

Calculated discards of king mackerel from commercial fishing vessels in the Gulf of Mexico, South Atlantic, and the Mixing Zone

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Introduction

In August 2001, the Southeast Fisheries Science Center (SEFSC) initiated a program to collect commercial fishing vessel discard data from Gulf of Mexico and South Atlantic fisheries. A reporting form was developed that supplements the existing vessel coastal logbook forms that are currently mandatory for those fisheries (Poffenberger and McCarthy, 2004). As part of the data provided for the Southeast Data Assessment and Review (SEDAR) Data Workshop for Gulf of Mexico and south Atlantic king mackerel, discard data from the SEFSC coastal fisheries logbook program were used to calculate the number of king mackerel that were discarded during the period January 1, 2002 through December 31, 2006.

Data collection for the discard logbook program involves, each year, a 20% random sample of the vessels with South Atlantic snapper-grouper, Gulf of Mexico reef-fish, king mackerel, Spanish mackerel or shark permits selected to report the number of animals discarded by species. To assure that the sample was representative of vessels with these Federal permits, the universe of permitted vessels was stratified by region and gear fished. A random sample was selected, without replacement, from each stratum. Region was defined as the Gulf of Mexico (Gulf-side of the Florida Keys-Dry Tortugas to the Texas-Mexican border) and the South Atlantic (which extends from the North Carolina - Virginia border to the ocean-side of the Florida Keys- Dry Tortugas). Fishing gear strata included handline, electric reel (bandit rig), trolling, longline, trap, gillnet, and diving. The selected fishers were instructed to complete a supplemental discard form for every fishing trip that they made. Trips with no discards were reported as such.

Reported data included the numbers of discards by species, estimated condition of the fish when released, reason for release (due to regulations or unmarketable/unwanted), and the fishing area where the animal was discarded. There are six options for the condition of released fish: all animals are dead, majority of the animals are dead, all animals are alive when released, majority of animals are alive, the fish are kept but not sold, and the condition of the animals is unknown. To calculate species specific discard rates, discard data were matched to the landings and effort data reported (for the appropriate trip) to the coastal logbook program.

Methods

The data set for this analysis included all trips from vessels that reported discards between January 1, 2002 and December 31, 2006 in the US south Atlantic, Gulf of Mexico, and king mackerel mixing zone. The Gulf of Mexico included all areas from southwest Florida to Mexico other than areas 1 and 2 (Figure 1). The south Atlantic was defined as the area north of 30° N to 37° N. The "Mixing Zone" was defined as the area south of 30° N to 24° N in the south Atlantic and including Gulf of Mexico fishing areas 1 and 2.

During this period, discard forms were submitted for 7,786 Gulf of Mexico trips, 11,189 mixing zone trips, and 3,733 south Atlantic trips. Of those trips, discards were reported on 81.5% of Gulf of Mexico trips, 37% of mixing zone trips, and 58% of south Atlantic trips. Discards of king mackerel were reported on 66 Gulf of Mexico trips (0.8% of trips), 665 mixing zone trips (5.9%), and 62 south Atlantic trips (1.7%). By way of comparison, there were 66,652 Gulf of Mexico, 118,048 mixing zone, and 32,941 south Atlantic

trips reported to the coastal logbook program during 2002-2006. King mackerel landings were reported for 7,534 Gulf of Mexico (11.3%), 53,751 mixing zone (45.5%), and 12,722 south Atlantic (38.6%) of all trips.

The objective of this analysis was to calculate the numbers of king mackerel discarded by commercial vessels that fished for species other than shrimp or other shellfish. Fishing activity for these analyses included only hook and line gear (handlines, electric reels, and trolling). Other than hook and line gear, reports of king mackerel discards were made for vessels fishing longlines in the Gulf of Mexico (two trips), gillnets in the mixing zone (15 trips) and gillnets in the south Atlantic (8 trips). The available data for those gears were too few for discards to be calculated.

Eight factors were considered as possible influences on the king mackerel discard rate. In order to develop a well balanced sample design, the eight factors were defined as:

Gulf of Mexico

Factor	Levels	Value
Year	5	2002-2006
Area	2	Gulf of Mexico shrimp grids 3-12, 13-21; see Figure 1.
Days at sea	2	1- 2, 3+
Season	2	1=November-March, 2=April-October
Crew	4	1, 2, 3, or 4+ crew members
Vessel length	3	35 feet or less, >35, unknown
Number of lines fished	3	1-2, 3, 4+
Number of hooks/line	2	1, 2+
Gear*	2	Handline (includes electric reels), trolling

*Electric reel (bandit rig) was reported as handline until 2002 and the proper reporting of those gears required several years of transition, therefore electric reel gear was classified as handline gear for these analyses.

Mixing Zone*

Factor	Levels	Value
Year	5	2002-2006
Area**	5	Areas 1-2 and 2480-2482; 2575-2580; 2674-2680; 2777-2781; 2842-2981 see Figure 1.
Season	2	1=November-March, 2=April-October
Crew	2	1, 2+ crew members
Vessel length	4	25 feet or less, >25-30, >30, unknown
Number of lines fished	3	1,-2, 3, 4+
Number of hooks/line	2	1, 2+
Gear	2	Handline (includes electric reels), trolling

*Days at sea was not included as a factor in the mixing zone analysis because >97.5% of all hook and line trips from that region were single day trips.

**All areas south of 25°N (1, 2, and 2479-2482) were combined.

South Atlantic

Factor	Levels	Value
Year	5	2002-2006
Area	4	Areas 3075-3081; 3179-3279; 3377-3378; 3476-3675 see Figure 1.
Days at sea	2	1, 2+
Season	2	1=November-March, 2=April-October
Crew	3	1, 2, 3-4 crew members
Vessel length	3	30 feet or less, >30, unknown
Number of lines fished	2	1-3, 4+
Number of hooks/line	2	1, 2+
Gear	2	Handline (includes electric reels), trolling

Generalized linear model (GLM) analyses were used to identify any significant effects the above factors may have had on the king mackerel discard rate of hook and line gear commercial fishing trips. Only trips reporting king mackerel discards were included in the analyses. Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc., Cary, NC, USA). A type3 model assuming lognormal error distribution was employed. The linking function selected was “normal”, and the response variable was log(CPUE) calculated as $\log(\text{CPUE}) = \log(\text{number of king mackerel/hook hour})$. Only main effects were examined. No analysis of the effect these factors may have had on the proportion of trips reporting discards was attempted because the proportion of trips with king mackerel discards in the Gulf of Mexico and south Atlantic were so low that assumptions of the binomial model were violated.

A forward stepwise regression procedure was used to determine the set of main effects that explained a significant portion of the observed variability. Each potential factor was added to the null model sequentially and the resulting reduction in deviance per degree of freedom was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test ($p < 0.05$), and the reduction in deviance per degree of freedom was $\geq 1\%$. This model then became the base model, and the process was repeated, adding factors individually until no factor met the criteria for incorporation into the final model.

Once the significant main effects were identified the data were stratified by those factors and a mean discard rate was calculated for each stratum. Those mean rate calculations included all hook and line discard trips within each stratum, i.e. trips with no king mackerel discards were included in the discard rate calculations to produce a mean nominal discard rate. Total hook and line gear effort (hook hours) was calculated from the coastal logbook data set for each region specific stratum. Total discards for each stratum were then calculated as: stratum mean discard rate*stratum total effort.

Results and Discussion

The final models for the lognormal on CPUE of trips reporting discards were:

Gulf of Mexico:

$$\text{LOG(CPUE)} = \text{LINES FISHED} + \text{GEAR} + \text{YEAR} + \text{DAYS at SEA} + \text{HOOKS/LINE} \\ + \text{VESSEL LENGTH} + \text{AREA}$$

Mixing Zone:

$$\text{LOG(CPUE)} = \text{LINES FISHED} + \text{HOOKS/LINE} + \text{AREA} + \text{YEAR}$$

South Atlantic:

$$\text{LOG(CPUE)} = \text{VESSEL LENGTH} + \text{HOOKS/LINE} + \text{SEASON} + \text{YEAR}$$

When the discard logbook data set was stratified by all significant factors, many of the strata were unpopulated due to the small size of the data set. Factors were then eliminated from the matrix, beginning with those that had explained the least amount of the observed variability in the data, until all strata were populated. This resulted in the data being stratified by:

Gulf of Mexico:

$$\text{LOG(CPUE)} = \text{LINES FISHED} + \text{GEAR}$$

Mixing Zone:

$$\text{LOG(CPUE)} = \text{LINES FISHED} + \text{HOOKS/LINE}$$

South Atlantic:

$$\text{LOG(CPUE)} = \text{VESSEL LENGTH} + \text{HOOKS/LINE}$$

Calculated total discards for each region specific stratum by year are provided in Tables 1-3 for commercial fishing trips deploying hook and line gear. Yearly discard totals for each region are included in Table 4. Prior to 1998, reports of king mackerel fishing effort and landings reported to the coastal logbook program are incomplete because no reporting requirement was in place. Given the high proportion of king mackerel trips in each region (11.3% Gulf of Mexico, 45.5% mixing zone, and 38.6% south Atlantic), total king mackerel discards cannot be reliably calculated for the years prior to 1998.

The release condition of discarded king mackerel is reported in Table 5. In most cases less than 20% of king mackerel were reported as dead or “majority dead” when released. The category “kept” also accounted for a low percentage of king mackerel in the discard reports. The number of king mackerel reported in the “all alive” or “majority alive” are generally higher than the number reported in either of the “dead” categories or as “kept”.

The mixing zone had the highest number of reported king mackerel discards and, therefore, provides the best measure of discard mortality available from these data. Over all years in that region approximately 13% of reported king mackerel discards were classified as “all dead”, “majority dead”, or “kept”. Almost 75% of king mackerel discards from the mixing zone were reported as “all alive” or “majority alive”.

The reason “due to regulatory restrictions” accounted for more than 82% of reported king mackerel discards over all regions. Market conditions were reported as the reason for discarding king mackerel in 6.1% of cases and an additional 11.8% of cases were either unknown or unreported.

The number of trips reporting king mackerel discards in the US south Atlantic and Gulf of Mexico was very low. Only one year had more than 20 trips with king mackerel discards in the south Atlantic while only two years had more than 20 king mackerel discard trips reported in the Gulf of Mexico. More trips reported king mackerel discards in the mixing zone including 100 or more trips during three of the five reporting years, but king mackerel discards were uncommon even in that region. Methods used in prosecuting the king mackerel fishery may limit the number of discards from the fishery. In addition, king mackerel appear to have been an uncommon bycatch in other fisheries.

Literature Cited

Poffenberger, J. and K. McCarthy. 2004. Estimates of red snapper discards by vessels with Federal permits in the Gulf of Mexico. SEDAR 7-DW-22.

Table 1. Calculated yearly total discards of king mackerel from hook and line gear vessels for each Gulf of Mexico stratum. Discards are reported as number of fish.

Year	Hooks per Line	Gear	Mean Discards per Hook Hour	Discard CV	Total Effort (Hook Hours)	Calculated Discards
1998	1	H	0.0004	1675.4305	190,148	74
1999	1	H	0.0004	1675.4305	195,389	76
2000	1	H	0.0004	1675.4305	186,237	73
2001	1	H	0.0004	1675.4305	231,930	90
2002	1	H	0.0004	1675.4305	220,860	86
2003	1	H	0.0004	1675.4305	217,095	85
2004	1	H	0.0004	1675.4305	210,982	82
2005	1	H	0.0004	1675.4305	187,089	73
2006	1	H	0.0004	1675.4305	171,785	67
1998	1	TR	0.1326	121.2243	23,823	3,159
1999	1	TR	0.1326	121.2243	32,221	4,272
2000	1	TR	0.1326	121.2243	33,099	4,389
2001	1	TR	0.1326	121.2243	33,115	4,391
2002	1	TR	0.1326	121.2243	33,527	4,445
2003	1	TR	0.1326	121.2243	31,301	4,150
2004	1	TR	0.1326	121.2243	27,515	3,648
2005	1	TR	0.1326	121.2243	21,183	2,809
2006	1	TR	0.1326	121.2243	25,644	3,400
1998	2+	H	5.73944E-07	3210.9833	3,567,532	2
1999	2+	H	5.73944E-07	3210.9833	4,670,177	3
2000	2+	H	5.73944E-07	3210.9833	3,923,955	2
2001	2+	H	5.73944E-07	3210.9833	3,735,097	2
2002	2+	H	5.73944E-07	3210.9833	3,591,604	2
2003	2+	H	5.73944E-07	3210.9833	3,697,514	2
2004	2+	H	5.73944E-07	3210.9833	3,354,833	2
2005	2+	H	5.73944E-07	3210.9833	3,128,248	2
2006	2+	H	5.73944E-07	3210.9833	3,478,736	2
1998	2+	TR	0.0232	113.6476	94,204	2,189
1999	2+	TR	0.0232	113.6476	89,440	2,078
2000	2+	TR	0.0232	113.6476	34,683	806
2001	2+	TR	0.0232	113.6476	30,569	710
2002	2+	TR	0.0232	113.6476	31,256	726
2003	2+	TR	0.0232	113.6476	41,473	964
2004	2+	TR	0.0232	113.6476	24,447	568
2005	2+	TR	0.0232	113.6476	12,022	279
2006	2+	TR	0.0232	113.6476	34,221	795

Table 2. Calculated yearly total discards of king mackerel from hook and line vessels for each Mixing Zone stratum. Discards are reported as number of fish.

Year	Lines Fished	Hooks per Line	Mean Discards per Hook Hour	Discard CV	Total Effort (Hook Hours)	Calculated Discards
1998	3	1	0.0621	251.5297	103,482	6,422
1999	3	1	0.0621	251.5297	89,798	5,573
2000	3	1	0.0621	251.5297	87,919	5,456
2001	3	1	0.0621	251.5297	97,140	6,029
2002	3	1	0.0621	251.5297	93,975	5,832
2003	3	1	0.0621	251.5297	105,353	6,538
2004	3	1	0.0621	251.5297	71,304	4,425
2005	3	1	0.0621	251.5297	71,001	4,406
2006	3	1	0.0621	251.5297	80,415	4,991
1998	3	2+	0.0408	103.1166	210,315	8,587
1999	3	2+	0.0408	103.1166	229,797	9,382
2000	3	2+	0.0408	103.1166	229,942	9,388
2001	3	2+	0.0408	103.1166	200,460	8,184
2002	3	2+	0.0408	103.1166	159,120	6,496
2003	3	2+	0.0408	103.1166	110,746	4,521
2004	3	2+	0.0408	103.1166	103,293	4,217
2005	3	2+	0.0408	103.1166	85,625	3,496
2006	3	2+	0.0408	103.1166	89,223	3,643
1998	1-2	1	0.0562	397.8579	127,861	7,190
1999	1-2	1	0.0562	397.8579	126,491	7,113
2000	1-2	1	0.0562	397.8579	116,104	6,529
2001	1-2	1	0.0562	397.8579	132,375	7,444
2002	1-2	1	0.0562	397.8579	127,952	7,195
2003	1-2	1	0.0562	397.8579	144,456	8,123
2004	1-2	1	0.0562	397.8579	133,884	7,529
2005	1-2	1	0.0562	397.8579	120,218	6,760
2006	1-2	1	0.0562	397.8579	127,395	7,164
1998	1-2	2+	0.1162	715.1825	203,027	23,591
1999	1-2	2+	0.1162	715.1825	220,913	25,669
2000	1-2	2+	0.1162	715.1825	224,904	26,133
2001	1-2	2+	0.1162	715.1825	178,792	20,775
2002	1-2	2+	0.1162	715.1825	164,156	19,074
2003	1-2	2+	0.1162	715.1825	144,521	16,793
2004	1-2	2+	0.1162	715.1825	111,310	12,934
2005	1-2	2+	0.1162	715.1825	92,196	10,713
2006	1-2	2+	0.1162	715.1825	89,682	10,421
1998	4+	1	0.0232	255.3848	71,470	1,661
1999	4+	1	0.0232	255.3848	61,145	1,421
2000	4+	1	0.0232	255.3848	58,016	1,348
2001	4+	1	0.0232	255.3848	59,576	1,385
2002	4+	1	0.0232	255.3848	48,664	1,131
2003	4+	1	0.0232	255.3848	61,006	1,418
2004	4+	1	0.0232	255.3848	49,572	1,152
2005	4+	1	0.0232	255.3848	47,597	1,106
2006	4+	1	0.0232	255.3848	44,126	1,025
1998	4+	2+	0.0092	406.4508	150,596	1,380
1999	4+	2+	0.0092	406.4508	139,689	1,280
2000	4+	2+	0.0092	406.4508	148,503	1,361
2001	4+	2+	0.0092	406.4508	87,272	800
2002	4+	2+	0.0092	406.4508	100,594	922
2003	4+	2+	0.0092	406.4508	44,265	406
2004	4+	2+	0.0092	406.4508	47,707	437
2005	4+	2+	0.0092	406.4508	25,146	231
2006	4+	2+	0.0092	406.4508	39,668	364

Table 3. Calculated yearly total discards of king mackerel from hook and line vessels for each south Atlantic stratum. Discards are reported as number of fish.

Year	Vessel Length	Hooks per Line	Mean Discards per Hook Hour	Discard CV	Total Effort (Hook Hours)	Calculated Discards
1998	<30	1	0.0053	827.4223	6,744	36
1999	<30	1	0.0053	827.4223	5,373	28
2000	<30	1	0.0053	827.4223	4,450	23
2001	<30	1	0.0053	827.4223	4,412	23
2002	<30	1	0.0053	827.4223	5,320	28
2003	<30	1	0.0053	827.4223	6,545	34
2004	<30	1	0.0053	827.4223	5,809	31
2005	<30	1	0.0053	827.4223	7,628	40
2006	<30	1	0.0053	827.4223	11,808	62
1998	<30	2+	0.0059	341.1567	91,115	535
1999	<30	2+	0.0059	341.1567	86,477	508
2000	<30	2+	0.0059	341.1567	76,360	448
2001	<30	2+	0.0059	341.1567	84,940	499
2002	<30	2+	0.0059	341.1567	89,538	526
2003	<30	2+	0.0059	341.1567	75,805	445
2004	<30	2+	0.0059	341.1567	64,382	378
2005	<30	2+	0.0059	341.1567	72,191	424
2006	<30	2+	0.0059	341.1567	83,334	489
1998	30-<35	1	0.1197	265.8151	10,899	1,305
1999	30-<35	1	0.1197	265.8151	11,517	1,379
2000	30-<35	1	0.1197	265.8151	11,351	1,359
2001	30-<35	1	0.1197	265.8151	10,495	1,256
2002	30-<35	1	0.1197	265.8151	8,326	997
2003	30-<35	1	0.1197	265.8151	11,004	1,317
2004	30-<35	1	0.1197	265.8151	11,210	1,342
2005	30-<35	1	0.1197	265.8151	12,884	1,542
2006	30-<35	1	0.1197	265.8151	14,429	1,727
1998	30-<35	2+	0.0033	1148.2605	165,184	552
1999	30-<35	2+	0.0033	1148.2605	136,682	457
2000	30-<35	2+	0.0033	1148.2605	231,830	775
2001	30-<35	2+	0.0033	1148.2605	237,009	793
2002	30-<35	2+	0.0033	1148.2605	170,407	570
2003	30-<35	2+	0.0033	1148.2605	137,634	460
2004	30-<35	2+	0.0033	1148.2605	114,802	384
2005	30-<35	2+	0.0033	1148.2605	100,131	335
2006	30-<35	2+	0.0033	1148.2605	107,432	359
1998	ge35	1	0.1372	87.5294	21,274	2,919
1999	ge35	1	0.1372	87.5294	16,986	2,331
2000	ge35	1	0.1372	87.5294	15,798	2,168
2001	ge35	1	0.1372	87.5294	18,658	2,560
2002	ge35	1	0.1372	87.5294	16,091	2,208
2003	ge35	1	0.1372	87.5294	12,703	1,743
2004	ge35	1	0.1372	87.5294	13,744	1,886
2005	ge35	1	0.1372	87.5294	15,948	2,189
2006	ge35	1	0.1372	87.5294	16,516	2,267
1998	ge35	2+	9.83865E-05	1905.2559	413,915	41
1999	ge35	2+	9.83865E-05	1905.2559	427,268	42
2000	ge35	2+	9.83865E-05	1905.2559	400,747	39
2001	ge35	2+	9.83865E-05	1905.2559	444,377	44
2002	ge35	2+	9.83865E-05	1905.2559	353,519	35
2003	ge35	2+	9.83865E-05	1905.2559	296,990	29
2004	ge35	2+	9.83865E-05	1905.2559	300,409	30
2005	ge35	2+	9.83865E-05	1905.2559	328,772	32
2006	ge35	2+	9.83865E-05	1905.2559	401,753	40

Table 3 (continued). Calculated yearly total discards of king mackerel from hook and line vessels for each south Atlantic stratum. Discards are reported as number of fish.

Year	Vessel Length	Hooks per Line	Mean Discards per Hook Hour	Discard CV	Total Effort (Hook Hours)	Calculated Discards
1998	unk	1	0.0047	666.2664	15,111	71
1999	unk	1	0.0047	666.2664	6,775	32
2000	unk	1	0.0047	666.2664	2,594	12
2001	unk	1	0.0047	666.2664	3,305	16
2002	unk	1	0.0047	666.2664	4,726	22
2003	unk	1	0.0047	666.2664	2,986	14
2004	unk	1	0.0047	666.2664	2,057	10
2005	unk	1	0.0047	666.2664	1,751	8
2006	unk	1	0.0047	666.2664	508	2
1998	unk	2+	0.0043	467.0148	144,976	621
1999	unk	2+	0.0043	467.0148	96,224	412
2000	unk	2+	0.0043	467.0148	94,834	406
2001	unk	2+	0.0043	467.0148	94,840	406
2002	unk	2+	0.0043	467.0148	77,536	332
2003	unk	2+	0.0043	467.0148	46,619	200
2004	unk	2+	0.0043	467.0148	28,442	122
2005	unk	2+	0.0043	467.0148	9,824	42
2006	unk	2+	0.0043	467.0148	706	3

Table 4. Calculated yearly commercial hook and line vessel king mackerel discards by region. Discards are reported in number of fish.

Year	Mixing Zone Discards	Gulf of Mexico Discards	South Atlantic Discards	Yearly Total
1998	48,831	5,423	6,080	60,335
1999	50,438	6,429	5,189	62,056
2000	50,216	5,269	5,232	60,716
2001	44,616	5,193	5,597	55,406
2002	40,651	5,260	4,718	50,628
2003	37,799	5,200	4,243	47,243
2004	30,694	4,300	4,181	39,176
2005	26,712	3,163	4,612	34,487
2006	27,607	4,264	4,949	36,820

Table 5. Percent of king mackerel discards by estimated condition at release from commercial hook and line vessels reported by region.

Region	Year	All Dead	Majority Dead	All Alive	Majority Alive	Kept	Unknown	Unreported	N Fish
Gulf of Mexico	2002	2.6	2.6	42.7	52.2				232
	2003	1.6		50.0	48.4				62
	2004		7.9	92.1					38
	2005	58.7	4.8	3.2	22.2	1.6	9.5		63
	2006	73.1		4.5	20.9	1.5			67
	Total	20.1	2.6	36.8	38.7	0.4	1.3		462
Mixing Zone	2002	3.6	2.9	68.3	19.6	5.7			419
	2003	4.3	5.1	65.1	19.8	5.4	0.3		739
	2004	25.5	15.3	40.8	15.6	2.8			353
	2005	0.3	1.5	28.3	19.2	0.8		49.9	661
	2006	1.1	3.2	43.8	47.2	0.2		4.5	625
	Total	5.2	4.8	49.1	25.2	2.9	0.1	12.8	2,797
South Atlantic	2002	7.0	32.2	22.7	37.4	0.7			286
	2003	12.5		87.5					16
	2004					100.0			12
	2005	5.3		87.1	6.1	1.5			132
	2006	12.1		75.8		12.1			33
	Total	6.9	19.2	45.7	24.0	4.2			479

Figure 1. Coastal Logbook defined fishing areas with king mackerel regions indicated.

