Survival of Hook-Caught Spotted Seatrout

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Abstract: Spotted seatrout (*Cynoscion nebulosus*) (242–585 mm total length) were captured by hook and line in 7 Texas bay systems and placed in wire cages during June to September 1981 and December 1982 to April 1983 to estimate survival of hook-caught handled fish. No significant difference ($P > 0.05$) in survival was found between fish which received a wide range of handling stress such as sport fisherman might handle them and fish handled carefully as controls. No significant difference ($P > 0.05$) was found among summer and winter survival of hook and line caught spotted seatrout. Significant differences ($P < 0.05$) in survival of spotted seatrout among bay systems may be attributed to differing handling techniques by area biologists, transport distance, or differing environmental conditions. Mean survival of fish, adjusted for controls, ranged from 50% to 100% in summer and 67% to 100% in winter. Management techniques which require the release of spotted seatrout will result in a majority of released fish surviving.

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Daily bag, possession, and size limits are commonly used as marine fishery management tools to reduce harvest and enhance growth and recruitment (Rounsefell 1975). Ultimate success of these measures depends upon the survival after release of those fish over the bag limits and above or below size limits.

In 1978, the Texas Parks and Wildlife Commission adopted a bag limit of 20 and minimum size limit of 305 mm for spotted seatrout (*Cynoscion nebulosus*) caught by recreational fishermen in 14 of the 18 counties under its jurisdiction (Texas Parks and Wildl. Dep. 1979). Initial studies conducted in Matagorda Bay in summer 1979 indicated survival of rod and reel caught fish held in wire cages (Matlock and Dailey 1981). However, the variation in survival of 44% to 100% in the 2 experiments confirmed the need for additional testing as well as application on a coastwide basis. Hegen et al. (1982, 1984) repeated handling survival studies in cages on a coastwide basis.

This paper compares the survival of spotted seatrout caught by hook and line in 7 bay systems during summer and winter collection periods and determines the applicability of minimum size limits for this species.

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Methods

Spotted seatrout (242–585 mm total length) were captured with hook and line in 7 Texas bay systems during June to September 1981 and December 1982 to April 1983. Single shank and treble hooks (No. 5 or 6) with live or dead shrimp and artificial lures (spoons, plastic worm jigs, or plugs) were used.

All captured fish were carefully transported no more than 30 km via water-filled ice chests to predetermined areas in each bay system where cages were secured. Hardware cloth (wire) cages were 1.2 m long, 1.2 m wide, and 0.4 m deep with 4 x 4 cm mesh.

Fish were placed in cages according to 2 defined treatments (control and handled). Although all fish underwent some degree of handling during capture, transport, and placement into cages, control fish were treated as carefully as possible with no additional abuse other than what occurred during their acquisition. Handled fish were treated in a manner recreational fishermen might handle fish they intended to release. Handling differed in each bay system based on the biologist's judgement, but included such treatment as extended holding out of water, squeezing, and dropping of fish.

Three to 5 fish were placed in each of 3 cages during each season in each bay. An equal number of fish were placed in all cages during each season in each bay system except in Galveston Bay in July 1981 when the control cage contained 6 fish and the remaining cages contained 5 fish each, and in Aransas Bay in December 1983 when the control cage contained 3 fish and the remaining cages contained 4 fish each. During each season, 1 cage contained fish designated as control and 2 cages contained handled fish. Fish were held for 7 days during each season. Dead fish were removed daily. Fish were not fed during the study except in Aransas Bay in July 1981 when fish were fed once.

Percent survival in each cage was calculated at the end of 7 days. Differ-

Table 1. Percent survival of spotted seatrout held for 7 days in each of 5 wire cages after being handled carefully (control) and handled roughly (handled) in each of 7 Texas bays during June to September 1981 and December 1982 to April 1983.

Year	Bay	Survival (%) Control Cage 1	Handled Cage 2	Handled Cage 3
1981	Galveston	83	80	20
	Matagorda	100	100	100
	San Antonio	100	60	100
	Aransas	100	80	100
	Corpus Christi	60	40	60
	Upper Laguna Madre	60	20	100
	Lower Laguna Madre	60	20	0
	All bays ($\overline{X}$ ± 1 SE)	80.4 ± 8	57.1 ± 12	68.6 ± 16
	Treatments ($\overline{X}$ ± 1 SE)	80.4 ± 8	62.8 ± 10	
1982–83	Galveston	100	100	67
	Matagorda	100	100	100
	San Antonio	100	80	100
	Aransas	100	75	100
	Corpus Christi	33	100	100
	Upper Laguna Madre	67	33	33
	Lower Laguna Madre	100	80	100
	All bays ($\overline{X}$ ± 1 SE)	85.7 ± 9	81.1 ± 8	85.7 ± 9
	Treatments ($\overline{X}$ ± 1 SE)	85.7 ± 9	84.2 ± 5	
Overall treatments ($\overline{X}$ ± 1 SE)		83.1 ± 6	73.1 ± 6	

ences ($P \leqslant 0.05$) among mean percent survival for control and handled among seasons and bays were determined using a 3-way analysis of variance with unequal but proportional sample sizes using SAS (SAS Inst. Inc. 1982). Bay systems and seasons were considered random effects and treatments were considered fixed effects. Percentages were arcsine transformed prior to analysis to reduce variance heterogeneity.

Table 2. Results of 3-way analysis of variance of arcsine transformed mean percent survival among control and handled spotted seatrout held for 7 days in wire cages in Texas bays during June to September 1981 and December 1982 to April 1983.

Source of variation	df	Mean square	*F*
Total	41	0.2925	
Treatments	1	0.2311	1.11
Bay systems	6	3.9647	3.18[a]
Years	1	0.6291	3.03
Treatments x bay systems	1	1.0356	0.83
Treatments x years	6	0.0505	0.24
Bays x years	6	1.5291	1.23
Treatments x bays x years	6	0.7177	0.58
Error	14	0.2079	

[a] Significant at $P \leqslant 0.05$.

Table 3. Mean daily water temperature (° C ± 1 SE) and salinity (o/oo ± 1 SE) in Texas bay systems in summer and winter spotted seatrout handling studies.

Bay	Temperature		Salinity	
	Summer	Winter	Summer	Winter
Galveston	31.7 ± 0.7	19.4 ± 0.9	4.0 ± 0.7	2.1 ± 0.5
Matagorda	32.2 ± 0.5	13.5 ± 0.9	6.8 ± 0.3	15.9 ± 0.9
San Antonio	31.2 ± 0.3	13.2 ± 0.8	24.8 ± 1.9	27.9 ± 0.3
Aransas	28.7 ± 0.2	15.1 ± 0.6	10.7 ± 0.8	26.1 ± 0.3
Corpus Christi	31.2 ± 0.3	19.7 ± 1.0	25.2 ± 0.4	29.1 ± 0.5
Upper Laguna Madre	30.0 ± 0.5	22.1 ± 0.7	25.3 ± 1.0	34.7 ± 0.4
Lower Laguna Madre	29.2 ± 0.7	19.2 ± 0.5	34.8 ± 0.2	25.6 ± 0.8

Surface water temperatures and salinity were measured during each inspection. Differences ($P \leq 0.05$) of daily mean water temperature and salinity among bay systems and between seasons were determined using a 2-way analysis of variance. Bay systems and seasons were considered random effects.

Results

Mean survival of spotted seatrout was 83.1 ± 6% in the control treatment and 73.1 ± 6% in the handled treatment (Table 1); mean survival was not significantly different among treatments (Table 2). Spotted seatrout in summer averaged 62.8 ± 10% survival; whereas, survival in winter averaged 84.2 ± 5%. However, mean survival was not significantly different between seasons. Mean survival among bays ranged from 52.2 ± 11% in the upper Laguna Madre to 100% in Matagorda Bay, and means varied significantly among bays.

Mean temperatures ranged from 28.7 ± 0.2° C to 32.2 ± 0.5° C in sum-

Table 4. Results of two-way analyses of variance of mean temperature (°C) and salinity (o/oo) among seasons and bay systems for spotted seatrout held for 7 days in wire cages in Texas bays during June to September 1981 and December 1982 to April 1983.

Dependent variable	Source of variation	*df*	Mean square	*F*
Temperature	Total	111	52.6177	
	Season	1	4,843.1451	1,429.47[a]
	Bay	6	46.9459	13.86[a]
	Season x bay	6	63.9524	18.88[a]
	Error	98	3.3881	
Salinity	Total	111	116.9600	
	Season	1	505,7500	107.38[a]
	Bay	6	1,743.3125	370.14[a]
	Season x bay	6	259.2292	55.04[a]
	Error	98	4.7098	

[a] Significant at $P \leq 0.05$.

mer and 13.2 ± 0.8° C to 22.1 ± 0.7° C in winter, and mean salinity ranged from 4.0 ± 0.7 o/oo to 25.3 ± 1.0 o/oo in summer and 2.1 ± 0.5 o/oo to 34.7 ± 0.4 o/oo in winter (Table 3). Mean temperature and salinity varied significantly among seasons and bay systems and within seasons by bay system (Table 4).

Discussion

Effective management of spotted seatrout can include a minimum size limit and daily bag limit because most fish too small to retain or caught in excess of the bag limit will survive handling during hook removal and release. Some fish will die due to the location of hooking or due to total disregard for the fish's well-being during unhooking. Previous studies have shown that swallowed baits and deep hooking can cause mortality (Hunsaker et al. 1970, Warner and Johnson 1978). However, the current study indicates that sport fishermen can contribute to the conservation of a species by carefully handling and releasing unwanted fish. Although the sensitivity of the statistical analyses is reduced by having several people capture and handle spotted seatrout, the findings of this study and previous studies (Matlock and Dailey 1981, Hegen et al. 1982, 1984) demonstrate that the fish population will be protected even with the variability in handling of fish by sport fishermen.

The lack of significant differences in mortalities among treatments suggests that the same external mortality-causing factors equally affect all fish. Carmichael et al. (1983) described the physiological effects of handling and hauling stress on smallmouth bass (*Micropterus dolomieui*). Osmoregulatory dysfunctions and changes in the plasma chemical concentrations were noted. In addition to identifying fatigue as an intermediate mortality factor during capture and handling, Parker et al. (1964) described the behavioral changes (i.e., sharp drop in swimming rate, break up of schooling behavior, and change from active to passive evasion) of stressed fish. Sackett and Hein (1979) felt that the increased length of time required to catch enough spotted seatrout with rod and reel before experiment initiation influenced water quality and fish condition and thus affected mortality.

The hardships encountered by fish during cage studies are far greater than those caused by routine capture and handling by biologists or by recreational fishermen. Hegen et al. (1982) questioned the influence of cage construction on mortality when they noted dermal abrasions on spotted seatrout held in wire cages. Boydstun and Hopelain (1977) reported that steelhead trout (*Salmo gairdneri*) actively darted into hardware cloth (0.6-cm mesh wire) cages when frightened or when cages were raised. This resulted in ≥18% of all fish having ≥25% fin erosion. Although Moring (1982) found no correlation to density, he noted that the percentage of fin damaged chinook salmon (*Oncorhynchus tshawytscha*) (10%–25%) held in cages of nylon netting (6.4-mm square mesh) increased with time. Hegen et al. (1982) initially recommended the use of wood cages as a possible way to reduce water turbulence and subsequent damage and mortality on captive fish. However, they found that wood cages provided more surface area for water turbulence causing fish to suffer a high degree of dermal abrasion and, therefore, recommended against their continued use.

The failure to find significant differences in mean survival between seasons was unexpected. Higher temperatures in summer were expected to increase stress and reduce survival (Vernberg and Vernberg 1972, Strange 1980), but this apparently did not occur.

Significant differences in mean survival of handled fish among bay systems may have been caused by numerous external factors. The necessity of having different persons conduct the experiments in each bay system undoubtedly contributed to variation among bays. Fish capture, transport, experimental handling, and study site may also have varied among bay systems.

If mortalities suffered by the fish serving as controls are assumed to have occurred equally in all cages and treatments and during both seasons, then the estimate of handling survival can be adjusted by this amount. The overall handling survival of 73% adjusted by 17% mortalities in the control yields 90% survival. Mean handling survival, adjusted for controls, ranged from 50% to 100% within bay systems. These values include the probable success of management techniques which employ minimum size limits.

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