

SPOTTED SEATROUT

PARAMETER BASIS FOR GXPOPS MODEL AND TRENDS IN THE FISHERY

INTRODUCTION

This paper is intended to provide the basis for a GXPOPS model of spotted seatrout and update existing descriptions of trends in the fishery. The available information has been collected and summarized. Publications cited in the text are attached. Recommendations on parameter selection are made. These are summarized in Tables 10, 11, and 12. Some problem areas are identified, with suggestions on how to approach the problem or deal with uncertainty.

GXPOPS MODEL

Landings Data

Recreational data was assembled from the National Marine Fishery Service Marine Recreation Fishing Survey. Attachment 1 contains the raw data for the period 1977 through 1986. For the purpose of developing parameters for the GXPOPS model, the following adjustments were made:

- 1) The year 1979 was deleted because weight data for fish less than one kilogram was not included in the sample;
- 2) The year 1986 was eliminated because the possibility that redfish regulations may have affected fishing patterns for seatrout; and
- 3) The January-February sampling wave was not conducted in 1981. Therefore, mean landings for that wave were calculated based on a five year average rather than six years.

Mean recreational landings were calculated by taking the mean value of each wave over the available years. Mean total landings were the sum of the wave means.

- 4) Each month's recreational catch, was assumed to be one half of the catch on that wave.

Commercial Data Base

Commercial landings data was obtained from the NMFS Statistical Reporting System for the years 1977 - 1986. Data from the years 1980 - 1985 were used to match recreational data and set catch and seasonality parameters for the model.

One adjustment was made. A dealer in Lee County was found to have substantially over-reported his landings in the years prior to 1985. Data from this dealer were deleted after efforts to get corrected figures were unsuccessful. Complete deletion of these data under estimates commercial catch by an unknown degree. Recent landings by this dealer have been small (38,229 lbs. in 1985). However, there is a possibility that landings in earlier years may have been substantial. This bias will not significantly affect the calculation of seasonality of harvest or of total yield. However, it might affect other calculations such as recreational/commercial division of historical catch or any local regulations in Lee County which related past catch levels to future regulations.

Use Of Landings Data In A GXPOPS Model

The model must be adjusted to reproduce the total and seasonal landings pattern exhibited by the fishery. Table 1 provides catch by month and total catch for the East coast, West coast, and Florida total. These data have been adjusted as described above.

Once growth, mortality, and reproduction parameters have been set, the model's recruitment parameter (A1) is adjusted by trial and error until the model replicates the initial annual yield from Table 1. Then the fishing mortality matrix is adjusted by trial and error, beginning in month one and preceding to month twelve until the estimated monthly yields match the observed monthly values in Table 1. Finally, the initial population age structure is set equal to age structure in year 5 of the model's simulation.

GROWTH PARAMETERS

Von Bertalanffy Parameters

Age and growth for spotted seatrout have been studied by numerous authors. These are summarized in Mercer, (1984), Perret *et al.*, (1980), and Condry *et al.*, (1984). Murphy, unpublished, fitted von Bertalanffy equations to several age and growth studies from various parts of Florida, and cited another study for which von Bertalanffy parameters were calculated for a Florida population (Table 2).

For the purpose of modeling, the best available von Bertalanffy parameters for Florida are those of Murphy, unpublished, (Table 2). The annual values of T_0 and K must be translated in monthly values to use in the model. This has been done for the recommended model parameters (Table 10 & 11). Work underway within DNR will yield revised estimates of von Bertalanffy parameters in approximately June, 1987.

Length/Weight Relationships

Length/weight relations are summarized in Mercer, (1984). Those used by Murphy (unpublished) are found in Table 3 and should be used to calculate weight (infinity) from L_{∞} for the appropriate age and sex being modeled.

Recruitment Function

The GXPOPS model provides three stock/recruitment relations, a Ricker model, Beverton-Holt model and a constant recruitment model, alternative 2. For constant recruitment, parameter A_2 is set at 0 and constant recruitment will occur at a level determined by the formula $1/A_1$.

Spawning Cycle

The available information on spawning cycle is summarized by Mercer, (1984) and indicates a long spawning season for spotted seatrout with the possibility of multiple spawning by individual fish. Spawning may extend from mid-April through September or October with some differences by area which are probably related to temperature. Spawning season in the northern portion of the range appear to be shorter. In extreme south Florida ripe fish were found in every month of the year (Rutherford et al., 1982).

For the purpose of modeling the midpoint of the spawning season, July, is chosen as the birthdate. July becomes month one of the model.

The model contains parameters for the months that spawning cycle begins and ends. For species like seatrout which do not carry fertilized eggs, this parameter should be set at 1. The model also contains a parameter for rate of contact in mating. This does not apply to species like seatrout and should be set at 1.0.

Birthdate

Birthdate must be coordinated with the method of age determination and von Bertalanffy equation parameter T_0 so that the model's birthday corresponds with the predicted size at age

1.0, 2.0, 3.0, etc. In seatrout, size at age is based on scale analysis where the effective birthdate is the time of annulus formation. Klima and Tabb (1959), Maceina et al., (1987), and Rutherford et al., (1982) all found annular formation in March or April. Assuming an April 1 date of annulus formation, T_0 must be adjusted so that the predicted size in month one of the model is size in July rather than size in April. This is done by subtracting 0.25 years from T_0 . The value for T_0 in table 10 & 11 incorporate this adjustment and are expressed as monthly values.

Size And Age At Sexual Maturity

Numerous studies have been done on reproduction of seatrout. Most of these are collected in Mercer (1984) and Perret et al., (1980). These include five studies in Florida. Inspection of these studies shows reasonable consistency with the following conclusions:

- 1) Size at first maturity of females occurs about 220 to 230 mm SL (10.6 - 11.0 in. TL) during the third year of life;
- 2) All females are mature by between 270 and 300 mm SL (13.0 - 14.4 in. TL) during the fourth year of life;
- 3) Males mature at smaller sizes than females and approximately 1 year earlier; and
- 4) There appear to be some differences by area in the size at which the majority of female fish are mature. However, most studies were not specifically directed at this question. Difference in results may well be an artifact of different study designs or data interpretation.

A revised version of the GXPOPS model is being sent to the Commission office. This version allows direct calculations of spawning stock biomass provided a maturity schedule is available for the species being modeled. For the purpose of modeling, a reasonable assumption for females would be 50% maturity at age 3 and 100% maturity for age 4 and older. For males, 50% maturity at age 2 and 100% maturity for age 3 and older is reasonable. Because the model counts age 0 fish as age 1, add one year when inserting age at maturity in the model.

Size And Age At Recruitment

The model provides for two types of recruitment, recruitment to the fishing grounds called "Age (months) at first recruitment", and recruitment to the gear, which is controlled by the model's "

selectivity matrix. Age at first recruitment can be set at any age prior to the onset of fishing mortality, month six in this case. Setting the selectivity matrix for age at recruitment to the gear is more complex and cannot be accurately determined with available data. The correct analytical approach, limitations on available data, and reasonable approximation are described below.

Setting the selectivity matrix to mimic age at recruitment to the gear requires consideration of two different distributions, size selectivity of the gear and variability of size at a given age. Selectivity in a given month is equal to the probability that fish of that age are a given size times the probability of capture of that size, summed over all size classes.

The data necessary to precisely calculate the selectivity for recruitment to the gear includes statistical estimates of the variability of size at age for both sexes by area of the state and size selectivity for commercial and recreational gear. Most of this is not available in sufficiently precise form.

Good data on the size of fish caught by recreational fishermen is available. Size at recruitment to the fishery (fishing gear) varies from year to year (Table 4). Data from the NMFS National Recreational Fishing Survey for the years 1979 - 1986 shows a range in modal size from 310 mm TL to 350 mm TL (12.2 - 13.8 inches) on the East coast and 290 mm to 370 mm, (11.4 - 14.6 inches) on the West coast. (frequency distributions attached). The modal size for all data combined, 1979 - 1986, was 320 mm TL statewide, 320 mm TL on the East coast and 330 mm TL on the West coast. There are no recent data available on size at recruitment to commercial gear but public testimony and studies done during the 1950's indicate that the modal size in the commercial catch is larger, with few fish taken at less than 12 inches. Ongoing DNR research could be used to estimate size at recruitment to commercial gears.

There is no available information from which a reliable estimate of statistical variability in size at age in Florida can be calculated. What is available suggest that variability is substantial. There is considerable variation in average size at age between sexes and among areas (Table 5). There is also wide variation in age at a given size. Most studies show fish of a given size may be from 2 to 4 different year classes. This is probably a reflection of long spawning period and variations in growth rate among fish of the same population. Wide variation in size at age for different areas may be to some degree an artifact of different study designs but supports the appearance of high variability in seatrout growth rates.

For the purpose of modeling, an approximation of the selectivity matrix for age at recruitment to the gear can be

constructed by using von Bertalanffy parameters for West Coast females, assuming a normal distribution of age at size with a standard deviation of 0.5 years and constructing a selectivity curve based on all recreational length frequency data combined and reformed into an age/length distribution based on predicted size at age in months.

Technical correctness requires calculation of such a distribution for each sex and area. However, uncertainty about the real values of these parameters make such an exercise largely academic. Accordingly, the same frequency distribution of selectivity relative to age at modal size was assumed for all other areas and sex combinations (Table 12). Age at modal size are found in Table 6.

To respecify age/size at recruitment for size limit higher than 12 inches, use the appropriate von Bertalanffy parameters for sex and area being modeled and calculate the distribution of size at age around that size limit by again assuming a reasonable standard deviation.

The above approach assumes that size at recruitment to the recreational fishery represents full recruitment. This may not be entirely correct as commercial fishing gear appears to target larger fish. Ongoing DNR research may show that size at recruitment to commercial gear is substantially larger than recruitment to recreational gear. If so, there should be some analysis to see if increasing F with size can be detected. Ongoing DNR research will also provide accurate estimates of statistical variability of size at age which should be used in combination with revised age and growth estimates to revise the selectivity matrix.

Mortality Rates

Mortality rates for seatrout have been examined by Tatum (1980), Condry (1984), Rutherford *et al.*, (1982), Rago and Goodyear (1985), and Murphy (unpublished). Tatum (1980) examined tournament records in Alabama and calculated a mean annual mortality of 49.8% ($Z=0.69$) in Alabama for years 1964 - 1977. Condry (1984) reviewed the literature on spotted seatrout and performed a yield per recruit analysis based on literature values. Using Pauly's formula, he estimated natural mortality at $M=0.45$. Rutherford *et al.*, (1982) estimated total, fishing and natural mortality rates for Everglades Natural Park (Table 7). Using age frequency analysis, they estimated natural mortality (M) at 0.35, 0.36, & 0.27 with fishing mortality (F) at 1.37, 1.02, & 1.21 for males, females and combined sexes, respectively. Rago and Goodyear (1985) analyzed tagging data for Everglades Natural Park and calculated conditional fishing and natural mortality rates for seatrout. For total mortality rate, their

conclusions were similar but slightly lower than Rutherford's. However, they found much higher mortality from natural causes and less from fishing. Conditional fishing mortality rates ranged from 8% to 27% after including an estimate of release mortality and depending on the assumed rate of reporting of tags (100% to 25%). These rates correspond to instantaneous fishing mortality rates of $F=0.08 - 0.32$. Estimated instantaneous rates of natural mortality were $M=1.02 - 0.78$. Rago and Goodyear's conclusions are weakened by the very small sample size (20), 2% return rate and unknown rate of handling mortality and tag reporting rate. Their estimates of natural mortality are very high given the observed life span of spotted seatrout, 8 to 10 years. This suggests that some fishing mortality may be included in their estimate of natural mortality rate, over-estimating M and under-estimating F . Murphy (unpublished) estimated natural mortality rates for seatrout by various methods using data from previous studies (Table 8). He found a wide range of estimates of M , $0.11 - 0.58$. Using age frequency and tagging data from studies done in Florida in the 1950's and 1960's, he calculated total annual mortality rate of $A=0.46 - 0.90$, equivalent to $Z=0.62 - 2.30$ (Table 9). In his yield per recruit analysis, Murphy concluded that the most reasonable values of M were within a range of 0.30 to 0.40 and used a best estimate of Z of 1.3 and 1.4 for females and males, respectively, on the West coast and 0.60 and 0.90 for females and males on the East coast.

For the purpose of developing a GXPOPS model the following parameters are recommended:

Natural Mortality

1) Based on the available data, the likely range of natural mortality is $M = 0.30-0.40$ with 0.35 as the best estimate. If males and females are analyzed separately, the upper end of the range (0.40) is a better estimate for males, with 0.35 the best estimate for females. These are converted to monthly rates in Tables 10 & 11.

Fishing Mortality Rate

2) Based on the available data, it is reasonably certain fishing mortality rates in Florida are high. The results of Rago and Goodyear are the only contradictory information. While the wide range of mortality estimates show that there is need for additional study, the majority of the available information supports a high F . It should also be noted that present statewide rates of fishing mortality are probably higher than those calculated in literature. Murphy's calculations were based on data taken from the fishery in the 1950's and 1960's. Length frequency data from Tabb, 1960, (Table 13) indicates much larger fish than are found in catches today, strongly suggesting that

fishing mortality rates are higher today. The other two studies were done in Everglades Natural Park which may have a slightly lower fishing mortality rate than most of the rest of Florida due to its relative inaccessability. Also, tight regulation of redfish may be shifting fishing effort to seatrout.

For the purpose of GXPOPS modeling, reasonable bounds of fishing mortality rate for both sexes on the West coast, are $F=1.00-1.40$. Given the nature of existing data, $F=1.40$ is a more conservative and most likely to be nearest the real value of F . The only values for the East coast are from Murphy, unpublished, 0.90 and 0.60 for males and females, respectively. These estimates seem low and should be used with caution.

Condensing The Analysis

The high degree of variability in estimates of growth for spotted seatrout and lack of up to date, precise information make it necessary to condense the analysis if useful management advice is to result. I recommend using data for the West coast female seatrout population to set up a general statewide model. For initial yield, use the sum of East and West coast landings. The following support this recommendation:

1) Landings data are not available segregated by sexes. Without such a segregation, accurate models by sex are not possible;

2) Female seatrout make up the bulk of the catch in sizes larger than 12 inches total length;

3) A major consideration in management should be spawning stock biomass. For seatrout, spawning biomass can be adequately modeled looking only at female fish;

4) The West coast is the majority of the Florida fishery in landings, area, and participation for both recreational and commercial fishermen;

5) Fishing mortality rates calculated for the East coast appear to be too low.

6) More studies are available for the West coast of Florida and are relatively consistent in their results.

7) Use of West coast female parameters is a conservative choice and will minimize the risk of underestimating the severity of overfishing or degree of regulation needed to reach whatever biological goal is set by the Marine Fisheries Commission.

It could reasonably be argued that differences in growth rate between the East and West coast of Florida require different

models for each coast. If the Commission wish to take that approach I recommend using female parameters for each coast with an initial fishing mortality rate of $F=1.4$. The higher F is consistent with the observed decline in size frequency in the catch on the East coast.

Factors Which Should Be considered In Population Modeling

Release Mortality

Information in the scientific literature on release mortality is limited. Moffett, (1961) held 15 fish for 66 days to test tag shedding. He found no mortality. Iverson and Moffett (1962) held 94 fish, half of which were tagged, for approximately 3 weeks. Within 10 days, mortality of untagged fish was 6.4% while 11% of tagged fish died. Sackett and Hein (1979), in a test of floy tags, found 88% survival of seine caught seatrout and 70% survival of hook and line caught fish after 30 days. They noted that long distance transport of hook and line caught fish was a factor in lower survival. Ludwig (unpublished) found 5% mortality in hook and line caught seatrout, 58% mortality in trammel nets, and almost 100% mortality in gill nets. In that study, nets were used as strike nets with short soak times. No difference was found in mortality of tagged versus untagged fish. Saul¹, (personal communication) reviewed Texas data files and found that 75% of seatrout caught in gillnets set by Texas Park's Wildlife Department were dead in the net after sets of 8 to 12 hours. During tagging programs in Florida Bay, Funcelli² (personal communication) found that most seatrout caught in gill nets were in poor condition and generally were not considered likely to survive. In Texas, Hegan *et al.*, (1984) looked specifically at the question of mortality of seatrout released by recreational fishermen. All fish were caught with hook and line and held in cages for seven days. The study was repeated seasonally and in seven bay systems. Mean survival rates were 83% for controls and 73% for fish handled as recreational fishermen normally would. Results varied widely among bay systems. Mean mortality rates in summer were higher than winter but the differences were not statistically significant. They concluded that holding and transporting seatrout the long distances required in the study caused greater stress and mortality than normally would have been encountered by fish caught and released by recreational anglers. After adjusting for control mortality, they concluded that mean mortality for recreational hook and line caught fish was 10%.

Based on the above information, it appears that seatrout release mortality from hook and line is higher than for redfish but is still relatively low. However, it is possible that some

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conditions, such as high summer temperatures or particular types of bait, may increase mortality. For modeling purposes, a reasonable assumption would be 10% release mortality. A very conservative assumption would be 20% mortality. For net caught fish, there is much less information. What is available suggests that mortality is much higher than for hook and line caught fish. A reasonable range for gill net caught fish would be 75%-100%. Mortality in seines or trammel nets is probably less.

Release mortality from undersize fish or during closed seasons may be inserted in the GXPOPS model by estimating the percentage of total fishing mortality represented by release mortality then increasing the value in the selectivity matrix by that percentage during closed seasons or prior to the age at legal size. With that approach, the model will give accurate estimates of standing stock but will over-estimate yield. Yield estimates from the model must be reduced by the percentage of fishing mortality which is represented by release mortality.

Release mortality from catches in excess of bag or trip limits must be handled differently because such mortality will be present during both open and closed seasons. One method would be to use recreational survey data to estimate the percentage of fish caught in excess of the bag limit, multiply that figure by the estimated release mortality and add the equivalent percentage to the recreational component of F_{mult} . The same procedure could be used for a commercial trip limit. This again would yield accurate estimates of standing stock but would over-estimate yield. Yield can be corrected by the method outlined above.

The GXPOPS model could be modified to automatically account for release mortality. An additional mortality matrix could be added which would extract release mortality from the fished population and separate it from yield.

Harvest Of Sublegal Size Fish

Any modeling which explores the effect of changing size limits should account for harvest below that size limit. Length frequency of the recreational catch (1977 - 1986) shows that a substantial catch is made at sizes less than the size limit (14% East coast, 25% West coast, and 18% statewide). (Length frequency distribution attached). Sublegal catches can be modeled by adjusting the selectivity matrix to a younger size/age at recruitment. This is not necessary to model initial conditions, but should be done if larger size limits are modeled.

Effort Shifting

Fishermen will change their fishing activity and behavior in response to regulation in order to maximize their success. If very restrictive measures are implemented, this effort shifting is likely to be significant, as was seen in Spanish mackerel. If not accounted for in a population model, the model results will over-estimate the effect of proposed regulations, increasing the risk of continued overfishing. Unfortunately, there are no data or studies available which explore this issue. Commission and staff should explore this issue during public testimony. Based on that testimony, a correction for effort shifting should be inserted in the model if very restrictive measures are proposed.

TRENDS IN THE FISHERY

Several surveys of the Florida seatrout fishery were conducted in the late 1950's. Klima and Tabb, (1959) reported on the commercial fishery in northwest Florida between Steinhatchee and Apalachicola. They found gillnets to be the primary commercial gear. Commercial hook and line fishing was confined to East Point and Steinhatchee. The sport fishery was relatively small and was conducted primarily from fish camps using rental boats and guides. Moffett (1961) reviewed the commercial fishery in Apalachicola, Cedar Key, and Lee County. In Cedar Key and Lee County, commercial hook and line was the predominant gear. However, during winter most fishermen switched to gill nets or trammel nets to target seatrout. In Apalachicola, gill nets and beach seines were the primary commercial gear. Tabb (1960) surveyed the fishery in the Indian River area. He found both sport and commercial fishing to be important, with commercial fishing declining and recreational fishing increasing with increasing population and development. Fishermen who fished for sport but sold some or all of their catch out numbered full time commercial fishermen by 10 to 1. He found that commercial hook and line accounted for a large (but unspecified) percentage of commercial production. Net catches were made as a bycatch in the mullet fishery and as a directed fishery during the coldest months of the year.

In 1984, Parsons, unpublished, examined the Florida commercial fishery for seatrout and found a substantial long-term decline in statewide landings (Figure 2). He examined landing trends in northeast Florida (Duval County), Indian River Lagoon, Charlotte Harbor, and Tampa Bay, finding declining catches in Tampa Bay and Indian River but increases in Charlotte Harbor and Duval County. Wholesale fish dealers were interviewed to determine the source of their reported landings. Parsons found that trammel and gill nets accounted for 55% of the total catch, haul seines 3%, and commercial hook and line 17%. Sale of fish

by recreational fishermen was estimated at 25% of the total catch. These percentages varied substantially around the state.

Landings data for all major Florida bay systems for the period 1977 through 1986 was assembled (Tables 14 and 15). Examination of those data show clear declines in all bay systems in the state except Southwest Florida, Charlotte Harbor, the Big Bend area and the eastern Panhandle. In Charlotte Harbor the problems with over-reporting by one dealer made it impossible to be sure of the direction of any long-term trend. However, comparisons with long-term data in Parsons (unpublished) suggest an increasing trend from the 1950's through mid 1970's then stable catches until the mid 1980's with a decline beginning in 1984. Landings in the Southwest Florida, the Big Bend and eastern Panhandle show year to year fluctuations but no overall trend. However, within the Big Bend area there have been substantial fluctuations in the distribution of catch by county, with catches in Taylor County rising and Dixie County declining.

Data on catch by gear from the NMFS agree with Parsons on the major gears in use but show a different distribution of catch among those gears (Table 16). Total hook and line landings by both commercial and recreational fishermen were substantially less in the NMFS statistic (mean=17%) than found by Parsons while total landings from gill and trammel nets were greater (mean=77%). Trawl bycatch is significant in some years.

Recreational Catch Trends

Recreational catch data show great year to year fluctuations but no clear long-term trend (Tables 17).

General Conclusions Regarding Trends In The Fishery

Several trends emerged from the available information on the commercial fishery:

- 1) Commercial landings are declining statewide in a long-term trend stretching back to the 1950's. Areas where commercial catch is stable are those with the least habitat degradation and population increase. Several possible causes may be contributing to the decline, including declining productivity due to habitat degradation, competition with recreational fishing, growth overfishing, and recruitment overfishing. The first two are reasonably certain to be occurring. Growth overfishing is likely to be contributing a portion of the decline. Recruitment overfishing is a possible source of decline but the available data are not sufficient to demonstrate that it is occurring.

2) The commercial fishery has shifted from a primarily hook and line fishery to a primarily gill and trammel net fishery. This is probably a response to declining abundance.

TABLE 1. Spotted Seatrout, Monthly And Annual Landings,
Mean Values 1980 - 1985

	EAST COAST			WEST COAST			STATEWIDE
	<u>Adjusted Rec.</u>	<u>Adjusted Comm.</u>	<u>Adjusted Total</u>	<u>Adjusted Rec.</u>	<u>Adjusted Comm.</u>	<u>Adjusted Total</u>	<u>Adjusted Total</u>
Jan.	61,251	75,858	137,109	262,596	216,066	478,662	615,771
Feb.	61,251	47,196	108,447	262,596	121,865	384,461	492,908
Mar.	41,002	42,524	83,526	102,164	68,870	171,034	254,560
Apr.	41,002	50,953	91,955	102,164	71,818	173,982	265,937
May	86,516	41,041	127,557	328,356	69,090	397,446	525,003
Jun.	86,516	37,640	124,156	328,356	53,005	381,361	505,517
Jul.	88,296	49,222	137,518	481,706	59,221	540,927	678,445
Aug.	88,296	40,193	128,489	481,706	72,972	554,678	683,167
Sep.	36,452	29,454	65,906	422,553	100,619	523,172	589,078
Oct.	36,452	38,682	75,134	422,553	106,372	528,925	604,059
Nov.	113,762	37,802	151,564	578,808	177,954	756,762	908,326
Dec.	<u>113,762</u>	<u>50,428</u>	<u>164,190</u>	<u>578,808</u>	<u>241,707</u>	<u>820,515</u>	<u>984,705</u>
Total:	854,555	540,993	1,395,548	4,352,361	1,359,559	5,711,920	7,107,468

TABLE 2. Von Bertalanffy Parameters, From Murphy (unpublished)

Table 2. Von Bertalanffy growth parameters for red drum and spotted seatrout in Florida. Nonlinear regression was used to develop equations for spotted seatrout on the west and east-central coast using back-calculated lengths.

	<u>L_{oo}</u>	<u>W_{oo}</u>	<u>K</u>	<u>t₀</u>
Red drum:				
West-central coast ¹	934 mm FL	9.85	0.46	+0.029
East-central coast ¹	980 mm FL	10.69	0.42	-0.149
Spotted seatrout (females)				
West coast ²	670 mm SL ⁵	5.41	0.15	-0.40
East-central coast ³	832 mm SL ⁵	10.32	0.13	-0.42
Everglades ⁴	656 mm SL	3.48	0.13	-2.04
Spotted seatrout (males)				
West coast ²	515 mm SL ⁵	2.39	0.21	-0.272
East-central coast ³	702 mm SL ⁵	6.14	0.11	-1.10
Everglades ⁴	591 mm SL	2.61	0.12	-2.95

¹from Murphy and Taylor (in prep.)

²from Klima and Tabb (1959) and Moffett (1961)

³from Iverson and Tabb (1962)

⁴from Rutherford (1982)

⁵Standard lengths converted to total length using Moffett's (1961) equation.

TL=1.22 SL for use in length-weight relations

TABLE 3. Length Weight Relationships, From Murphy (unpublished).

Table 1. Length-weight relations for red drum and spotted seatrout by area (where W is weight and L is length measured as indicated).

	$W=10^aL^b$		Units of measure	
	a	b	W	L
Red drum:				
West-central coast ¹	-5.2099	3.0984	grams	mm FL
East-central coast ¹	-5.0269	3.0275	grams	mm FL
Spotted seatrout:				
West coast ²	-5.333	3.113	grams	mm TL
East-central coast ³	-5.192	3.062	grams	mm TL
Everglades ⁴	-5.191	2.745	decagrams	mm SL

¹ from Murphy and Taylor (in prep.)

² from Moffet (1961)

³ from Harrington et al. (1979). Although from a Texas study, this equation included approximate length range found in east-central Florida by Tabb (1961)

⁴ from Rutherford (1982)

TABLE 4. Modal Size (5mm increments) For Spotted Seatrout
Recreational Catches

	<u>East Coast</u>	<u>West Coast</u>	<u>Florida Total</u>
1979	310	330	330
1980	340	320	340
1981	350	370	380
1982	320	310	310
1983	340	330	340
1984	320	290	320
1985	320	330	330
1986	320	330	320
Years combined	320	330	320

Source: National Marine Fisheries Service - National
Recreational Fishing Survey

TABLE 5. Variation In Size At Age, From Mercer, 1984

Table 6. Mean back-calculated standard lengths (mm) at age for spotted seatrout as reported in the literature.

Study	Location	Sex	Age											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Brown (1981)*	Chesapeake Bay, Va.	Male	128 (68)	206 (66)	267 (56)	323 (26)	370 (28)	430 (7)	430 (7)	475 (2)				
		Female	161 (92)	237 (91)	296 (80)	346 (57)	385 (35)	449 (18)	449 (16)	481 (12)	504 (4)	553 (1)		
		Combined	143 (247)	221 (221)	302 (199)	354 (122)	378 (80)	447 (35)	447 (35)	482 (21)	518 (8)	557 (5)	591 (3)	620 (2)
Music and Pafford (1984)*	Georgia	Male	148 (213)	228 (210)	280 (189)	323 (26)	363 (13)	385 (9)						
		Female	161 (333)	256 (326)	328 (227)	386 (188)	425 (57)	463 (27)	523 (7)	572 (2)				
		Combined	155 (548)	244 (538)	313 (336)	373 (134)	413 (70)	443 (36)	523 (7)	572 (2)				
Tabb (1961)	East-Central, Fla.	Male	138 (281)	200 (195)	259 (189)	322 (43)	380 (14)	410 (4)	437 (1)					
		Female	145 (682)	220 (509)	300 (336)	353 (183)	408 (74)	480 (27)	520 (10)	545 (2)				
		Combined	165 (592)	248 (563)	317 (436)	384 (254)	457 (135)	533 (73)	561 (38)	624 (1)				
Stewart (1961)	Flamingo, Fla.	Male	128 (433)	210 (417)	267 (217)	313 (33)	348 (5)							
		Female	137 (562)	236 (538)	280 (372)	345 (133)	401 (58)	434 (10)	451 (2)					
Rutherford (1982)	Everglades National Park, Fla.	Male	215 (205)	260 (202)	292 (164)	327 (65)	377 (12)	403 (2)						
		Female	210 (326)	264 (325)	307 (275)	354 (134)	402 (32)	420 (3)	488 (3)					
		Combined	212 (539)	262 (535)	301 (446)	345 (201)	395 (44)	417 (12)	488 (3)					
Hoffett (1961)	Fort Meyers, Fla.	Male	128 (258)	206 (255)	259 (154)	310 (39)	354 (13)	437 (1)						
		Female	131 (386)	209 (383)	266 (293)	322 (118)	371 (46)	409 (21)	431 (5)	438 (1)				
		Combined	130 (644)	208 (638)	264 (447)	320 (157)	368 (59)	430 (22)	431 (5)	438 (1)				
Hoffett (1961)	Cedar Key, Fla.	Male	129 (83)	206 (83)	263 (52)	323 (19)	380 (4)	434 (1)						
		Female	130 (217)	212 (215)	269 (151)	323 (48)	383 (5)							
		Combined	130 (300)	211 (298)	268 (203)	323 (67)	382 (9)							
Klima and Tabb (1959)	Apalachicola, Fla.	Male	115 (316)	188 (312)	250 (251)	304 (71)	341 (7)	369 (1)						
		Female	117 (549)	191 (549)	258 (525)	315 (251)	372 (66)	423 (8)	437 (1)					
		Combined	116 (865)	190 (861)	255 (786)	312 (322)	369 (73)	422 (9)	437 (1)					
Pearson (1929)*	Texas	Combined	123 (396)	203 (303)	259 (230)	305 (160)	340 (94)	377 (57)	418 (36)	444 (8)	488 (3)			

TABLE 6. Predicted Age At Size For Florida Spotted Seatrout

<u>Total Length</u> ¹	Age In Years ²			
	East Coast		West Coast	
	<u>Male</u>	<u>Female</u>	<u>Male</u>	<u>Female</u>
12 in.	3.09	2.45	3.06	2.86
12.6in. (320mm)	3.35	2.63	3.30	3.08
13in. (330mm)	3.55	2.75	3.49	3.23
14in.	4.07	3.08	4.98	3.63

¹Calculated from von Bertalanffy parameters of Murphy, unpublished.

$$\text{Total Length (mm)} = 9.353 + 1.142 \cdot \text{SL}$$

²Age based on April 1 birthdate. To use in GXPOPS model for July 1 birthdate, subtract 0.25 years.

TABLE 7 . Mortality Rates Based On Age Frequency Analysis From
Rutherford et al., 1982.

Table 2. Estimates of annual survival (S) and monthly (A), instantaneous fishing (F) and natural mortality (M) coefficients, exploitation ratio (E), and ratio of conditional fishing mortality (m) to conditional natural mortality (n) for spotted seatrout males, females and combined sexes in Everglades National Park.

	S ¹	A	M	F	m/n	E
<u>Combined Sexes</u>	.23 ± .05	.77	.27	1.21	2.92	.82
<u>Males</u>	.18 ± .10	.82	.35	1.37	2.52	.80
<u>Females</u>	.25 ± .07	.75	.36	1.02	2.11	.74

¹ Survival rates with 95% confidence intervals.

TABLE 8 . National Mortality Rate Estimates From Murphy (unpublished).

Table 4. Empirical estimates of instantaneous natural mortality rates (M) for red drum and spotted seatrout sexes combined (W=West coast, E=East coast, ENP=Everglades National Park).

Red Drum		
Method	Method Reference	M
Maximum age (15-25 yrs)	Tanaka (1960)	0.10-0.18 ¹
	Royce (1972)	0.19-0.33 ¹
Growth parameters	Pauly (1978)	0.71 (W)
		0.66 (E)
	M/K, Beverton	0.46-0.92 (W)
	and Holt (1952)	0.42-0.84 (E)
Spotted Seatrout		
Method	Method Reference	M
Maximum age (8-10 yrs)	Tanaka (1960)	0.25-0.30
	Royce (1972)	0.46-0.58
Growth parameters	Pauly (1978)	0.36 (W)
		0.31 (E)
		0.35-0.36 (ENP) ²
	M/K, Beverton	0.15-0.42 (W)
	and Holt (1952)	0.11-0.26 (E)
		0.12-0.26 (ENP)

¹from Swingle et al. (1984)

²from Rutherford (1982)

TABLE 9. - Total Mortality Rate Estimates, From Murphy (unpublished).

Murphy, 20

Table 3. Total annual mortality rate (1-S) and instantaneous total mortality coefficient estimates for red drum and spotted seatrout in Florida. The estimates in parentheses were used in the model.

	<u>Study years</u>	<u>Ages</u>	<u>Z</u>	<u>1-S</u>
Red drum:				
West-central coast:				
males and females ¹	1981-83	II-IV	2.5-3.2 (2.7)	0.92-0.96
males and females ²	1961-65	-	1.8-2.7	0.84-0.93
East-central coast				
males and females ¹	1981-83	II-VII	0.8-1.3(1.1)	0.54-0.73
males and females ²	1961-65	-	1.0	0.63
Everglades				
males and females ³	1980	II-IV	1.1	0.65
Spotted seatrout:				
West coast:				
females ⁴	late 1950's	IV-VIII	1.2-1.4(1.3)	0.69-0.74
males ⁴	late 1950's	IV-VI	1.3-2.3(1.4)	0.73-0.90
males and females ²	1951-65	-	2.2	0.89, m
East-central coast:				
females ⁵	late 1950's	III-VIII	0.6(0.6)	0.46
males ⁵	late 1950's	III-VII	0.9(0.9)	0.61
males and females ²	1961-65	-	1.6	0.80
Everglades:				
females ⁶	1978-80	IV-VII	1.4(1.4)	0.75
males ⁶	1978-80	IV-VI	1.7(1.7)	0.82
males and females ⁶	1978-80	IV-VII	1.5	0.78

¹from Murphy and Taylor (in prep.)²from analysis of Schlitz tagging data, 1961-1964³from D. Buker (Everglades National Park, pers. comm.)⁴from Moffett (1961) and Klima and Tabb (1959)⁵from Tabb (1961)⁶from Putherford (1982)

Table 10. GXPOPS Parameters For Spotted Seatrout,
Initial Conditions, Florida East Coast

	<u>Males</u>	<u>Females</u>
Year classes	8	10
Age (month) at first recruitment	1	1
Month Spawning begins	1	1
Month spawning ends	1	1
Year of first maturity	3	4
Rate of contact	1	1
Recruitment regulation option	2	2
Recruitment parameters;		
A1	*	*
A2	0	0
Natural mortality monthly	.033	.029
Selectivity matrix	***	***
Fishing mortality matrix	**	**
Fmult (Annual F)	06.0	0.90
Male maturity fraction		
age 1-2	0	-
age 3	.5	-
age 4-8	1.0	-
Female maturity fraction		
age 1-3	-	0
age 4	-	.5
age 5-10	-	1.0
Von Bertalanffy parameters:		
W (infinity)	13.51b	22.71b
K (monthly)	0.0092	0.0833
T ₀ (monthly)	16.200	-8.040
Initial annual yield (Both Sexes)	(1,396,000)	

* A1 is derived by trial and error to provide the recruitment which results in the initial annual yield.

** Fishing mortality matrix derived by trial and error (after setting A1) to reproduce observed seasonal pattern of catch.

*** See Table 12

Table 11. GXPOPS Parameters For Spotted Seatrout,
Initial Conditions, Florida West Coast

	<u>Males</u>	<u>Females</u>
Year classes	8	10
Age (month) at first recruitment	1	1
Month Spawning begins	1	1
Month spawning ends	1	1
Year of first maturity	3	4
Rate of contact	1	1
Recruitment regulation option	2	2
Recruitment parameters;		
A1	*	*
A2	0	0
Natural mortality (monthly)	.033	.029
Selectivity matrix	***	***
Fishing mortality matrix	**	**
Fmult (Annual F)	1.4	1.4
Male maturity fraction		
age 1-2	0	-
age 3	.5	-
age 4-8	1.0	-
Female maturity fraction		
age 1-3	-	0
age 4	-	.5
age 5-10	-	1.0
Von Bertalanffy parameters:		
W (infinity)	5.25 lb.	11.9 lb.
K (monthly)	0.0175	0.0125
T ₀ (monthly)	-6.264	-7.800
Initial annual yield (Both Sexes)	(5,712,000 lbs)	

* A1 is derived by trial and error to provide the recruitment which results in the initial annual yield.

** Fishing mortality matrix derived by trial and error (after setting A1) to reproduce observed seasonal pattern of catch.

*** See Table 12

TABLE 12. Selectivity Matrixes For Age At Recruitment
Under Initial Conditions

EAST COAST

Males

Year 3: 0, 0, .01, .08, .15, .22, .29, .36, .43, .50, .57, .64

Year 4 .71, .78, .85, .92, .99, 1.0, 1.0, 1.0, 1.0, 1.0

Females

Year 2: 0, 0, 0, 0, 0, 0, .01, .08, .15, .22, .29, .36

Year 3: .43, .50, .57, .64, .71, .78, .85, .92, .99

WEST COAST

Males

Year 3: 0, 0, 0, .01, .08, .15, .22, .29, .36, .43, .50, .57

Year 4: .64, .71, .78, .85, .92, .99, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0

Females

Year 2: 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, .01

Year 3: .08, .15, .22, .29, .36, .43, .50, .57, .64, .71, .78, .85

Year 4: .92, .99, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0

TABLE 13. Changes In Length Frequency Of Spotted Seatrout
On The East Coast between 1956 and The peroid
1979 - 1986.

<u>Length Class</u> (mm TL)	1976 - 1986 ²	1956 ¹
	Percent Frequency	Percent Frequency
300-349	43.5	19.8
350-399	25.5	21.2
400-449	18.3	20.3
450-499	5.9	15.5
500-549	3.4	9.1
550-599	1.4	5.3
600-649	.9	5.5
650-699	.4	2.2
700-749	.3	.9
750-799	.2	

Source:

¹Tabb (1980), numerical values approximated from Figure 3 for unskilled anglers. Sample includes only those fish between 300 to 800 mm TL. Standard length converted to total length by the formula $TL = 11.804 + 1.138 SL$.

²NMFS National Recreational Fishing Survey, Florida east coast 1979-1986. Sample includes only fish from 300 to 800 mm TL.

TABLE 14. Commercial Landings of Spotted Seatrout By
Bay System, East Coast, 1977 - 1986

	<u>N.E. Florida</u> ¹	<u>Indian River</u> ²
1977	63,107	419,360
1978	65,850	321,946
1979	61,386	393,734
1980	61,692	483,702
1981	55,176	651,277
1982	98,284	611,823
1983	60,609	388,078
1984	48,423	303,925
1985	40,132	322,423
1986	43,601	265,323

1. Nassau, Johns, Putnam, Flagler
2. Volusia, Brevard, Indian River, St. Lucie

TABLE 15. Commercial Landings of Spotted Seatrout
By Bay Systems, West Coast, 1977-1986

	<u>Pensacola Bay¹</u>	<u>Choctaw- hatchee Bay²</u>	<u>St. Andrews Bay³</u>	<u>N.E. Panhandle⁴</u>	<u>Big Bend⁵</u>	<u>Tampa Bay⁶</u>	<u>Charlotte Harbor⁷</u>	<u>S.W. Florida⁸</u>
1977	129,732	37,628	151,925	70,450	244,240	266,734	-	53,508
1978	163,712	37,485	137,568	95,023	172,204	286,160	-	46,208
1979	102,570	20,887	108,972	74,713	294,612	206,751	665,383	24,299
1980	71,610	14,875	61,454	65,872	244,673	178,181	686,215	47,679
1981	99,066	15,034	69,766	81,181	205,067	215,678	654,970	49,085
1982	154,121	58,792	89,021	89,842	78,506	161,835	681,575	38,675
1983	104,542	7,590	76,527	94,329	158,811	152,126	637,547	72,457
1984	89,244	13,908	90,257	68,624	266,362	159,952	560,608	128,263
1985	62,053	15,409	75,149	58,281	249,547	121,624	422,406	52,855
1986	76,673	16,299	68,178	72,181	230,579	121,016	-	32,107

1. Escambia, Santa Rosa
2. Walton, Okaloosa
3. Bay
4. Gulf, Franklin, Wakulla
5. Citrus, Dixie, Pasco, Taylor, Hernando, Levy, Jefferson
6. Hillsborough, Manatee, Pinellas
7. Lee, Charlotte
8. Collier, Monroe

TABLE 16. Spotted Seatrout Commercial Landings By
Gear 1979 - 1985

	1979	1980	1981	1982	1983	1984	1985
Haul Seines	143,103	105,070	105,387	104,698	95,569	88,050	74,562
Trawls	25,000	17,692	20,426	46,321	19,379	2,539	736
Gillnets	1,851,800	1,335,653	1,505,385	1,500,257	1,228,404	974,974	765,183
Trammel nets	290,600	586,763	588,646	582,742	554,483	498,904	339,232
Hook & Line	243,100	462,275	479,803	500,205	448,232	346,436	315,205
Cast net	8,000	7,246	10,030	7,419	5,781	7,537	5,840
Total:	2,561,600	2,514,552	2,708,677	2,741,642	2,351,848	1,918,439	1,500,785

TABLE 17. Spotted Seatrout Recreational Catch Estimates
1979 - 1986

	<u>East Coast</u>	<u>West Coast</u>	<u>Florida Total</u>
1979	2,599,371	3,420,282	6,019,653
1980	563,420	4,828,843	5,392,263
1981*	838,504	1,881,362	2,719,866
1982	670,625	6,330,082	7,000,707
1983	836,148	3,720,990	4,557,138
1984	985,603	4,724,217	5,709,820
1985	1,110,532	4,103,483	5,214,015
1986	656,930	3,691,045	4,347,975

Source: National Marine Fisheries Service - National
Recreational Fishery Survey

*Incomplete

Figure 1. Florida Commercial Landings of Spotted Seatrout, 1951 - 1983

LANDINGS ($\times 100000$ lbs)

