CATCH-AND-RELEASE MORTALITY OF SPOTTED SEATROUT

by

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Abstract

The spotted seatrout (*Cynoscion nebulosus*) is a highly sought-after marine sportfish along the Gulf Coast and in Texas. Despite the apparent abundance of spotted seatrout, increasing fishing pressure has raised concerns over its sustainability, particularly as it relates to the larger individuals. As a result, a maximum size limit management regulation has been enacted that requires the release of larger individuals. This strategy will work only if the fish survive post-release. The purpose of this study was to estimate catch-and-release mortality associated with hook-and-line captured spotted seatrout by recreational anglers as a function of anatomical hooking location, season, and tournament-related mortality. From July 2004 to June 2005, a total of 479 spotted seatrout ranging from 220 – 555 mm TL were captured by hook-and-line in Aransas and Corpus Christi Bays and maintained in replicated 3.5-m^3 field enclosures for 72 h. Overall mortality for the experimental studies was 19%. For anatomical studies, hooking location was assigned to four body regions: mouth, gills, esophagus, and external. Study results suggest anatomical hooking location is a major factor influencing spotted seatrout mortality. Fish hooked in the gills and esophagus had mortality rates of 75% and 95%, respectively, whereas fish hooked external and in the mouth had mortality rates of 8% and 10%, respectively. A significant relationship was found between season and catch-and-release mortality of spotted seatrout with higher mortality rates in spring and summer months than fall and winter. Trends were observed when examining monthly mortality rates and environmental conditions. These trends showed significant relationships with water temperature, dissolved oxygen, and salinity. Data was also collected on 1,373 spotted seatrout from nine live-release tournaments. Overall tournament mortality was 23% with initial and delayed mortality rates of 11% and 14%, respectively. To assess delayed long-term tournament survival, fish were maintained in a laboratory holding facility for up to 30 d. These results reveal a high percentage (>80%) of tournament caught fish survive post-release. No significant relationship was observed between size class and percent mortality of fish caught during the seasonal study or tournament-caught fish held for long-term studies. A tagging study was conducted to assess movement and long-term, post-release survival of spotted seatrout. Seven hundred twenty-six spotted seatrout were tagged and released. Tag recovery rate was 1.2% with a total of nine fish recaptured with variable movement patterns. Overall, relatively low mortality rates for hook-and-line captured spotted seatrout were observed suggesting current catch-and-release management regulations in the spotted seatrout fishery are a viable management strategy.

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Acknowledgements

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Introduction

The spotted seatrout (*Cynoscion nebulosus*) is a highly sought-after marine sportfish along the Gulf Coast and in Texas (Blanchet et al. 2001; VanderKooy and Muller 2003; Anderson and Ditton 2004). They are an estuarine-dependent species often found in association with seagrass beds such as *Halodule wrightii*, *Thalassia testudinum*, and *Ruppia maritima*. They are also found in association with other estuarine habitats including sandy bottoms, submerged or emergent islands, oyster reefs, and near tidal inlets (Perret et al. 1980; Blanchet et al. 2001). The popularity of this sportfish is due to their close association with estuarine habitats making them accessible to both shore and boat anglers and because of their ease of capture (Blanchet et al. 2001). Anglers are able to successfully use a variety of fishing techniques ranging from live to artificial baits to catch spotted seatrout (VanderKooy and Muller 2003). A majority of Texas saltwater anglers (~750,000) fish for spotted seatrout with 72% of the recreational fishing trips targeting this species (Green and Campbell 2005).

The popularity of spotted seatrout in Texas equates to economic gain for coastal communities. A spotted seatrout angler survey conducted by Texas A&M University and Texas Parks and Wildlife Department (TPWD) found the average cost of a typical fishing trip targeting spotted seatrout was US$132 (Ditton 1993). The typical fishing trip lasted two days with round-trip travel of 170 miles. An estimated $495 million was spent by these anglers in 1992 fishing for this species. Their major expenditures were for transportation, lodging, boat operation, food, drinks and ice. These figures do not include equipment purchases of boats, rods, reels, and other expenditures (Ditton 1993). Texas Parks and Wildlife Department has reported that fishing effort since 1992 has increased

20% for private boat anglers and 300% for guided anglers. The number of Texas saltwater anglers is expected to continue increasing over the next few decades (Green and Campbell 2005).

Despite the economic benefits created by the fishery, increasing fishing pressure has raised concerns over its sustainability. Over one million spotted seatrout are harvested annually by Texas anglers (Green and Campbell 2005). Analyses of gill net surveys conducted by TPWD from 1975 to 2003 indicate spotted seatrout population numbers in Texas are increasing (Martinez-Andrade et al. 2005). Texas Parks and Wildlife Department has reported the spotted seatrout spawning biomass to be at an all-time high. While an increase in spotted seatrout availability and spawning biomass would appear to indicate a healthy fishery, TPWD gill net surveys also indicate a decline in the species mean length (Martinez-Andrade et al. 2005); a common indication of overfishing (Hilborn and Walters 1992). Fishery scientists are concerned by this trend coupled with the projected increase in fishing pressure along coastal areas (VanderKooy and Muller 2003). Some angling groups comprised of recreational fishermen and fishing guides are also concerned by this trend and want to increase the potential to catch "trophy" spotted seatrout, trout over 635 mm (25 in).

Texas has managed the spotted seatrout fishery since 1978 in response to overfishing and catastrophic events that have affected the fishery (Blanchet et al. 2001). In 1978, Texas adopted a minimum size limit of 305 mm (12 in) and a bag limit of 20 for recreational anglers (Hegen et al. 1984). In 1981, the state legislature declared spotted seatrout a gamefish and banned the sale of native spotted seatrout, thus eliminating the commercial fishery of the species in Texas waters (Blanchet et al. 2001). Adjustments to the spotted seatrout fishing regulations have since occurred to improve the health of the fishery. In 1984, the minimum size limit was increased to 356 mm (14 in) and the bag limit was decreased to 10. The minimum size limit was increased six years later in June 1990 to the present limit of 381 mm (15 in) (Blanchet et al. 2001). The most recent modification to the regulations occurred in 2003 when TPWD created a controversial slot regulation by adding a maximum size limit of 635 mm (25 in) to the pre-existing minimum size limit of 381 mm (15 in). The modification allows anglers to retain only one fish over the maximum length of 635 mm (25 in) per day (TPWD 2003).

The regulation on maximum size is an attempt to increase the relative stock density of trophy spotted seatrout, trout over 635 mm (25 in). Analyses of gill net surveys conducted by TPWD from 1982 to 2000 estimate 3.5% of the spotted seatrout population is ≥ 660 mm (26 in) in total length (TPWD unpublished data). Creel interviews conducted by TPWD indicate 2% of recreational fishing trips catch one trophy spotted seatrout and less than 1% catch more than one. Models created by TPWD project an additional 75,000 trophy spotted seatrout for the fishery with a 20% reduction in landings (TPWD unpublished data). However, the modification has been highly criticized by some angling groups even before its inception. These groups contend the fishery will not benefit from this change but will suffer due to potentially high mortality rates associated with the release of over-sized spotted seatrout. Even with data presented by TPWD indicating 80 – 90% of spotted seatrout survived catch-and-release, these angling groups remained opposed to the modification. Their opposition to the modification has caused renewed interest in determining the mortality rate of spotted seatrout released following capture by hook-and-line.

The practice of “catch-and-release” is the hooking, playing, landing, and releasing of a fish. The first use of catch-and-release in a fishery management program occurred in 1952 on Michigan trout streams noted for naturally-reproducing populations of high-quality fish (Radonski 2002). An objective of the program was to quantify trout post-release mortality. Anglers were required to release all fish and to use only artificial baits to minimize post-release mortality. The program’s goal was to eliminate the need for expensive stocking programs, the principle management tool at the time (Radonski 2002). Albert Hazzard, a fishery scientist, is credited with the program’s concept of catch-and-release, originally termed “fishing-for-fun.” The Hazzard Plan, as the program would be called, was a popular trout management program adopted by many states (Barnhart 1989; Radonski 2002). The plan was also used for other freshwater species including muskellunge (*Esox masquinongy*) and largemouth bass (*Micropterus salmoides*) (Radonski 2002). “Fishing-for-fun” eventually became known as “catch-and-release fishing,” and as the term changed so did the general rules (Barnhart 1989; Radonski 2002). Anglers were still encouraged to release most of their catch but were allowed to retain some fish depending on existing fishery management regulations. These regulations included size and bag limits (Barnhart 1989).

Today, catch-and-release in the United States has increased in popularity with anglers and as a management tool with fishery managers (Barnhart 1989; Pope and Wilde 2004). Pope and Wilde (2004) reported two primary reasons for the increased practice of catch-and-release. First, anglers have adopted a philosophy of catch-and-release as a conservation measure intent on maintaining or improving the quality of the fishery. Secondly, increasing fishing pressure coupled with finite fishery resources has necessitated that fishery managers create regulations that promote catch-and-release including no-take, bag and possession limits, and minimum and maximum size limits (Matlock 2002; Radonski 2002; Pope and Wilde 2004). Several freshwater and anadromous species have benefited from the enactment of regulations promoting catch-and-release including rainbow trout (*Oncorhynchus mykiss*) and Atlantic salmon (*Salmo salar*) (Barnhart 1989). Saltwater species have also benefited from such regulations including red drum (*Sciaenops ocellatus*) and striped bass (*Morone saxatilis*) (Diodati and Richards 1996; Matlock 2002; Radonski 2002). Clearly, the success of catch-and-release depends upon the post-release survival of the fish, and for many marine species such data does not exist (Matlock 2002).

Several studies have examined the mortality of spotted seatrout associated with catch-and-release but reported wide ranging mortalities (0 - 56%). Each study captured spotted seatrout on hook-and-line gear (rod and reel) using single and treble hooks with natural and artificial baits. Matlock and Dailey (1981) observed hooking mortalities of 56% in August and 0% in September. Hegen et al. (1984) reported the mortality rate to range from 37% in the summer to 16% in the winter, with an overall mortality rate of 27%. Matlock et al. (1993) found the mortality rate for spotted seatrout caught in July and August to be 7.3%. Murphy et al. (1995) reported the mortality rate for spotted seatrout caught in Florida to be 4.6%, and Duffy (2002) determined the mortality rate for spotted seatrout caught in Alabama to range from 9.1 – 16.3% depending on hook type. This wide variation in mortality rates may be attributed to differences in study design including the lack of control fish, limited replication, and various handling techniques. While these studies provided useful information on spotted seatrout mortality, none examined seasonal mortality or tournament-related mortality, and only Murphy et al. (1995) examined mortality associated with anatomical hooking location. There is a need to fully examine seasonal mortality with replicates, effects of anatomical hooking location, and mortality associated with tournament fishing to understand catch-and-release mortality in the spotted seatrout fishery.

Hooking mortality is usually dependent upon several variables including species of fish, environmental conditions, variation within and between populations, gear selection, and anatomical location of hook wounds. One of the more obvious causes of hooking mortality is the location of hook wounds or anatomical hooking location (Muoneke and Childress 1994). One of the most studied marine species in terms of mortality associated with anatomical hooking location has been the striped bass (Cooke and Suski 2005). Diodati and Richards (1996) reported the mortality rate of striped bass hooked in the head, jaws, fins, and body was 5.8% and those hooked in the eyes, gills, and esophagus was 24%. They also observed striped bass hooked anterior to the pharynx experienced a 5.3% mortality rate and those hooked in or posterior to the pharynx experienced a 25.9% mortality rate. Lukacovic and Uphoff (2002) reported increasing mortality with depth of anatomical hooking location in striped bass. They observed an 8.2% mortality rate for fish hooked in the lip, mouth or gills and a 54% mortality rate for fish hooked posterior to the gills. Millard et al. (2003) reported higher mortality rates for striped bass hooked both anterior and posterior to the gills. Fish hooked anterior to the gills had a 27% mortality rate and fish hooked posterior to the gills experienced a 69% mortality rate.

Other marine species have been examined to determine the mortality associated with anatomical hooking location. Carbines (1999) observed New Zealand blue cod (*Parapercis colias*) hooked in the lip and mouth had 0% mortality while fish hooked in the gills and gut had 60% and 87.5% mortality, respectively. Taylor et al. (2001) determined the mortality rate associated with anatomical hooking location of common snook (*Centropomus undecimalis*) increased from 1.2% for fish hooked in the mouth to 16.7% for gut-hooked fish. Aalbers et al. (2004) reported 0% mortality for white seabass (*Atractoscion nobilis*) hooked anterior to the esophagus and 67% mortality for fish hooked in the esophagus. Two studies have examined anatomical hooking location mortality in sciaenids. Jordan and Woodward (1992) observed that the mortality rate of red drum increased with the depth of ingestion of the hook. Red drum hooked in the maxilla had a mortality rate of 8.4% increasing to 32.5% and 52.8% for fish hooked in the gills and esophagus, respectively. Murphy et al. (1995) found that spotted seatrout showed a combined mortality rate of 1.7% for fish hooked in the jaw and inside the mouth and a 26.4% mortality rate for fish hooked in the gut. In general, mortality is higher for fish hooked deep within the oral cavity and in vital organs (Muoneke and Childress 1994).

Competitive sportfishing tournaments have increased over the last thirty years (Shupp 1979; Duttweiler 1985; Schramm et al. 1991b). In 1989 the American Fisheries Society (AFS) Competitive Fishing Committee conducted a survey to obtain information about competitive fishing activities on inland and marine waters in North America. An annual total of 20,697 competitive fishing tournaments were reported (Schramm et al. 1991b). Schramm et al. (1991b) estimated the annual total to be at least 31,000 tournaments after adjustments for agencies not responding and incomplete reporting. Texas reported 402 tournaments on inland waters targeting largemouth bass (95%) and striped bass (5%). Thirty-three tournaments were reported in marine waters targeting spotted seatrout (36%), red drum (29%), mackerel (*Scomber* spp. and *Scomberomorus* spp.) (27%), billfish (*Xiphias gladius* and Istiophoridae) (27%) and sharks (Squaliformes) (9%) (Schramm et al. 1991b). Oh et al. (2005) reported the number of saltwater fishing tournaments held in Texas during 2003 had increased to 183 events. Anderson and Ditton (2004) reported 14% of Texas saltwater anglers have participated in a saltwater fishing tournament. Eighty-seven percent of those anglers had participated in a tournament within the previous twelve months (Anderson and Ditton 2004).

Negative impacts from competitive fishing tournaments on fishery resources have long been concerns of fishery managers, tournament organizers, and the general public (Barnhart 1989; Schramm et al. 1991a; Schramm et al. 1991b; Radonski 2002). Concerns regarding intensified harvest and sustainability of fish stocks have lead more tournament organizers to adopt live-release formats, encouraging anglers to keep their fish alive throughout the tournament (Nielsen 1985; Barnhart 1989; Fielder and Johnson 1994; Muoneke and Childress 1994; Radonski 2002). Live-release tournaments reduce mortality at weigh-in; however, there is much concern regarding post-release survival (Plumb et al. 1988; Schramm et al. 1991a; Muoneke and Childress 1994). Unlike catch-and-release with recreational anglers, tournament anglers subject their fish to considerably more stress. Stressors include maintaining fish in on-board live-wells for extended periods of time, the weigh-in process, and photographic opportunities. The additional stress subjected on tournament fish may increase the potential for post-release mortality. Numerous studies have examined the initial (at weigh-in) and delayed (at time of release) mortality of freshwater fish, but research is lacking for marine fish (Muoneke and Childress 1994; Wilde et al. 2003).

Fish tagging programs have provided fishery managers with valuable biological information on the tagged species and have helped in the development of fishery management strategies (McFarlane et al. 1990). Tagging programs have been used to determine stock contribution, population statistics, age and growth, behavior, movement, and survival (Hilborn et al. 1990; McFarlane et al. 1990; Guy et al. 1996). The first tagging program in the United States was conducted by Charles G. Atkins in 1873 when he marked Atlantic salmon in the Penobscot River, Maine, with a dangler-type tag (McFarlane et al. 1990). A variety of external tags have been used including Peterson discs, Carlin tags, internal anchor tags, dart tags, and Floy t-bar anchor tags (McFarlane et al. 1990; Guy et al. 1996). Each tag has a set of limitations that must be considered when designing a tagging program (McFarlane et al. 1990). A thorough knowledge of the species biology is important when selecting a tag to insure that survival and behavior are not affected (McFarlane et al. 1990; Guy et al. 1996). Assumptions associated with tagging programs are that all tagged fish will retain their tags and tagged fish will be recognized and reported (Guy et al. 1996). Selection of the proper fish tag can increase retention (Ebener and Copes 1982; Dunning et al. 1987; Franzin and McFarlane 1987; Muoneke 1992), and tag recognition and reporting can increase with highly visible tags, monetary rewards, and public education (Matlock 1981; Green et al. 1983).

Several tagging studies along the Atlantic and Gulf Coasts have examined spotted seatrout movement and migration patterns (Guest and Gunter 1958; Lucy et al. 1999;

Blanchet et al. 2001). Virginia studies have reported resident fish within the Chesapeake Bay system (Lucy et al. 1999). Louisiana and Florida studies have reported most fish remain within 50 km of their release point, rarely leaving the estuary (LDWF 2000; Blanchet et al. 2001). Studies in South Carolina, Alabama and Mississippi indicate little movement from point of release with fish generally traveling less than 32 km (Wenner and Archambault 1996; Blanchet et al. 2001). Tag returns in Texas indicate a majority of spotted seatrout (84%) were caught in the bay of release with little inter-bay movement (Guest and Gunter 1958; Blanchet et al. 2001). However, fish may travel great distances, as was the case with a spotted seatrout tagged in Florida that traveled over 500 km to Louisiana (Blanchet et al. 2001). Tag recovery rates were 1 – 12% in studies examined by Blanchet et al. (2001). Texas Parks and Wildlife Department has had a recovery rate of 5% since 1950, tagging 44,072 spotted seatrout with 2,255 fish recaptured (TPWD unpublished data).

The purpose of this study was to assess spotted seatrout mortality caused by recreational and tournament fishing. Specifically, this study assessed the catch-and-release mortality of spotted seatrout in the recreational fishery as a function of anatomical hooking location, seasonality, and tournament-related mortality. A tagging study was also conducted to assess movement and long-term, post-release survival of spotted seatrout.

Objectives

1) Examine the relationship of anatomical hooking location and mortality in hook-and-line capture of spotted seatrout.

    H_{O1}: Mortality rates of spotted seatrout do not vary with changes in anatomical hooking location.

H_{A1}: Spotted seatrout mortality is dependent upon anatomical hooking location.

2) Examine the seasonal catch-and-release mortality of spotted seatrout.

H_{O2}: There is no relationship between the mortality rate of spotted seatrout and season of capture.

H_{A2}: Catch-and-release mortality of spotted seatrout varies seasonally.

3) Examine the mortality rate of spotted seatrout caught in live-release fishing tournaments.

H_{O3}: The tournament format does not increase the catch-and-release mortality rate of spotted seatrout.

H_{A3}: Catch-and-release mortality of spotted seatrout increases during tournaments.

Methods

Study site.—Aransas and Corpus Christi Bays are primary bays located along the middle Texas coast. Surface area of Aransas Bay is 447 km^2 and Corpus Christi Bay is 485 km^2. They are barrier-built, positive estuaries with freshwater inflow from the Aransas and Mission Rivers for Aransas Bay and the Nueces River for Corpus Christi Bay. Aransas Bay is connected to the Gulf of Mexico via a single tidal inlet, Aransas Pass. Corpus Christi Bay is connected to the Gulf of Mexico via two tidal inlets, Aransas Pass and the recently reopened Packery Channel. Like other Texas bays, Aransas and Corpus Christi Bays are shallow bays, both with a maximum depth of 3.1 m. Bay margins slope gently, less than one percent, for a distance of about 0.8 km into the deeper central bay. Sediment composition along the bay margins consists primarily of sand-sized grains with small amounts of silt and clay (Britton and Morton 1997). The gentle slope and sediment composition provide ideal conditions for the establishment of seagrass beds, a habitat with which spotted seatrout are often associated (Perret et al. 1980; Blanchet et al. 2001).

The seagrass beds, sandy bottoms, and submerged/emergent islands of Aransas and Corpus Christi Bays provide ideal habitats for spotted seatrout (Perret et al. 1980; Blanchet et al. 2001). Texas Parks and Wildlife Department spring gill net surveys indicate near record abundance levels of spotted seatrout in Aransas and Corpus Christi Bays (TPWD 2005). Saltwater anglers are aware of the prime fishing conditions within these bays. Anderson and Ditton (2004) reported Corpus Christi and Aransas Bays are the second and third heaviest fished bays in Texas, respectively. Specific study sites were Mud Island in Aransas Bay (27°56’ N 97°01’ W) and Shamrock Cove in Corpus Christi Bay (27°45’ N 97°09’ W). These sites were selected on the basis of fishing productivity (Zaidle 2003) and close proximity to the field enclosures.

Field enclosures.—For the short-term (72-h) studies, five replicate field enclosures were constructed to maintain four experimental groups and one control group of spotted seatrout. The enclosures had dimensions of 2.4 m (L) x 1.2 m (W) x 1.2 m (H) and were constructed with 1.9-cm polyvinylchloride (PVC) pipe surrounded with 1.9-cm extruded plastic mesh attached with plastic cable ties. Holes were drilled in the bottom and side frames to allow enclosures to sink. Enclosures were secured beneath a dock allowing shade in a residential canal located on Mustang Island, Texas. Water depth was approximately 1.5 m under the dock and enclosures were completely covered by water, dependent upon tide level, during most experimental trials.

Capture method.—To assess the effect of caging on mortality, a control group of spotted seatrout was captured on hook-and-line (rod and reel) using 6.4 cm (2.5 in) soft plastic swimming baits (Tsunami, Mahwah, NJ) at night under illuminated lights adjacent to the field enclosures. Each control fish was landed with minimal handling and immediately placed in a designated enclosure. The control group consisted of five fish maintained in one enclosure. During a previous study, control fish were successfully captured using this method with 100% survivorship suggesting no caging effect.

Experimental fish were captured by hook-and-line (rod and reel) using 12.7 cm (5 in) soft plastic swimming baits (Salt Water Assassin, Bass Assassin, Mayo, FL, and Texas Trout Killer, Texas Tackle Factory, Victoria, TX) with 1.8 g (1/16 oz) jig heads (Assassin Jighead, Bass Assassin, Mayo, FL). All fish were landed by hand gripping the fish dorsally near the nape and humeral region. Hooks were removed from each fish either by hand or with pliers and anatomical hooking location was recorded. Anatomical hooking locations were designated among four body regions (mouth, gills, esophagus, and external) as modified from Nelson (1998) (Figure 1).

Fish were placed in floating mesh baskets (45 cm diameter, 65 cm length; Flo-Well, Suncoast of America, Inc., Morehead City, NC) for at least 30 min but less than 60 min with a maximum of five fish per basket. Fish used in the anatomical hooking location study were placed in pre-designated baskets according to anatomical hooking location. Following the holding period, fish were removed from the baskets, measured in total length (mm), and placed in oxygenated, insulated short-term holding boxes (143 L cooler, Igloo, Katy, TX) for transport to the field enclosures. Water quality of the holding boxes was frequently monitored and maintained approximately at ambient water conditions (salinity, temperature, and dissolved oxygen). For each treatment, five fish were maintained in each replicate field enclosure with the goal of eight replicates total (N = 8; 40 fish total). Fish hooked in the mouth were used for both seasonal and anatomical hooking location mortality studies. Fish hooked in the gills, esophagus, and external were only used in the anatomical hooking location mortality study. In certain instances, fish died during transport, and four fish were used in some replicates.

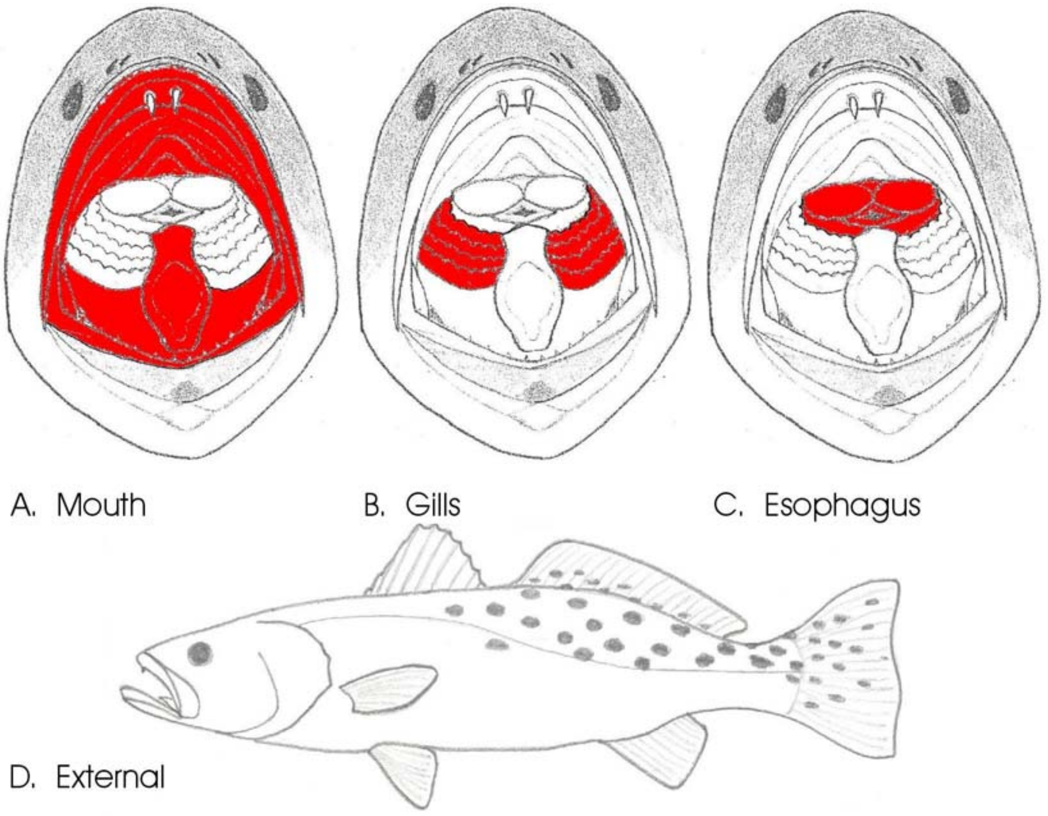

Figure 1. Four designated body regions for anatomical hooking location study. Fish hooked in the blackened areas were designated as being hooked in the mouth (A), gills (B), and esophagus (C). Fish hooked outside the oral cavity were designated as external hooking (D). Figures by Jason T. James.

Observation period.—The field enclosures were monitored for 72 hrs. A 72-hr period was selected as the observation time based on other studies that determined mortality typically occurs within that time period (Klein 1965; Mason and Hunt 1967; Hunsaker et al. 1970; Marnell and Hunsaker 1970; Warner and Johnson 1978). Salinity (ppt, ‰), temperature (°C), and dissolved oxygen (mg/L) determinations were made twice daily to assess environmental conditions. After 72 hrs, mortality was assessed by removing fish from the enclosures. Fish were tagged and total length measured prior to release.

Tournament mortality.—Nine separate live-release tournaments were visited to assess tournament mortality. Initial and delayed mortality rates were determined and an overall tournament mortality rate was calculated for each event. Initial mortality rates were defined as the percentage of dead fish from the overall number of fish brought to weigh-in. A fish was considered dead if there was no operculum movement. Delayed mortality rates were defined as the percentage of fish that died in the tournament holding tanks from the original number of live fish placed in the tanks. Five tournaments allowed fish to be tagged and total length measured before post-tournament release. To assess delayed long-term mortality for two tournaments, a percentage of tournament fish were transported to a laboratory holding facility (TPWD/CCA Marine Development Center, Flour Bluff, TX) and maintained in large, circular holding tanks (12,160 L). A maximum of thirty fish per tank were monitored for 14 and 30 d. Fish were fed live shrimp or finfish every 3 – 4 d. Overall tournament mortality was the percentage of all dead fish, initial and delayed, from the overall number of fish brought to weigh-in. Water temperature (°C), dissolved oxygen (mg/L), and salinity (ppt, ‰) were recorded daily to assess environmental conditions in the holding tanks.

Movement Pattern.—Spotted seatrout from experimental trials and tournaments were tagged with a Floy FD-68B t-bar anchor tag using a Floy Mark II tagging gun (Floy Tag and Mfg. Inc., Seattle, WA). Tag insertion point was free of scales and in the left side of each fish, at 45° from the body, ventral to the middle of the second dorsal fin base. The tag head was inserted beyond the midline of the fish without penetrating the other side, and the tagging gun was rotated 90° to secure the tag head behind the pterygiophores (Ebener and Copes 1982; Franzin and McFarlane 1987; Muoneke 1992; Guy et al. 1996). Tags were gently tugged to ensure secure placement before releasing the fish (Guy et al. 1996). Printed on the tag shaft were an identification code, reward, TAMU-CC, and contact phone number. Identification code, capture date and location, total length, and release date and location were recorded for all tagged fish released. Anglers catching a tagged fish reported the identification code, recapture date and location, and total length. Days at-large (DAL) and distance traveled (km) were calculated for each tagged recovery. Anglers were given a certificate of appreciation and small monetary reward. Additionally, anglers catching pre-selected tournament fish received a fishing rod from the tournament organizer.

Statistics.—Single-factor Analysis of Variance (ANOVA; $\alpha = 0.05$) was used to analyze seasonal and monthly mortality. Mean percent mortality was calculated from each replicate field enclosure. Arcsine transformation, a data transformation converting binomial distribution of percentages to a nearly normal distribution (Zar 1996), was performed using the calculated mean percent mortality. Student’s t-tests ($\alpha = 0.05$) were used to analyze initial, delayed and overall mortality rates for tournaments allowing and prohibiting wadefishing. Simple linear regressions ($\alpha = 0.05$) were used to examine relationships between environmental conditions and seasonal and anatomical hooking location mortality and between fish size and mortality. Significant differences in ANOVA were further examined using Fisher's Least Significant Difference method to test for differences among treatment means ($\alpha = 0.01$).

Results

Anatomical Hooking Location Mortality.—A total of 479 spotted seatrout were captured to assess mortality associated with anatomical hooking location. Approximately 86% of these fish were hooked in the mouth, followed by 9% hooked in the esophagus and ~ 2.5% each hooked in the gills and external (Table 1). Ninety-two (19%) experimental fish died during the 72-hr observation period. The majority of these fish were hooked in the gills and esophagus. Highest survival rates were seen with fish hooked external (92.3%) and in the mouth (90%). Fish hooked in the gills and esophagus had lower survival rates, 25% and 4.7% respectively (Table 1). Replicate treatments for fish hooked external and in the gills were not possible because of low number of fish hooked in those anatomical locations. Replicate treatments for fish hooked in the esophagus were not possible because of high mortality immediately following capture.

Seasonal Mortality.—A total of 364 spotted seatrout were captured to assess seasonal mortality. The number of replicates and fish varied by season due to weather conditions and availability of fish. Twenty-two (6%) experimental fish died during the 72-hr observation period. Season was significantly (F = 5.404, *df* = 77, P = 0.002) associated with mortality (Figure 2). Fall and winter yielded mean percent survival rates of 100%. Spring and summer mean percent survival rates were 91% and 90%, respectively. For all trials, control fish experienced 100% survival over the 72-hr observation period.

Seasonal data was further examined for monthly mortality differences. Month of capture was also significantly (F = 2.96, *df* = 77, P = 0.003) associated with mortality (Figure 3). Mean percent survival increased from the lowest month of June (78%) gradually during the months of July, August, and September with mean percent survival rates of 88%, 90%, and 93%. Mean percent survival rates reached 100% from October to May with the exception of April (98%).

Table 1. Overall percent catch and survival of spotted seatrout per designated anatomical hooking location. The number of spotted seatrout caught on hook-and-line and released after 72-h observation period (total fish captured = 479; total fish released = 387; combined survival rate = 81%).

Anatomical Hooking Location	No. Caught	% Catch	No. Released	% Survival
Mouth	411	85.8	370	90.0
Gills	12	2.5	3	25.0
Esophagus	43	9.0	2	4.7
External	13	2.7	12	92.3

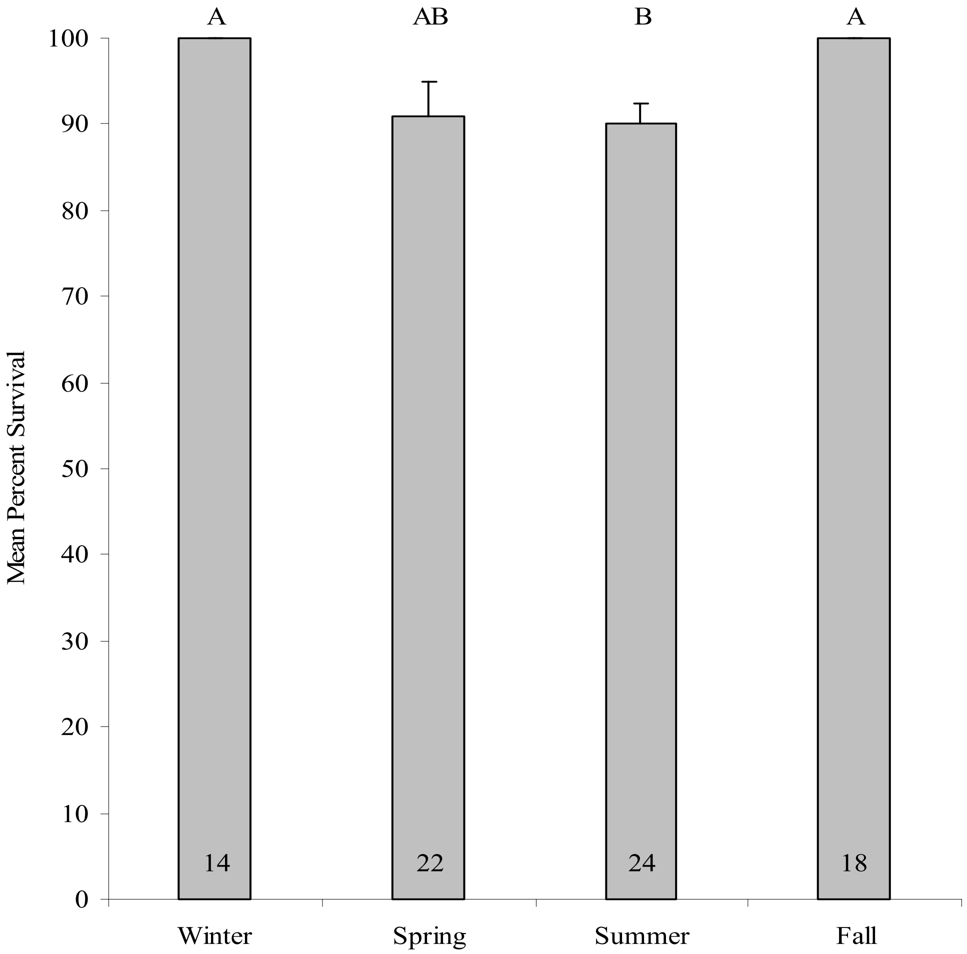

Figure 2. Seasonal mean percent survival (± SE) of hook-and-line caught spotted seatrout. Number of replicates per season are indicated at base of bar. Significant differences among seasons were observed (P = 0.002) and are indicated by letters above bars. Bars sharing the same letter are not significantly different (Fisher's PSLD; α = 0.01).

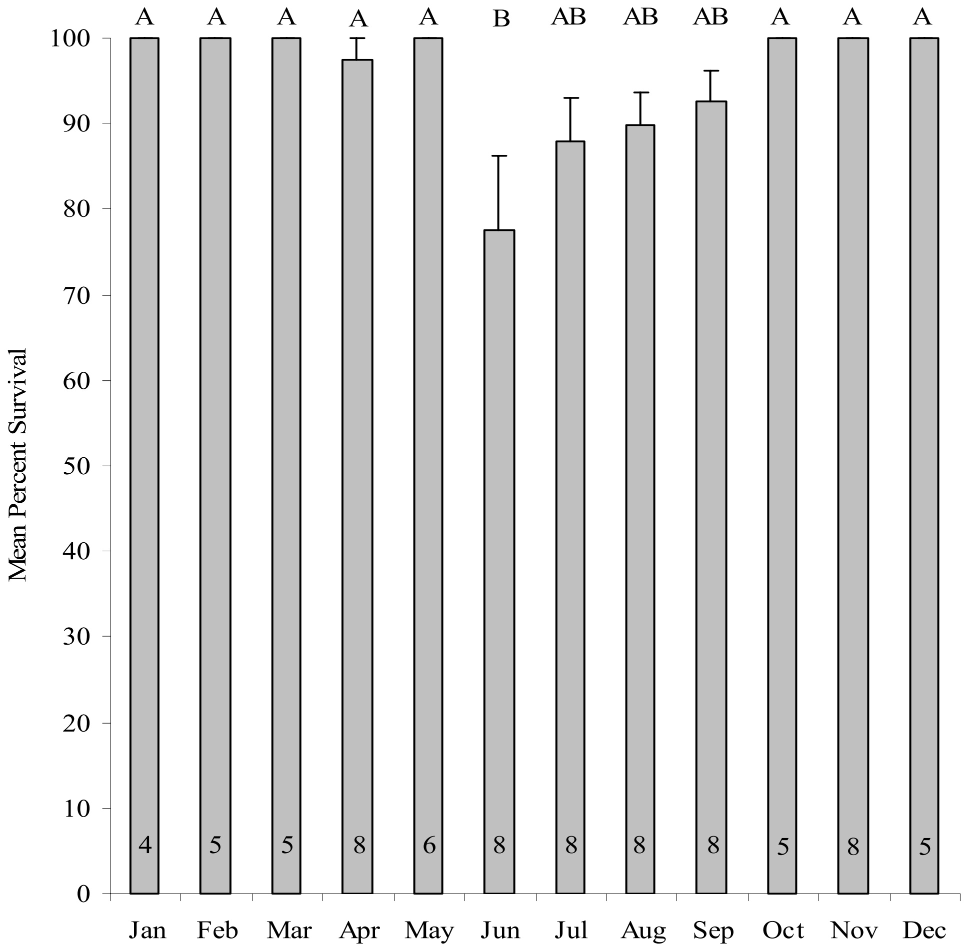

Figure 3. Monthly mean percent survival (± SE) of hook-and-line caught spotted seatrout. Number of replicates per month are indicated at base of bar. Significance differences among months were observed (P = 0.003) and are indicated by letters above bars. Bars sharing the same letter are not significantly different (Fisher's PSLD; α = 0.01).

Simple linear regression was used to assess the relationships between environmental conditions (water temperature, dissolved oxygen, and salinity) and mortality. Environmental conditions in the holding pens ranged 16.2 – 32.9ºC, 4.6 – 7.5 mg/L, and 25 – 34 ppt, ‰ (Table 2). Water temperature, dissolved oxygen, and salinity were significantly ($R^2 = 0.487$, $N = 27$, $P < 0.001$, $R^2 = 0.237$, $N = 27$, $P = 0.01$, and $R^2 = 0.183$, $N = 27$, $P = 0.026$, respectively) related to mortality for spotted seatrout hooked in the mouth (Figure 4, 5 and 6). Relationships between mortality rates of other anatomical hooking locations (gills, esophagus, and external) and environmental conditions were not observed with one exception (Table 3). Significance was observed with external-hooked spotted seatrout and dissolved oxygen ($R^2 = 0.993$, $N = 5$, $P < 0.001$).

Tournament Mortality.—Mortality was assessed from nine live-release fishing tournaments held from February 2004 – June 2005 (Figure 7). Combined overall mean percent survival was 76.8% with 1,373 fish brought to weigh-in and 1,036 fish released alive at the end of the 2-d tournament events. Combined initial and delayed mean percent survival rates were 89% and 86.1%, respectively (Figure 8). Tournaments allowing anglers to wadefish ($n = 6$) yielded a combined overall mean percent survival of 73.8% with initial and delayed mean percent survival rates of 87.7% and 84.2%, respectively. Tournaments prohibiting wadefishing ($n = 3$) yielded a combined overall mean percent survival of 82.9% with initial and delayed mean percent survival rates of 91.6% and 90%, respectively (Figure 9). However, initial, delayed, and overall mean percent survival between tournaments allowing and prohibiting anglers to wadefish were not significant ($t = -0.755$, $df = 7$, $P = 0.475$, $1 - \beta = 0.05$, $t = 1.49$, $df = 7$, $P = 0.18$, $1 - \beta = 0.153$, and $t = -1.307$, $df = 7$, $P = 0.233$, $1 - \beta = 0.109$, respectively).

Table 2. Mean monthly environmental conditions and percent survival of hook-and-line caught spotted seatrout. Environmental conditions, water temperature (°C), dissolved oxygen (mg/L), and salinity (ppt, ‰), were recorded twice daily and percent survival was calculated from replicate field enclosures during the 72-h observation period.

	Environmental Conditions			
Month	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Salinity (ppt, ‰)	% Survival
Jan	17.1	7.5	27	100
Feb	16.2	7.4	27	100
Mar	20.3	6.7	25	100
Apr	24.4	6.9	27	98
May	27.1	6.4	31	100
Jun	32.9	5.6	33	78
Jul	31.0	4.6	32	88
Aug	30.5	5.0	34	90
Sep	29.9	4.8	31	93
Oct	27.2	4.9	32	100
Nov	22.5	5.8	32	100
Dec	19.4	6.8	25	100

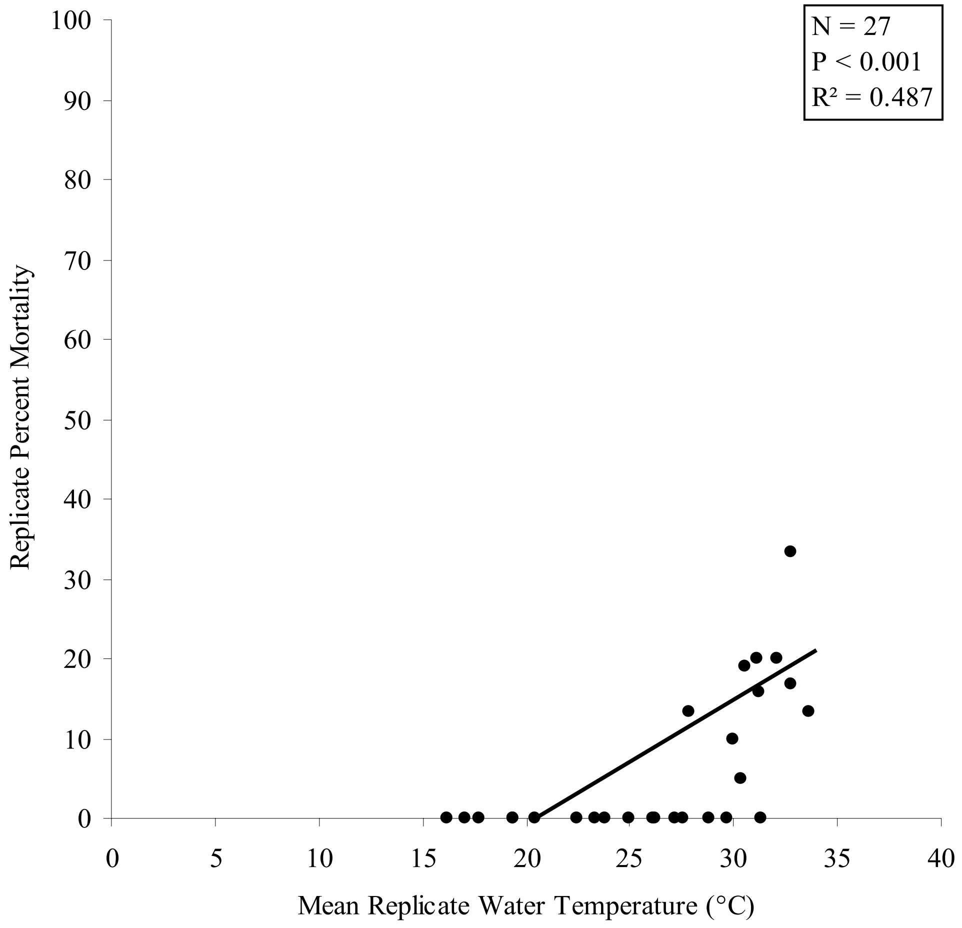

Figure 4. Relationship between mean replicate water temperature (°C) and replicate percent mortality of mouth-hooked spotted seatrout caught on hook-and-line. Water temperature was recorded twice daily and percent mortality was calculated from replicate field enclosures during the 72-h observation period. Mortality = 1.587 (water temperature) – 33.235.

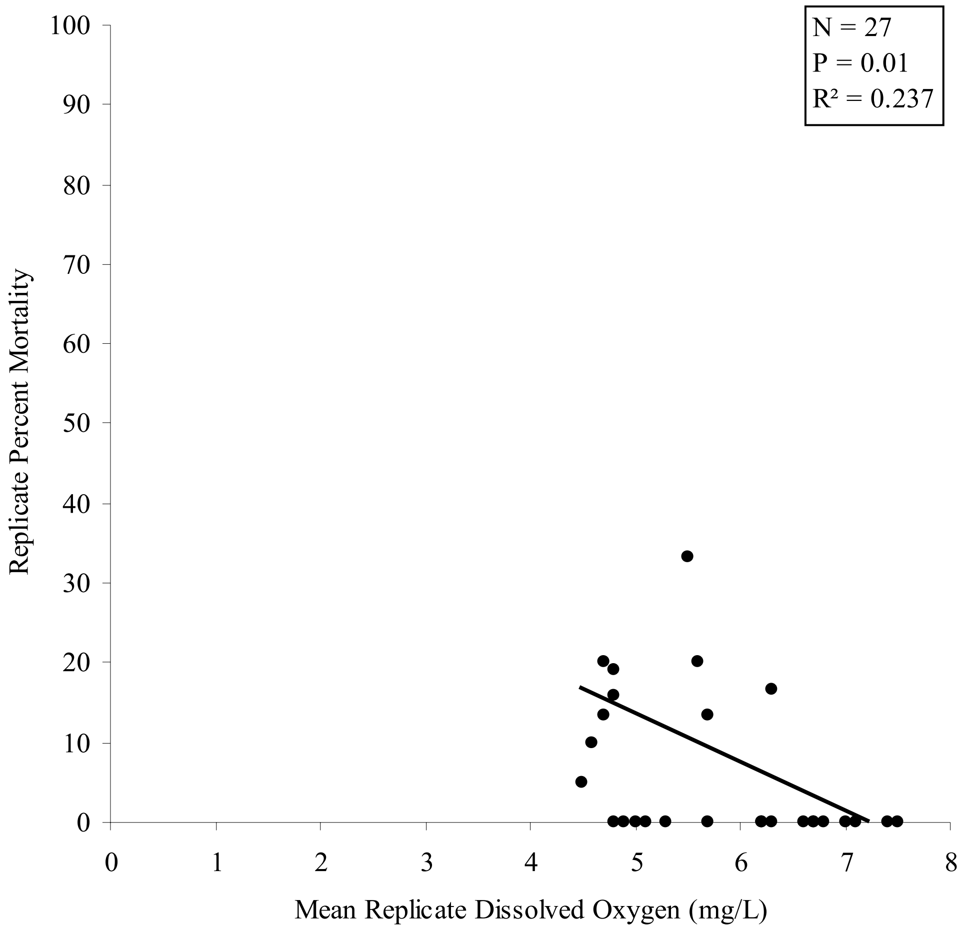

Figure 5. Relationship between mean replicate dissolved oxygen (mg/L) and replicate percent mortality of mouth-hooked spotted seatrout caught on hook-and-line. Dissolved oxygen was recorded twice daily and percent mortality was calculated from replicate field enclosures during the 72-h observation period. Mortality = -6.201 (dissolved oxygen) + 44.677.

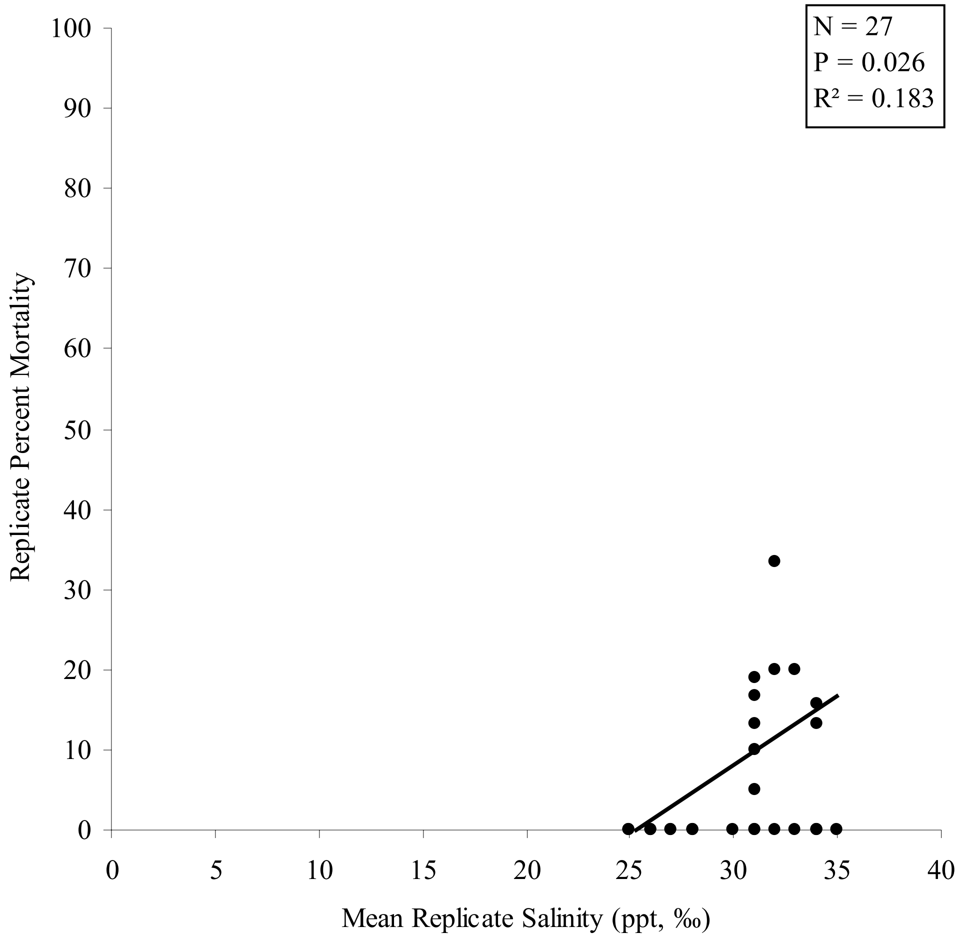

Figure 6. Relationship between mean replicate salinity (ppt, ‰) and replicate percent mortality of mouth-hooked spotted seatrout caught on hook-and-line. Salinity was recorded twice daily and percent mortality was calculated from replicate field enclosures during the 72-h observation period. Mortality = 1.677 (salinity) – 42.081.

Table 3. Relationships among mean replicate environmental conditions and replicate mortality rates by anatomical hooking location of spotted seatrout caught on hook-and-line. Environmental conditions, water temperature (°C), dissolved oxygen (mg/L), and salinity (ppt, ‰), were recorded twice daily and percent mortality by anatomical hooking location (mouth, gills, esophagus, and external) was calculated from replicate field enclosures during the 72-hr observation period. Italicized p-values indicate significance between environmental condition and anatomical hooking location.

	Environmental Conditions		
Anatomical Hooking Location	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Salinity (ppt, ‰)
Mouth	N = 27	N = 27	N = 27
	$P < 0.001$	*$P = 0.01$*	*$P = 0.026$*
	$R^2 = 0.487$	$R^2 = 0.237$	$R^2 = 0.183$
Gills	N = 7	N = 7	N = 7
	$P = 0.613$	$P = 0.276$	$P = 0.360$
	$R^2 = 0.055$	$R^2 = 0.230$	$R^2 = 0.169$
Esophagus	N = 16	N = 16	N = 16
	$P = 0.164$	$P = 0.865$	$P = 0.136$
	$R^2 = 0.133$	$R^2 = 0.002$	$R^2 = 0.152$
External	N = 5	N = 5	N = 5
	$P = 0.121$	*$P < 0.001$*	$P = 0.185$
	$R^2 = 0.606$	$R^2 = 0.993$	$R^2 = 0.495$

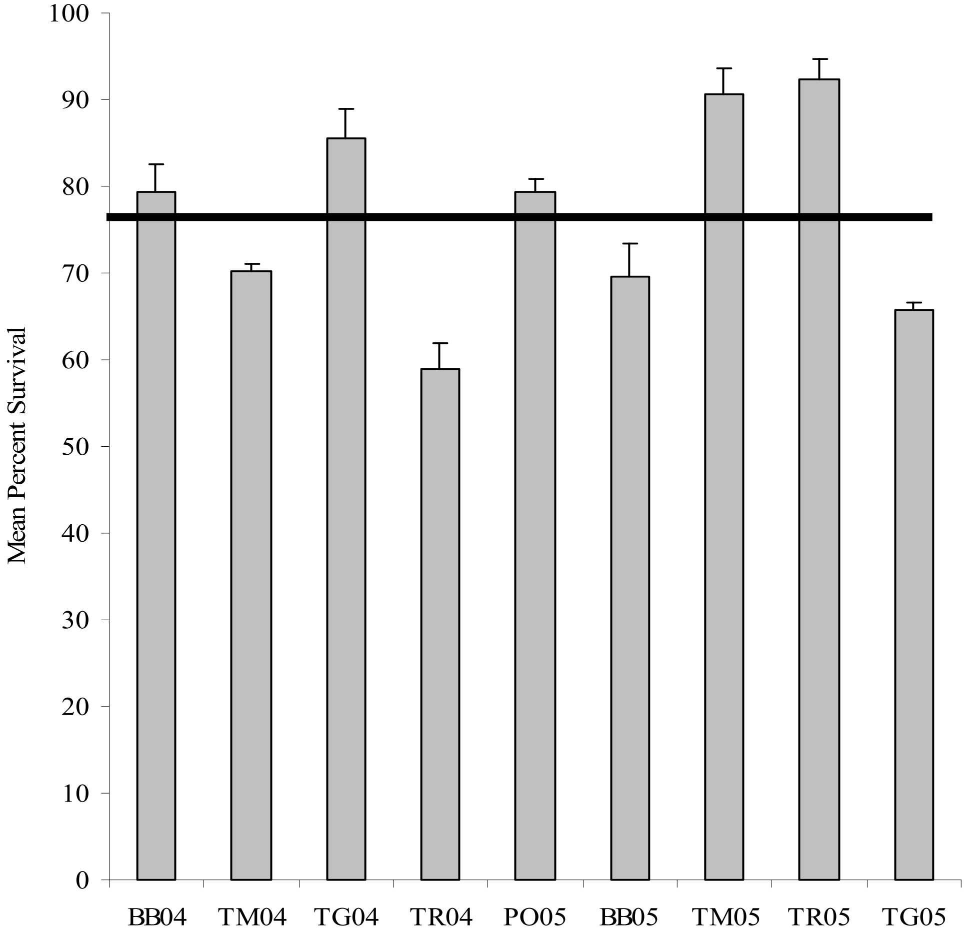

Figure 7. Overall mean percent survival (± SE) of spotted seatrout recorded at nine live-release fishing tournaments held from February 2004 – June 2005. Combined overall mean percent survival indicated by solid line across bars. Tournaments are indicated below bars by letter for tournament event (BB = Baffin Bash, TM = Troutmasters Matagorda, TG = Troutmasters Galveston, TR = Troutmasters Rockport, PO = Port O'Conner Bash) and number for year (04 = 2004, 05 = 2005).

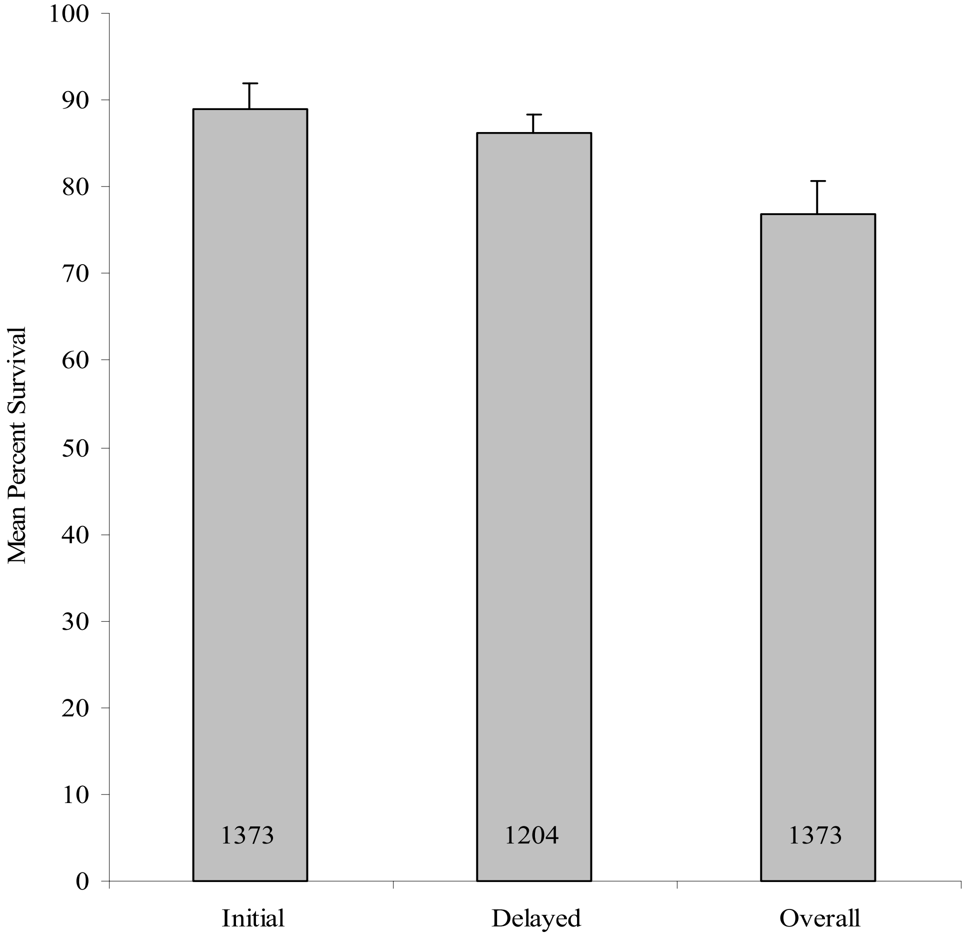

Figure 8. Combined mean percent survival (±SE) of spotted seatrout recorded during each observation period at nine live-release fishing tournaments held from February 2004 – June 2005. Number of fish during each observation period indicated at base of bar. Observation periods: initial = at weigh-in, delayed = holding tanks pre-release, overall = number of fish released of total number brought to weigh-in.

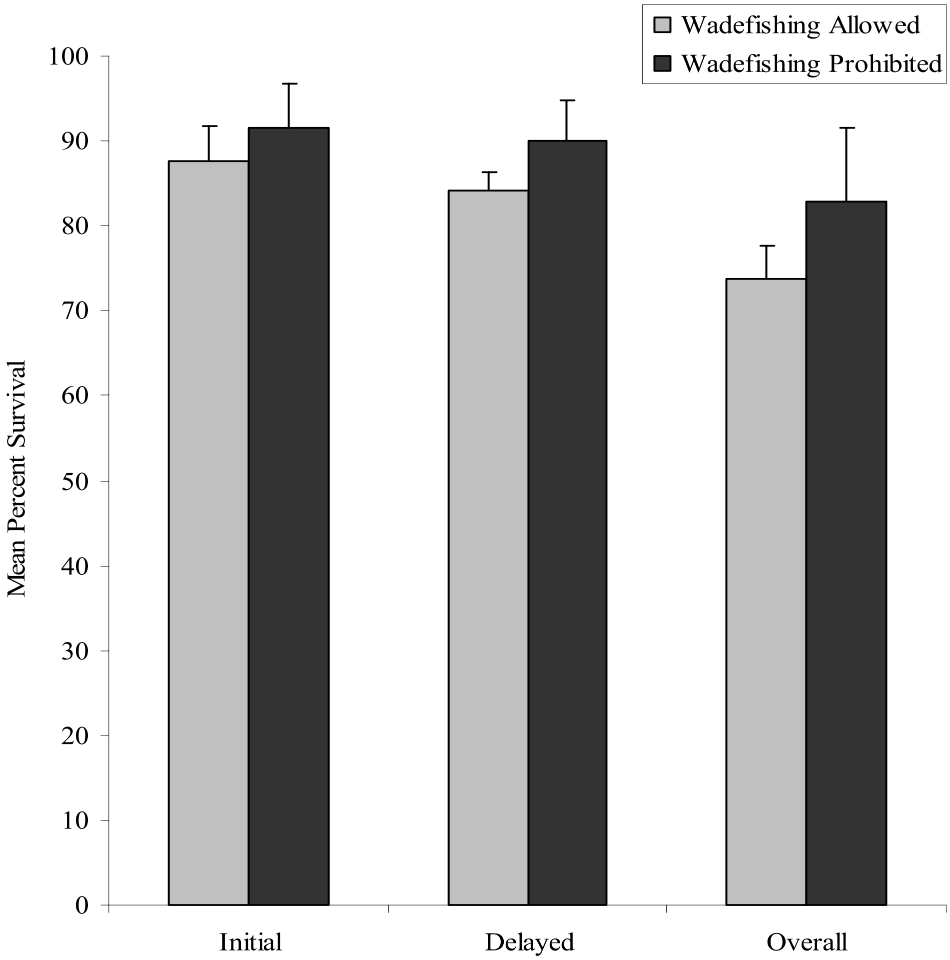

Figure 9. Combined mean percent survival (±SE) of spotted seatrout recorded during each observation period at live-release fishing tournaments allowing (n = 6) and prohibiting (n = 3) anglers to wadefish. Observation periods: initial = at weigh-in, delayed = holding tanks pre-release, overall = number of fish released of total number brought to weigh-in.

Delayed long-term mortality of tournament caught spotted seatrout was assessed from two 14-d studies. Fish held during the 2004 tournament year (n = 108) had 3 d and 14 d percent survival rates of 90.7% and 81.5%. Fish held during the 2005 tournament year (n = 105) had 3 d and 14 d percent survival rates of 100% and 98.1% (Figure 10). The 14-d long-term mortality study conducted in 2004 was extended to a 30-d study to further assess delayed long-term mortality of tournament caught spotted seatrout. The 30 d percent survival was 79.6% (Figure 11). The majority of the individual mortalities observed during the 2004 study occurred during the first week (Figure 12).

Length Mortality Relationship.—Simple linear regression was used to assess the relationship between spotted seatrout total length and mortality. Fish were grouped into 25.4 mm (1 in) size classes. Total length of fish captured in the seasonal mortality study (n = 364) ranged from 220 – 539 mm (8.7 – 21.2 inches). No significant relationship ($R^2 = 0.059$, N = 14, P = 0.402, $1 - \beta = 0.128$) was observed between size class and percent mortality of fish caught during the seasonal mortality study (Figure 13). Total length of tournament-caught fish held during the 14-d and 30-d long-term mortality studies (n = 213) ranged from 470 – 742 mm (18.5 – 29.2 inches). No significant relationship ($R^2 = 0.206$, N = 12, P = 0.138, $1 - \beta = 0.312$) was observed between size class and percent mortality of tournament-caught fish held for long-term studies (Figure 14).

Movement Pattern.—A tagging study was conducted to assess movement and long-term, post-release survival of spotted seatrout. Seven hundred twenty-six spotted seatrout, 375 from experimental trials and 351 from tournaments events, were tagged and released. Tag recovery rate was 1.2% with a total of nine fish recaptured, one from experimental trials and eight from tournaments. Tag recovery rate for fish tagged in experimental trials was 0.3%. Tag recovery rate for fish tagged at tournament events was 2.3%. Days at-large and distance traveled by recaptured fish were 7 – 63 d and 3 – 48 km, respectively (Table 4).

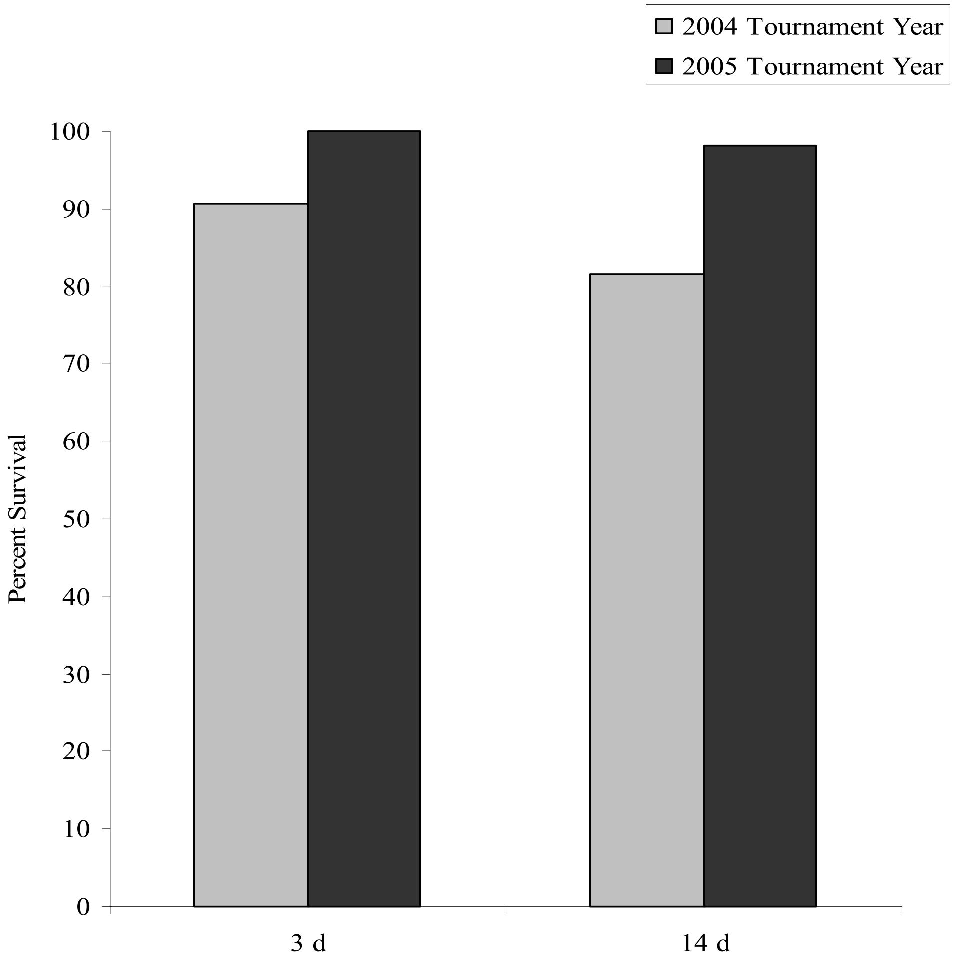

Figure 10. Percent survival of tournament-caught spotted seatrout held for delayed long-term mortality studies (14 d). Fish were collected from a live-release tournament held in 2004 (n = 108) and 2005 (n = 105). Percent survival was calculated by the number of fish alive at day 3 and 14 from the total number of fish in the study.

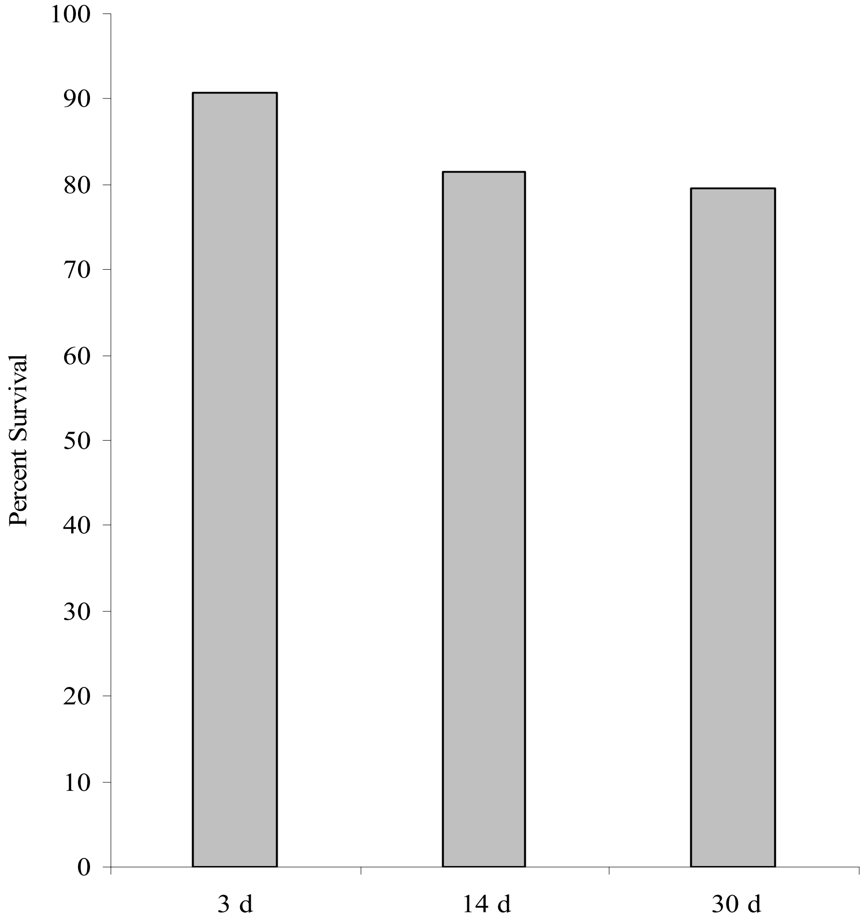

Figure 11. Percent survival of tournament-caught spotted seatrout held for delayed long-term mortality study (30 d). Fish were collected from a live-release tournament held in 2004 (n = 108). Percent survival was calculated by the number of fish alive at day 3, 14, and 30 from the total number of fish in the study.

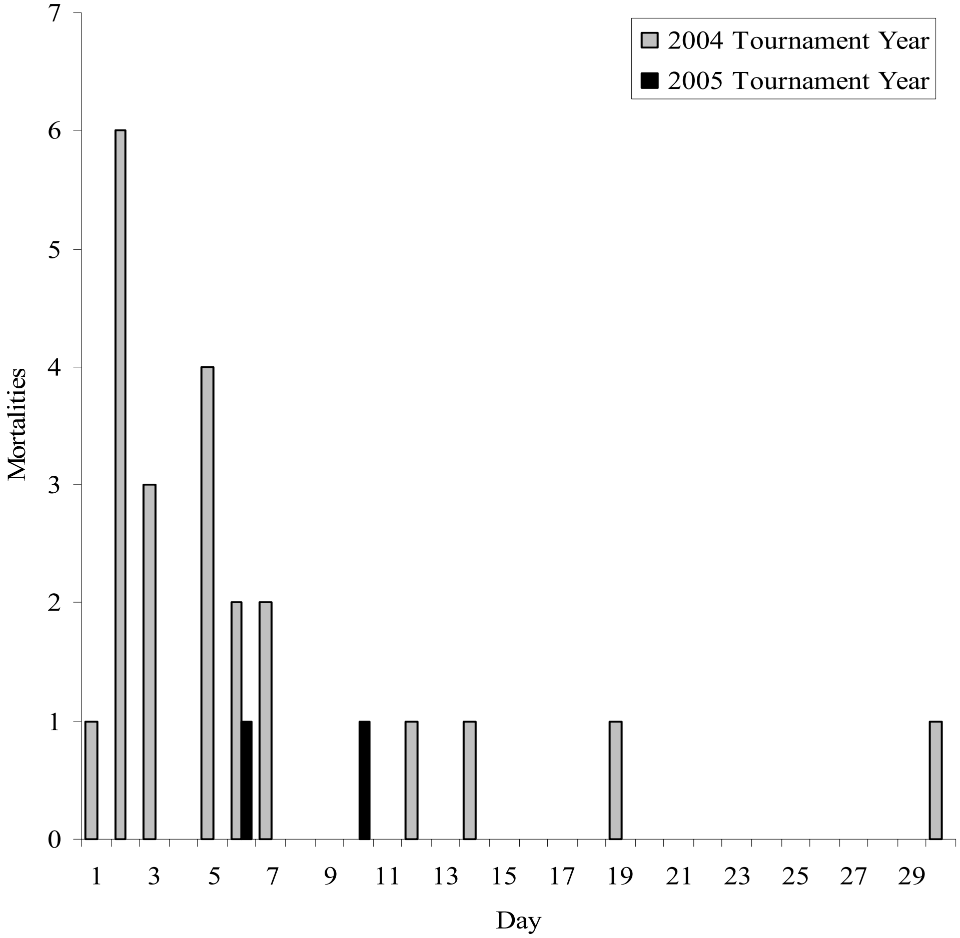

Figure 12. Daily mortalities of tournament-caught spotted seatrout held for delayed long-term mortality studies (14 and 30 d). Mortalities are the number of fish that died during that particular day. Fish were collected from a live-release tournament held in 2004 (n = 108) and 2005 (n = 105).

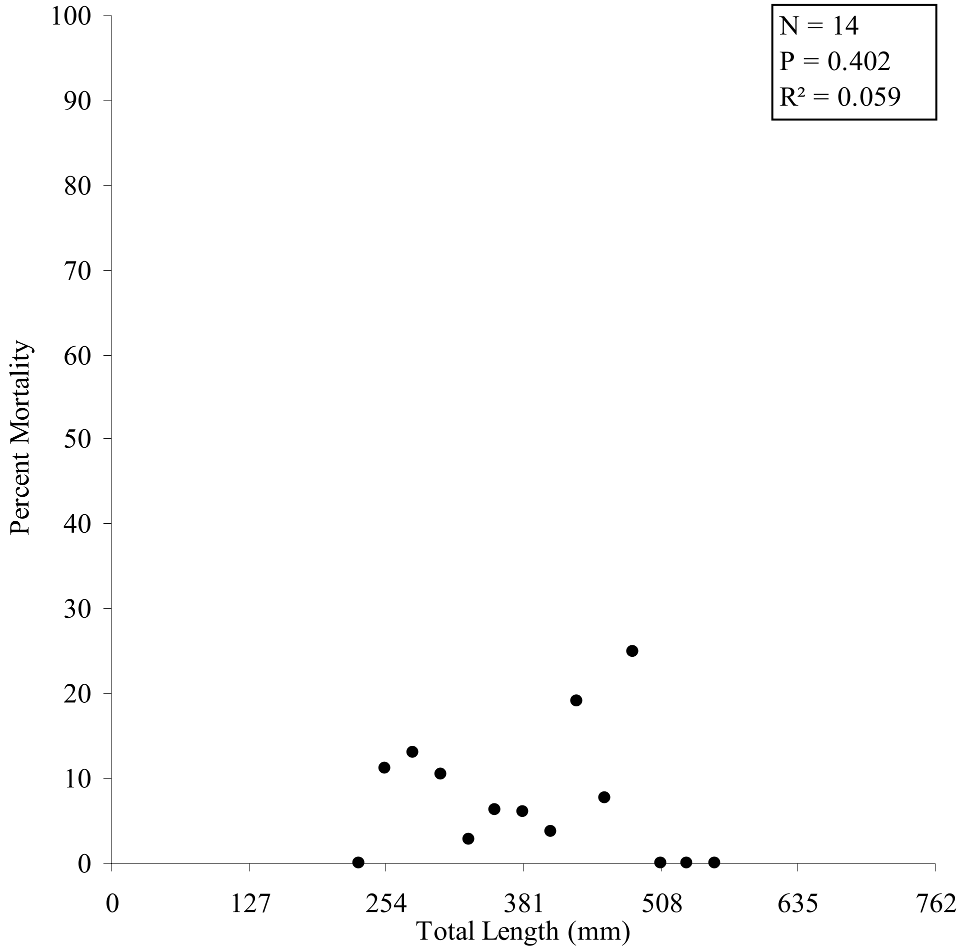

Figure 13. Relationship between total length and percent mortality of spotted seatrout caught in seasonal mortality study. Fish were grouped into 25.4 mm (1 in) size classes. No significant relationship was observed.

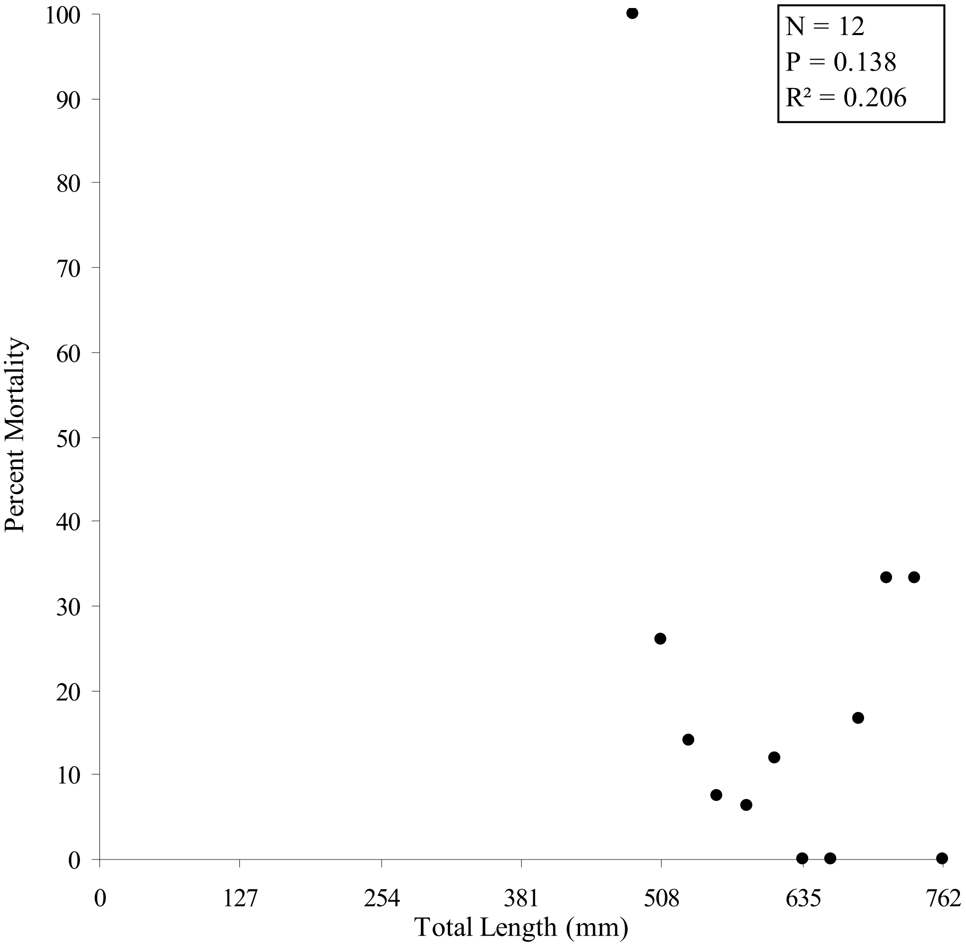

Figure 14. Relationship between total length and percent mortality of tournament-caught spotted seatrout held for long-term mortality studies. Fish were grouped into 25.4 mm (1 in) size classes. No significant relationship was observed.

Table 4. Tag recovery data of spotted seatrout tagged from experimental trials and tournament events. Tag number is the identification code printed on the Floy t-bar anchor tag. Days at-large were calculated from the release date to the recapture date. Distance traveled was calculated from the release site to recapture site.

Tag No.	Release Site/Bay	Recapture Site/Bay	Days at-large	Distance (km)
237	Port Aransas, TX, Corpus Christi Bay	Shamrock Island, TX, Corpus Christi Bay	12	9.8
366	Port O'Connor, TX, Matagorda Bay	Port O'Connor, TX, Matagorda Bay	8	3.0
447	Matagorda, TX, Matagorda Bay	Sargent, TX, Caney Creek	37	48.0
558	Rockport, TX, Aransas Bay	Rockport, TX, Aransas Bay	7	5.2
570	Rockport, TX, Aransas Bay	Mud Island, TX, Aransas Bay	42	6.4
658	Rockport, TX, Aransas Bay	Traylor Island, TX, Aransas Bay	63	4.6
664	Rockport, TX, Aransas Bay	Traylor Island, TX, Aransas Bay	14	4.6
668	Rockport, TX, Aransas Bay	Ingleside, TX, Corpus Christi Bay	27	29.8
717	Clear Lake, TX, Galveston Bay	Seabrook, TX, Galveston, Bay	28	3.2

Discussion

This study examined spotted seatrout mortality associated with recreational and tournament fishing. Specifically, it assessed the catch-and-release mortality of spotted seatrout in the recreational fishery as a function of anatomical hooking location, seasonality, and tournament-related mortality. Overall, these results suggest that catch-and-release mortality is relatively low, and is a viable management strategy; although these results indicate mortality is dependent upon anatomical hooking location, varies seasonally, and is higher during tournament fishing.

Anatomical hooking location is a major factor in catch-and-release mortality of spotted seatrout. Mortality rates of spotted seatrout caught on hook-and-line increased with depth of hooking location within the oral cavity. A large difference in mortality rates was evident between fish hooked in the gills and esophagus and fish hooked external and in the mouth. Fish hooked in the gills and esophagus experienced mortality rates over seven-fold greater than fish hooked external and in the mouth. These observations are similar to other anatomical hooking location studies. Studies examining anatomical hooking location mortality of striped bass (Diodati and Richards 1996; Lukacovic and Uphoff 2002; Millard et al. 2003) reported higher mortality rates for fish hooked posterior to the gills than anterior to the gills. Jordan and Woodward (1992), Carbines (1999), and Aalbers et al. (2004) observed large differences in mortality rates of red drum, New Zealand blue cod, and white seabass, respectively, with the depth of ingestion of the hook suggesting mortality increases with hook depth. Murphy et al. (1995) also recorded higher mortality rates for gut-hooked spotted seatrout than those hooked in the jaw and inside the mouth.

Mortalities associated with anatomical hooking location can be attributed to the extent of hooking injury, including large wounds from hook penetration or removal and excessive bleeding. The only mortality of an external-hooked spotted seatrout was a fish hooked in the abdomen, a rare occurrence. The hook penetrated the body cavity leaving a 20 mm wide opening. No bleeding was observed internally or from the wound. This mortality may be attributed to unobserved damage to internal organs or the wound providing a portal for bacterial infection. Fish subjected to stress, as in the case with catch-and-release, can develop suppressed immune systems which may decrease their ability to fight infections (Helfman et al. 1997). Other mortalities attributed to the extent of hooking injury included mouth-hooked fish. Several mouth-hooked fish had a large wound in the roof of their mouth where the hook had penetrated. Some of these fish had excessive bleeding indicating a major blood vessel had ruptured, excessive blood loss being the most likely cause of mortality. Fish with minimal to no blood loss and large wounds may have died from bacterial infections facilitated by the wound opening and suppressed immune system. However, no necropsies were performed to determine actual causes of mortality.

Other mortalities associated with anatomical hooking location can be attributed to the damage of vital organs. A majority of the fish that died during this study were hooked either in the gills or esophagus. Most gill- or esophagus-hooked fish initially appeared to behave normally after capture but soon began to exhibit signs of stress and ultimately died before transport to the field enclosures. Mortality of gill-hooked fish likely resulted from reduced gas exchange across the gills attributed to gill damage caused by hook penetration as well as excessive blood loss. Proper gas exchange is critical in the recovery from metabolic and respiratory acidosis fish experience during the angling process (Thompson et al. 2002). During periods of elevated stress and metabolic rates, an insufficient exchange of gases across damaged gills may be lethal, and this may account for the mortalities of gill-hooked fish that survived initially but died in the field enclosures. Thompson et al. (2002) reported striped bass mortality was affected by increased angling time and associated acid-base disturbances. Esophagus-hooked fish may have additional unseen damage to adjacent vital organs caused by hook penetration. The hook may penetrate through the esophagus and into the pericardial cavity puncturing the heart. The hook may also penetrate through the stomach and into the liver or kidneys. Aalbers et al. (2004) reported additional damage to the liver, kidney, and heart on deeply hooked white seabass. This unseen damage to vital organs may explain the near equal mortality rates observed when hooks were either removed or left embedded in the esophagus-hooked fish.

Seasonality plays an important role in the catch-and-release mortality of spotted seatrout. Seasonal trends on spotted seatrout mortality were observed with mortalities beginning in late spring and continuing through summer with no mortalities recorded in fall and winter. Hegen et al. (1984) reported similar observations for spotted seatrout with high mortality rates during summer and lower mortality rates during winter. Seasonal trends on mortality have been recorded for other species. Wilde et al. (2000) compiled results from striped bass mortality studies and concluded striped bass mortality is also season-dependent. Seasonal mortality trends for spotted seatrout are distinct when examining monthly mean percent mortalities. June marked the highest mean percent mortality rate with a gradual decrease during the following summer months until no mortalities were recorded during the fall, winter, and early spring months.

This seasonal trend in mortality is most likely attributed to the changing environmental conditions. Increases in mortality rates were observed as water temperature and salinity levels increased and as dissolved oxygen levels decreased through spring and into summer, with no mortalities observed during the fall and winter. Results showed that a positive relationship exists between water temperature and mortality of mouth-hooked spotted seatrout. The highest mean percent mortality was observed in June when the highest mean water temperature was recorded. Mean percent mortality rates gradually decreased through the summer months with decreasing water temperature until no mortalities were recorded during the cooler water temperature months of the fall, winter, and early spring. Most mortality occurred when the water temperature exceeded 29°C. Murphy et al. (1995) also observed spotted seatrout mortality increased with increasing water temperature. Dotson (1982), Plumb et al. (1988), and Wilde et al. (2000) reported similar temperature and mortality relationships with trout (*Salmo clarki* and *S. gairdneri*), largemouth bass, and striped bass.

A negative relationship was indicated between dissolved oxygen and mortality of mouth-hooked spotted seatrout. The lowest dissolved oxygen levels were recorded during the summer months when most mortality occurred and the highest oxygen levels were during the winter months when no mortality was observed. Most mortality occurred when dissolved oxygen levels were below 5 mg/L. The capacity of water to retain dissolved oxygen is inversely related to water temperature. Increasing water temperature diminishes the solubility of dissolved oxygen creating a stressful condition for fish. High water temperature and low dissolved oxygen levels were present during late spring and summer when mortality rates were the highest. Conditions promoting stress have been attributed to increased fish mortality (Dotson 1982).

A positive relationship was indicated between salinity and mortality of mouth-hooked spotted seatrout. Most mortality occurred during the summer months when salinity levels exceeded 30 ppt, ‰. Spotted seatrout must regulate their internal osmotic levels to assure proper cellular function. Osmoregulation is accomplished by excreting excess salts and conserving water. Any deviation in this process can alter internal ionic concentrations and lead to osmotic stress (Helfman et al. 1997). The stressful conditions of high water temperature and low dissolved oxygen levels during summer months coupled with high salinity levels may affect spotted seatrout osmoregulation and ion balance thus amplifying physiological stress. Such stress is most likely the cause of the observed mortality during the late spring and summer months otherwise absent during cooler water temperature months with lower salinity levels.

The overall mortality rate of live-release tournament-caught spotted seatrout was higher than the mortality rates for all fish caught in the anatomical hooking location and seasonal experimental studies. The difference in mortality rates between tournament-caught fish and fish caught in the anatomical and seasonal studies may be attributed to excessive handling involved with tournament live-release practices. Mortality rates of spotted seatrout caught during live-release fishing tournaments were low considering the degree of handling and other physiological stresses these fish are subjected to during these events. In general, tournament anglers handle their fish more than recreational anglers. Fish are landed and placed in live-wells, removed from live-wells for weigh-in, handled during the weigh-in process, held for photographs, and maintained in holding tanks prior to release. They may be injured in the live-wells during transport from capture site to weigh-in, especially when fishing and boating conditions are unfavorable. Fish may also be confined in live-wells for long durations without properly regulated water conditions. Results from this study led to the development of a pamphlet detailing the “best” spotted seatrout catch-and-release handling techniques (Appendix I).

The higher than expected survival rate for tournament-caught spotted seatrout, in spite of excessive handling, may be attributed to bonus incentives in tournament formats. All tournaments surveyed in this study had a bonus weight incentive for live fish brought to weigh-in. This encouraged anglers to take additional care with their fish including better handling techniques and use of oxygen systems in live-wells. Weigh-in procedures were organized in an attempt to minimize the duration fish were out of the water with one tournament series providing multiple holding tanks leading to the weigh-in station. Additionally, this tournament series had an increase in overall survival rate after it changed the format to prohibit anglers from wadefishing.

Delayed long-term mortality rates of spotted seatrout caught during live-release fishing tournaments were also low. Initial and delayed tournament mortalities caused from acute stresses and severe physical damage are easily observed. True post-release mortality caused by sublethal stresses including damage of protective slime coat and osmoregulatory dysfunction and their additive effect is generally never known (Schramm et al. 1987; Neal and Lopez-Clayton 2001). However, the long-term tournament mortality studies with high post-release survival rates indicated these sublethal stresses are minimal. Both 14- and 30-d delayed long-term mortality studies resulted in few spotted seatrout mortalities. These fish were subjected to additional stresses other tournament-caught fish did not experience including increased handling, overcrowding in the transport trailer, and transport from the tournament site to the laboratory holding facility. These data should be encouraging to fishery managers and others concerned about potential adverse effects created by tournament fishing on the fishery resource.

No significant relationship between total length and percent mortality of spotted seatrout caught in the seasonal and long-term mortality studies was observed. Fishery managers frequently use size limits to regulate fisheries. It is important that managers know the relationship between fish length and hooking mortality when establishing fishing regulations (Muoneke and Childress 1994). Muoneke and Childress (1994) reviewed previous studies examining length and hooking mortality and concluded the relationship is variable within taxonomic groups. Results from the current study indicate spotted seatrout have high post-release survival rates regardless of size when caught by recreational and tournament anglers. When considering the maximum size limit management regulation, it is important to know that it will not be detrimental to the fishery. These results suggest the majority of fish over the maximum size limit should survive post-release.

Fish tagging studies have been used by fishery managers for many years to increase the understanding of population dynamics and develop management strategies. Tagging studies also provide useful information concerning spotted seatrout movement post-release. Results from the tagging study indicate spotted seatrout are surviving post-release with some recaptured by anglers. These results also show most tagged fish are being recovered close to the release site and within the same bay system. Previous tagging studies have reported that spotted seatrout remain close to the release site, seldom leaving the bay system (Guest and Gunter 1958; Wenner and Archambault 1996; Lucy et al. 1999; Blanchet et al. 2001). Tag recovery rates for spotted seatrout in this study are slightly lower than reported for other tagging studies in Texas (Blanchet et al. 2001). This may be due to fewer fish being tagged in this study. Additionally, fish were not released at the site of capture rather in areas with low fishing pressure.

Results from this study suggest current catch-and-release management regulations for spotted seatrout are a viable management strategy. Given the excessive handling and confinement spotted seatrout experienced during this study it can be expected that mortality rates will be lower if fish are released immediately after being landed.

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Appendix I. Spotted Seatrout Catch and Release Handling Techniques Pamphlet

In collaboration with Texas Parks and Wildlife Department, results from this study led to the development of a pamphlet detailing the “best” spotted seatrout catch-and-release handling techniques for recreational and tournament anglers.

TOURNAMENT RECOMMENDATIONS, CONTINUED

- Add frozen containers of water to live-wells if water temperatures exceed 85°F. CAUTION – Avoid lowering water temperature more than 10°F in 30 minutes.

Weigh-in Procedures:
- Allow early "weigh-ins" to increase fish survival.
- Use "fish-handling" bags to transport fish to the weigh-in station and to the release tank.
- Provide aerated and oxygenated temporary holding tanks for fish waiting to be weighed and measured.
- Use the recommended lipping tool or wet latex gloves while handling fish.

Release Procedures:
- When releasing fish, acclimate holding tank or live-well water to the approximate temperature of water at release site. This is important to avoid the stress induced by temperature shock, especially when releasing from colder to warmer waters.
- Revive fish by supporting them in the water and gently moving them back and forth allowing water to pass over their gills.
- Release fish when they are able to swim away on their own.

INCREASING SURVIVAL

The projected increases in fishing pressure on spotted seatrout populations of Texas place a greater emphasis in the role anglers will play in protecting this valuable resource. The overall survival of spotted seatrout caught and released can be improved by following some basic handling techniques described here.

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SPORT FISH RESTORATION
Texas A&M University Corpus Christi
The Island University
COASTAL CONSERVATION ASSOCIATION
TEXAS PARKS & WILDLIFE

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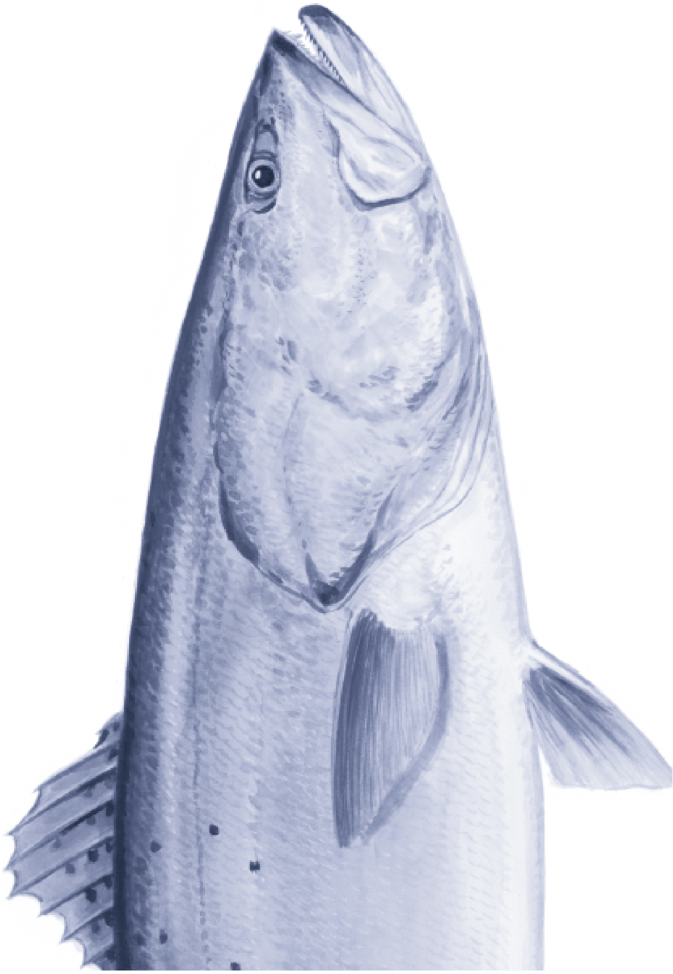
TEXAS PARKS AND WILDLIFE

SPOTTED SEATROUT CATCH AND RELEASE HANDLING TECHNIQUES



SPOTTED SEATROUT

The spotted seatrout (*Cynoscion nebulosus*) is a highly sought-after marine sportfish in Texas. The Texas Parks and Wildlife Department (TPWD) manages the fishery with regulations that include size and bag limits. A key element in the regulations is the post-capture survival of released fish.

Fish experience a combination of stressors during the fight, landing/handling, and release process. Post-capture survival of fish improves by minimizing the amount of stress. Listed below are some types of stress fish can experience.

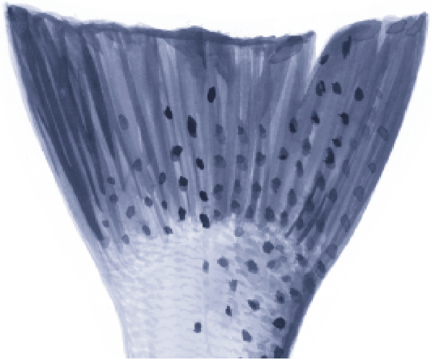
- Exercise – exhaustive swimming
- Handling – capture and struggle
- Hypoxial – oxygen deprivation when removed from water
- Behavior – confinement and crowding (e.g., live-well and tournaments)
- Temperature – change in water temperature
- Salinity – change in salinity
- Toxicity – exposure to ammonia

Proper techniques and care should be practiced to minimize these stresses to ensure releasing a healthy fish with a greater chance of survival. The following are recommendations for spotted seatrout catch and release handling techniques.

SPORTFISHING RECOMMENDATIONS

Handling Techniques:

- Land the fish quickly.
- When possible, avoid using a landing net especially those with large mesh. It is best to bring the fish within hand reach and retrieve it from the water using a wet hand. This reduces damage to the protective mucous coating and scales which protect the fish from disease and parasites.
- Minimize the time the fish is out of the water.
- With larger fish, provide support of the abdomen, with a wet hand.
- Use needle nose pliers or similar devices to quickly remove hooks. If fish is deep-hooked, cut the line near the mouth to avoid injury to vital organs and other sensitive areas of the fish.
- Use a lipping tool when weighing and photographing fish.
- Measure fish on a smooth wet surface to protect the mucous coating and scales.
- Revive fish by supporting them in the water and gently moving them back and forth allowing water to pass over their gills. Release fish when they are able to swim away on their own.



TOURNAMENT RECOMMENDATIONS

Time of Year:

Avoid scheduling tournament dates during "hot" months (June - Sept.). Spotted seatrout mortality increases substantially when water temperatures are above 85°F .

Handling Techniques:

- Follow the handling techniques recommendations.
- Distribute fish evenly between live-wells and avoid overcrowding.
- Place fish in boat's rear live-wells to reduce injuries incurred during transportation (back of boat is less bouncy than front).

Aeration and Water Management:

- Fill holding tanks with water taken near the capture site. Provide 1.5-2.0 gallons of water per pound of fish.
- Maintain adequate live-well or other type of holding tank aeration via oxygen or water recirculation systems. Oxygen systems provide the most efficient oxygenation, however care must be taken when using these because too much oxygen can cause mortality.
- Exchange water at a rate of 10% per hour with constant aeration.
- Monitor oxygen (8-10 ppm), salinity (15-35 ppt) and water temperature (below 85°F) when meters are available.