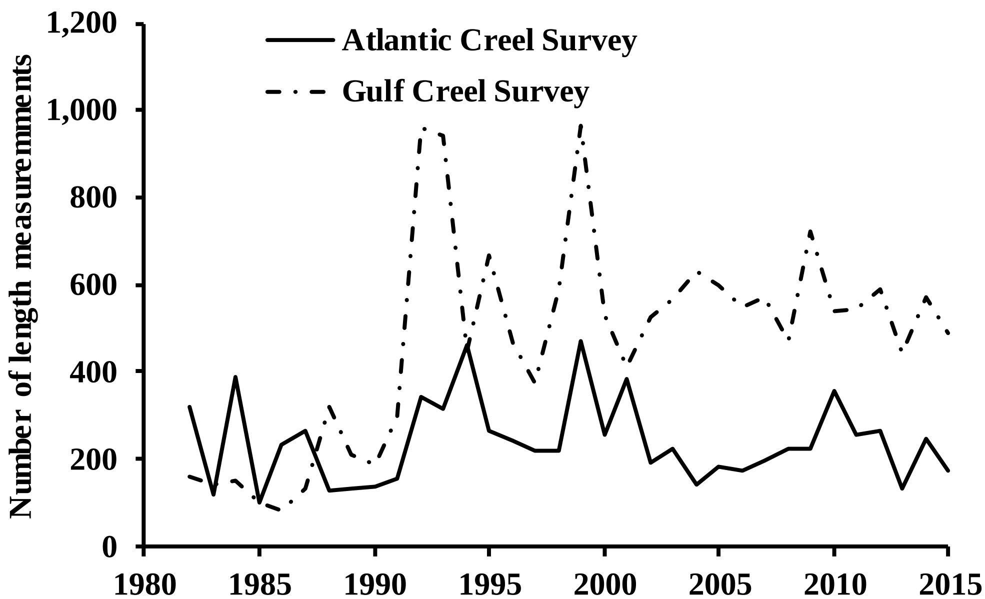


Figure 5.12 Number of Sheepshead measured for fork length by MRFSS/MRIP samplers on Florida's coasts for Sheepshead during 1982–2015.

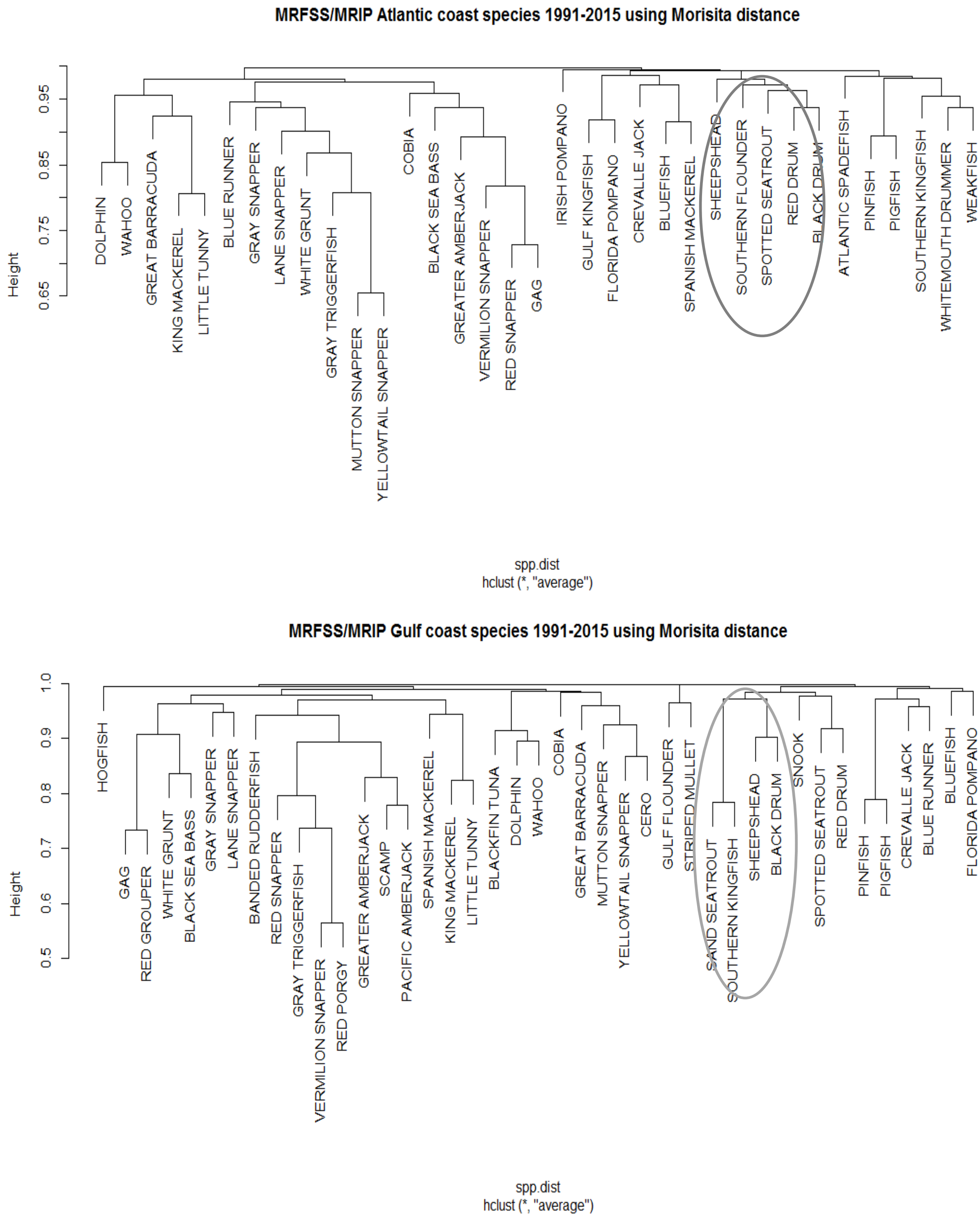


Figure 5.13 Cluster analysis of the MRFSS/MRIP (1991–2015) catch data by species and coast.

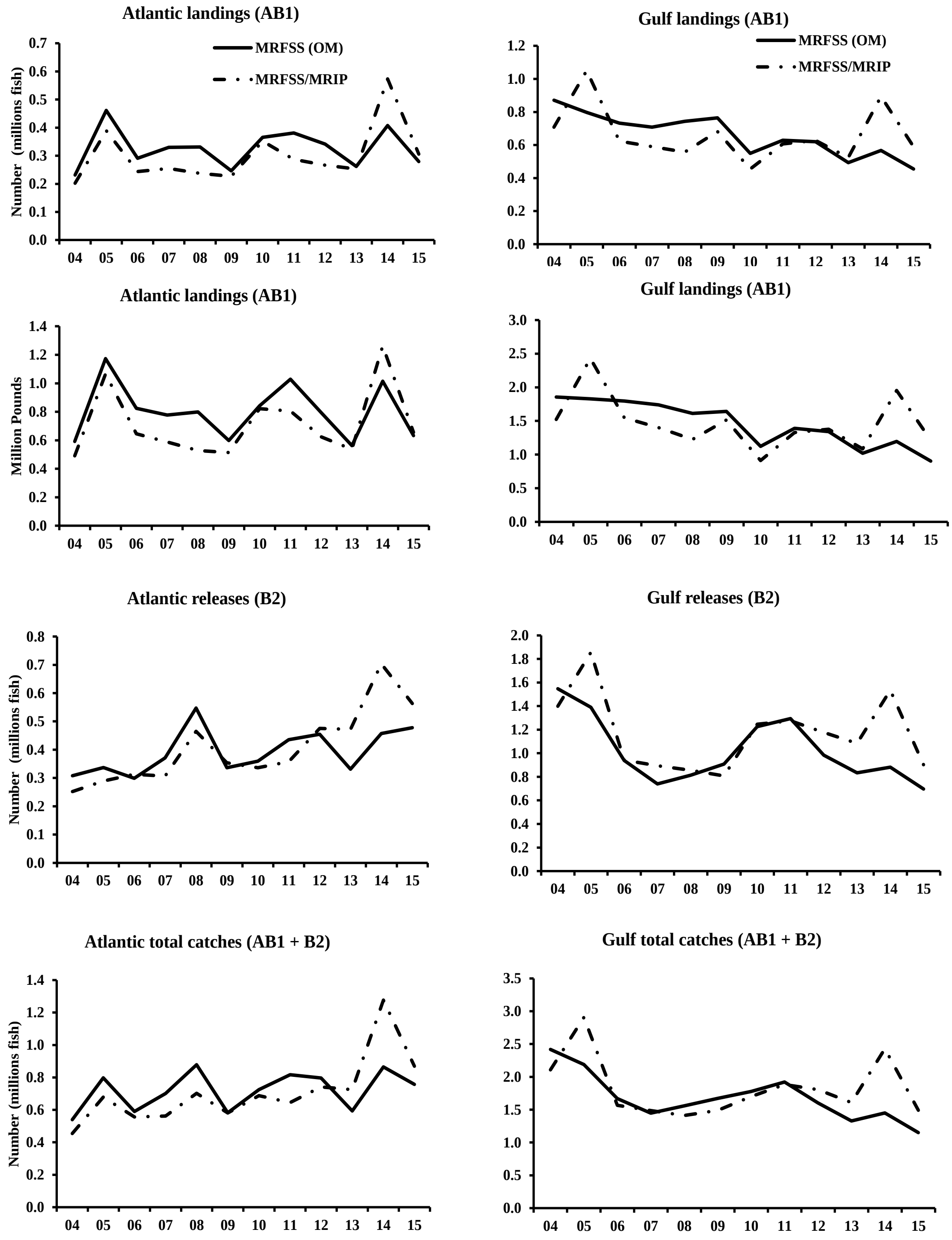


Figure 5.14 Comparison of estimates by MRFSS' old method (MRFSS (OM)) and by the new MRIP analytical procedures (MRFSS/MRIP) for Sheepshead by coast during 2004–2015.

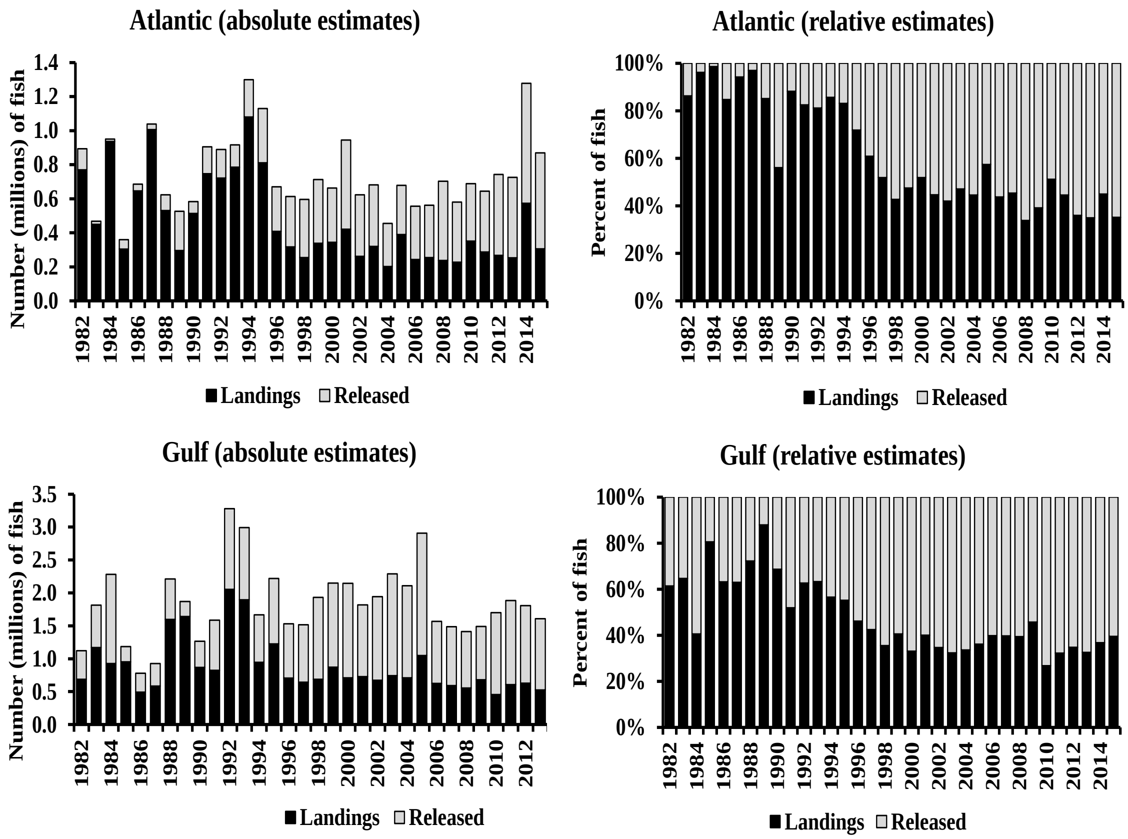


Figure 5.15 Total recreational catch of Sheepshead including fish released alive and fish kept on the Atlantic and Gulf coasts of Florida during 1982–2015.

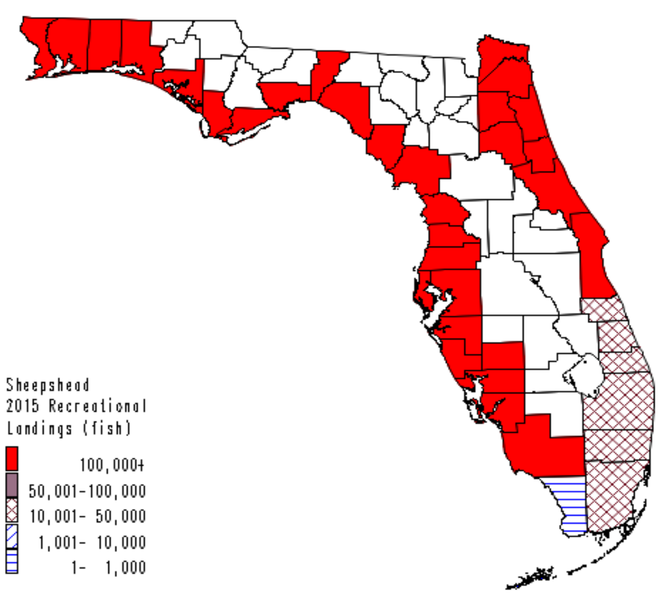
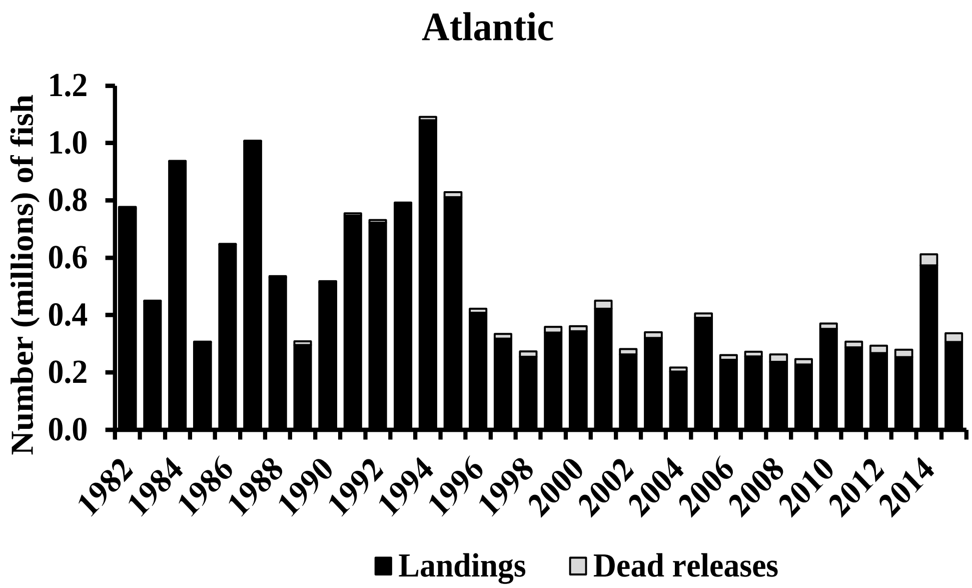


Figure 5.16 Distribution of Sheepshead landed by anglers in Florida during 2015.



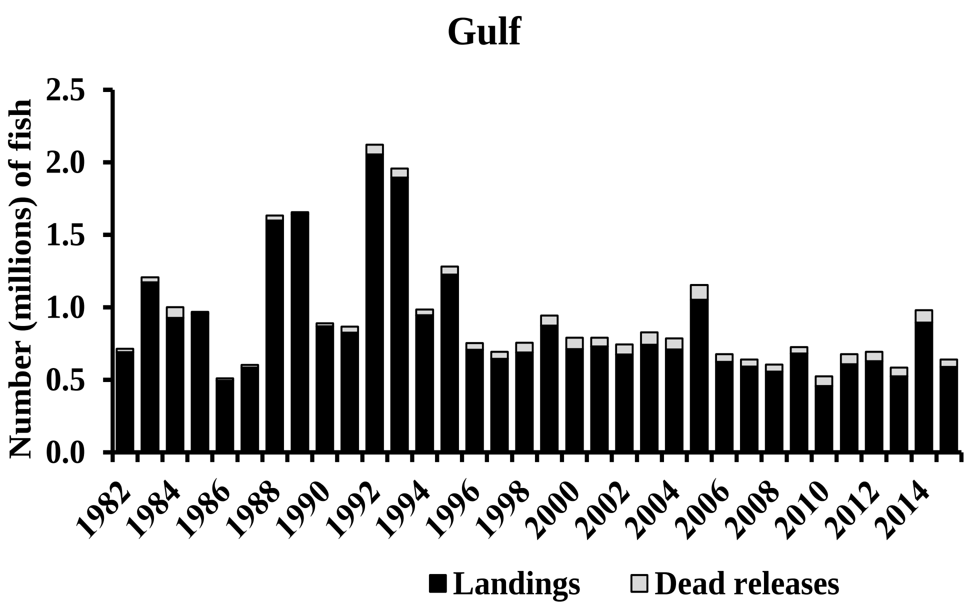


Figure 5.17 Total recreational harvest (number) of Sheepshead (fish landed and kept plus those that died after being released alive) by coast of Florida during 1982–2015.

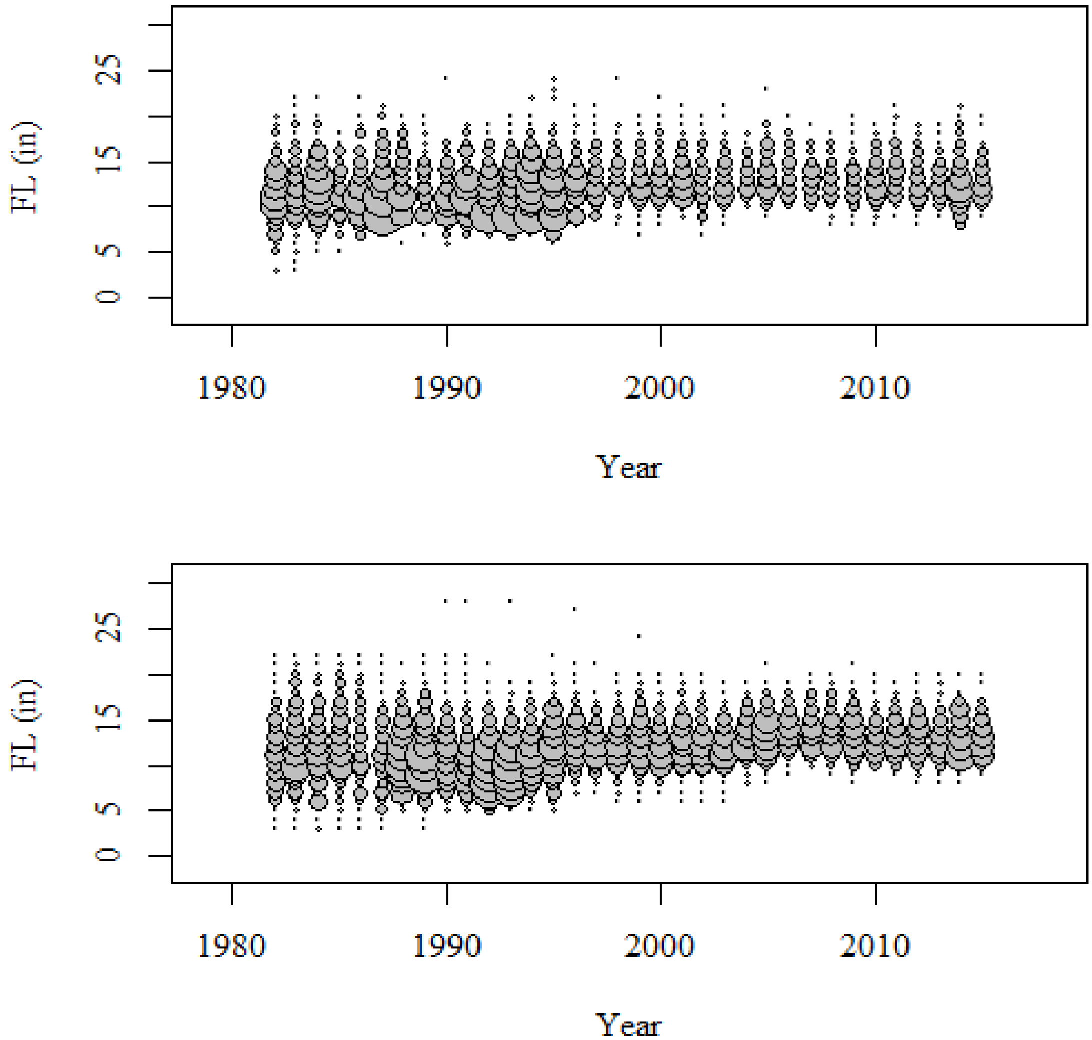


Figure 5.18 Estimated length frequencies (FL inches) of Sheepshead caught and landed (Type A + B1 fish) by anglers (Table 5.1) on the Atlantic (top) and Gulf (bottom) coasts of Florida during 1982–2015.

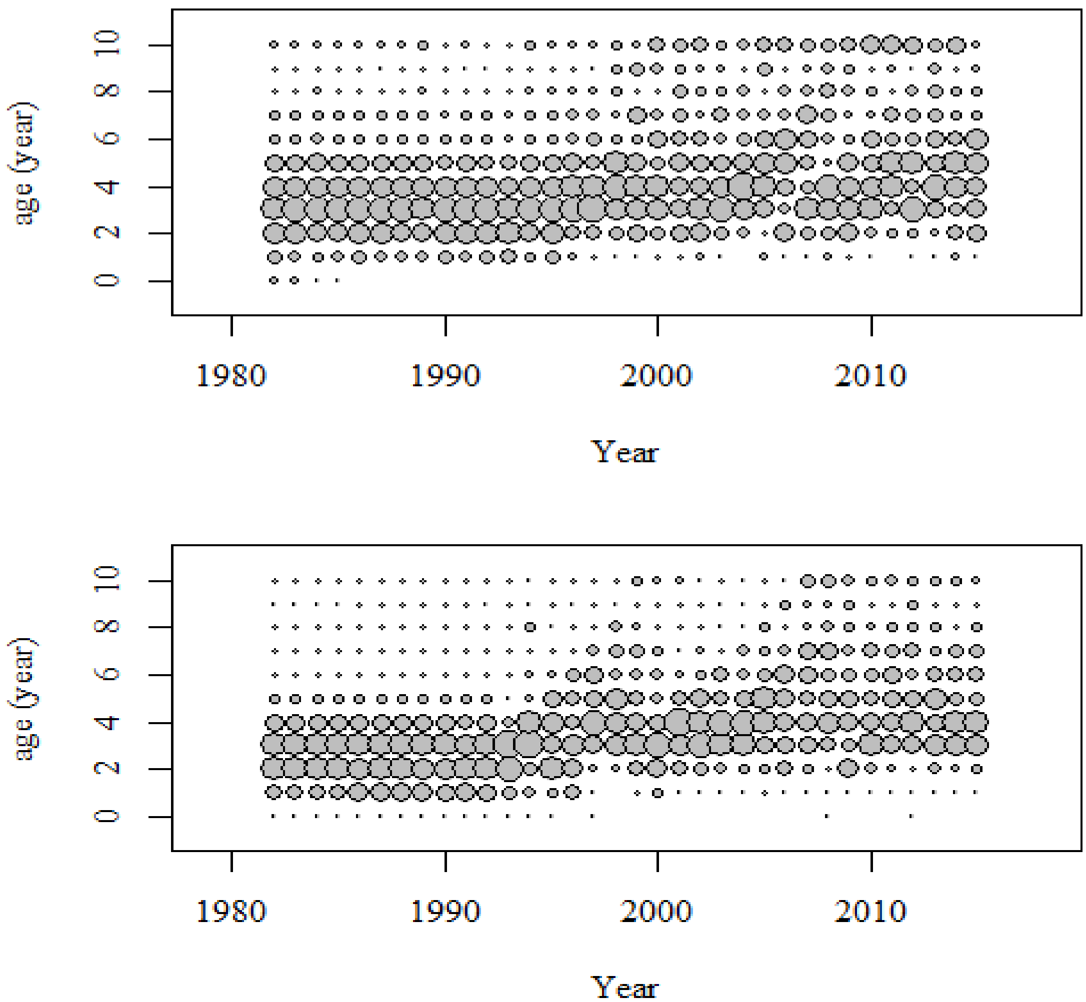


Figure 5.19 Estimated age proportions (January 1 birthdate) of Sheepshead caught by anglers and landed (Type A + B1 fish) on the Atlantic (top) and Gulf (bottom) coasts of Florida during 1982–2015.

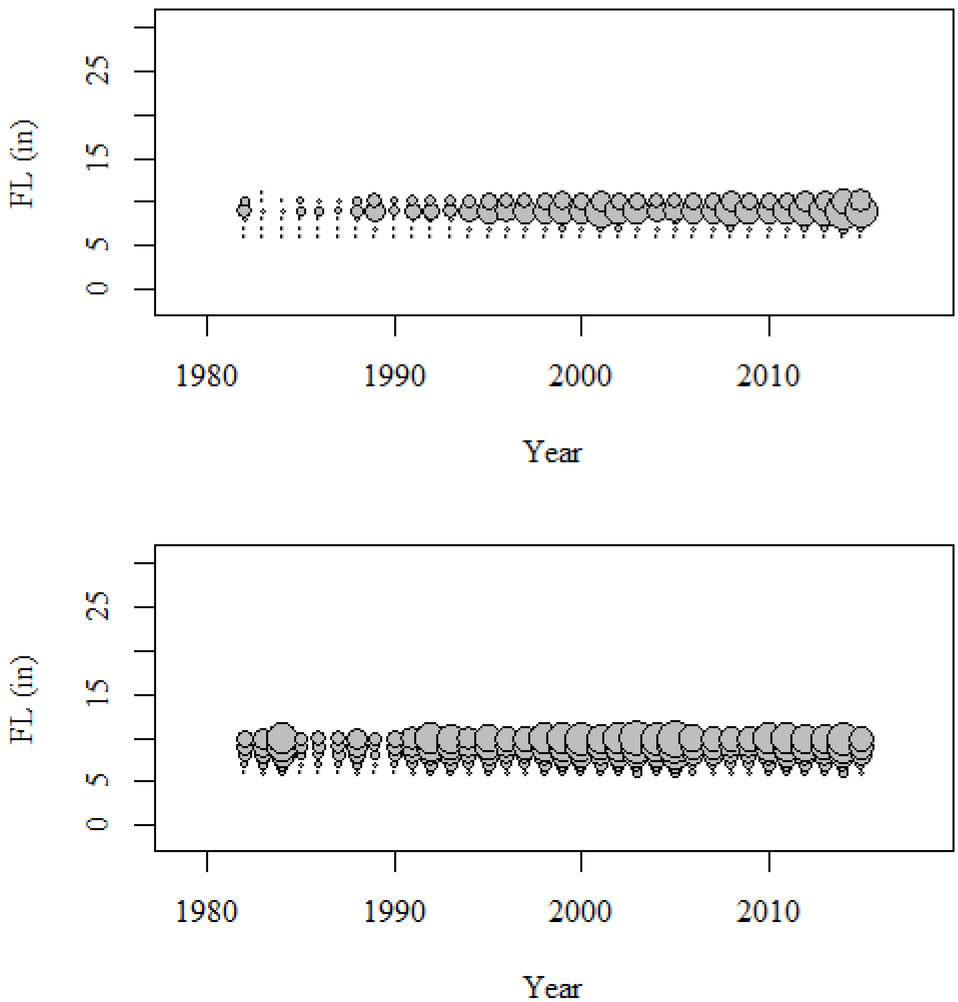


Figure 5.20 Estimated length frequencies (FL inches) of Sheepshead released alive (Type B2 fish) by anglers (Table 5.1) on the Atlantic (top) and Gulf (bottom) coasts of Florida during 1982–2015.

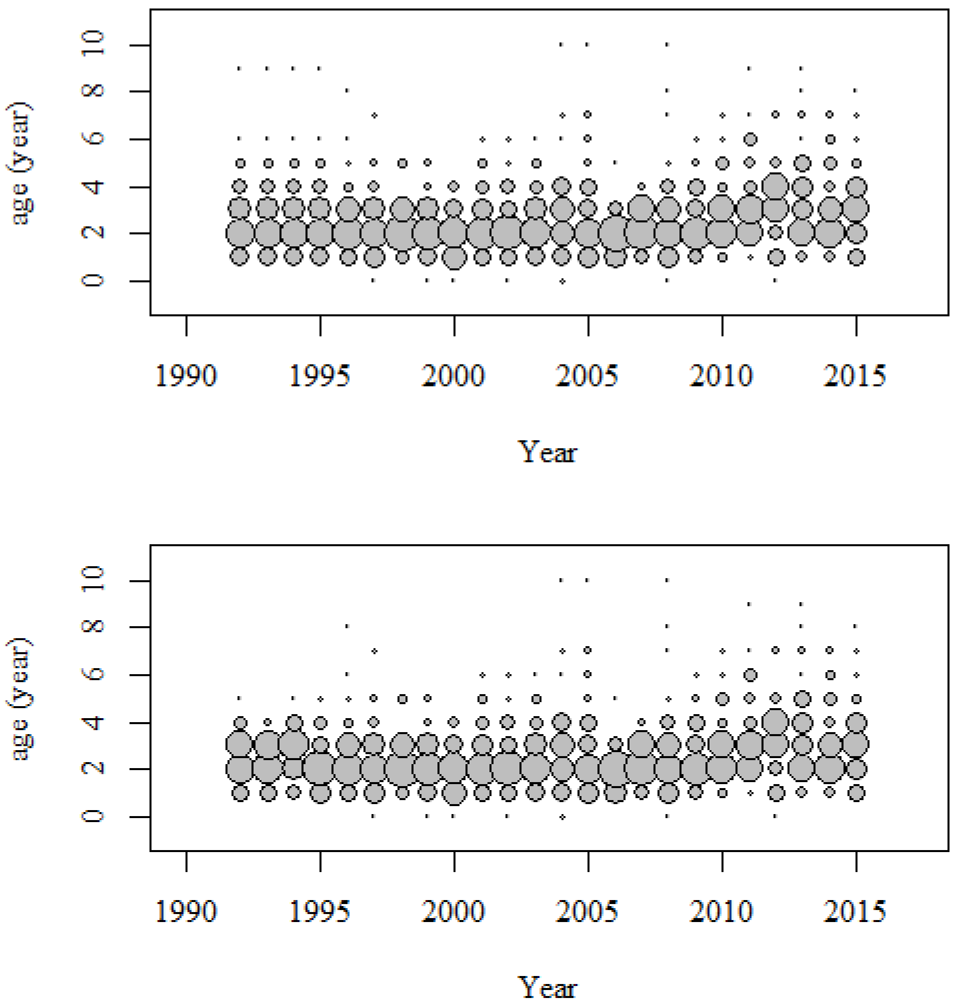


Figure 5.21 Estimated age proportions (January 1 birthdate) of Sheepshead released alive by anglers (Type B2 fish) on the Atlantic (top) and Gulf (bottom) coasts of Florida during 1982–2015.

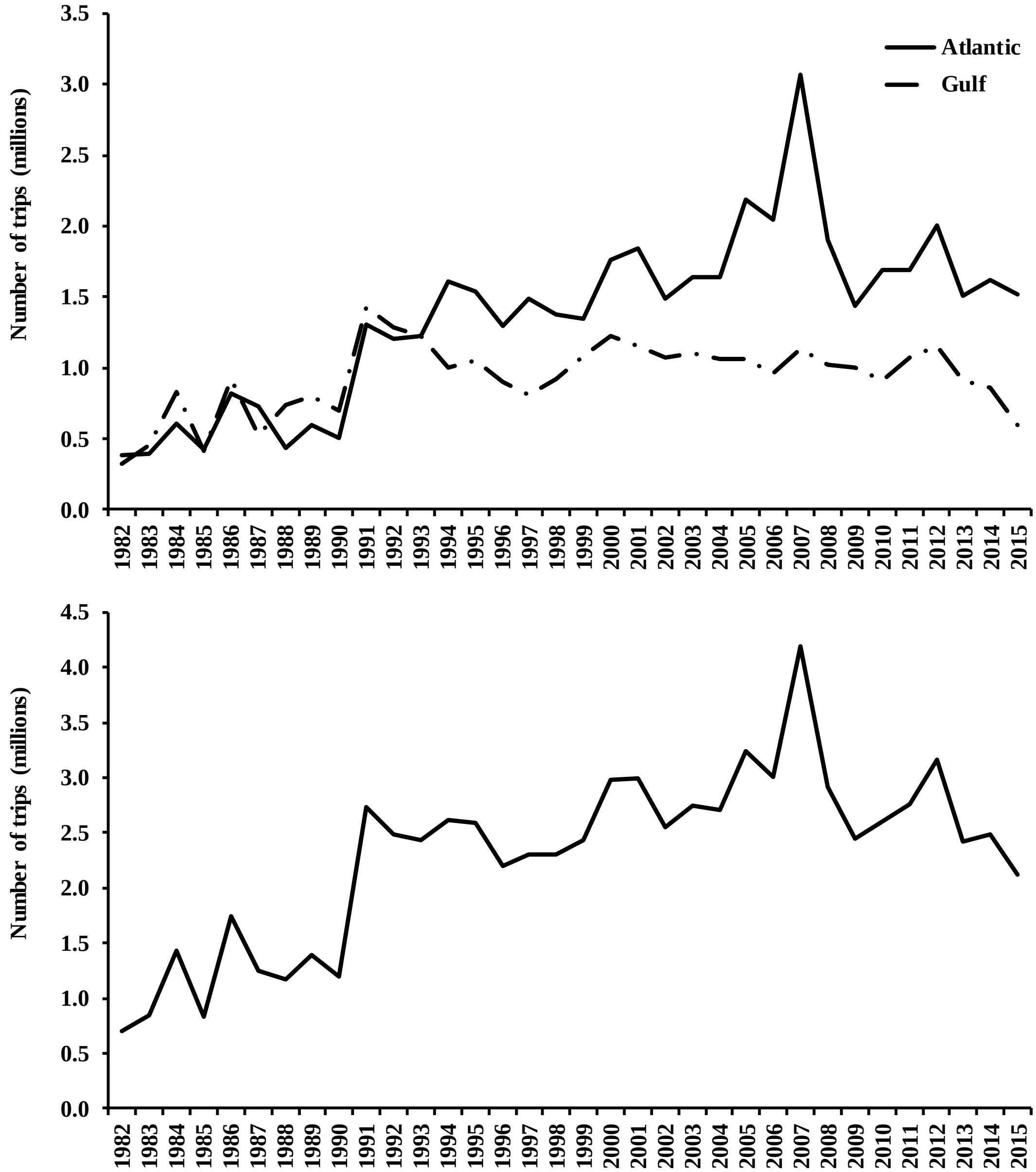


Figure 5.22 Coast-specific (top) and statewide (bottom) estimates of directed trips for the Sheepshead clusters in Florida during 1982–2015.

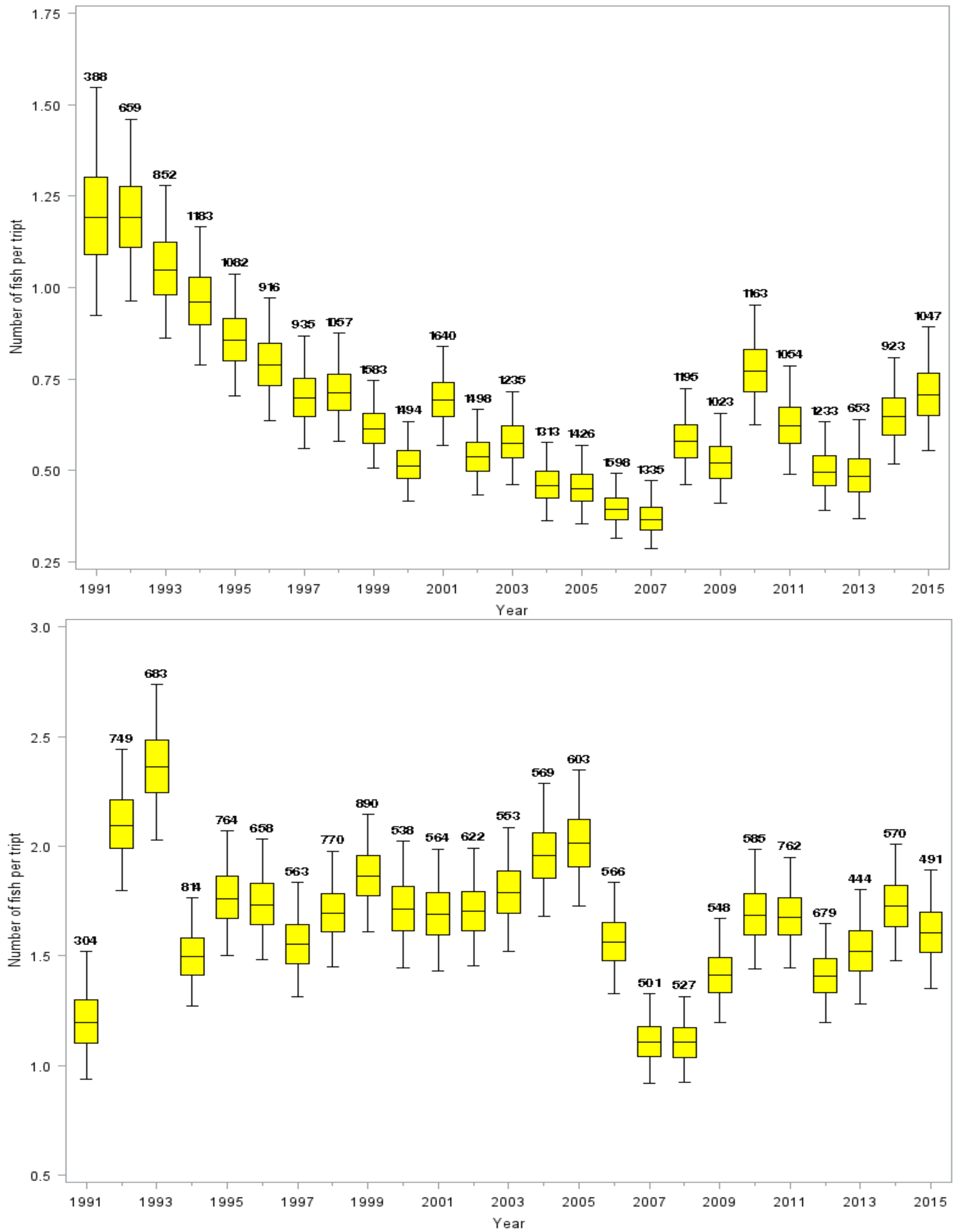


Figure 5.23 MRFSS/MRIP standardized total-catch rate of Sheepshead on the Atlantic (top) and Gulf (bottom) coasts of Florida during 1991–2015. The black dash represents the median, the box represents the 25th–75th percentiles and the vertical whiskers extend from the 2.5th–97.5th percentiles. Numbers of positive trips are shown above the upper whisker.

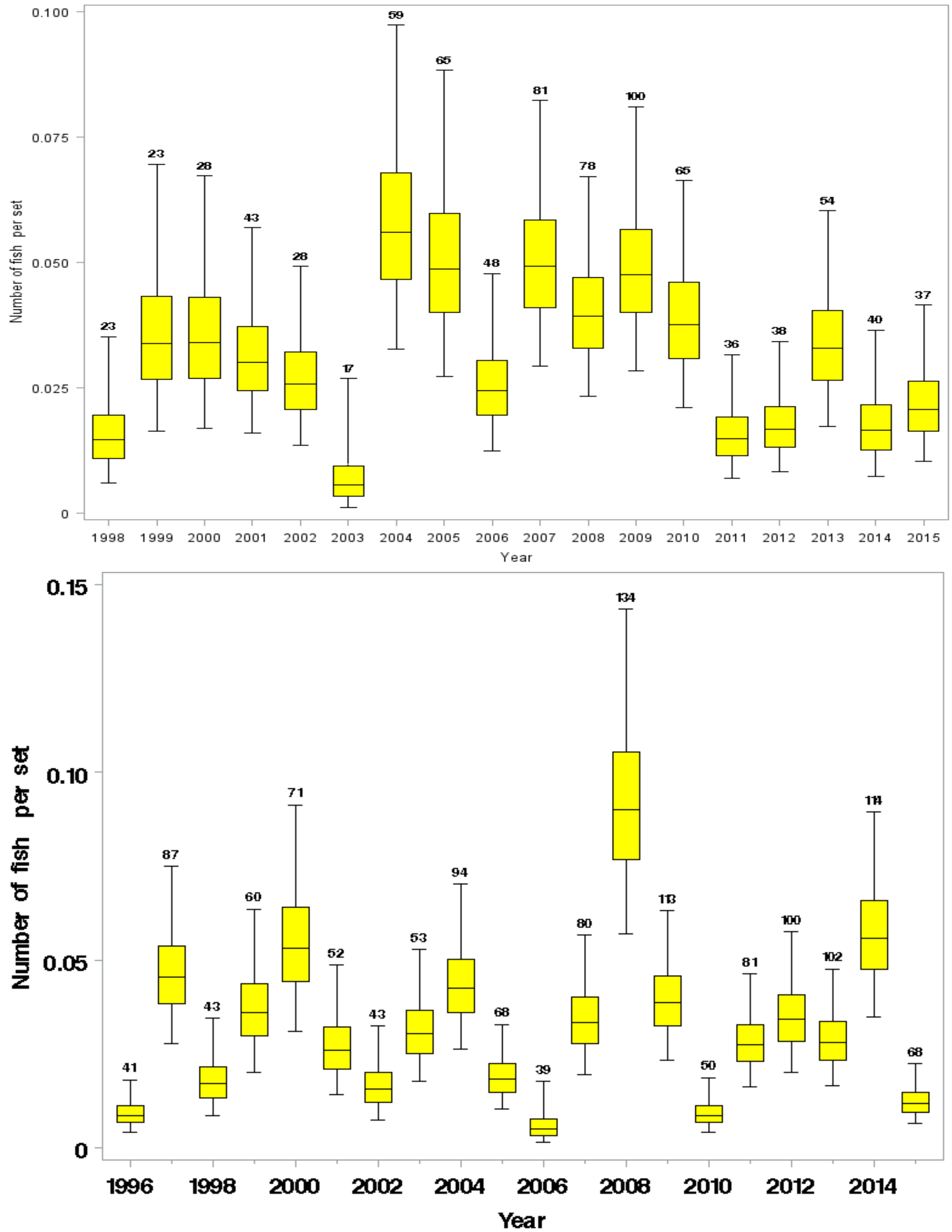


Figure 5.24 Standardized catch rates of young-of-the-year Sheepshead (≤ 40-mm SL) captured by 23.1-m bag seines during the FWC fishery Independent Monitoring program each April–July period on the Atlantic (top) and Gulf (bottom) coasts of Florida. Numbers of positive sets are shown above the upper whisker.

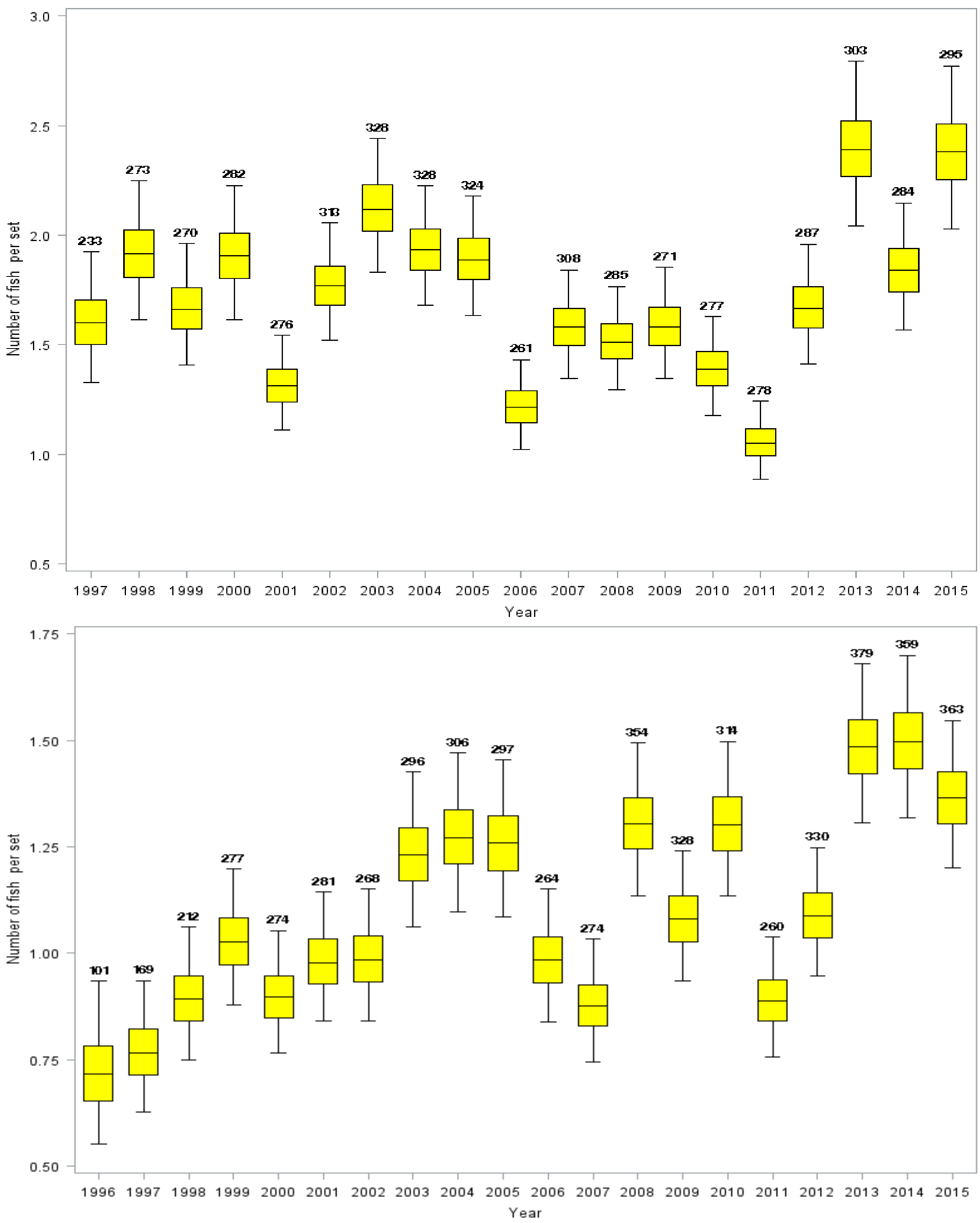
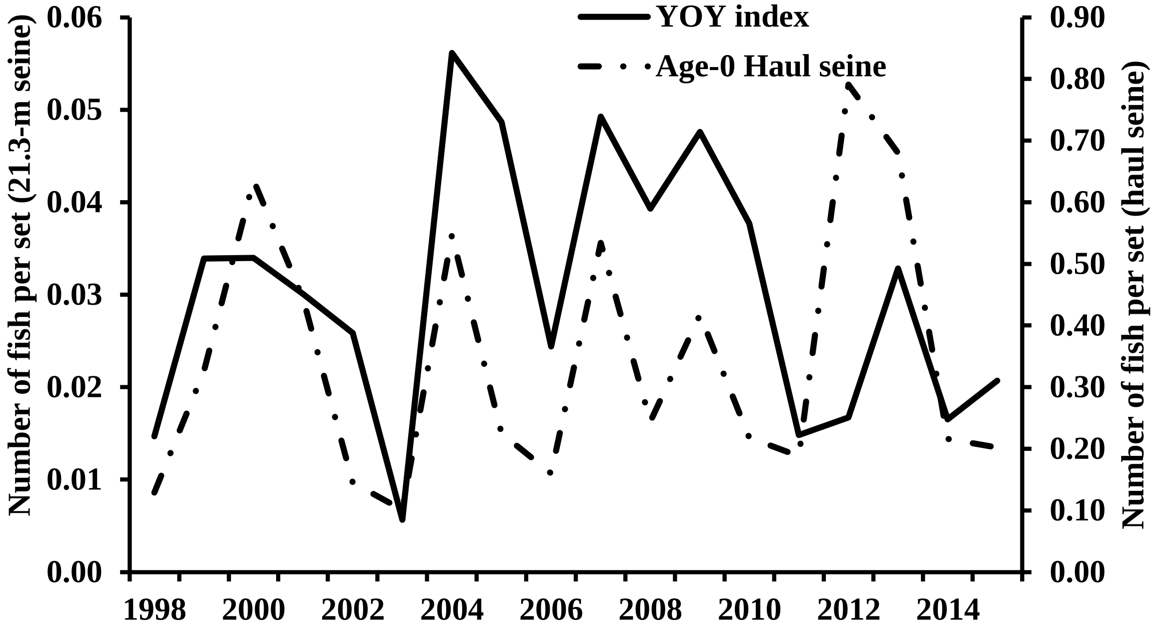


Figure 5.25 Standardized catch rates of age-1+ old Sheepshead (≥ 100-mm SL) captured by 183-m haul seines during the FWC fishery Independent Monitoring program on the Atlantic (top) and Gulf (bottom) coasts of Florida. Numbers of positive sets are shown above the upper whisker.



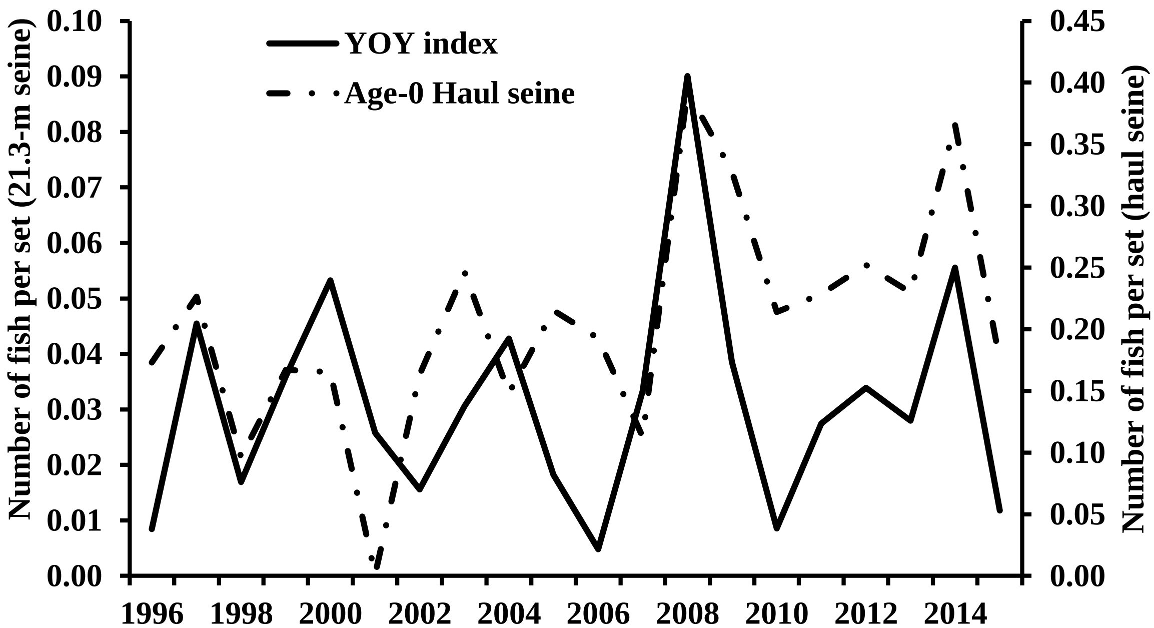


Figure 6.1 Comparison of the FIM YOY index (21.3-m bag seine) and age-0 estimates of the FIM haul seine collections at age for Sheepshead on the Atlantic (top) and Gulf (bottom) coasts of Florida.

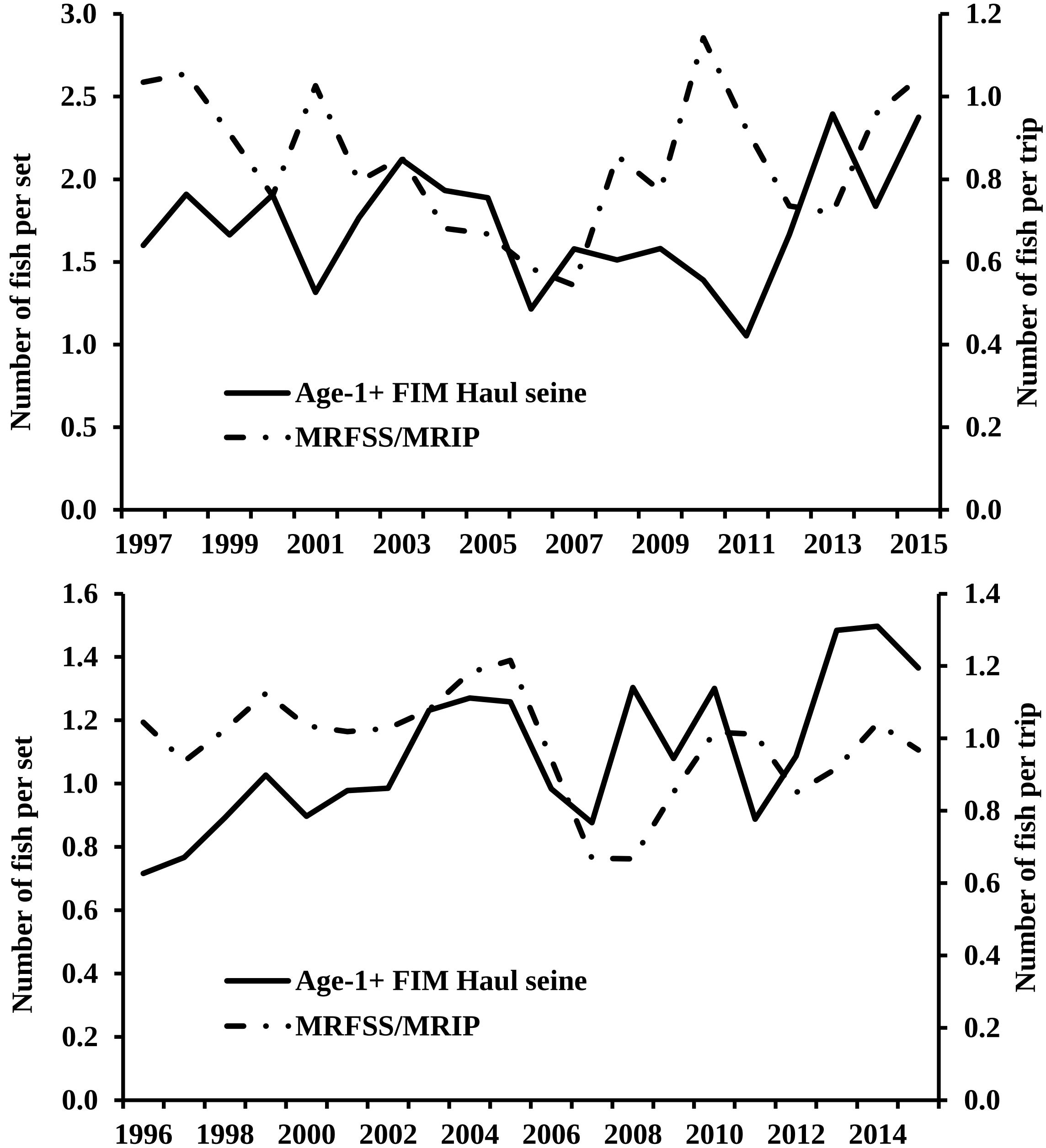


Figure 6.2 Comparison of fishery-independent (FIM Haul seine) and fishery-dependent indices (MRFSS/MRIP) of Sheepshead on the Atlantic (top) and Gulf (bottom) coasts of Florida in years they co-occur.

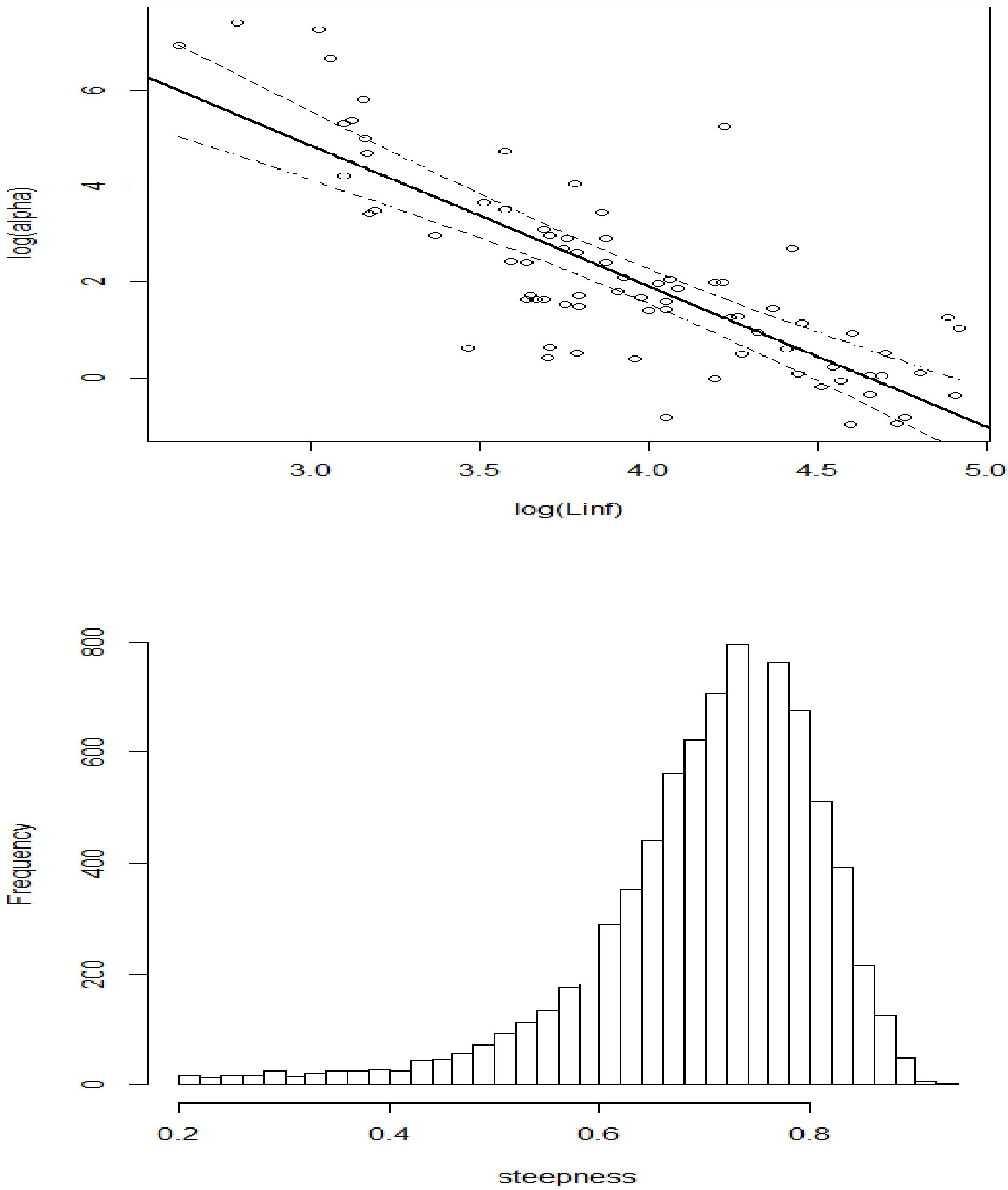


Figure 6.3 A relationship between "observed" values of alpha and L_∞ from the literature (top; $\log(\alpha) = 13.66 - 2.94\log(L_\infty)$; $r^2 = 0.67$, $P < 0.001$) and the inferred empirical distribution of steepness of a Beverton–Holt stock–recruitment relationship for Sheepshead off Florida's coasts (bottom; mode = 0.73; SD = 0.109, median = 0.73, mean = 0.71, and 80% probable range: 0.57–0.82).

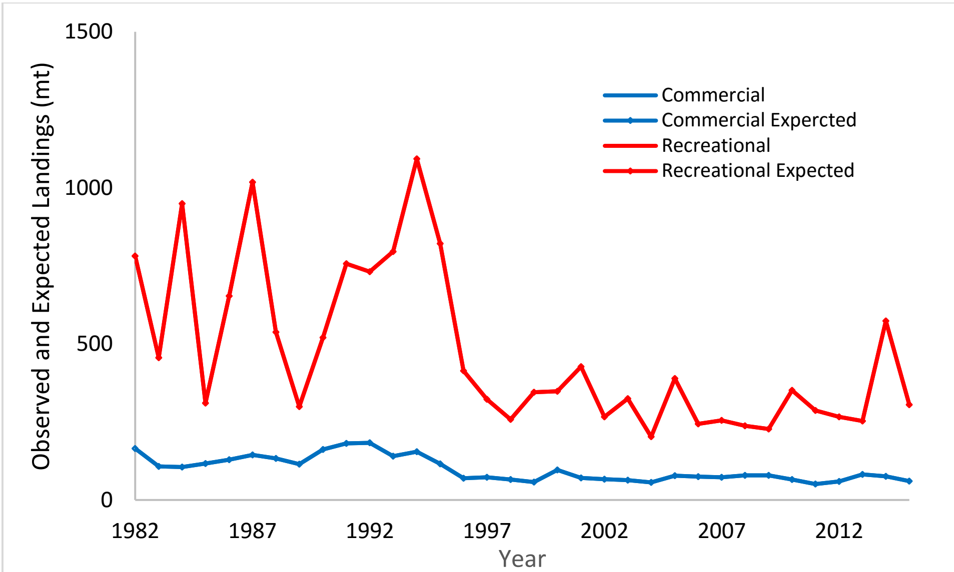


Figure 6.4 Estimated and observed landings for the Atlantic stock base model configuration.

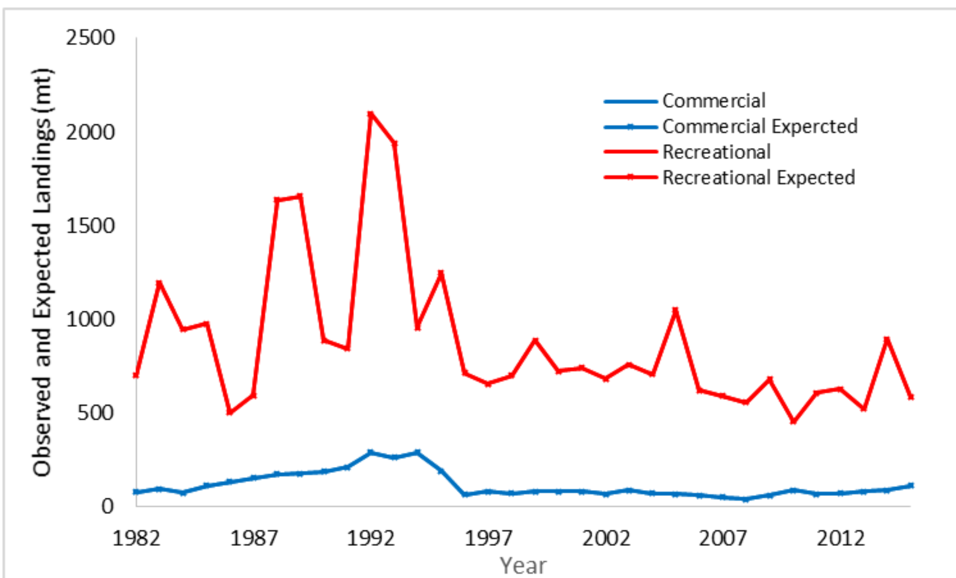


Figure 6.5 Estimated and observed landings for the Gulf stock base model configuration.

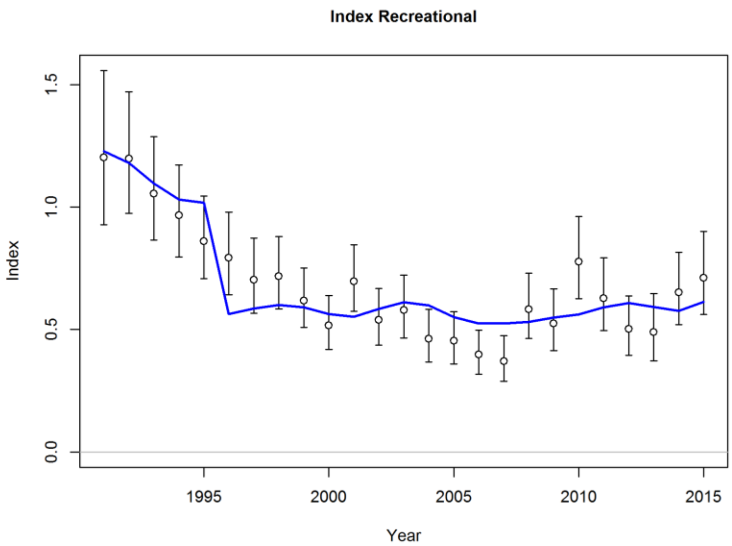


Figure 6.6 Model fit to standardized recreational CPUE index for the Atlantic coast base model configuration.

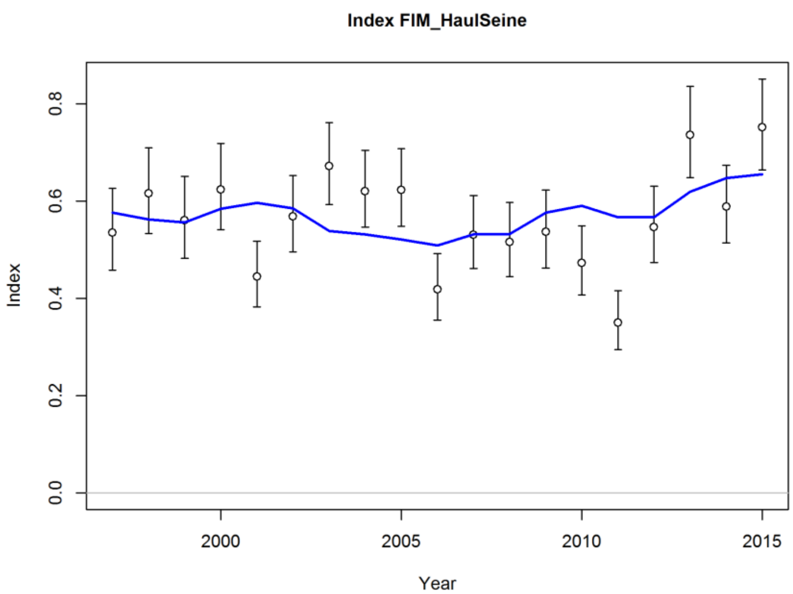


Figure 6.7 Model fit to standardized FIM haul seine survey CPUE index for the Atlantic coast base model configuration.

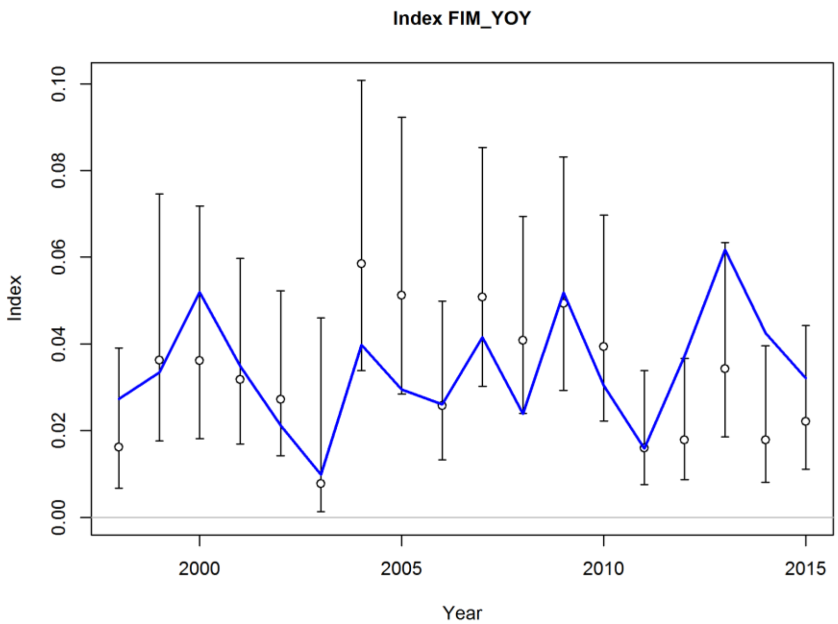


Figure 6.8 Model fit to standardized FIM YOY survey CPUE index for the Atlantic coast base model configuration.

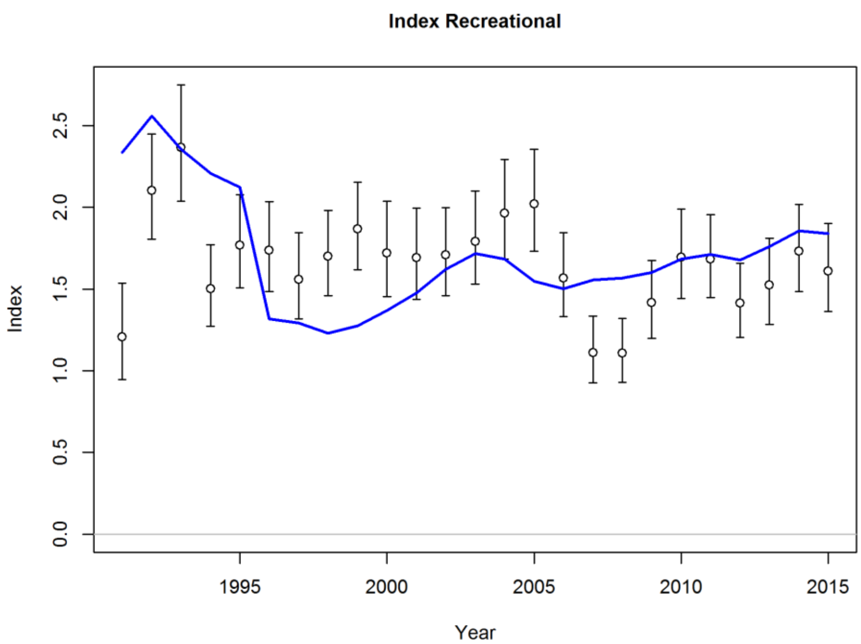


Figure 6.9 Model fit to standardized recreational CPUE index for the Gulf coast base model configuration.

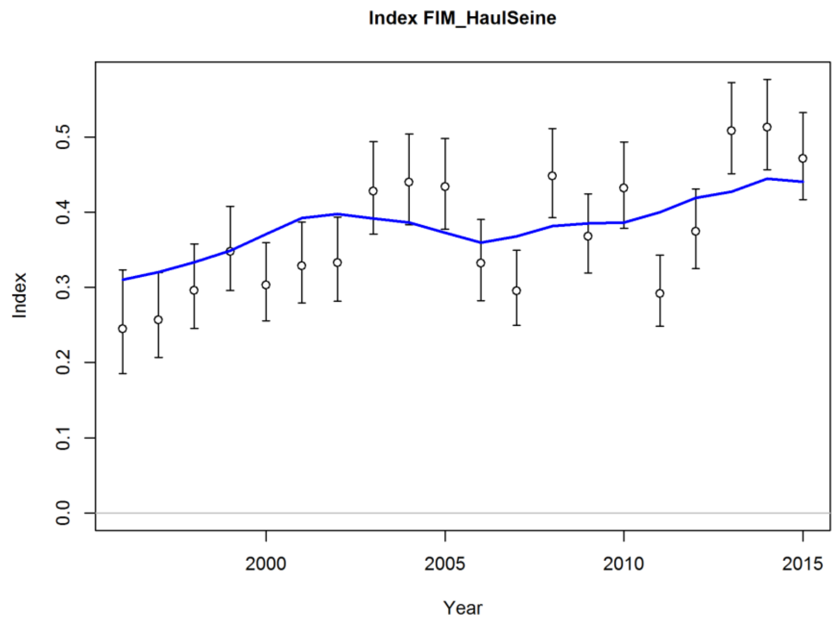


Figure 6.10 Model fit to standardized FIM haul seine survey CPUE index for the Gulf coast base model configuration.

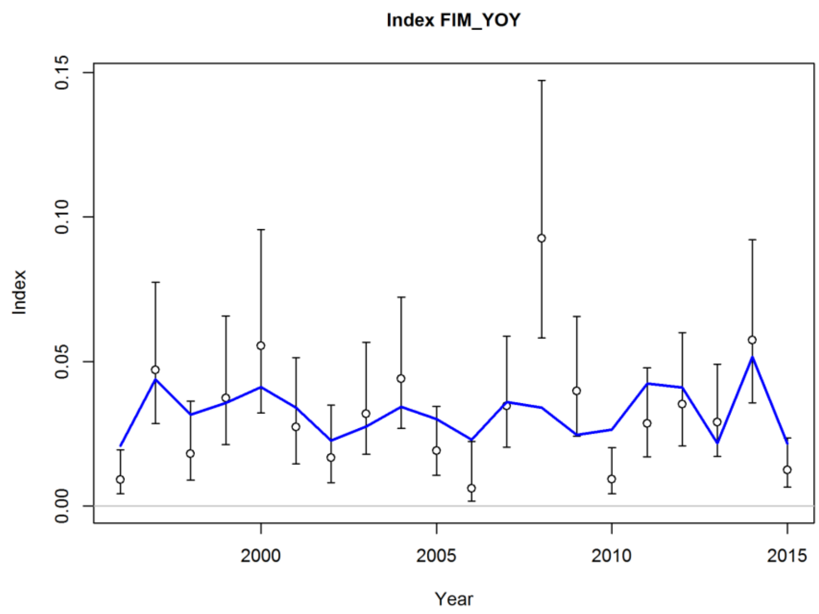


Figure 6.11 Model fit to standardized FIM YOY survey CPUE index for the Gulf coast base model configuration.

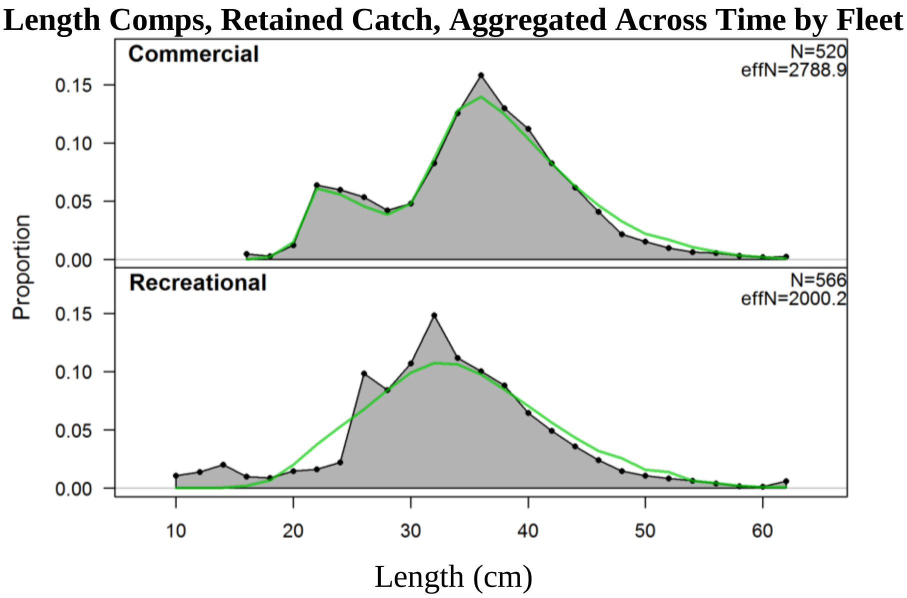


Figure 6.12. Observed and predicted length composition from both the commercial and recreational fisheries averaged across years for the Atlantic Coast base model configuration. Observed sampled sizes were capped at a maximum of 200 fish.

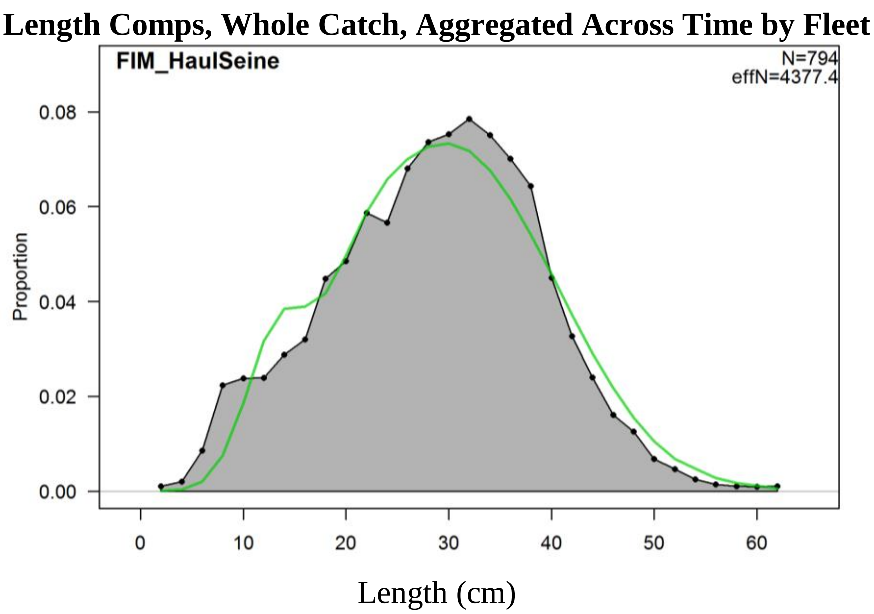


Figure 6.13 Observed and predicted length composition from the FIM haul seine survey averaged across years for the Atlantic Coast base model configuration. Observed sampled sizes were capped at a maximum of 200 fish.

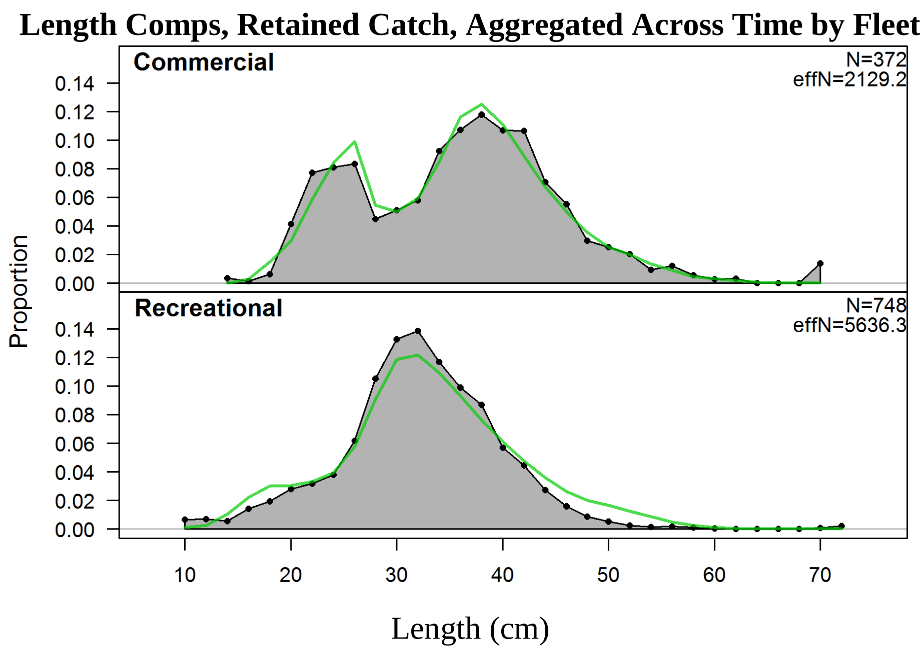


Figure 6.14 Observed and predicted length composition from both the commercial and recreational fisheries averaged across years for the Gulf Coast base model configuration. Observed sampled sizes were capped at a maximum of 200 fish.

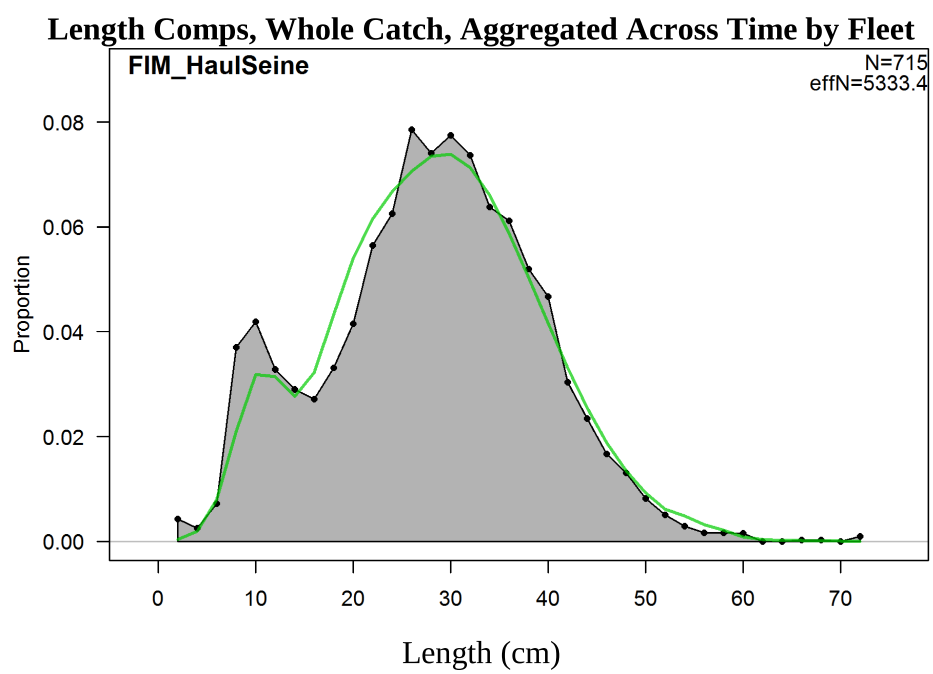


Figure 6.15 Observed and predicted length composition from the FIM haul seine survey averaged across years for the Gulf Coast base model configuration. Observed sampled sizes were capped at a maximum of 200 fish.

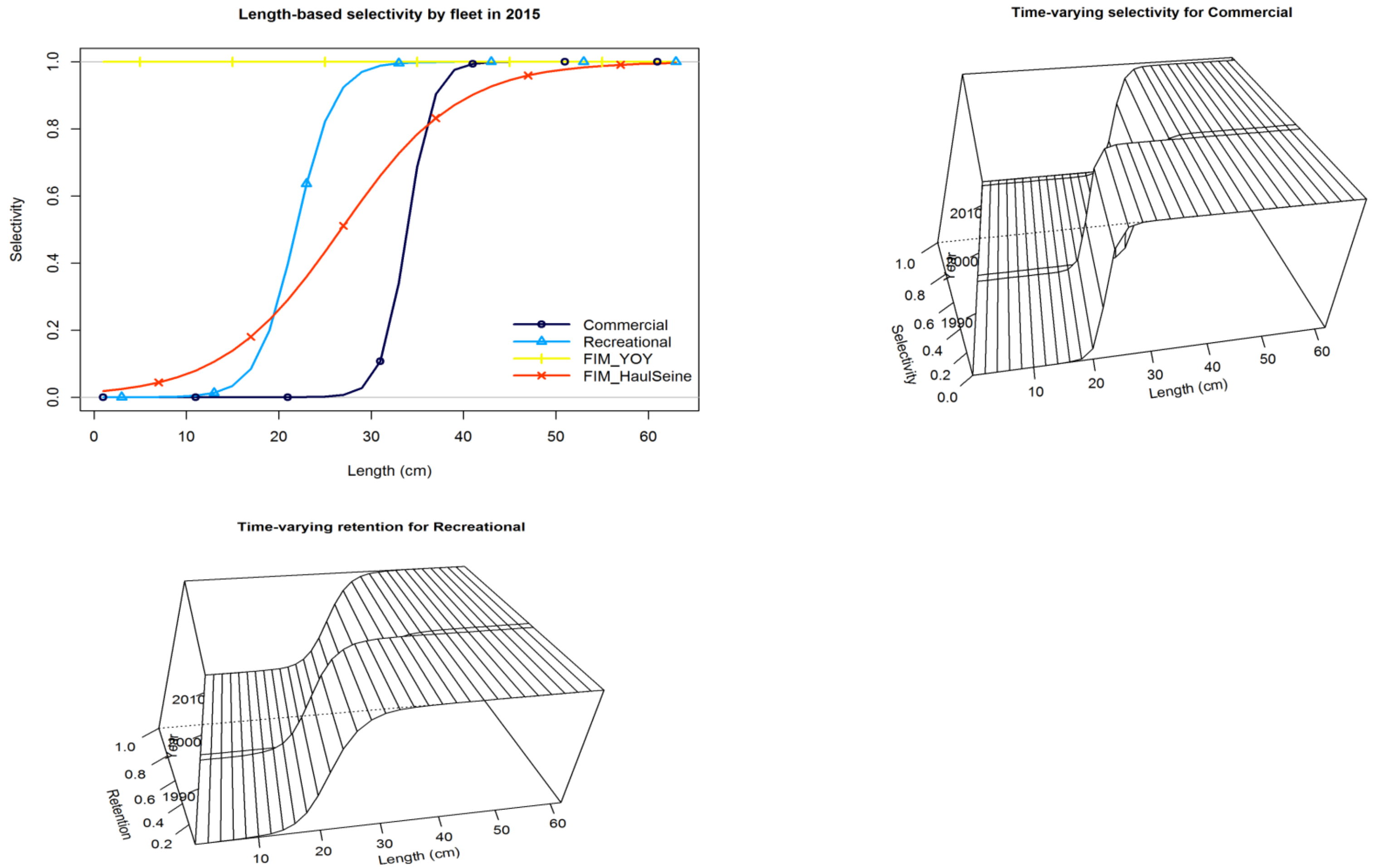


Figure 6.16 Length-based selectivity patterns estimated by the Atlantic base model configuration.

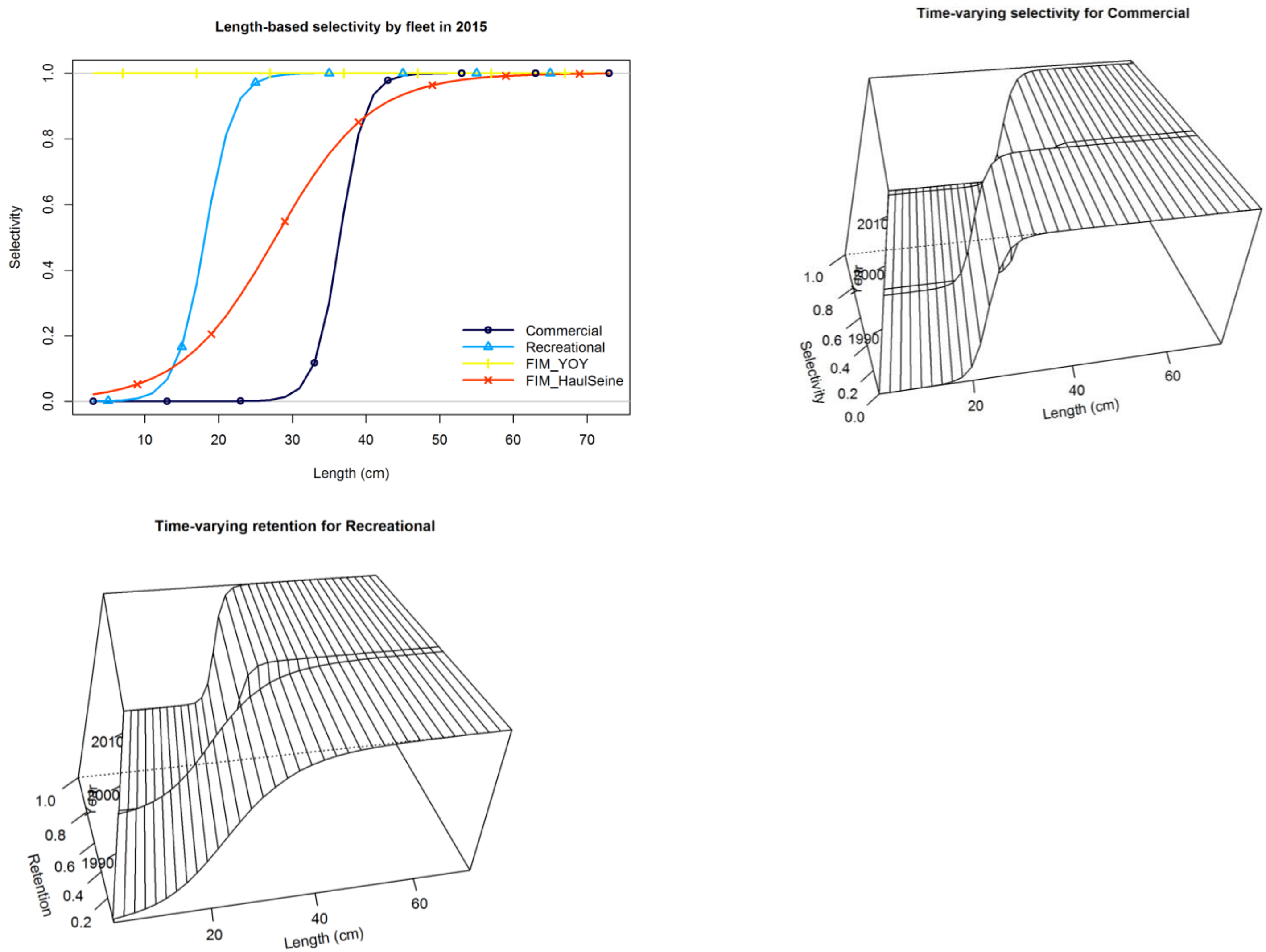


Figure 6.17 Length-based selectivity patterns estimated by the Gulf base model configuration.

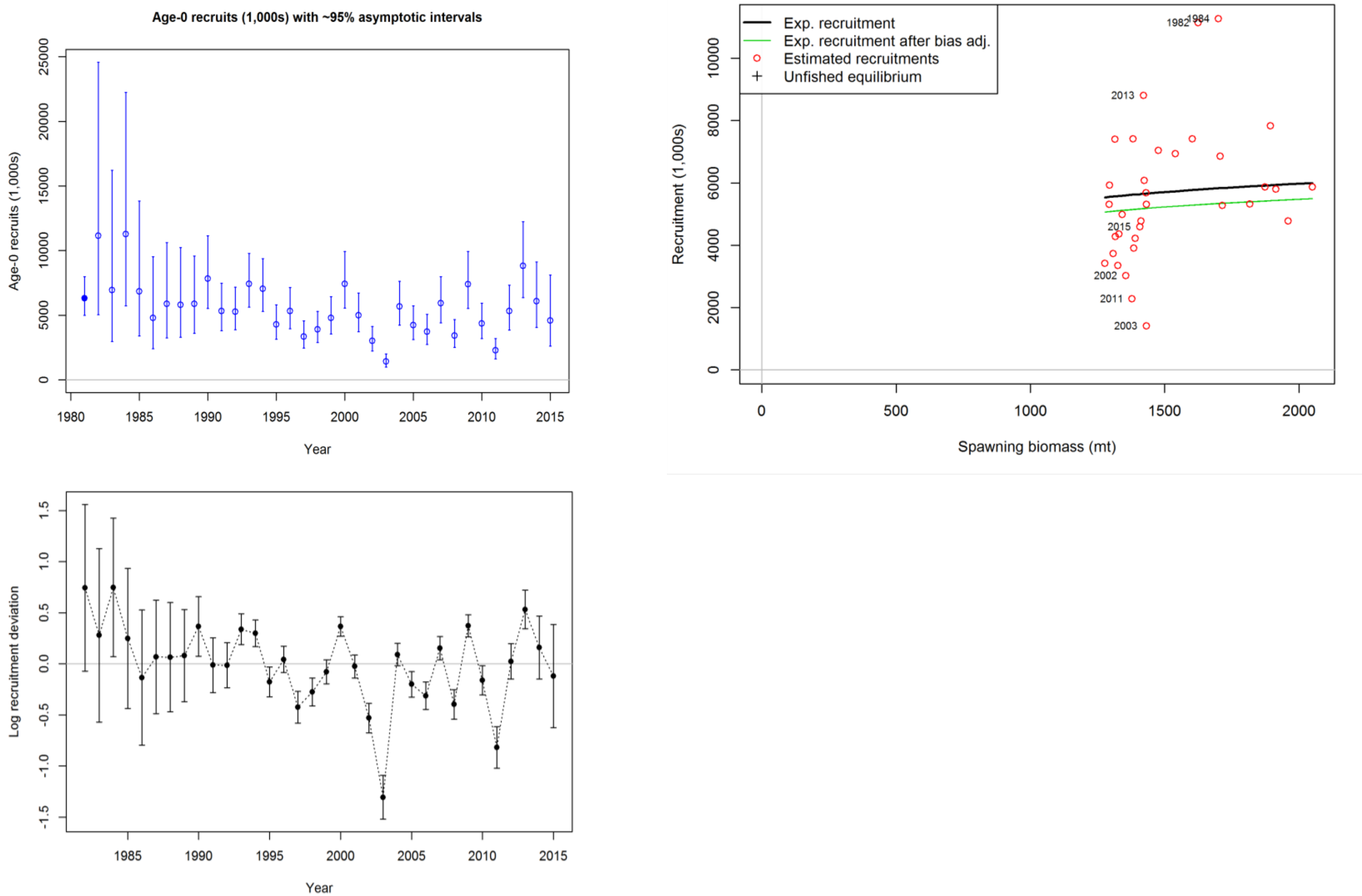


Figure 6.18 The number of age-0 recruits with associated 95% asymptotic intervals (top left), the spawner-recruit relationship (top right), and log recruitment deviations with 95% asymptotic intervals (bottom left) for the Atlantic base model configuration.

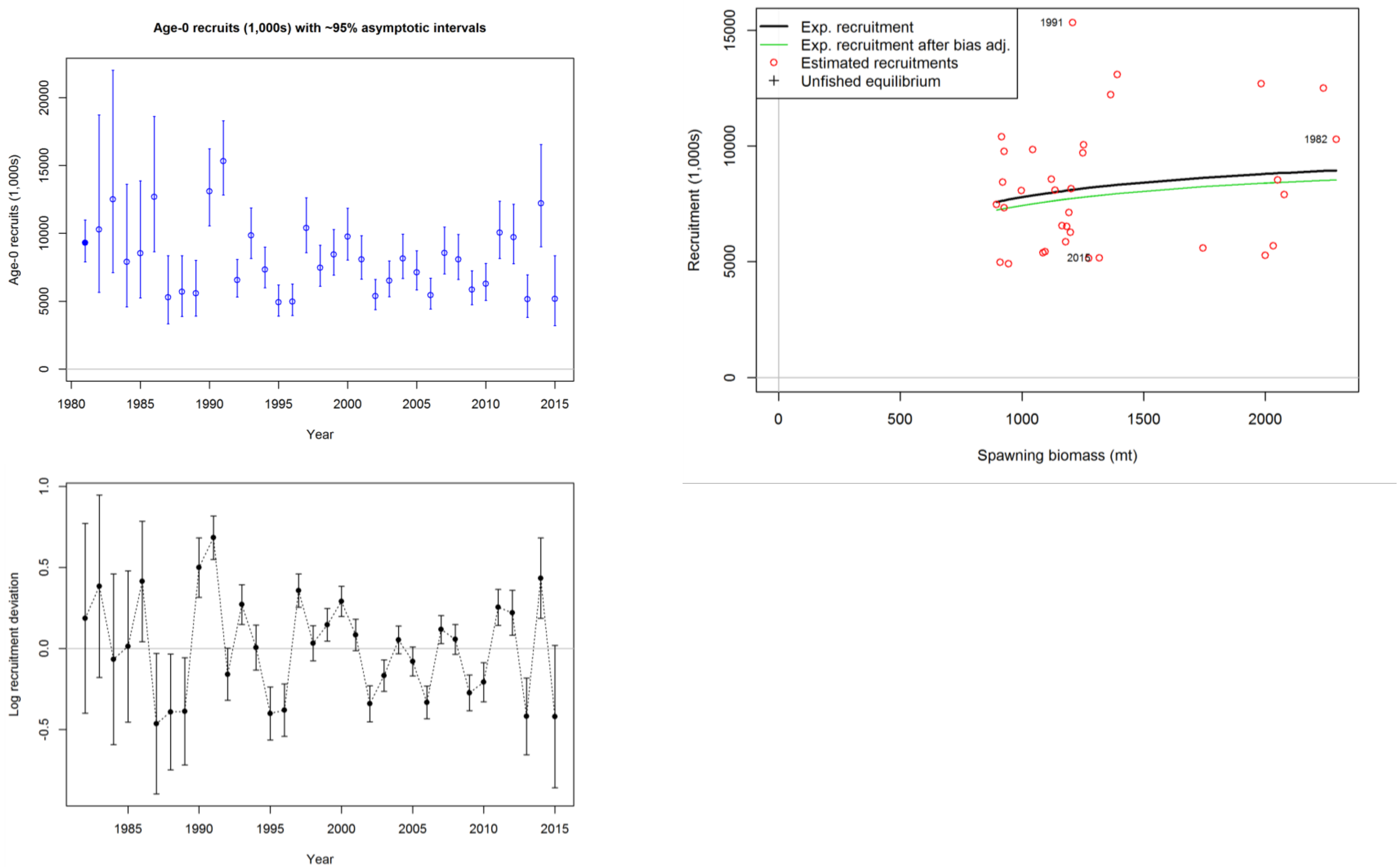


Figure 6.19 The number of age-0 recruits with associated 95% asymptotic intervals (top left), the spawner-recruit relationship (top right), and log recruitment deviations with 95% asymptotic intervals (bottom left) for the Gulf base model configuration.

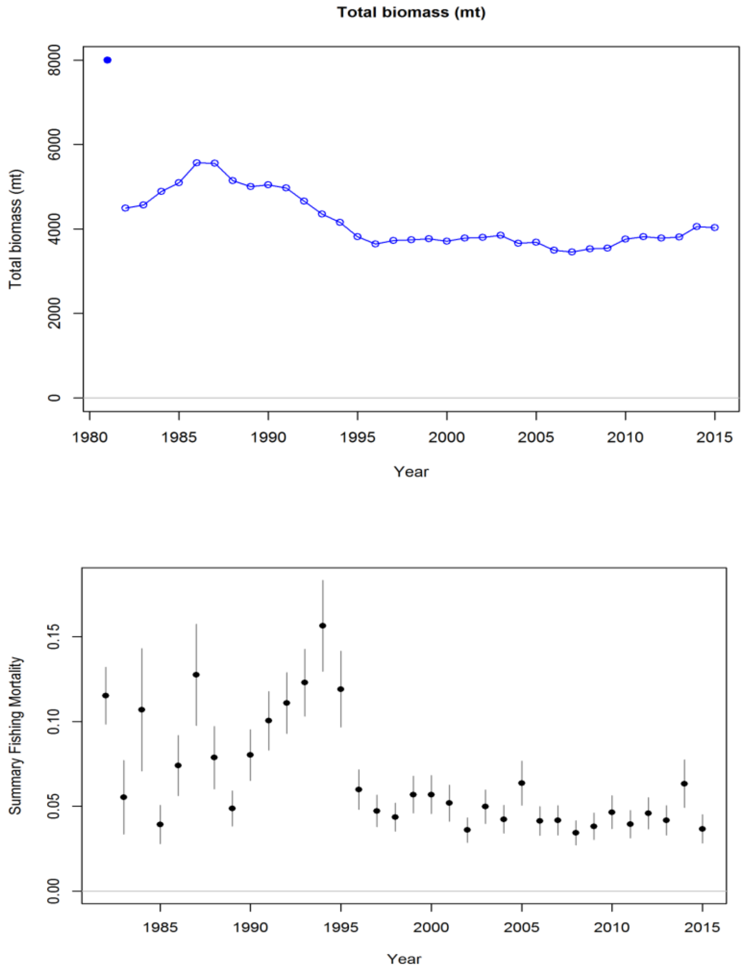
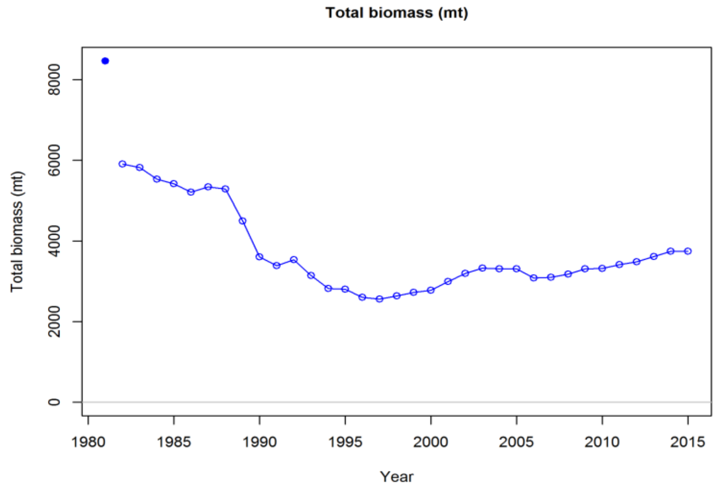


Figure 6.20 Time series of total biomass (top) and fishing mortality for ages 1–6 (bottom) from SS3 base model for Sheepshead on the Atlantic coast of Florida, 1982–2015.



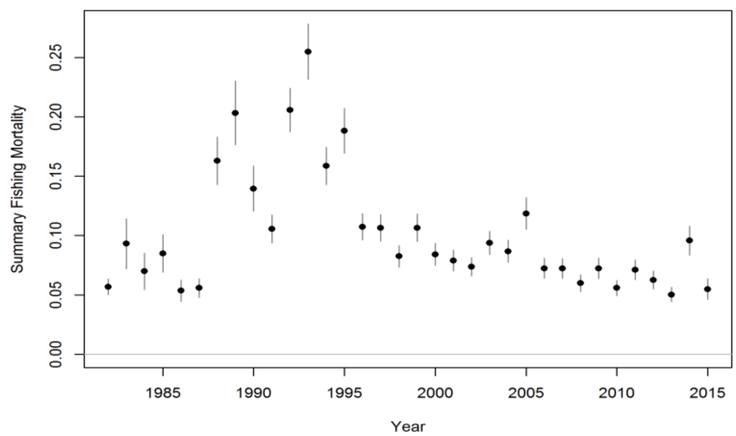


Figure 6.21 Time series of total biomass (top) and fishing mortality for ages 1–6 (bottom) from SS3 base model for Sheepshead on the Gulf coast of Florida, 1982–2015.

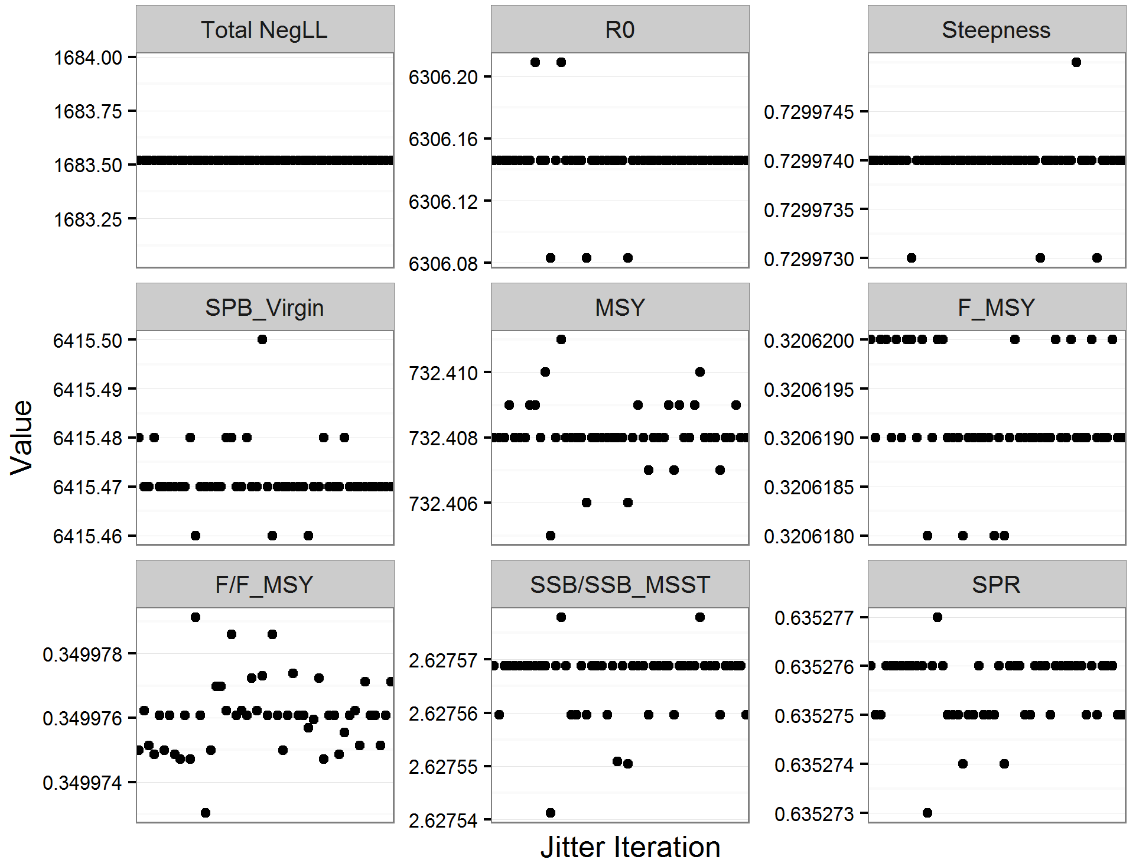


Figure 6.22 Total negative log-likelihood, stock-recruitment parameters, derived quantities, and stock-status reference points (current F/FMSY, SSB/SSBMSST, and SPR) from the 50 jitter trials, used to test for model convergence for the Atlantic base model.

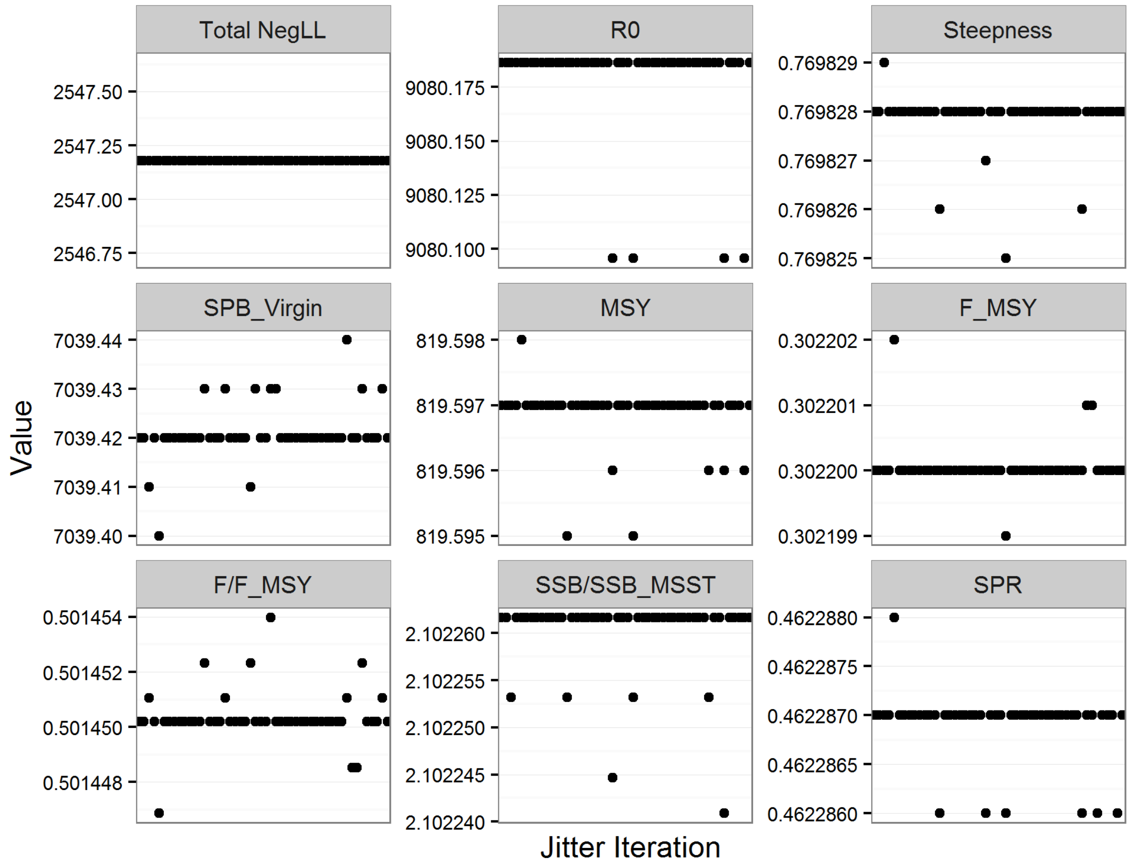


Figure 6.23 Total negative log-likelihood, stock-recruitment parameters, derived quantities, and stock-status reference points (current F/FMSY, SSB/SSBMSST, and SPR) from the 50 jitter trials, used to test for model convergence for the Gulf base model.

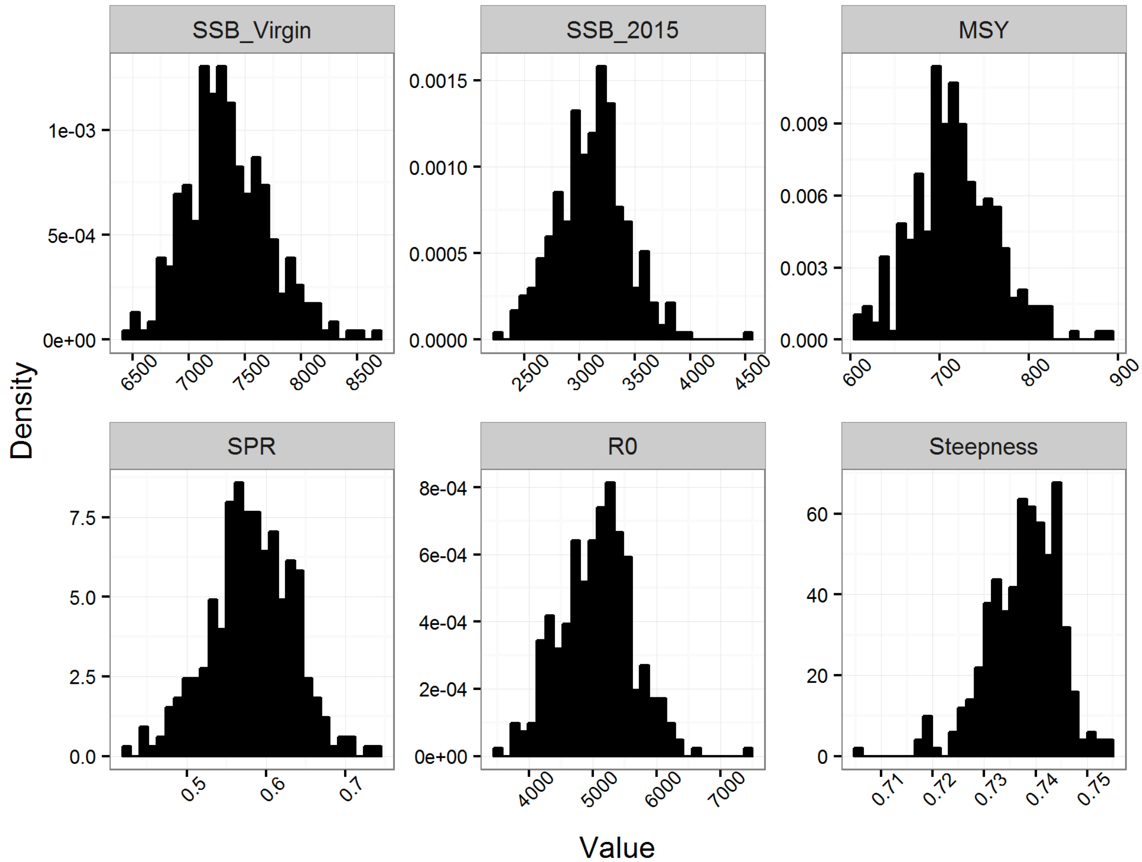


Figure 6.24 Density plots for derived quantities and stock-recruit parameters from the bootstrap analysis to test for model uncertainty for the Atlantic base model. SPR is the terminal year spawning potential ratio. Only F30% is presented here for reference to MSY, but terminal F40% was also analyzed.

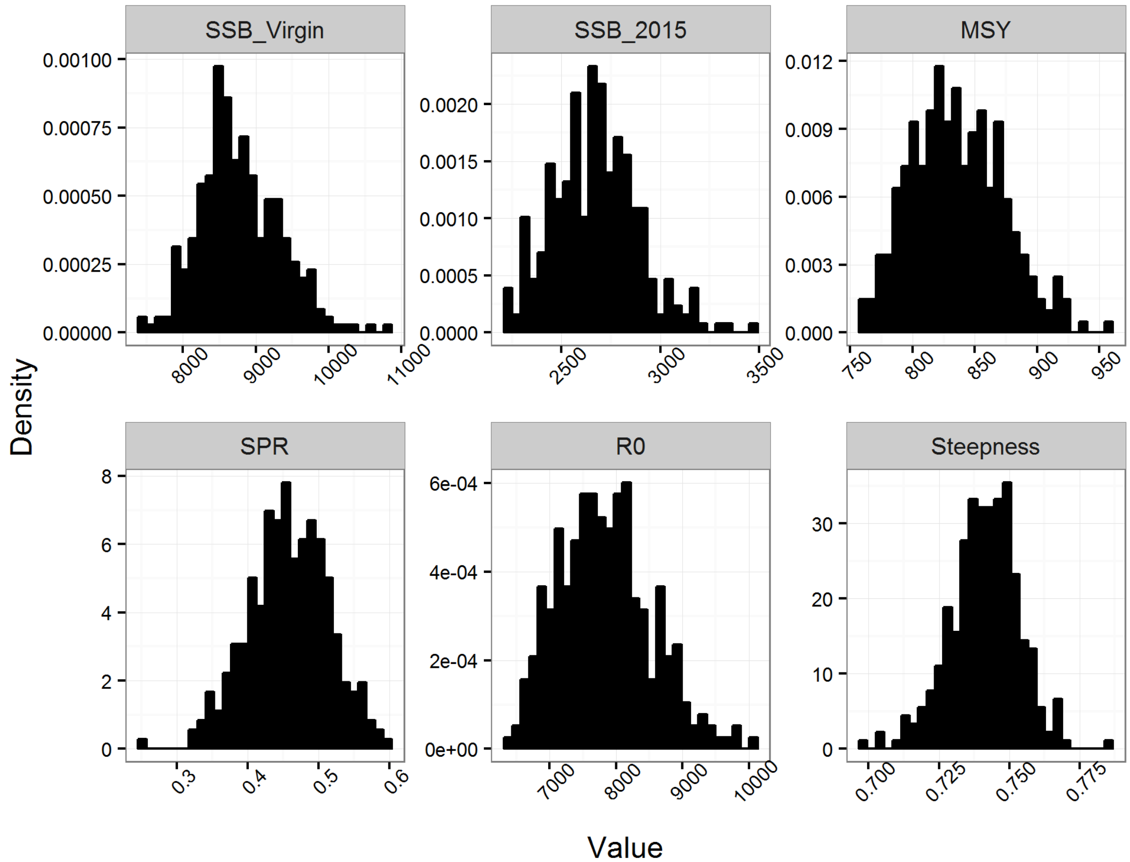


Figure 6.25 Density plots for derived quantities and stock-recruit parameters from the bootstrap analysis to test for model uncertainty for the Gulf base model. SPR is the terminal year spawning potential ratio. Only F30% is presented here for reference to MSY, but terminal F40% was also analyzed.

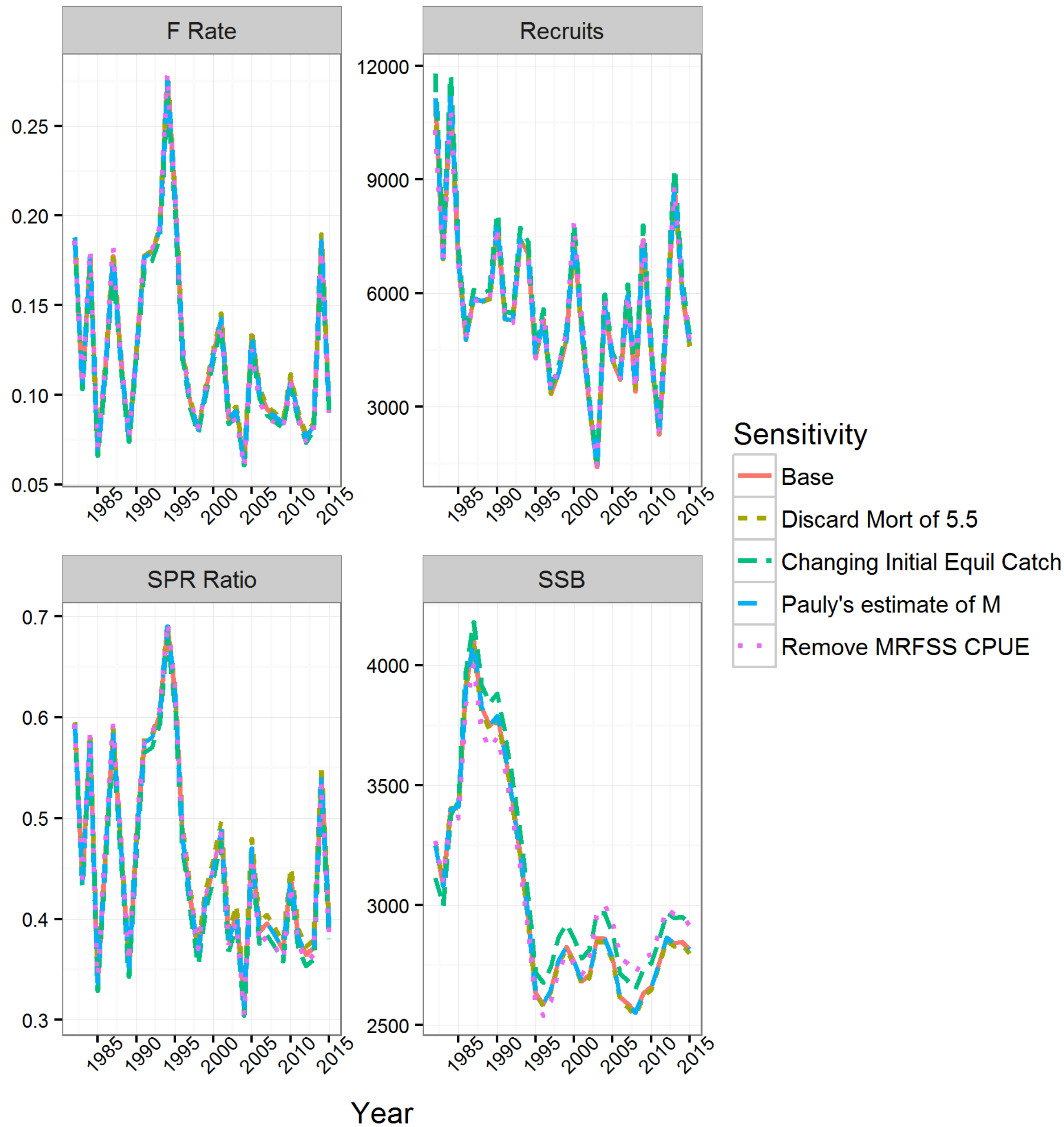


Figure 6.26 Sensitivity analysis for the Atlantic base model run. The solid red line shows the base model configuration. Using the base model configuration we then tested the following, independently: (1) a discard mortality equal to 5.5% (dashed yellow line), (2) changing the intial equilibrium catch estimate from 50% of 1982 to 75% of 1982 (dashed green line), (3) using Pauly's method to estimate M (dashed blue line) and (4) removing the MRFSS CPUE (dashed purple line).

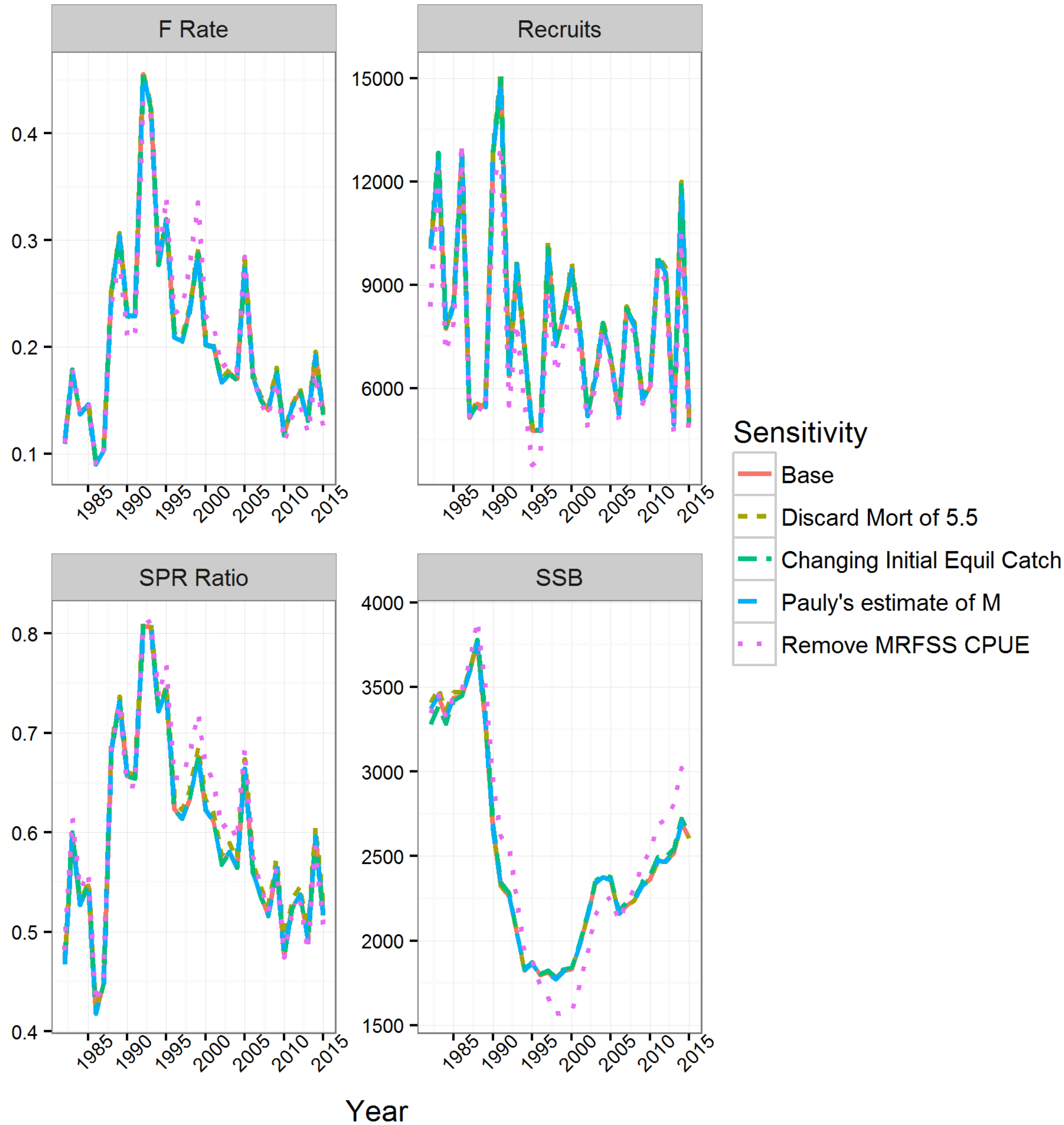


Figure 6.27 Sensitivity analysis for the Gulf base model run. The solid red line shows the base model configuration. Using the base model configuration we then tested the following, independently: (1) a discard mortality equal to 5.5% (dashed yellow line), (2) changing the intial equilibrium catch estimate from 50% of 1982 to 75% of 1982 (dashed green line), (3) using Pauly's method to estimate M (dashed blue line) and (4) removing the MRFSS CPUE (dashed purple line).

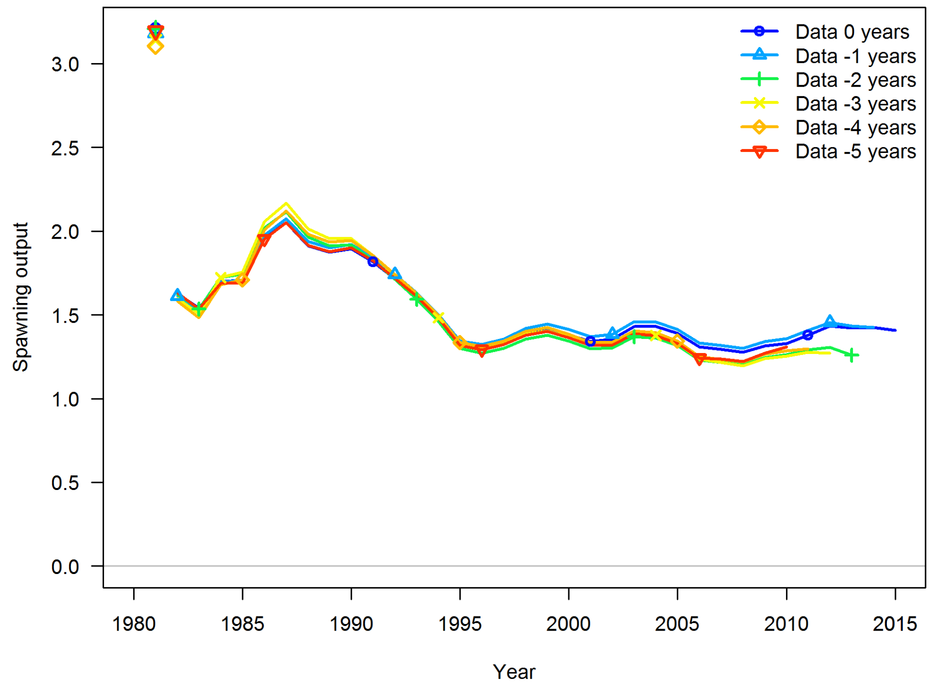


Figure 6.28 Spawning output from the retrospective analysis for the Atlantic base model configuration.

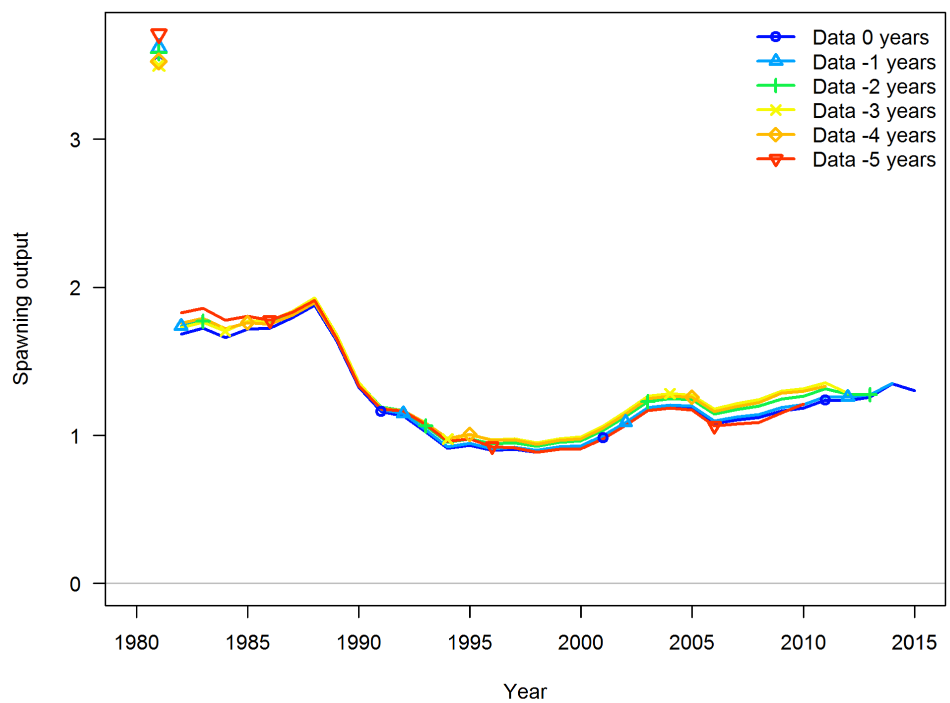


Figure 6.29 Spawning output from the retrospective analysis for the Gulf base model configuration.

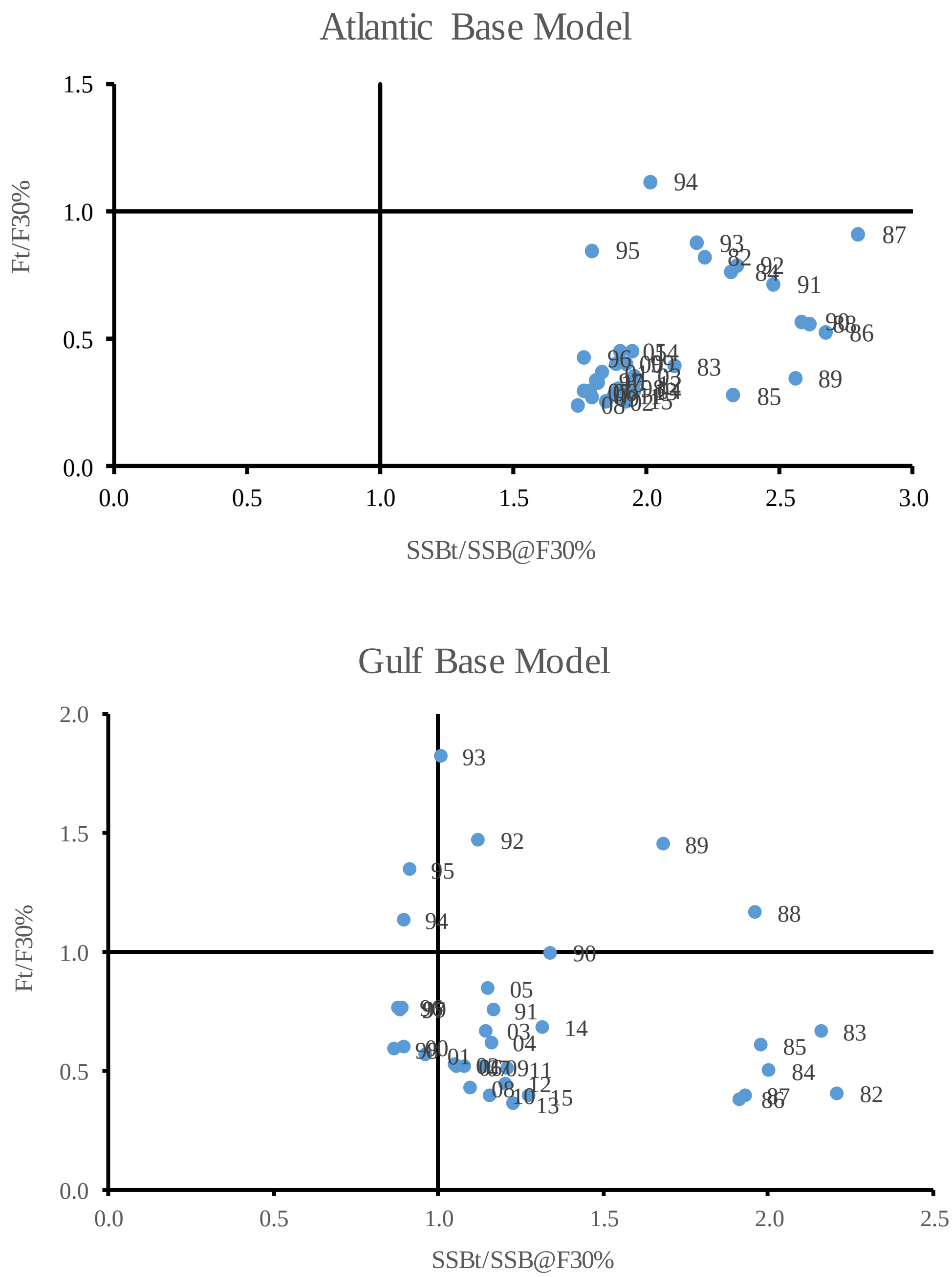


Figure 7.1 Performance indicators for Sheepshead on the Atlantic and Gulf coasts of Florida based on phase plots of the ratios $F_t/F_{30\%}$ versus the ratios SSBt/SSB@$F_{30\%}$. Years are indicated next to data points by two-digit numbers.

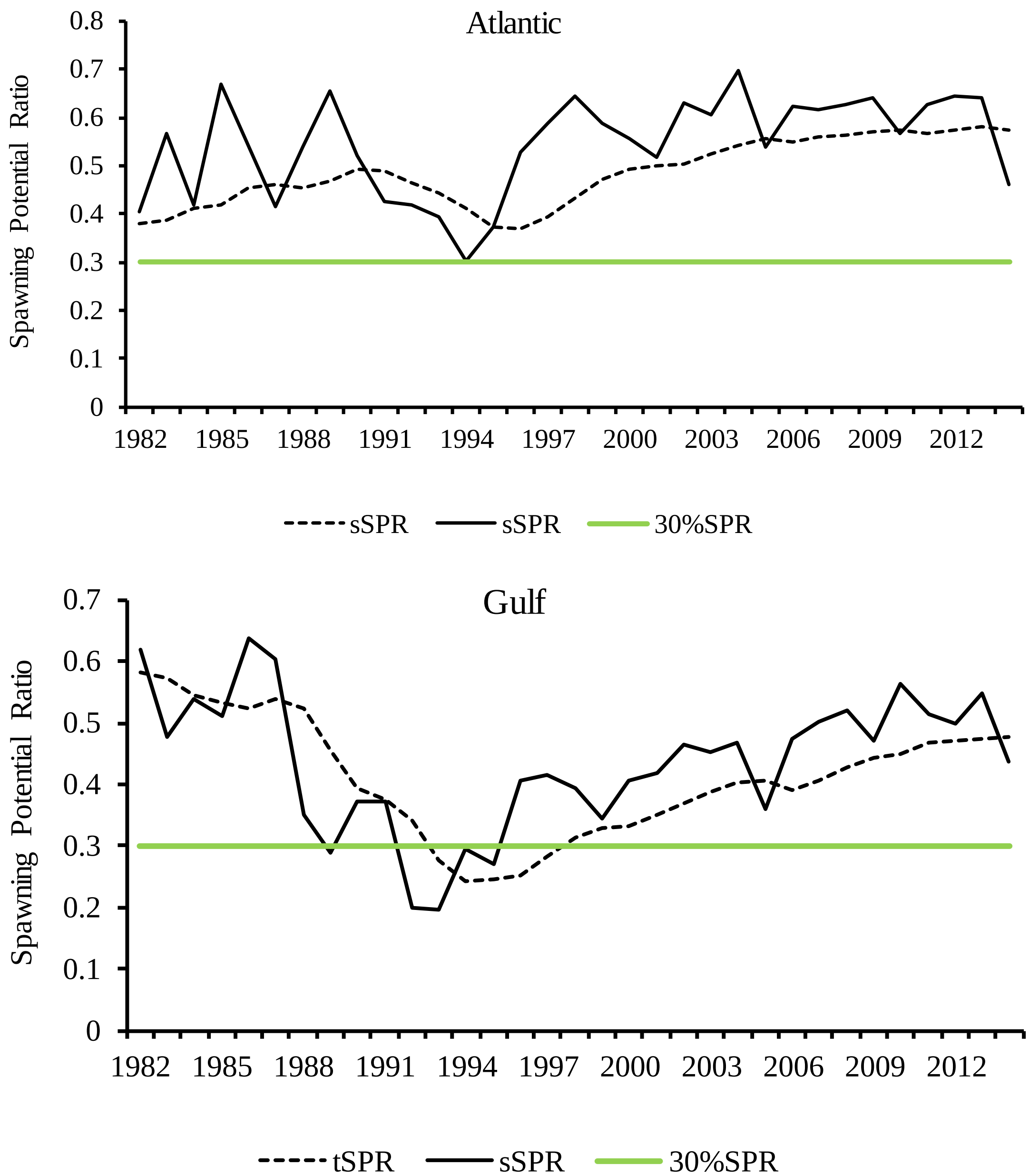
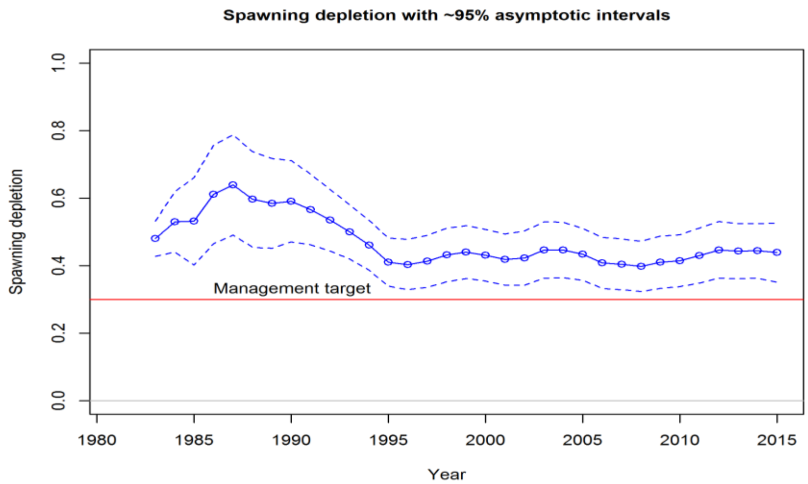


Figure 7.2 Static and transitional spawning potential ratios (sSPR and tSPR) estimated using SS3 base model results for Sheepshead on the **Atlantic** coast and **Gulf** coast of Florida during 1982–2014. The level of the equilibrium 30%SPR is also indicated for comparison.



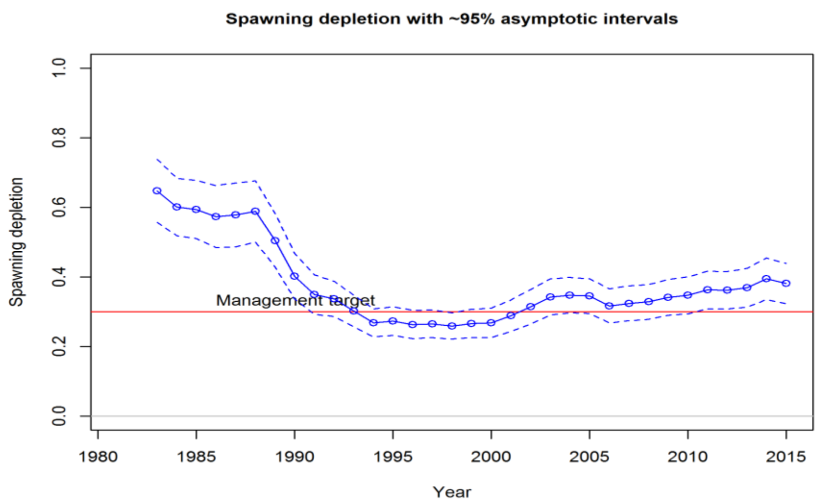


Figure 7.3 Time series of the estimated spawning depletion (SSB/SSB unfished) showing a (hypothetical) management target threshold of 30% of spawning depletion for Sheepshead on the Atlantic coast of Florida, 1982–2015.

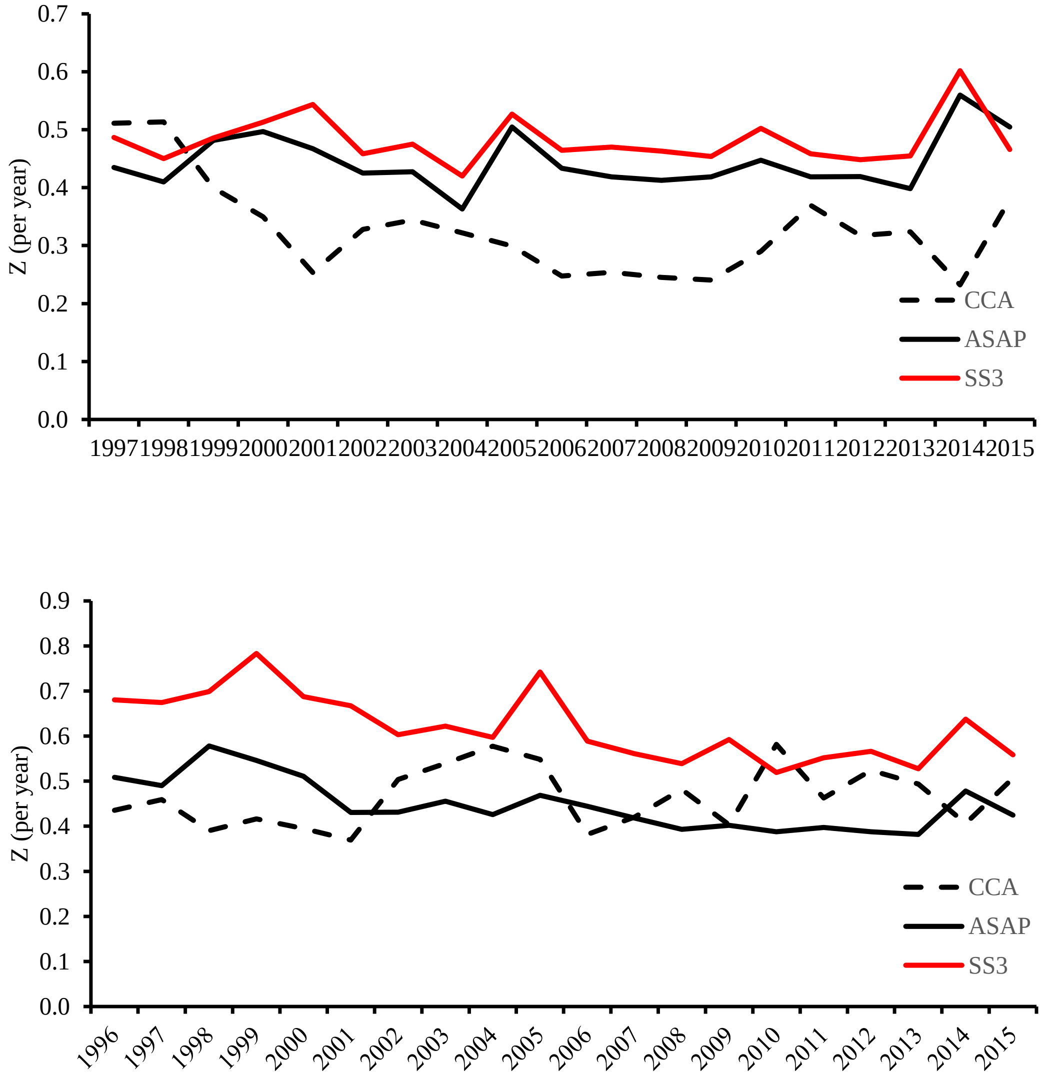


Figure 8.1. Trajectories of the estimated total mortality (Z) of Sheepshead off the Atlantic coast (top) and Gulf coast (bottom) of Florida using the three assessment methods during 1996–2015.

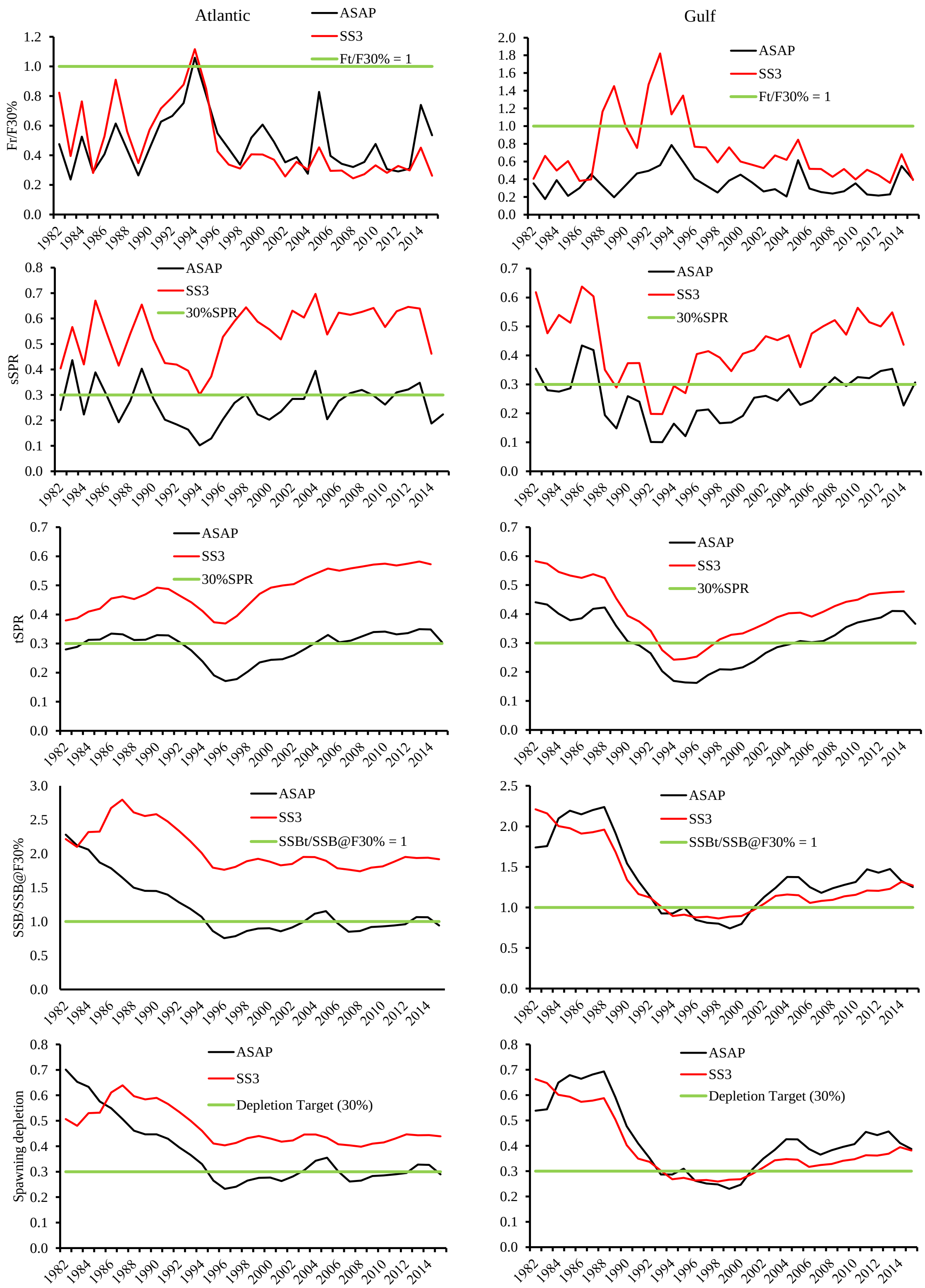


Figure 8.2 Trajectories of the ratio $F_t/F_{30\%}$, sSPR, tSPR, the ratio $SSB_t/SSB@F_{30\%}$, and the spwaning depletion from ASAP and SS3 base models for Sheepshead on the Atlantic (left panels) and Gulf (right panels) coasts of Florida, 1982–2015.

16 Appendix

16.1 Catch curves

It is common to do simple analyses as checks on more complex population models. Catch curves (i.e., plots of the number of fish on a log-scale against age) are one of the simplest methods for estimating total mortality rates (Z), whereby the estimators are the slopes of the curves. This method is underlain by restrictive assumptions (Smith et al., 2012): (1) age compositions free of errors; (2) constant recruitment or recruitment at least varying without trend; (3) constant Z over time and across ages groups; and (4) equal availability and vulnerability to the fishery for all animals above a predetermined age. Because of these assumptions, this method is rarely used as a final analysis tool; it is used only to provide rough estimates of the magnitude of Z.

16.1.1 Catch curve configuration

Estimators of $\hat{Z}$ using catch curves were based on estimated numbers of Sheepshead captured by the FIM haul seine surveys. Instead of using linear regressions of logarithm (number of fish sampled) on age, the Chapman and Robson approach was applied because it is insensitive to missing ages (Murphy, 1997). Estimators of $\hat{Z}$ were based on Smith et al's. (2012) equation as implemented in the R library FSA:

16.1.2 Estimated parameters and Uncertainty

The survival (S) was the only parameter estimated using the catch curve model. The uncertainty in Z was evaluated in terms of its variance (V), the equation of which also is in Smith et al. (2012) and was implemented in the R library FSA:

16.2 Age-Structured Assessment Program (ASAP)

ASAP is a statistical, forward-projecting catch-at-age model that allows for multiple fisheries/fleets, discards and tuning indices. ASAP uses a maximum likelihood to estimate various parameters; it has been mostly applied on the US Atlantic coast (Dichmont et al., 2016). ASAP3 was used as a continuity model in this assessment.

16.2.1 ASAP Model Description

In ASAP3, the spawning stock biomass (SSB) in year t is a function of the abundance at age, the fecundity at age, and the proportion of the total mortality (Z) at age during the year prior to spawning.

The expected recruitment in year t+1 from the SSB in year t is calculated using a Beverton–Holt stock–recruitment relationship, reparametrized in terms of the unexploited SSB (SSB_0) or unexploited recruitment (R_0), the steepness (h), and the unexploited SSB per-recruit (SPR_0). The scalers SSB_0 and R_0 relate to each other through SPR_0: $SPR_0 = SSB_0/R_0$. The calculation of SPR_0 uses life-history values of the last year in the assessment. The stock–recruitment is fixed, but the values of SSB_0 or R_0, SPR_0, and h can be calculated each year as long the life-history parameters making SPR_0, for example, are year-specific. The actual recruitment is the product of the expected recruitment and a recruitment deviation. The recruitment occurs at age-1.

Fleet selectivity is computed by blocks (periods of time) defined independently for each fleet. Within each block, selectivity can be estimated by age or by using a 2-parameter logistic function or a 4-parameter double logistic function.

Natural mortality (*M*) is entered as a year by age matrix.

Fishing mortality (*F*) at age is the product of a year effect (*F*mult) and selectivity at age. For each fleet in a given year, *F*mult (i.e.., full instantaneous fishing 'encounter' rate) is determined by the logarithm of *F*mult in the first year and its deviation from the first year's *F*mult. The directed *F* (*F*dir) by fleet, year, and age (i.e., proportion of *F* that contributes to landings) is the product of the fleet-specific *F*mult and the selectivity at age which is then decremented by the product of *F*mult, selectivity, and the proportion of the catch released (*prop_release*) for that fleet, year, and age. The bycatch *F* (*F_bycatch*) by fleet, year and age is the product of *F*mult, selectivity, proportion released alive, and release mortality rate. Finally, the fishing mortality by fleet, year, and age (*F*fleet) is the sum of *F*dir and *Fbycatch*; the total mortality is the sum of all *F*leets and *M* at age and year.

The population abundance in the first year for ages 2 through the maximum age are derived from the initial guesses and the deviation of the first year's population abundance at age-1, and by employing a set of equations.

F-based outputs of ASAP3 include *F*mult, fleet-specific and combined full *F* matrices (which may be sufficient indicators of fishing intensity if selectivity does not change over time), and an *F* report (*F*report) by year. *F*report averages the total fishing mortality across fleets over an input range of ages that may be significantly targeted by the fisheries. The averaging method can be done as unweighted, weighted by the population abundance at age, or weighted by the population biomass at age.

The predicted landings and discards in numbers by fleet, year, and age, are derived from the Baranov catch equation. They are in turn used to predict the total weight of landings and discards by fleet and year and to predict the corresponding proportions. The total observed discards in weight only include those fish that die after capture and release.

The catchability for each index is calculated similarly to *F*mult (the natural log of the parameter for the deviation in the first year is defined as zero).

The time of year and the units (numbers or biomass) of the index are required to match the predicted index values with the observed index values. The index selectivity can be an input or matched to a fleet selectivity (especially if it is expressed as catch-per-unit-effort). Proportions at age are also estimated if any index selectivity parameters are estimated, but the biomass indices have these proportions based on biomass, not numbers.

ASAP3 computes common reference points ($F_{0.1}$, F_{MAX}, $F_{30\%}$, $F_{40\%}$, F_{MSY}, MSY and B_{MSY}) based on the estimated *F* and biological characteristics of the final year.

ASAP3 has a built-in projection capability using the same calculations as the main assessment routine; no fitting is done. Projections are options-driven depending on how one wants to define a fishery (e.g., matching a directed catch in weight, fishing at F_{MSY}).

ASAP3 is able to quantify model structure uncertainty through sensitivity tests, in which assumptions of the assessment and/or data sources are changed, and through retrospective analyses. It also computes "statistical" uncertainty associated with model outputs using asymptotic and Bayesian methods.

For more details about the basic equations and the script underlying ASAP3 features, see the accompanying Technical Documentation.

16.2.2 ASAP Model Calibration

ASAP3 was configured to allow two selectivity blocks (1982–1995 and 1996–2015) for the commercial and recreational fisheries and to include the recreational discards. Input data were: (1) the annual landings and annual dead discards in weight (MT); (2) proportion by age and year for landings and dead discards; (3) year-specific ratio-at-age of released alive, including dead discards, to year-specific total catch; (4) natural and release mortalities, weight-at-age (kg) and age-at-maturity; and (5) indices of abundance.

16.2.2.1 Biological Inputs

Biological inputs within ASAP3 consisted of age-by-year matrices of natural mortality (*M*), maturity and weight. *M* and maturity schedules were the same each year. Weight matrices were separate for the fishery-dependent catches and discards, January-1 biomass, and the SSB (spawning offset = 0.25).

16.2.2.2 Selectivity Blocks

Prior to 1996, a 4-parameter double logistic function was used for the commercial fishery to mimic the selectivity of entangling net gears which were predominantly used at that time. For both recreational selectivity blocks and for the 1996–2015 commercial selectivity block, the single logistic function option was chosen.

The previous functions were initiated with parameters derived as follows. For each fishery, the block-specific proportions (of landings in number) at age were first calculated. The cumulative proportions were treated as “observed” selectivity schedules and were fitted with logistic functions, the parameters of which served as starting values for the estimation of logistic selectivity. For the commercial dome-shaped selectivity during 1982–1995, the proportions at age were first scaled to the maximum proportion. The rescaled proportions were then fitted with a 4-parameter logistic function.

16.2.2.3 Fishery-Dependent Inputs

In addition to the catch weight matrix, inputs to ASAP3 models were: (1) the commercial landings age compositions (LAA) and total landings (MT), (2) the recreational LAA (Type A+B1) and total landings (MT), (3) the estimated age compositions of the commercial dead discards and the total weight of commercial dead discards (MT), (4) the age compositions of the recreational dead discards and the total weight of recreational dead discards (MT), and (5) the release proportions-at-age for each fishery.

The age compositions for landings and discards were filled in as unavailable (-999) prior to 1997 on the Atlantic coast and prior to 1993 on the Gulf coast, because there were no age-length data in those years. Regardless, in years without observed age compositions, ASAP3 calculates internally “observed” age compositions which, for each age and year are 1/N where N is the total number of ages (here, N = 11). Developing full matrices of release proportions-at-age (released alive/total catch) was straightforward during 1997–2015 on the Atlantic coast and during 1993–2015 on the Gulf coast; it was challenging prior to those periods because of the lack of age compositions. This challenge was circumvented by constructing an average ALK based on the first two years ALKs in the time series and by applying that average ALK to the landings and estimated discards during years with missing age-length data (unlike in the 2011 assessment, those estimated landings and discards at age were not included in the age composition matrices).

As indicated in Section 5.1.1.6, the weight of Sheepshead commercially released alive was inferred from the ratio of Type B2/Type A+ B1 in the recreational fishery. To obtain the weight of recreational discards, the estimated number of Sheepshead released alive by age and year was first multiplied by the mean weight-at-age in landings. For each year, the total weight was obtained by summing the estimated weight-at-age across ages.

For each fishery, the annual weight of dead discards was the product of the annual total weight of all released alive and the assumed release mortality.

It is useful to keep in mind that the selectivity schedule in ASAP applies to the total catch of a fleet/fishery and not to its individual subcomponents. That is, there are no separate selectivity schedules for the directed fishery and the discards.

16.2.2.4 Tuning Indices

The indices of relative abundance used to tune ASAP3 were: (1) the age-aggregated MRFSS/MRIP median catch rates, (2) the FIM YOY index, (3) the FIM age-1+ haul-seine index, and (4) the FIM haul-seine catch rates at age. Log-transformed values of the FIM YOY index were assumed to be log-linearly related to the recruitment abundance (age-1). Because the YOY index relates to age-0 fish and because the recruitment in ASAP3 occurs at age-1, each annual value of the YOY index was shifted one year ahead, a procedure that dropped the last year estimate of the index time series. The FIM haul-seine catch rates at age followed a multinomial distribution whereas the FIM haul-seine age-1+ index was assumed to be log-linearly related to the abundance of age-1 to age-6 (this age-range represents the majority of the haule seine survey catches). The MRFSS median catch rates were assumed to be log-linearly related to the abundance of age-2 to age-6 Sheepshead.

The selectivity for the FIM YOY index was fixed at 1. The FIM age-1 index selectivity was described by a two-parameters logistic function. Its initialization parameters were estimated similarly as for the recreational selectivity by block, using the estimated age composition of the haul seine catches. The selectivity of MRFSS/MRIP catch rates was linked to the recreational fishery.

16.2.2.5 Weighting of Likelihoods

For the total catch and index values, ASAP allows users to specify weights in the form of lambdas (a single multiplier per data set that is applied to the likelihood component) and CVs (annual estimates that are included in the calculation of the likelihood component of the data). Effective sample size (ESS) is used to help predictions of proportions based on the multinomial likelihood for the landing and index age compositions. ESS inputs were the square roots of annual sample sizes for the FIM haul seine surveys or the annual total number of trips retained in the catch rate standardizations for the commercial and recreational fisheries. Although ESS should be 0 in years without fisheries' age compositions and in years without age-specific estimates of the FIM haul-seine catch rates, they were set to 1 for the fisheries for helping the mixing of MCMC runs. ASAP runs produce new ESS that are suggested for use, only once, for fine-tuning the fits.

The CVs associated with the estimation of various selectivity parameters were set to 1. The calibrated MRFSS/MRIP PSEs were used as CVs on the recreational landings and discards; a CV of 0.1 was applied for the commercial fishery throughout the time series. Annual index CVs were obtained during the index standardizations. A recruitment CV of 0.66 was applied each year assuming a standard deviation of 0.6 as estimated by Rose et al. (2001) using natural log-transformed residuals of recruitment for periodic species. The deviations from the initial guesses (see below) were allowed with CVs of 0.9, except for the initial steepness the deviation of which had a CV of 0.15.

16.2.2.6 Initial Guesses

The stock–recruit steepness (and CV), maximum *F*, index catchabilities, unexploited spawning stock biomass (SSB_0), and fleet-specific *F*mult in the first year were initiated at 0.73 (CV = 0.15), 5 yr^{-1}, 0.0001, 7,500 (thousands) MT on the Atlantic coast and 6,500 (thousands) MT on the Gulf coast, and 0.1yr^{-1}, respectively. For each coast, SSB_0 was about 10 times the 1982 total kills (landings + estimated dead discards). The steepness initial (prior) value was the mode of Figure 6.3.

16.2.2.7 Uncertainty in Model Results

ASAP runs generate asymptotic standard errors as measures of precision for the estimated and calculated parameters from the Hessian. MCMC calculations may provide more robust characterization of uncertainty for *F*, SSB, total and exploited biomasses, and reference points. For the ASAP base model, 10,000,000 MCMC runs were conducted, of which 1,000 were kept.

16.2.2.8 Sensitivity Runs

Three sensitivity analyses were made, keeping the basic input data of the base run:

- Dropping the MRFSS/MRIP CPUE;
- Using Lorenzen *M*-at-age scaled to Pauly' s nonlinear estimator (Then *et al.* 2015);
- Using an assumed 5.5% release mortality that was estimated for Portuguese sparids (Veiga *et al.* 2011).

16.2.2.9 Retrospective Analyses

The base model and sensitivity runs were subject to a retrospective analysis that removed successive years of data from the model for 6 years.

16.2.2.10 Projections

No projections were made.

16.3 Results

16.3.1 Catch Curve Analyses

The ages of full recruitment in FIM haul seine collections ranged between 3 and 7 years on both coasts of Florida. In other words, the catch curve analyses included age-3 through age-25. On the Atlantic coast, estimates of mean *Z* were 0.51 in 1997 and 1998, but declined thereafter at an annual rate of about 0.007 (Figure 16.1). On the Gulf coast, the estimated values of mean *Z* generally varied without trend, ranging between 0.37 and 0.58 $year^{-1}$. Overall, Z was estimated with relatively good precision as reflected in the 95% confidence intervals, except in 2008 on the Atlantic coast.

16.3.2 ASAP Model

16.3.2.1 Goodness-of-Fit and Diagnostics

ASAP base model tracked the observed total catch (typically landings), commercial and recreational dead discards and abundance index values and fitted them fairly well (Figures 16.2–16.5). On the Atlantic coast, however, the total catch and discards showed strong patterning in the residuals: ASAP overestimated total catch and underestimated discards in most years. The Atlantic MRFSS/MRIP CPUE was also underestimated during 1991–1997 and overestimated thereafter.

One of the factors that can cause trends in index residuals is incorrect assumptions about the catchability. ASAP model assumed the indices were directly proportional to stock size and the catchability was constant over time. These assumptions may be reasonable because there were no significant changes to the design of the MRFSS/MRIP and FIM surveys over the model time period. There were also no large-scale changes to recreational fisheries regulations over this time; however, if the spatial distribution of a population expands or contracts into areas of varying catchability, temporal changes in catchability may result even if the survey design remains constant (Armstrong 2008). The effects of possible seasonal distributions of Sheepshead in Florida waters on the catch rates developed from various surveys should be explored in more depth.

Year-specific plots of ASAP model predicted proportions-at-age for each fleet and for the FIM haul seine surveys are not shown to preserve space; they are available upon request. However, the age composition residuals indicated good predictions of observed proportions-at-age in years when age data were available (Figures 16.6–16.10). In contrast, large residuals and obvious year class effects (overestimations of age-1 through age-3 individuals) were apparent in the residual patterning in years when there were no age data: the model suggested that the landings and discards mainly consisted of age-1 through age-3 Sheepshead, especially on the Atlantic coast. The Francis approach focuses on the model fits to the observed mean catch-at-age, which were again generally good in years with age data, especially for the haul seine surveys (Figures 16.11–16.15).

There were 129 estimated parameters for fishery selectivity (10), first year's *F*mult (2), deviations from first year's *F*mult (66), recruitment deviations (34), deviations from first year's abundance (10), index catchability (3), index selectivity (2), stock- recruitment scaler (1) and steepness (1). The age compositions contributed most in the total likelihoods on both coasts of Florida (Figure 16.16).

16.3.2.2 Selectivity

Prior to 1996, the selectivity patterns estimated by ASAP base model indicated that the commercial fleets mostly targeted age-1 through age-7 on the Atlantic coast and age-2 through age-10 on the Gulf coast. Since 1996, full selectivity of the commercial fleets appeared incomplete (was rather linear) on the Atlantic coast, but occurred from age-3 on the Gulf coast (Figure 16.17). The recreational selectivity on the Atlantic coast was gradual and became full for older fish before 1996, but shifted towards younger animals during the post-regulatory period (Figure 16.17). This result apparently was the consequence of the increased amounts of discards over time, making the bulk of the recreational total catch. On Florida's Gulf coast, the recreational fishery targeted Sheepshead at least 2 years old, and the selectivity did not change over time.

The FIM haul seine surveys mostly selected fish of age-3 through age-7 (Figure 16.18). This selectivity pattern was the consequence of the assumption made about the age ranges to be related to the populations.

16.3.2.3 Model Trajectories

16.3.2.3.1 Fishing Mortality Rates

The fishing mortality rates by fleet and year estimated by ASAP base model are in Table 16.1 and Figures 16.19 and 16.20. Commercial full *F* (*F*mult) varied without trend on the Atlantic coast at less than 0.1 year^{-1} and peaked at 0.1–0.14 year^{-1} in the early 1990s on the Gulf coast. Prior to 1992, full *F* averaged 0.05 year^{-1} on the Atlantic coast and 0.06 year^{-1} on the Gulf coast. Since 1996, average full *F* was 0.06 year^{-1} on the Atlantic coast and 0.04 year^{-1} on the Gulf coast.

During 1982–1995, recreational full *F* increased up to 0.4 year^{-1} on the Atlantic coast (average: 0.18 year^{-1}) and 0.48 year^{-1} on the Gulf coast (average: 0.24 year^{-1}). Since then, it averaged 0.19 year^{-1} and 0.29 year^{-1} annually, respectively.

Average fishing mortality rates for the most vulnerable age-groups (1–6) were of the same magnitude and varied similarly as the recreational full *F* (Table 16.1, Figure 16.20). They showed multiple peaks that culminated between 1990 and 1995. The average of the unweighted, number-weighted and biomass-weighted average *F* during 1996–2015 ranged between 0.12 and 0.19 year^{-1} annually on both coasts of Florida.

16.3.2.3.2 Population Sizes

The estimated population sizes of Sheepshead were lower on the Atlantic coast than on the Gulf coast (Table 16.2, Figure 16.21). The total abundance over 1982–2015 varied similarly on both coasts, without trend since 1996. The FIM haul seine index appears to have been the main driver of the total abundance on both coasts since the late 1990's; this index also contributed in calibrating the relative importance of the selected age groups.

On the Atlantic coast, the total abundance amounted to 11 million in 1982. It declined until 1996 and stabilized since then with an average of about 7 million individuals. The recruits (age-1 Sheepshead) on the Atlantic coast represented an average of 35% of the total abundance, declined slightly during 1982–2015, but showed no trend since 1998.

On the Gulf coast, the estimated total abundance of Sheepshead averaged about 18.6 million individuals during 1982–1995 and 14.8 million fish thereafter. The recruits represented an average of 40% of the total abundance; they declined during 1982–2015 including when the turning index was available.

The trends of Sheepshead total biomass, SSB and exploitable biomass on the Atlantic coast were similar to the trend of total abundance (Tables 16.3, Figures 16.22 and 16.23). From highs of 7,753, 3,854 and 5,143 MT in 1982, respectively, they declined to 3,987, 1,279 and 2,117 MT in 1996. Since then, they have averaged 4,364, 1,584 and 2,035 MT annually, respectively. Sheepshead total biomass, SSB and exploitable biomass on the Gulf coast (Table 16.3, Figures 16.22 and 16.23) were also highest prior to 1990 (averages: 8,675, 5,000, and 6,965 MT, respectively). They declined between 1990 and 1998 to 4,000, 2,000, and 2,500 MT and rebounded until the mid-2000's when they stabilized at around 5,800, 3,300 and 3,200 MT.

The estimated numbers at age were dominated by age-1 through age-5 Sheepshead on both coasts of Florida (Table 16.3, Figure 16.24). The SSB was mainly composed of age-3 and older fish, with the predominance of ages 4–6 (Figure 16.25). Note that the ASAP model predicted the possible presence of older individuals that may have largely contributed to the recruitment production during the 1980's–early 1990's, when there were no indices of abundance to guide the model. Such predictions were needed to support the higher rates of reported landings and estimated discards during that period.

16.3.2.4 Precision of Estimates and Model Uncertainty

ASAP runs report standard deviations for estimated parameters. However, like any other program developed under the ADMB platform, these estimates of variability are considered biased low when constraints are placed on the parameters.

MCMC results indicated that the fishing mortality rates were precise (i.e., similar and relatively narrow 95% credibility intervals, 95%CIs) throughout the time series (Figure 16.20). Regarding the estimated biomasses, they were quite imprecise (wide 95% CIs), and hence uncertain, during the 1980s–early 1990's when the ASAP base model was guided by fisheries removals only (Figures 16.22 and 16.23). Their precision improved in years when age and length data as well as turning indices were available.

16.3.2.5 Sensitivity Analyses

Inputs with underlying assumptions and with different values have can affect a model results, including reference points. The effects of inputs tested are as follows.

16.3.2.5.1 Sensitivity of ASAP Model to Dropping the MRFSS/MRIP CPUE

Compared with ASAP base model, the ASAP model run without the MRFSS/MRIP CPUE on the Atlantic coast produced slightly different estimates of fishing mortality rates (Figure 16.26). These rates were a bit lower in the early 1980's, higher during the late 1980's–early 1990's and again lower since 1996. On the Gulf coast, different types of fishing mortality generated without the MRFSS/MRIP CPUE were a little lower after 1996.

In response to those sequences of lower and higher rates of fishing mortalities estimated without the MRFSS/MRIP CPUE, the estimated stock sizes expectedly were slightly optimistic and pessimistic, respectively (Figure 16.27).

16.3.2.5.2 Sensitivity of ASAP Model to a Release Mortality of 0.055

ASAP was insensitive to whether the release mortality was 1% or 5.5% (Figures 16.26 and 16.27).

16.3.2.5.3 Sensitivity of ASAP Model to Pauly's Estimator of Natural Mortality

ASAP model was sensitive to *M*-at-age scaled using Pauly's nonlinear estimator of *M*. Different types of *F* estimated using *M*-at-age scaled by employing Pauly's *M* estimator were 1.2–1.45 times higher on the Atlantic coast and 1.26–1.73 times higher on the Gulf coast than those *F* values estimated with ASAP base model (Figures 16.26). Conversely, *M*-at-age based on Pauly's nonlinear estimator of *M* led to stock sizes that were 16–36% lower on the Atlantic coast and 19–58% lower on the Gulf coast than those estimated with ASAP base model (Figures 16.27).

These results are coherent in that ASAP base model employed *M*-at-age scaled using Hoenig's nonlinear estimator of *M*, which resulted in larger *M*-at-age values than Pauly's updated nonlinear estimator of *M*. Yet higher *M* values in an assessment model inflate the stock sizes, especially the recruitment, and lower F estimates needed to support the reported/estimated fisheries catches.

16.3.2.6 Retrospective Analyses

Retrospective patterns were examined for the biomass-weighted mean fishing mortality (F), January-1 abundance (N), recruitment (age-1 fish, R) and SSB, (Figures 16.28 and 16.29). There was little evidence of patterns in those estimates. On the Atlantic coast, the Mohn's rho statistics were close to zero for F, N, R and SSB (−0.019, 0.011, −0.017 and −0.075). These statistics on the Gulf coast were 0.047, 0.057, −0.114 and −0.278, respectively: the estimated N and R were slightly increasing with time.

Retrospective analyses of ASAP sensitivity models produced similar results (plots not shown to preserve space), but the dropping of the MRFSS/MRIP CPUE increased the Mohn's rho statistics to absolute values of 0.2–0.35, especially on the Atlantic coast.

16.3.2.7 Projection of Estimates

No projections were made.

16.4 Stock-Recruitment Analysis

The annual values of the Beverton–Holt stock–recruitment steepness from the ASAP base model were 0.69–0.71 on the Atlantic coast and 0.74–0.76 on the Gulf coast. Atlantic Sheepshead recruitment estimates ranged from 0.855 to 4.27 million fish from a SSB of 1,183 to 4,032 M (Figure 16.30). Estimated Gulf recruitment ranged from 2.75 to 12.03 million fish from 1,827 to 5,509 MT of SSB.

16.5 Yield and SSB per-Recruit Analyses

ASAP calculated the equilibrium yield per-recruit (YPR) and SSB per-recruit (SBR) on the basis of: (1) the 2015 selectivity pattern accounting for both the recreational and commercial fleets; and (2) a selectivity pattern averaged across 2013–2015 during MCMC runs. Moreover, the static spawning potential ratios (sSPR) and the transitional spawning potential ratios (tSPR) were developed using age-specific M and total fishing mortality by year (see Section 7.2 about the use of sSPR and tSPR). ASAP's MCMC results were also examined under (pure) hypotheses of 30%SPR and 40%SPR as well the related F and SSB levels as management targets.

The equilibrium YPR and SBR analyses (Figure 16.31) produced F_{max} = 1.31 year^{-1} (SPR = 0.04), $F_{0.1}$ = 0.18 year^{-1} (SPR = 0.43) $F_{30\%}$ = 0.29 year^{-1} and $F_{40\%}$ = 0.19 year^{-1} on the Atlantic coast; F_{max} = 2.17 year^{-1} (SPR = 0.011), $F_{0.1}$ = 0.43 year^{-1} (SPR = 0.28), $F_{30\%}$ = 0.39 year^{-1} and $F_{40\%}$ = 0.26 year^{-1} on the Gulf coast. Current F of 0.18 year^{-1} on the Atlantic coast (SPR = 0.54) and of 0.15 year^{-1} on the Gulf coast (SPR = 0.65) were lower than those F_{BRP}s based on per-recruit analyses.

The tSPR and sSPR of Sheepshead have trended up on both coasts of Florida since 1996 (Table 16.5, Figure 16.32). The sSPR was less than 30%SPR during 1987–2007 (suggesting high fishing mortality rates) and the tSPR was less than 30%SPR during the 1990's–early 2000's (suggesting overfished conditions in terms of the distorsion of the age structure). Since 2000, the overall increase of the sSPR and tSPR suggests relaxation of the fishing pressure on and expansion of the age structure of Sheepshead in Florida.

The phase plots of current F (geometric mean of F_{2013}, F_{2014} and F_{2015}) relative to $F_{30\%}$ and $F_{40\%}$ against current SSB (geometric mean of SSB_{2013}, SSB_{2014} and SSB_{2015}) relative to the $SSB_{atF30\%}$ and the $SSB_{atF40\%}$ indicate that all F-ratios were less than one and all SSB-ratios were >1 if $F_{30\%}$ and the corresponding SSB were management target reference points (Figure 16.33). An hypothesis of $F_{40\%}$ and the SSB at $F_{40\%}$ as target reference points would result in some risks of current overfishing and overfihed conditions on the Atlantic coast: 25.5% of F-ratios were > 1 and 65% of SSB-ratios were < 1. On the Gulf coast, all F-ratios were < 1 and only 0.6% of SBB-ratios were < 1.

16.6 ASAP Model Tables

Table16.1 – Fishing mortality rates estimated by the ASAP base model

	Atlantic Coast					Gulf Coast				
	Commercial Fleet Full F	Recerational Fleet Full F	Unweighted F	N-weighted Average F (2-7)	B-Weighted Average F (2-7)	Commercial Fleet Full F	Recerational Fleet Full F	Unweighted F	N-weighted Average F (2-7)	B-Weighted Average F (2-7)
1982	0.05	0.15	0.15	0.14	0.15	0.02	0.11	0.10	0.05	0.07
1983	0.03	0.06	0.07	0.07	0.07	0.02	0.16	0.13	0.10	0.11
1984	0.03	0.17	0.16	0.15	0.16	0.03	0.21	0.15	0.10	0.13
1985	0.04	0.08	0.09	0.08	0.09	0.02	0.14	0.13	0.11	0.13
1986	0.04	0.12	0.13	0.12	0.12	0.03	0.07	0.08	0.05	0.07
1987	0.04	0.19	0.19	0.18	0.19	0.03	0.08	0.09	0.07	0.08
1988	0.05	0.14	0.14	0.13	0.14	0.04	0.25	0.23	0.19	0.23
1989	0.05	0.10	0.10	0.08	0.09	0.03	0.29	0.28	0.25	0.28
1990	0.06	0.12	0.14	0.13	0.14	0.06	0.18	0.18	0.14	0.17
1991	0.06	0.21	0.21	0.18	0.20	0.09	0.22	0.22	0.15	0.20
1992	0.08	0.22	0.23	0.19	0.21	0.11	0.48	0.44	0.28	0.35
1993	0.06	0.26	0.24	0.22	0.23	0.10	0.43	0.42	0.29	0.34
1994	0.07	0.40	0.35	0.31	0.33	0.14	0.30	0.31	0.21	0.25
1995	0.06	0.36	0.30	0.23	0.26	0.09	0.44	0.39	0.27	0.35
1996	0.06	0.26	0.23	0.16	0.18	0.04	0.32	0.25	0.16	0.22
1997	0.06	0.20	0.18	0.13	0.15	0.05	0.32	0.23	0.16	0.22
1998	0.06	0.20	0.15	0.10	0.12	0.05	0.41	0.32	0.17	0.27
1999	0.06	0.26	0.22	0.15	0.18	0.04	0.38	0.29	0.16	0.22
2000	0.08	0.26	0.24	0.18	0.21	0.04	0.32	0.25	0.14	0.19
2001	0.04	0.28	0.21	0.14	0.17	0.03	0.26	0.17	0.11	0.14
2002	0.06	0.19	0.17	0.10	0.13	0.03	0.25	0.17	0.10	0.14
2003	0.05	0.20	0.17	0.11	0.13	0.04	0.30	0.20	0.12	0.17
2004	0.04	0.14	0.11	0.08	0.09	0.03	0.27	0.17	0.12	0.16
2005	0.05	0.29	0.25	0.24	0.27	0.03	0.39	0.21	0.15	0.21
2006	0.06	0.19	0.18	0.11	0.15	0.02	0.23	0.19	0.11	0.17
2007	0.07	0.20	0.16	0.10	0.13	0.02	0.21	0.16	0.09	0.14
2008	0.07	0.20	0.16	0.09	0.12	0.02	0.20	0.14	0.08	0.12
2009	0.07	0.19	0.16	0.10	0.12	0.02	0.21	0.15	0.09	0.12
2010	0.05	0.24	0.19	0.14	0.16	0.05	0.23	0.13	0.07	0.10
2011	0.04	0.22	0.16	0.09	0.12	0.04	0.28	0.14	0.09	0.12
2012	0.06	0.22	0.16	0.08	0.11	0.03	0.24	0.13	0.08	0.11
2013	0.08	0.21	0.14	0.09	0.11	0.05	0.25	0.12	0.08	0.11
2014	0.07	0.47	0.30	0.21	0.25	0.05	0.41	0.22	0.15	0.21
2015	0.06	0.37	0.25	0.16	0.20	0.06	0.27	0.17	0.12	0.16
Mean_8295	0.05	0.18	0.18	0.16	0.17	0.06	0.24	0.22	0.16	0.20
Mean_9615	0.06	0.24	0.19	0.13	0.16	0.04	0.29	0.19	0.12	0.17

Table 16.2 – Coast-specific abundance, recruits and biomass types estimated by the ASAP base model for Sheepshead, 1982-2015.

	Atlantic Coast Total Jan1 abundance (Tousands fish)	Total recruits (Tousands age-1 fish)	TotJan1B (MT)	SSB (MT)	ExploitableB Biomass (MT)	**Gulf Coast** Total Jan1 abundance (Tousands fish)	Total recruits (Tousands age-1 fish)	TotJan1B (MT)	SSB (MT)	ExploitableB Biomass (MT)
1982	10,801	2,968	7,753	3,854	5,143	23,136	7,655	8,664	4,280	6,112
1983	9,875	2,981	7,060	3,588	5,506	21,942	6,916	9,070	4,323	7,326
1984	9,715	3,392	6,942	3,482	5,382	20,208	11,558	8,889	5,159	6,038
1985	9,518	3,259	6,467	3,163	4,280	23,808	6,897	8,974	5,395	8,260
1986	9,640	3,105	6,474	3,018	4,940	21,164	6,059	8,887	5,282	6,861
1987	9,349	3,041	6,255	2,785	4,738	19,307	4,445	8,962	5,414	6,854
1988	8,770	3,214	5,759	2,535	4,161	16,507	7,069	8,593	5,509	7,441
1989	8,857	3,412	5,676	2,456	3,193	16,423	5,321	7,361	4,707	6,823
1990	9,373	4,209	5,914	2,454	3,984	14,306	12,026	6,170	3,794	5,693
1991	10,201	2,381	6,140	2,360	3,768	20,428	9,278	6,441	3,254	4,668
1992	8,632	2,751	5,578	2,172	3,451	21,064	4,576	6,741	2,796	4,152
1993	7,963	3,290	5,105	2,011	3,461	15,554	6,008	5,806	2,279	4,221
1994	8,000	3,459	4,830	1,811	3,303	14,100	4,794	5,087	2,277	3,040
1995	7,901	2,037	4,438	1,456	2,734	12,703	4,420	5,060	2,459	3,554
1996	6,662	3,033	3,987	1,279	2,117	11,275	5,963	4,156	2,082	2,764
1997	7,256	2,604	4,169	1,326	2,083	12,558	7,279	4,076	1,998	2,580
1998	7,368	2,529	4,268	1,456	1,921	14,628	7,063	4,182	1,967	2,551
1999	7,442	2,729	4,476	1,517	2,339	15,545	7,572	4,750	1,827	3,167
2000	7,538	3,712	4,455	1,523	2,367	16,616	8,492	4,927	1,958	3,423
2001	8,514	2,672	4,623	1,447	2,008	18,242	6,780	5,886	2,432	3,553
2002	8,220	1,486	4,851	1,544	2,319	17,719	4,347	6,244	2,781	3,458
2003	6,947	806	4,769	1,680	2,524	15,036	5,196	6,096	3,055	3,294
2004	5,402	2,941	4,061	1,885	2,197	14,195	6,407	6,008	3,385	3,555
2005	6,633	2,145	4,248	1,952	2,803	14,981	5,877	5,883	3,380	3,404
2006	6,294	2,162	3,899	1,655	2,104	14,695	4,463	5,635	3,077	4,515
2007	6,322	2,715	3,845	1,438	1,678	13,291	7,563	5,339	2,902	3,903
2008	6,931	1,811	4,055	1,457	1,653	15,691	7,416	5,512	3,041	3,422
2009	6,448	3,791	4,118	1,555	1,905	17,007	4,832	5,848	3,145	4,110
2010	8,072	2,848	4,614	1,569	2,026	15,153	4,685	6,147	3,234	2,471
2011	8,145	1,462	4,760	1,591	2,035	14,070	6,577	6,512	3,616	2,613
2012	6,930	2,500	4,591	1,623	1,786	15,236	5,838	5,828	3,516	3,031
2013	7,170	2,934	4,557	1,802	1,439	15,208	2,745	6,317	3,628	2,335
2014	7,770	1,970	4,754	1,797	1,792	12,097	5,238	5,622	3,264	2,898
2015	6,781	-	4,179	1,591	1,611	12,355	-	5,258	3,078	2,634
Mean_8295	9,186	3,190	6,028	2,653	4,146	18,618	7,123	7,479	4,066	5,789
Mean_9615	7,142	2,444	4,364	1,584	2,035	14,780	5,938	5,511	2,868	3,184

Table 16.3 – Abundance at age (thousands) of Sheepshead estimated by the ASAP base model on the Atlantic coast, 1982–2015.

	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10	Age-11+
1982	3,000	2,335	1,499	1,055	819	539	406	416	379	181	172
1983	2,968	1,843	1,494	967	683	532	351	266	276	256	240
1984	2,981	1,900	1,238	1,030	678	485	381	254	195	204	370
1985	3,392	1,809	1,192	787	660	436	314	248	167	129	384
1986	3,259	2,162	1,207	810	541	458	305	221	177	121	376
1987	3,105	2,019	1,393	791	537	362	308	207	152	124	351
1988	3,041	1,846	1,236	861	491	334	226	194	132	98	310
1989	3,214	1,896	1,192	803	561	321	220	150	130	90	281
1990	3,412	2,086	1,289	818	552	385	220	150	104	93	265
1991	4,209	2,101	1,334	835	534	363	255	147	102	71	250
1992	2,381	2,555	1,303	820	511	325	221	155	91	65	206
1993	2,751	1,414	1,559	790	494	306	194	132	94	57	171
1994	3,290	1,606	848	931	468	290	179	113	78	57	139
1995	3,459	1,887	919	462	492	241	148	91	58	41	104
1996	2,037	2,050	1,145	534	260	269	129	78	48	32	80
1997	3,033	1,339	1,338	702	320	154	157	74	45	29	65
1998	2,604	2,029	899	867	449	197	93	95	45	31	57
1999	2,529	1,748	1,404	594	557	285	128	56	58	28	54
2000	2,729	1,697	1,193	906	331	333	162	73	32	33	47
2001	3,712	1,828	1,158	731	506	191	191	92	42	18	46
2002	2,672	2,486	1,241	746	443	296	112	109	53	26	37
2003	1,486	1,790	1,706	829	469	274	181	69	72	32	39
2004	806	1,000	1,242	1,143	513	288	168	111	43	44	44
2005	2,941	543	699	852	797	338	194	110	73	28	58
2006	2,145	1,971	378	424	481	446	188	109	62	41	49
2007	2,162	1,442	1,366	242	269	294	272	115	67	38	55
2008	2,715	1,449	995	934	157	167	178	165	72	41	60
2009	1,811	1,819	1,008	684	607	102	99	106	102	43	66
2010	3,791	1,217	1,246	676	442	381	62	61	66	63	67
2011	2,848	2,548	831	821	408	276	225	36	36	39	77
2012	1,462	1,917	1,784	577	517	255	166	136	22	22	71
2013	2,500	983	1,345	1,243	388	309	152	99	82	13	56
2014	2,934	1,679	686	948	847	238	195	92	61	49	41
2015	1,970	1,939	1,097	427	576	452	117	90	43	28	42

Table 16.3 (Cont.) – Abundance at age (thousands) of Sheepshead estimated by the ASAP base model on the Gulf coast, 1982–2015.

	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9	Age-10	Age-11+
1982	6,653	11,177	1,724	930	623	382	456	161	646	133	252
1983	7,655	3,877	6,982	1,101	598	398	246	296	106	425	258
1984	6,916	4,452	2,382	4,323	682	367	245	153	186	67	437
1985	11,558	4,021	2,789	1,500	2,674	402	213	144	90	111	307
1986	6,897	6,711	2,452	1,707	927	1,661	252	135	92	58	273
1987	6,059	4,036	4,236	1,594	1,122	609	1,098	168	91	62	230
1988	4,445	3,531	2,537	2,733	1,038	728	397	724	112	61	201
1989	7,069	2,529	2,048	1,440	1,529	569	399	220	405	63	151
1990	5,321	3,954	1,387	1,087	766	810	304	215	120	221	120
1991	12,026	3,058	2,371	829	643	445	470	178	127	71	209
1992	9,278	6,873	1,827	1,418	487	355	239	255	98	70	164
1993	4,576	5,069	3,625	908	672	209	145	99	106	41	105
1994	6,008	2,542	2,711	1,819	423	285	90	63	43	47	69
1995	4,794	3,433	1,500	1,509	967	209	135	43	30	21	61
1996	4,420	2,738	1,971	775	725	427	90	59	19	13	39
1997	5,963	2,601	1,692	1,175	409	379	222	47	34	10	27
1998	7,279	3,515	1,615	986	629	226	192	124	24	17	20
1999	7,063	4,294	2,211	930	438	328	104	89	58	11	18
2000	7,572	4,155	2,645	1,247	471	227	159	51	44	29	14
2001	8,492	4,455	2,542	1,526	722	236	116	82	26	23	23
2002	6,780	5,019	2,783	1,545	870	428	145	64	46	15	26
2003	4,347	4,011	3,172	1,659	927	496	257	81	36	26	23
2004	5,196	2,572	2,531	1,892	955	552	275	135	43	19	26
2005	6,407	3,073	1,643	1,590	1,150	509	316	165	74	24	30
2006	5,877	3,783	1,957	989	897	579	284	181	81	37	31
2007	4,463	3,479	2,414	1,194	543	513	330	163	105	47	40
2008	7,563	2,641	2,240	1,530	702	311	298	194	97	62	52
2009	7,416	4,476	1,703	1,437	941	422	183	180	120	58	71
2010	4,832	4,391	2,786	1,071	894	562	255	107	107	71	77
2011	4,685	2,861	2,825	1,795	632	580	333	152	61	61	85
2012	6,577	2,774	1,848	1,839	1,063	381	367	186	82	38	80
2013	5,838	3,893	1,774	1,198	1,201	644	212	225	106	47	68
2014	2,745	3,456	2,494	1,099	788	761	361	134	131	64	65
2015	5,238	1,624	2,215	1,457	568	465	406	194	63	62	61

Table 16.5 – Estimated static and transitional spawning potential ratios (sSPR and tSPR) for Sheepshead on the **Atlantic** and **Gulf** coasts of Florida during 1982–2015.

	Atlantic		Gulf	
	sSPR	tSPR	sSPR	tSPR
1982	0.24	0.28	0.35	0.44
1983	0.44	0.29	0.28	0.43
1984	0.22	0.31	0.28	0.40
1985	0.39	0.31	0.29	0.38
1986	0.30	0.33	0.43	0.39
1987	0.19	0.33	0.42	0.42
1988	0.28	0.31	0.19	0.42
1989	0.40	0.31	0.15	0.36
1990	0.29	0.33	0.26	0.31
1991	0.20	0.33	0.24	0.29
1992	0.18	0.30	0.10	0.26
1993	0.16	0.28	0.10	0.20
1994	0.10	0.24	0.16	0.17
1995	0.13	0.19	0.12	0.16
1996	0.20	0.17	0.21	0.16
1997	0.27	0.18	0.21	0.19
1998	0.30	0.20	0.17	0.21
1999	0.22	0.24	0.17	0.21
2000	0.20	0.24	0.19	0.22
2001	0.23	0.25	0.25	0.24
2002	0.28	0.26	0.26	0.27
2003	0.28	0.28	0.24	0.29
2004	0.39	0.31	0.28	0.30
2005	0.20	0.33	0.23	0.31
2006	0.28	0.30	0.24	0.30
2007	0.31	0.31	0.29	0.31
2008	0.32	0.32	0.32	0.33
2009	0.30	0.34	0.29	0.35
2010	0.26	0.34	0.33	0.37
2011	0.31	0.33	0.32	0.38
2012	0.32	0.34	0.35	0.39
2013	0.35	0.35	0.35	0.41
2014	0.19	0.35	0.23	0.41
2015	0.22	0.30	0.31	0.37

16.7 Catch Curve Analysis and ASAP Model Figures

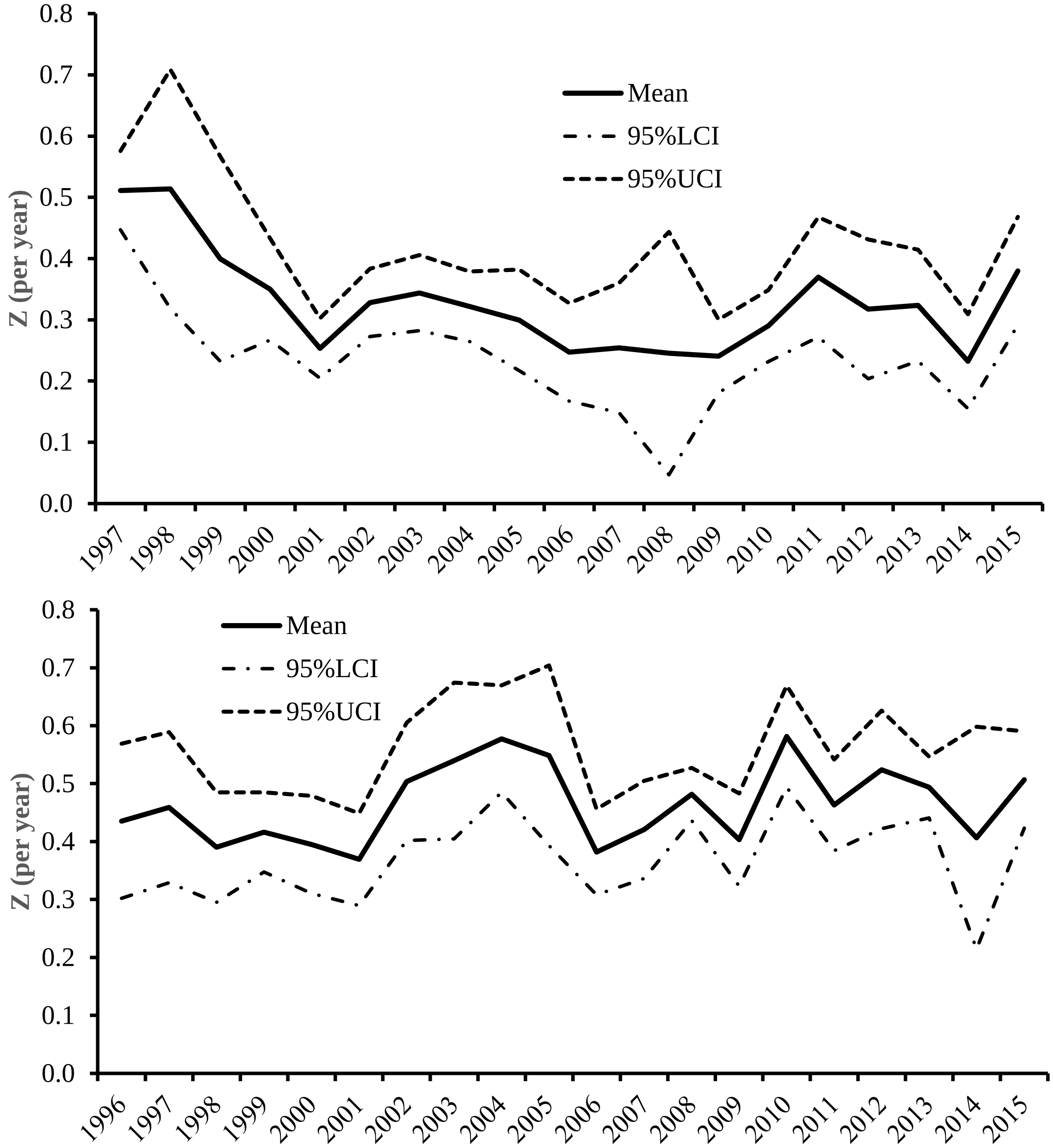


Figure 16.1 Estimates of the mean, 95% lower confidence interval (95%LCI) and 95% upper confidence interval (95%UCI) of the instantaneous rates of total mortality (*Z*) for Sheepshead using the estimated numbers at age sampled by the FIM haul seine surveys on the Atlantic (top) and Gulf (bottom) coasts of Florida.

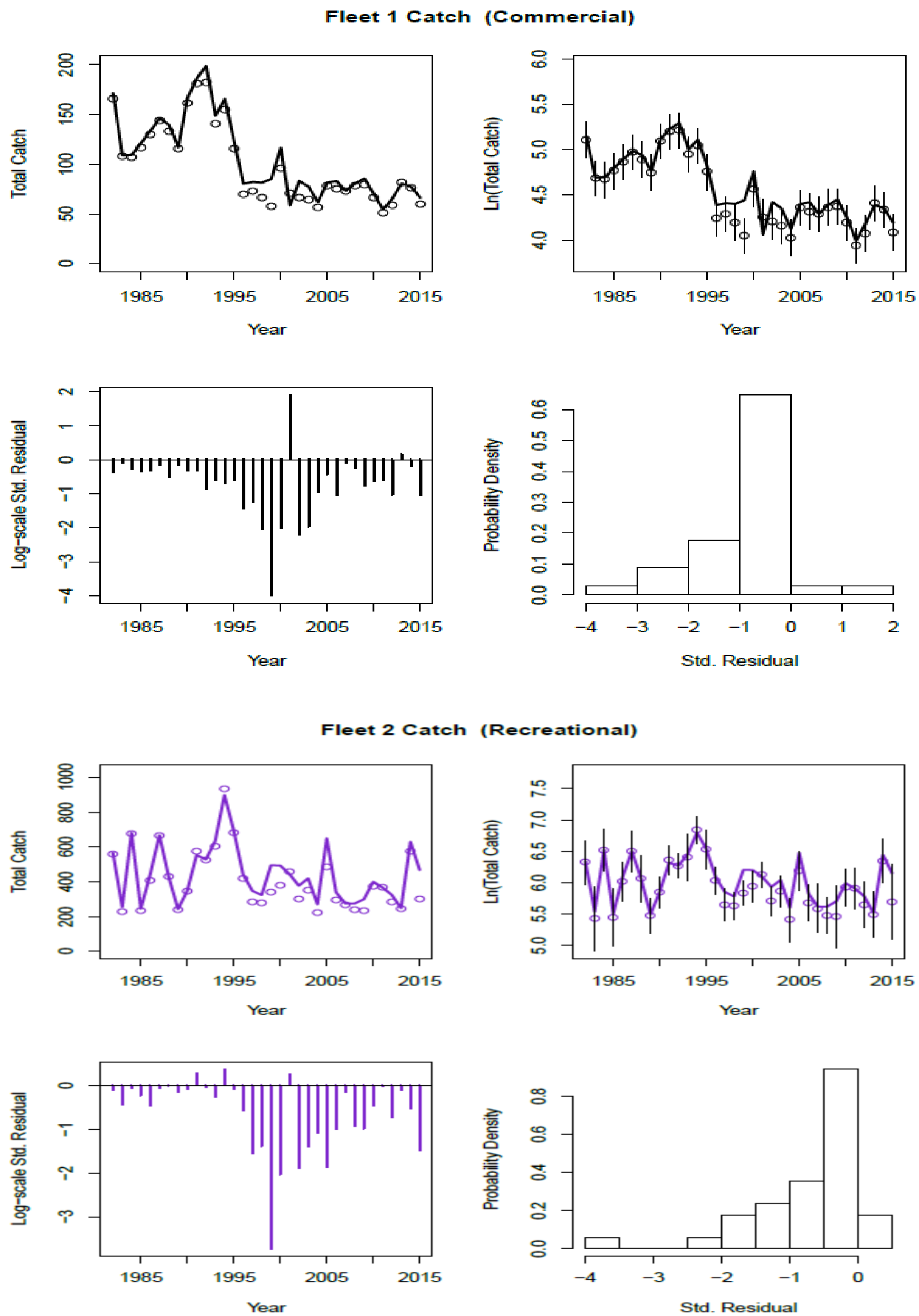


Figure 16.2. – ASAP base model fit to commercial (top) and recreational (bottom) total catch (MT) of Sheepshead on Florida's Atlantic coast, 1982–2015.

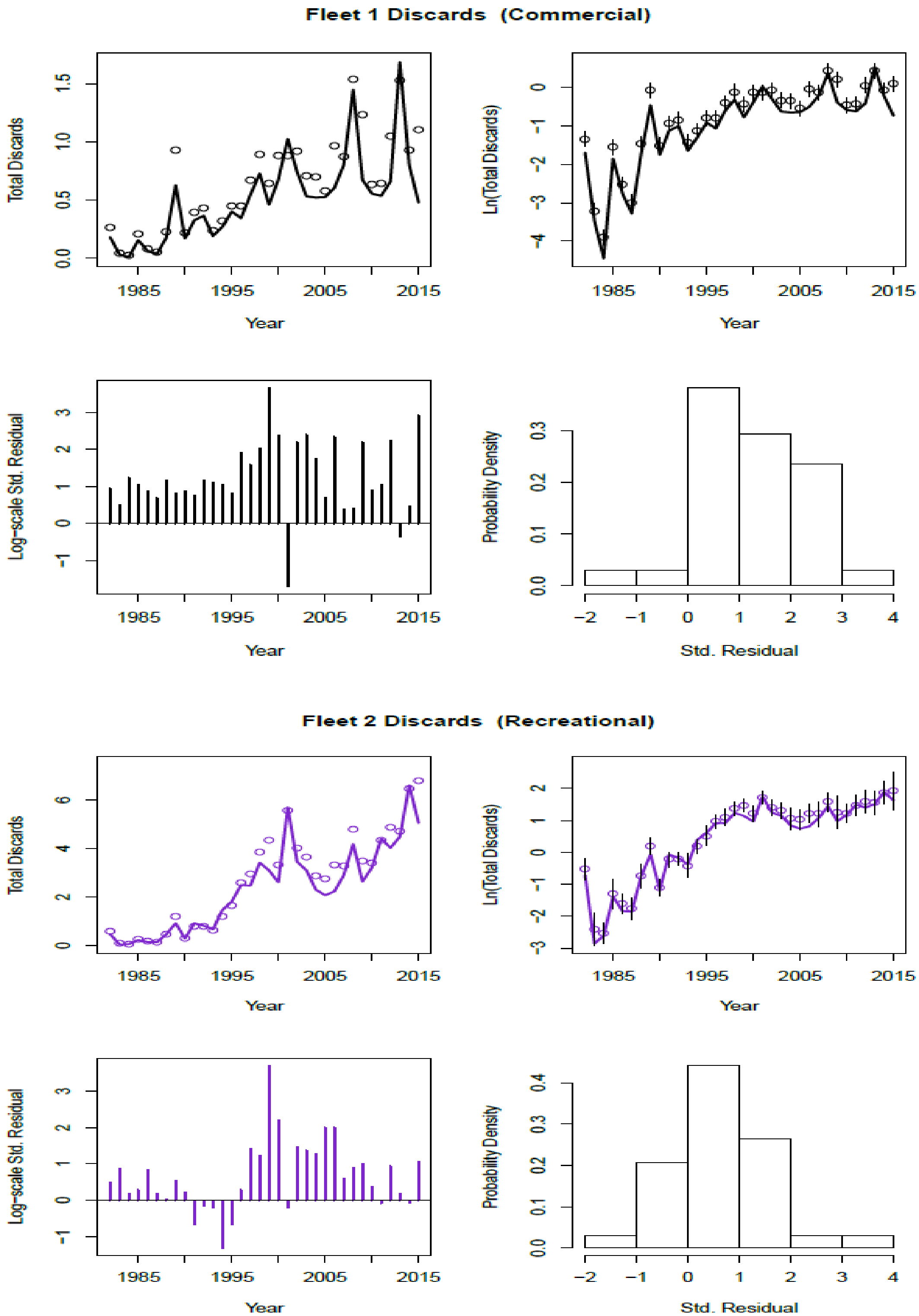


Figure 16.2 (Cont.) –ASAP base model fit to commercial (top) and recreational (bottom) discards (MT) of Sheepshead on Florida's Atlantic coast, 1982–2015.

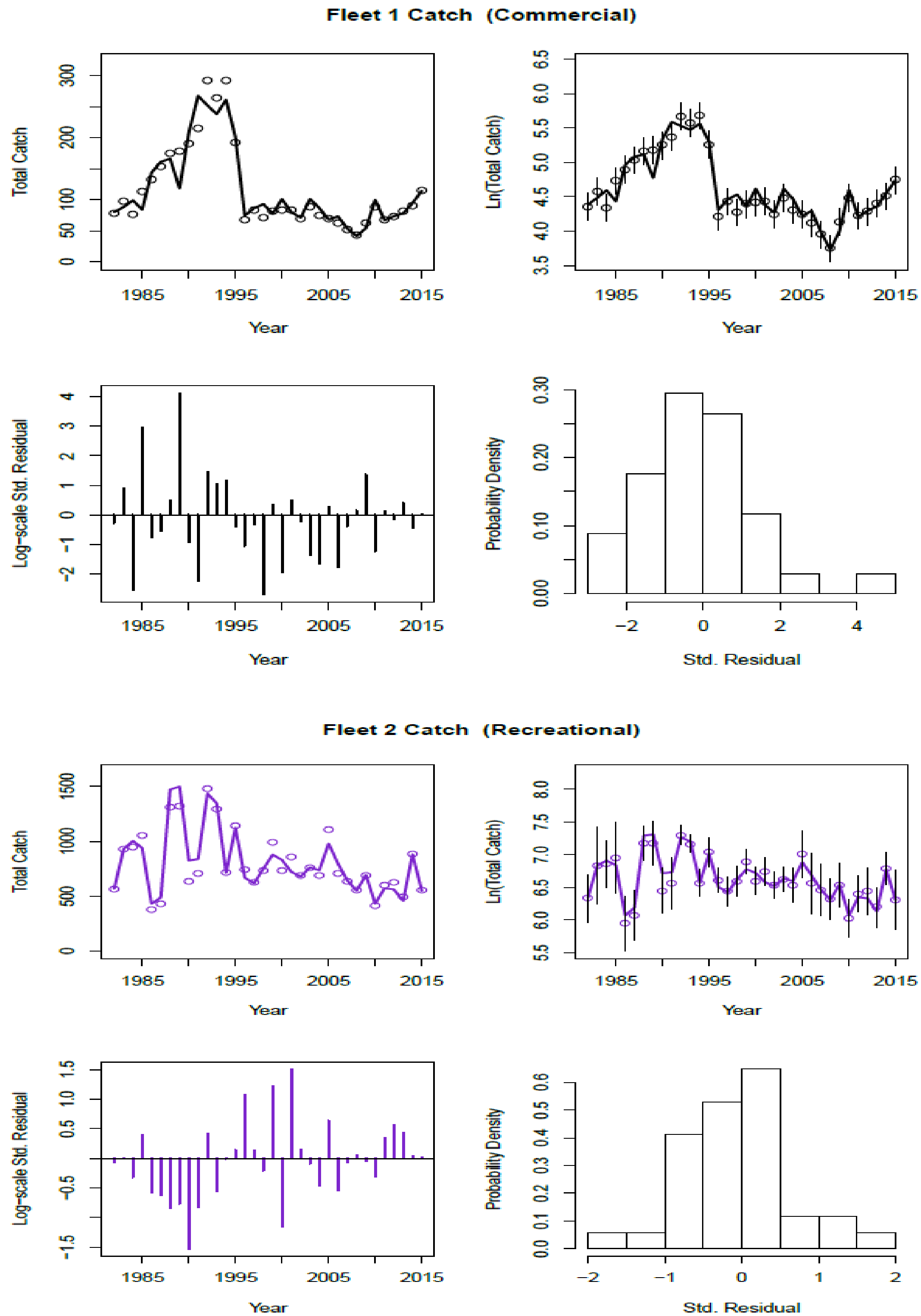


Figure 16.3 – ASAP base model fit to commercial (top) and recreational (bottom) total catch (MT) of Sheepshead on Florida's Gulf coast, 1982–2015.

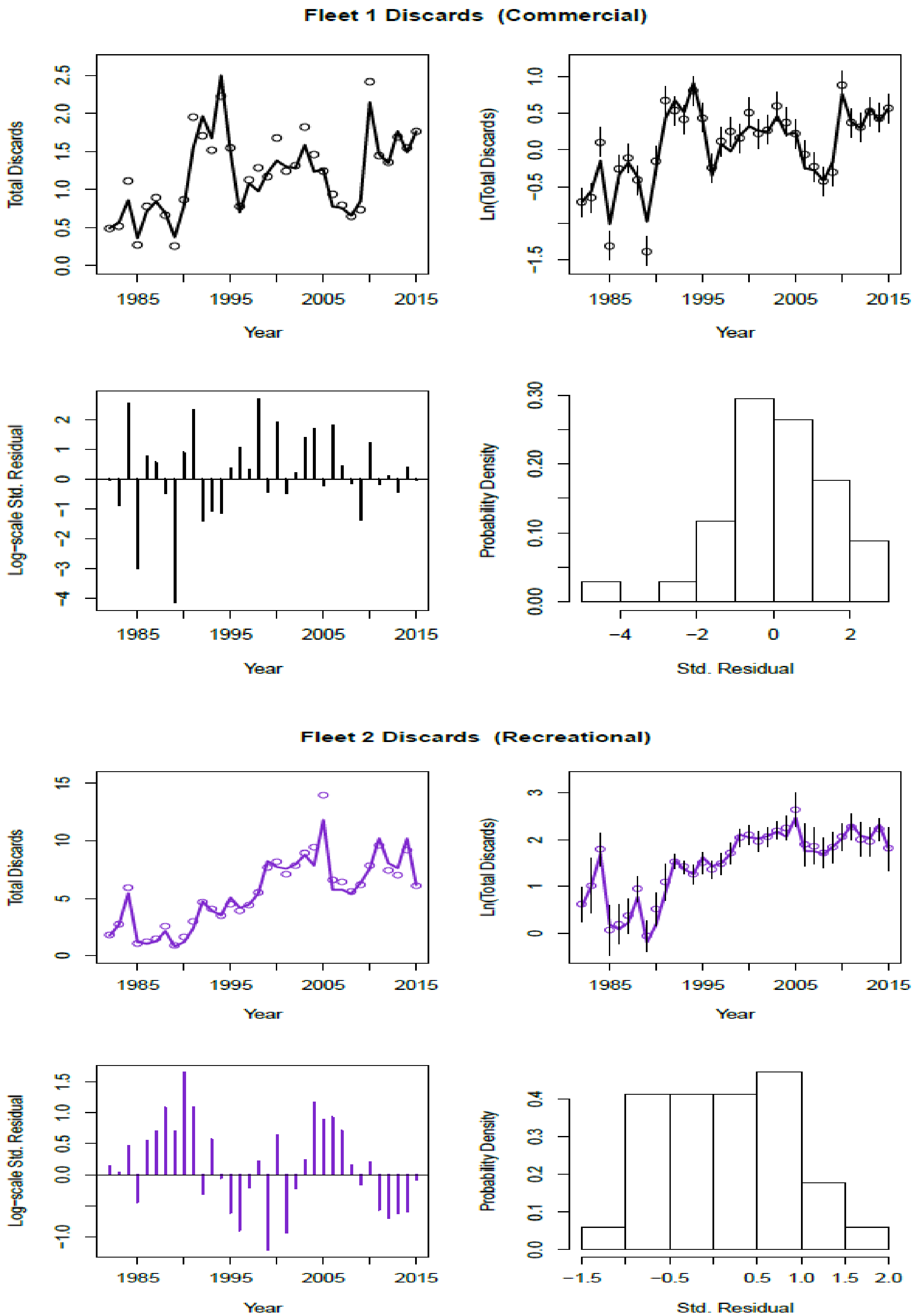


Figure 16.3 (Cont.)–ASAP base model fit to commercial (top) and recreational (bottom) discards (MT) of Sheepshead on Florida's Gulf coast, 1982–2015.

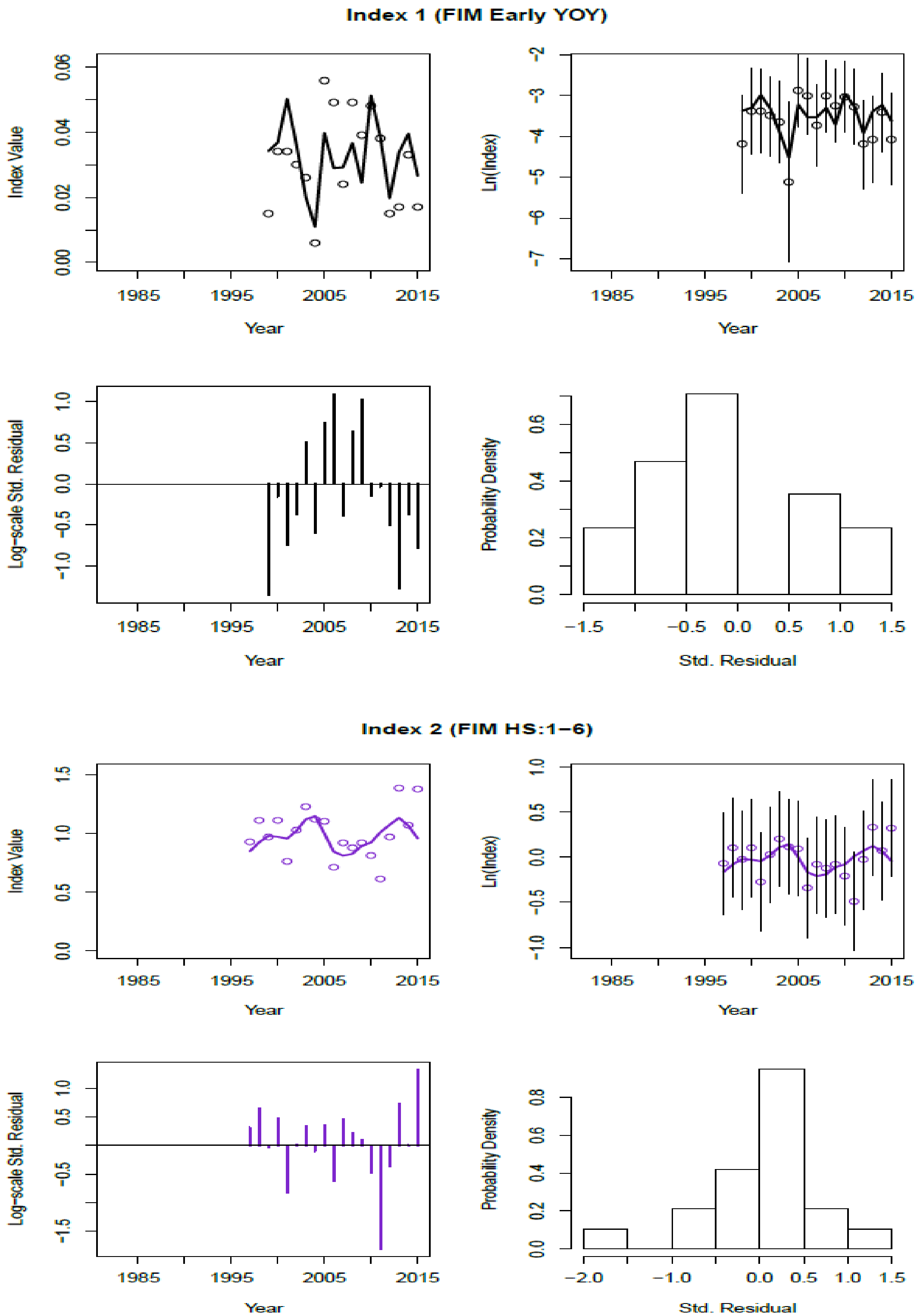


Figure 16.4–ASAP base model fit to FIM YOY (top) and FIM haul seine (bottom) indices of abundance for Sheepshead on Florida's Atlantic coast.

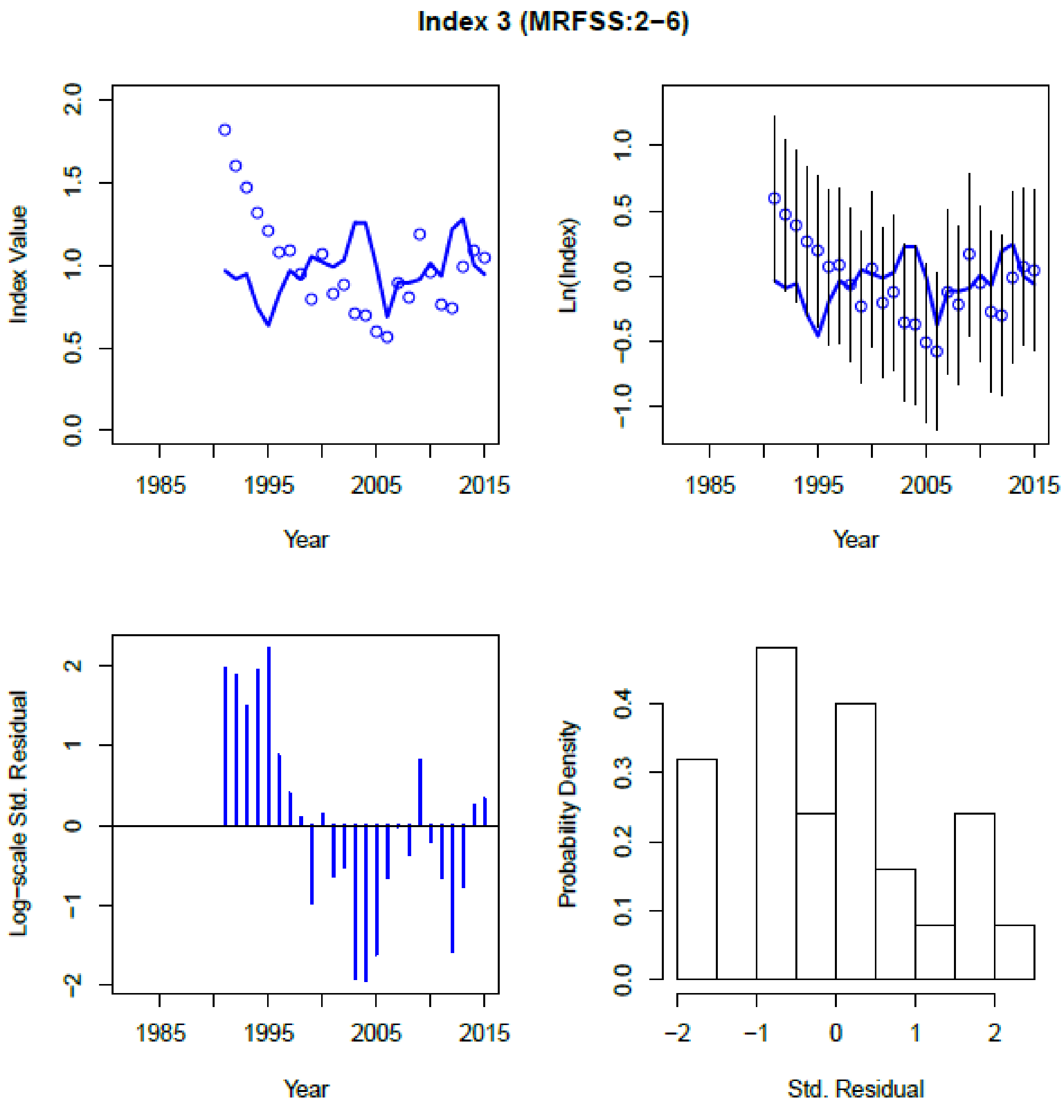


Figure 16.4 (Cont.)–ASAP base model fit to MRFSS/MRIP CPUE of Sheepshead on Florida's Atlantic coast.

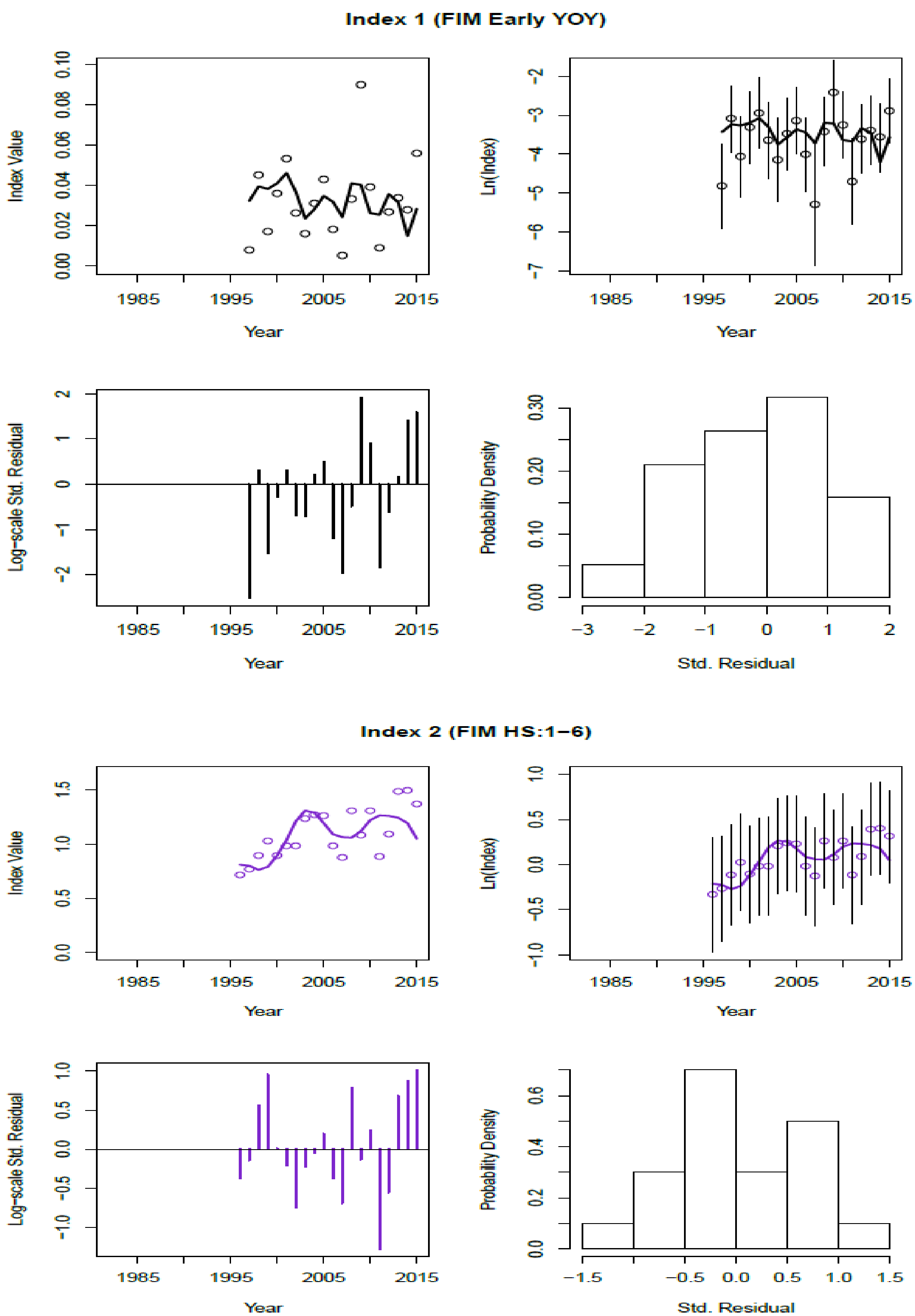


Figure 16.5–ASAP base model fit to FIM YOY (top) and FIM haul seine (bottom) indices of abundance for Sheepshead on Florida's Gulf coast.

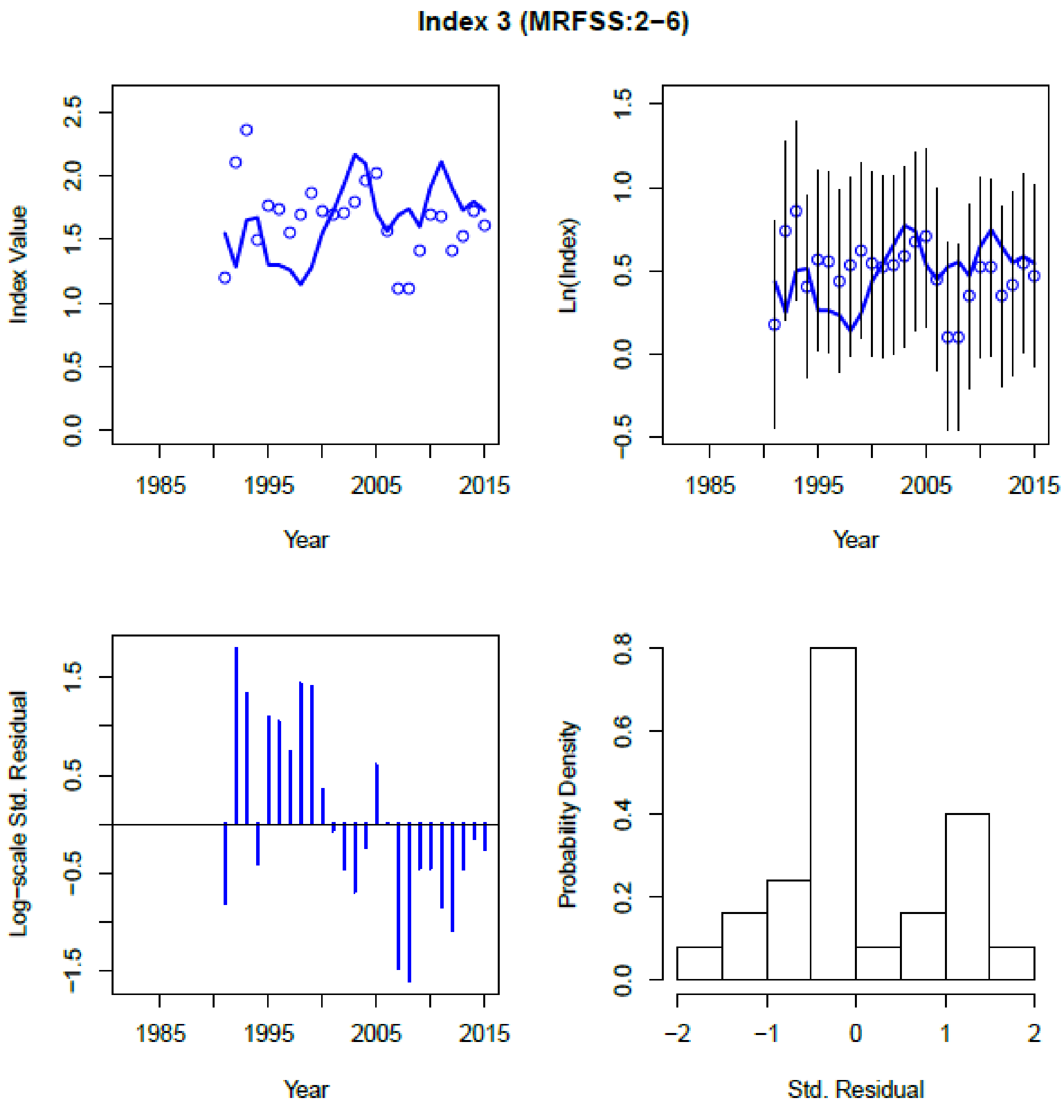
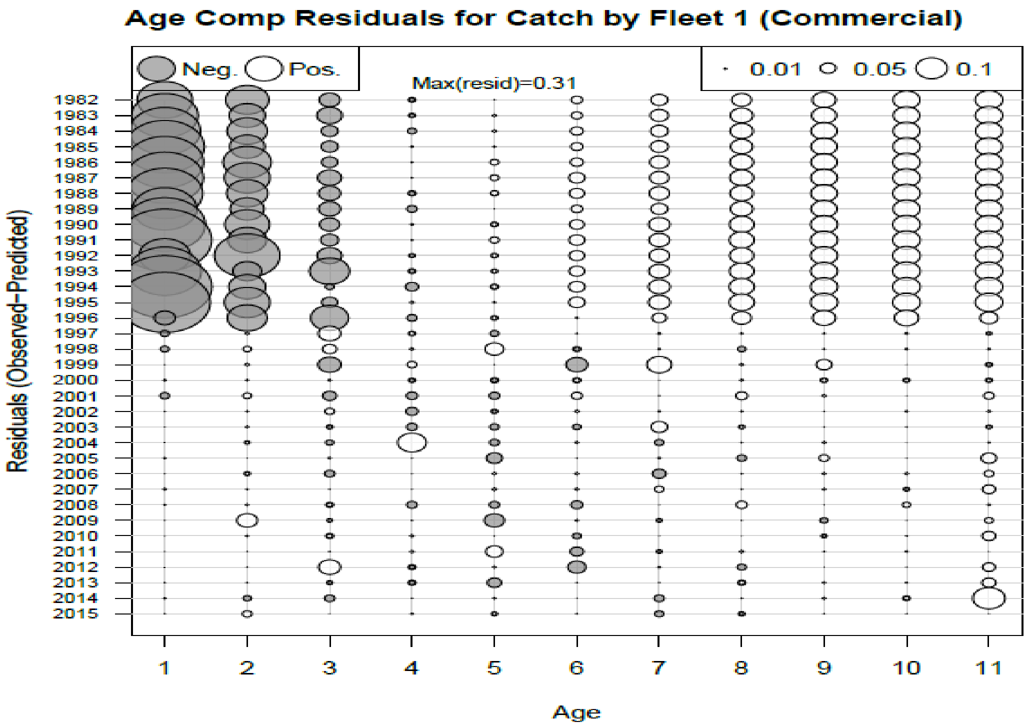


Figure 16.5 (Cont.)–ASAP base model fit to MRFSS/MRIP CPUE of Sheepshead on Florida's Gulf coast.



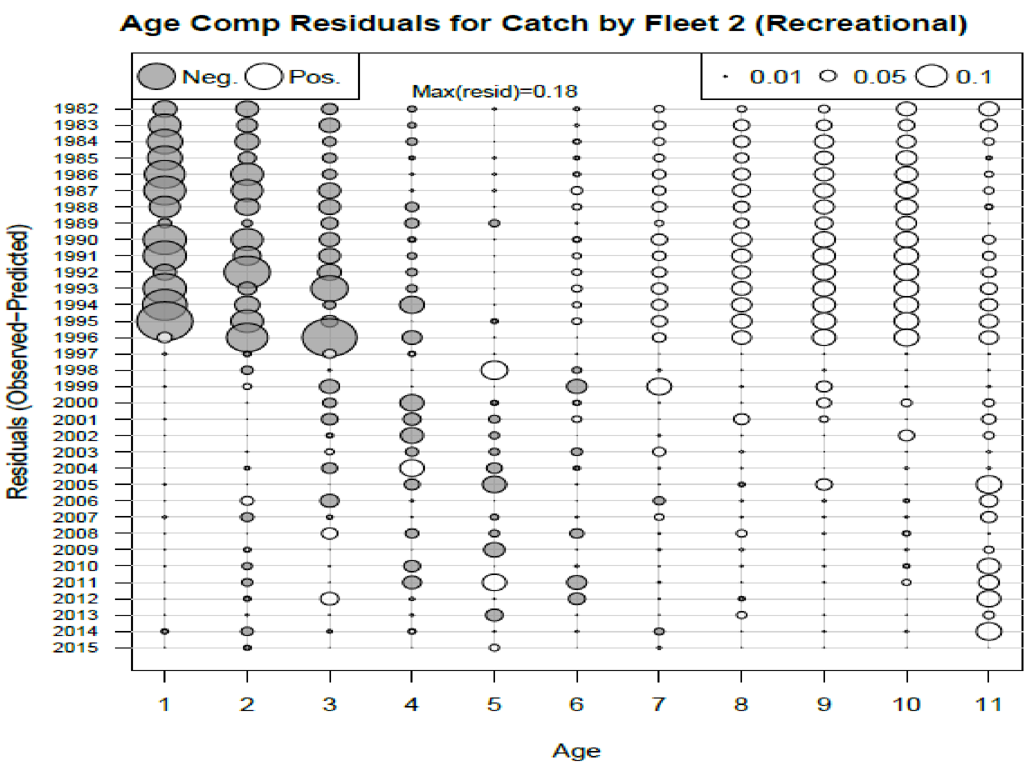
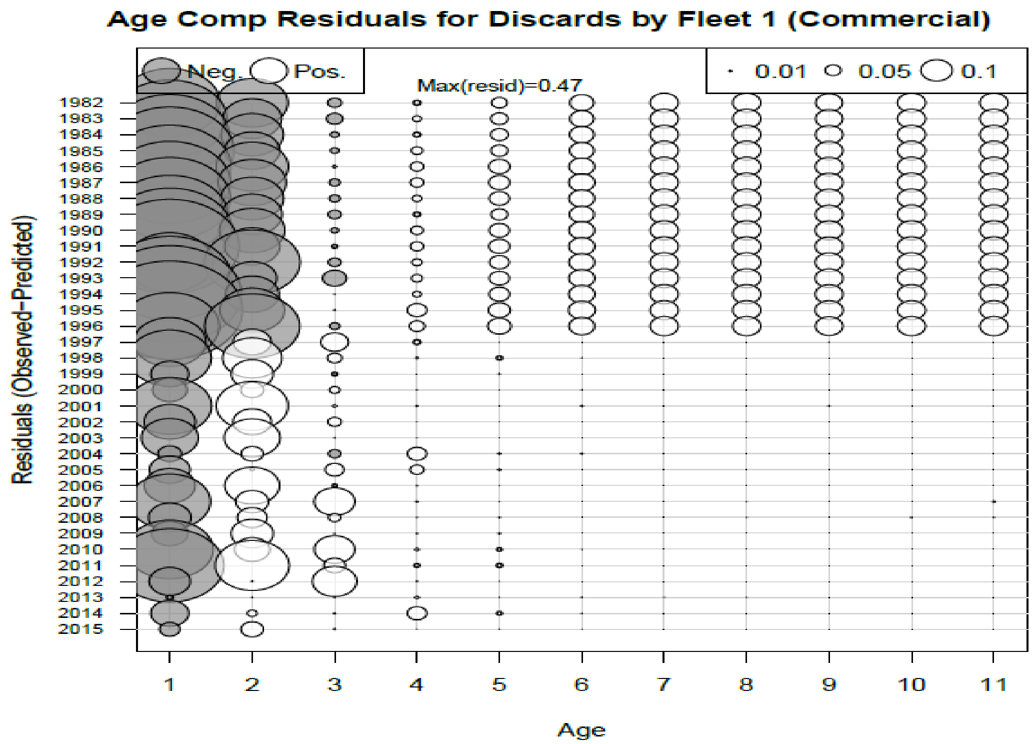


Figure 16.6 – ASAP base model fit residuals for the commercial (top) and recreational (bottom) fleets catch-at-age of Sheepshead on Florida's Atlantic coast, 1982–2015.



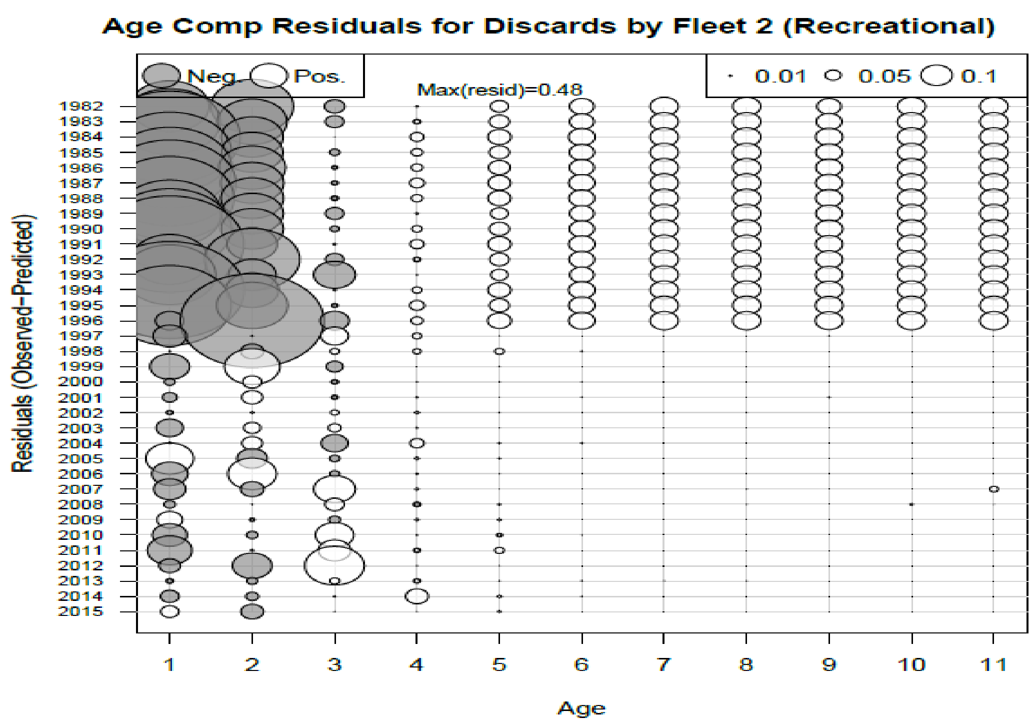
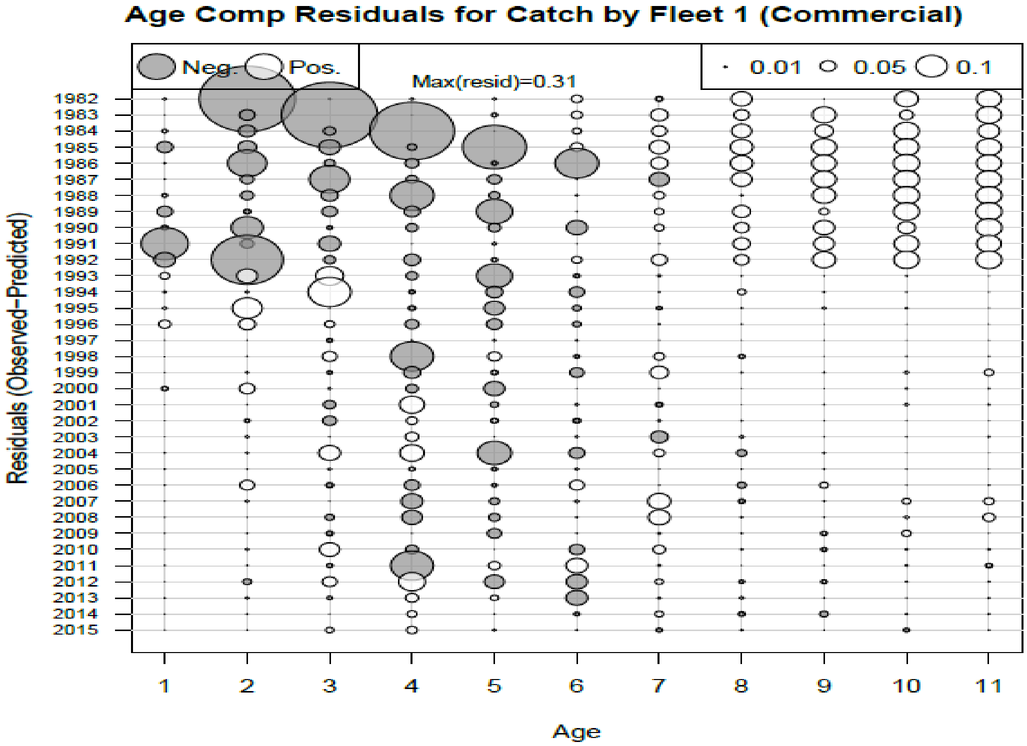


Figure 16.7– ASAP base model fit residuals for the commercial (top) and recreational (bottom) discards-at-age of Sheepshead on Florida's Atlantic coast, 1982–2015.



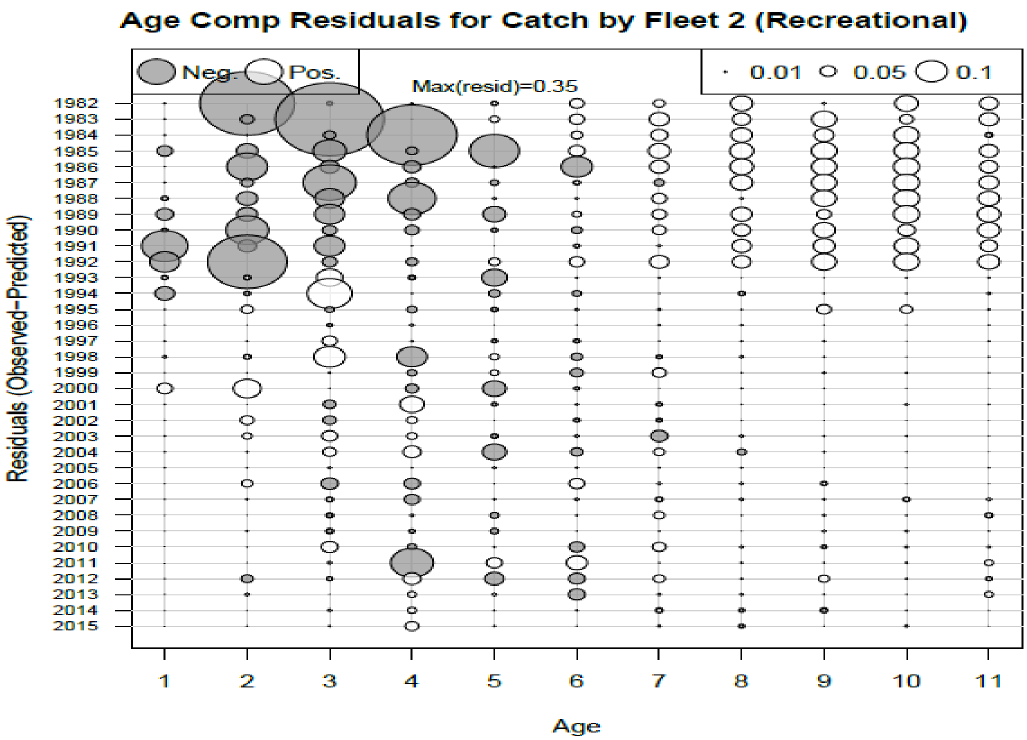
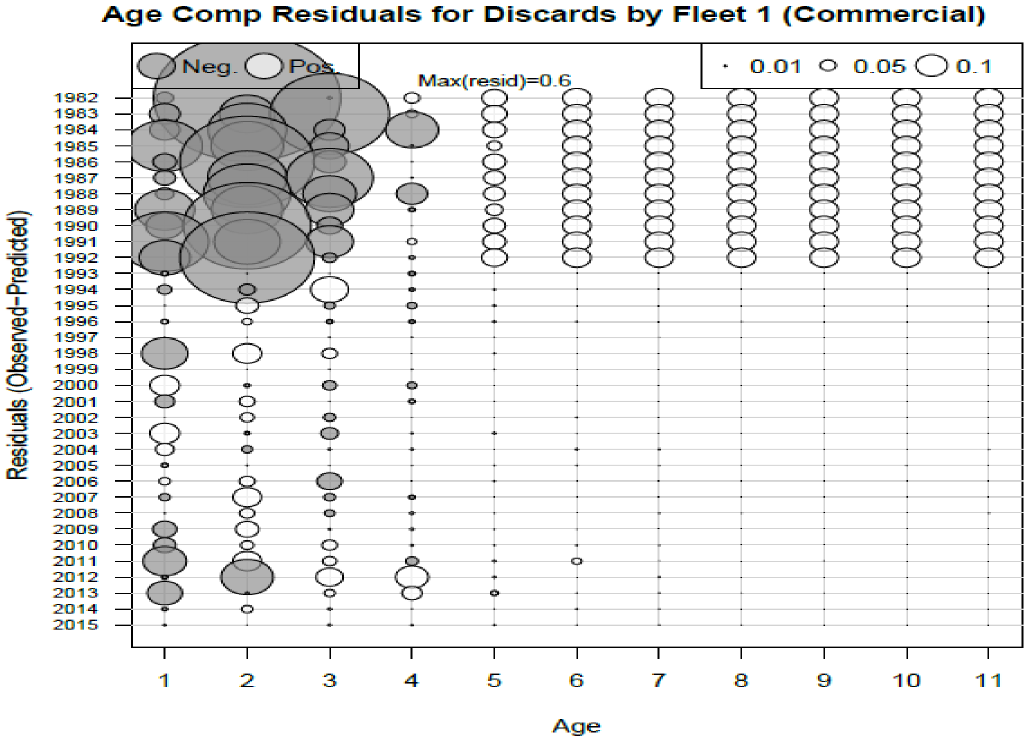


Figure 16.8 – ASAP base model fit residuals for the commercial (top) and recreational (bottom) fleets catch-at-age of Sheepshead on Florida's Gulf coast, 1982–2015.



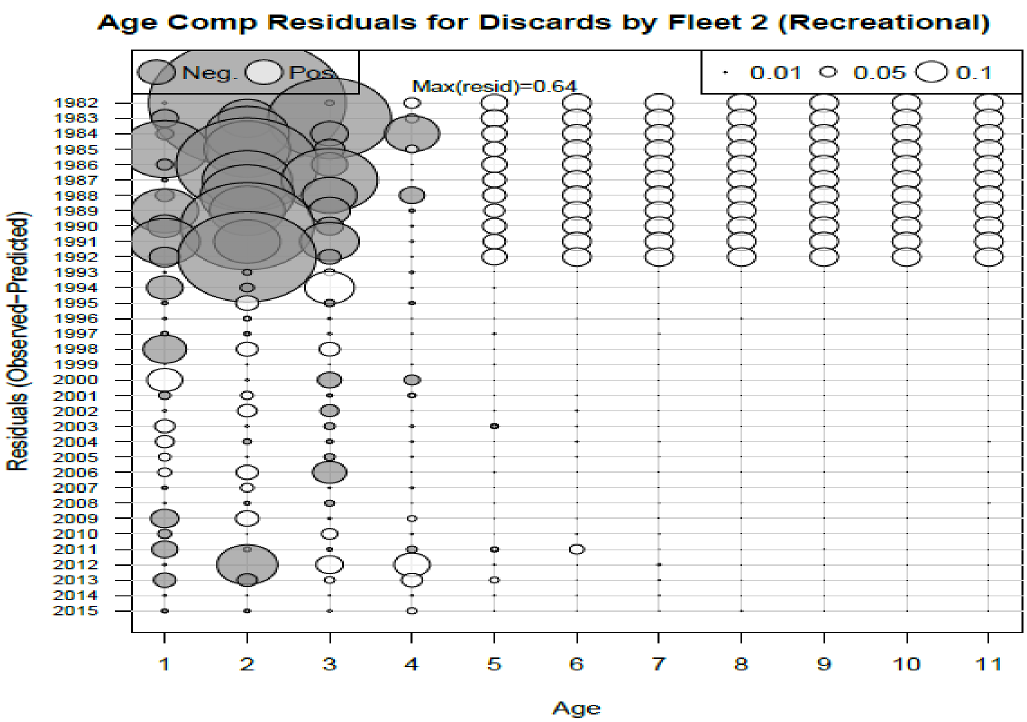
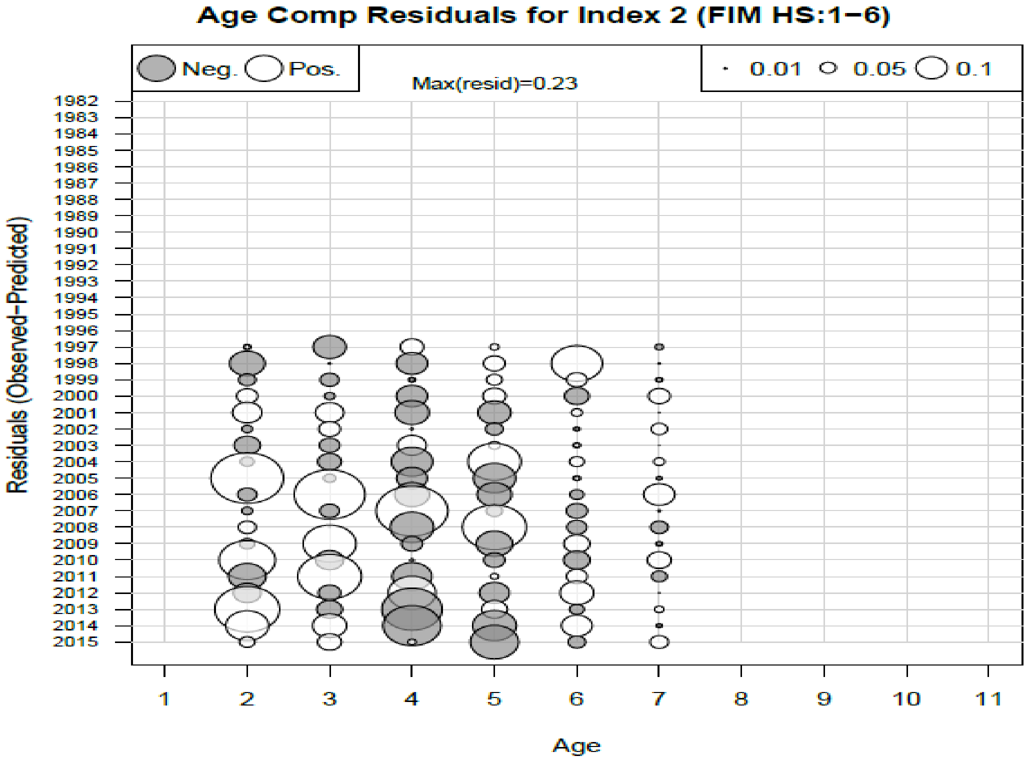


Figure 16.9– ASAP base model fit residuals for the commercial (top) and recreational (bottom) discards-at-age of Sheepshead on Florida's Gulf coast, 1982–2015.



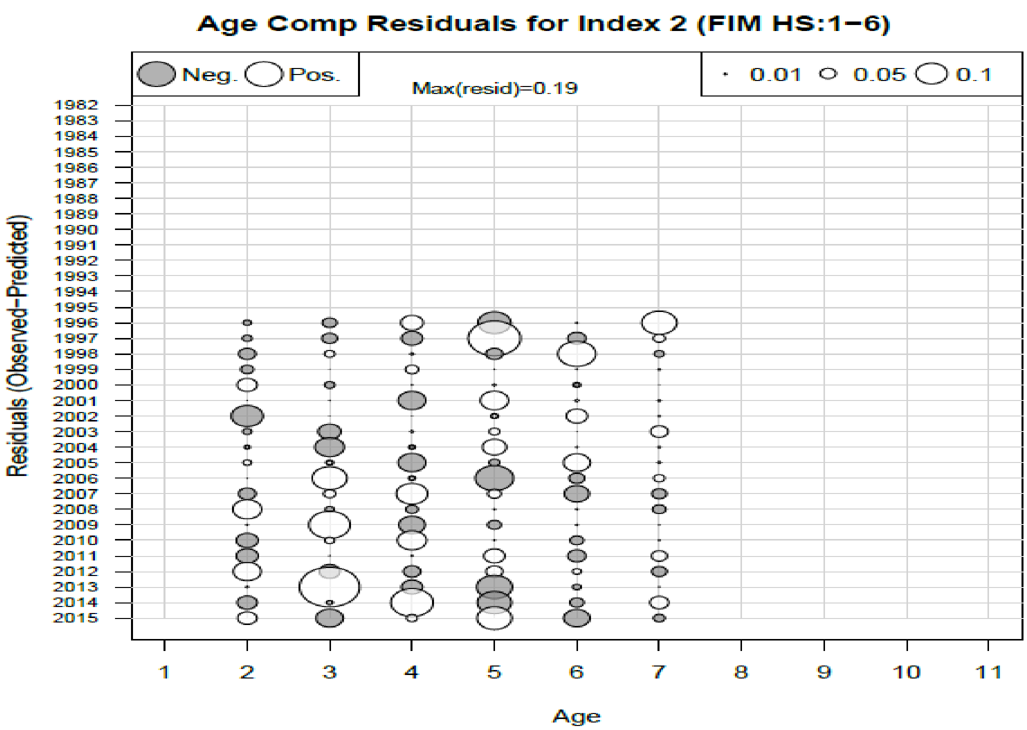


Figure 16.10 - ASAP base model fit residuals for Sheepshead catch at-age made by the FIM haul seine survey on Florida's Atlantic (top) and Gulf (bottom) coasts, 1997–2015.

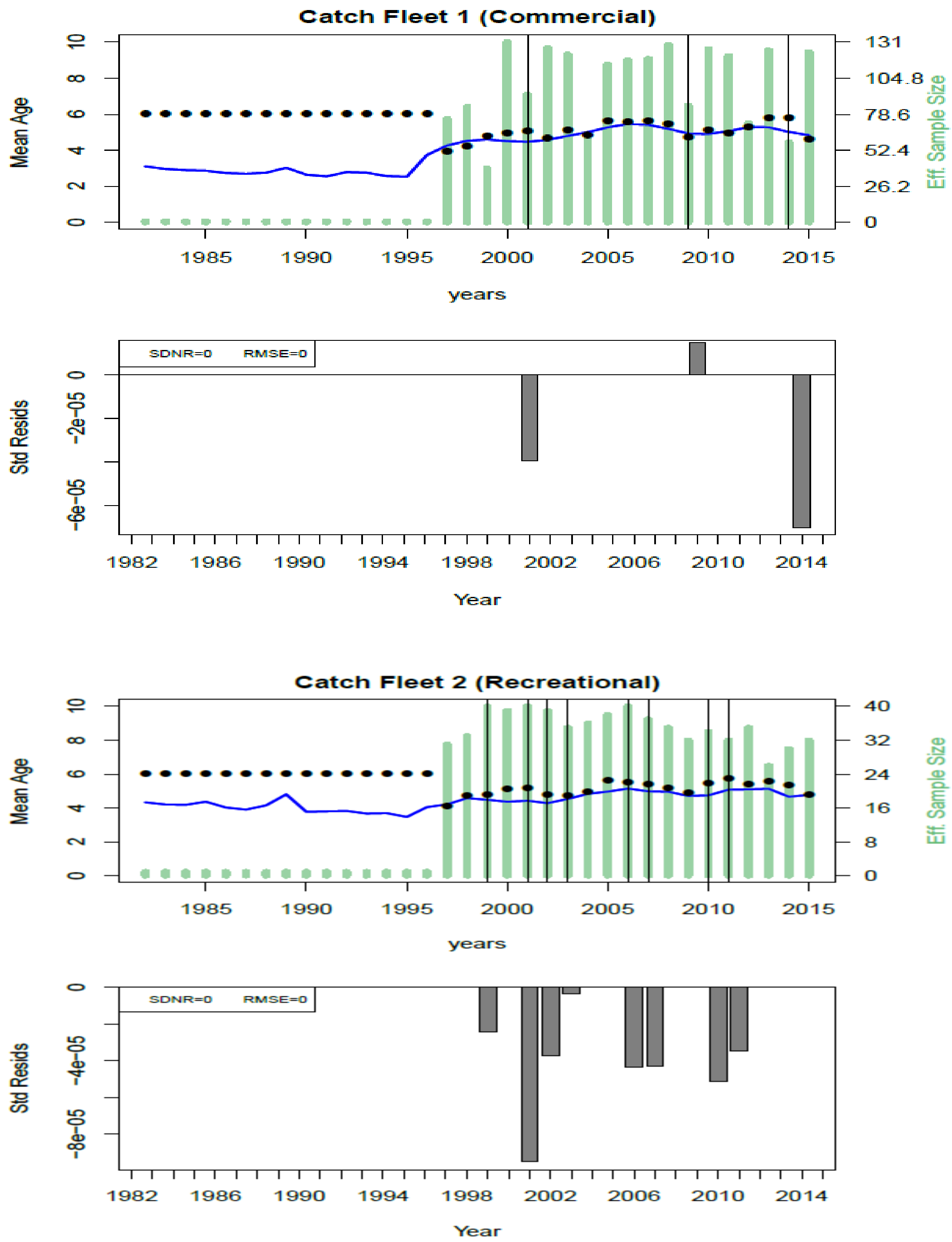


Figure 16.11 – ASAP base model predicted mean age (blue line) compared to observed mean age (top plot, along with the effective sample sizes applied) and the residuals about the mean (bottom plot) for the Sheepshead commercial and recreational landings on Florida's Atlantic coast, 1982–2015.

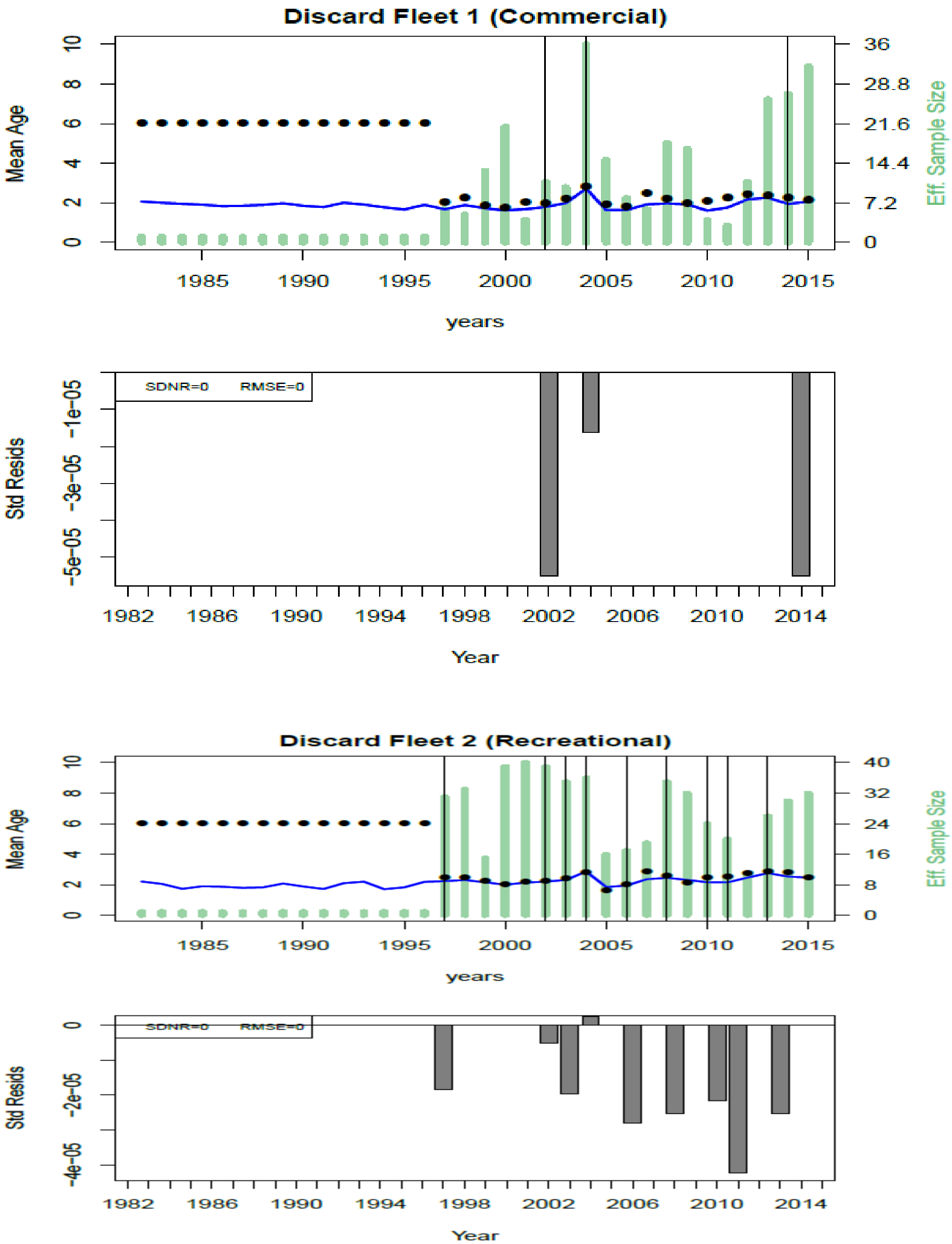


Figure 16.12 – ASAP base model predicted mean age (blue line) compared to observed mean age (top plot, along with the effective sample sizes applied) and the residuals about the mean (bottom plot) for the Sheepshead commercial and recreational discards on Florida's Atlantic coast, 1982–2015.

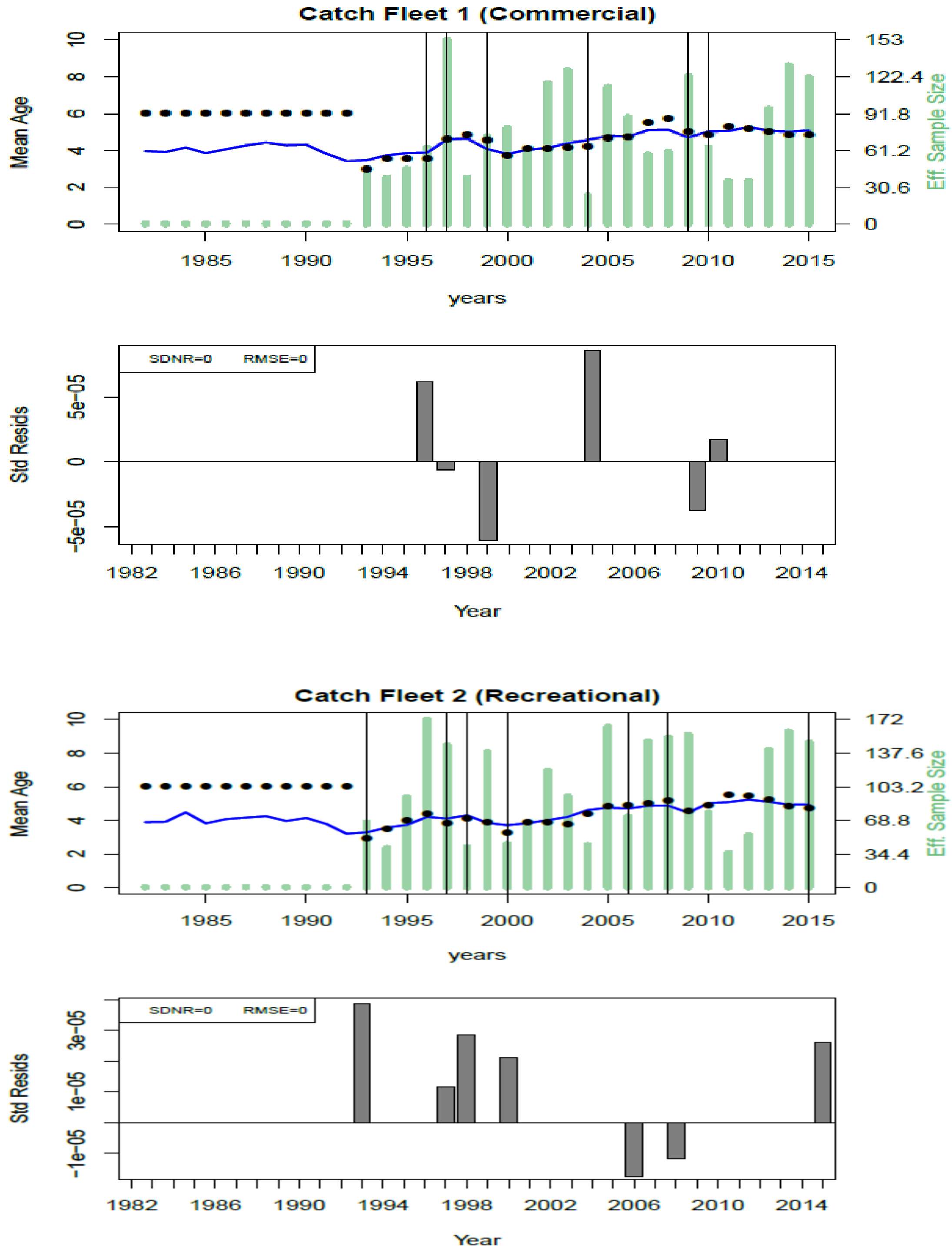


Figure 16.13 – ASAP base model predicted mean age (blue line) compared to observed mean age (top plot, along with the effective sample sizes applied) and the residuals about the mean (bottom plot) for the Sheepshead commercial and recreational landings on Florida’s Gulf coast, 1982–2015.

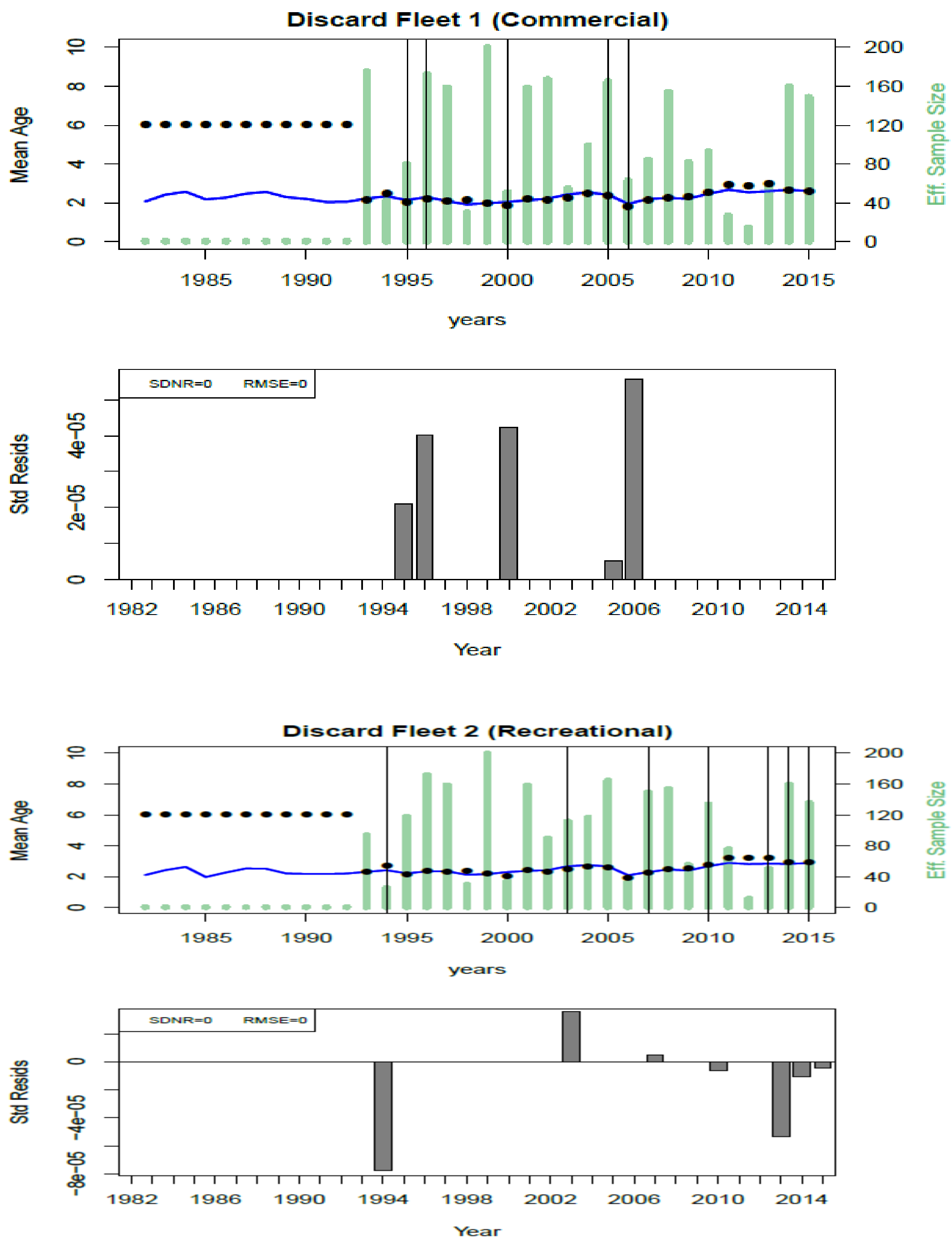


Figure 16.14 – ASAP base model predicted mean age (blue line) compared to observed mean age (top plot, along with the effective sample sizes applied) and the residuals about the mean (bottom plot) for the Sheepshead commercial and recreational discards on Florida's Gulf coast, 1982–2015.

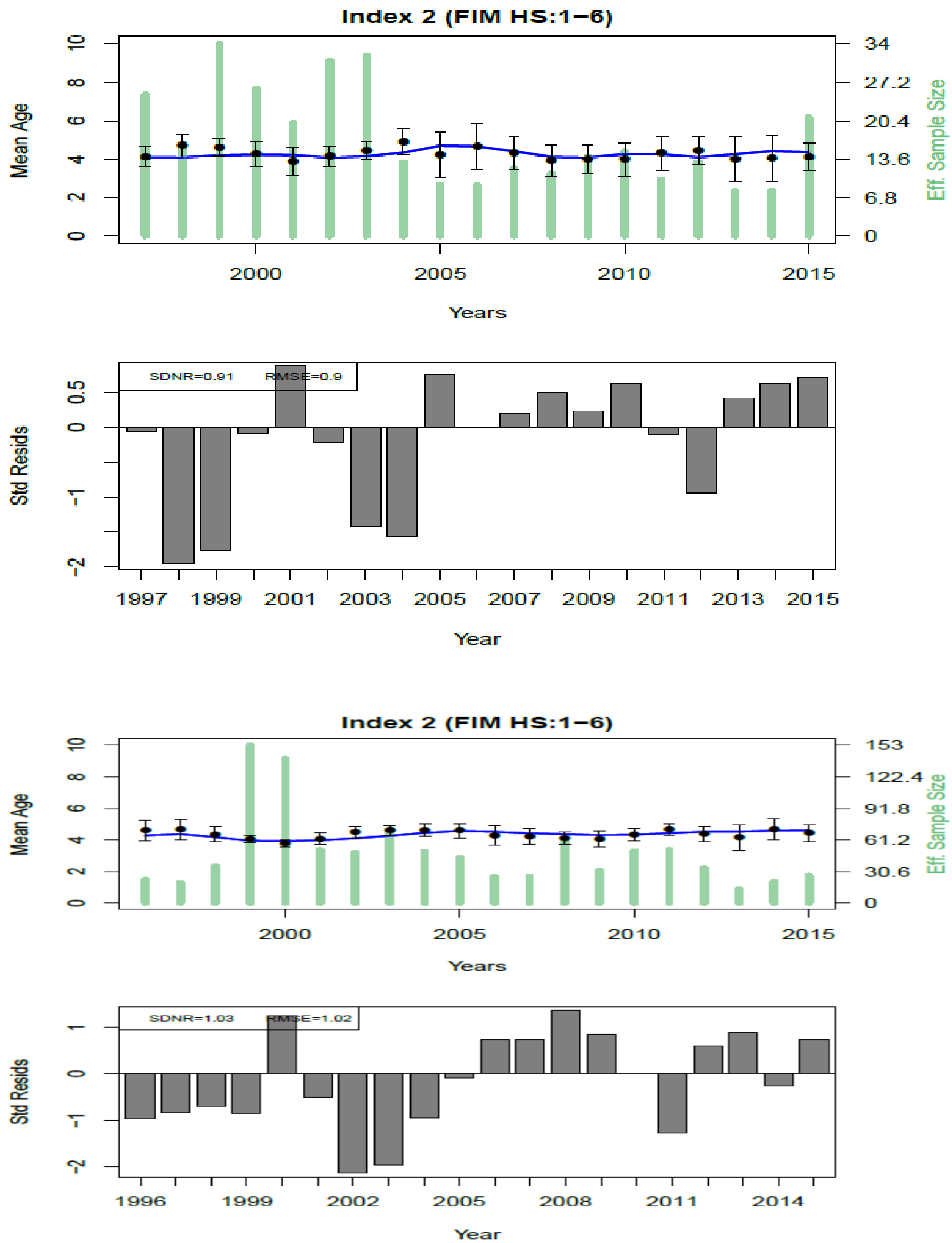


Figure 16.15 – ASAP base model predicted mean age (blue line) compared to observed mean age (top plot, along with the effective sample sizes applied) and the residuals about the mean (bottom plot) in the Sheepshead haul seine surveys on Florida's Atlantic (top panels) and Gulf (bottom panels) coasts, 1996–2015.

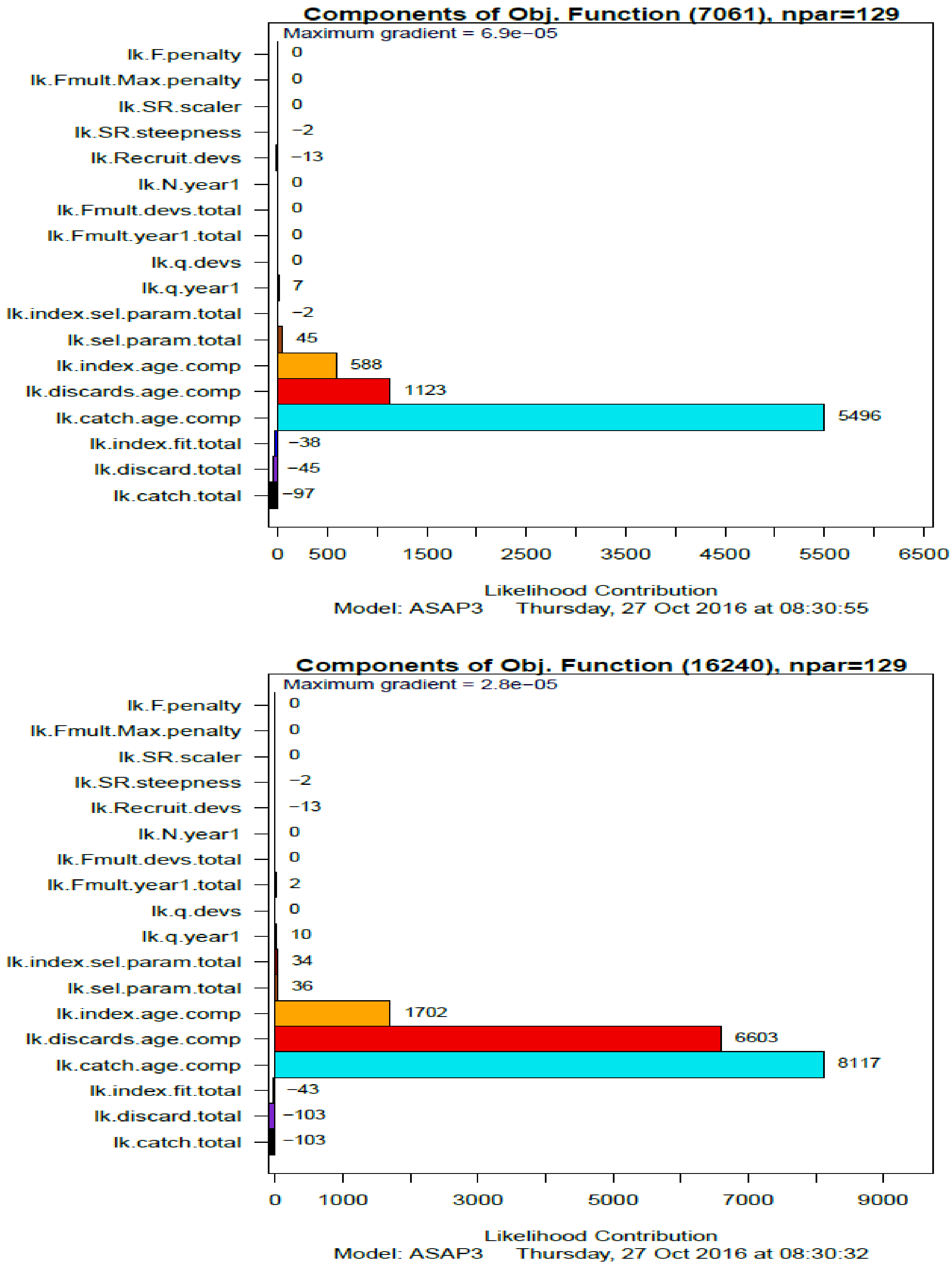


Figure 16.16 – Likelihood contributions of various components in the total objective function from ASAP base model for Sheepshead off Florida's Atlantic (top) and Gulf (bottom) coasts.

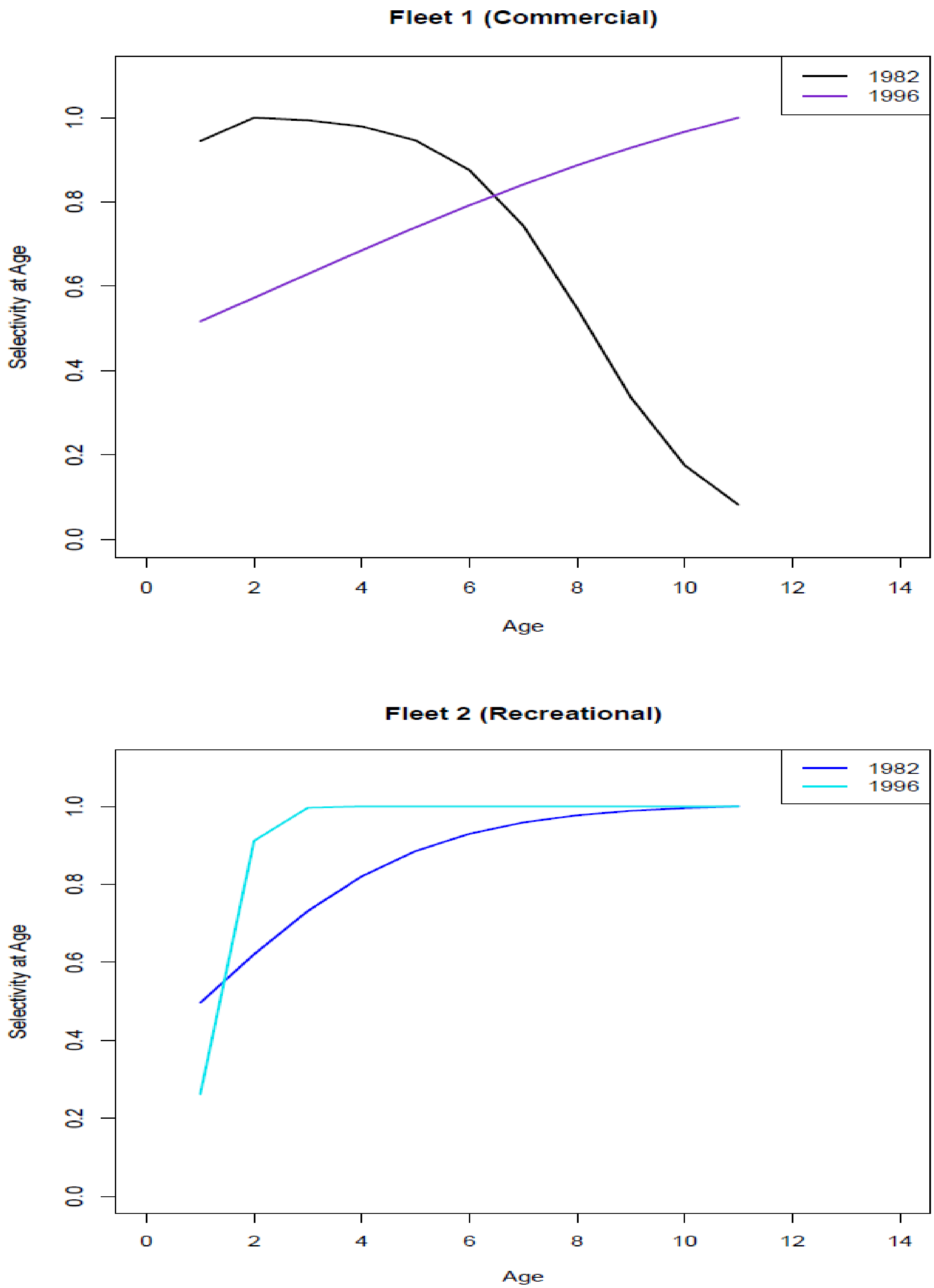


Figure 16.17 – Selectivity patterns estimated by the ASAP base model for Sheepshead caught by the commercial and recreational fleets on the Atlantic coast of Florida.

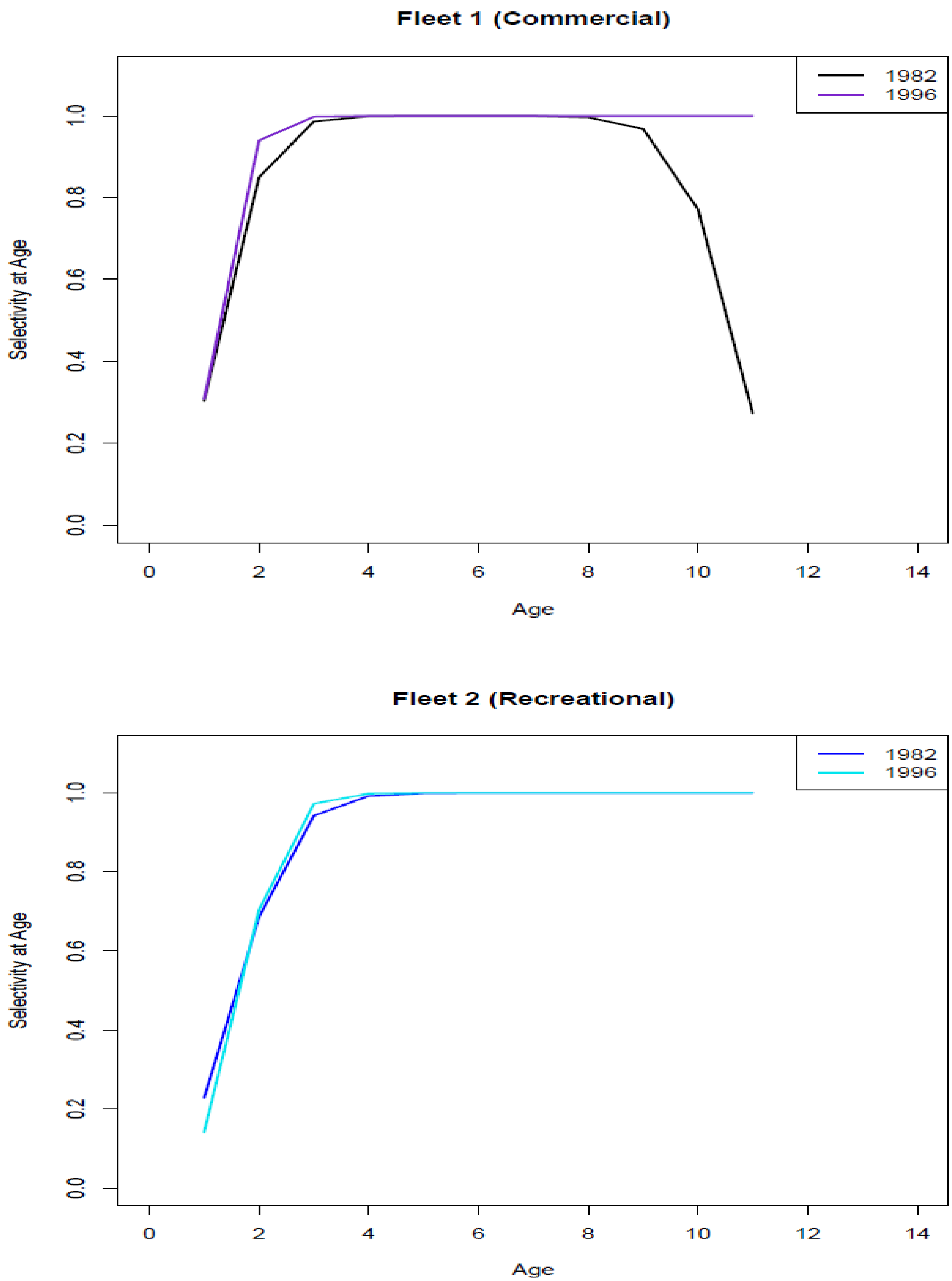


Figure 16.17 (Cont.) – Selectivity patterns estimated by the ASAP base model for Sheepshead caught by the commercial and recreational fleets on the Gulf coast of Florida.

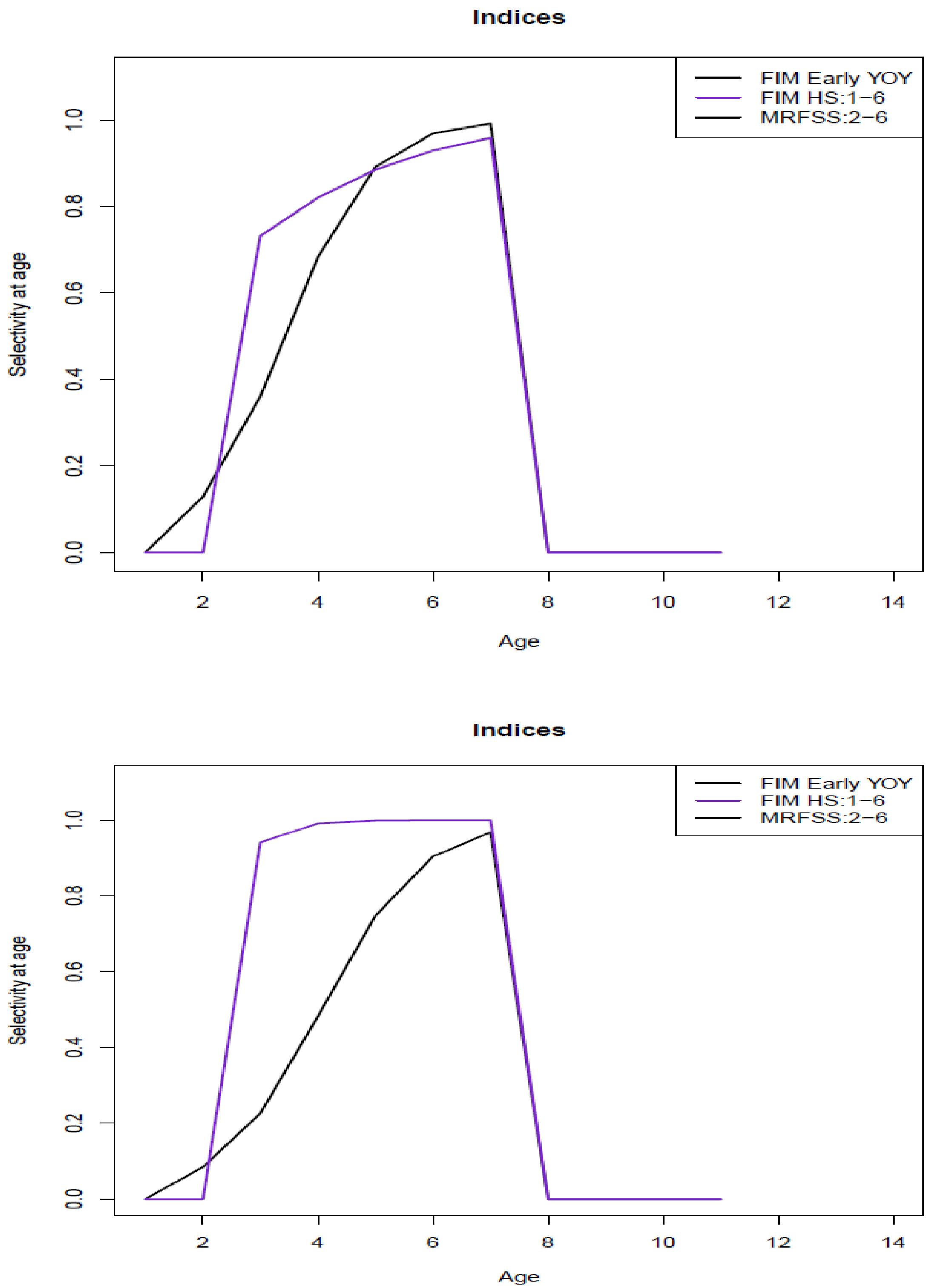
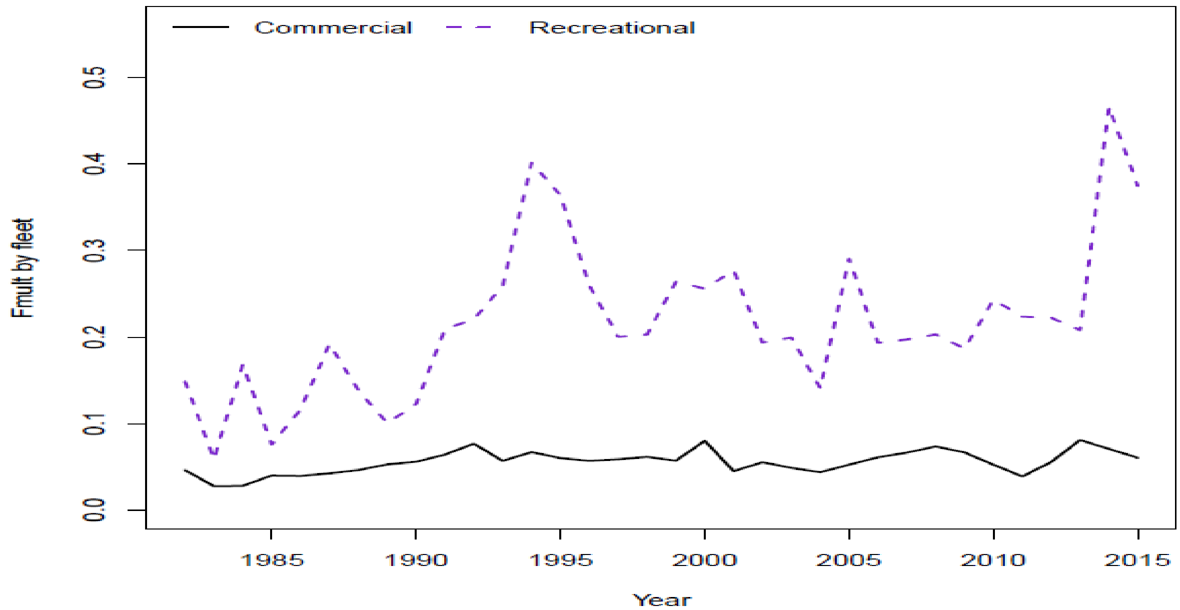


Figure 16.18 – Selectivity patterns estimated by the ASAP base model for Sheepshead's indices of abundance on Florida's Atlantic (top) and Gulf (bottom) coasts.



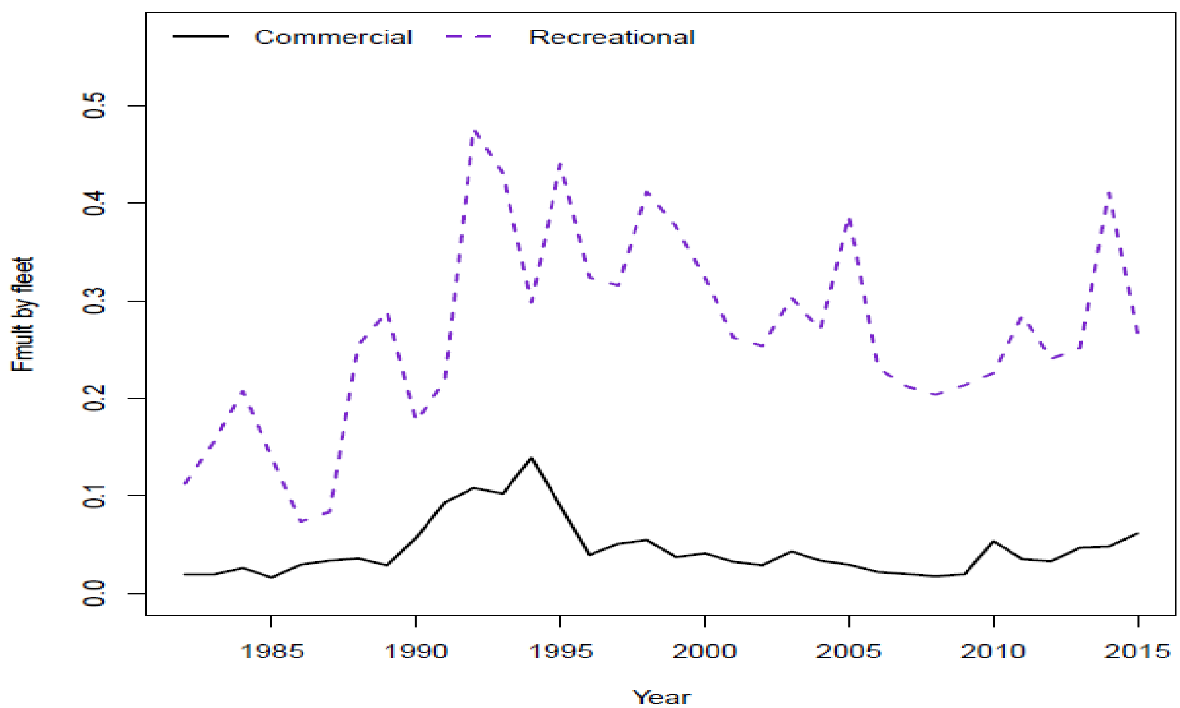


Figure 16.19 – Fleet-specific fishing mortality (*F*mult) estimated by the ASAP base model for Sheepshead on the Atlantic (top) and Gulf (bottom) coasts of Florida, 1982–2015.

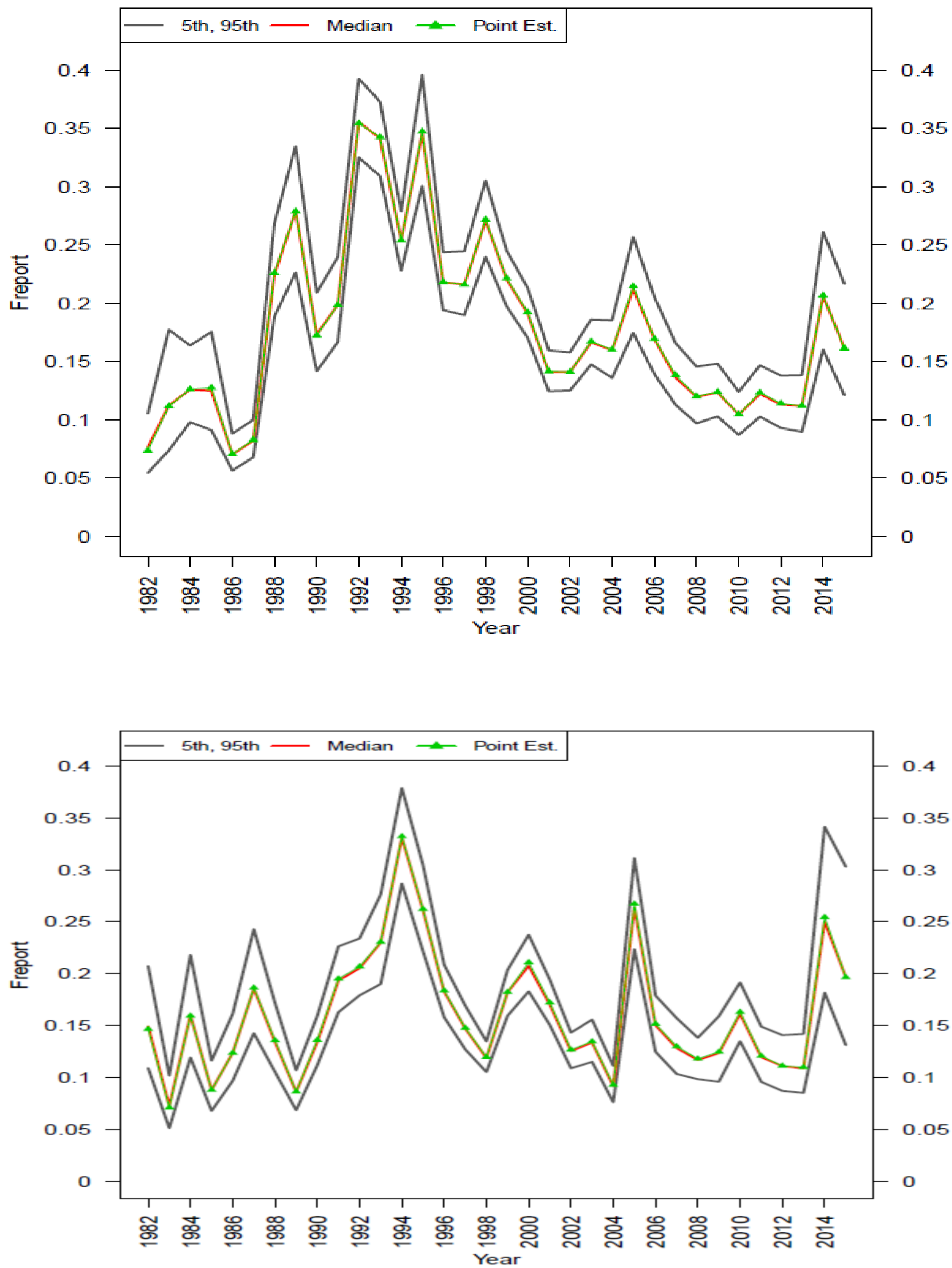
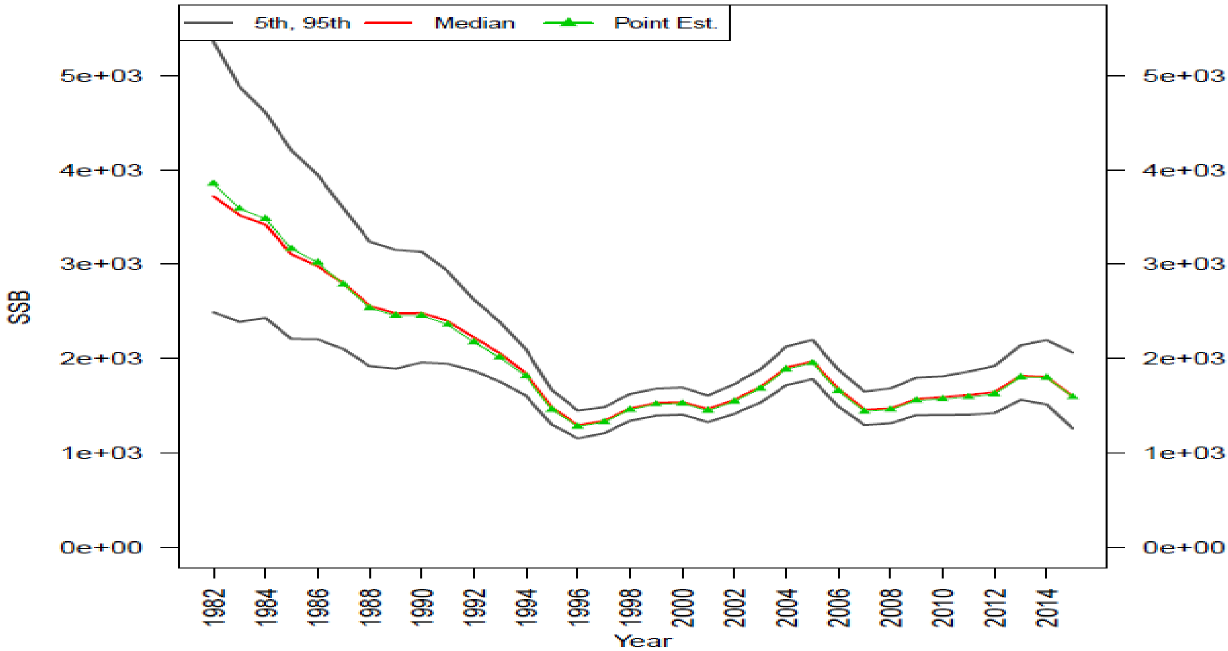


Figure 16.20 – Biomass-weighted average fishing mortality estimated by the ASAP base model for Sheepshead on the Atlantic (top) and Gulf (bottom) coasts of Florida, 1982–2015.

Figure 16.21 – Total abundance of Sheepshead estimated by the ASAP base model on the Atlantic (top) and Gulf (bottom) coasts of Florida, 1982–2015.

Figure 16.22 – Total biomass of Sheepshead estimated by the ASAP base model on the Atlantic (top) and Gulf (bottom) coasts of Florida, 1982–2015.



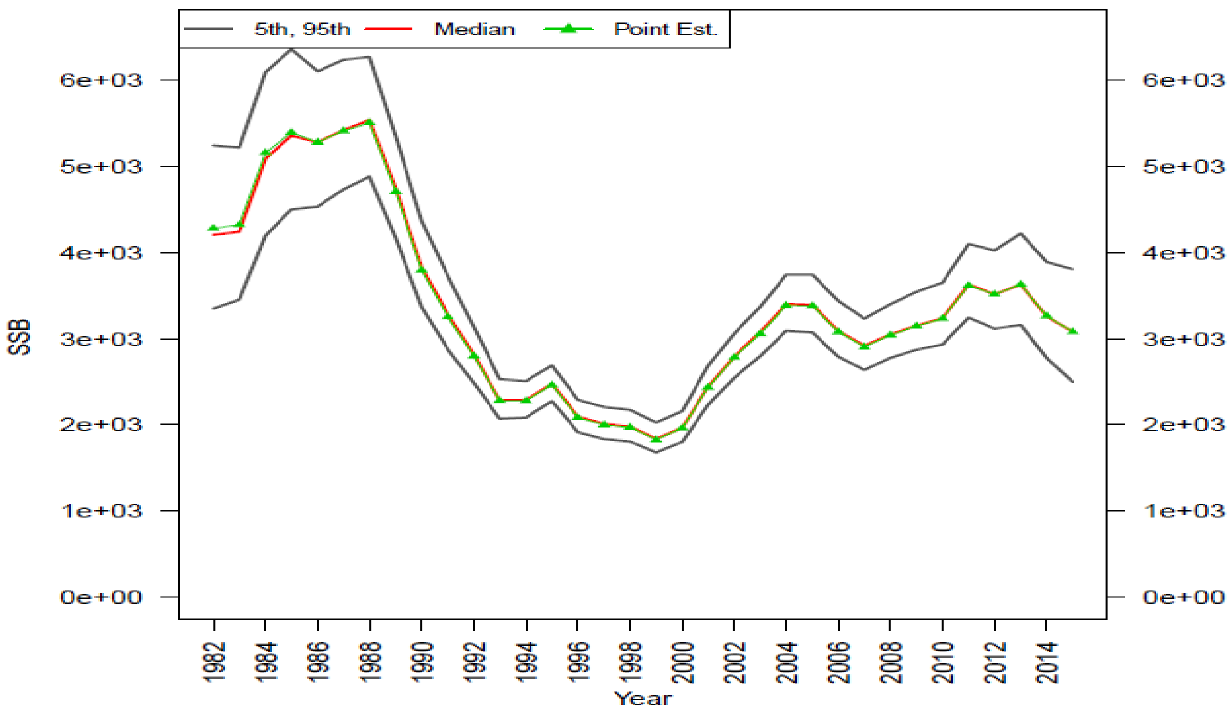


Figure 16.23 – Spawning stock biomass of Sheepshead estimated by the ASAP base model on the Atlantic (top) and Gulf (bottom) coasts of Florida, 1982–2015.

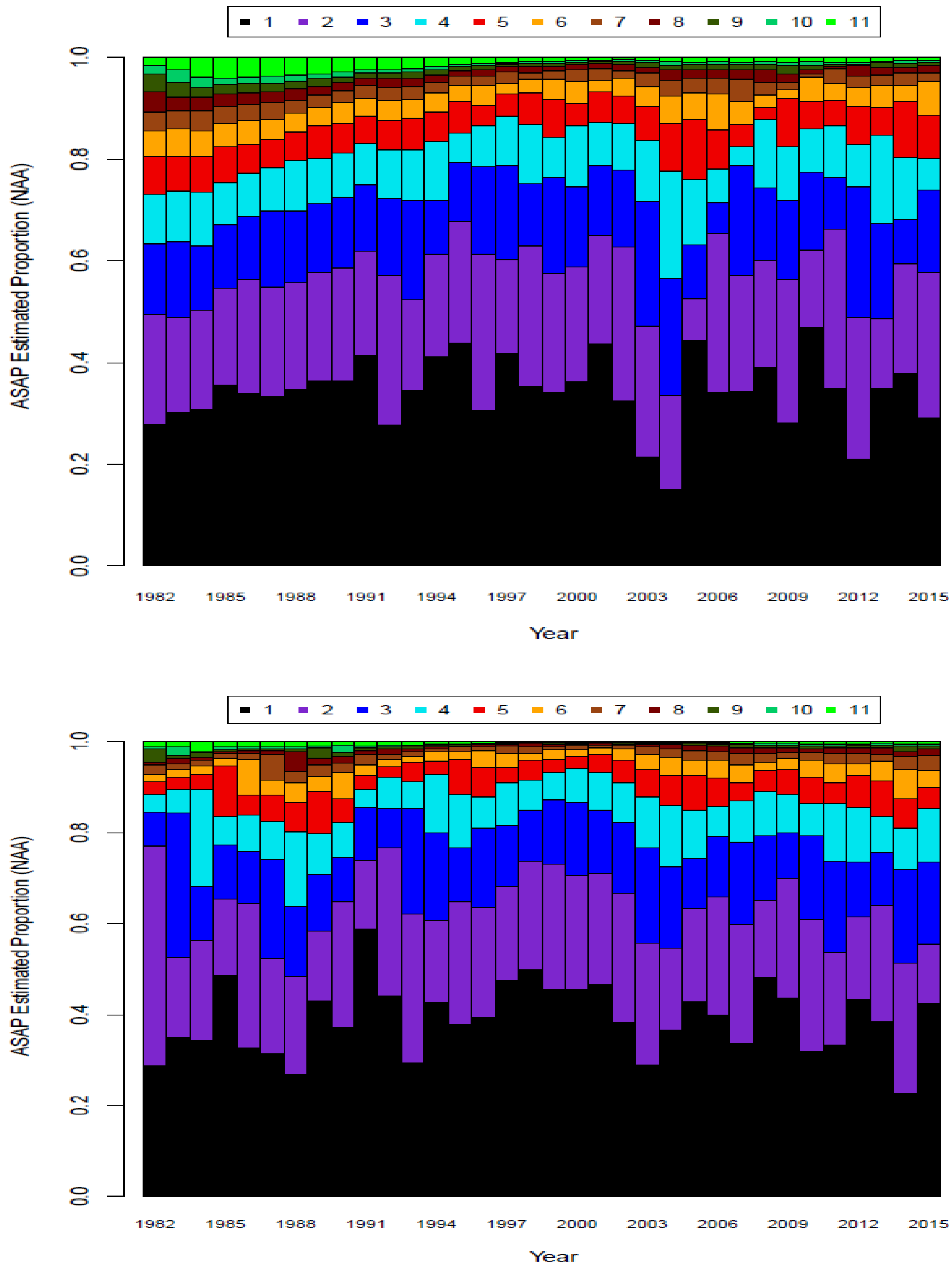


Figure 16.24 – Proportions of the number at age of Sheepshead estimated by the ASAP base model on the Atlantic (top) and Gulf (bottom) coasts of Florida, 1982–2015.

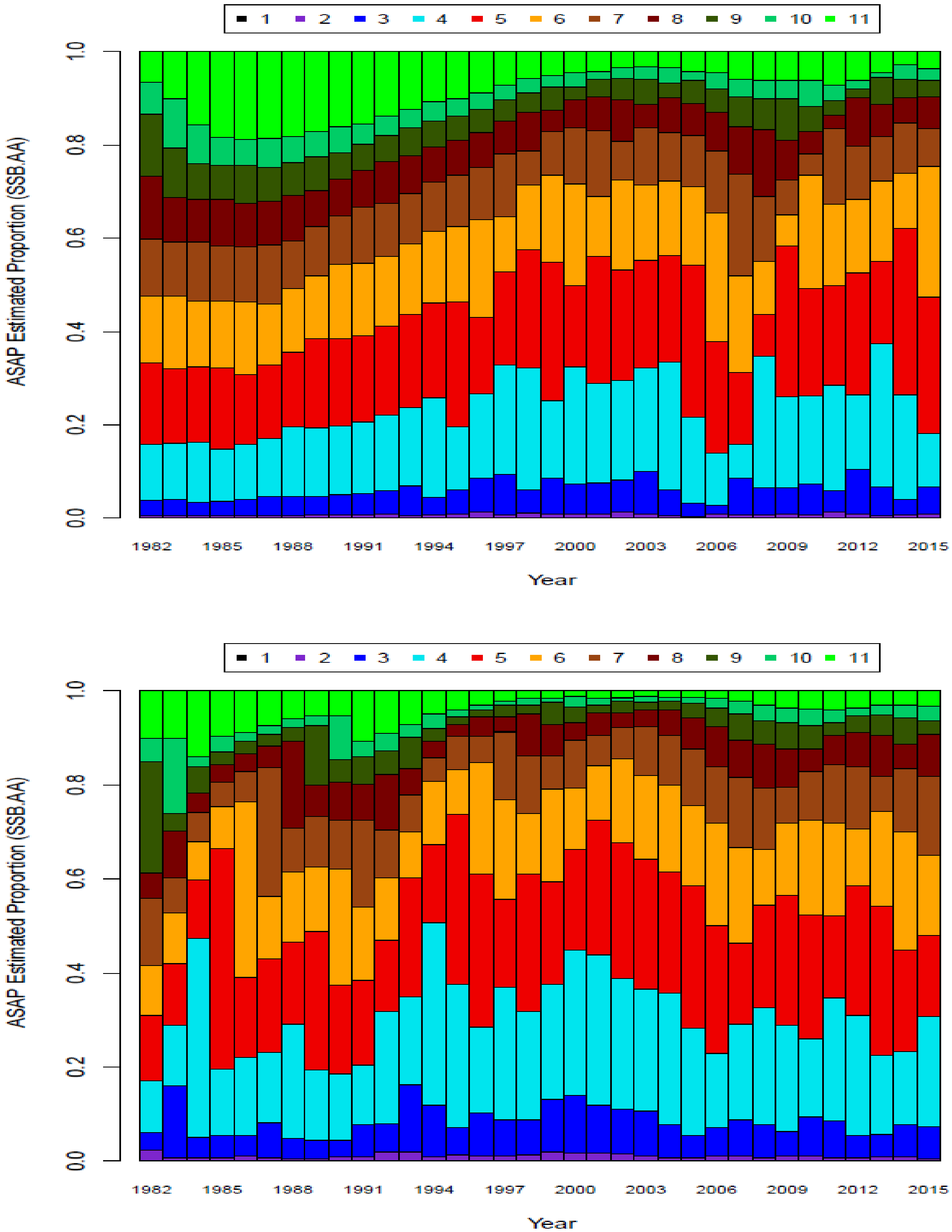


Figure 16.25 – Proportions of the spawning stock biomass at age of Sheepshead estimated by the ASAP base model on the Atlantic (top) and Gulf (bottom) coasts of Florida, 1982–2015.

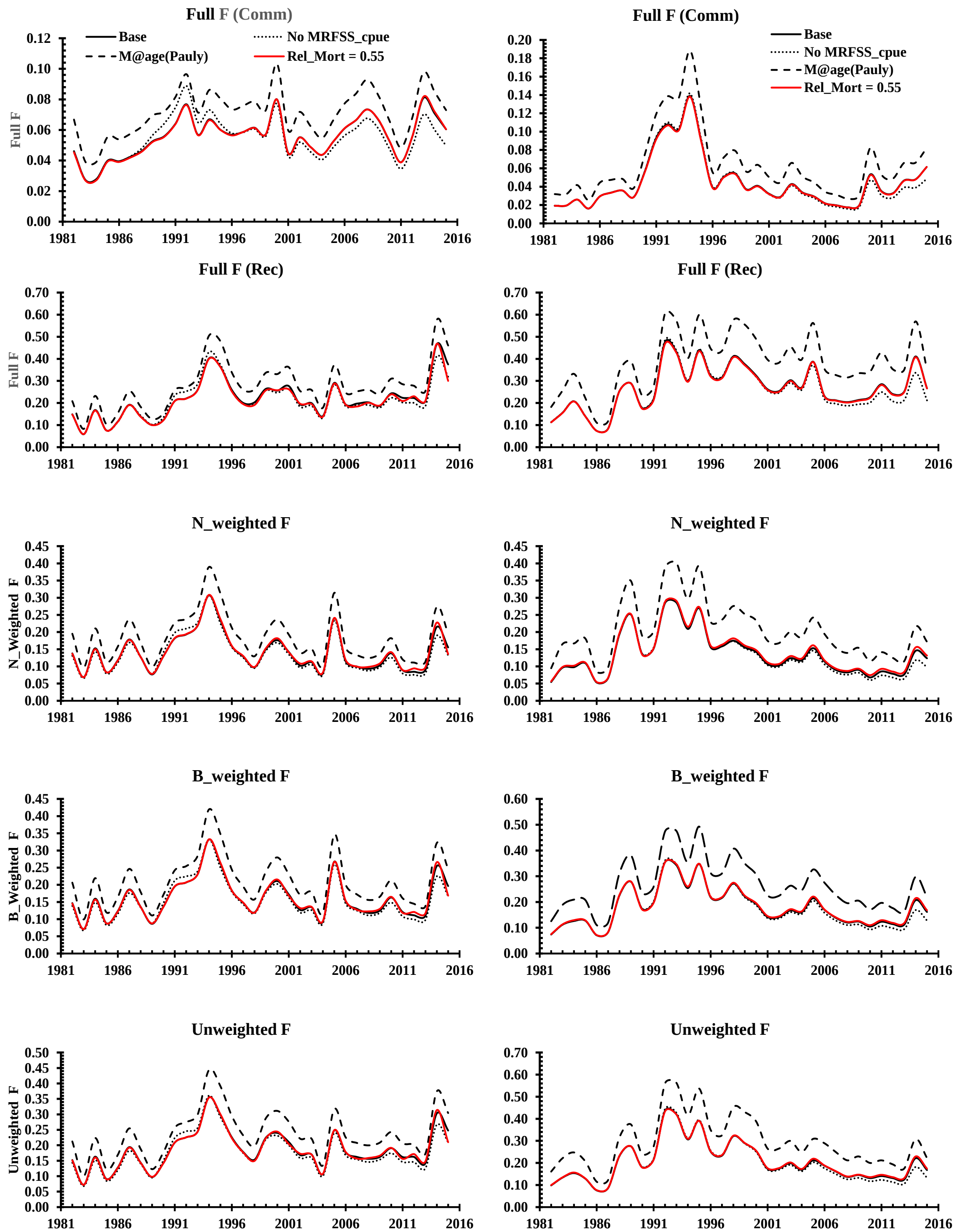


Figure 16.26 – Comparisons of different types of fishing mortality rates estimated by ASAP base and sensitivity runs for Sheepshead on the Atlantic (left panels) and Gulf (right panels) coasts of Florida, 1982- 2015.

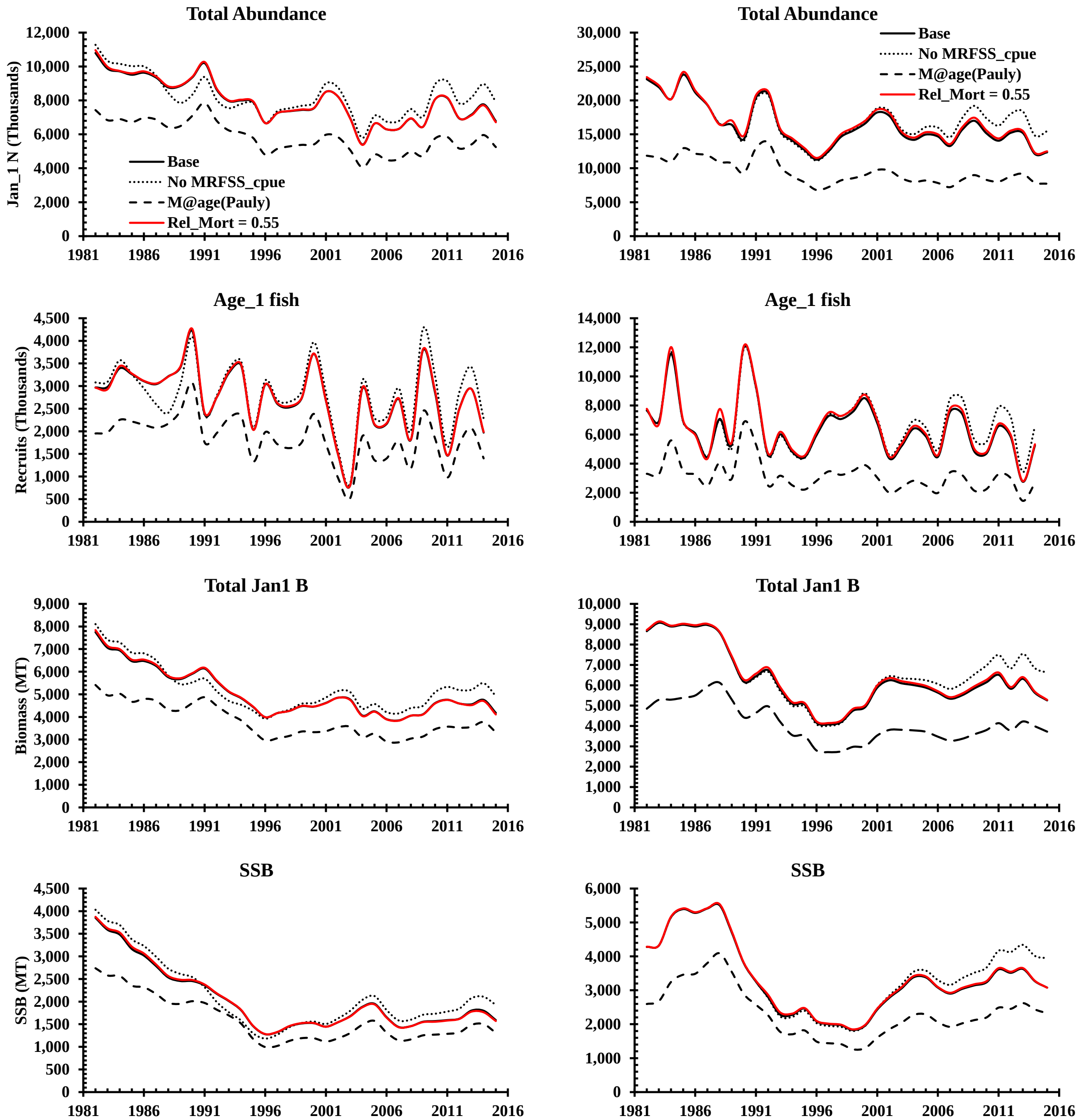


Figure 16.27 – Comparisons of different types of Sheepshead stock sizes estimated by ASAP base and sensitivity runs on the Atlantic (left panels) and Gulf (right panels) coasts of Florida, 1982- 2015.

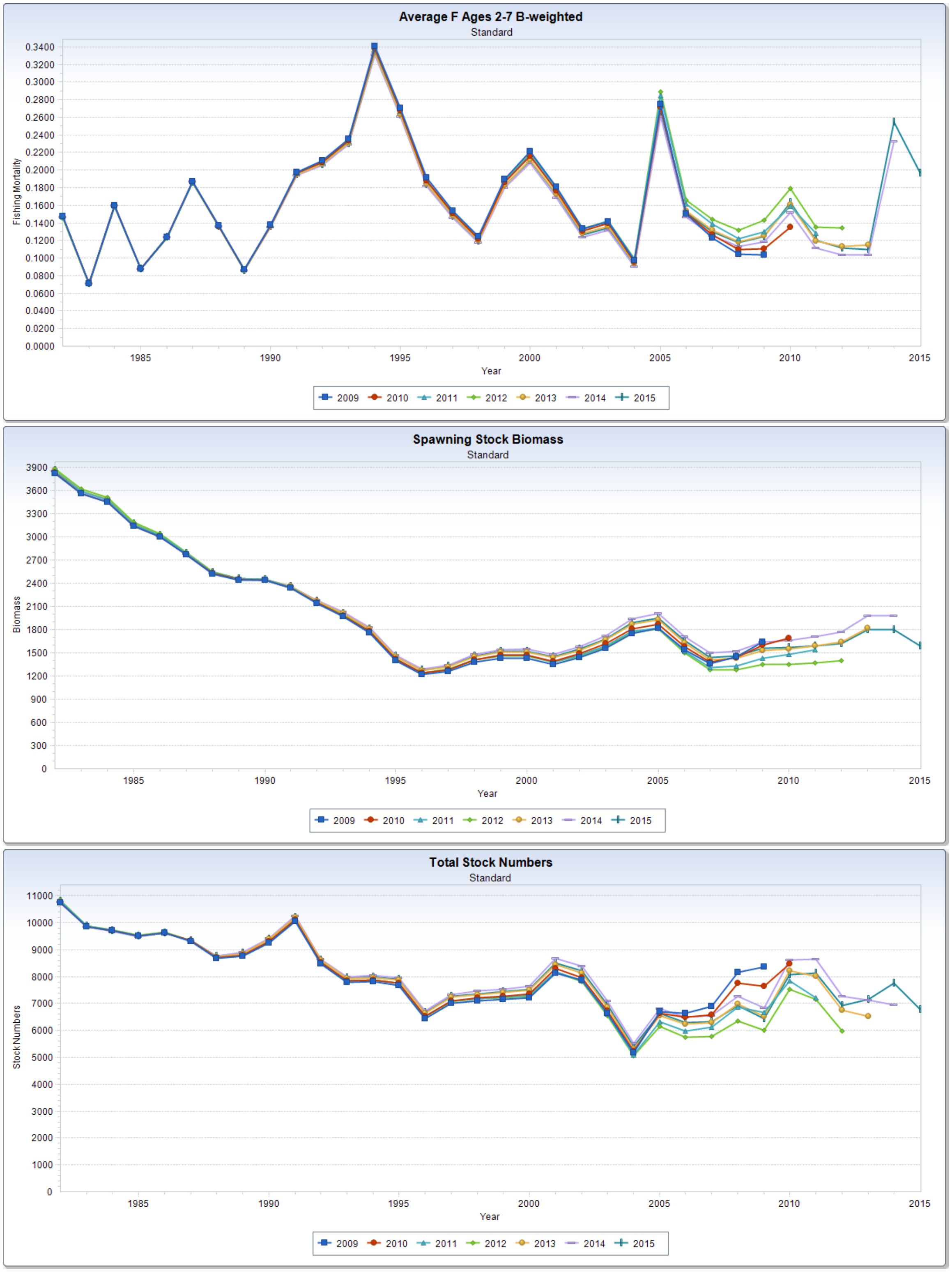


Figure 16.28 – Retrospective patterns for ASAP base model on Florida's Atlantic coast

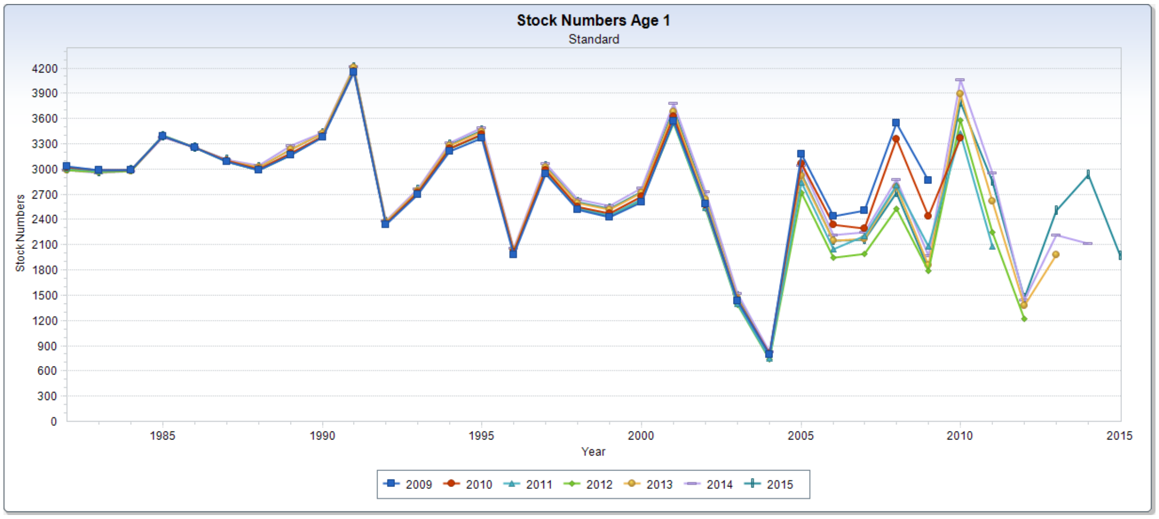


Figure 16.28 (Cont.) – Retrospective patterns for ASAP base model on Florida's Atlantic coast

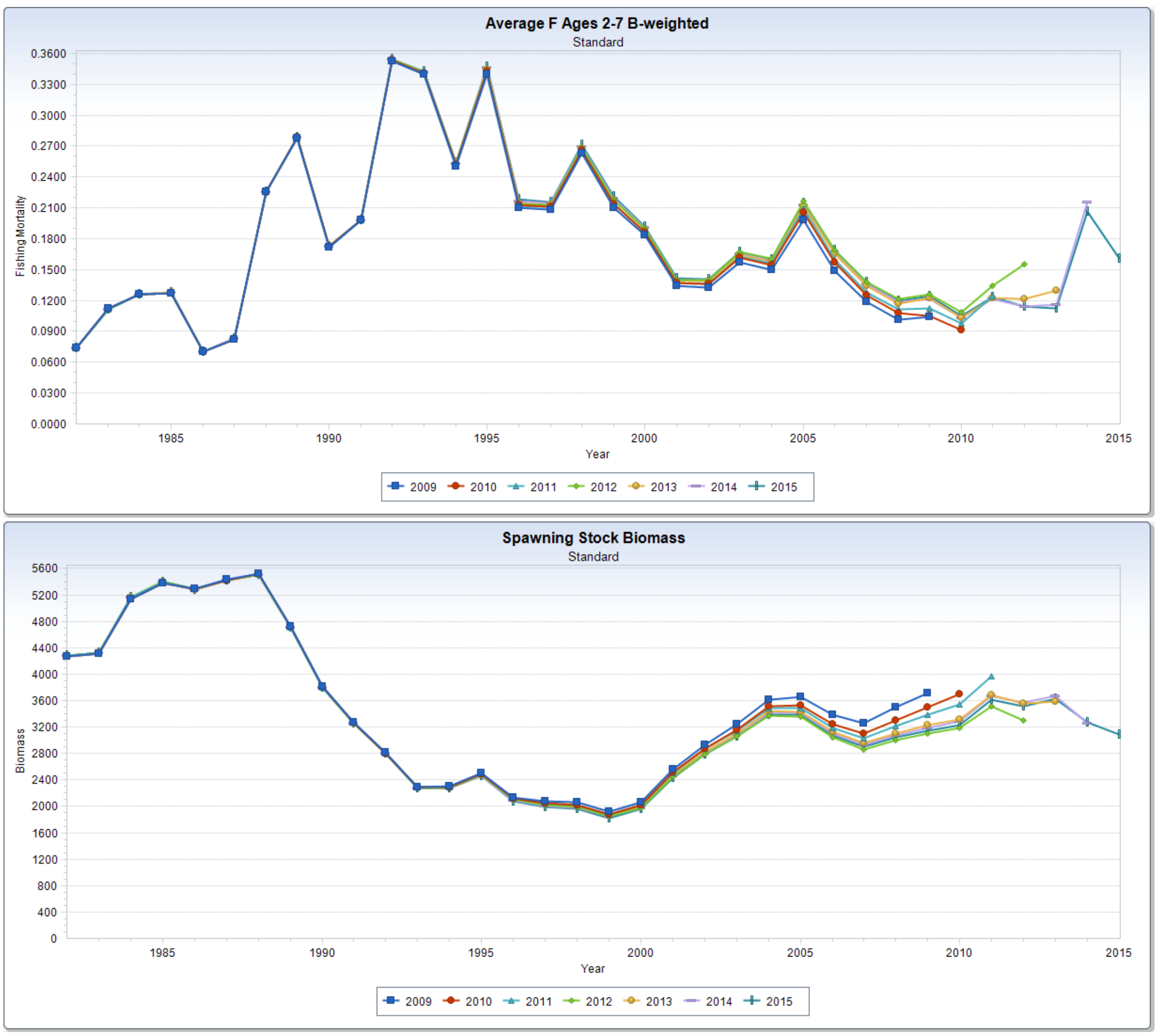
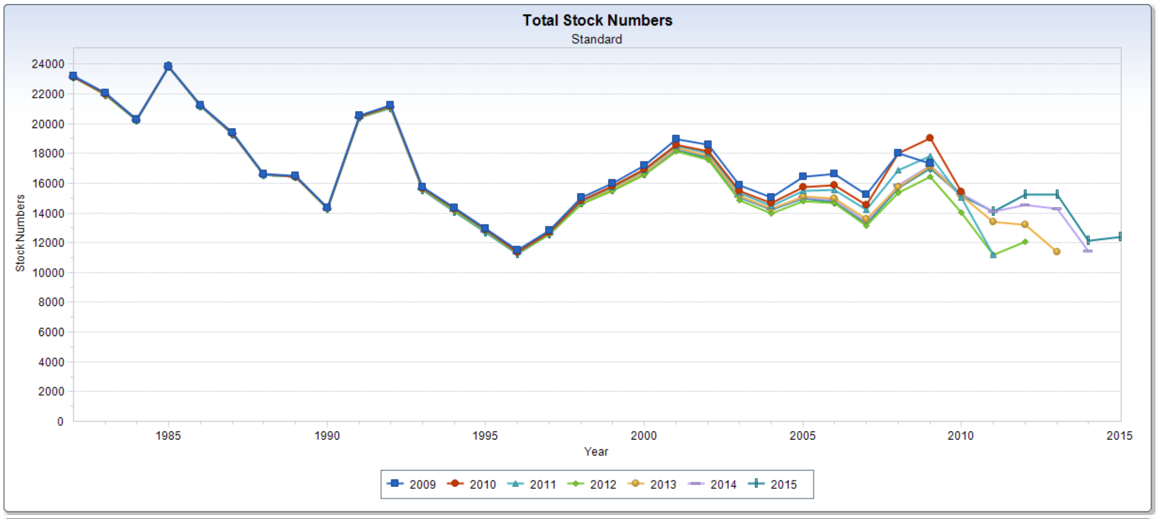


Figure 16.29 – Retrospective patterns for ASAP base model on Florida's Gulf coast



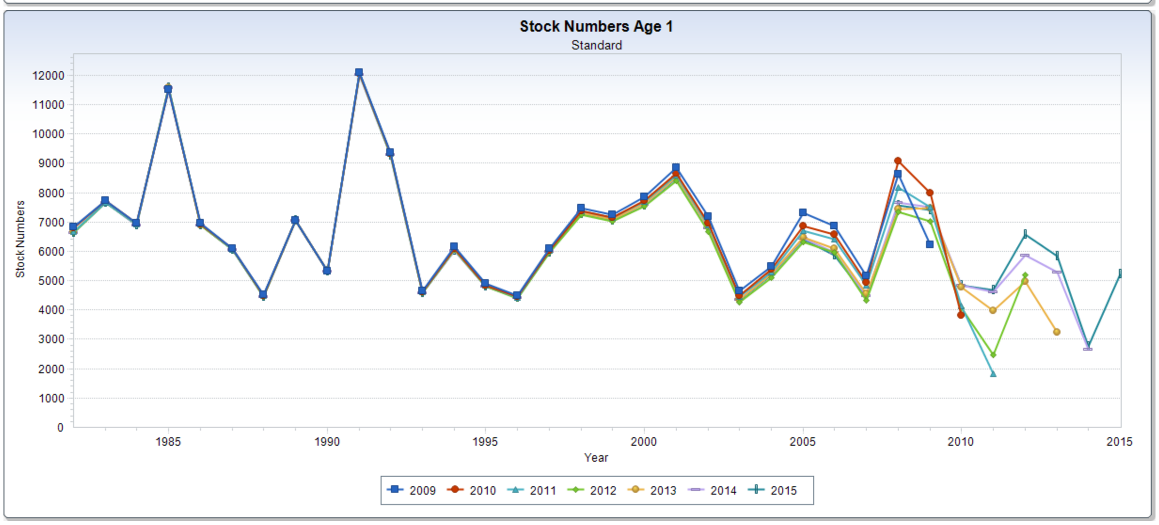


Figure 16.29 (Cont.) – Retrospective patterns for ASAP base model on Florida's Gulf coast

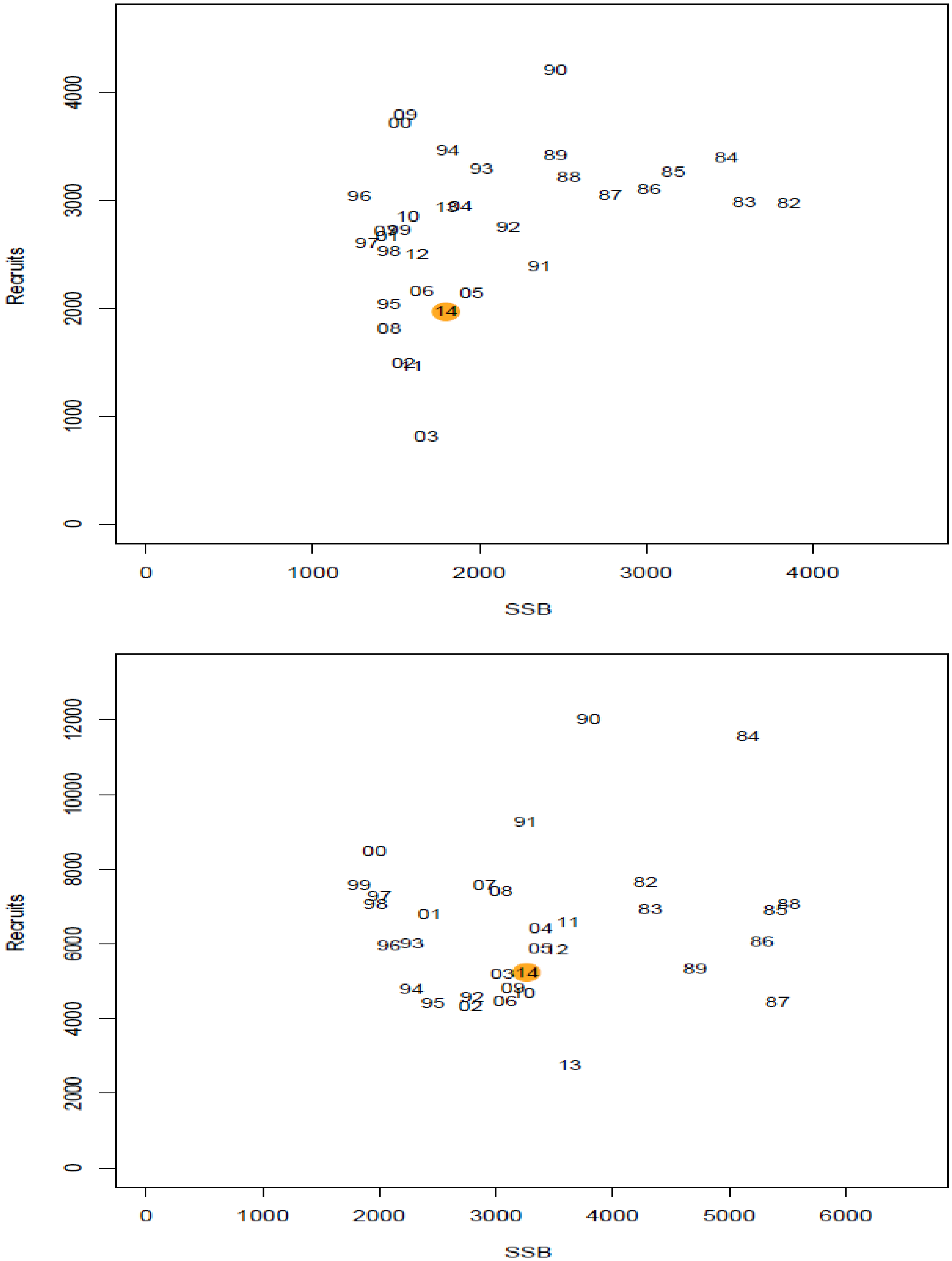
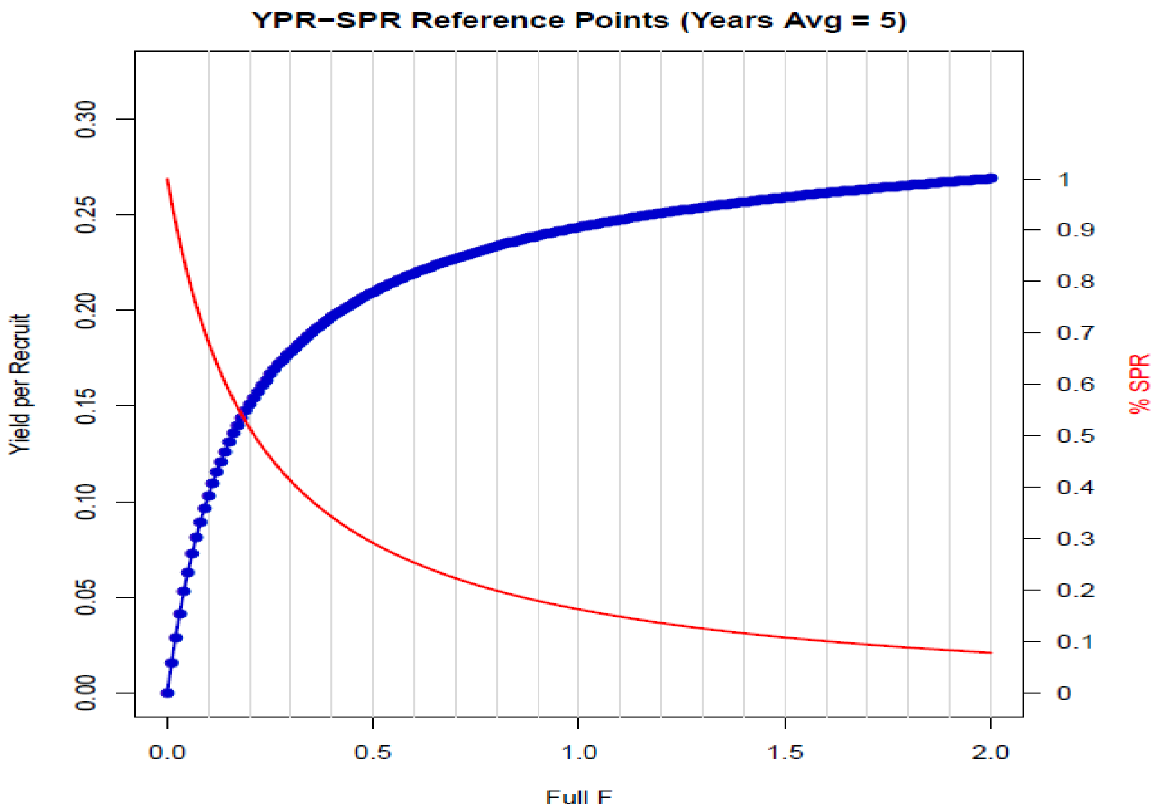


Figure 16.30 – Estimates of next-year recruitment (thousands) of age-0 Sheepshead produced by the spawning stock biomass (SSB, MT) in a given year on the Atlantic (top) and Gulf (bottom) coasts of Florida for during 1982–2014. The year-class designation for recruitment at each point would be the year+1. The SSB includes both males and females



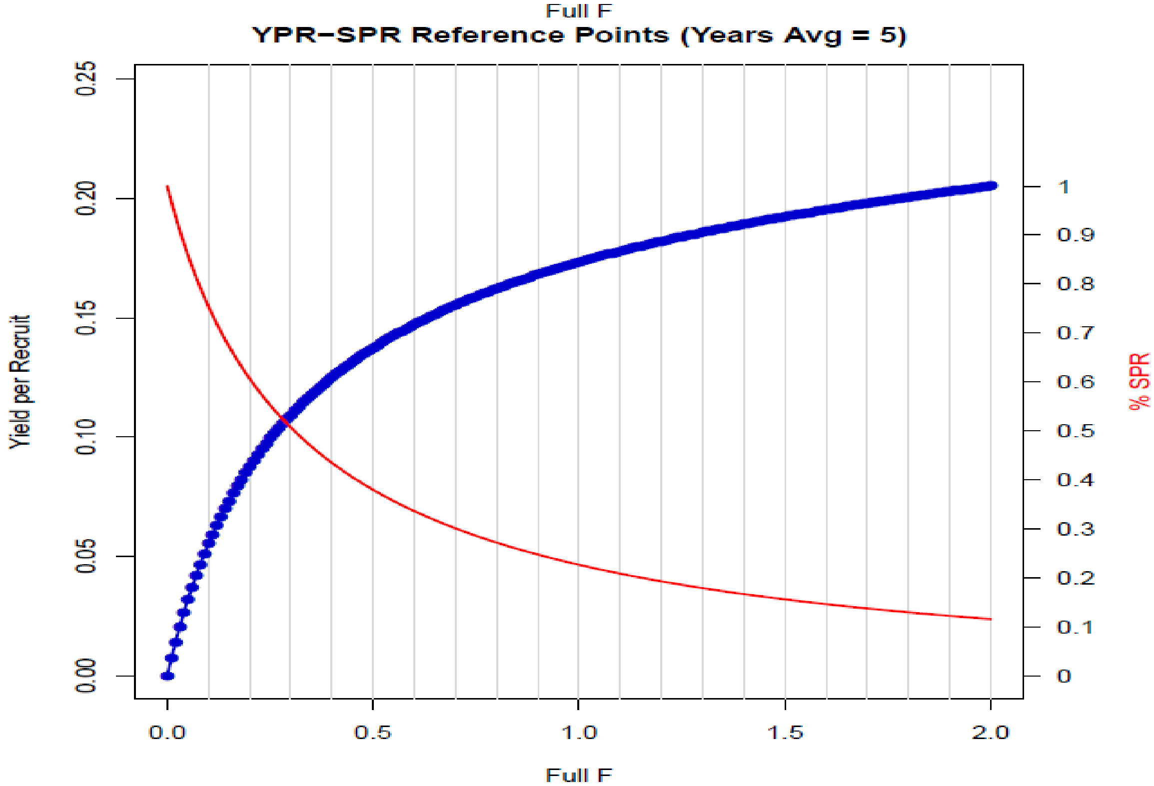


Figure 16.31 – Equilibrium plots of yield per-recruit (kg; blue dots) and spawning potential ratio, %SPR, for Sheepshead of the **Atlantic (top)** and **Gulf** (bottom) coasts of Florida under selectivity pattern averaged across 2011–2015.

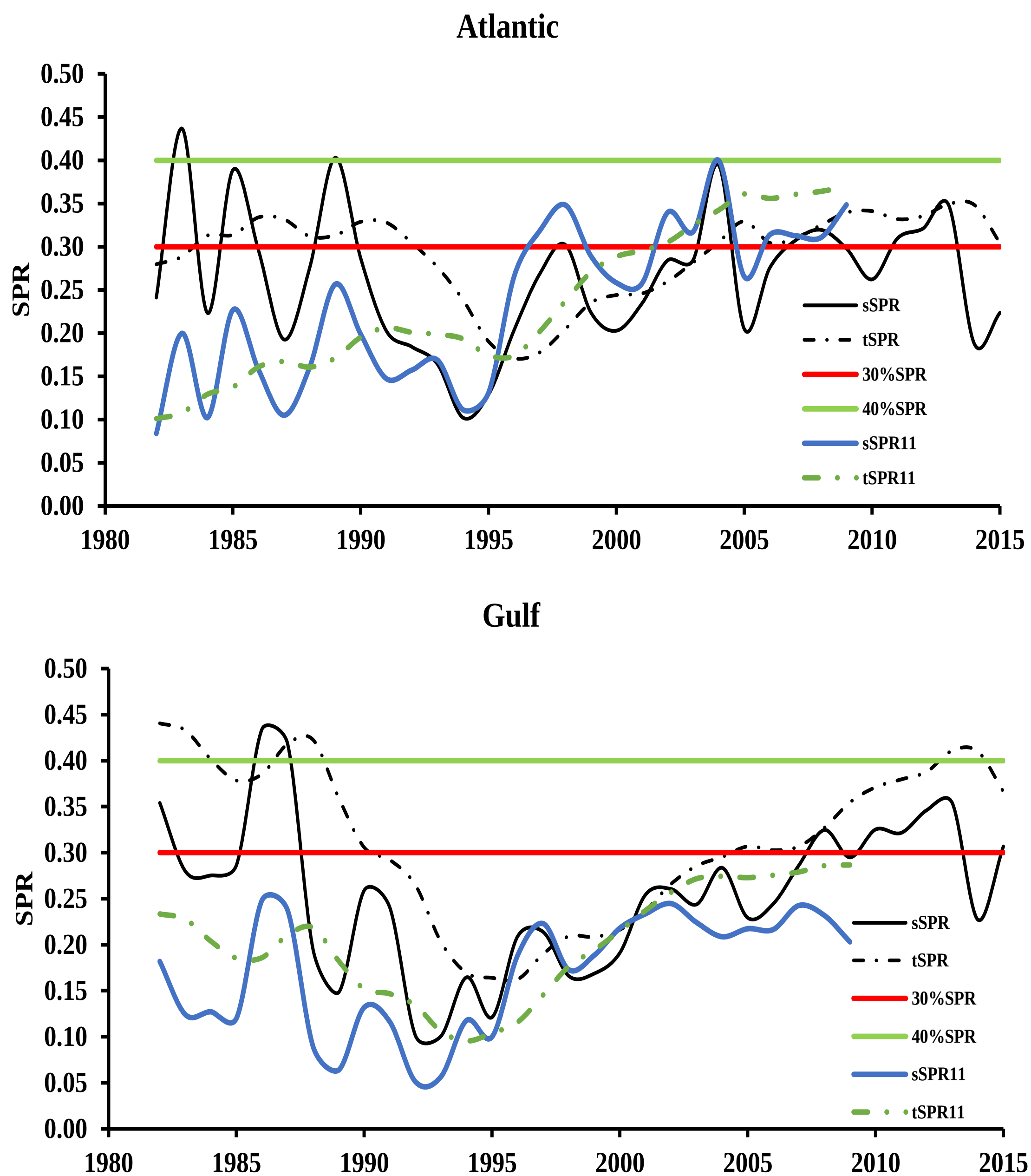
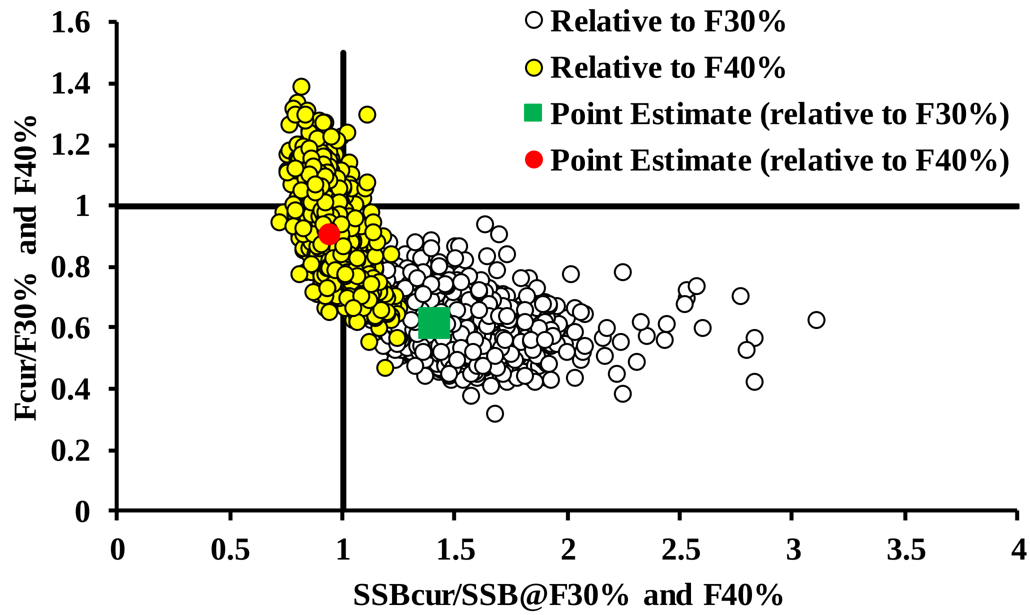


Table 16.32 – Static (full line) and transitional (dashed line) spawning potential ratios (sSPR and tSPR) estimated with ASAP based total fishing mortality by age and year for Sheepshead on the Atlantic coast and Gulf coast of Florida during 1982–2015. The levels of 30%SPR and 40%SPR are also indicated for comparison. The 2011 estimates of sSPR and tSPR (sSPR11 and tSPR11) are also shown for comparison.



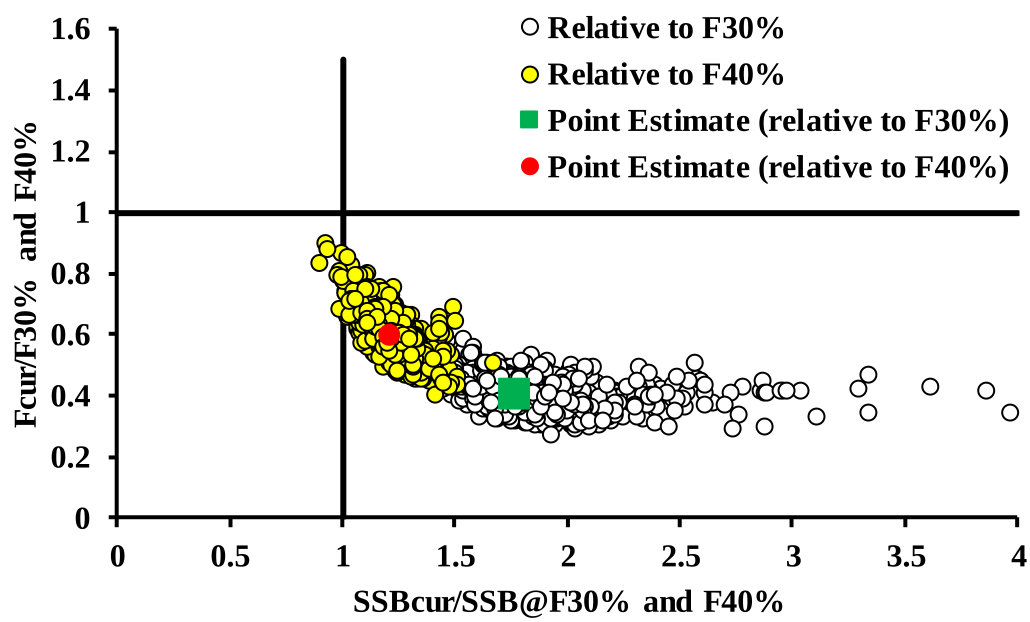


Figure 16.33 – Phase plots of the ratio of current fishing mortality (geometric mean of F_{2013}, F_{2014} and F_{2015}) to $F_{30\%}$ and $F_{40\%}$ ($F_{cur}/F_{@30\%}$ and $F_{cur}/F_{@40\%}$) versus the ratio of current spawning stock biomass (geometric mean of SSB_{2013}, SSB_{2014} and SSB_{2015}) to SSB at $F_{30\%}$ and at $F_{40\%}$ ($SSB_{cur}/SSB_{F@F30\%}$ and $SSB_{cur}/SSB_{F@F40\%}$) obtained from ASAP base model's MCMC simulations for Sheepshead on the Atlantic (top) and Gulf (bottom) coasts of Florida. Also shown are the point estimates of the model.