The growth and movement of Scup (*Stenotomous chrysops*) in Narragansett Bay, Rhode Island and along the Atlantic Coast

Project Number

3-138-R

Completion Report

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Introduction:

The scup (Stenotomous chrysops) is a migratory species which is caught in Rhode Island coastal waters from April until October.

Commercial scup landings in Rhode Island declined from 10.08 million pounds in 1965 to 2.08 million pounds in 1969 (R.I. landings). Finklestein (1969) reported a similar decline in New York landings. Of the Rhode Island landings, approximately 67% come from floating fish traps, and the remaining 33% come from the otter trawl catch.

In the past, no concentrated effort has been made to explain the decline of the commercially valuable species in Rhode Island waters.

Because of the increased demand for this species as a food fish, and its rapidly declining availability, investigations of certain life history stages were deemed necessary. These determinations are essential prior to developing any management scheme aimed at reversing the downward trend in landings and the eventual restoration of a fishery which benefits both the scup population and the fishing industry.

Project objectives included a determination of the age structure of the scup population in Narragansett Bay, Rhode Island; the growth and movement of the scup population within Narragansett Bay; and a determination of the capture location of locally tagged scup.

Finally, management recommendations for harvesting scup in Rhode Island are to be formulated from data collected during this study.

Job I. Determine the age structure of the scup population in Narragansett Bay, Rhode Island.

Methods:

Otter trawl sampling was conducted at four locations in Narragansett Bay. The stations were geographically located to sample an area near the mouth of Narragansett Bay's west passage (Dutch Island Station), the lower bay (Jamestown Hole Station), middle bay (Davisville Station) and the upper bay (Poppasquash Point Station. (Figure 1).

One half-hour tows were made at each station with a 3/4 scale 'Yankee' otter trawl towed by a 36 foot western rigged dragger. The numbers of scup, fork length in millimeters and weight in grams were recorded. Length frequency was recorded for 10 millimeter size groups. A sample of fifty fish was put aside for gonad analysis.

In the laboratory an incision was made into the body cavity of the fish and a gross visual inspection of the gonads was made. Gonad condition was recorded as ripe, unripe or immature. No further detailed identification was attempted.

Approximately 20-25 scales were removed from the left side of the distal portion of the pectoral fin and were placed in a labeled envelope. (Stoddard, 1958). Scales were later mounted between glass slides and were examined under a binocular microscope. Age was determined from annuli counts (Edwards, Stoddard, Lavday, 1960), (Lux, 1971).

To further classify scup by year class, cumulative length frequencies for monthly samples for the three year study were

Figure 1

Narragansett Bay, Rhode Island showing location of finfish trawl stations

A. Dutch Island

B. Jamestown Hole

C. Davisville

D. Poppasquash Point

Figure 1.
HARRAGANSETT BAY

Methods (continued)

plotted on probability paper (Cassie, 1954). A regression analysis was performed on length data taken from tagged fish and was used to confirm the results of the cumulative frequency analysis for age grouping of otter trawl caught scup.

In addition to otter trawl sampling, the catch of a commercial floating fish trap located at the mouth of the west passage of Narragansett Bay, was monitored. Whenever the trap was in the water and being tended, a weekly sample of fifty scup was taken from the trap boat upon its return from emptying the trap. The fork length and weight of each fish was recorded, and a scale sample was procured, mounted, and examined in the same manner as those from otter trawl samples. Gonad analysis was not possible because all fish were returned to the trap operator to be sold.

Cumulative length frequency and regression analysis were performed on these data in the same manner as with otter trawl data.

Results:

Sampling by otter trawl was conducted on a monthly basis at each of the four 'trawl' stations in Narragansett Bay (Figure 1).

During the three year study, scup were captured at the Dutch Island Station as early as May when the surface water temperature was 12.2^{O}C and as late as November when the surface temperature was 16.8^{O}C. Scup were taken at the Jamestown Hole Station from April, when the surface water temperature was 8.0^{O}C to November when the surface temperature was 15.0^{O}C. Trawl samples at the

Davisville station yielded scup from May, when the surface water was 10.5°C to September when the surface temperature was 18.2°C. Few scup were taken at the Poppasquash trawl station from April through October when surface water temperatures were from 10°C to 16.1°C.

Results of monthly otter trawl sampling at the Dutch Island station and the Jamestown Hole station for 1970 through 1973 were used to estimate the success of various year classes of Scup. Totals for all finfish species caught were used as a basis for calculating the percentage of Scup in the sample for each year during 1970-1973. Table 1 contains a summary of the percentage of the total catch for the four most commonly occurring species for the Dutch Island and Jamestown Hole stations combined. From 1970 to 1973, these included winter flounder (Pseudopleuronectes americanus) Scup (Stenotomous chrysops) butterfish (Peronotus triacanthus) and herring (Clupea harengus). From 1970 through 1972, the percentage of scup in the catch varied little, but the 1973 catch was approximately one half that of each of the three previous years.

Fish trap hauls produced scup from April until November.

Age Class Determination for Otter Trawl Samples:

Age determination from analysis of scale annuli was accomplished with little difficulty for fish less than four years old. Age determination problems for older fish are consistent with those reported by Smith and Morcross (1968), who documented that age determination past the third annular ring cannot be reliably accomplished because of failure to delineate the entire ring on the scale.

Table 1.

Per Cent Composition of Four Dominant Species from Otter Trawl Sampling in Narragansett Bay, Rhode Island 1971-1973

Year	1970	1971	1972	1973
Species				
Winter Flounder	28.46	21.80	17.87	33.58
Scup	27.89	17.64	26.81	15.33
Butterfish	13.02	17.99	20.90	14.21
Herring	0.0	23.97	21.37	23.83

Note: Monthly trawl data has been combined as an annual catch summary.

Otter trawl samples indicated that scup entered Narragansett Bay in pulses of different size groupings, larger fish appearing first.

May samples were characterized by larger 2, 3 and 4 year class fish (Table 2), followed in June by waves of smaller one and two year old fish. The mean lengths of the age groups segregated by plotting on probability paper (Cassie, 1954) varied for the same month in each of the three years of the study. Table 2 lists mean lengths and standard deviation for age classes by month and year.

The age structure of trawl caught scup is presented in Table 3. The major population constituent in May was the two year old fish. Three, four, and four plus fish comprised the remainder of the population. One year old fish appeared in June and in 1972 and 1973 were the major segment of the population during that month. In June, 1971, two year olds were dominant. Three and three plus fish were also evident in June, but comprised less than 3.0% of the sampled population. July samples in 1971, 1972, were dominated by two year old scup, while in 1973 the dominant age class for that month was one year old. One year old fish comprised approximately 98% of the August trawl caught sample for all three years of the study. 92% of the September samples were zero age class fish. (Table 3).

Two year old fish dominated the otter trawl catch for all three years of this investigation. The considerably smaller percentage of all scup in relation to the other species which have dominated the otter trawl catch was probably a result of poor year class occurring in 1971.

Age Class Determination for Fish Trap Samples:

Accurate age determination from scales was limited to scup less than four years old.

Scup caught in the fish trap during May were predominantly two year old fish. Less than 30.0% were three year old fish and less than 10% of the sample was four years old or older. Fish four years of age and older are grouped together because of the inability to clearly identify annuli past the third ring on the scale.

Fish trap samples in June revealed greater than 65.0% of the catch to be two year old fish. Less than 30% were three years old or older, and less than 5.0% were one year old fish in June, July, and August. The four year old class was absent in all three years of the study (Table 4). Mean and standard deviation for age classes one through four are presented in Table 5.

Gonad Analysis

Gross analysis of gonads of otter trawl caught scup revealed ripe and unripe fish for both sexes, as well as young fish with reproductive organs so undeveloped that determination of sex was not possible. Those fish were designated as immature.

Two, three, and four year old fish with ripe gonads were predominant components of the overall sample. Roughly 10% of the one year old fish were ripe in May, June and July. The mean fork length of fish whose gonads were unrecognizable as ovaries or testes was 125.06 $\pm$ 10.13 millimeters. (Table 6).

Because the largest number of fish are in a ripe condition in May, June and July, it was assumed that this was the spawning season in Narragansett Bay.

Table 2.

Mean length (F.L.) and Standard Deviation of Otter Trawl caught Scup by months for 1971, 1972, 1973, from Narragansett Bay, Rhode Island

	1971		MAY 1972		1973	
Age Class,	$\bar{X}_L$ (mm)	s	$\bar{X}_L$ (mm)	s	$\bar{X}_L$	
0						
1	No data					
2			223	8.0	180	6
3			248	3.0	237.5	2
4			287	7.0		
4+			369	47.83		
			JUNE			
0						
1	128	5.0	136.5	3.5	102	4.
2	193	9.0	208	7.0	192	9.
3	260	7.0	238	3.0	245	0.
4	322	3.0				
4+						
			JULY			
0						
1	133.5	7.5	131.6	6.6	114.0	4.
2	149.0	7.0	184.0	13.0	179.0	11.
3	190	0.5	220.0	7.0	195.0	4.
4	255	0.5				
4+						

Table 2. (cont'd)

	1971		August: 1972		1973	
Age Class	$\bar{X}_L$ (mm)	s	$\bar{X}_L$ (mm)	s	$\bar{X}_L$ (mm)	s
0						
1	139.0	0.6	143.7	7.5	130.0	4.0
2	191.0	0.80	202.0	3.20	172.0	2.0
3						
4						
4+						
			September			
0	72.5	1.70				
1	148.0	2.50	142.0	7.5		
2			162.5	4.5		
3						
4						
4+						

Table 3.

Age Class Distribution by percent of Otter Trawl caught Scup from Narragansett Bay, Rhode Island from 1971, 1972, 1973

	May	June	July	August	September
1971	%	%	%	%	%
Age Class 0	No data				92.2
1		22.8	6.5	)	7.8
2		67.2	75.0	)98.4	
3		8.6	17.35	1.6	
4		1.4	1.15		
4+					
1972					
Age Class 0					92.5
1		91.0	7.0	98.4	7.5
2	54.0	44.6	64.0	1.6	
3	24.0	4.4	29.0		
4	15.8				
4+	6.2				
1973					
Age Class 0				98.6	No data
1		93.5	93.5	1.4	
2	95.0	4.8			
3	5.0	1.7	5.3		
4			1.2		
4+					

Table 4.

Age Class Distribution, by percent, of Scup from Narragansett Bay Fish Trap samples, 1971, 1972, 1973

	May	June	July	August	September
1971	%	%	%	%	%
Age Class					
0					
1				42.0	
2		76.0	60.0	46.0	97.5
3		21.0	20.10	12.0	2.5
4					
4+		3.0	20.0		
1972					
Age Class					
0					
1			42.0	96.8	99.9
2	56.0	100.0	37.0	3.2	
3	28.0		5.0		
4	)		16.0		
4+	)12.0)				
1973					
Age Class					
0					
1		4.5			
2	97.8	67.5	72.0	No. Smpls.	No. Samples
3	2.2	28.0	28.0		
4					
4+					

Table 5.

Mean length (F.L.) and Standard Deviation of Scup from Narragansett Bay Fish Trap samples, 1971, 1972, 1973.

MAY

	1971		1972		1973	
Age Class	$\bar{X}_L$ (mm)	s	$\bar{X}_L$ (mm)	s	$\bar{X}_L$ (mm)	s
0						
1						
2			201	24.6	176.5	9.0
3			250	13.60	220.0	9.4
4						
4+			307	20.8		
			JUNE			
0						
1					113.0	17.4
2	174.0	2.23	183.5	15.75	179.52	10.4
3	252.0	9.95			243	20.7
4	279.0	9.68				
4+						
			JULY			
0						
1			132	16.21		
2	190	1.169	185	13.76	195.0	15.4
3	253	2/74	247	27.96	245	22.8
4					271.92	32.9
4+	308.2	0.855	355	32.25		

Table 5. (cont'd).

AUGUST

Age Class	1971 $\bar{X}_L$ (mm)	1971 s	1972 $\bar{X}_L$ (mm)	1972 s	1973 $\bar{X}_L$ (mm)	1973 s
0						
1	151.0	12.09	132	8.87	No Data	
2	206.5	18.41	187	7.53		
3	272	8.18				
4						
4+						

SEPT.

0						
1	170	6.80	137	11.83	No Data	
2	190	17.13				
3	237	2.45				
4						
4+						

Table 6.

Gonad Condition of Otter Trawl captured Scup, by month, from Narragansett Bay, Rhode Island

Gonad Analysis

Age Class	MAY				JUNE				JULY				AUGUST		
	No. Fish	Ripe	Un-Ripe	IMM.	No. Fish	Ripe	Un-Ripe	IMM.	No. Fish	Ripe	Un-Ripe	IMM.	No. Fish	Ripe	Un-Ripe
0															
1					112	1 1.0%	1 1.0%	110 98%	116		116 100%		30		
2	52	46 88%	5	1	48	34 71%	9 19%	5 10%	38	32 84%	6 16%				
3	12	5 42%	7		20	13 65%	7 35%		38	38 100%					
4	2		2 100%		13	8 62%	5 38%		2	2 100%					
4+	4	1 25%	3 75%		4	4 100%			1	1 100%					

Job 2. Growth and Movement

Methods:

The initial step in determining the growth and movement of scup in Narragansett Bay and coastal waters was to initiate a large scale marking program.

Two different tags were used to mark fish. The first was a dart tag produced by the Floy Tag Company. It was inserted, with a Denison tagging gun, into the left side of the scup and was anchored into the dorsolateral musculature (Edwards, Stoddard, Lawday, 1960). This tag was used on fish 100 millimeters fork length or greater.

The Floy produced fingerling tag was used on fish less than 100 millimeters in fork length. This tag is constructed of a plastic flag inscribed with a legend, strung on monofilament line and is inserted through the dorsal portion of the scup by means of a sewing needle. After insertion, the needle is discarded and the monofilament tied with a square knot.

Fork length (millimeters), and weight (grams) were recorded for all tagged fish.

Scup were obtained for marking with a 3/4 scale "Yankee" otter trawl. Tows lasted from fifteen to twenty minutes. The catch was placed directly into a compartmented 'live' tank on the deck of the dragger. Only lively fish were retained.

Individual scup were taken from the tank with a dip net, were measured (fork length) to the nearest millimeter, and weighed to the nearest gram on an Ohaus Dial-A-Gram balance. Each was tagged and returned to a second section of the holding tank. Fish appear-

ing weak, subsequent to tagging were released after removing the tag. Groups of approximately 100 tagged fish were released after an observation period of about one hour in the holding tank.

A publicity campaign complemented the marking program. State and Federal fisheries agencies were notified of the tagging program as were the commanders of foreign fleets operating off the Atlantic Coast. This was achieved with the cooperation of enforcement personnel of the National Marine Fisheries Service. Fish trap operators and vessel captains were informed, and reward posters were placed in fish houses, on fishing piers, and in retail fish outlets.

Results

In 1971 a total of 3800 scup were tagged with Floy Dart Tags. The fish were predominantly one year old scup (23%) and two year old scup (67%). Only two of the 3800 tags were returned. The first was recaptured in Block Island Sound, Rhode Island, 2½ months after release in Narragansett Bay. The fork length of this fish has increased from 143 Millimeters to 172 millimeters (growth of 39 millimeters). A second tag was returned from Cape May, New Jersey, five months after release in Narragansett Bay. The fork length of this fish had increased from 139 millimeters to 190.5 millimeters (51.8 millimeters growth).

The growth rate for the two returned fish was probably not significantly different. The first fish averaged 2.9 millimeters of growth per week for the ten weeks from tagging to recapture and the second grew an average of 2.6 millimeters each week for the twenty weeks from tagging to recapture.

In 1972, 3719 Scup were tagged. 3231 were marked with Floy Dart Tags and 498 with the fingerling tag.

Short recapture times characterized the 1972 returns. These are listed in the following table:

Duration	Fork Length at tagging (mm)	Fork Length (mm) at recapture	Growth (mm)	Growth per week (mm)
4 weeks	181	184	3	0.75/wk
3 weeks	184	190.5	6.5	0.2/wk
3 weeks	157	184.6	18.6	6.2/wk

Two other tags were returned with no length or weight data. Both were released three weeks prior to recapture. All seven tagged fish were returned by sport fishermen who had caught them within 3.5 nautical miles of the release area. These length increases probably represent maximum rates of growth during the months when the fish attain their largest growth increment. From trawl catch and trap data it can be stated that scup moved into Narragansett Bay in pulses, remained in the Bay throughout the summer and early autumn and then moved out of Narragansett Bay through Rhode Island Sound.

Although movement data was very limited, it may, however, serve as an indication that some scup residing in Narragansett Bay during the summer do move seaward and down the Atlantic Coast. It was, also, conceivable that these scup, as adults, contributed in part to the population of coastal bays and estuaries along the Atlantic Coast from Connecticut to North Carolina.

Because of limited returns of marked fish, growth data was not complete enough to permit meaningful analysis based on tag return information. Growth was determined by constructing a growth curve (Fig.2) with length data from the four year classes available to the fish trap and otter trawl.

Finkelstein (1969) used fish length-scale length relationships to illustrate growth of scup by back calculating fish length at previous

ages using the equation $L_n = C + \frac{S_n(L_t - C)}{S_t}$

L_n=length of fish at time of formation of $_n$th annulus
L_t=length of fish at time of capture
S_n=distance from focus of scale to $_n$th annulus
S_t=distance from focus of scale to anterior margin
C=the x-axis intercept of the function which describes the fish length - scale length relationship (C=.05).

Fitting the data collected from Narragansett Bay scup to the above equation produced a growth curve which illustrated that scup in Narragansett Bay grew at a faster rate and might have reached a smaller asymtotic length sooner than male fish from the Peconic Bays (Finkelstein 1969). Male scup were chosen for comparison because they provided length frequency distributions similar to Narragansett Bay scup, but still revealed definite differences in growth pattern (Figure 2).

Length frequencies for scup used in the above analysis are presented in Table 7, with the calculated mean lengths and standard deviations which were used to construct the above growth curve (Figure 2.) for age classes one through four. Too few fish greater than 290 millimeters fork length were sampled to allow expansion of the growth curve to older fish.

Table 8 summarizes mean length and standard deviation for the age classes 0-4 for each month in each of the three years that the study was being conducted.

Polymodal analysis of length frequency data (Cassie, 1954) bears out the observation that Narragansett Bay provides important habitat for scup in age groups zero through three during the summer months. However, this method of analysis was not sensitive enough to provide data for fish in age groups four and older.

The lack of any number of older scup, and the fact that one group of young of the year (1 yr. old) was found, strongly suggested that

FIGURE 2

Growth Curve For Narragansett Bay

and

Peconic Bay, Long Island (Pinkelstein, 1969) Scup

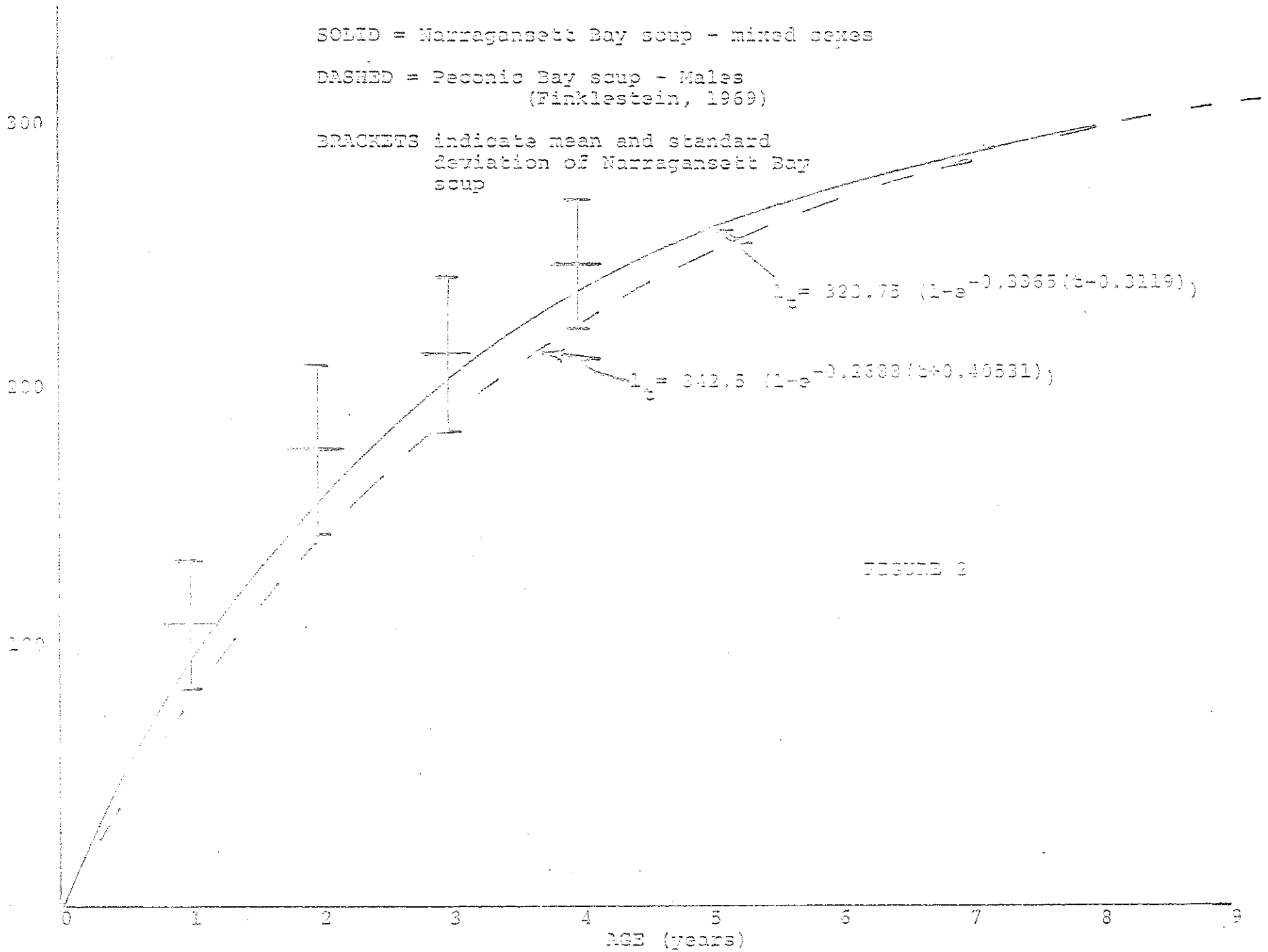
SOLID = Narragansett Bay scup - mixed sexes
DASHED = Peconic Bay scup - Males (Finklestein, 1969)
BRACKETS indicate mean and standard deviation of Narragansett Bay scup
$L_t = 323.75\ (1-e^{-0.3365(t-0.3119)})$
$L_t = 342.8\ (1-e^{-0.2688(t+0.40531)})$
300
200
0
1
2
3
4
5
6
7
8
9
AGE (years)
FORK LENGTH MM

FIGURE 2

Table 7.

Length (F.L.) Frequency Distribution of Scup in Age Classes I through IV from Narragansett Bay Rhode Island, Calculated Mean and Standard Deviation for each Age Class I through IV are included.

Age Class	I	II	III	IV
Fork Length	Frequency	Frequency	Frequency	Frequency
50-59	1			
60-69	3			
70-79	3			
80-89	7			
90-99	21			
100-109	14	3		
110-119	19	5		
120-129	20	1		
130-139	6	4		
140-149	1			
150-159		4	2	
160-69	1	5	2	
170-179	1	15	4	
180-189	1	13	4	
190-199		12	6	1
200-209	2	5	4	1
210-219		2	6	1
220-229		2	5	3
230-239			6	2
240-249		1	4	1
250-259		1	3	5
260-269			4	6
270-279		1		3
280-289				2
	100	75	50	25
ΣX	11091	13261	10693	6250
ΣX^2	1291935	2425767	2333895	1575964
$\bar{X}$	110.91	176.81	213.86	250.00
s	24.99	38.09	29.30	23.69

Table 8.

Monthly Mean Length (F.L.) and Standard Deviation for Scup Aged 0-III sampled by Otter Trawl during 1971, 1972, 1973.

		Age Class			
		0	I	II	III
May	1973			180±6	227±2.5
June	1971		128±6	193±9	260±7
	1972		137±8	208±8	238±3
	1973		102±4		
July	1971		143±15	190±5	255±3
	1972		132±6	185±11	220±7
	1973		114±4	179±11	184±15
August	1971		142±10	191±20	
	1972		144±8	201±4	
	1973		130±4	172±2	
September	1971	73±9	144±7		
	1972		142±8		

Narragansett Bay was a spawning ground and nursery area for scup. The Peconic Bay data (Finkelstein, 1969) presented a definite contrast because of the broad range of age classes, including some age classes that were not found in Narragansett Bay.

Tagging Mortality and Tag Retention Studies

Methods

In conjunction with the marking studies an evaluation of tag retention and tag induced mortality was undertaken. Studies were conducted at the Wickford laboratory which is located on the West Passage of Narragansett Bay.

Twenty-five scup, greater than 100 millimeters fork length, were tagged with Floy Dart Tags and released in an open system live tank measuring 4' x 8' x 18". The same number of untagged control fish were released into the tank. A daily record was kept of temperature, mortality, number of tags cast, and condition of wounds caused by tag insertion.

Dead and moribund assay fish were analyzed by a fish pathologist at the University of Rhode Island.

A second evaluation of tag retention and tagging mortality was conducted at our Jamestown laboratory where the water appears to contain less silt and is slightly cooler in summer than that at Wickford. Forty scup less than 100 millimeters fork length were tagged with Floy fingerling tags and were released into a two hundred gallon open system circular tank. Forty-nine scup greater than one hundred millimeter fork length were marked with the Floy dart tag and were released into a similar tank. Twenty-four unmarked 'control' animals were released in each of the two tanks. A daily record was maintained of water temperature (^{o}C), mortality of tagged and control fish, and of

visual prescence of tag induced damage. The number of cast tags was also recorded.

Results

Observations of tagged scup held in open system tanks at the Wickford laboratory indicated that the retention time of Floy dart tags may be very short, and that some mortality resulted from tag insertion. Ten of twenty-five fish (40%) cast their tags within seven weeks of tagging. Five tagged fish (20%) died within twelve days of tagging. However, thirteen of twenty-five controls (52%) died during the seven week study. Tagging alone cannot be the sole cause of mortality.

Fin rot and tail rot was evident on all fish as was infection at the point of tag insertion for those fish held at the Wickford laboratory.

Dr. Richard E. Woelke, D.V.M., P.H.D. of the University of Rhode Island fish pathology laboratory (personal communication) has indicated that his analysis of moribund fish revealed the presence of Vibriosis sp. He also identified lesions on the fish as ulcerative dermatitis, myosistitis, pancreatitis and proliferative hepatic lesions. He stated "a very interesting case - probably a first in this fish...". Dr. Woelke (personal communication) reported that tag loss was probably due to weakened tissue caused by lesions and disease at the point of tag insertion and that mortality of controls might have been due to vibriosis.

Similar investigations conducted at the Jamestown laboratory assessed the effect of inserting Floy fingerling tags as well as dart tags. Twelve of forty-nine (24%) of the fish tagged with the dart died during the 9½ week study. Five (12.5%) scup tagged with the fingerling tag also died. One control animal died during the study, indicating that tagging mortality is a factor of great importance in an investigation

of this type.

Seven (14.6%) of the dart tagged fish cast their tags.

Dr. Woelke (personal communication) indicated that wounds inflicted in tagging the scup had healed well in the Jamestown study tanks, and that the quality of the water at this location may be more representative of actual field tagging conditions than those at the Wickford laboratory where a heavy silt load was common.

JOB 3.
Discussion and Management Recommendations

Narragansett Bay contributes a portion of the recruits into the Atlantic Coast scup fishery. Data from this study does not indicate the magnitude of the contribution, but does indicate that the bay provides important summer habitat for the fish in age classes one through four. The occurrence of ripe adults during the spawning season, May through July, and the appearance of young of the year in late summer, provided conclusive evidence of its importance as a spawning area.

Based upon returns, growth and movement determinations from the tagging program were almost a total failure. It should be mentioned that the few returns received agree with the findings of Neville and Talbot (1964) who reported that scup migrate in autumn from the summer fishing grounds along the shores of southern New England and New Jersey to the fishing grounds off of the Virginia Capes and in spring make a return migration.

Scup marked and released in the autumn of 1931 off southern New Jersey migrated to the region of the winter trawl fishery off the Virginia Capes. These fish returned the following year to the general area in which they were tagged.

Scup tagged and released at Woods Hole, Massachusetts, were recaptured in the southern winter fishery during the first winter following the tagging period. In the subsequent spring and summer, most of the Woods Hole scup returned to the region of tagging (Neville & Talbot, 1964).

The long migration indicated in the above tagging studies revealed the extreme vulnerability of Narragansett Bay stocks to fishing pressure i.e. otter trawl, and fish traps as the fish seasonably move up and down the Atlantic Coast. As a result, the Narragansett Bay stock could be heavily exploited by foreign and domestic trawlers, and by uncontrolled use of fish traps before these fish return to Rhode Island waters to spawn.

Smith and Norcross (1968) indicated that since decreasing water temperatures concentrated scup into smaller geographic locations, a resulting concentration of effort upon these stocks could occur which would result in heavy exploitation of scup in these locations.

In recent years there has been heavy pressure placed on coastal stocks of finfish by foreign trawler fleets. Their method of 'pulse fishing' has removed large quantities of fish without much regard for the future of the resource. Concentrations of fish resulting from the conditions previously mentioned would intensify foreign fishing effort and result in heavy exploitation of the stock.

In 1968, a fishing agreement was entered into by the United States and Soviet Union which limited the annual catch of scup by Russian vessels in the area from Rhode Island to Cape Hatteras, North Carolina. Smith and Norcross (1968) have expressed doubt about any advantageous results of this provision. To date, the Rhode Island scup harvest has not increased to any significant degree, which puts the merits of such

an agreement in doubt. The 1967 scup catch of 1.24 million pounds did increase to 2.08 million pounds in 1969, and had stabilized at that level in 1972.

Reduced annual poundage landings may not be a good estimate of the actual number of fish landed. It is possible that the stock now consists of large numbers of small fish with a marked absence of larger, more valuable, individuals. Such a condition would indicate overfishing and require appropriate measures to insure that growth to a larger size will occur. This, coupled with successful recruitment of older year classes, should produce a viable fishery. To accomplish this, cod end mesh restrictions may have to be imposed and self dictated conservation measures such as careful onboard handling and culling to insure safe return to the water of all small fish which are not suited to processing as food fish. A related restriction might prohibit the landing of small scup at trash fish plants.

Neville and Talbot (1964) indicated excessive mortality of young scup caused by fishing gear which did not select according to size. Culling at sea is also wasteful. This fact was noticeable during trawling operations in Narragansett Bay where extreme care was taken to insure the proper handling of scup.

Smith and Norcross, (1968) stated that a larger cod end mesh was desireable. They felt that if all one year old scup ($\bar{X}$ length 113$\pm$ 17.42 millimeters in June in Narragansett Bay) were allowed to escape through larger mesh size requirements, and that if natural mortality was as great as 50% there would be no less in total poundage of fish from age class one to age class two for any given year class.

Smith & Norcross (1968) indicated that a mesh size which would allow most fish under 205mm(FL) to escape would have to be determined.

One estimate that they made was that 95% of the scup between 183 and and 210mm(FL) have a body depth of 75mm. A cod end with 4 inch stretch mesh would have a diagonal opening of approximately 3 inches (76mm) under tow. This would allow escapement of scup up to 210 mm and virtually all fish under 193 millimeters. Data collected on trawl caught scup in Narragansett Bay revealed that mesh restriction of this type would allow escapement of all fish in age classes one and two and a portion of those in class three (Figure 2). The mean length of two year old scup from Narragansett Bay was 177± 33mm, and the mean length of three year old fish was 214±31mm.

These restrictions would encompass the majority of the scup caught in Narragansett Bay. Based on these data, one would have to conclude that a total ban on the use of an otter trawl for harvesting scup in Narragansett Bay is an appropriate management tool. It also may be an appropriate time to place this species under state management with appropriate regulations, in the bays along the Atlantic coast. Presently, the effort toward harvesting scup in Narragansett Bay is low due to small stock sizes and low prices for small fish. Restrictions at this time would probably impose less of a burden on the overall fishing industry than at a time when capital outlay and effort directed toward harvesting scup is at a high level.

It is also in order to suggest that this is the time for more careful handling of the otter trawl catch after haul-back. In fisheries where scup is considered incidental to other pelagic species and in the fishery directed toward scup, care should be taken to return unsuitable i.e. small scup to the water as expediently as possible.

Smith & Norcross (1968) indicated that in brief experiments in-

volving side by side fishing of two nets with a 10 millimeter difference in mesh size, not only did the larger mesh allow escapement of more small fish, but it caught greater numbers of larger fish. They state that by increasing the mesh size of the net, fishermen would, in all probability, realize greater profit because larger fish command higher prices and a self-culling net would reduce time spent in sorting the catch. However, because the winter-trawl fishery is not a single species fishery, some compromises on mesh size would have to be made.

Further evidence for allowing two year old scup to escape comes from results of gonad analysis which reveal ripe males and females which are two years old. Finkelstein (1969) presents evidence to support this contention. Because these two year old fish constitute such a large portion of the catch it might be wise to allow them to spawn at least once prior to harvesting. This would suggest that a minimum legal length is appropriate to consider, provided additional supportive data on age at maturity can be supplied.

Data on size distribution of the trap caught scup indicated that very few one and two year old scup are retained by the traps until August. There is a good possibility that those two years old that were capable of spawning had done so by the time of capture, and that growth during that particular year was sufficient to, late in the season, make the scup vulnerable to the trap during fall migrations from Narragansett Bay.

Based on this evidence it does not appear that any mesh regulations for fish traps are necessary.

Summary

1. Scup are captured by otter trawl in Narragansett Bay from May until November, and in commercial traps from April until November. These fish appear to move into Narragansett Bay in pulses, the larger fish appearing first. Age classes one through four constitute the greatest proportion of all samples, two year olds being the most prevalent.
2. Analysis of gonads revealed male and female fish to be in a ripe condition at two years of age as determined from scale annuli counts.
3. Results of growth determinations from tag recapture data was inconclusive because of poor tag returns. Growth of from two to three millimeters per week was indicated. Growth was also determined using fish length-scale length relationships. A growth curve was constructed which illustrated that Narragansett Bay scup grew at a faster rate and reached a smaller asymptotic length sooner than Peconic Bay, Long Island scup.
4. Movement data was incomplete but indicated a seaward and then southern movement of scup after leaving Narragansett Bay.
5. Studies of tag retention and tagging induced mortality indicated that Floy dart tags do not remain with the fish for more than seven weeks after tagging.

Fish tagged with dart tags suffered some mortality. Fin rot and tail rot was evident on all fish, both tagged and control.

6. Cod end mesh restriction may be necessary to insure escapement of fish less than 193 millimeters fork length, allowing them to mature sexually and also to grow to a more valuable size at harvesting.

7. Provided additional supportive data is available, a minimum legal length may be appropriate.

8. A ban on the use of the otter trawl for scup should be imposed in Narragansett Bay, and other estuaries along the Atlantic Coast. This would minimize the mortality on young of the year and one year old fish.

9. At this time there appears to be no need for restrictions on the floating trap fishery.

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LITERATURE CITED

Bigelow, Henry B. and William C. Schroeder 1953. Fishes of the Gulf of Maine, Fish. Bull. of Fish and Wildlife Services No. 74 Vol. 53 P407

Briggs, Phillip T., 1968. Sport fisheries for scup in Long Island waters. New York Fish and Game Journal Vol. 15, No.2 July p. 165-185

Cassie, R.M. 1954. Some uses of probability paper in analysis of size frequency distribution. Australia Journal Marine & Freshwater Research 5:513-522

Edwards, R.L., R.R. Stoddard, and L.M. Lawday 1960. Industrial fishery. Ann.Report B.C.F. Biological Laboratory, Woods Hole, Mass. Circ. 99 p 22

Finkelstein, Samuel L., 1969. Age and growth of Scup in the waters of eastern Long Island. New York Fish & Game Journal. Vol. 16 No. 1 Jan. p. 84-110

Lux, Fred E. 1971. Age Determination of Fishes (Revisal) Fisheries Leaflet 637 U.S. Dept. Commerce NOAA, NMFS Seattle, Wash.

Neville, Wm. C. and Gerald B. Talbot, 1964. A fishery for scup with special reference to fluctuation in yield and their causes U.S. Fish & Wildlife Service. Spec. Science Report Fisheries 459 p 1-61

Rhode Island Landings Annual Summary 1965 to 1969. U.S. Dept. of Commerce, NOAA, NMFS. Washington, D.C.

Stoddard, Ruth R. 1958. Scup (Sub-project industrial) age and growth Ann. Report Woods Hole Laboratory U.S. Fish & Wildlife Service.

PROJECT FINAL REPORT

PL 88-309

State of: Rhode Island

Project No: 3-138-R-3

Contract No: 04-3-043-34

Project Title: The growth and movement of Scup (Stenotomus chrysops) in Narragansett Bay, Rhode Island and along the Atlantic Coast.

Period Covered: February 1, 1973 - December 31, 1973

Job No. 1

Objectives: To determine movement of age classes of Scup into Narragansett Bay, and to determine the age structure of the Scup population in Narragansett Bay throughout the seasons that Scup occupy its waters.

Job No. 2

Objectives: To determine growth and movement of Scup found in Narragansett Bay and after they leave the bay. Determine whether tagged fish are harvested locally or elsewhere.

Job No. 3

Objectives: Use data collected to formulate a management plan for Rhode Island Scup harvests, and to contribute these data to research programs of other Atlantic coast states.

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