

## Status of Southern Flounder Fishery in Texas

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### ABSTRACT

The objective of this paper is to report on the current status of the southern flounder fishery in Texas. Estimates were made using data originating from activities, studies, and programs of the Texas Parks and Wildlife Department (TPWD).

Presently, in the recreation fishery, nearly 100,000 fishermen consider southern flounder their primary species preference and they spend approximately one hundred million dollars annually. Annually, 850,000 saltwater anglers fish 6 million man-hours to catch 250,000 southern flounder. Southern flounder, averaging 370 mm in length, are caught at the rate of 0.04 fish/hour.

Since 1982, according to Monthly Marine Products Reports (MMPR), commercial landings of southern flounder have remained around 250,000 kg annually with an ex-vessel value of \$540,000. Southern flounder fishing mortality depends on the trawl mortality rate. From 1978 through 1987, assuming a trawl mortality rate of 50%, sport and commercial fishing resulted in an estimated 6 million southern flounder mortalities annually with trawls accounting for 94% of them. Tag return data from 1975 - 1987 indicated an exploitation rate of 45% for southern flounder with sport and commercial fishing accounting for 60% and 40%, respectively.

Coastwide bag seine data from the TPWD standardized fishery independent monitoring program showed a significant difference in southern flounder catch rates among years and there appears to be a 4 or 5 year cycle in juvenile flounder abundance. Gill net ( $< 0.20/h$ ) and shrimp trawl (0.53/h mean) catch rates were low with no apparent temporal trend in population abundance.

### INTRODUCTION

Southern flounder (*Paralichthys lethostigma*) inhabit coastal waters of the Atlantic coast and the Gulf of Mexico from North Carolina to Mexico (Reagan and Wingo, 1985), but is most prevalent in the western Gulf of Mexico (Topp and Hoff, 1972). It is common to depths of 40 meters (Nall, 1979) and frequently occurs in brackish to freshwater (Ross, 1980).

Southern flounder is an important commercial and recreational species in Texas. Southern flounder caught for commercial sale in the Gulf of Mexico are taken predominantly as by-catch in shrimp trawls (Reagan and Wingo, 1985), although rods and reels, nets and gigs are also used. According to Swingle (1976), 95% of the commercially landed flounders in Alabama were caught by shrimp trawlers. In Texas, commercial landings, for all gears combined, has exhibited substantial fluctuations. However, from 1982 through 1987, the mean annual landing was 223,600 kg with a mean ex-vessel value of \$473,400 (Quast

*et al.*, 1988).

The recreational fishery for southern flounder extends along the entire northern Gulf of Mexico (Reagan and Wingo, 1985). In Texas, it includes wade fishermen and fishermen fishing from private sport boats, party boats, headboats, banks and piers using rods and reels, and gigs. In Mobile Bay, Alabama, flounder fishing was most productive from piers (Wade, 1977). In Biloxi Bay, Mississippi, southern flounder contributed only 2.6% of the total sport catch (Jackson, 1972). In Texas, during 1974 – 1987, southern flounder had the fourth highest mean annual recreational landing (168,200 fish) by private-boat fishermen, constituting 6.1% of their landings (Osburn *et al.*, 1988).

The first management measure directed at southern flounder was a 12-inch (305 mm) size limit imposed in 1925 by the Texas Game and Fish Commission. Although legally binding initially for recreational and commercial fishermen, the regulation was removed for recreational fishing in most counties in 1945. From 1945 to 1988, no management measures were directed toward the flounder fishery. In September 1988, a minimum total length of 12 inches for recreational and commercial fishermen, and a 20 bag limit and 40 possession limit for recreational fishermen only was implemented. At the same time, commercial netting, which may impact flounder populations, was banned, however this measure was not specifically targeted at flounder.

The objective of this paper is to report on the current status of the southern flounder fishery in Texas.

#### METHODS

The annual number of saltwater fishermen in Texas (A) was estimated using:

$$A = .35A + BC + D$$

where:

.35 = estimated percent of unlicensed legal saltwater fishermen < 17 and ≥ 64 years of age and illegal saltwater fishermen (Green *et al.*, 1982);

B = ratio of saltwater fishing stamps to total fishing licenses sold per year;

C = total number of exemptions for the blind and for disabled veterans;

D = total number of saltwater fishing stamps sold.

The annual number of southern flounder saltwater fishermen in Texas (F) was estimated using:

$$F = EA$$

where:

- E = estimated annual percent of fishermen in Texas who fished primarily for southern flounder (Ditton *et al.*, in prep., E = 10.6 for 1986, E = 11.9 for 1987);
- A = estimated annual number of saltwater fishermen in Texas.

Direct expenditures for 1986 and 1987 were estimated using statewide mail surveys (Ditton *et al.*, in prep.). Incomplete responses were removed from the data set. Only fishermen responding with southern flounder as their primary target species were used to make estimates.

Annual sport fishing pressure, landings, mean lengths, and catch rates of southern flounder landed by sport fishermen were estimated using data from surveys conducted by the TPWD beginning in 1974 (Heffernan *et al.*, 1976; Breuer *et al.*, 1977; Green *et al.*, 1978; McEachron, 1980a, 1980b, 1983, 1984; McEachron and Green, 1981, 1982, 1983; McEachron *et al.*, 1984; Osburn and Ferguson, 1985a, 1985b). These surveys monitored the activities and landings of private sportboat fishermen since 1974, headboat and party boat fishermen since 1983, and wade, bank and pier fishermen during 1974 – 1976 and during 1979 – 1980. Data on size, number, and landings per unit of effort were obtained for southern flounder. Between year comparisons of private sport boat catch rates of southern flounder were made using a non-parametric goodness-of-fit test (Kruskal-Wallis). A posteriori non-parametric comparisons of mean ranks (Zar, 1984) were used to determine where significant differences occurred. For years when headboats, party boats, wade/bank, and pier fishermen were not surveyed, landings were estimated using a proportionality between those strata and sport-boat landings calculated for years in which both were available.

### **Commercial Fishery**

#### *Monthly Marine Product Report*

Since 1936, the TPWD has monitored the landings and value of the marine fishes through a mandatory, self reporting system known as the Monthly Marine Products Report (MMPR) which is completed by seafood dealers. This study presents the reported landings and ex-vessel value of southern flounder from 1977 through 1987 (Quast *et al.*, 1988). Southern flounder reported in the MMPR's may be caught on all gear types including shrimp trawl, rod and reel, net, and gig.

#### *Legal Nets*

The annual landings of southern flounder by commercial fishermen using legal nets ( $N_{LN}$ ) was estimated using:

$$N_{LN} = N_F / f (C \times 13.4 \times 74)$$

where:

- $N_F$  = the feet of net licensed by commercial saltwater fishermen;  
 $f$  = the adjustment to convert commercial nets to standard TPWD net sets (from 1978 through 1983,  $f = 600$ ; from 1984 through 1987,  $f = 150$ );  
 $C$  = catch rate (no./h) of southern flounder in TPWD spring and fall gill nets (from 1978 through 1983, all meshes combined and from 1984 through 1987, 6 inch mesh only);  
13.4 = mean number of fishing hours for a commercial fishermen per day (mean from TPWD gill net sets);  
74 = mean number of fishing days for a commercial fishermen per year (mean of gill nets and trammel nets from Wagner *et al.*, 1990).

Two values were given for "f" and for "C" because any size mesh greater than 3 inches was legal until 1984, so catch rates were estimated using TPWD nets which were 600 feet long and made up of 4 x 150 foot sections, each having a different mesh size (3, 4, 5, and 6 inch). After 1983, mesh smaller than 6 inches were illegal, so catch rates were estimated using only the 150 foot section of net that contained 6 inch mesh.

#### *Illegal Nets*

The annual landings of southern flounder by commercial fishermen using illegal nets ( $N_{IN}$ ) was estimated using:

$$N_{IN} = (N_F / 600) C$$

where:

- $N_F$  = feet of illegal net confiscated (obtained from TPWD law enforcement division);  
600 = No. of feet per TPWD gill net set (all meshes combined);  
 $C$  = catch rate (no./set) of southern flounder in TPWD nets (all meshes combined).

#### *Trawl By-Catch*

The annual by-catch of southern flounder by commercial shrimpers using bay shrimp trawls ( $N_T$ ) was estimated using:

$$N_T = L_{BS} \times 2,560$$

where:

- $L_{BS}$  = the number of bay shrimp trawl licenses sold that year;  
2,560 = the estimated mean annual by-catch of southern flounder per shrimp trawl license sold (calculated using data from Matlock, 1982).

Data was not available for estimating the percent of trawl caught southern flounder that were landed commercially.

#### *Exploitation Rate*

Southern flounder exploitation rate ( $E_{RF}$ ) for sport and commercial fishermen combined was estimated using tag return data. The exploitation rate was calculated as:

$$E_{RF} = (T_S/0.31) + ((T_S/0.31) \times (P_C/P_S)) / (T_T \times 0.725 \times 0.80)$$

where:

- $T_S$  = the number of tags returned by sport fishermen;  
0.31 = the tag return rate for sport fishermen (Green *et al.*, 1983);  
 $P_C$  = percent of southern flounder landed by commercial fishermen (this percent was estimated using a proportionality between MMPR reported landings and estimated sport landings);  
 $P_S$  = percent of southern flounder landed by sport fishermen (used same proportionality used for commercial percent);  
 $T_T$  = total number of southern flounder tagged by TPWD (2,339);  
0.725 = average survival rate of southern flounder tagged with internal anchor tags (Harrington, 1968; Elam, 1971);  
0.80 = retention rate of internal anchor tags (Elam, 1971).

#### *Trends in Resource Abundance*

The relative abundance and size of southern flounder were estimated using data from the TPWD standardized fishery independent monitoring program initiated in 1975 using gill nets, expanded to include bag seines in 1977, trawls in bays in 1982, and trawls in the Gulf of Mexico in 1985 (Hammerschmidt *et al.*, 1988). In the fall of 1981, the TPWD increased the number of gill net samples collected during periods of consistently high catch rates (spring and fall) to provide more precise estimates of annual abundance for each bay (Hegen *et al.*, 1983). Gill net sets during spring (15 April – 15 June) and fall (15 September – 15 November), and monthly bag seine and trawl samples provide a statistically consistent and cost efficient method for obtaining information on adult, sub-adult, and juvenile finfish populations (Matlock *et al.*, 1978; Matlock, 1982; Matlock *et al.*, 1982; Hegen, 1983; Hegen *et al.*, 1983; McEachron and Green, 1986a).

A non-parametric goodness-of-fit test (Kruskal-Wallis) was used on bag seine catch rates to test for differences among years. A posteriori non-parametric comparisons of mean ranks (Zar, 1984) were used to identify significant differences. Parametric analyses were not used since no transformation was found to reduce inequalities of bag seine catch rate variances.

A three-way ANOVA was used to compare gill net catch rates among seasons, years, and bay systems. Mean catch rates were log transformed to equalize variances required for ANOVA. A posteriori analyses (Duncan's multiple range test) of spring and fall catch rates were used to test differences when significant interactions existed.

## RESULTS

### Sport Fishing

#### *Pressure*

Even though the number of saltwater fishermen in Texas decreased from 861,940 in 1986 to 836,643 in 1987, the number of southern flounder fishermen increased from 91,366 (10.6%) in 1986 to 99,561 (11.9%) in 1987 (Table 1). However, total expenditures by southern flounder fishermen in saltwater decreased \$62 million from 1986 to 1987 with expenditures per person decreasing from \$1,688.57 in 1986 to \$925.22 in 1987. Expenditures by a southern flounder fisherman in saltwater were 17.9% less than expenditures by an average fishermen in 1986 and were 23.6% less in 1987 with vehicles, boats, and boat motors accounting for most of the difference (Table 2).

Private sport-boat fishing pressure in Texas coastal bays and passes reached over 6 million man-hours in 1986 - 1987 (Figure 1). Since 1976 - 1977 private sport-boat pressure in the bays and passes has increased 88%, paralleling increases in fishing license sales and recreational boat registration (Figure 2).

#### *Landings*

The annual daytime sport landing of southern flounder fluctuated over the 12 years studied, ranging from 115,400 fish in 1976 - 1977 to 680,000 fish in 1979 - 1980, and averaged 247,400 fish (153,388 kg) (Table 3). Private sport-boat fishermen accounted for 74% of the southern flounder landings, wade/bank fishermen landed 20%, while party boat, headboat, and lighted pier fishermen only accounted for 6% of the landings. The high landings in 1979 - 1980 reflected an extremely high harvest in the Galveston Bay system (88% of coastwide total).

#### *Mean Length and Catch Rates*

Mean total length of southern flounder landed by private-boat fishermen remained fairly constant from 1974 - 1976 to 1982 - 1983 (Figure 3). However, following the December 1983 freeze, the mean length of southern flounder

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**Table 1.** Number of saltwater fishermen, flounder fishermen, and fishing expenditures, 1986-1987.

Year	Kind of fishermen	Number of fishermen	Annual expenditures	
			Per fishermen	All fishermen (x 1,000)
1986	Saltwater	861,940	2,056.98	1,772,993
	Flounder	91,377	1,688.57	154,278
1987	Saltwater	836,643	1,211.68	1,013,744
	Flounder	99,561	925.22	92,116

landed decreased from 382 mm (15.0 in) to 356 mm (14.2 in). Mean length remained near that size until 1986 – 1987 when it increased to 369 mm (14.8 in).

Although catch rates decreased slightly after the freeze, they remained fairly constant over time except in 1979 – 1980 (Figure 3). Low catch rates and high variances precluded detecting yearly trends. However, catch rates of southern flounder by private sport boat fishermen were higher in 1982, 1985, and 1987 than some other years (Kruskal-Wallis Test,  $\chi^2 = 105.2$ ,  $df = 10$ ,  $p < 0.01$ ), indicating generally higher catch rates in the 1980's (Table 4).

### Trends in Commercial Landings and By-Catch

#### *MMPR Reported Landings*

According to MMPR reports, commercial landings of southern flounder declined from 1978 (107,500 kg) to 1981 (59,200 kg). However, in 1982 landings increased to 243,100 kg and remained fairly constant thereafter (Table 5). The dramatic increase in commercial landings of southern flounder reported on MMPR's in 1982, probably resulted from the prohibition of red drum and spotted seatrout sales in 1981. There was a small decline in landings following the December 1983 freeze, but populations apparently recovered quickly. In 1986, the landings (254,200 kg) and ex-vessel value (\$540,300) of southern flounder were at their highest levels.

#### *Legal Nets*

In general, the annual estimated commercial landing of southern flounder caught in legal nets decreased from a high in 1980 (174,344 kg) to a low in 1987 (25,457 kg) (Table 6). From 1978 through 1987, estimated annual catches of southern flounder in legal nets were equal to 39% of MMPR landings (Table 5).

#### *Illegal Nets*

The estimated annual commercial landing of southern flounder caught in illegal nets was highest in 1982 when landings of 599 kg, 1,198 kg, and 5,990

Table 2. Expenditures on equipment items by survey respondents by target species, 1986-1987.

Description of items	SOUTHERN FLOUNDER FISHERMEN-1986			ALL SALTWATER FISHERMEN-1986		
	Avg spent in Texas per person	Avg spent per person for Texas SW fishing	% Respondents buying at least one	Avg spent in Texas per person	Avg spent per person for Texas SW fishing	% Respondents buying at least one
<b>Tackle</b>						
Rods	40.25	28.13	77%	48.85	36.90	76%
Reels	37.72	28.70	42%	39.60	28.49	36%
Lures, tackle boxes, landing nets, etc.	35.53	25.59	64%	42.43	31.66	68%
Live bait equipment	14.80	12.24	41%	13.48	11.43	39%
Fish attracting lights	2.74	2.06	7%	6.75	3.97	5%
Lure color selector	2.24	1.77	3%	1.45	0.79	4%
<b>Camping equipment</b>						
Trailer or camper	247.99	82.47	7%	169.68	64.47	5%
Tents, sleeping bags, lanterns, stoves, ice chests, etc.	34.88	16.52	38%	36.64	20.05	37%
<b>Boating</b>						
Electronic equipment; Depth finders, fish locators, radio, etc.	21.93	13.30	7%	33.64	23.36	9%
Boat accessories; anchors, safety equipment, etc.	17.32	11.92	19%	20.44	14.79	20%
Boats	561.06	250.43	22%	908.08	640.14	22%
Boat motors	330.77	175.40	26%	509.94	371.66	24%
Boat trailers	159.59	107.77	24%	142.58	108.52	19%
<b>Vehicles</b>						
Autos, vans, pickups, RVs, all-terrain vehicles	2,915.74	925.08	32%	2,736.22	679.37	29%
<b>Other equipment</b>	11.29	7.19	14%	30.06	21.38	12%
<b>Total</b>	4,433.85	1,688.57		4,739.84	2,056.98	



Table 2. Continued. Expenditures on equipment items by survey respondents by target species, 1987.

Description of items	SOUTHERN FLOUNDER FISHERMEN-1987			ALL SALTWATER FISHERMEN-1987		
	Avg spent in Texas per person	Avg spent per person for Texas SW fishing	% Respondents buying at least one	Avg spent in Texas per person	Avg spent per person for Texas SW fishing	% Respondents buying at least one
<b>Tackle</b>						
Rods	24.84	18.05	50%	38.16	28.39	55%
Reels	23.55	16.64	44%	37.20	27.07	51%
Lures, tackle boxes, landing nets, etc.	31.02	22.12	67%	43.09	29.55	69%
Live bait equipment	13.06	10.84	39%	13.72	11.00	38%
Fish attracting lights	3.06	2.67	6%	4.29	3.31	5%
Lure color selector	0.78	0.30	3%	1.25	0.60	4%
<b>Camping equipment</b>						
Trailer or camper	49.29	26.69	3%	97.23	25.73	3%
Tents, sleeping bags, lanterns, stoves, ice chests, etc.	29.95	15.49	36%	39.56	19.10	36%
<b>Boating</b>						
Electronic equipment; Depth finders, fish locators, radio, etc.	19.46	10.45	7%	26.60	18.04	8%
Boat accessories; anchors, safety equipment, etc.	14.69	9.56	18%	18.57	13.46	18%
Boats	588.30	430.68	13%	469.61	295.31	13%
Boat motors	160.73	74.88	12%	272.55	175.54	13%
Boat trailers	70.62	42.98	10%	79.27	49.09	10%
<b>Vehicles</b>						
Autos, vans, pickups, RVs, all-terrain vehicles	1,386.20	234.52	18%	1,903.62	474.09	20%
<b>Other equipment</b>	13.82	9.35	14%	52.70	41.40	13%
<b>Total</b>	2,429.37	925.22		3,097.42	1,211.68	

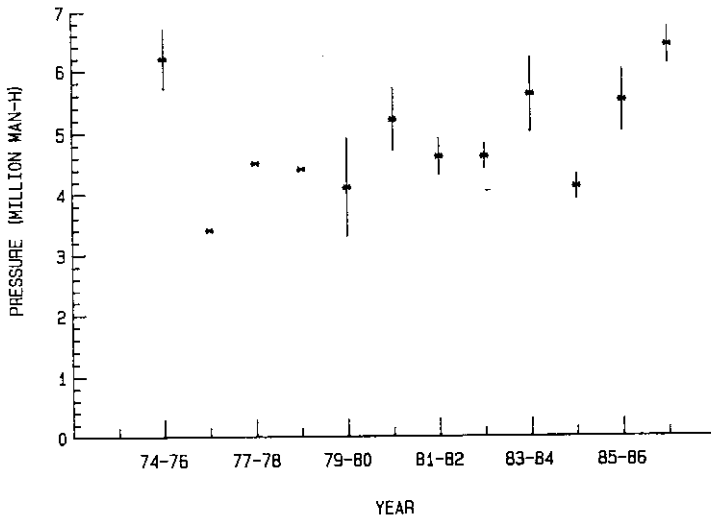


Figure 1. Coastwide annual private-boat fishing pressure ( $\pm 1$  SE) in Texas bays and passes, May 1974-May 1987.

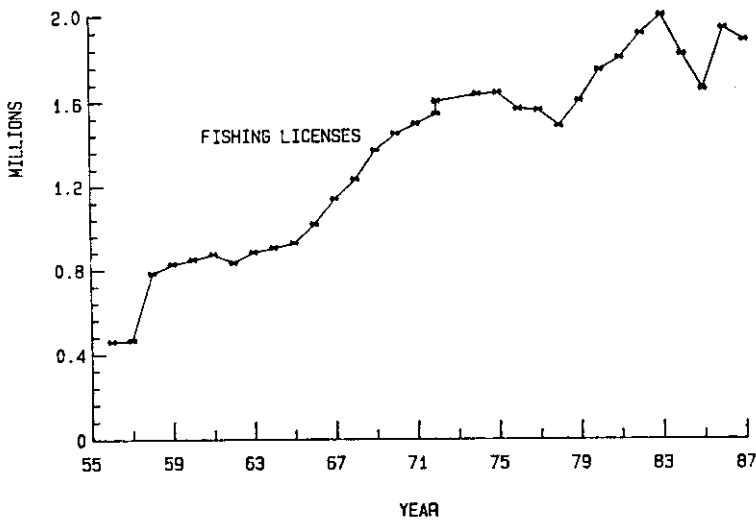


Figure 2. Number of fishing licenses sold per year from 1955 to 1987.

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**Table 3.** Estimated number (x 1,000) and percent (%) of southern flounder landed by recreational fishermen coastwide, from 1974-1976 to 1986-1987.

Year	Private boat	Other boats <sup>a</sup>	Wade bank	Lighted pier	Total
1974-76	220.2	6.2	59.2	13.2	298.8
1976-77	85.0	2.4	22.9	5.1	115.4
1977-78	102.2	2.9	27.5	6.1	138.7
1978-79	106.0	3.0	28.5	6.4	143.9
1979-80	501.0	14.1	134.8	30.1	680.0
1980-81	180.2	5.1	48.5	10.8	244.6
1981-82	145.4	4.1	39.1	8.7	197.3
1982-83	181.0	5.1	48.7	10.9	245.7
1983-84	156.0	4.4	42.0	9.4	211.8
1984-85	138.2	3.9	37.2	8.3	187.6
1985-86	194.4	5.5	52.3	11.7	263.9
1986-87	178.1	5.0	47.9	10.7	241.7
Mean	182.3 (73.7)	5.1 (2.1)	49.0 (19.8)	11.0 (4.4)	247.4

<sup>a</sup> Other boats include party boats and head boats.

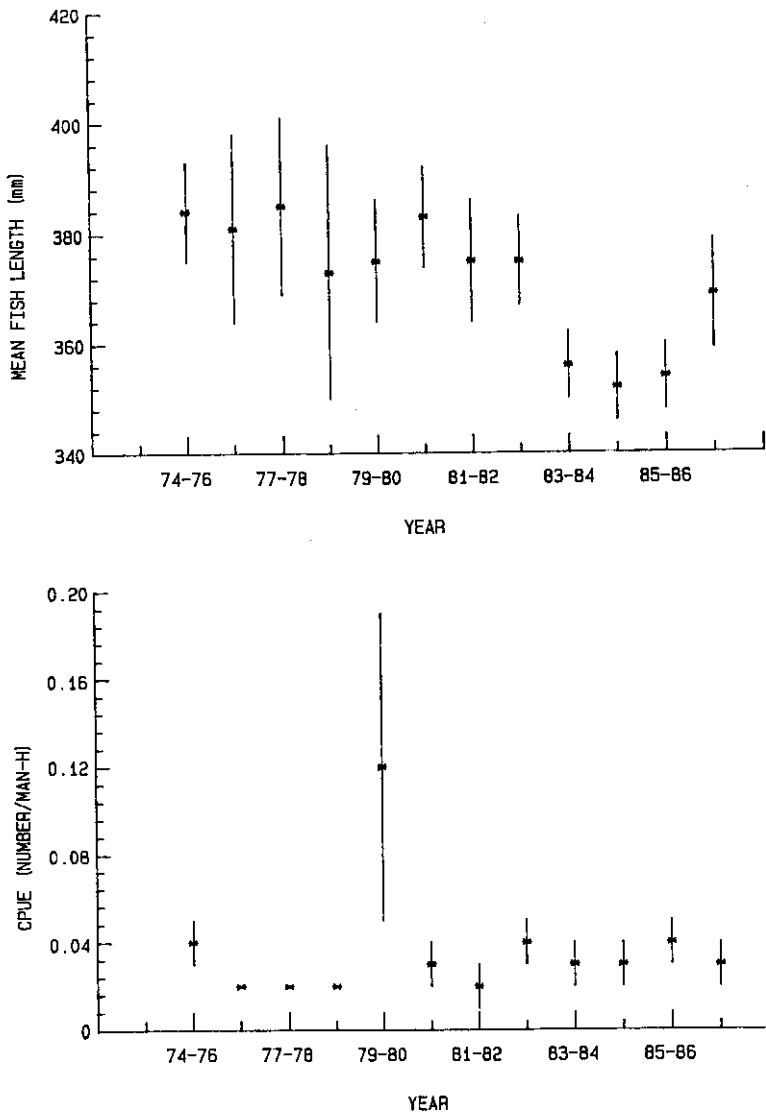
kg were projected at confiscation rates of 100%, 50%, and 10%, respectively (Table 7). Since 1982, estimated landings have generally decreased, reaching a low in 1987 when projected landings were 186 kg, 372 kg, and 1,860 kg at confiscation rates of 100%, 50% and 10%, respectively. This decrease in estimated landings is the result of a decrease in the amount of illegal net confiscated in succeeding years. From 1978 through 1987, illegal nets accounted for 2% of the MMPR landings (Table 5).

#### *Trawl by-catch*

The by-catch of southern flounder in commercial shrimp trawls fluctuated annually, ranging from 8,709,120 fish in 1987 to 13,350,400 fish in 1981 for a mean annual by-catch of 11,103,984 fish (Table 8). Data on the number of trawl caught flounder that were commercially harvested was not available, consequently it was not possible to estimate the percent of flounder on MMPRs that were trawl caught. However, assuming only a 25% mortality rate for trawl caught flounder, trawl by-catch would have accounted for 89% of southern flounder fishing mortality during the ten year period (Table 9).

#### **Exploitation Rate**

From 1975 through 1987, the TPWD tagged a total of 2,339 southern



**Figure 3.** Coastwide annual mean fish lengths (mm) and annual mean catch rates (no/month) for southern flounder landed from bays and passes by private-boat fishermen, May 1974-May 1987.

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**Table 4.** Comparison of mean ranked catch rates for private boat recreational fishermen using a nonparametric multiple comparison procedure for southern flounder, coastwide, with similar years grouped.

Year	Mean	Grouping
1984	2,618.4	
1978	2,621.8	
1981	2,654.5	
1980	2,739.9	
1983	2,786.6	
1979	2,896.5	
1977	2,928.1	
1986	3,023.5	
1982	3,101.6	
1985	3,151.7	
1987	3,215.8	

**Table 5.** Weight (kg X 1,000) and ex-vessel value (\$ X 1,000) of southern flounder landed commercially in Texas from bay systems and the Gulf during 1978-1986. Data based on Monthly Marine Products Reports (MMPR).

Year	Texas Bay Systems		Gulf		Total	
	Weight	Value	Weight	Value	Weight	Value
1978	87.4	149.1	20.1	24.1	107.5	173.2
1979	93.8	173.6	11.6	16.5	105.4	190.1
1980	67.9	122.6	20.4	31.1	88.3	153.7
1981	46.2	117.7	13.0	20.6	59.2	138.3
1982	199.3	439.0	43.8	82.4	243.1	521.4
1983	181.2	394.4	34.0	51.2	215.2	445.6
1984	136.6	295.4	42.3	55.6	178.9	351.0
1985	167.6	382.5	33.5	62.8	201.1	445.3
1986	223.8	485.5	30.4	54.8	254.2	540.3
1987	217.5	475.2	31.5	61.4	249.0	536.6

flounder. However, after correcting for tag mortality and tag loss, only 1,357 flounder were actually available for capture by fishermen (Table 10). Sport fishermen returned 114 tags which converted into 368 tags (27%) recovered by sport fishermen using the 0.31 tag return rate. Comparing MMPR landings to estimated sport landings of southern flounder, commercial fishermen landed 40.3% of taggable size fish which converted into 248 tags (18%) recovered by commercial fishermen. Therefore, the exploitation rate was 45% for the period

Table 6. Catch statistics for southern flounder in legal nets during 1978-1987 (assuming 74 nights of fishing annually).

Year	Licensed coastwide saltwater net (ft)	Number of sets	Catch per hour	Daily catch	Total catch (no.)	Mean fish Wt. (kg)	Weight total catch (kg)
1978	873,800	1,456	0.075	1,456	107,744	0.805	86,734
1979	1,018,900	1,698	0.080	1,817	134,458	0.865	116,306
1980	823,500	1,372	0.115	2,113	156,362	1.115	174,344
1981	572,700	954	0.070	897	66,378	0.805	53,434
1982	472,800	788	0.110	1,158	85,692	0.775	66,411
1983	488,700	814	0.085	928	68,672	0.835	52,341
1984	438,900	2,926	0.015	585	43,290	0.745	32,251
1985	413,400	2,756	0.015	551	40,774	0.715	29,153
1986	433,000	2,887	0.015	577	42,698	0.865	36,934
1987	309,100	2,061	0.015	412	30,488	0.835	25,457

**Table 7.** Catch statistics for southern flounder in illegal nets during 1978-1987 at rates of 100%, 50%, and 10% confiscation.

Year	Confiscated coastwide saltwater net (ft)	Number of 600 ft sets	Catch pers 600 ft set (no.)	Catch with 100% confiscated			Catch with 50% confiscated			Catch with 10% confiscated		
				no.	wt. (kg) <sup>b</sup>	no.	wt. (kg)	no.	wt. (kg)	no.	wt. (kg)	
				1978	325,248	542	0.97	526	224	1,052	448	5,260
1979	547,008	912	1.03	939	502	1,878	1,004	9,390	5,020			
1980	516,384	861	1.48	1,274	573	2,548	1,146	12,740	5,730			
1981	767,712	1,280	0.92	1,178	294	2,356	588	11,780	2,940			
1982	539,616	899	1.48	1,331	599	2,662	1,198	13,310	5,990			
1983	596,112	994	1.117	1,163	593	2,326	1,186	11,630	5,930			
1984	376,992	628	0.89	559	238	1,118	476	5,590	2,380			
1985	333,168	555	1.24	688	310	1,376	620	6,880	3,100			
1986	292,512	488	1.04	508	272	1,016	544	5,080	2,720			
1987	239,184	399	0.95	379	186	758	372	3,790	1,860			

<sup>a</sup> Assumes the catch rate by illegal commercial nets is the same as that for TPWD nets (all meshes combined).

<sup>b</sup> Weights were calculated using mean lengths from TPWD nets and converting to whole weights.

**Table 8.** By-catch estimates and mortality estimates at rates of 75%, 50%, and 25% for southern flounder caught by commercial bay shrimp boats during 1978-1987.

Year	Shrimp licenses no.	Estimated catch		Estimated by-catch mortality		
		No. <sup>a</sup>	Wt. (kg) <sup>b</sup>	75%	50%	25%
1978	3,768	9,646,080	530,534	7,234,560	4,823,040	2,411,520
1979	4,444	11,376,640	625,715	8,532,480	5,688,320	2,844,160
1980	4,473	11,450,880	629,798	8,588,160	5,725,440	2,862,720
1981	5,215	13,350,400	734,272	10,012,800	6,675,200	3,337,600
1982	4,479	11,366,240	630,643	8,524,680	5,683,120	2,841,560
1983	4,711	12,060,160	663,309	9,045,120	6,030,080	3,015,040
1984	4,922	12,600,320	693,018	9,450,240	6,300,160	3,150,080
1985	4,387	11,230,720	617,690	8,423,040	5,615,360	2,807,680
1986	3,613	9,249,280	508,710	6,936,960	4,624,640	2,312,320
1987	3,402	8,709,120	479,002	6,531,840	4,354,560	2,177,280

<sup>a</sup> Estimated numbers were calculated using the catch rate (5.3 fish/h) calculated by Matlock (1982).

<sup>b</sup> Estimated weights were calculated using the mean total length (176mm) calculated by Matlock (1982) and converting to whole weight using conversions calculated by Harrington *et al.* (1979).



**Table 9.** Average annual distribution of southern flounder fishing mortality in numbers (x 1000) and percent ( ) by fishing type.

Trawl mortality rate (T)	Sports <sup>a</sup>			Commercial		Total
	Boat	Wade/Bank	Lighted Pier	Legal <sup>b</sup>	Illegal <sup>c</sup>	
100	187.4 (1.6)	49.0 (0.4)	11.0 (0.1)	77.7 (0.7)	9.0 (0.1)	11,104 (97.1)
75	187.4 (2.2)	49.0 (0.6)	11.0 (0.1)	77.7 (0.9)	9.0 (0.1)	8,662.1 (96.1)
50	187.4 (3.2)	49.0 (0.8)	11.0 (0.2)	77.7 (1.4)	9.0 (0.2)	5,886.1 (94.2)
25	187.4 (6.0)	49.0 (1.6)	11.0 (0.4)	77.7 (2.6)	9.0 (0.3)	2,776 (89.1)

<sup>a</sup> Means calculated from 12 years of data (Table 3).

<sup>b</sup> Means calculated from 10 years of data (Tables 5 and 6).

<sup>c</sup> Means assumes 10% confiscation of illegal nets.

<sup>d</sup> Means calculated from 10 years of data (Table 7).

**Table 10.** Number of southern flounder tagged by TPWD resource program with internal abdominal anchor tags and number of tags returned by fishing category by year.

Year	Tagged	Returned			Total
		Sport	Commercial	Unknown	
1975	80	0	21	0	2
1976	300	8	0	0	8
1977	216	16	4	1	21
1978	256	19	3	0	22
1979	256	16	5	0	21
1980	136	9	5	0	14
1981	107	5	5	0	10
1982	97	4	0	0	4
1983	108	2	2	0	4
1984	146	7	1	0	8
1985	192	7	1	0	8
1986	251	13	2	0	15
1987	183	8	0	0	8
Total	2,339	114	30	1	145

(616 tags out of 1,357 available tags were recovered by sport and commercial fishermen, combined).

### Trends in Resource Abundance

#### *Bag Seines*

In coastwide bag seine samples, from 1977 through 1987, the annual mean total length of southern flounder was fairly constant with the exception of 1977, ranging from 42 mm to 71 mm for a mean annual total length of 58 mm (Table 11). Mean catch rates were highest during the fall, ranging from 3 fish/ha to 18 fish/ha, while annual mean catch rates ranged from < 1 fish/ha to 8 fish/ha. Catch rates, and presumably year class strength, differed among years ( $p < 0.01$ ), with higher catch rates in 1981, 1982, and 1986 compared to 1978, 1979, and 1984 indicating about a 5 year cycle in juvenile flounder abundance (Table 12).

#### *Gill Nets*

Catch rate of southern flounder in gill nets was higher during fall (0.08 – 0.15) than during spring (0.03 – 0.08) (Figure 4). Although southern flounder catch rates differed among years (3-way ANOVA,  $df = 11$ ,  $F = 5.62$ ,  $p < .01$ ), there was no apparent temporal trend in abundance (Table 13). During fall, mean total lengths ranged from 328 mm to 361 mm and during the spring,

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**Table 11.** Annual and fall catch rates (no./ha) and mean total length (mm) for southern flounder caught with bag seines coastwide during October 1977-December 1987.

Year	Annual		Fall <sup>a</sup>	
	no./ha	Length	no./ha	Length
1977	<1 <sup>a</sup>	171	ND	ND
1978	3	42	5	41
1979	1	71	3	60
1980	4	51	8	49
1981	4	64	12	58
1982	8	51	18	38
1983	4 <sup>b</sup>	46	9	44
1984	2	69	4	50
1985	3	65	8	54
1986	6	63	14	58
1987	6	53	12	45

<sup>a</sup> Data for October-December only.

<sup>b</sup> Does not include East Matagorda Bay data.

<sup>c</sup> Based on February-May season (McEachron and Green, 1984).

**Table 12.** Comparison of mean ranked bag seine catch rates using a nonparametric multiple comparison procedure for southern flounder, coastwide, with similar years grouped.

Year	Mean	Grouping
1982	1,410.5	
1981	1,405.5	
1986	1,357.6	
1980	1,323.6	
1983	1,320.1	
1987	1,318.6	
1985	1,296.3	
1984	1,238.3	
1978	1,222.8	
1979	1,205.6	

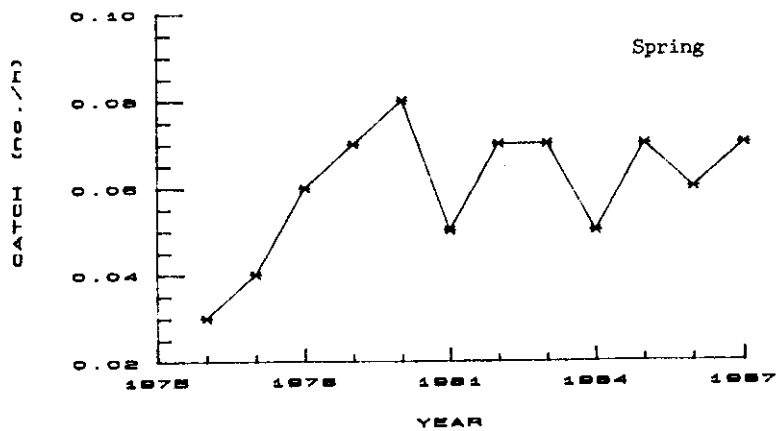
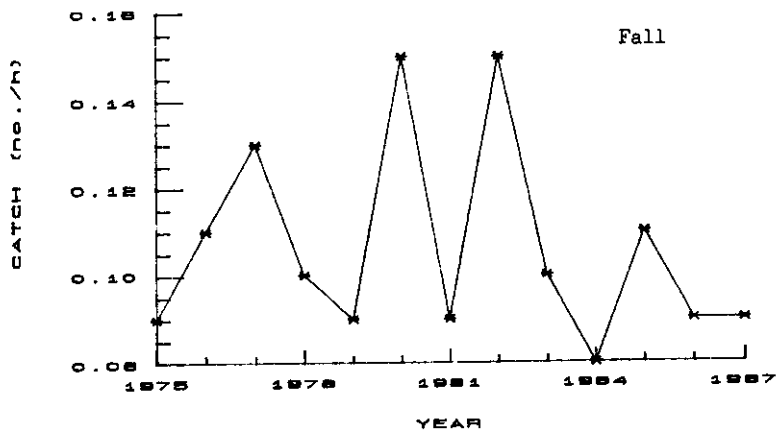


Figure 4. Fall and spring mean catch rates (no/h) of southern flounder in TPWD gill nets from 1975 through 1987.

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**Table 13.** Duncan's Multiple Range Test (Log + 1 Transformed) for gill net catches of southern flounder, coastwide, with similar years grouped.

Year	Mean	Grouping
1980	0.0458	
1976	0.0427	
1982	0.0408	
1985	0.0408	
1977	0.0355	
1979	0.0349	
1981	0.0342	
1978	0.0332	
1983	0.0332	
1986	0.0306	
1987	0.0268	
1984	0.0267	

**Table 14.** Mean catch rates (no./h) and mean total lengths (mm) of Southern flounder caught with 600 feet gill nets (all meshes combined) during fall 1975-1987 and spring 1976-1987.

Year	FALL		SPRING	
	no./h	Length	no./h	Length
1975	0.1	344	ND	ND
1976	0.1	347	<.1	345
1977	0.1	342	<.1	347
1978	0.1	352	0.1	321
1979	0.2	363	0.1	354
1980	0.1	354	0.1	330
1981	0.1	346	0.1	323
1982	0.2	346	0.1	332
1983	0.1	361	0.1	357
1984	0.1	326	0.1	342
1985	0.1	339	0.1	344
1986	0.1	361	0.1	354
1987	0.1	351	0.1	351
Mean		345		343

<sup>1</sup> ND = No data collected

ranged from 321 mm to 365 mm (Table 14). For all years combined, fall and spring were similar with mean total lengths of 345 mm and 343 mm, respectively.

#### *Shrimp Trawls*

From 1982 through 1987, mean annual catch rates of southern flounder in TPWD shrimp trawls were less than 1.0 fish/h with no apparent temporal trend in abundance (Table 15). From 1978 through 1987, southern flounder caught in TPWD spring trawl samples were primarily juveniles (Figure 5). The mean annual total length of southern flounder ranged from 160 mm to 191 mm and averaged 176 mm during the six year period.

### DISCUSSION

With continued population growth in Texas and its coastal counties, fishing pressure directed at southern flounder will likely continue to increase. The numbers of fishing licenses and saltwater stamps sold (Figure 2) underestimate actual number of fishermen because 3-day fishing licenses and nonresident fishing licenses are not included. In addition, 27% of resident fishermen in Texas legally fish without a license (Green *et al.*, 1982), including individuals either younger than 17 or older than 64 years of age. The increase in pressure by private sport-boat fishermen is indicative of a proportional increase in other forms of sport fishing.

The decrease in the size of southern flounder landed by private sport-boat fishermen in 1984, 1985, and 1986 and the decrease in MMPR flounder landings in 1984 may have reflected some flounder mortality due to the freeze in December 1983. McEachron *et al.* (1984) reported extensive losses of some sport and commercial fishes resulting from the freeze, but original estimates of southern flounder mortality were low. However, following a freeze and subsequent fish kill in 1940, southern flounder appeared unaffected based on sampling for dead fish; even so, commercial catches of southern flounder decreased 95% the following year, more than for any other commercial fish (Gunter, 1941).

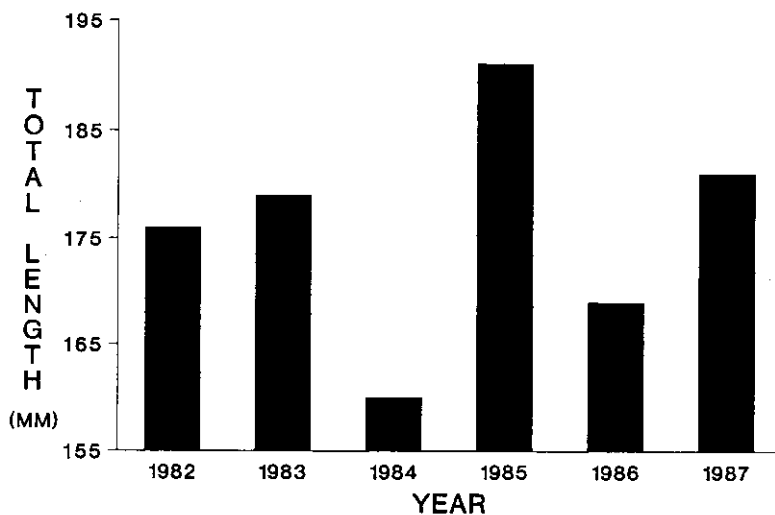
The reduction in estimated annual landings of southern flounder in legal nets reflected a decrease in number of nets deployed from over 1 million ft in 1979 to just over 0.3 million in 1987. This reduction in nets can probably be attributed to changes in fishing regulations. Beginning in 1980, only multifilament net could be used in saltwater. This greatly increased the cost of net fishing because multifilament net is considerably more expensive to buy and maintain than monofilament net. In 1981, red drum and spotted seatrout, the target species for most commercial net fishermen were banned from commercial harvest. As a result of these two regulations, many fishermen either left the commercial net fishery or began fishing illegally. In 1982, recreational

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**Table 15.** Catch rate (no./h) of southern flounder in TPWD shrimp trawl samples by year. Blanks indicate no data.

Year	Trawls	Fish	Rate
1978	80	33	1.65
1979	60	10	0.66
1980	60	3	0.20
1981			
1982	482	90	0.76
1983	687	59	0.64
1984	656	125	0.79
1985	714	107	0.64
1986	830	109	0.84
1987	909	61	0.42
Mean	498	66	0.53



**Figure 5.** Mean total lengths (mm) of southern flounder in TPWD shrimp trawl samples, March through June from 1978 through 1987.

fishermen were prohibited from using nets.

Annual landings of southern flounder using illegal nets are probably underestimated. These estimates were made using the assumption that each net was set only once, because there was no data available on the number of sets that illegal net fishermen make annually. If the assumption were made that illegal nets were fished as often as legal nets, the flounder landings in illegal nets would have been greater than for legal nets after 1981, when the amounts of licensed nets began decreasing.

The use of TPWD gill net catch rates for southern flounder to estimate commercial landings in legal and illegal nets may be biased. Many netters used trammel nets and catch rates in trammel nets and gill nets may not have been the same. Also, catch rates in TPWD random net sets may not be the same as the catch rates in non-random net sets made by netters, who were actively seeking fish.

Because the proportion of southern flounder by-catch in shrimp trawls which is released and survives, and the number of marketable size flounder sold are unknown, fishing mortality by shrimp trawls is difficult to determine. Therefore estimates were made using mortality rates of 25, 50, 75, and 100%. Even if mortality is only 25%, the estimated loss of flounder in shrimp trawls is greater than all other commercial and sport landings combined.

From 1982 through 1987, the annual MMPR reported landings exceeded the estimated landings in commercial nets by as much as 650%. The commercial gig fishery undoubtedly accounted for some of this difference, but to what degree is unknown, because the gig fishery was not effectively monitored historically. It was not effectively monitored by the TPWD sport harvest program because interviews were not conducted during night or early morning hours when most gig fishermen completed their trips. It was not effectively monitored by the TPWD commercial harvest program because most commercial landings of gilled flounder occurred at boat ramps and not at commercial landing sites where commercial interviews took place. A study in 1974 estimated that 83,000 flounder were gilled in the Aransas Bay system alone. This estimate was 38% as many flounder as the TPWD sport harvest program estimated coastwide by private sport-boat fishermen for that year, which indicated an extensive gig fishery in Texas.

In estimating southern flounder mortality using tag return data from sport and commercial fishermen, a tag return rate for commercial fishermen was not used because according to Marwitz (1986) the tag recovery rate from commercial fishermen began a steady decline in 1978 and reached a low in 1982. This drop in recovery rate was probably due to commercial fishermen opposition to state laws and commission regulations restricting commercial fishing activities (Marwitz, 1986). Consequently, this study used a proportionality between sport and commercial landings to estimate the number



of tagged flounder captured by commercial fishermen. Also, this mortality rate can only be applied to that portion of the flounder population which were of sufficient size to be tagged by the TPWD and legally landed by commercial fishermen (305 mm), which means that most trawl caught flounder were excluded.

The low catch rates of southern flounder in TPWD gill nets (< 0.2 fish/h) probably caused by low gear selectivity, may make this gear inappropriate to monitor southern flounder adult abundance (McEachron and Green, 1986b). The flat body shape of the southern flounder and its habit of partially burrowing on the bottom contributes to its low susceptibility to gill nets (Stokes, 1977; Hegen and Matlock, 1980).

The low catch rates of southern flounder in TPWD shrimp trawl samples (< 1 fish/h) compared to the mean catch rate (5.3 fish/h) for commercial trawls found by Matlock (1982), reflects the smaller size of TPWD trawls, no tickler chains on TPWD trawls, and TPWD random sampling procedures.

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