SURVIVAL OF HANDLED AND TAGGED SPOTTED SEATROUT HELD IN WOOD AND WIRE CAGES

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ABSTRACT

Spotted seatrout (Cynoscion nebulosus) (209-585 mm total length) were captured by hook and line in each of six Texas bay systems and placed in wood cages during July-September 1982 and were captured by hook and line in each of seven bay systems and placed in wire cages during December 1982-April 1983. Within each cage type, there were no significant differences ($P > 0.05$) in estimates of survival of handled and tagged fish held for 7 days. Mean coastwide survival in wood cages ranged from 37.5 $\pm$ 16% to 42.5 $\pm$ 12%, whereas, coastwide survival in wire cages ranged from 77.1 $\pm$ 13% to 85.7 $\pm$ 9%. Mean coastwide survival rates adjusted for controls was 74% and 95% for wood and wire cages, respectively. Survival in wood cages was probably less than in wire cages because some fish escaped the wood cages and were considered mortalities and because wood cages were less stable than wire.

INTRODUCTION

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 Wildlife Department 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 two experiments confirmed the need for additional testing as well as application on a coastwide basis. Hegen et al. (1982) repeated handling survival studies in wire cages on a coastwide basis and recommended a change in cage construction to reduce excessive dermal abrasion. This study examines survival of spotted seatrout in wood cages for comparison to wire cages. Additionally, survival in other seasons was unknown, therefore, this study also examines survival of rod and reel caught spotted seatrout in winter.

This study also examines the survival of spotted seatrout tagged by Texas Parks and Wildlife Department (TPWD). Tagging of fish to determine movement and growth has been used as an intergral part of the TPWD coastwide finfish monitoring program since 1975 (Matlock and Weaver 1979). In 1981, the TPWD initiated studies to evaluate the use of hook and line as a capture gear to obtain spotted seatrout for tagging and to evaluate total mortality rates of this species in Texas bays.

MATERIALS AND METHODS

Spotted seatrout (209-585 mm total length) were captured with hook and line in each of six Texas bay systems during July-September 1982 and in each of seven Texas bay systems during December 1982-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 $\leq$ 30 km via water-filled ice chests to predetermined areas in each bay system where the cages were secured. Wood cages used during July-September 1982 were 0.8 m long, 0.6 m wide, 0.6 m deep and constructed of pine slats (1 X 4 cm) with a 2-cm spacing between all slats. Hardware cloth (wire) cages used during December 1982-April 1983 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 three defined treatments (control, handled and tagged). 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. Tagged fish were carefully handled during measurement of total length and tagging with an internal abdominal anchor tag (Osburn et al. 1979).

Three to five fish were placed in each of five cages during each study in each bay. An equal number of fish were placed in all cages during each study in each bay system except in Aransas Bay in December 1983 when the control cage contained three fish and the remaining cages contained four fish each. During each study, one cage contained fish designated as control, two cages contained handled fish and two cages contained tagged fish. Fish were held for 7 days during each study. Each cage was checked and dead fish were removed daily. Fish were not fed during the study. Surface water temperatures and salinity were measured during each inspection.

Percent survival for each cage was calculated as the ratio of the number of fish alive at the end of 7 days divided by the number of fish initially placed in the respective cage. Fish which escaped wood cages due to warping of slats were considered as mortalities during all calculations.

Significant differences ($P \leq 0.05$) among mean percent survival for control, handled and tagged fish for each cage type were determined using a two-way analysis of variance with unequal but proportional sample sizes (Sokal and Rohlf 1969). Bay systems were considered random effects and treatments were considered fixed effects. Percentages were arcsine transformed prior to analysis to reduce variance heterogeneity.

RESULTS

Mean survival of control, handled and tagged fish was not significantly different in wood cages during July-September 1982 or in wire cages during December 1982-April 1983 (Table 1). Significant differences among bay systems within each cage type were found. Mean coastwide survival of spotted seatrout held in wood cages during July-September 1982 ranged from 24.5 $\pm$ 10% (tagged treatment) to 57.5 $\pm$ 16% in the control treatment cages (Table 2). Within each treatment, survival ranged from 0 to 100% among bay systems. Coastwide mean survival of handled and tagged treatments combined was 40.2 $\pm$ 6%. Mean coastwide survival of spotted seatrout held in wire cages during December 1982-April 1983 ranged from 77.1 $\pm$ 13% (tagged treatment) to 85.7 $\pm$ 9% for the handled and control treatments (Table 3). No mortalities occurred in any cages in the Matagorda Bay System. Coastwide mean survival of handled and tagged combined was 80.6 $\pm$ 5%.

Water temperature and salinity varied widely between wood cage tests in July-September 1982 and wire cage tests in December 1982-July 1983. During July-September 1982 coastwide daily temperatures ranged from 28.0 to 33.0 C and daily salinities ranged from 14.0 to 41.5 o/oo (Table 4). During December 1982-April 1983 coastwide daily temperatures ranged from 9.0 to 25.5 C and daily salinities ranged from 0.0 to 36.5 o/oo (Table 5).

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 studies indicate 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, handle and tag spotted seatrout, the findings of this study and previous studies (Matlock and Dailey 1981, Hegen et al. 1982) demonstrate that the fish population will be protected even with the variability in handling of fish by sport fishermen.

Time of year did not apparently influence survival of fish in the control treatment. Hegen et al. (1982) found 80 $\pm$ 8% survival of control fish in summer as compared to 87.7 $\pm$ 9% survival of control fish in winter found in this study. Although the mean survival of fish in the handled treatment was higher in winter in this study than found in summer by Hegen et al. (1982), standard errors overlap indicating similarity in results. Mean survival of spotted seatrout in the tagged treatment was higher in winter in this study than found by Hegen et al. (1982) indicating the success of spotted seatrout tagging studies may be enhanced by winter tagging efforts.

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 $\geq$ 18% of all fish having $\geq$ 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) recommended the use of wood cages as a possible way to reduce water turbulence and subsequent damage and mortality on captive fish. However, the wood cages provided more surface area for water turbulence and fish suffered from a high degree of dermal abrasion. Survival rates of fish in the control treatment were lower in wood cages in this study than in the studies conducted in wire cages by Matlock and Dailey (1981) or Hegen et al. (1982) during the same time of year. Based on the low survival rates of the controls, wood cages were not recommended for continued use.

If mortalities suffered by the controls are assumed to have occurred equally to all cages and treatments, then the estimates of handling and tagging survival combined could be adjusted for each cage type. Handling and tagging survival combined in wood cages (40%) adjusted by 43% mortality in controls would yield 83% survival. This is similar to the adjusted survival of 74% for wire cages in the summer (Hegen et al. 1982). Sackett and Hein (1979) found 70% survival of handled and tagged spotted seatrout caught with rod and reel held in 1/4-acre ponds in August and September. Adjusting the combined handling and tagging survival (80.6%) of fish held in wire cages by the control mortality (∿15%) would yield ∿95% survival for these fish in the winter (December-April). This is similar to that found by Matlock and Dailey (1981) in September 1979 (100% survival).

The lack of significant differences in mortalities among treatments within cage types suggests that the same external mortality-causing factors equally affects 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, handling and marking, 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 intrinsic hardships encountered by fish during cage studies are far greater than those caused by routine capture and tagging by biologists or by recreational fishermen.

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Table 1. Results of two-way analyses of variance of arcsine transformed mean percent survival among control, handled and tagged spotted seatrout held for 7 days in wood and wire cages in Texas bays during July-September 1982 and December 1982-April 1983, respectively.

Group	Source of variation	Degrees of freedom	Mean square	F
Wood cages	Total	29	653.4220	
	Treatments	2	516.3019	1.0842
	Bay systems	5	2165.3957	4.5461*
	Treatments x bay systems	10	476.2168	2.6918
	Error	12	176.9120	
Wire cages	Total	34	531.7155	
	Treatments	2	285.2367	0.8118
	Bay systems	6	1491.2156	4.8055*
	Treatments x bay systems	12	351.3491	1.1322
	Error	14	310.3122	

*Significant at $P \leq 0.05$.

Table 2. Percent survival of spotted seatrout held for 7 days in each of five wood cages after being handled carefully and not tagged (Control), handled roughly (Handled) or handled carefully and tagged (Tagged) in each of six Texas bays, July-September 1982.

	Survival (%)				
	Control	Handled		Tagged	
Bay system	Cage 1	Cage 2	Cage 3	Cage 4	Cage 5
Matagorda	100	40	40	20	20
San Antonio	25	25	25	25	25
Aransas	0	25	50	0	50
Corpus Christi	80[a]	20[b]	60	100	80[a]
Upper Laguna Madre	40	20	0	0	0
Lower Laguna Madre	100	100	80	80	80
All bays ($\bar{X} \pm 1$ SE)	57.5 ± 16	38.3 ± 12	24.5 ± 10	37.5 ± 16	42.5 ± 12
Treatment means		40.4 ± 8		40.0 ± 10	

[a]One fish escaped cages due to warped wooden slats.

[b]Four fish escaped cages due to warped wooden slats.

Table 3. Percent survival of spotted seatrout held for 7 days in each of five wire cages after being handled carefully and not tagged (Control), handled roughly (Handled) or handled carefully and tagged (Tagged) in each of seven Texas bays, December 1982-April 1983.

	Survival (%)				
	Control	Handled		Tagged	
Bay system	Cage 1	Cage 2	Cage 3	Cage 4	Cage 5
Galveston	100	100	67	100	100
Matagorda	100	100	100	100	100
San Antonio	100	80	100	60	60
Aransas	100	75	100	100	75
Corpus Christi	33	100	100	100	67
Upper Laguna Madre	67	33	33	0	67
Lower Laguna Madre	100	80	100	80	80
All bays ($\bar{X} \pm 1$ SE)	85.7 ± 9	81.1 ± 8	85.7 ± 9	77.1 ± 13	78.4 ± 6
Treatment means		83.4 ± 6		77.8 ± 7	

Table 4. Number of spotted seatrout alive in each wood cage 7 days after capture with hook and line in each of six Texas bay systems and associated hydrological data, July-September 1982.

Bay system	Date	Days after stocking	Time (CST)	Temperature (C)	Salinity (°/oo)	Number Alive				
						Control	Handled		Tagged	
						Cage 1	Cage 2	Cage 3	Cage 4	Cage 5
Matagorda	08-17-82	0.0	1300	33.0	14.0	5	5	5	5	5
	08-18-82	1.1	1555	31.0	14.0	5	3	4	3	3
	08-19-82	2.1	1600	33.0	14.0	5	2	3	1	2
	08-20-82	2.8	0845	29.0	15.0	5	2	2	1	2
	08-21-82	4.1	1500	31.0	15.0	5	2	2	1	2
	08-22-82	5.2	1745	31.0	15.0	5	2	2	1	2
	08-23-82	6.2	1700	31.0	15.0	5	2	2	1	2
	08-24-82	7.1	1630	30.0	15.0	5	2	2	1	1
San Antonio	07-28-82	0.0	0830	28.0	24.0	4	4	4	4	4
	07-29-82	1.0	0800	29.0	24.0	2	3	2	1	1
	07-30-82	1.9	0656	29.0	21.0	1	1	1	1	1
	07-31-82	2.9	0700	29.0	21.5	1	1	1	1	1
	08-01-82	4.1	0930	32.0	27.0	1	1	1	1	1
	08-02-82	4.9	0821	28.0	23.5	1	1	1	1	1
	08-03-82	6.1	0700	28.5	26.5	1	1	1	1	1
	08-04-82	7.1	0730	29.0	24.0	1	1	1	1	1
Aransas	07-19-82	0.0	1300	31.5	35.0	4	4	4	4	4
	07-20-82	0.7	0630	28.0	34.0	4	4	4	4	3
	07-21-82	1.7	0630	28.0	34.0	1	2	3	1	2
	07-22-82	2.7	0640	28.0	35.0	0	1	3	0	2
	07-23-82	3.7	0630	28.0	34.0	0	1	3	0	2
	07-24-82	4.7	0630	28.0	34.0	0	1	2	0	2
	07-25-82	5.9	0640	28.0	36.0	0	1	2	0	2
	07-26-82	6.9	0620	28.0	35.0	0	1	2	0	2

Table 4. (Cont'd).

Bay system	Date	Days after stocking	Time (CST)	Temperature (C)	Salinity (°/oo)	Number Alive				
						Control	Handled		Tagged	
						Cage 1	Cage 2	Cage 3	Cage 4	Cage 5
Corpus Christi	08-02-82	0.0	1200	31.0	34.0	5	5	5	5	5
	08-03-82	1.0	1230	31.0	32.0	5	5[a]	3	5	5
	08-04-82	2.0	1205	30.0	34.0	5	4[a]	3	5	5
	08-05-82	3.0	1220	32.0	34.0	5	2[a]	3	5	5[a]
	08-06-82	4.0	1255	32.0	34.0	5	1[a]	3	5	4[a]
	08-07-82	5.0	1100	30.0	35.0	5[a]	1	3	5	4
	08-08-82	6.1	1130	29.0	35.0	4[a]	1	3	5	4
	08-09-82	7.2	1250	28.0	35.0	4	1	3	5	4
Upper Laguna Madre	09-02-82	0.0	2200	32.0	40.0	5	5	5	5	5
	09-03-82	0.6	1210	32.0	40.0	3	1	0	0	0
	09-04-82	1.1	1230	31.0	40.0	2	1	0	0	0
	09-05-82	2.9	1905	32.0	41.5	2	1	0	0	0
	09-06-82	3.8	1610	32.0	40.0	2	1	0	0	0
	09-07-82	4.8	1620	32.0	35.5	2	1	0	0	0
	09-08-82	5.9	1603	30.0	35.5	2	1	0	0	0
	09-09-82	6.9	1615	30.0	39.0	2	1	0	0	0
Lower Laguna Madre	08-24-82	0.0	1945	28.0	32.0	5	5	5	5	5
	08-25-82	0.7	1320	31.0	38.0	5	5	4	4	5
	08-26-82	1.7	1225	31.5	38.0	5	5	4	4	5
	08-27-82	2.5	0725	29.5	36.0	5	5	4	4	4
	08-28-82	3.9	1800	31.0	38.0	5	5	4	4	4
	08-29-82	4.5	0730	30.0	38.0	5	5	4	4	4
	08-30-82	5.6	0655	30.5	38.0	5	5	4	4	4
	08-31-82	6.6	0645	29.0	36.0	5	5	4	4	4

[a] Fish escaped cages due to warped wooden slats.

Table 5. Number of spotted seatrout alive in each wire cage 7 days after capture with hook and line in each of seven Texas bay systems and associated hydrological data, December 1982-April 1983.

Bay system	Date	Days after stocking	Time (CST)	Temperature (C)	Salinity (°/oo)	Number Alive				
						Control	Handled		Tagged	
						Cage 1	Cage 2	Cage 3	Cage 4	Cage 5
Galveston	03-08-83	0.0	1400	23.0	5.0	3	3	3	3	3
	03-09-83	0.9	1130	19.5	0.0	3	3	3	3	3
	03-10-83	1.9	1130	18.0	1.0	3	3	3	3	3
	03-11-83	2.9	1145	16.0	3.0	3	3	3	3	3
	03-12-83	4.0	1400	19.0	2.0	3	3	3	3	3
	03-13-83	4.9	1130	17.0	2.0	3	3	3	3	3
	03-14-83	5.9	1120	20.0	2.0	3	3	3	3	3
	03-15-83	7.0	1400	23.0	2.0	3	3	2	3	3
Matagorda	01-21-83	0.0	1300	10.0	15.0	3	3	3	3	3
	01-22-83	0.9	1030	9.5	15.0	3	3	3	3	3
	01-23-83	2.2	1840	12.5	14.0	3	3	3	3	3
	01-24-83	3.2	1700	15.0	14.0	3	3	3	3	3
	01-25-83	4.2	1715	16.0	15.0	3	3	3	3	3
	01-26-83	5.2	1720	14.0	14.0	3	3	3	3	3
	01-27-83	5.9	1630	14.0	20.0	3	3	3	3	3
	01-28-83	7.1	1630	17.0	20.0	3	3	3	3	3
San Antonio	01-13-83	0.0	1800	15.0	27.5	5	5	5	5	5
	01-14-83	0.8	1300	15.0	27.5	5	4	5	5	5
	01-15-83	1.8	1300	14.0	27.5	5	4	5	5	5
	01-16-83	2.8	1300	14.0	27.5	5	4	5	5	5
	01-17-83	3.6	0845	14.0	28.5	5	4	5	5	5
	01-18-83	4.6	0830	14.0	29.0	5	4	5	5	5
	01-19-83	5.6	0815	9.0	29.0	5	4	5	3	4
	01-20-83	6.7	0815	11.0	26.5	5	4	5	3	3

Table 5. (Cont'd).

Bay system	Date	Days after stocking	Time (CST)	Temperature (C)	Salinity (°/oo)	Number Alive				
						Control	Handled		Tagged	
						Cage 1	Cage 2	Cage 3	Cage 4	Cage 5
Aransas	12-16-82	0.0	0805	16.0	27.0	3	4	4	4	4
	12-17-82	1.0	0800	12.5	25.0	3	4	4	4	4
	12-18-82	2.0	0800	14.5	27.0	3	4	4	4	4
	12-19-82	3.0	0810	14.5	27.0	3	4	4	4	4
	12-20-82	4.0	0810	13.5	26.0	3	3	4	4	3
	12-21-82	5.0	0800	15.5	25.0	3	3	4	4	3
	12-22-82	6.0	0800	17.0	26.0	3	3	4	4	3
	12-23-82	7.0	0900	17.0	26.0	3	3	4	4	3
Corpus Christi	04-07-83	0.0	1900	17.0	30.0	3	3	3	3	3
	04-08-83	0.7	1230	18.0	28.0	3	3	3	3	3
	04-09-83	1.7	1200	17.5	27.0	3	3	3	3	3
	04-10-83	2.7	1145	18.0	28.0	3	3	3	3	3
	04-11-83	3.8	1455	22.0	29.0	2	3	3	3	2
	04-12-83	4.7	1245	20.0	30.0	2	3	3	3	2
	04-13-83	5.8	1525	25.0	32.0	2	3	3	3	2
	04-14-83	6.7	1205	20.0	29.0	1	3	3	3	2
Upper Laguna Madre	04-07-83	0.0	1100	20.0	33.5	3	3	3	3	3
	04-08-83	1.0	1104	20.0	33.5	3	3	3	3	3
	04-09-83	2.2	1458	22.0	34.5	3	2	3	2	3
	04-10-83	3.0	1045	21.5	34.5	3	2	1	2	3
	04-11-83	4.1	1249	24.0	34.5	2	1	1	1	2
	04-12-83	5.1	1355	25.5	34.5	2	1	1	1	2
	04-13-83	6.1	1401	22.5	36.5	2	1	1	0	2
	04-14-83	7.1	1326	21.0	36.0	2	1	1	0	2

Table 5. (Cont'd).

Bay system	Date	Days after stocking	Time (CST)	Temperature (C)	Salinity (°/oo)	Number alive				
						Control	Handled		Tagged	
						Cage 1	Cage 2	Cage 3	Cage 4	Cage 5
Lower Laguna Madre	03-10-83	0.0	1745	21.0	25.0	5	5	5	5	5
	03-11-83	0.7	1000	18.0	24.0	5	4	5	4	4
	03-12-83	2.0	1710	19.0	25.0	5	4	5	4	4
	03-13-83	2.6	0800	17.5	30.0	5	4	5	4	4
	03-14-83	3.6	0915	20.0	28.0	5	4	5	4	4
	03-15-83	4.6	0715	21.0	24.0	5	4	5	4	4
	03-16-83	5.6	0815	19.5	24.0	5	4	5	4	4
	03-17-83	6.6	0750	18.0	25.0	5	4	5	4	4

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