An assessment of cobia in Southeast US waters

Nancy B Thompson

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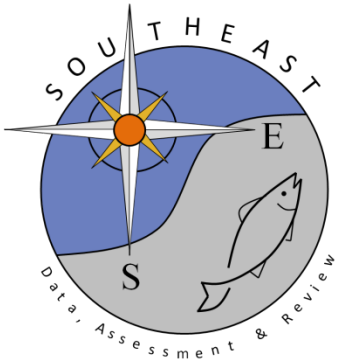

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Introduction

Cobia (Rachycentron canadum) are pelagic fish found in U.S. waters from Massachusetts to Texas (Shaffer and Nakamura 1989). According to the three previous assessments (Isley 1992; Thompson 1993; Thompson 1994), cobia are caught primarily by the recreational sector in both the Atlantic and the Gulf of Mexico. In addition, it was determined that there is a significant bycatch of cobia that occurs incidental to the bottom shrimp trawl fishery in the Gulf of Mexico (Thompson 1993; Thompson 1994). The 1994 assessment determined that with stable catches and low F, the Atlantic stock was not overfished. It was also determined that the Gulf stock was more heavily exploited and at that time was not overfished.

In the 1994 assessment, an age length key provided by Mr. Jim Franks, Gulf Coast Research Laboratory was used to age fish in both the Atlantic and Gulf of Mexico. It was recommended by the Mackerel Stock Assessment Panel that it would be more appropriate to age fish landed in the Atlantic from data more representative of this area. To this end, data were provided by Mr. Joseph Smith, SEFSC, Beaufort Laboratory and used to construct an age length key for Atlantic landed fish. Fish landed in the Gulf of Mexico were aged with the key provided by Mr. Jim Franks.

Other changes in the data which impact the assessment, include "new" estimates of Gulf of Mexico bycatch in the shrimp trawl fishery provided by Dr. Scott Nichols, SEFSC, Pascagoula Laboratory; no estimates are yet available for the Atlantic. Recreational estimates from MRFSS derived from the "new" method were incorporated into the catch data.

Finally, the South Atlantic Fishery Management Council specifically requested that all information on stock identification be summarized.

Stock Identification

While there is no new mark recapture information from the project of Mr. Jim Franks, there are new recaptures from the NMFS/SEFSC Cooperative Gamefish Tagging Program (Table 1). A total of 1301 fish have been released through March, 1995 and of these, 120 recaptures have been reported (Table 1). All the recaptures have been reported since 1986. Notably, from 1987 through 1994, about 5-14% of fish released were reported as recaptured. Of the 120 recaptures, 5 were released from an unknown location. Of the 115 fish recaptured with know release location, all but 9 (8%) were recaptured in the body of water of release using the Dade/Monroe counties line to separate the Gulf and Atlantic waters (Table 1). For these 9 fish, all were released in

the Atlantic and recaptured in the Gulf. For these 115 recaptures the mean straight line distance between was 158.66 nm (range 0-764.46 nm). Mean days at large was estimated as 264.38 (range 0-1124 days at large). Of the five fish without release location, 4 were recaptured in the Gulf of Mexico and one in the Atlantic defined by the Dade/Monroe counties line.

Table 1. Releases and recaptures of cobia from the SEFSC database as of 3/95.

YEAR	RELEASES	RECAPTURES	o/o RECAPTURED
1940	6	0	0
1962	1	0	0
1965	4	0	0
1966	1	0	0
1969	1	0	0
1972	1	0	0
1973	2	0	0
1977	1	0	0
1978	2	0	0
1984	7	0	0
1985	2	0	0
1986	1	1	100
1987	39	2	5
1988	27	0	0
1989	41	5	12
1990	203	13	6
1991	274	14	5
1992	305	43	14
1993	204	25	12
1994	177	16	9
1995	1	0	0
[GRAND TOTAL	==========	==========	==========
	1301	**120**	

As summarized in the previous assessment, Franks and McBee(1994) tagged and released 5,260 fish from the northern Gulf of Mexico to North Carolina and by 1993, 322 (6.1%) had been recaptured. Franks and McBee (1994) noted that recaptures indicate that movement between the Gulf of Mexico and the Atlantic is typical and seasonal. These authors hypothesize that the Florida Keys represent a winter aggregating area for cobia and that fish move in the spring from the Florida Keys to spawning areas off North Carolina and the northern Gulf. The longest distance between release and recapture was from Vermilion Bay,Louisiana and Daytona Beach, FL.; a total of 1300 nm. They conclude from their results that cobia demonstrate some movement between the Gulf and the Atlantic that interaction occurs in the Florida Keys. Franks and

McBee (1994) indicate that this movement between the Gulf and Atlantic suggests that there is a single cobia stock. Genetic work by Biesiot and Franks (pers. comm) further supports the one stock hypothesis although sample sizes were limited in number by location. Franks (pers comm) indicated that the limited samples from the Atlantic were genetically indistinguishable from those obtained from the northern Gulf of Mexico. Genetic homogeneity implies some level of mixing of fish from the Gulf of Mexico and the U.S. North Atlantic. Franks (pers. comm) considers these results preliminary.

Franks hypothesizes that there is a single stock of cobia in U.S. Atlantic waters including the Gulf of Mexico. Thompson (1993) suggested that resource conservation argued to evaluate cobia utilizing a two stock hypothesis. The two stock approach was endorsed by the Mackerels Stock Assessment Panel in 1993. Therefore, for the purposes of this assessment, the two stock hypothesis was examined.

Catches

Catches for the Gulf and Atlantic were updated from the previous assessment for both the commercial and recreational sector. (Table 2). Commercial catches were derived from the NMFS/SEFSC General Canvass and the states. Recreational data are obtained from the Beaufort Headboat Survey, the Texas Parks and Wildlife Creel Survey, and the National Marine Recreational Fishery Statistics Survey (MRFSS). Estimates of catch in numbers from MRFSS include those from the old and new methods for the period 1988 through 1992. Catch estimates for 1993 and 1994 are from the new method only.

The commercial catch data are provided by weight. The TIP samples from the commercial sector separated by Gulf and Atlantic were used to derive average weight per fish and to estimate numbers of fish landed. The recreational catch from is provided as an estimate of total numbers landed. To derive weight, samples from TPWD, Headboat, MRFSS, and recreational TIP data were used to derive average weights for the Gulf and Atlantic respectively which were then multiplied by numbers to derive total weight landed. The catch in numbers of fish derived from new MRFSS catch estimates for 1988 through 1992 were used to re-estimate catch in weight as presented for the recreational catch.

Table 2. Cobia U.S. Atlantic and Gulf of Mexico catch summary in number and by weight in pounds. Year denotes calendar year. For the period 1988 through 1992, estimates using the new and old MRFSS catch estimates are included, with the old estimates in parentheses. The 1994 estimates are preliminary and only include commercial data through June and only the MRFSS data are included for the recreational estimate.

Atlantic Catch in Numbers

Year	Commercial	Recreational		Total	
84	1479	40750		42229	
85	1328	44204		45532	
86	3099	33130		36229	
87	5401	29211		34612	
88	4684	29578	(27138)	34262	(31822)
89	5799	48068	(48880)	53867	(54679)
90	5482	30876	(26242)	36358	(31775)
91	5533	34458	(27010)	39991	(32543)
92	6078	55741	(60057)	61819	(66135)
93	3432	29199		32631	
94	1013	21535		22548	

Gulf Catch in Numbers

84	10161	54160		64321	
85	9404	48580		57984	
86	10301	67229		77530	
87	11764	42787		54551	
88	10488	67753	(64073)	78241	(74561)
89	13535	51055	(43191)	64590	(56726)
90	10143	50361	(43074)	60504	(53217)
91	10272	70574	(51555)	80846	(61827)
92	13552	60711	(48790)	74263	(62552)
93	6446	53652		60098	
94	2591	40832		43423	

Atlantic Catch in Weight X 1000 lbs.

84	33.4	951.4		984.9	
85	30.0	1313.6		1343.6	
86	70.0	735.4		805.4	
87	122.8	695.9		808.6	
88	105.6	704.9	(728.0)	810.5	(833.6)
89	131.1	1185.4	(1151.0)	1316,5	(1282.1)
90	123.3	818.0	(823.4)	941.3	(946.7)
91	125.0	837.6	(719.4)	962.6	(844.4)
92	137.3	1244.5	(1362.7)	1381.8	(1500.0)
93	129.0	644.2		773.2	
94	39.9	512.5		552.4	

Gulf Catch in Weight X 1000lbs.

84	174.4	1066.9		1240.3	
85	161.4	1115.8		1277.3	
86	176.8	1492.2		1669.1	
87	201.9	1145.6		1347.5	
88	180.0	1358.8	(1249.6)	1538.8	(1484.0)
89	232.3	1477.6	(1249.6)	1709.9	(1482.0)
90	174.1	1541.3	(1405.6)	1715.4	(1579.7)
91	176.3	1508.3	(1986.6)	2162.9	(1756.6)
92	232.6	1061.7	(1196.2)	1293.3	(1428.8)
93	129.0	1028.3		1157.3	
94	39.9	881.0		920.9	

As noted in the previous assessments, in both number and weight, annual catches in the Gulf of Mexico are higher than in the Atlantic over the period 1984-1994. As before, the majority of the total catch for both stocks, both in weight and numbers, is from the recreational sector. For both sectors, catch is typically from hook and line or longline. For the period 1988 through 1992, combined catches were at or slightly higher than MSY (2.2 million pounds).

Bycatch Estimates in Gulf Shrimp Fishery

The bycatch data from the commercial shrimp trawl fishery in the Gulf of Mexico that were utilized in the previous two years assessment were updated for this assessment (Figure 1). New data, available from the NMFS/SEFSC observer program have been accumulated with data from previous sampling periods to produce updated estimates for the time period. As before, size samples from the bycatch were used to apportion the bycatch by age based on the age-length key of Franks. Bycatch are either of age zero or 1 based on length. No data are yet available for the Atlantic. These bycatch estimates are included in the annual catch at age estimates and in all analyses.

Catch at Age

Gulf of Mexico

As was done in the previous assessment, the age-length key of Franks and McBee (1991) was used to catches by number for the Gulf of Mexico. The annual catch at age is included with the results of the VPA. Without bycatch, fish appear to be fully recruited at age 2. Based on the age-length key provided by Franks, there are no fish older than age 9 in the catch of either "stock". Thus, catch at age was pooled at age 8+.

Atlantic

To age the Atlantic catches in number, the age length key provided by Mr. Joseph Smith, SEFSC, Beaufort Laboratory was applied. Notably, this resulted in no fish of age 0 in the catches. Fish are fully recruited at age 3 rather than age 2 as in the Gulf of Mexico. Fish were aged to 14 years, and pooled at this age. The resulting distribution of ages is from age 1 through age 14. It appears that fish in the Atlantic grow more slowly than in the Gulf of Mexico and live longer.

Table 3. Catch at age in numbers of fish for combined commercial and recreational catches. Gulf of Mexico catch at age includes estimated bycatch for ages 0 and 1. Gulf of Mexico catch at age was derived from the results of Franks and McBee (1991) and Atlantic catch at age was derived using the results of Smith (pers comm.)

CATCH AT AGE GULF OF MEXICO

	84	85	86	87	88	89
0	84420	122220	44100	69300	46230	90258
1	49580	71780	25900	40700	38739	62575
2	24809	22364	29903	21040	31972	26393
3	12813	11550	15444	10867	14916	12313
4	6387	5758	7699	5417	9170	7570
5	1852	1670	2233	1571	2251	1858
6	624	562	752	529	844	697
7	225	203	271	191	651	542
8+	109	99	132	93	235	199
Total	180819	236206	126434	149708	145008	202405
1-3	87202	105694	71247	72607	85627	101281
2-8+	46819	42206	56434	39708	60039	49572
1-8+	96399	113986	82334	80408	98778	112147

	90	91	92	93
0	103278	155978	136745	188308
1	69616	103567	91310	119394
2	24724	33002	30346	24537
3	11534	15406	14157	11457
4	7091	9475	8704	7043
5	1740	2325	2136	1729
6	652	872	801	648
7	503	672	618	500
8+	182	243	223	180
Total	219320	321540	285040	353796
1-3	105874	151975	135813	155388
2-8+	46426	61995	56985	46094
1-8+	116042	165562	148295	165488

CATCH AT AGE ATLANTIC

	84	85	86	87	88	89
1	2275	2992	2380	1928	2251	3539
2	3412	3679	2928	2797	2769	4353
3	11017	11879	9452	9030	8939	14053
4	7343	7918	6300	6019	5958	9367
5	5062	5458	4343	4149	4107	6458
6	3719	4010	3191	3048	3018	4744
7	2179	2350	1869	1786	1768	2780
8	1782	1922	1529	1461	1446	2273
9	1305	1407	1120	1070	1059	1665
10	1110	1197	952	910	900	1416

11	487	525	418	399	395	621
12	194	209	167	159	158	248
13	323	348	277	264	262	412
14+	253	273	217	208	206	323
Total	40462	44166	35142	33227	33234	52250
1-3	16704	18550	14760	13755	13958	21945
2-8	34515	37215	29611	28290	28004	44028
1-8	36790	40207	31992	30218	30255	47567

	90	91	92	93
1	2197	2627	4062	2144
2	2702	3232	4995	2554
3	8722	10433	16128	8415
4	5814	6954	10750	5502
5	4008	4589	7411	3762
6	2944	3317	5444	2776
7	1725	1653	3190	1639
8	1411	1547	2609	1332
9	1033	1171	1910	986
10	879	1051	1625	783
11	386	461	713	376
12	154	184	284	150
13	255	241	472	249
14+	201	240	371	196
Total	32430	37700	59964	30864
1-3	13621	16292	25185	13114
2-8	27326	31725	50527	25980
1-8	29523	34353	54588	28124

Reproduction

Shaffer and Nakamura (1989) reviewed information on the reproductive biology of cobia. They noted that spawning in the Atlantic off the Carolinas and Virginia and in the Gulf of Mexico off of Texas occurred between May and August and peaked in June/July. Lotz et al (1991) examined the gonads of fish sampled in the northern Gulf to the Florida Keys. A total of 459 fish were examined including 134 males and 361 females and GSI's were determined. They determined that the peak of ovarian developmental activity occurred from April to June, with a second peak in August and September. They suggested that spawning may occur two or even three times in a year, beginning in early spring and ending in early fall. Lotz et al (1991) provided an estimated mean spawn size of 4.8×10^7 eggs ($SE=9.8 \times 10^8$). They demonstrated that spawn size increased with increasing fork length of fish. However, fecundity was not estimated by age because of likely multiple spawning. Thus, while fecundity by size and therefore age cannot be estimated, it is valid to evaluate SPR based on biomass at age, since fish increase in size and fecundity with age.

Most recently, Biesot, Caylor, and Franks (1994) examined female cobia sampled from spawning grounds in the northern Gulf of Mexico. Their results confirm those from previous studies with the spawning season peaking in April through August in this area. More notably, they describe seasonal migrations with winter mixing in the waters of the Florida Keys and movement to spawning grounds in

the northern Gulf of Mexico in the spring and in waters off North Carolina to New Jersey in late spring to early fall.

Recruitment

The data provided by Pelligren and referenced by Thompson (1993) were used to evaluate recruitment again. These data from the fall groundfish surveys from 1972-1992 provided numbers of cobia by tow which were used to estimate numbers of fish by year (Figure 2). Catch frequency as before is reasonably stable and the only statistical differences were noted for 1976 and 1977 (low estimate) as compared with 1983 (high estimate).

CPUE

As noted in previous assessments, the recreational catch is more significant than the commercial catch. Given that most of the catch comes from the private/rental recreational mode, the MRFSS CPUE data were evaluated as an index to calibrate VPA results. To derive an index, a general linear model (ANOVA) was completed for the Gulf and Atlantic MRFSS data by Mr. Michael Schirripa, Miami Laboratory. During this process, several variables were examined and those that were significant at $p<.05$ were maintained in the model to derive the index value. In this way, year, county, mode, and area were examined as variables significantly determining CPUE for the Gulf and year mode and county were significant for the Atlantic. The standardized annual values for CPUE from the MRFSS data for the Gulf and Atlantic are presented in Appendix I.

VPA

An age based analysis as described by Powers and Restrepo (1992) was completed for the Gulf and Atlantic stocks respectively. The full results of the Gulf analysis is presented in Appendix II for the Gulf of Mexico and Atlantic landed fish separately and for the Gulf and Atlantic landed fish combined.

Using results from the previous assessments, with M=.4, and the catch at age from table 3, the VPA was completed with Powers STAATS program. For the Gulf "stock" the catch at age including bycatch was applied. The CPUE indices evaluated from the MRFSS data were used to calibrate the results of the VPA. This approach provides stock at age and fishing mortality at age vectors by year.

Notably, fishing mortality rates are extremely low for the Atlantic area as noted in the previous assessments and effectively M=Z. Thus, there is no new information for this area and this group cannot be overfished. A combination of Atlantic and Gulf

catches effectively results in a Gulf analysis and does not offer additional information. The VPA therefore, only provides results for the Gulf group which is the more heavily exploited group.

SPR

SPR ratios was evaluated for the Gulf group only. Because fecundity estimates were not available by age, biomass was used to estimate SSBR with and without fishing mortality. SPR was evaluated using Goodyear's YPR-SPR program. As before, a vector of fishing mortality by age, which was estimated as an average of the F at age from the VPA, is required. This vector is derived from the F values for catch at age from the 1993 catch at age data. Each fishing mortality rate at age is standardized with the highest F at age value. Natural mortality was assumed to be .4 as used in the previous two assessments. Average weight per fish at age was estimated using the age and growth equations of Franks and McBee. Results are presented in Figure 3. Values of F for the fully recruited age classes, 2-8+, exceed $F_{0.1}$ for the time series. In 1993, estimated F is slightly below F_{max} and the resulting equilibrium SPR is below 20% for the Gulf fish. It is suggested that cobia assessments continue to be done separately for the Gulf and Atlantic.

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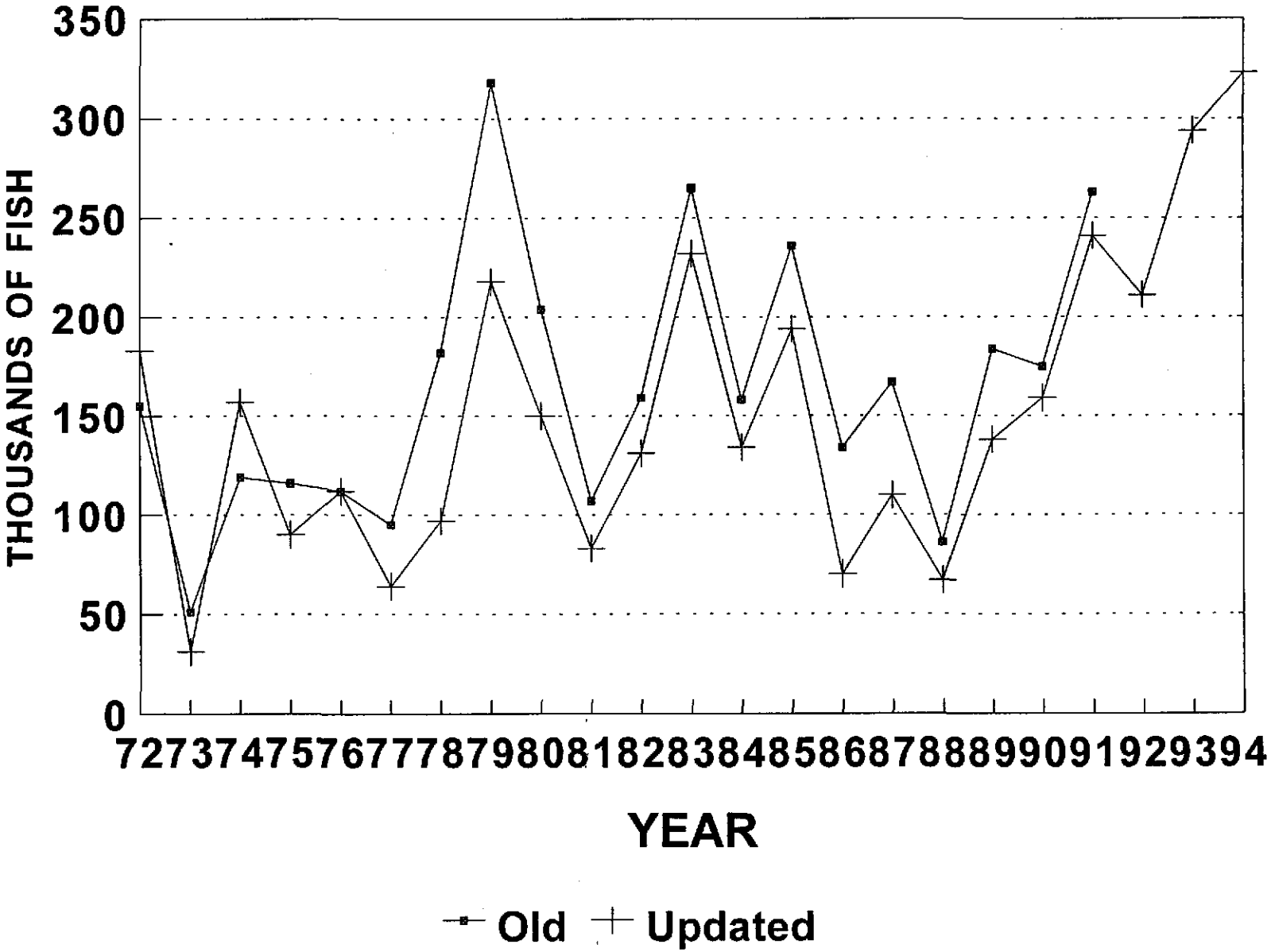
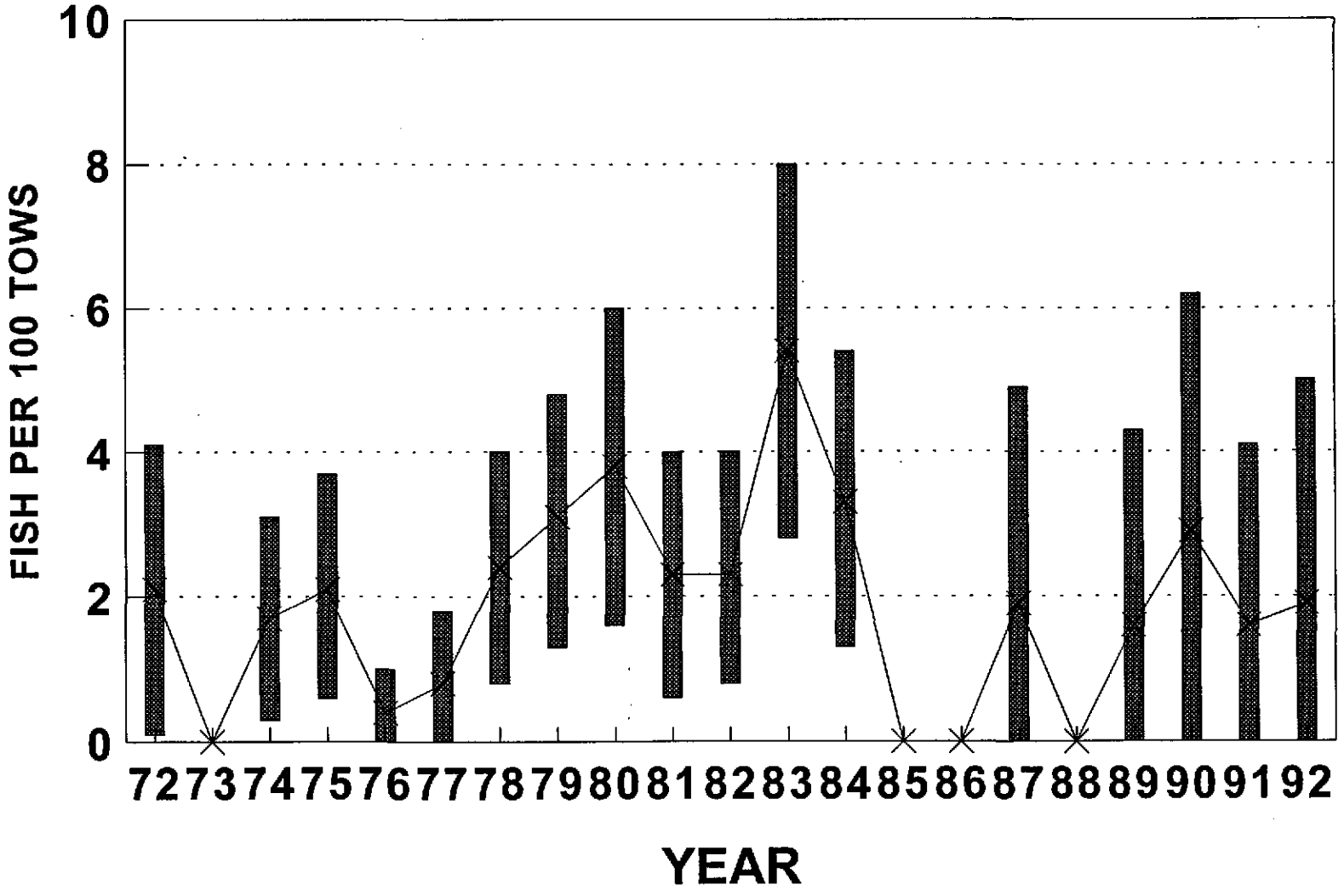
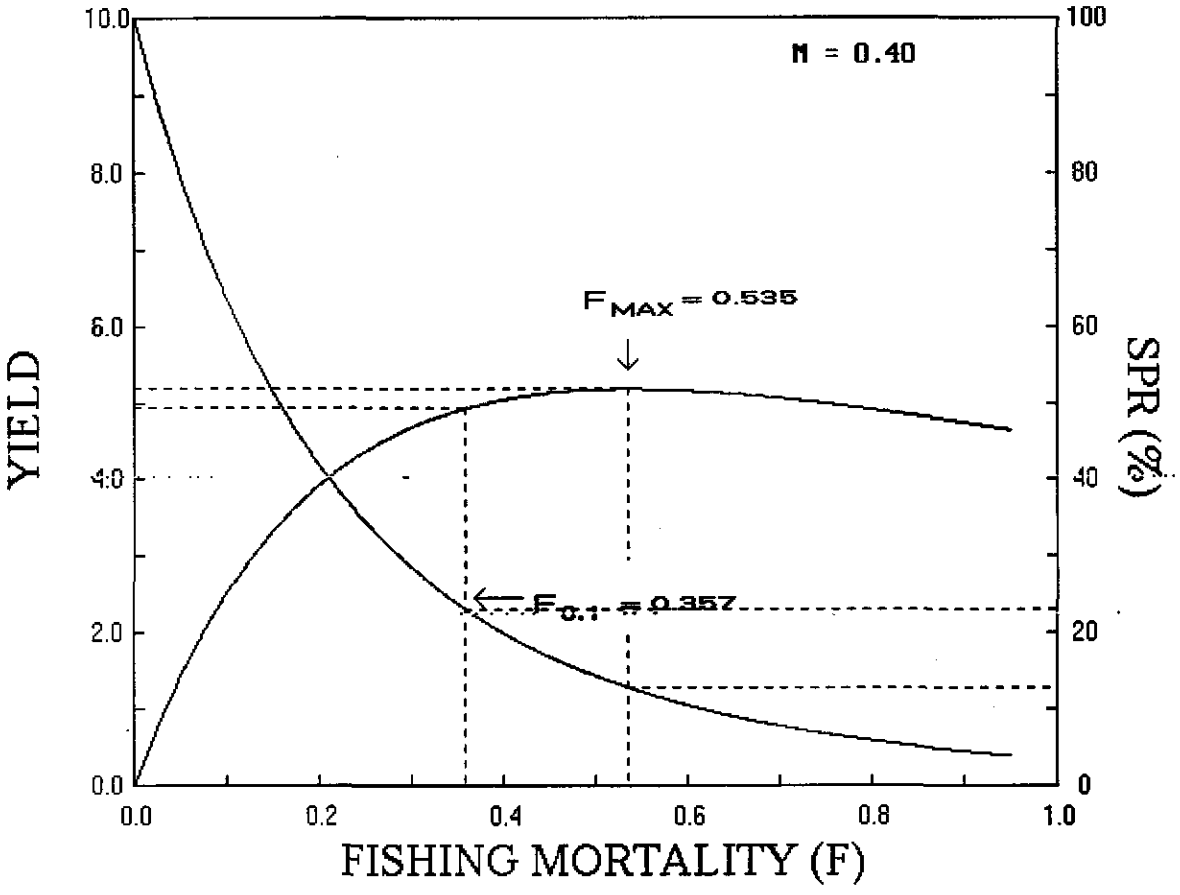
Bycatch in Gulf Shrimp Fishery



Recruitment Index
from Groundfish Surveys




M = 0.40
F_{MAX} = 0.535
$F_{0.1}$ = 0.357
YIELD
SPR (%)
FISHING MORTALITY (F)
10.0
8.0
6.0
4.0
2.0
0.0
100
80
60
40
20
0
0.0
0.2
0.4
0.6
0.8
1.0

MRFSS Gulf - catA + catB1 + catB2 = total catch 1
Nominal average CPUE (catch/man-hour)
9:48 Tuesday, January 31, 1995

YEAR	AVE_CPU	OBS_CPU	SE_CPU
82	111.322	62	13.0684
83	137.820	30	29.9229
84	139.782	24	28.6725
85	89.916	23	9.8685
86	161.868	53	25.6975
87	138.596	66	16.9041
88	258.193	61	74.7860
89	145.670	53	15.2560
90	187.619	64	25.5371
91	174.434	90	22.4668
92	143.713	141	17.8536
93	123.058	99	10.3468

MRFSS Gulf - catA + catB1 + catB2 = total catch 2
GLM on catches , numbers caught - all catch types
9:48 Tuesday, January 31, 1995

General Linear Models Procedure
Class Level Information

Class	Levels	Values
YEAR	12	82 83 84 85 86 87 88 89 90 91 92 93
COUNTY	21	1 2 3 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
MODE	4	1 2 3 4
AREA	6	0 1 2 3 4 5

Number of observations in data set = 766

MRFSS Gulf - catA + catB1 + catB2 = total catch 3
GLM on catches , numbers caught - all catch types
General Linear Models Procedure

Dependent Variable: LCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	39	117.7712068	3.0197745	3.76	0.0001
Error	726	583.0628752	0.8031169		
Corrected Total	765	700.8340820			

R-Square	C.V.	Root MSE	LCPUE Mean
0.168044	19.57672	0.896168	4.57772228

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	11	30.44855886	2.76805081	3.45	0.0001
COUNTY	20	30.00428388	1.50021419	1.87	0.0121
MODE	3	37.34808030	12.44936010	15.50	0.0001
AREA	5	8.29886764	1.65977353	2.07	0.0676

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		4.974848190 B	23.87	0.0001	0.20844656
YEAR	82	-0.339637490 B	-2.16	0.0314	0.15754132
	83	0.049833344 B	0.25	0.8035	0.20020092
	84	0.040342932 B	0.19	0.8519	0.21603088
	85	-0.336186619 B	-1.55	0.1219	0.21706496
	86	0.055698220 B	0.35	0.7279	0.16002909
	87	-0.063805970 B	-0.43	0.6667	0.14807199
	88	0.438734547 B	2.85	0.0044	0.15373674
	89	0.145114164 B	0.92	0.3575	0.15760350
	90	0.413539246 B	2.78	0.0055	0.14851592
	91	0.161474363 B	1.20	0.2291	0.13413797
	92	-0.066223634 B	-0.55	0.5842	0.12094698
	93	0.000000000 B	.	.	.
COUNTY	1	-0.192192882 B	-1.05	0.2928	0.18254172
	2	-0.439912190 B	-2.60	0.0095	0.16918079
	3	-0.234915581 B	-1.30	0.1948	0.18102870
	5	-0.146369079 B	-0.76	0.4504	0.19383616
	6	-0.284587766 B	-1.40	0.1620	0.20331386
	7	-0.745956488 B	-4.18	0.0001	0.17848048
	8	-0.561845767 B	-1.98	0.0477	0.28323121
	9	-0.437839514 B	-1.93	0.0544	0.22725346
	10	-0.503302993 B	-1.69	0.0919	0.29822212
	11	-0.450380384 B	-1.89	0.0591	0.23820169
	12	-0.669222972 B	-2.78	0.0057	0.24113679
	13	-0.366938116 B	-1.15	0.2513	0.31960047
	14	-0.594969975 B	-3.01	0.0027	0.19786802
	15	-0.367670250 B	-1.88	0.0600	0.19519318
	16	-0.132238374 B	-0.58	0.5621	0.22801238
	17	-0.530785009 B	-1.35	0.1783	0.39393984
	18	-0.352792512 B	-1.11	0.2695	0.31926282
	19	-0.582522614 B	-1.54	0.1229	0.37718474
	20	-0.431263174 B	-1.38	0.1667	0.31154693
	21	-0.053251618 B	-0.11	0.9100	0.47109959
	22	0.000000000 B	.	.	.
MODE	1	-0.038073496 B	-0.25	0.8051	0.15422712
	2	0.260319469 B	1.08	0.2824	0.24198269
	3	-0.585028849 B	-6.60	0.0001	0.08860274
	4	0.000000000 B	.	.	.
AREA	0	-0.982915027 B	-2.02	0.0440	0.48718023
	1	0.077210243 B	0.48	0.6311	0.16070947
	2	0.002289214 B	0.02	0.9877	0.14790805
	3	0.073890323 B	0.53	0.5947	0.13882096
	4	0.284540637 B	1.75	0.0804	0.16250655
	5	0.000000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular and a generalized inverse was used to solve the normal equations. Estimates followed by the letter 'B' are biased, and are not unique estimators of the parameters.

MRFSS Gulf - catA + catB1 + catB2 = total catch 4
GLM on catches , numbers caught - all catch types
9:48 Tuesday, January 31, 1995

General Linear Models Procedure
Least Squares Means

YEAR	LCPUE LSMEAN	Std Err LSMEAN	Pr > |T| HO:LSMEAN=0	LSMEAN Number
82	4.07404354	0.16228415	0.0001	1
83	4.46351438	0.19525122	0.0001	2
84	4.45402397	0.21068476	0.0001	3
85	4.07749442	0.21481411	0.0001	4
86	4.46937925	0.16957020	0.0001	5
87	4.34987506	0.16582921	0.0001	6
88	4.85241558	0.15193364	0.0001	7
89	4.55879520	0.16936244	0.0001	8
90	4.82722028	0.16548188	0.0001	9
91	4.57515540	0.15022648	0.0001	10
92	4.34745740	0.13791988	0.0001	11
93	4.41368103	0.14584308	0.0001	12

Pr > |T| HO: LSMEAN(i)=LSMEAN(j)

i/j	1	2	3	4	5	6	7	8	9
1	.	0.0651	0.0874	0.9878	0.0256	0.1023	0.0001	0.0072	0.0001
2	0.0651	.	0.9702	0.1357	0.9785	0.5899	0.0726	0.6673	0.0879
3	0.0874	0.9702	.	0.1632	0.9473	0.6476	0.0842	0.6523	0.0983
4	0.9878	0.1357	0.1632	.	0.0875	0.2266	0.0008	0.0402	0.0010
5	0.0256	0.9785	0.9473	0.0875	.	0.4886	0.0305	0.6262	0.0398
6	0.1023	0.5899	0.6476	0.2266	0.4886	.	0.0025	0.2289	0.0038
7	0.0001	0.0726	0.0842	0.0008	0.0305	0.0025	.	0.0964	0.8822
8	0.0072	0.6673	0.6523	0.0402	0.6262	0.2289	0.0964	.	0.1230
9	0.0001	0.0879	0.0983	0.0010	0.0398	0.0038	0.8822	0.1230	.
10	0.0017	0.5798	0.5752	0.0221	0.5107	0.1366	0.0779	0.9189	0.0994
11	0.0652	0.5503	0.6116	0.2039	0.4225	0.9863	0.0007	0.1610	0.0008
12	0.0314	0.8035	0.8519	0.1219	0.7279	0.6667	0.0044	0.3575	0.0055

Pr > |T| HO: LSMEAN(i)=LSMEAN(j)

i/j	10	11	12
1	0.0017	0.0652	0.0314
2	0.5798	0.5503	0.8035
3	0.5752	0.6116	0.8519
4	0.0221	0.2039	0.1219
5	0.5107	0.4225	0.7279
6	0.1366	0.9863	0.6667
7	0.0779	0.0007	0.0044
8	0.9189	0.1610	0.3575
9	0.0994	0.0008	0.0055
10	.	0.0696	0.2291
11	0.0696	.	0.5842
12	0.2291	0.5842	.

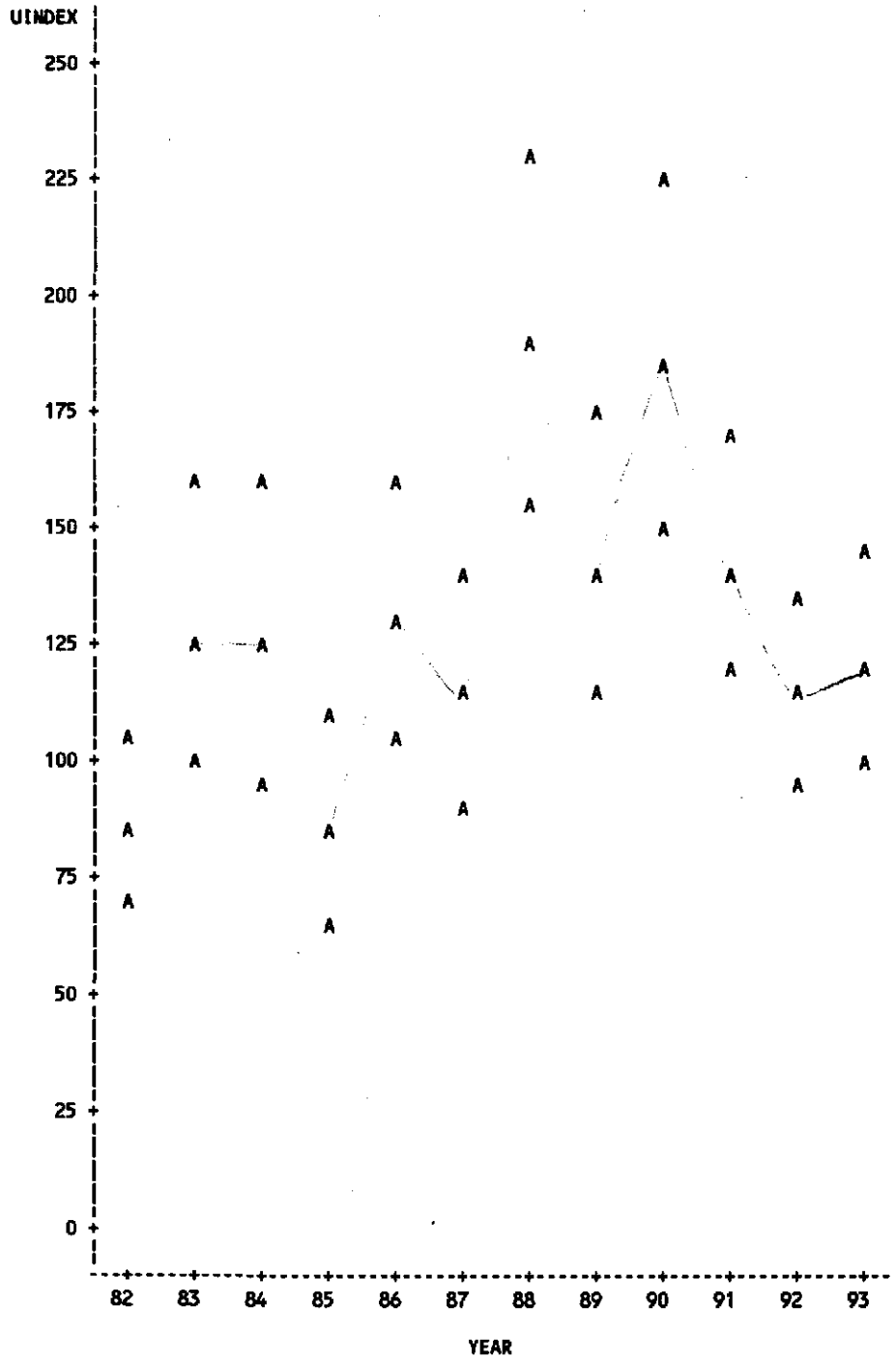
NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

MRFSS Gulf - catA + catB1 + catB2 = total catch 5
Index and variance calculations - Gulf Cobia

OBS	LCPUE	UC_CPU	INDEX	VAR_CP	CV
1	4.07404	57.794	85.621	240.151	0.18099
2	4.46351	85.792	126.206	610.297	0.19574
3	4.45402	84.972	124.611	689.638	0.21074
4	4.07749	57.997	85.124	336.613	0.21553
5	4.46938	86.303	127.555	474.056	0.17069
6	4.34988	76.469	113.146	357.903	0.16720
7	4.85242	127.049	188.090	828.751	0.15305
8	4.55880	94.468	139.584	565.578	0.17038
9	4.82722	123.863	182.990	926.114	0.16630
10	4.57516	96.043	142.340	465.913	0.15164
11	4.34746	76.282	113.353	251.269	0.13984
12	4.41368	81.573	121.046	318.917	0.14753

MRFSS Gulf - catA + catB1 + catB2 = total catch 6
Index with 80% ci, Gulf Cobia
9:48 Tuesday, January 31, 1995

Plot of UINDEX*YEAR. Legend: A = 1 obs, B = 2 obs, etc.
Plot of INDEX*YEAR. Legend: A = 1 obs, B = 2 obs, etc.
Plot of LINDEX*YEAR. Legend: A = 1 obs, B = 2 obs, etc.



Gulf Cobia M=.4

Catch at Age Data in file: C:\STAATS\COBIA\GULAGECO

Final year selectivity was entered as an input

	0	1	2	3	4	5	6	7	8+
Sel	0.397	0.660	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Reference Age for Selectivity

	0	1	2	3	4	5	6	7	8+
Age	2	2	2	2	2	2	2	2	2

Available Indices (** denotes indices selected for this fit)

Code #	Index Name	Ages at Which Index is Directed	
** 1	MRFSS	2 to 8+	No transformation was used: VPA Model

Indices were scaled to the mean after any transformations were taken.

No tri-cubic weighting used in the least squares

Minimization using a Marquardt Search

Catchability Q's estimated by MLE's and not through the search

F ratio (alpha) method used for bottom row F's

Natural Mortality Rate at Age

	0	1	2	3	4	5	6	7	8+
N Mort	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400

CATCH AT AGE DURING YEAR

	84	85	86	87	88	89
0	84420	122220	44100	69300	46230	90258

1	49580	71780	25900	40700	38739	62575
2	24809	22364	29903	21040	31972	26393
3	12813	11550	15444	10867	14916	12313
4	6387	5758	7699	5417	9170	7570
	1852	1670	2233	1571	2251	1858
	624	562	752	529	844	697
	225	203	271	191	651	542
8+	109	99	132	93	235	199
Total	180819	236206	126434	149708	145008	202405
1-3	87202	105694	71247	72607	85627	101281
2-8+	46819	42206	56434	39708	60039	49572
1-8+	96399	113986	82334	80408	98778	112147

	90	91	92	93
0	103278	155978	136745	188308
1	69616	103567	91310	119394
2	24724	33002	30346	24537
3	11534	15406	14157	11457
4	7091	9475	8704	7043
5	1740	2325	2136	1729
6	652	872	801	648
7	503	672	618	500
8+	182	243	223	180
Total	219320	321540	285040	353796
1-3	105874	151975	135813	155388
2-8+	46426	61995	56985	46094
1-8+	116042	165562	148295	165488

YIELD AT AGE (Lbs)

	84	85	86	87	88	89
0	84420	122220	44100	69300	46230	90258
1	49580	71780	25900	40700	38739	62575
2	24809	22364	29903	21040	31972	26393
3	12813	11550	15444	10867	14916	12313
4	6387	5758	7699	5417	9170	7570
5	1852	1670	2233	1571	2251	1858
6	624	562	752	529	844	697
7	225	203	271	191	651	542
8+	109	99	132	93	235	199
Total	180819	236206	126434	149708	145008	202405
1-3	87202	105694	71247	72607	85627	101281
2-8+	46819	42206	56434	39708	60039	49572
1-8+	96399	113986	82334	80408	98778	112147

	90	91	92	93
	103278	155978	136745	188308
	69616	103567	91310	119394
2	24724	33002	30346	24537
3	11534	15406	14157	11457
4	7091	9475	8704	7043

5	1740	2325	2136	1729
6	652	872	801	648
7	503	672	618	500
8+	182	243	223	180
	219320	321540	285040	353796
	105874	151975	135813	155388
	46426	61995	56985	46094
1-8+	116042	165562	148295	165488

Initial Parameter Estimates

	Estimate	Lower Bound	Upper Bound
1. N Age 3	1000000	1	1E+08

```
It= 1   SSQBef= 6.089601   SSQAft= 1.412947   No.Rewt= 0
It= 2   SSQBef= 1.412947   SSQAft= 1.322562   No.Rewt= 0
It= 3   SSQBef= 1.322562   SSQAft= .9441431   No.Rewt= 0
It= 4   SSQBef= .9441431   SSQAft= .5494056   No.Rewt= 0
It= 5   SSQBef= .5494056   SSQAft= .5321798   No.Rewt= 0
It= 6   SSQBef= .5321798   SSQAft= .5321589   No.Rewt= 0

eration= 6
 f Squares Before = .5321798          After  = .5321589
 mbda =  9.999999E-07     omega =  6.721274E-03
Convergence in Marquardt Search: tolerance RSS =  .0001 ; parameter =  .0005
```

STOCK AT AGE AT BEGINNING OF YEAR

	84	85	86	87	88	89
0	452738	401031	357436	364215	383088	480019
1	193556	235396	170892	203921	188262	219389
2	89835	89907	100279	93628	103891	94984
3	39499	40307	42290	43250	45826	44027
4	14726	16223	17754	16020	20257	18782
5	4635	4798	6276	5785	6408	6306
6	1572	1632	1882	2423	2617	2497
7	540	557	645	663	1198	1079
8+	262	272	314	323	433	396
1-3	322890	365610	313460	340799	337979	358401
2-8+	151069	153696	169439	162092	180630	168071
1-8+	344625	389092	340331	366014	368892	387460

	90	91	92	93	94
	500411	509325	903880	1222835	0
1	248981	252229	216447	495414	667579
2	96865	111035	86668	72495	236073
3	42489	45064	47975	33850	28976

4	19632	19222	17892	20809	13530
5	6564	7499	5394	5108	8317
6	2737	3002	3164	1915	2042
7	1114	1310	1313	1477	765
	403	474	474	532	803
	388335	408328	351090	601760	932628
	169805	187606	162880	136186	290506
1-8+	418786	439835	379327	631600	958085

F AT AGE DURING YEAR

	84	85	86	87	88	89
0	0.2540	0.4530	0.1612	0.2599	0.1574	0.2565
1	0.3668	0.4533	0.2017	0.2744	0.2841	0.4175
2	0.4015	0.3542	0.4410	0.3145	0.4585	0.4045
3	0.4898	0.4199	0.5707	0.3585	0.4919	0.4076
4	0.7214	0.5498	0.7213	0.5164	0.7671	0.6514
5	0.6436	0.5360	0.5516	0.3934	0.5425	0.4345
6	0.6379	0.5285	0.6438	0.3041	0.4863	0.4068
7	0.6822	0.5694	0.6898	0.4230	1.0155	0.8968
8+	0.6822	0.5694	0.6898	0.4230	1.0155	0.8968
1-3	0.3907	0.4244	0.3179	0.2956	0.3617	0.4128
2-8+	0.4622	0.3985	0.5062	0.3478	0.5048	0.4348
1-8+	0.4075	0.4313	0.3418	0.3062	0.3861	0.4250
F8+/F7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	90	91	92	93
0	0.2851	0.4557	0.2013	0.2053
1	0.4075	0.6682	0.6938	0.3413
2	0.3652	0.4392	0.5401	0.5171
3	0.3932	0.5237	0.4353	0.5171
4	0.5625	0.8707	0.8535	0.5171
5	0.3822	0.4628	0.6359	0.5171
6	0.3366	0.4269	0.3617	0.5171
7	0.7640	0.9258	0.8120	0.5171
8+	0.7640	0.9258	0.8120	0.5171
1-3	0.3953	0.5847	0.6156	0.3702
2-8+	0.3964	0.5008	0.5390	0.5171
1-8+	0.4030	0.5934	0.6244	0.3766
F8+/F7	1.0000	1.0000	1.0000	1.0000

SELECTIVITY AT AGE DURING YEAR

	84	85	86	87	88	89
0	0.3521	0.7956	0.2235	0.5033	0.1550	0.2860
1	0.5084	0.7962	0.2796	0.5314	0.2798	0.4656
	0.5565	0.6221	0.6114	0.6090	0.4515	0.4510
	0.6790	0.7375	0.7912	0.6942	0.4845	0.4545
4	1.0000	0.9655	1.0000	1.0000	0.7554	0.7263
5	0.8922	0.9414	0.7647	0.7617	0.5342	0.4845
6	0.8842	0.9281	0.8926	0.5889	0.4789	0.4536

7	0.9456	1.0000	0.9563	0.8191	1.0000	1.0000
8+	0.9456	1.0000	0.9563	0.8191	1.0000	1.0000

	90	91	92	93
0	0.3732	0.4923	0.2359	0.3970
1	0.5334	0.7218	0.8130	0.6600
2	0.4781	0.4744	0.6329	1.0000
3	0.5147	0.5657	0.5100	1.0000
4	0.7363	0.9405	1.0000	1.0000
5	0.5002	0.4999	0.7450	1.0000
6	0.4406	0.4611	0.4238	1.0000
7	1.0000	1.0000	0.9515	1.0000
8+	1.0000	1.0000	0.9515	1.0000

INDEX RESULTS

Index No. 1 MRFSS VPA Index: Applied to ages 2 to 8+

Index Fitted to Mid-Year Stock Size in NUMBERS

Age Selectivity by the Gear/Fishery

	2	3	4	5	6	7
	1.000	1.000	1.000	1.000	1.000	1.000
	1.000	1.000	1.000	1.000	1.000	1.000
	.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000
88	1.000	1.000	1.000	1.000	1.000	1.000
89	1.000	1.000	1.000	1.000	1.000	1.000
90	1.000	1.000	1.000	1.000	1.000	1.000
91	1.000	1.000	1.000	1.000	1.000	1.000
92	1.000	1.000	1.000	1.000	1.000	1.000
93	1.000	1.000	1.000	1.000	1.000	1.000

	8+
84	1.000
85	1.000
86	1.000
87	1.000
88	1.000
89	1.000
90	1.000
91	1.000
92	1.000
93	1.000

Index Data: Observed, Scaled (and/or Transformed), Predicted

Obs Index Yr Weights Scaled Index Pred Index Wted Resid

84	139.7820	1.0000	0.8944	0.9255	-0.0311
85	89.9160	1.0000	0.5753	0.9682	-0.3929
86	161.8680	1.0000	1.0357	1.0188	0.0169
	138.5960	1.0000	0.8868	1.0441	-0.1572
	258.1930	1.0000	1.6521	1.0866	0.5655
	145.6700	1.0000	0.9321	1.0421	-0.1100
90	187.6190	1.0000	1.2005	1.0706	0.1298
91	174.4340	1.0000	1.1161	1.1299	-0.0138
92	143.7130	1.0000	0.9196	0.9653	-0.0458
93	123.0580	1.0000	0.7874	0.8156	-0.0282

	Stock Sizes: VPA and Scaled		Standardized Residuals	
Year	VPA Stock Size	Index Stock Size	----------|	----------|
84	151069	145997	#	
85	153696	91331	#########	
86	169439	172256		
87	162092	137681	####	
88	180630	274638		###########
89	168071	150330	###	
90	169805	190399		##
91	187606	185318	#	
92	162880	155154	#	
93	136186	131471	#	

Q = 9.149237E-06
Residuals Squared Weighted by 1 ; Percent of Total RSS =100.000

Total Residual Analysis

	Sorted Weighted Residuals	Index	Year	Cumul Prob	Normal Z
1	-0.39287	MRFSS	85	0.1000	-1.5889
2	-0.15724	MRFSS	87	0.2000	-0.6195
3	-0.11000	MRFSS	89	0.3000	-0.4251
4	-0.04579	MRFSS	92	0.4000	-0.1609
5	-0.03107	MRFSS	84	0.5000	-0.1004
6	-0.02824	MRFSS	93	0.6000	-0.0887
7	-0.01378	MRFSS	91	0.7000	-0.0293
8	0.01694	MRFSS	86	0.8000	0.0971
9	0.12985	MRFSS	90	0.9000	0.5617
10	0.56550	MRFSS	88	1.0000	2.3540

Weighting Given to Indices in Sum of Squares

84	85	86	87	88	89

MRFSS	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

90	91	92	93
1.000000	1.000000	1.000000	1.000000

Proportion of Sum of Squares from each Index Point

	84	85	86	87	88	89
MRFSS	0.001815	0.290035	0.000539	0.046460	0.600935	0.022738
Total	0.001815	0.290035	0.000539	0.046460	0.600935	0.022738

	90	91	92	93	Total
MRFSS	0.031683	0.000357	0.003940	0.001499	1.000000
Total	0.031683	0.000357	0.003940	0.001499	1.000000

Residual Sum of Squares = .5321589
Number of Parameters = 2
Number of Data Points = 10
Mean Squared Error = 6.651986E-02

Parameter Estimates

	Estimate	Std Error	Coeff of Var
1. N Age 3	28976.09	11123.19	0.38387

Correlation Matrix of Parameters

	N Age 3
N Age 3	1.000000