Descriptions of the U.S. Gulf of Mexico Reef Fish Bottom Longline and Vertical Line Fisheries Based on Observer Data

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Introduction

Amendment 22 to the Gulf of Mexico Fishery Management Council's (GMFMC) Reef Fish Fishery Management Plan (GMFMC[1]) dictates mandatory observer coverage. In July 2006, in collaboration with the commercial fishing industry and the GMFMC, the National Marine Fisheries Service's (NMFS) Southeast Fisheries Science Center (SEFSC) implemented a mandatory observer program to characterize the commercial reef fishery operating in the U.S. Gulf of Mexico (Gulf).

This fishery consists of approximately 890 Federally permitted vessels (SERO[2]). Primary gears used include bottom longline, vertical line (bandit or handline), and more recently, modified buoy gear. Although many reef fish species are retained, the predominant target species are groupers, *Epinephelus* spp., and snappers, *Lutjanus* spp.

Longliners off the coast of Florida generally target red grouper, *Epinephelus morio,* in shallow waters, and in deeper waters yellowedge grouper, *E. flavolimbatus*; tilefish (Malacanthidae), and sharks (Carcharhinidae). Vertical line vessel operators target shallow-water grouper (e.g. red grouper), red snapper, *Lutjanus campechanus*, and may also seek yellowedge grouper and vermilion snapper, *Rhomboplites aurorubens*. From historical effort data, most commercial fishing effort for red snapper occurs in the western Gulf of Mexico (SEDAR[3]).

In November 1984, the Reef Fish Fishery Management Plan (GMFMC[4]) was implemented to rebuild declining reef fish stocks. Since that time, Federal regulations have restricted size and landings of several reef fish species. Weight quotas regulate commercial landings for grouper, with 7.57 million lbs for shallow-water grouper and 1.02 million lbs for deepwater grouper (SERO[2]). The current total allowable catch (TAC) for red snapper is 6.3 million lbs, divided between the commercial (51%) and recreational (49%) fishing sectors. An individual fishing quota (IFQ) program for the commercial red snapper fishery was implemented in 2007 and for the grouper and tilefish fisheries in 2010.

Certain areas for reef fish are closed or restricted based on gear type (GMFMC[5]). Federal waters are closed in the Tortugas North and Tortugas South Ecological Reserves in the Florida Keys National Marine Sanctuary and the Madison and Swanson and Steamboat Lumps Marine Reserves off the west central Florida coast. Longline and other buoy gear are prohibited inside

[1]GMFMC. 2005. Amendment 22 to the Reef Fish Management Plan. Gulf Mex. Fish. Manage. Counc., Tampa, Fla. (available at http://www.gulfcouncil.org).

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[2]SERO. 2010. Fishery permits and fishery quotas. Southeast Reg. Off., Natl. Mar. Fish. Serv., NOAA, St. Petersburg, Fla. (available at http://sero.nmfs.noaa.gov).

ABSTRACT—In July 2006, a mandatory observer program was implemented to characterize the commercial reef fish fishery operating in the U.S. Gulf of Mexico. The primary gear types assessed included bottom longline and vertical line (bandit and handline). A total of 73,205 fish (183 taxa) were observed in the longline fishery. Most (66%) were red grouper, Epinephelus morio*, and yellowedge grouper,* E. flavolimbatus*. In the vertical line fishery, 89,015 fish (178 taxa) were observed of which most (60%) were red snapper,* Lutjanus campechanus*, and vermilion snapper,* Rhomboplites aurorubens*. Based on surface observations of discarded under-sized target and unwanted species, the majority of fish were released alive; minimum assumed mortality was 23% for the vertical line and 24% for the bottom longline fishery. Of the individuals released alive in the longline fishery, 42% had visual signs of barotrauma stress (air bladder expansion/and or eyes protruding). In the vertical line fishery, 35% of the fish were released in a stressed state. Red grouper and red snapper size composition by depth and gear type were determined. Catch-per-unit-effort for dominant species in both fisheries, illustrated spatial differences in distribution between the eastern and western Gulf. Hot Spot Analyses for red grouper and red snapper identified areas with significant clustering of high or low CPUE values.*

[3]SEDAR. 2005. Stock assessment report of SEDAR 7 Gulf of Mexico red snapper. Southeast Data Assessment and Review, South Atl. Fish. Manage. Counc., Charleston, SC (available at www.sefsc.noaa.gov/sedar/).

[4]GMFMC. 1984. Reef Fish Management Plan. Gulf Mex. Fish. Manage. Counc., Tampa, Fla. (available at http://www.gulfcouncil.org).

[5]GMFMC. 2010. Commercial fishing regulations for Gulf of Mexico Federal waters. Gulf Mex. Fish. Manage. Counc., Tampa, Fla. (available at http://www.gulfcouncil.org).

the 50-fm contour west and the 20-fm contour east of Cape San Blas, Fla.

In May 2009, an emergency rule to protect sea turtles (Cheloniidae and Dermochelyidae) went into effect prohibiting the use of bottom longline gear east of Cape San Blas, Fla., shoreward of the 50-fm contour. Modification through subsequent regulations (GMFMC[5]) prohibited bottom longline gear east of Cape San Blas, Fla., shoreward of the 35-fm contour from June through August, restricted the number of hooks onboard to 1,000, of which only 750 could be rigged for fishing, and reduced the number of vessels through an endorsement system based on documentation of an average annual landing of at least 40,000 lbs during 1999 through 2007.

The effectiveness of quota systems, size limits, and area closures as management tools has been debated (Coleman et al., 2000; Nieland et al., 2007; Stephen and Harris, 2010). Once a vessel's red snapper quota is reached, for example, the vessel simply targets other reef fish, making red snapper a bycatch species. Currently, the minimum legal size for red snapper is 13 in total length (TL). The minimum size limit for red grouper was reduced from 20 in TL to 18 in TL, effective 18 May 2009 (GMFMC[5]).

The mortality rates of both undersized target species and nontargeted species caught on the various gear types remains a pressing concern. Findings from mark-release mortality studies (Gitschlag and Renaud, 1994; Schirripa and Legault[6]; Burns et al.[7]) indicate variable rates of mortality based on depth and method of capture.

In December 1993, SEFSC's Galveston Laboratory implemented a voluntary observer program to characterize the fish trap, bottom longline, and bandit reel fisheries in the U.S. Gulf of Mexico (Scott-Denton and Harper[8]; Scott-Denton[9]). Observer coverage of the commercial reef fish fishery operating primarily off the west coast of Florida and, to a lesser extent, off Louisiana, was conducted from 1993 through 1995. Data from 576 sets aboard fish trap vessels, 317 sets from bottom longline, and 580 sets from bandit reel vessels were analyzed. Findings from this study revealed a low proportion (<5% of total number caught) of fish discarded dead (immediate mortality) based on surface observations. However, due to the number of fish released in stressed state (air bladder expansion and/or eyes protruding), total predicted red snapper discards of 25% to 30% were used to estimate the number of discarded fish at age that died and thus contributed to fishing mortality (Goodyear[10]).

The continuing goal of the current observer program is to provide quantitative biological, vessel, and gear-selectivity information relative to the directed reef fish fishery. The specific objectives are to: 1) provide general fishery bycatch characterization for finfish species taken by this fishery, 2) estimate managed finfish discard and release mortality levels, and 3) estimate protected species bycatch levels. The specific objectives of this report are to: 1) summarize trip, vessel, environmental, and gear characteristics, 2) quantify fish and protected species composition and disposition based on surface observations, 3) examine size composition of target species, and 4) estimate catch-per-unit-effort (CPUE) trends and spatial distribution for dominant species.

Methods

Protocol sampling modification, randomized vessel selection, and observer deployment through mandatory efforts began in 2006 for the commercial reef fish fishery. NMFS observers were placed on reef fish vessels operating throughout the Gulf of Mexico based on randomized selection stratified by season, gear, and region. Proportional sampling effort, based on coastal logbook data, among seasons and gears in the eastern and western Gulf of Mexico was recommended by SEFSC stock assessment scientists in 2006 and used thereafter for vessel selection stratification purposes using annual updated effort data. Thus, proportional sampling was used to direct coverage levels (based on sea days, the National metric for percent observer coverage levels) toward region and gear strata with higher levels of fishing effort, while continuing to sample strata with lower fishing effort.

In 2008, for the longline fishery, seven trips were not selected through the mandatory process. Instead the trips were based on voluntary cooperation as part of a pilot project to assess the effectiveness of electronic monitoring equipment. Observers placed on these vessels were equipped with closed-circuit video cameras and associated electronics. Results of this study are reported by Pria et al. (2008).

In February 2009, increased coverage was directed toward the bottom longline fishery in the eastern Gulf to monitor for sea turtle interactions. In response to the bottom longline closure inside the 50-fm contour in the eastern Gulf in 2009, some traditional longline vessels used modified buoy gear. This gear type was deployed during three trips inside 50 fm in December 2009 with observers onboard.

Shrimp statistical zones (Patella, 1975) were used to delineate area designations (Fig. 1). Conventionally, statistical areas 1–9 represent areas off the west coast of Florida, 10–12 delineate Alabama/Mississippi, 13–17 depict

[6]Schirripa, M. J., and C. M. Legault. 1999. Status of red snapper in U.S. waters of the Gulf of Mexico: updated through 1998. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Panama City Lab. Sustainable Fish. Div. Contrib. SFD-99/00-75.

[7]Burns, K. M., N. F. Parnell, and R. R. Wilson, Jr. 2004. Partitioning release mortality in the undersized bycatch: Comparison of depth vs. hooking effects. MARFIN Grant No. NA97FF0349, 36 p., on file at Southeast Reg. Off., Natl. Mar. Fish. Serv., NOAA, St. Petersburg, Fla.

[8]Scott-Denton, E., and D. Harper. 1995. Characterization of the reef fish fishery of the eastern Gulf of Mexico. SEFSC Rep. to Gulf Fish. Manage. Counc. July 17, 1995, Key West, Fla., 45 p.

[9]Scott-Denton, E. 1996. Characterization of the reef fish fishery of the eastern U.S. Gulf of Mexico. MARFIN Grant No. 95MFIH07. Suppl. Rep. to MARFIN Grant No. 94MARFIN17, on file at Southeast Reg. Off., Natl. Mar. Fish. Serv., NOAA, St. Petersburg, Fla.

[10]Goodyear, C. P. 1995. Red snapper in U.S. waters of the Gulf of Mexico. U.S. Dep. Commer., NOAA. Natl. Mar. Fish. Serv., Southeast Fish. Sci. Cent., Miami Lab. Rep. Contrib. MIA 95/96-05, 171 p.

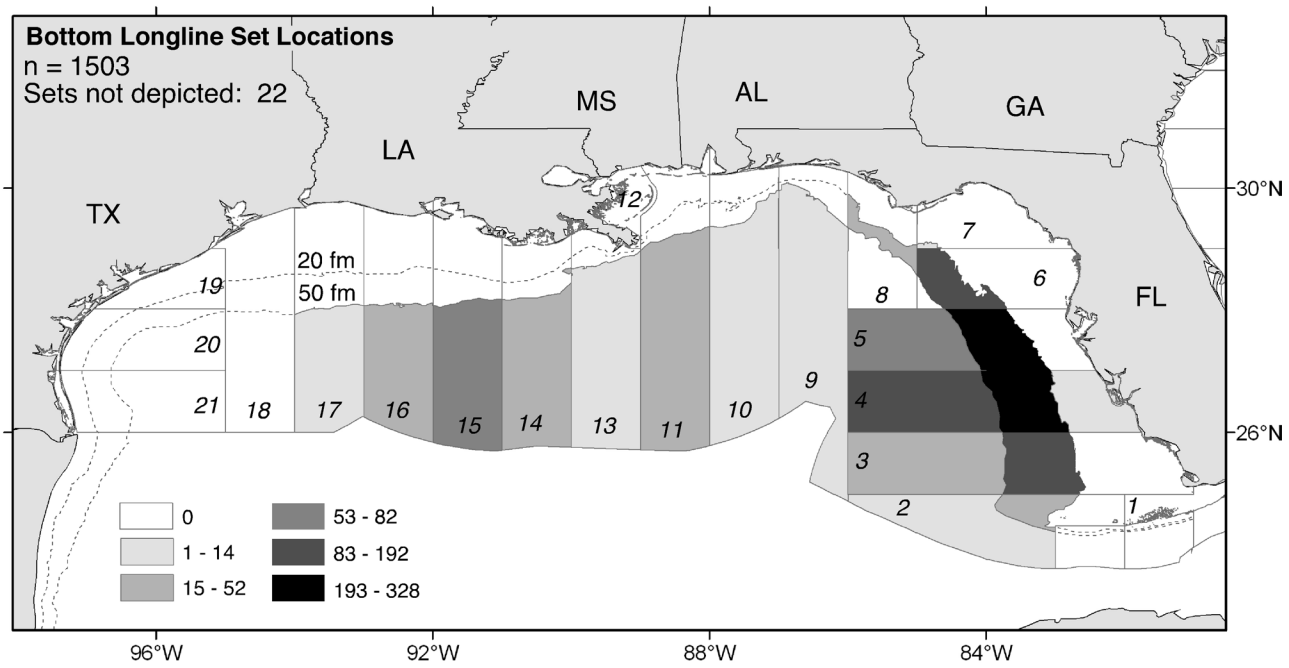

Figure 1.—Distribution of sampling effort (sets) based on observer coverage of the U.S. Gulf of Mexico bottom longline reef fish fishery from August 2006 through November 2009.

Louisiana, and 18–21 denote Texas. For the reef fish fishery, statistical areas 1–8 represent the eastern Gulf and areas 9–21 the western Gulf. Seasonal categories were: January through March, April through June, July through September, and October through December. The three primary gear types assessed included bottom longline, bandit reel, and handline. The latter two were combined to represent the vertical line fishery.

Among the several provisions promulgated under Magnuson-Stevens Conservation and Management Act (MSFCMA) § 303(b)(8) is the mandate for Federal permit holders to have a current Commercial Fishing Vessel Safety Examination decal prior to the selection period for mandatory observer coverage. The safety decal requirement, in combination with other factors, led to low vessel compliance, especially in the first 2 years of the study. A dedicated effort by NOAA Office of Law Enforcement (OLE) has substantially increased compliance (>95%). Additionally, a minimum sea day requirement by gear type was established to prevent early trip termination due to observer effect. Reef fish permit holders are required to carry an observer for a minimum of 7 days during a selection period when using longline gear, 3 days for bandit gear, and 2 days for handline.

Once deployed, vessel length, hull construction material, gross tonnage, engine horsepower, and crew size were obtained for each vessel. For each set (the location of gear placement at a defined time), the type, number, and construction material of the fishing gear were recorded. Latitude, longitude, depth, and environmental parameters including sea state and bottom type were recorded at the start of each set. The total time the gear remained in the water (soak or fishing time) was calculated.

Fishery data were obtained from each set. If a set could not be sampled due to time constraints or weather conditions, a minimum of location, depth, and fishing time were recorded. The condition of fish when brought onboard was categorized into one of the following: 1) live—normal appearance, 2) live—stomach/air bladder protruding, 3) live—eyes protruding, 4) live—combination of 2 and 3, 5) dead on arrival, or 9) not determined.[11] Categories 2 through 4 were combined to represent a stressed condition.

Fate of fish after release was recorded as alive if it swam down or as discarded dead if it swam erratically, floated, or sank, or if undetermined. Nontarget and undersized target species were processed first by recording length, weight, condition when brought onboard, and fate after release to provide an estimate of immediate mortality (number discarded dead divided by the number of total discards).

If venting occurred, air bladders of live discarded fish were punctured in the same manner as demonstrated by the captain and crew if requested. Retained species were processed by recording length, weight, condition when brought onboard, and if kept or retained for bait. Sightings or captures of sea turtles were recorded in accordance with SEFSC protocol (NMFS, 2008). Data pertaining to sea turtle interactions were reported

[11]Category 9 is the default for a condition that is unknown or not recorded.

to SEFSC for annual sea turtle mortality estimates.

On some (19%) vertical line sets, due primarily to time constraints and the magnitude of the catch, not all reels were sampled for the set. The species total number was extrapolated proportionally based on subsampled reels for that set. Negative sets, or sets where no fish were caught, were included in CPUE calculations. No extrapolation procedures were required for longline and modified buoy sets (i.e. all hooks sampled).

Overall catch rates are presented collectively for all years, areas, seasons, and depths. Due to data confidentiality rules, a minimum of three vessels were required for spatial and temporal stratification purposes, and analysis of modified buoy gear data was restricted.

Effort was calculated using methods described by McCarthy and Cass-Calay.[12] The number of hooks set at each location was multiplied by soak time to derive hook-hours. Catch rates were calculated in number of fish per hook-hour. For the vertical line fishery, total soak time was used for one set location using the sum of all hooks per reel. Therefore, effort may be overestimated due to the repeated deployment (e.g. drops) of multiple gear configurations (e.g. hooks) on the same reel at one set location. Moreover, average haul in time was not documented for all sets, therefore not used in the effort calculation. For sets when the average haul in time was recorded, the average value was less than one minute.

Ratio estimation was used for analyses of species-specific catch rates. As described by Snedecor and Cochran (1967) and Watson et al. (1999), the ratio estimation (1) below was used as the sample estimate of the mean.

$$R = \frac{\sum Y}{\sum X} \qquad (1)$$

where: R = ratio estimate,
Y = extrapolated number for species of a particular disposition code for selected strata, and
X = hook-hours for selected strata.

The estimated standard error of the estimate is given in equation 2:

$$s(R) = \frac{1}{\bar{x}}\sqrt{\frac{\sum (Y - RX)^2}{n(n-1)}} \qquad (2)$$

where: $\bar{x}$ = mean of hook-hours for selected strata, and
n = number of sets occurring in selected strata.

A density surface of CPUE, based on number of fish kept per 1,000 hook-hours for dominant species by fishery, was created using Fishery Analyst.[13,14] This is an ArcGIS extension developed to graphically present temporal and spatial trends in fishery statistics (Riolo, 2006). A search radius of 25 km was used to ensure the search parameter encompassed the maximum length of a fishing set. A cell size of 5 km produced the desired resolution.

Density of catch and effort values for each 5 km cell were calculated by summing those values contained within the 25 km search radius and dividing the value by the area of the circle as defined by the search radius. A summary CPUE value for all years combined was calculated for each cell by calculating CPUE values for individual years and dividing by the number of years for which fishing activity occurred in that cell.

To identify patterns in CPUE for the most frequently captured species in each fishery, a local spatial statistic, the Getis-Ord Gi* (Gi*), was calculated using the Hot Spot Analysis tool in ArcGIS[15], to locate clusters of features with similarly high or low values. The Gi* statistic was also calculated for all discarded and kept species in order to assess if geographical areas of particularly high levels of bycatch occurred.

The Hot Spot Analysis tool evaluates each feature within the context of neighboring features. If the value of the feature is high, and the values for all of its neighboring features are also high, it is a part of a hot spot. Conversely, if a feature is surrounded by similarly low values, it is identified as a cold spot. The Gi* statistic is a Z-score test statistic. For statistically significant positive Z-scores, the larger the Z-score is, the more intense the clustering of high values. The Z-score can produce misleading results when used with local statistics because the test assumes independence between features. Since the GIS runs the test to calculate a Z-score for each feature, the test will end up using many of the same neighbors for adjacent features (Mitchell, 2005). For this reason, the statistical tests associated with local measures of spatial autocorrelation for data exploration were used, rather than as confirmatory statistical testing (Nelson and Boots, 2008).

To standardize bycatch (discard) estimates as prescribed in "Evaluating Bycatch" (NMFS, 2004), the coefficient of variation (CV) was used as a measure of precision for bycatch estimates. CV estimates were calculated by dividing the estimated standard error by the estimate of the mean CPUE (number per hook-hour) for Federally managed discarded species. Less than 0.3% of the total fish processed had an undetermined fate code and were assumed to be discarded in an unknown condition.

Length data are given for the dominant target species. Fish measurements were recorded in metric units for age and growth assessment. To be consistent with the current regulatory mandates relative to size limits, metric measurements were converted to U.S. system equivalents. Fork to total length conversions for red grouper were based on metric regression (Lombardi-Carlson

[12]McCarthy, K. J., and S. Cass-Calay. 2006. Standardized catch rates for red grouper from the United States Gulf of Mexico handline, longline, and trap fisheries, 1990–2005. SEDAR 12-DW-16. Southeast Data Assessment and Review, South Atl. Fish. Manage. Counc., Charleston, SC (available at www.sefsc.noaa.gov/sedar/).

[13]Fishery Analyst, Mappamondo GIS, Via Rubens 3, 43100 Parma(PR)–Italy.

[14]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

[15]ArcGIS 9.3 Computer Software. 380 New York Street, Redlands, Calif. 92373.

et al.[16]). Red snapper total lengths were derived from fork length measurements using equation 3 (SEDAR, 2005):

$$TL \text{ (in)} = 0.1729 + FL \text{ (in)} * 1.059. \quad (3)$$

After converting, length values were placed into 1 in intervals. Any lengths ranging from 19.000 to 19.999, for example, were categorized as 19 in. Hence, some degree of error is assumed. Only length measurements were considered. Weight data were not recorded for all specimens, therefore were not included in the analysis.

Results

Fishing Characteristics

From July 2006 through December 2009, data from 9,468 sets collected during 308 trips (1,919 sea days) aboard 205 reef fish vessels were analyzed. Number of trips, sets, sea days, and percent coverage levels are given by year and project (Table 1).

Trip, vessel, set, and gear characteristics varied by gear type (Tables 2, 3). Trip length averaged 11.7 days for longline and 4.8 days for vertical line. Vessel length ranged from 23 to 70 ft, with longline vessels typically at the larger end of the range. The majority (≥85%) of vessels were fiberglass construction.

For longline, the distance of mainline set at a location averaged 5.6 nmi. Mean gangion length was 5.8 ft. On average, 991 circle hooks were set at a location. Most hooks (43%) were 13 aught in size and ranged from 12 to 15 aught. In the vertical line sector, the number of reels used at a set averaged 3.3. The majority (51%) of reels were electric. The number of hooks deployed during a set averaged 26 hooks, with circle hooks deployed most often. The majority (43%) of hooks were smaller hooks (8 aught) as compared to longline.

[16]Lombardi-Carlson, L. A., G. R. Fitzhugh, and J. J. Mikulas. 2002. Red grouper (*Epinephelus morio*) age-length structure and description of growth from the eastern Gulf of Mexico: 1992–2001. U.S. Dep. Commer., NOAA. Natl. Mar. Fish. Serv., Southeast Fish. Sci. Cent., Contrib. Ser. 2002-06, 42 p.

Table 1.—Reef fish trips, sets, and sea days by year and project from July 2006 to December 2009.

Trips by Year and Project

Year	Bandit	Handline	Longline	Electronic Monitoring	Buoy Gear	Total
2006	30	8	12			50
2007	72	25	11			108
2008	34	19	5	7		65
2009	28	21	33		3	85
Total	164	73	61	7	3	308

Sets by Year and Project

Year	Bandit	Handline	Longline	Electronic Monitoring	Buoy Gear	Total
2006	1,078	62	201			1,341
2007	2,424	505	194			3,123
2008	1,353	298	110	245		2,006
2009	1,361	310	753		574	2,998
Total	6,216	1,175	1,258	245	574	9,468

Sea Days by Year and Project

Year	Bandit	Handline	Longline	Electronic Monitoring	Buoy Gear	Total	Industry Sea Days	Percent Coverage
2006	184	12	113			309	21,379	1.4
2007	396	69	120			585	38,200	1.5
2008	219	38	45	108		410	37,348	1.1
2009	162	36	397		20	615	36,818	1.6
Total	961	155	675	108	20	1,919	133,745	1.4

Fishing and environmental conditions differed by gear type (Tables 2, 3). Average fishing depth for longline sets was 51.5 fm. Fishing depths were shallower (27.3 fm) for vertical line. Average soak time was 5.1 h for longline and 0.7 h for vertical line. Most sets (≥47%) occurred over rock bottom in seas <2 ft during daylight hours for both gear types.

Bottom Longline Allocation of Sampling Effort

Data from 68 trips aboard 48 bottom longline vessels from August 2006 through November 2009 were analyzed. The capture of 73,205 fish (Table 4) occurred during 1,503 sets deploying traditional longline gear (Fig. 1). For longline, 1,431 sets had associated effort data (7,232 h; 1,395,320 hooks). Approximately 90% of fishing effort, based on hook-hours, occurred in the eastern Gulf. The greatest concentration of effort (hook-hours) occurred in statistical areas 3 through 5 (Fig. 2), with most (35%) in area 4. By season, 20% of the sets occurred from January through March; 52% April through June; 16% July through September; and 12% October through December for all years combined.

Species Composition

Of the 73,205 fish (183 taxa) caught on longline gear, 46% of the individuals were kept, 35% were released alive, 12% were discarded dead, 4% were discarded with an unknown condition, and 3% were retained for bait (Tables 5 and 6). By number, red grouper dominated the catch composition at 56%. Yellowedge grouper comprised 10% of the catch, followed by blueline tilefish, *Caulolatilus microps,* at 5%; red snapper, tilefish, *Lopholatilus chamaeleonticeps*, and Atlantic sharpnose shark, *Rhizoprionodon terraenovae,* each at 3%. All other species combined constituted 20% of the catch.

By category, red grouper, yellowedge grouper, tilefish, and blueline tilefish comprised the majority (82%) of the 33,335 individuals kept by longliners. Four species (red grouper, Atlantic sharpnose shark, smooth dogfish, *Mustelus canis*; and red snapper) accounted for 83% of the released alive category. Of the 25,471 individuals released alive, 42% exhibited visual signs of stress, while 46% exhibited a normal appearance. Of the 2,414 individuals used for bait, the species

caught and used most often for bait were king snake eel, *Ophichthus rex* (29%), and palespotted eel, *Ophichthus puncticeps* (11%). Red grouper, blueline tilefish, Atlantic sharpnose shark, and red snapper comprised the majority (81%) of 9,037 individuals in the discarded dead category. Approximate minimum assumed mortality was: red grouper (20%), blueline tilefish (76%), Atlantic sharpnose shark (34%), and red snapper (27%). The fate of 2,948 individuals was undetermined. Of these, approximately 77% were red grouper.

Table 2.—Trip, vessel, set, gear, and environmental characteristics observed in the longline fishery from August 2006 to November 2009.

Longline				
Trip	Vessel	Set	Gear	Environmental
783 Sea Days 68 trips aboard 48 vessels 1,503 sets	Length: Avg: 48.3 ft Range: 35 to 69 ft (± 8.4 s.d.).	Soak time: Avg: 5.1 h (± 2.9 s.d.) Range: 0.9 to 32.2 h	Mainline material: Cable (92%) Monofilament (7%) Test: Avg: 1,472.8 lbs (± 784 s.d.) Range: 310 to 4,000 lbs	Water Depth: Avg: 51.5 fathoms (± 37.8 s.d.) Eastern: 44.5 Western: 51.5 Range: 19.3 to 212.0
Trip Length: Avg: 11.7 days (± 3.8 s.d.) Range: 4 to 20 days	Hull Construction: Fiberglass: 85% Steel: 10% Fiberglass/wood: 4%	Mainline: Avg length: 5.6 nmi (± 2.0 s.d.) Range: 0.9 to 12.0 nmi	Gangion: Monofilament (99.9%) •Nylon (0.1%) Avg length: 5.8 ft (± 2.1 s.d) Range: 2.5 to 11.0 ft	Sea State: 0 to 2 foot seas: 46% 3 to 5 foot seas: 35% 6 to 8 foot seas: 17% 8+ foot seas: 2%
Crew size: 1 to 3 individuals (excluding captain)	Engine Horsepower: Avg: 277.1 hp (± 205.3 s.d.) Range: 76 to 1400 hp		Hooks: Avg: 991.1 hooks (± 426.4 s.d.) Range: 150 to 2,500 hooks Type: Circle hooks (100%), offset (63.4%), straight (36.6%) Shaft length avg 2.1 in Distance between hooks: Avg: 22.5 ft (± 13.0 s.d.) Range: 7.0 to 75.0 ft Size: 13 aught (43%) Range: 12 to 15 aught Brand: Mustad®: 82% Eagle Claw®: 18%	Bottom type: Rock: 47% Unknown: 14% Shell: 16% Coral: 10% Mud: 8% Sand: 2% Boulder, clay, and grass: 1% each

Table 3.—Trip, vessel, set, gear, and environmental characteristics observed in the vertical line fishery from July 2006 to December 2009.

Vertical Line				
Trip	Vessel	Set	Gear	Environmental
1,116 Sea Days 237 trips aboard 157 vessels 7,391 sets	Length: Avg: 39.2 ft Range: 23 to 70 ft (± 9.6 s.d.)	Soak time: Avg: 0.7 hrs (± 1.1 s.d.) Range: 0.02 to 15.3 h Haul in time: Recorded: 68% Avg: 0.8 min (± 0.6 s.d.) Range: <0.1 to 5.9 min	Reel type: Electric: 51.4% Hydraulic: 21.7% Hand: 27.0% Rod mount: Fixed: 73.1% Portable: 26.7%	Water Depth: Avg: 27.3 fathoms (± 15.8 s.d.) Range: 0.7 to 305.0
Trip Length: Avg: 4.8 days (± 3.6 s.d.) Range: 1 to 17 days	Hull Construction: Fiberglass: 89% Wood: 5% Steel: 4% Fiberglass/wood: 1% Unknown: 1%	Number of reels/set: Avg: 3.3 (± 1.4 s.d.) Range: 1 to 14	Mainline material: Monofilament (76.8%), Cable (13.7%), Mono/nylon/poly (3.2%), Other (6.3%) Test: Avg: 258.3 lbs (± 233.6 s.d.) Range: 12 to 1,400 lbs	Sea State: 0 to 2 foot seas: 59% 3 to 5 foot seas: 31% 6 to 8 foot seas: 8% 8+ foot seas: 2%
Crew size: 0 to 4 individuals (excluding captain)	Engine Horsepower: Avg: 326.9 hp (± 195.6 s.d.) Range: 40 to1200 hp	Hooks: Avg: 26.1 hooks (± 44.8 s.d.) Range: 1 to 330 hooks Type: Circle hooks (83.3%), J-hooks (12.7%), double J-hooks (3.1%), other (0.8%) Size: 8 aught (43%), 9 aught (20%) Range: 1 to 18 aught Brand: Mustad® (44%), Eagle Claw® (0.4%)	Subline material: Monofilament: 97.8% Test: Avg: 127.2 lbs (± 58.5 s.d.) Range: 10 to 800 lbs Hooks/Reel: Avg: 7.4 hooks (± 10.8 s.d.) Range: 1 to 45 hooks	Bottom type: Rock: 67% Unknown: 16% Shell: 2% Coral: 4% Mud: 5% Sand: 5% Wreck: 1% Fishing State: On anchor: 68% Drifting: 24% Trolling: 2% Unknown: 6%

Red Grouper Disposition and Size Composition

All 40,992 red grouper caught using longline were in the eastern Gulf of Mexico, with the exception of two individuals recorded in the western Gulf. Based on visual observations, the majority (43%) of the fish were released alive, 40% were kept, 12% were discarded dead, and 6% were of unknown condition.[17] One red grouper was used for bait.

A total of 36,764 red grouper were measured and ranged from 4 to 37 in TL with the mode of 4,440 individuals at 18 in TL (Fig. 3). Of these, 32% of the fish caught were <18 in TL, the legal minimum size, with 69% released alive, 19% discarded dead, 11% discarded in an unknown condition, and 0.3% kept. Of the 68% of red grouper ≥18 in TL, 62% were kept, 26% were released alive, 8% were discarded dead, and 3% discarded in an unknown condition.

Depths of red grouper captures ranged from 19.3 to 120.5 fm. Most (67%) red grouper were caught between 20–25 fm, followed by 26–30 fm (21%), 31–35 fm (5%), and 36–40 fm (4%). Catch was ≤1% for the remaining zones (Fig. 4).

CPUE and Discard CV

Mean CPUE for all species and dispositions combined was 0.0095 fish per hook-hour (± 0.0002 SE; Table 5). The catch rate estimate for red grouper was 0.0021 fish kept per hook-hour (± 0.0001 SE). Spatial CPUE density (numbers of fish kept per 1,000 hook-hour) for dominant species for all years combined is depicted (Fig. 5–9). Red grouper were caught and retained primarily in statistical areas 2 through 8, with highest density CPUE observed in statistical area 5.

A similar pattern was detected for blueline tilefish with highest density CPUE in the eastern Gulf of Mexico. Yellowedge grouper, tilefish, and scamp, *Mycteroperca phenax*, were distributed throughout the Gulf with high CPUE observed in deeper waters of the western Gulf. Clusters of significantly high

[17]Percentages may not equal 100% due to rounding.

Table 4.—Number of fish observed using longline (*n*=1,503 sets) and vertical line (*n*=7,391 sets) gear in the Gulf of Mexico from July 2006 to December 2009.

Common name	Scientific name	Longline	Vertical line	Total
Red grouper	*Epinephelus morio*	40,992	13,855	54,847
Red snapper	*Lutjanus campechanus*	2,456	27,669	30,125
Vermilion snapper	*Rhomboplites aurorubens*	139	26,045	26,184
Yellowedge grouper	*Epinephelus flavolimbatus*	6,983	104	7,087
Red porgy	*Pagrus pagrus*	568	6,120	6,688
Blueline tilefish	*Caulolatilus microps*	3,591	23	3,614
Gag	*Mycteroperca microlepis*	723	2,624	3,347
Tilefish	*Lopholatilus chamaeleonticeps*	2,199	45	2,244
Atlantic sharpnose shark	*Rhizoprionodon terraenovae*	2,142	83	2,225
Scamp	*Mycteroperca phenax*	993	1,002	1,995
King snake eel	*Ophichthus rex*	1,573	12	1,585
Smooth dogfish	*Mustelus canis*	1,284	35	1,319
Sharks grouped	*General sharks*	1,025	96	1,121
Snowy grouper	*Epinephelus niveatus*	949	168	1,117
Gray snapper	*Lutjanus griseus*	110	822	932
King mackerel	*Scomberomorus cavalla*	16	886	902
Greater amberjack	*Seriola dumerili*	270	613	883
Blacknose shark	*Carcharhinus acronotus*	816	32	848
Gray triggerfish	*Balistes capriscus*	29	808	837
Chub mackerel	*Scomber japonicus*	0	818	818
Yellowtail snapper	*Ocyurus chrysurus*	11	770	781
Pinfish	*Lagodon rhomboides*	1	598	599
Blue runner	*Caranx crysos*	7	525	532
Speckled hind	*Epinephelus drummondhayi*	492	31	523
Lane snapper	*Lutjanus synagris*	93	416	509
Tomtate	*Haemulon aurolineatum*	1	494	495
Almaco jack	*Seriola rivoliana*	39	453	492
Knobbed porgy	*Calamus nodosus*	12	396	408
Spotted hake	*Urophycis regia*	377	3	380
Palespotted eel	*Ophichthus puncticeps*	288	0	288
Jolthead porgy	*Calamus bajonado*	132	154	286
Mutton snapper	*Lutjanus analis*	265	20	285
Sharksucker	*Echeneis naucrates*	213	64	277
Banded rudderfish	*Seriola zonata*	12	255	267
White grunt	*Haemulon plumieri*	4	259	263
Little tunny	*Euthynnus alletteratus*	127	128	255
Lesser amberjack	*Seriola fasciata*	20	219	239
Southern hake	*Urophycis floridana*	230	0	230
Spinycheek scorpionfish	*Neomerinthe hemingwayi*	208	3	211
Great barracuda	*Sphyraena barracuda*	153	45	198
Nurse shark	*Ginglymostoma cirratum*	163	34	197
Sand perch	*Diplectrum formosum*	38	130	168
Gulf hake	*Urophycis cirrata*	168	0	168
Silky shark	*Carcharhinus falciformis*	95	71	166
Lemon shark	*Negaprion brevirostris*	157	8	165
Bearded brotula	*Brotula barbata*	148	13	161
Dolphin	*Coryphaena hippurus*	91	67	158
Blackedge moray	*Gymnothorax nigromarginatus*	141	8	149
Blacktail moray	*Gymnothorax kolpos*	144	3	147
Moray (genus)	*Gymnothorax* sp.	133	8	141
Warsaw grouper	*Epinephelus nigritus*	80	54	134
Jack (genus)	*Seriola* sp.	114	18	132
Blacktip shark	*Carcharhinus limbatus*	87	40	127
Black sea bass	*Centropristis striata*	0	127	127
Remora	*Remora remora*	37	80	117
Florida pompano	*Trachinotus carolinus*	2	114	116
Tiger shark	*Galeocerdo cuvier*	107	6	113
Spotted moray	*Gymnothorax moringa*	83	29	112
Creole-fish	*Paranthias furcifer*	0	107	107
Purplemouth moray	*Gymnothorax vicinus*	97	9	106
Black grouper	*Mycteroperca bonaci*	67	34	101
Cobia	*Rachycentron canadum*	72	28	100
Sand seatrout	*Cynoscion arenarius*	24	74	98
Leopard toadfish	*Opsanus pardus*	79	13	92
Dogfish (genus)	*Squalus*	92	0	92
Bank sea bass	*Centropristis ocyurus*	20	61	81
Bluefish	*Pomatomus saltatrix*	2	78	80
Scalloped hammerhead	*Sphyrna lewini*	76	2	78
Cubera snapper	*Lutjanus cyanopterus*	76	2	78
Dogfish	*Mustelus* sp.	72	5	77
Whitebone porgy	*Calamus leucosteus*	6	67	73
Inshore lizardfish	*Synodus foetens*	66	4	70
Crevalle jack	*Caranx hippos*	9	59	68

continued

Table 4.—(Continued).

Common name	Scientific name	Longline	Vertical line	Total
Queen snapper	*Etelis oculatus*	16	50	66
Red drum	*Sciaenops ocellatus*	22	43	65
Grunt (genus)	Haemulon	0	63	63
Spanish mackerel	*Scomberomorus maculatus*	0	62	62
Sandbar shark	*Carcharhinus plumbeus*	59	2	61
Offshore lizardfish	*Synodus poeyi*	41	18	59
Bar jack	*Caranx ruber*	2	57	59
Blackfin tuna	*Thunnus atlanticus*	49	9	58
Blackbelly rosefish	*Helicolenus dactylopterus*	42	10	52
Cuban dogfish	*Squalus cubensis*	49	1	50
Clearnose skate	*Raja eglanteria*	50	0	50
Wenchman	*Pristipomoides aquilonaris*	23	25	48
Smalltail shark	*Carcharhinus porosus*	48	0	48
Sheepshead	*Archosargus probatocephalus*	0	46	46
Snakefish	*Trachinocephalus myops*	44	0	44
Bull shark	*Carcharhinus leucas*	43	0	43
Silver seatrout	*Cynoscion nothus*	20	18	38
Lizardfish (family)	Synodontidae	31	5	36
Gulper shark	*Centrophorus granulosus*	35	0	35
Sharpnose sevengill shark	*Heptranchias perlo*	33	0	33
Spinner shark	*Carcharhinus brevipinna*	28	2	30
Sand diver	*Synodus intermedius*	27	2	29
Bigeye	*Priacanthus arenatus*	0	29	29
Seatrout (genus)	*Cynoscion* sp.	0	26	26
Littlehead porgy	*Calamus proridens*	1	24	25
Gulf toadfish	*Opsanus beta*	21	4	25
Great hammerhead	*Sphyrna mokarran*	24	0	24
Chain dogfish	*Scyliorhinus retifer*	24	0	24
Short bigeye	*Pristigenys alta*	3	20	23
Ocean triggerfish	*Canthidermis sufflamen*	0	23	23
Squirrelfish	*Holocentrus adscensionis*	3	19	22
Cubbyu	*Pareques umbrosus*	0	22	22
Sand tilefish	*Malacanthus plumieri*	3	17	20
Night shark	*Carcharhinus signatus*	20	0	20
Yellowmouth grouper	*Mycteroperca interstitialis*	9	10	19
Triggerfish (family)	Balistidae	0	19	19
Rock hind	*Epinephelus adscensionis*	1	18	19
Goliath grouper	*Epinephelus itajara*	7	12	19
Wahoo	*Acanthocybium solandri*	10	8	18
Reticulate moray	*Muraena retifera*	18	0	18
Blackbar drum	*Equetus iwamotoi*	0	18	18
Round scad	*Decapterus punctatus*	0	17	17
Hake (genus)	*Urophycis* sp.	16	1	17
Jack (family)	Carangidae	4	12	16
Graysby	*Cephalopholis cruentata*	0	15	15
Tattler	*Serranus phoebe*	0	14	14
Squirrelfishes (family)	Holocentridae	3	11	14
Rainbow runner	*Elagatis bipinnulata*	6	8	14
Black margate	*Anisotremus surinamensis*	14	0	14
Bigeye scad	*Selar crumenophthalmus*	0	14	14
Bluntnose sixgill shark	*Hexanchus griseus*	13	0	13
Red hind	*Epinephelus guttatus*	2	11	13
Grouper (genus)	*Mycteroperca*	13	2	15
Scorpionfish	*Scorpaena* sp.	9	3	12
Rock sea bass	*Centropristis philadelphica*	8	4	12
Horse-eye jack	*Caranx latus*	0	12	12
Toadfish (genus)	*Opsanus* sp.	11	0	11
Silk snapper	*Lutjanus vivanus*	7	4	11
Longtail bass	*Hemanthias leptus*	1	10	11
Dusky shark	*Carcharhinus obscurus*	11	0	11
Bigeye sixgill shark	*Hexanchus nakamurai*	11	0	11
Atlantic croaker	*Micropogonias undulatus*	0	11	11
Smooth puffer	*Lagocephalus laevigatus*	10	0	10
Largescale lizardfish	*Saurida brasiliensis*	9	0	9
Atlantic spadefish	*Chaetodipterus faber*	0	9	9
Hardhead catfish	*Arius felis*	0	8	8
Grunt (family)	Haemulidae	8	0	8
Goldface tilefish	*Caulolatilus chrysops*	1	7	8
Southern stingray	*Dasyatis americana*	6	1	7
Cusk-eel (family)	Ophidiidae	5	2	7
Barracuda (genus)	*Sphyraena* sp.	6	1	7
Atlantic cutlassfish	*Trichiurus lepturus*	2	5	7
Spiny dogfish	*Squalus acanthias*	6	0	6

continued

CPUE for red grouper were located in statistical areas 3 through 8 (Fig. 10). For all kept species, clusters of significantly high CPUE were detected in statistical areas 5, 14, 15, and 16 (Fig. 11). Highest discard CPUE was evident in statistical areas 3 through 6 (Fig. 12).

CV estimates (Table 7) for discarded red grouper, red snapper, greater amberjack, *Seroila dumerili*; and gag, *Mycteroperca microlepis*, were low (≤0.1). Several other species of grouper; jacks, king mackerel, *Scomberomorus cavalla*; and cobia, *Rachycentron canadum*, had values ≤0.5.

Vertical Line
Allocation of Sampling Effort

Data from 237 trips were collected aboard 157 vertical line vessels from July 2006 through December 2009, with a total of 89,015 fish processed (Tables 3 and 4). Locations for 7,384 vertical line sets are depicted (Fig. 13). Effort data (5,266 h; 190,202 hooks) were available for 7,285 sets. Approximately 37% of the sampled reels had no catch reported during a set. The majority (75%) of sets were in the eastern Gulf of Mexico. However, the highest concentrated effort (74%), based on hook-hours, occurred in the western Gulf of Mexico (Fig. 14). By season, 23% of the effort occurred from January through March; 21% April through June; 33% July through September; and 22% October through December for all years combined.

Species Composition

Of the 89,015 fish (178 taxa) sampled, 71% of the individuals were kept, 19% were released alive, 6% were discarded dead, 1% were discarded in an unknown condition, and 4% were retained for bait (Tables 5 and 8). By number, red snapper ranked highest in catch composition at 31%. Vermilion snapper comprised 29% of the catch, followed by red grouper (16%), red porgy, *Pagrus pagrus* (7%); gag (3%), and the remaining species combined (14%).

Vermilion snapper, red snapper, red grouper, and red porgy comprised 86% of the 63,351 individuals in the kept category. Three species (red snapper, red grouper, and vermilion snapper)

accounted for 80% of the released alive category. Of the 16,872 individuals released alive, 35% exhibited visual signs of stress, while 61% exhibited a normal appearance.

Of the 2,805 individuals used for bait, the species caught and used most often were chub mackerel, *Scomber japonicus* (29%); pinfish, *Lagodon rhomboides* (20%); and tomtate, *Haemulon aurolineatum* (16%). Red snapper, vermilion snapper, and red grouper comprised 87% of 5,185 individuals in the discarded dead category. Minimum assumed mortality for these species was approximately: red snapper (28%), vermilion snapper (41%), and red grouper (11%). The fate of 802 individuals was not determined.

Red Snapper Disposition and Size Composition

A total of 27,669 red snapper were sampled on vertical line gear. Statistical areas of capture ranged from 3 to 21, with no reported takes in statistical area 12. Approximately 77% of the red snapper were captured in the western Gulf of Mexico, with the remaining 23% captured in the eastern Gulf. The majority (65%) of the fish were kept. Based on visual observations, 24% were released alive, 10% were discarded dead, and 1% discarded in an unknown condition.

A total of 25,650 red snapper were measured and ranged from 6 to 41 in TL, with the mode of 4,102 individuals at 15 in TL (Fig. 15). Of these, 92% were ≥13 in TL, the legal minimum size. Approximately 8% were <13 in TL, with 31% of the individuals discarded dead.

Depths of red snapper capture ranged from 3.3 to 305 fm. Most (29%) red snapper were caught in waters less than 20 fm, followed by 20–25 fm (26%), and 31–35 and 26–30 fm (13% each; Fig. 16). The remaining depth zones comprised 19%. No depth values were recorded for 762 red snapper.

CPUE and Discard CV

Mean CPUE for all species and dispositions was 0.9369 fish per hook-hour (± 0.0311 SE; Table 5). Red snapper mean catch rate was 0.2214 fish kept per hook-hour (± 0.0150 SE). Spatial

Table 4.—(Continued).

Common name	Scientific name	Longline	Vertical line	Total
Shortfin mako	*Isurus oxyrinchus*	6	0	6
Margate	*Haemulon album*	5	1	6
Grass porgy	*Calamus arctifrons*	1	5	6
Atlantic bonito	*Sarda sarda*	2	4	6
Swordfish	*Xiphias gladius*	5	0	5
Sailors choice	*Haemulon parra*	0	5	5
Honeycomb moray	*Gymnothorax saxicola*	4	1	5
Hammerhead (genus) shark	*Sphyrna* sp.	3	2	5
Green moray	*Gymnothorax funebris*	4	1	5
Florida smoothhound	*Mustelus norrisi*	5	0	5
Finetooth shark	*Carcharhinus isodon*	5	0	5
Thresher shark	*Alopias vulpinus*	1	4	5
Atlantic stingray	*Dasyatis sabina*	5	0	5
Starfish (family)	Astropectinidae	4	0	4
Spider (genus) crab	*Libinia* sp.	4	0	4
Southern flounder	*Paralichthys lethostigma*	4	0	4
Snake eel (family)	Ophichthidae	4	0	4
Sea bass (family)	Serranidae	1	3	4
Sailfish	*Istiophorus platypterus*	3	1	4
Queen triggerfish	*Balistes vetula*	3	1	4
Puffer (family)	Tetraodontidae	4	0	4
Porgy (genus)	*Calamus*	3	1	4
Pigfish	*Orthopristis chrysoptera*	0	4	4
Black snapper	*Apsilus dentatus*	0	4	4
Anchor tilefish	*Caulolatilus intermedius*	2	2	4
Spottail pinfish	*Diplodus holbrooki*	0	3	3
Spanish flag	*Gonioplectrus hispanus*	0	3	3
Shoal flounder	*Syacium gunteri*	3	0	3
Saucereye porgy	*Calamus calamus*	2	1	3
Octopus (genus)	*Octopus* sp.	0	3	3
Guaguanche	*Sphyraena guachancho*	0	3	3
Conger eel (family)	Congridae	1	2	3
Conger eel	*Conger oceanicus*	2	1	3
Bonnethead	*Sphyrna tiburo*	3	0	3
Black jack	*Caranx lugubris*	0	3	3
Black drum	*Pogonias cromis*	0	3	3
Bermuda chub	*Kyphosus sectatrix*	0	3	3
Yellowfin grouper	*Mycteroperca venenosa*	0	2	2
Yellow conger	*Hildebrandia flava*	2	0	2
Spotfin hogfish	*Bodianus pulchellus*	0	2	2
Southern puffer	*Sphoeroides nephelus*	1	1	2
Smooth butterfly ray	*Gymnura micrura*	2	0	2
Pufferfish (genus)	*Sphoeroides* sp.	2	0	2
Porgie (family)	Sparidae	0	2	2
Oyster toadfish	*Opsanus tau*	2	0	2
Mackerel (family)	Scombridae	0	2	2
Lefteye flounder (family)	Bothidae	2	0	2
Fish (superclass)	Pisces	2	6	8
Dusky flounder	*Syacium papillosum*	2	0	2
Drum (family)	Sciaenidae	0	2	2
Cero	*Scomberomorus regalis*	0	2	2
Broad flounder	*Paralichthys squamilentus*	2	0	2
Atlantic angel shark	*Squatina dumeril*	2	0	2
Yellow jack	*Caranx bartholomaei*	0	1	1
Whitespotted soapfish	*Rypticus maculatus*	0	1	1
Threadtail conger	*Uroconger syringinus*	0	1	1
Stingray (genus)	*Dasyatis* sp.	1	0	1
Stingray (family)	Dasyatidae	1	0	1
Spotted snake eel	*Ophichthus ophis*	1	0	1
Spanish sardine	*Sardinella aurita*	0	1	1
Spanish hogfish	*Bodianus rufus*	0	1	1
Skipjack tuna	*Katsuwonus pelamis*	0	1	1
Skate (genus)	*Raja*	1	0	1
Shrimp eel	*Ophichthus gomesi*	1	0	1
Sand tiger	*Carcharias taurus*	1	0	1
Saddled grenadier	*Caelorinchus caelorhincus*	1	0	1
Roughtongue bass	*Holanthias martinicensis*	0	1	1
Rosette skate	*Raja garmani*	1	0	1
Porkfish	*Anisotremus virginicus*	0	1	1
Offshore hake	*Merluccius albidus*	1	0	1
Octopus (order)	Octopoda	1	0	1
Ocellated frogfish	*Antennarius ocellatus*	0	1	1
Marbled grouper	*Epinephelus inermis*	0	1	1
Mantis (genus) shrimp	*Squilla* sp.	1	0	1

continued

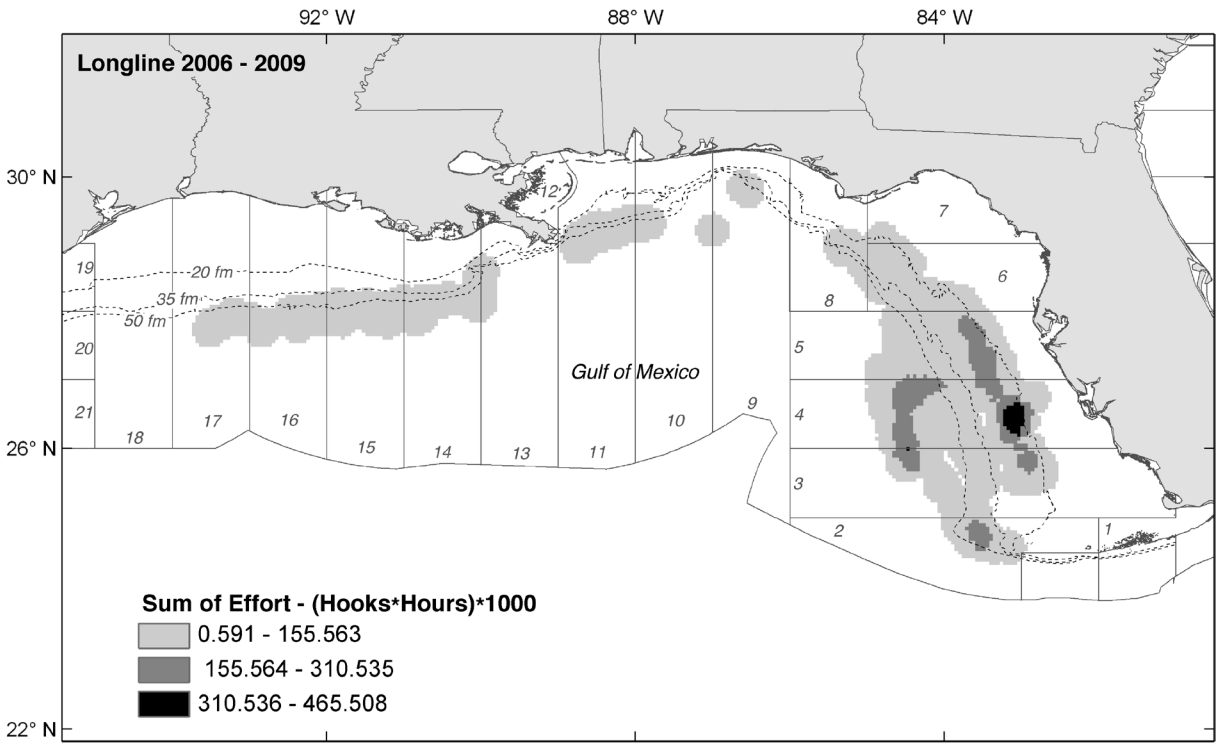

Figure 2.—Distribution of sampling effort (hook-hours) based on observer coverage of the U.S. Gulf of Mexico bottom longline reef fish fishery from August 2006 through November 2009.

CPUE density (numbers of fish kept per 1,000 hook-hours) for dominant species caught using vertical line gear is depicted in Figures 17 through 21. Red snapper were caught and retained throughout the Gulf, with highest density CPUE observed in statistical area 11. Similarly, vermilion snapper occurred in both Gulf regions with a spatial density similar to red snapper. Red grouper were concentrated in the eastern Gulf, with the highest CPUE density observed in statistical areas 3, 4, and 8. High density CPUE for red porgy was found primarily in the eastern Gulf, with the exception of statistical area 16. Gag were caught and retained primarily off Florida, predominantly in statistical areas 5–8.

Cluster locations of statistically significant high CPUE for retained red snapper were most pronounced in statistical areas 8 through 14, 16, and 17 (Fig. 22). For all retained species, clusters of significantly high CPUE were detected primarily in the western Gulf (Fig. 23). Conversely, highest discard CPUE values were observed in the eastern Gulf in statistical areas 5 through 7 (Fig. 24).

Based on number discarded, CV estimates for Federally managed species caught on vertical line gear (Table 9) were low for red grouper, red snapper, vermilion snapper, gag, and greater amberjack (≤0.1). Several other species of grouper, jacks, gray triggerfish, *Balistes capriscus*; king mackerel, and red drum, *Sciaenops ocellatus*, had values less than or equal to 0.5. Higher CV estimates for other species of importance, including

Table 4.—(Continued).

Common name	Scientific name	Longline	Vertical line	Total
Lookdown	*Selene vomer*	0	1	1
Longspine squirrelfish	*Holocentrus rufus*	0	1	1
Jack (genus)	*Caranx*	1	0	1
Gulf hagfish	*Eptatretus springeri*	1	0	1
Gulf flounder	*Paralichthys albigutta*	0	1	1
Gafftopsail catfish	*Bagre marinus*	0	1	1
Dog snapper	*Lutjanus jocu*	0	1	1
Decapod (order)	Decapoda	0	1	1
Big roughy	*Gephyroberyx darwinii*	0	1	1
Cusk-eel (genus)	*Lepophidium*	1	0	1
Cownose ray	*Rhinoptera bonasus*	1	0	1
Cottonwick	*Haemulon melanurum*	1	0	1
Cottonmouth jack	*Uraspis secunda*	0	1	1
Cardinal soldierfish	*Plectrypops retrospinus*	0	1	1
Butterfly ray	*Gymnura* sp.	1	0	1
Bluntnose stingray	*Dasyatis say*	1	0	1
Blackline tilefish	*Caulolatilus cyanops*	0	1	1
Bigeye tuna	*Thunnus obesus*	1	0	1
Barrelfish	*Hyperoglyphe perciformis*	1	0	1
Bank cusk-eel	*Ophidion holbrooki*	0	1	1
Atlantic moonfish	*Selene setapinnis*	0	1	1
Total		73,205	89,015	162,220

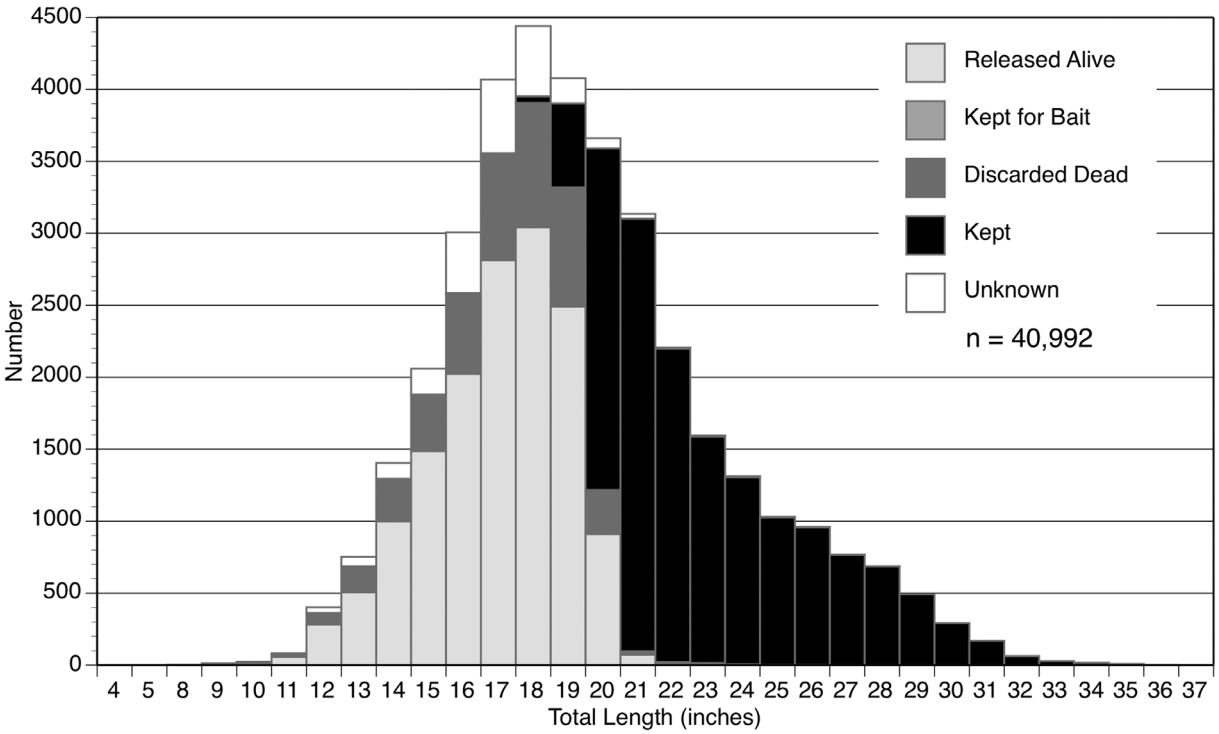

Figure 3.—Size and fate of red grouper caught on bottom longline gear based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from August 2006 through November 2009.

several species of snapper and grouper, were detected.

Interactions with Protected Species in the Reef Fish Fishery

Twenty sea turtles were captured on observed trips utilizing longline gear from 2006 to 2009; three occurred during the electronic monitoring pilot project. One sea turtle was captured on vertical line gear (bandit) during the same time period. Sea turtle mortality and projected take estimates by gear type were reported by SEFSC.[18]

Discussion

To gain a greater understanding of catch rates, bycatch composition,

[18]SEFSC. 2009. Estimated takes of sea turtles in the bottom longline portion of the Gulf of Mexico reef fish fishery July 2006 through December 2008 based on observer data. U.S. Dep. Commer., NOAA, NMFS Southeast Fish. Sci. Cent. Contrib. PRD-08/09-07, March 2009, 23 p. [Updated 4/2009, Erratum; updated 6/2009].

Table 5.—Species composition and disposition by gear type observed from July 2006 to December 2009.

Longline	Vertical line
73,205 fish of 183 taxa	89,015 fish of 178 taxa
Kept: 46% Red grouper: 49% Yellowedge grouper: 21% Tilefish: 6% Blueline tilefish: 5%	Kept: 71% Vermilion snapper: 37% Red snapper: 28% Red grouper: 12% Red porgy: 9%
Released alive: 35% (42% stressed: air bladder expansion and/or eyes protruding; 46% normal; 12% not recorded) Red grouper: 69% Atlantic sharpnose shark, Smooth dogfish, Red snapper: 5% each	Released alive: 19% (35% stressed: air bladder expansion and/or eyes protruding; 61% normal; 4% not recorded) Red snapper: 39% Red grouper: 34% Vermilion snapper: 7%
Discarded dead: 12% Red grouper: 54% Blueline tilefish: 15% Atlantic sharpnose shark: 8% Red snapper: 5%	Discarded dead: 6% Red snapper: 53% Vermilion snapper: 21% Red grouper: 13%
Unknown: 4% Red grouper: 77% Atlantic sharpnose shark, Gulf hake, Grouped sharks: 3% each	Unknown: 1% Vermilion snapper: 45% Red snapper: 43% Red grouper: 5%
Kept for bait: 3% King snake eel: 29% Palespotted eel: 11% Little tunny: 5%	Kept for bait: 4% Chub mackerel: 29% Pinfish: 20% Tomtate: 16%
Mean CPUE (fish/hook hour): All: 0.0095 (± 0.0002) Kept: 0.0043 (± 0.0001) Red grouper: 0.0021 (± 0.0001)	Mean CPUE (fish/hook hour): All: 0.9369 (± 0.0311) Kept: 0.6500 (± 0.0221) Red snapper: 0.2214 (± 0.0150)
Sea turtle captures: 19	Sea turtle captures: 1

Table 6.—Number, condition (when brought onboard), and fate of fish species with *n*>25 caught using longline gear in the Gulf of Mexico from August 2006 to November 2009.

Fate upon release		Kept				Released alive			Kept for bait				Discarded dead				Unknown		
Condition upon capture			Live				Live			Live				Live				Live	
Common name	Total	Total	Normal	Stressed	Dead	Total	Normal	Stressed	Total	Normal	Stressed	Dead	Total	Normal	Stressed	Dead	Total	Normal	Stressed
Red grouper	40,992	16,413	4,186	10,402	259	17,475	5,078	9,543	1			1	4,843	1,010	2,811	760	2,260	98	890
Yellowedge grouper	6,983	6,932	251	5,759	918	5		4	6	1	5		15		4	11	25	4	12
Blueline tilefish	3,591	1,767	551	1,179	37	417	152	264	67	43	14	10	1,331	212	782	332	9	3	5
Red snapper	2,456	784	501	269	3	1,161	376	702	1			1	450	132	208	92	60	16	35
Tilefish	2,199	2,130	996	1,036	93	9	8	1	4		3	1	32	6	10	16	24	3	21
Atlantic sharpnose shark	2,142	20	12	1	7	1,280	1,264	4	50	35	1	14	699	280	2	379	93	79	
King snake eel	1,573	2	2			714	711	1	692	672	4	5	150	110	11	8	15	6	
Smooth dogfish	1,284	1	1			1,176	1,173	2	52	52			44	31		10	11	8	1
Sharks grouped	1,025	1	1			710	701		13	13			275	141		129	26	10	
Scamp	993	955	453	439	14	22	10	5					13	3	6	4	3	1	
Snowy grouper	949	941	114	771	55				2	1	1		6	1	2	2			
Blacknose shark	816	6	6			576	572		15	9		6	162	92		58	57	54	
Gag	723	673	234	417		41	14	22					7	1	4	2	2	1	
Red porgy	568	507	363	119	2	16	13	3	29	24	2	1	10	3	4	3	6	6	
Speckled hind	492	453	99	324	28	17	5	9					22		17	4			
Spotted hake	377	7		3	4	2		2	68	2	60	6	262		163	99	38	5	32
Palespotted eel	288					9	7		271	261		1	6	4		1	2	1	
Greater amberjack	270	124	112	1	7	99	97		14	14			22	13	1	8	11	8	
Mutton snapper	265	264	216	47	1	1	1												
Southern hake	230	7	2	5		5	3	2	50	6	37	6	135	4	116	15	33	2	31
Sharksucker	213	1	1			148	128		47	47			5	4			12	1	
Spinycheek scorpionfish	208	202	62	114	25								5	1	3	1	1		1
Gulf hake	168					13	4	8	2		2		65		56	9	88	4	84
Nurse shark	163					142	127						1				20	11	
Lemon shark	157					153	153						4	1		3			
Great barracuda	153	11	11			15	14		107	79		13	14	7		7	6	5	
Bearded brotula	148	128	81	35	12	1		1	2	1	1		16	1	15		1	1	
Blacktail moray	144					11	11		89	85		4	44	42		2			
Blackedge moray	141	1	1			37	37		81	66		15	16	10		5	6	3	
Vermilion snapper	139	84	18	33	4	32	22	1	11	6		4	11	2	3	4	1		
Moray (genus)	133					9	9		100	78		21	18	5		9	6	1	
Jolthead porgy	132	127	115	3	1				1	1			4			4			
Little tunny	127	1			1				113	14		93	13	2		10			
Jack (genus)	114					71	69	1					5			5	38	38	
Gray snapper	110	105	25	49	1	3											2		
Tiger shark	107					97	94		1	1			4	1		1	5	2	
Purplemouth moray	97					4	4		64	47		17	29	15		12			
Silky shark	95					58	57		2	1		1	34	9		24	1	1	
Lane snapper	93	75	18	49	3	7	3	2	1				5	1	2	2	5		
Dogfish (genus)	92					52	52						38	38			2	2	
Dolphin	91	89	22		67				1				1			1			
Blacktip shark	87	7	4		3	55	54		7	5		2	17	1		15	1	1	
Spotted moray	83					19	19		54	27		23	10	3		7			
Warsaw grouper	80	78	6	71	1								1	1			1		1
Leopard toadfish	79					35	20	14	34	18	16		8	5	3		2	1	1
Cubera snapper	76	76	75	1															
Scalloped hammerhead	76	1	1			56	54		1			1	13			13	5	2	
Dogfish	72					69	68	1					1	1			2	2	
Cobia	72	38	34	1		29	28						2	2			3	3	
Black grouper	67	65	31	15		2		1											
Inshore lizardfish	66					20	3		40	32	1	4	5	1		1	1		
Sandbar shark	59					57	54						2			2			
Clearnose skate	50					9	7		41	39		2							
Cuban dogfish	49					36	36		8	8			5			5			
Blackfin tuna	49	38	17		21	2	2		6			6	2	1		1	1		
Smalltail shark	48					48	48												
Snakefish	44					8	2		33	21	1	11	3	1					
Bull shark	43					42	42						1			1			
Blackbelly rosefish	42	12	11	1		12	9	3					18	2	16				
Offshore lizardfish	41					7	7		26	11	1	13	8	3		3			
Almaco jack	39	19	19			3	3		11	11							6	6	
Sand perch	38					12	5	1	24	18	2	2	1			1	1		
Remora	37					34	34		3	2									
Gulper shark	35					30	30						5	5					
Sevengill shark	33					25	25						8			8			
Lizardfish (family)	31					5	5		23	12		11	2			2	1		
Gray triggerfish	29	26	16	8		3	1												
Spinner shark	28	2	2			15	15						9	8		1	2		
Sand diver	27								25	22		3	2			2			
Total (all species)	73,205	33,335	8,778	21,183	1,583	25,471	11,744	10,628	2,414	1,849	178	320	9,037	2,235	4,258	2,149	2,948	407	1,132

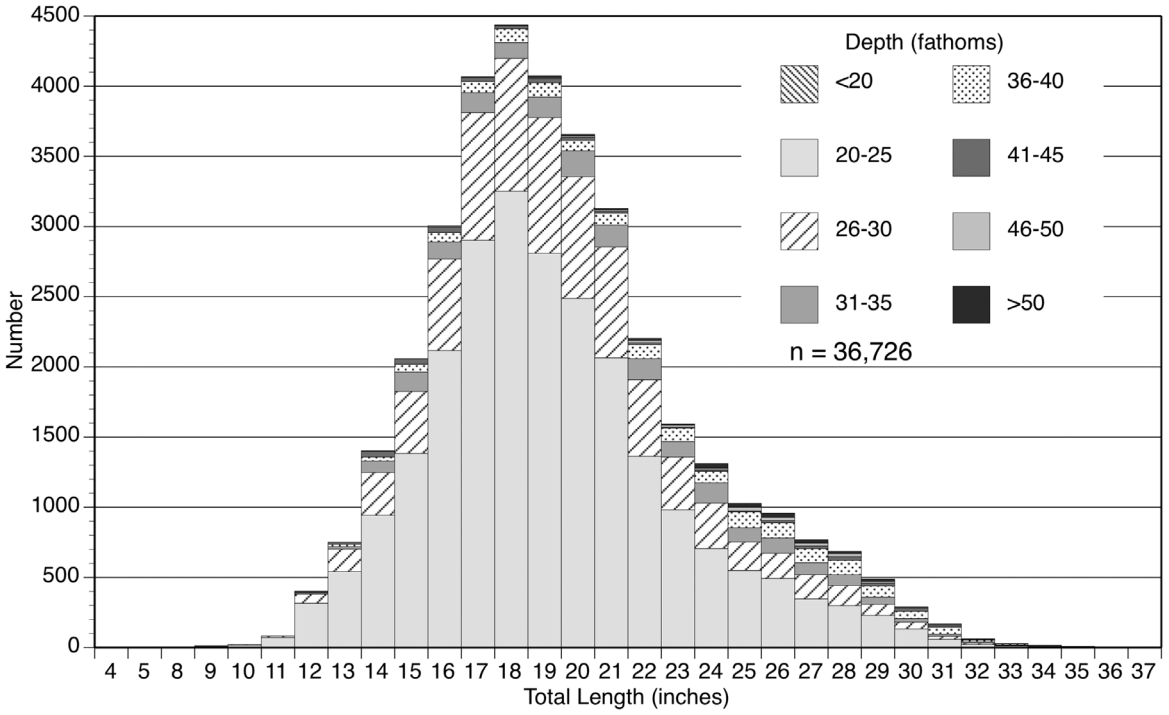

Figure 4.—Number of red grouper by size and depth zone caught on bottom longline gear based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from August 2006 through November 2009.

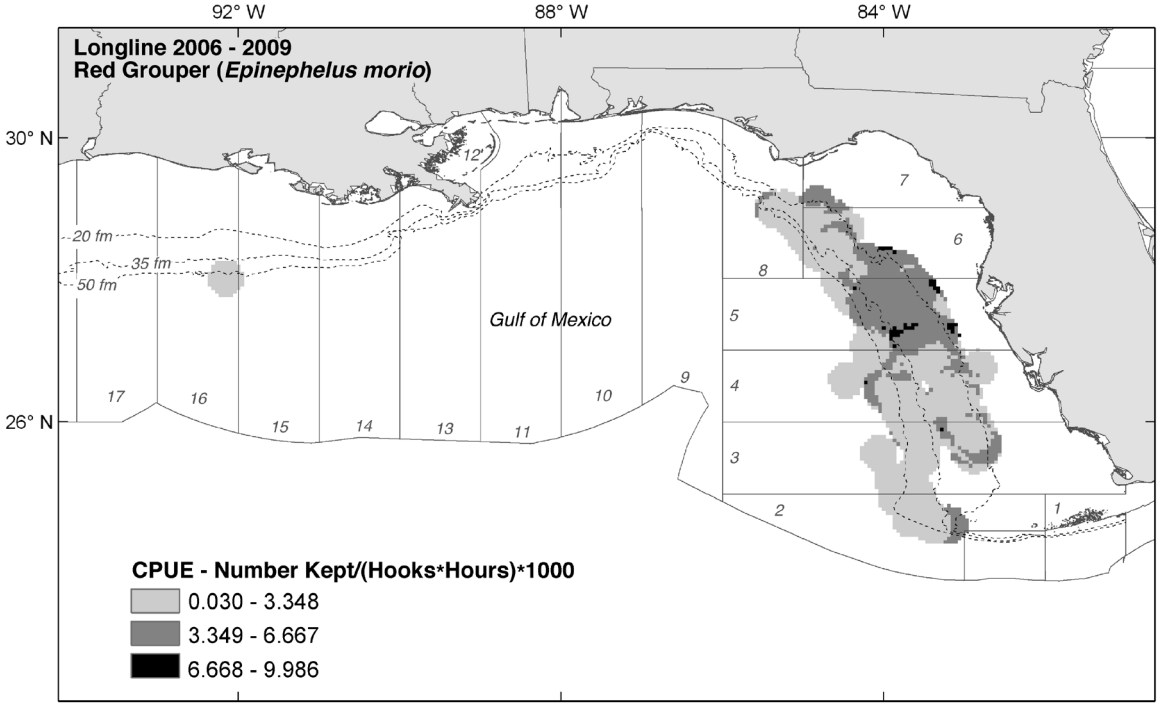

Figure 5.—CPUE density surface for red grouper kept in the bottom longline fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from August 2006 through November 2009.

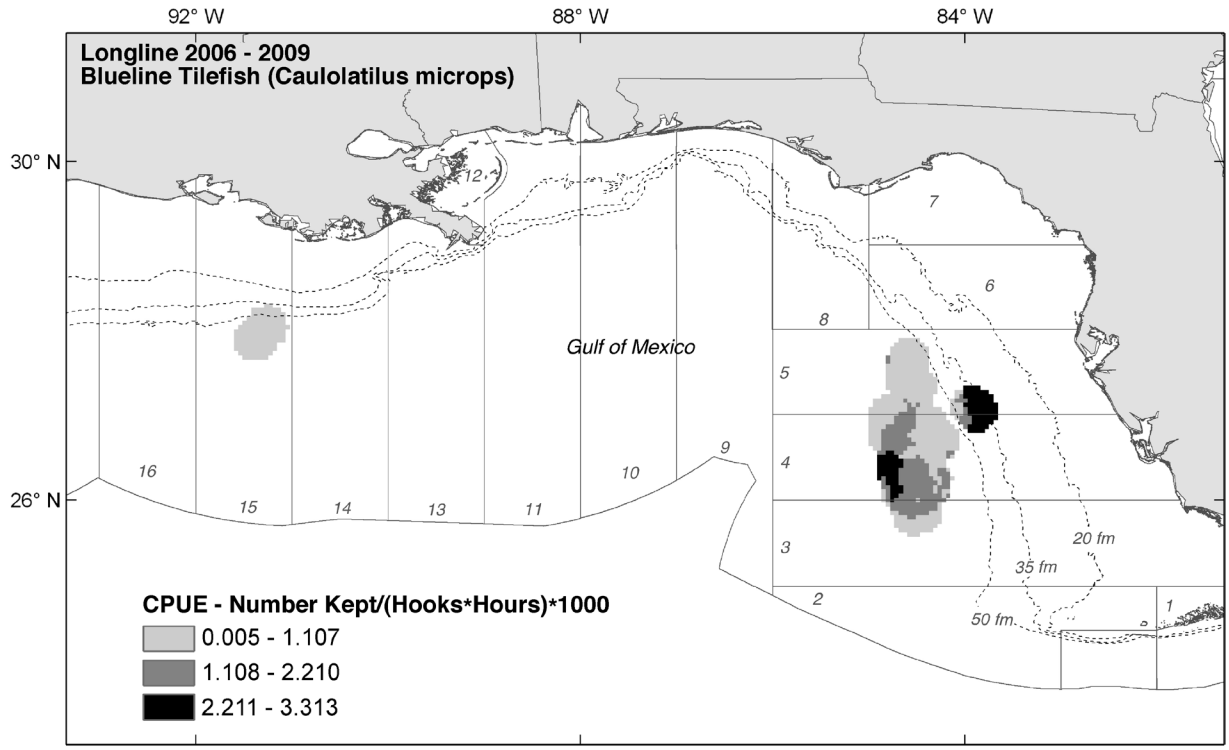

Figure 6.—CPUE density surface for blueline tilefish kept in the bottom longline fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from August 2006 through November 2009.

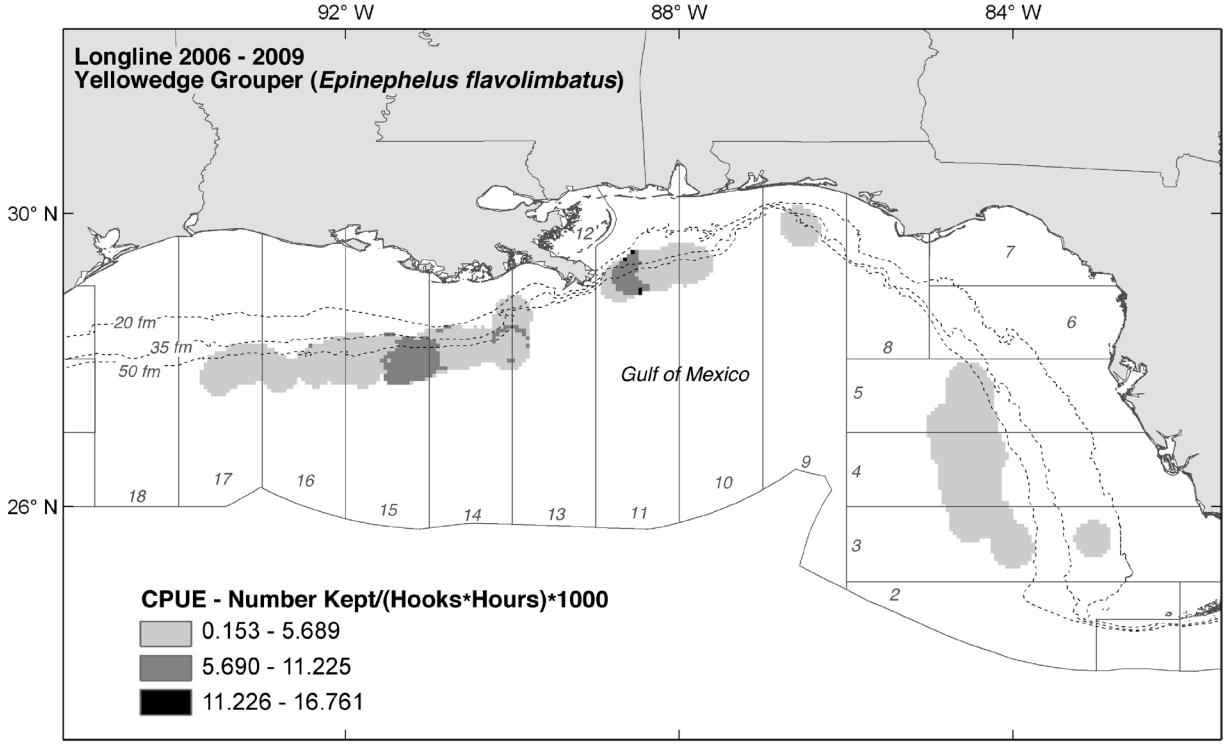

Figure 7.—CPUE density surface for yellowedge grouper kept in the bottom longline fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from August 2006 through November 2009.

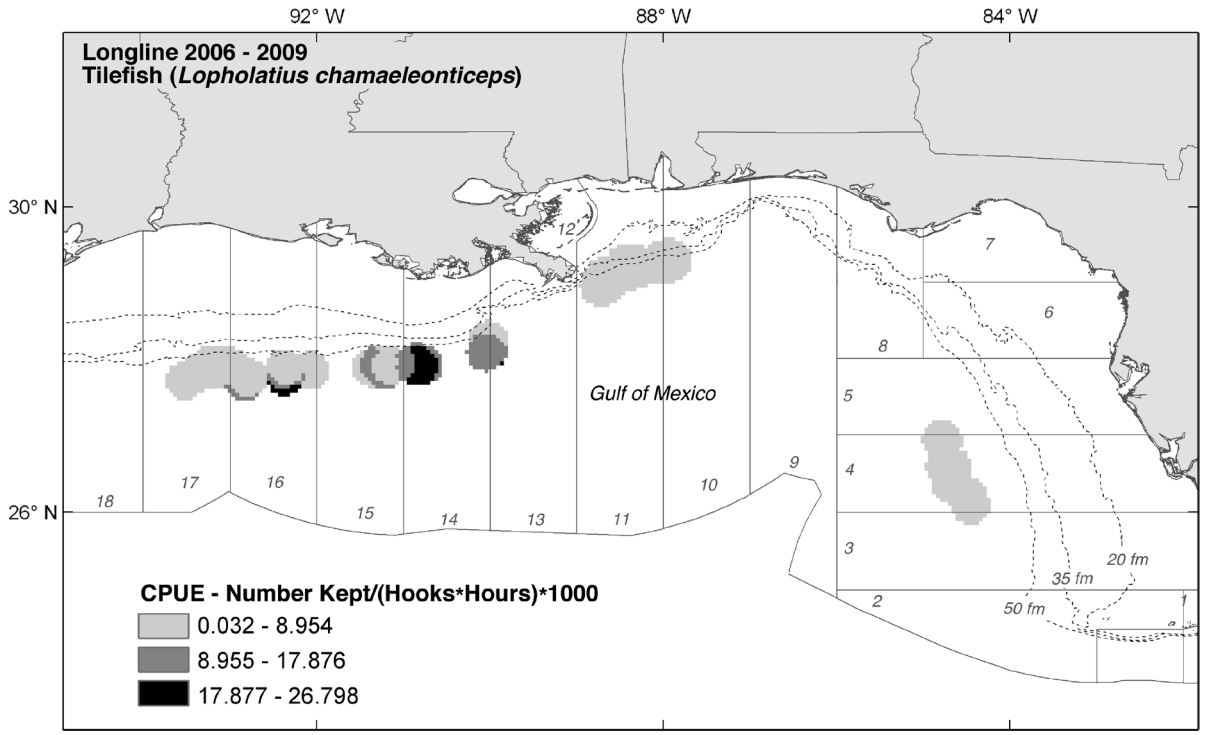

Figure 8.—CPUE density surface for tilefish kept in the bottom longline fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from August 2006 through November 2009.

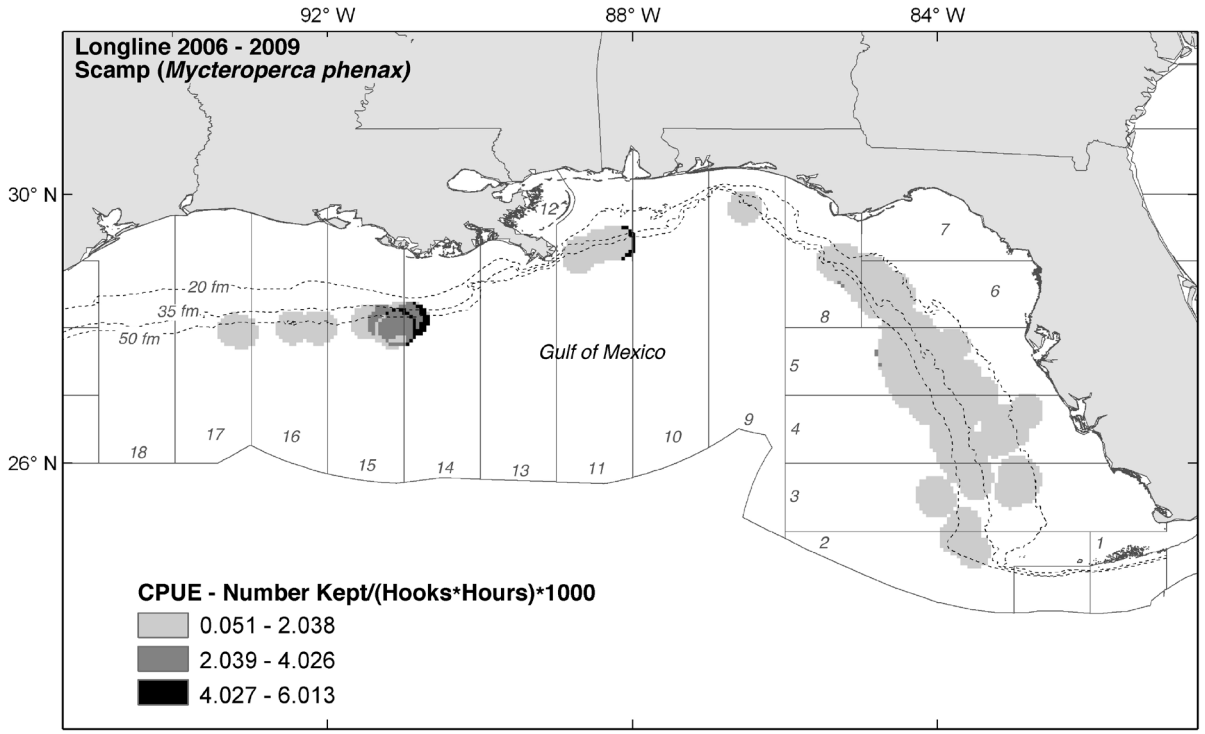

Figure 9.—CPUE density surface for scamp kept in the bottom longline fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from August 2006 through November 2009.

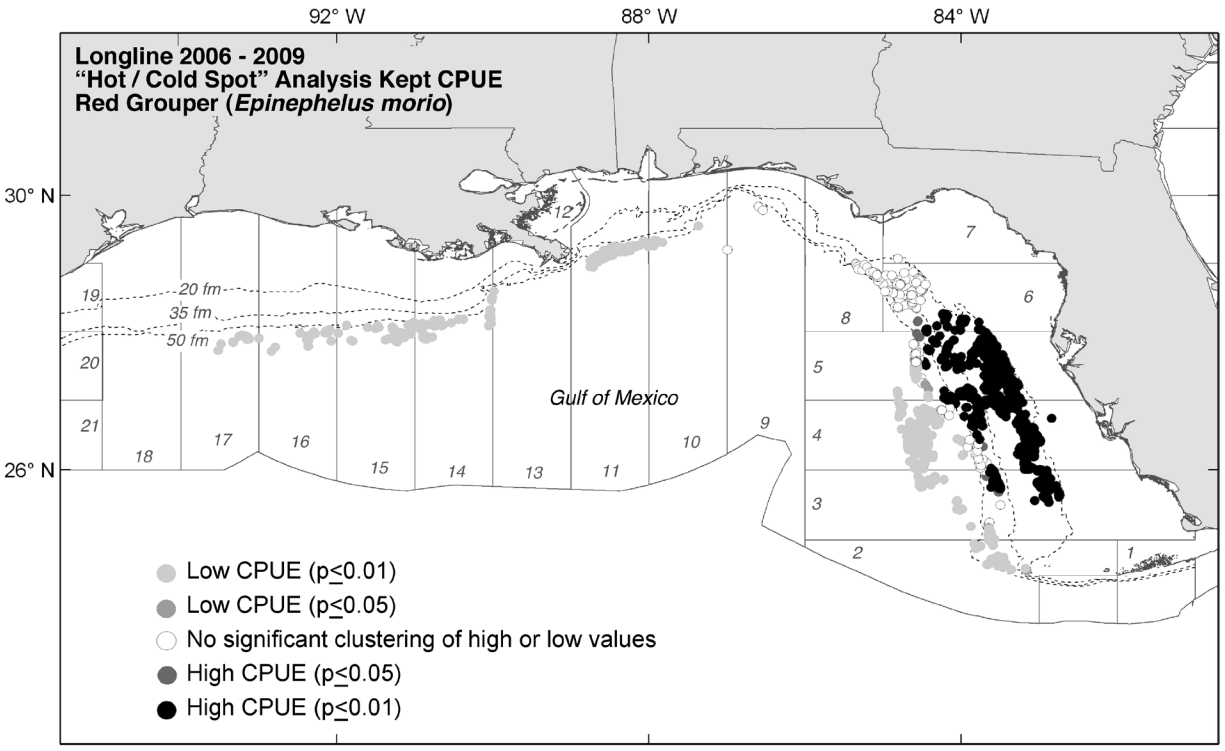

Figure 10.—Hot Spot Analysis for all kept red grouper in the bottom longline fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from August 2006 through November 2009.

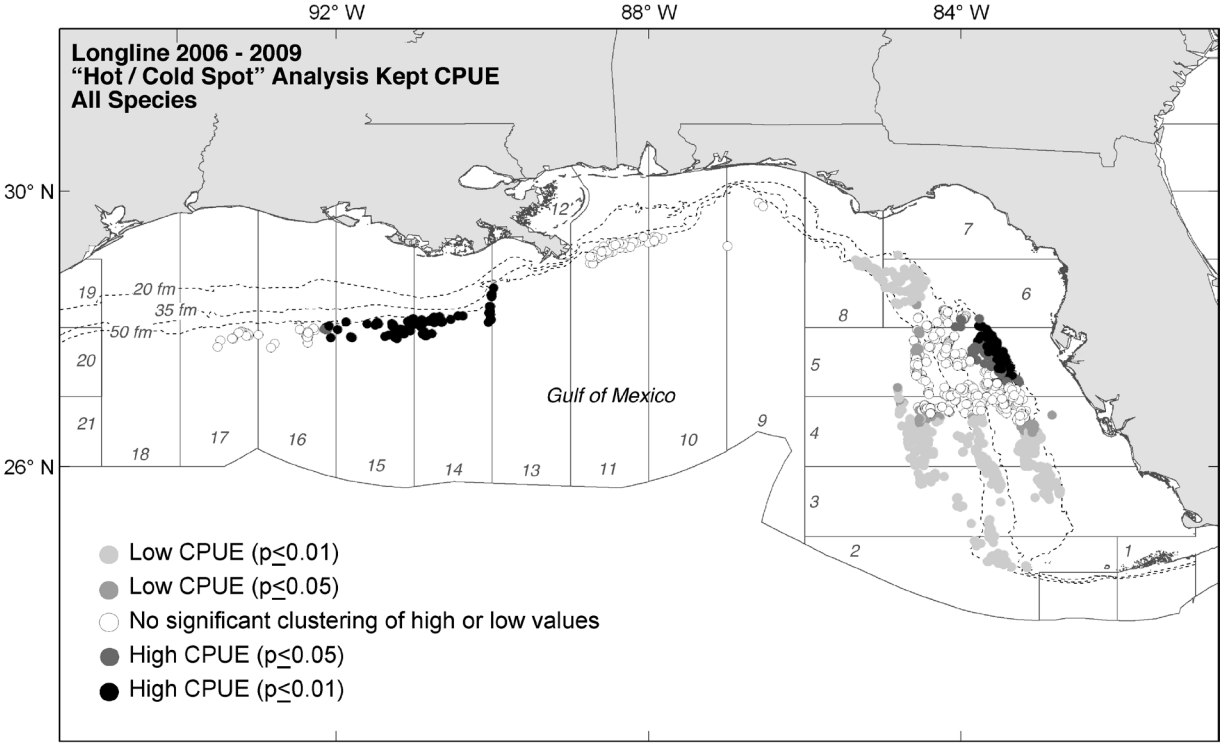

Figure 11.—Hot Spot Analysis for all kept species in the bottom longline fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from August 2006 through November 2009.

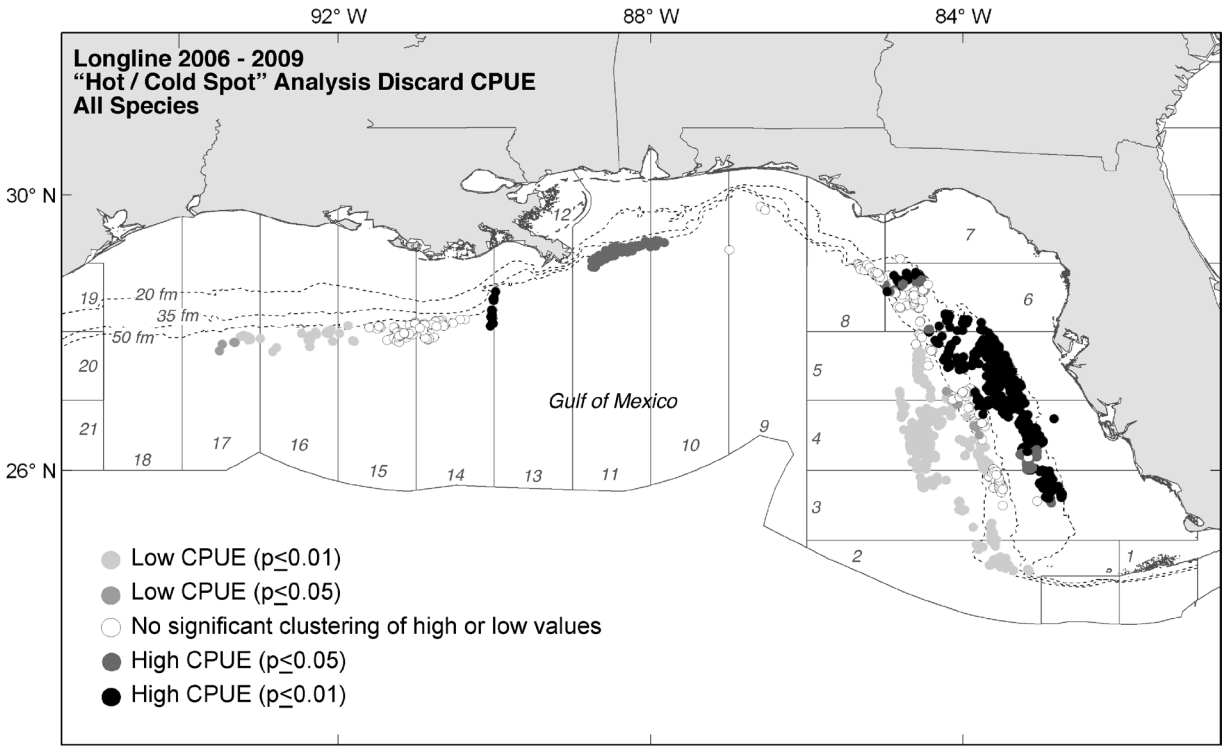

Figure 12.—Hot Spot Analysis for all discarded species in the bottom longline fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from August 2006 through November 2009.

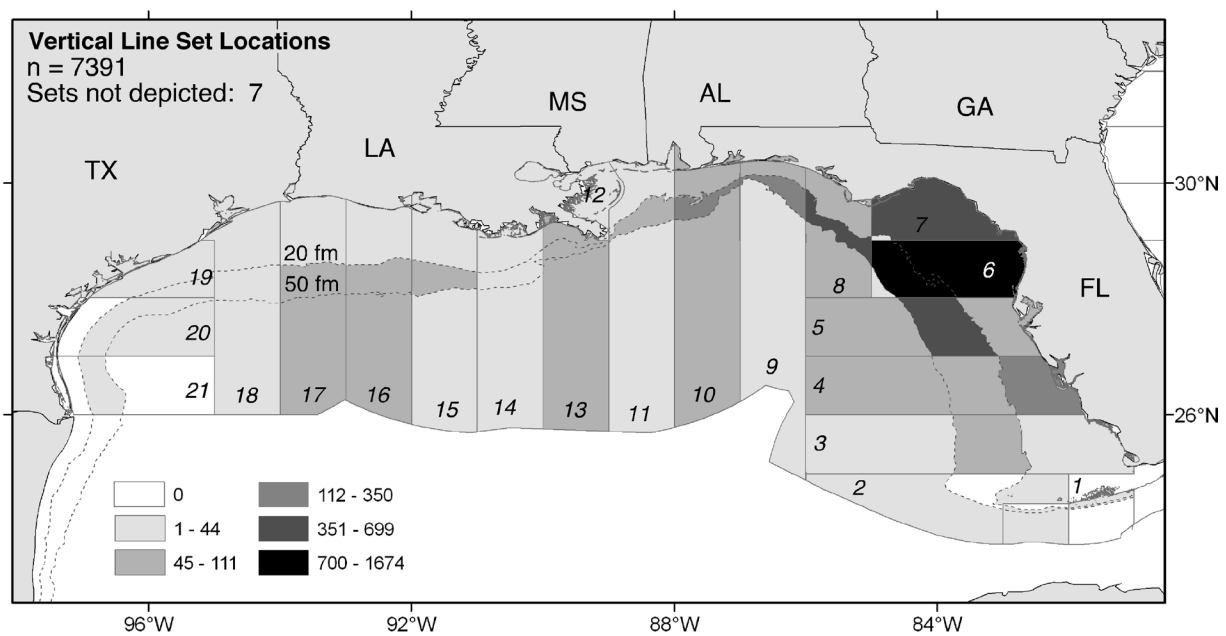

Figure 13.—Distribution of sampling effort (sets) based on observer coverage of the U.S. Gulf of Mexico vertical line reef fish fishery from July 2006 through December 2009.

and discard mortality associated with commercial fishing operations in the U.S. Gulf of Mexico reef fish fishery, a mandatory observer program was established in 2006 based on a proportional randomized sampling design stratified by season, gear, and region. Historically, these data, critical for population assessments, have not been available due to lack of time series and limited geographic ranges for affected species.

Table 7.—Coefficient of variation (CV) for Federally managed discarded species caught aboard longline vessels in the Gulf of Mexico from August 2006 to November 2009.

Common name	Scientific name	*n*	CV
Red grouper	*Epinephelus morio*	24,081	<0.1
Red snapper	*Lutjanus campechanus*	1,657	0.1
Blueline tilefish	*Caulolatilus microps*	1,824	0.1
Greater amberjack	*Seriola dumerili*	133	0.1
Gag	*Mycteroperca microlepis*	48	0.1
Vermilion snapper	*Rhomboplites aurorubens*	43	0.2
Tilefish	*Lopholatilus chamaeleonticeps*	67	0.2
Cobia	*Rachycentron canadum*	27	0.2
Speckled hind	*Epinephelus drummondhayi*	39	0.2
Yellowedge grouper	*Epinephelus flavolimbatus*	50	0.2
Lesser amberjack	*Seriola fasciata*	19	0.3
Lane snapper	*Lutjanus synagris*	18	0.3
Wenchman	*Pristipomoides aquilonaris*	17	0.3
Snowy grouper	*Epinephelus niveatus*	8	0.4
Scamp	*Mycteroperca phenax*	37	0.4
King mackerel	*Scomberomorus cavalla*	6	0.4
Gray snapper	*Lutjanus griseus*	5	0.5
Banded rudderfish	*Seriola zonata*	10	0.5
Red drum	*Sciaenops ocellatus*	16	0.6
Red hind	*Epinephelus guttatus*	2	0.7
Warsaw grouper	*Epinephelus nigritus*	2	0.7
Gray triggerfish	*Balistes capriscus*	2	0.7
Black grouper	*Mycteroperca bonaci*	2	0.7
Yellowtail snapper	*Ocyurus chrysurus*	3	0.7
Mutton snapper	*Lutjanus analis*	1	1.0
Rock hind	*Epinephelus adscensionis*	1	1.0

Data from this observer program revealed relatively high species richness from the two primary gears (longline n = 183 taxa; and vertical line n = 178 taxa). While diversity was high, red grouper and yellowedge grouper (in longline), and red snapper and vermillion snapper (in vertical line), comprised more than 60% by number of the species caught. These findings are similar to those described by Stephen and Harris (2010) of the snapper-grouper vertical line fishery off South Carolina. Their data revealed high overall diversity; however, a small number of species (17) accounted for 90% of catch.

Hale et al. (2010), through a mandatory bottom longline observer program, examined species composition and disposition of fish captured from longline sets targeting reef fish in the Gulf of Mexico and found, in order of abundance, that red grouper, blueline tilefish, tilefish, and yellowedge grouper comprised 76% of catch. In our current study, these four species accounted for 73% of the catch captured on longline gear. Moreover, disposition of these

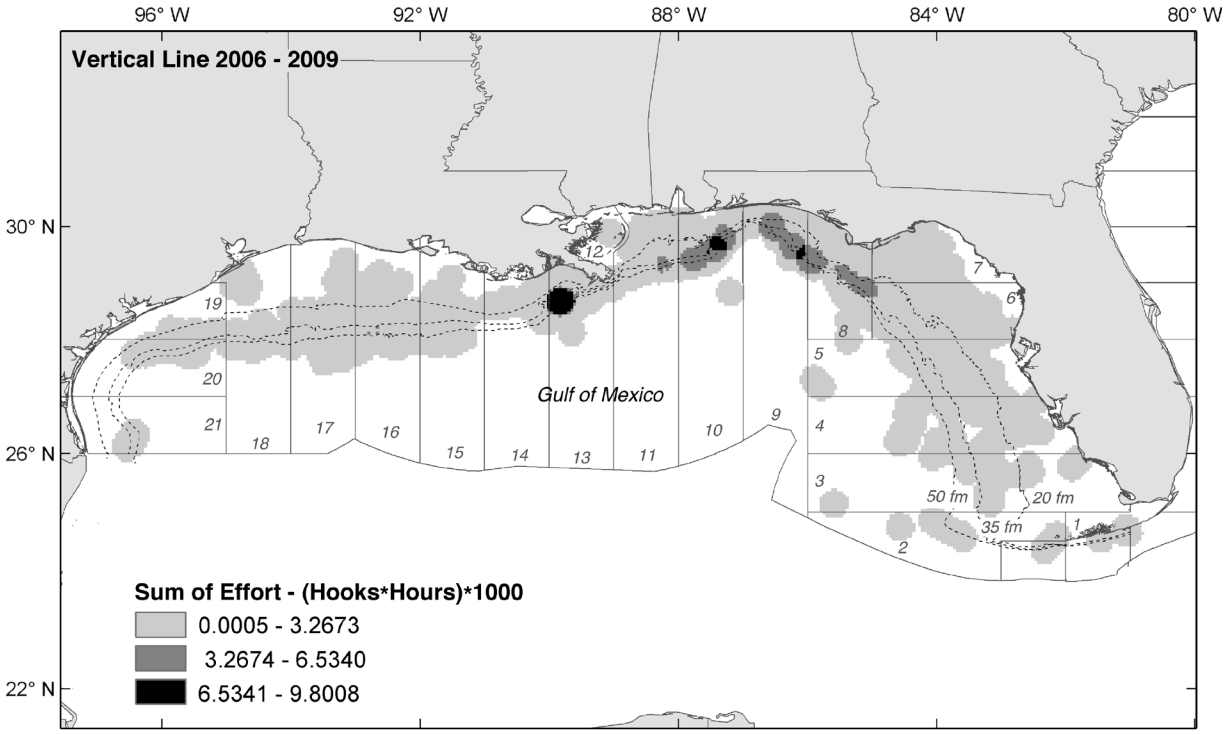

Figure 14.—Distribution of sampling effort (hook-hours) based on observer coverage of the U.S. Gulf of Mexico vertical line reef fish fishery from July 2006 through December 2009.

species was similar between the two programs for red and yellowedge grouper. Blueline tilefish and tilefish discard proportion rates were more variable, and most likely related to the 15 May 2009 tilefish quota closure.

In our current study, 46% of the individuals, predominately red and yellowedge grouper, were kept in longline. In vertical line, a larger percentage (71%) was kept and comprised primarily of vermilion and red snapper. While species-specific minimum size limits differ by region, Rudershausen et al. (2007), Stephen and Harris (2010), and Scott-Denton[9] reported low discard proportions for the vertical line trips; however, low discard

Table 8.—Number, condition (when brought onboard), and fate of fish species with $n>25$ caught using vertical line gear in the Gulf of Mexico from July 2006 to December 2009.

Fate upon release		Kept				Released alive				Kept for bait				Discarded dead				Unknown			
Condition upon capture			Live				Live				Live				Live				Live		
Common name	Total	Total	Normal	Stressed	Dead	Total	Normal	Stressed	Dead	Total	Normal	Stressed	Dead	Total	Normal	Stressed	Dead	Total	Normal	Stressed	Dead
Red snapper	27,669	17,992	11,368	5,771	38	6,590	4,824	1,673		8	1	6		2,737	1,367	1,308	16	342	104	64	
Vermilion snapper	26,045	23,240	21,994	920	5	1,235	1,095	108		105	64	8	2	1,105	1,037	42	21	360	189	1	
Red grouper	13,855	7,445	1,920	5,143		5,678	1,567	3,722		2	2			692	145	537	5	38	2	25	
Red porgy	6,120	5,971	5,022	196		40	38	1		81	77	1		22	13	8	1	6	1	1	
Gag	2,624	1,565	874	673		1,045	738	296						12	3	8	1	2		1	
Scamp	1,002	898	638	222	1	67	60	7						33	18	15		4		2	
King mackerel	886	868	861		5	11	11			2	1			5	1		4				
Gray snapper	822	775	497	183		44	44							3	3						
Chub mackerel	818					2	2			815	205		1	1							
Gray triggerfish	808	751	523	164		51	41	10						5	4	1		1	1		
Yellowtail snapper	770	722	720	2		37	37			5	5			6	5		1				
Greater amberjack	613	171	148			403	382	1		14	14			23	22			2	2		
Pinfish	598	8	8			13	13			570	103	2		7	6		1				
Blue runner	525	129	129			282	274			78	78			33	30		1	3	2		
Tomtate	494	2	2			16	16			457	279	1		19	19						
Almaco jack	453	285	280			105	103			52	52			11	10		1				
Lane snapper	416	388	141	242		9	3	6		3	2		1	16	12	3	1				
Knobbed porgy	396	377	293	1		6	6			13	13										
White grunt	259	118	108	10		58	58			50	47	3		25	25			8	8		
Banded rudderfish	255	55	54	1		87	87			65	59	1		34	34			14	14		
Lesser amberjack	219	139	121			62	62			9	9			9	9						
Snowy grouper	168	150	18	132		5		5						13	3	10					
Jolthead porgy	154	136	133	3		10	10			4	3	1		3	3			1			
Sand perch	130					6	5	1		123	49	28						1			
Little tunny	128	6	6			20	18			93	86		5	8	7		1	1	1		
Black seabass	127	67	61	6		54	45	9		2	1	1		3	2	1		1		1	
Florida pompano	114	112	112			2	2														
Creole-Fish	107	93	55	37		1	1			9	7	1	1	3	2	1		1		1	
Yellowedge grouper	104	88	1	86										15		15		1		1	
Sharks grouped	96					82	75			2	2			10	10			2			
Atlantic sharpnose shark	83	2	2			73	67			2	2			6	6						
Remora	80	1	1			61	58							18	18						
Bluefish	78	25	25			6	6			32	32			14	14			1	1		
Sand seatrout	74	30	11	17	2	5	4	1		6	5	1		31	18	13		2	2		
Silky shark	71	2	2			68	67							1	1						
Whitebone porgy	67	61	21		1	1	1			1	1			3	2			1	1		
Dolphin	67	45	45			3	3			19	19										
Sharksucker	64	2	1			58	54			1	1			3	3						
Grunt (genus)	63					2	2			60	60			1	1						
Spanish mackerel	62	44	44			13	13			3	3			2			2				
Bank seabass	61					22	10	12		26	10	2		13	4	9					
Crevalle jack	59					56	56			2	2			1	1						
Bar jack	57	44	37			8	7			4	4							1	1		
Warsaw grouper	54	33	3	29		12	2	10						8		8		1		1	
Queen snapper	50	48	31	17		1		1										1			
Sheepshead	46	46	39	7																	
Tilefish	45	44	13	31										1		1					
Great barracuda	45					23	21			4	4			18	17	1					
Red drum	43					37	17	19		1	1			5	1	4					
Blacktip shark	40					32	30							6	6			2	1		
Smooth dogfish	35	2	2			28	16							5	4						
Nurse shark	34					31	28							2	2			1			
Black grouper	34	32	15	11		2	1	1													
Blacknose shark	32					27	27							5	4		1				
Speckled hind	31	17	4	12		8	3	5						6	2	4					
Spotted moray	29					19	19			6	5			4	4						
Bigeye	29	26	26			2	2							1	1						
Cobia	28	13	12		1	14	14							1	1						
Seatrout (genus)	26	7	1	1		8	8			2	2			9	9						
Wenchman	25	4	1	3		2	1	1						19	5	14					
Total (all species)	89,015	63,351	46,602	13,988	55	16,872	10,350	5,914	0	2,805	1,363	61	12	5,185	2,972	2,086	63	802	333	98	0

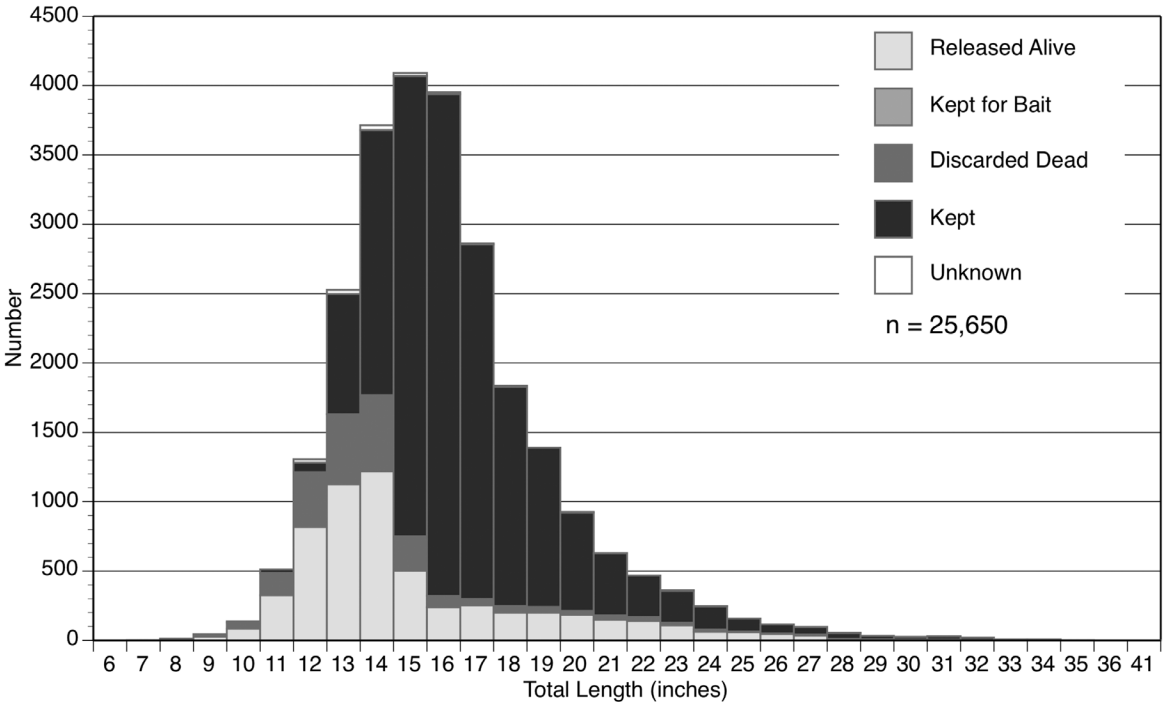

Figure 15.—Size and fate of red snapper caught on vertical line gear based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from July 2006 through December 2009.

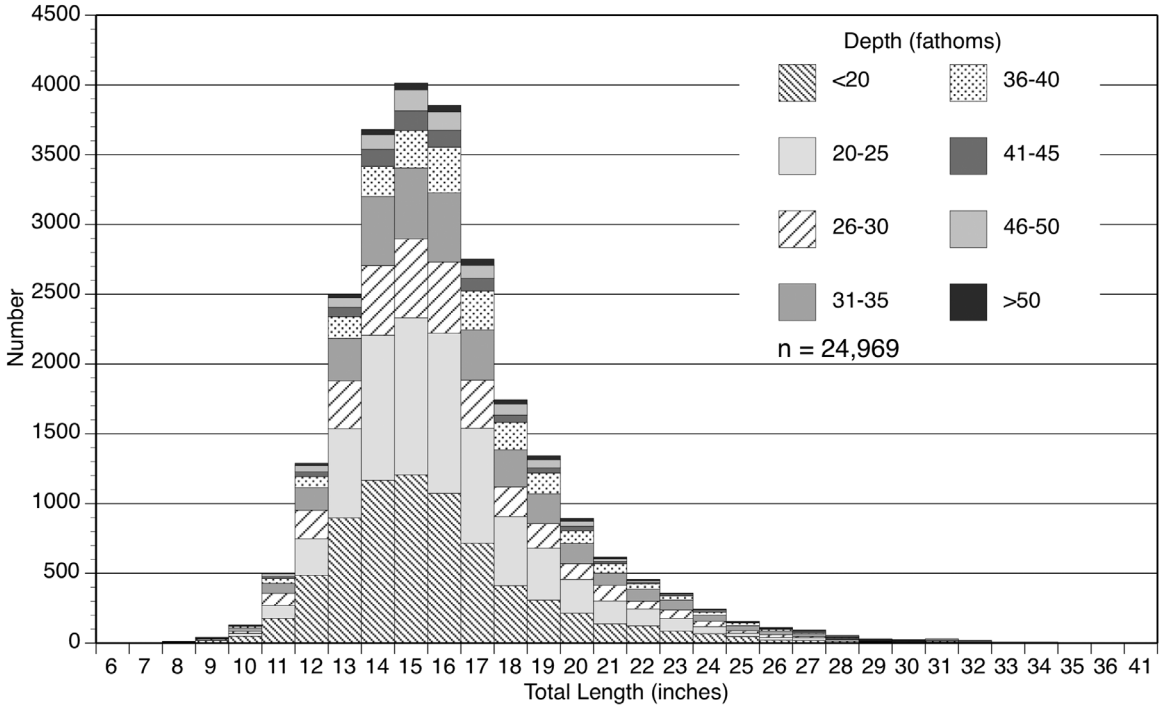

Figure 16.—Number of red snapper by size and depth zone caught on vertical line gear based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from July 2006 through December 2009.

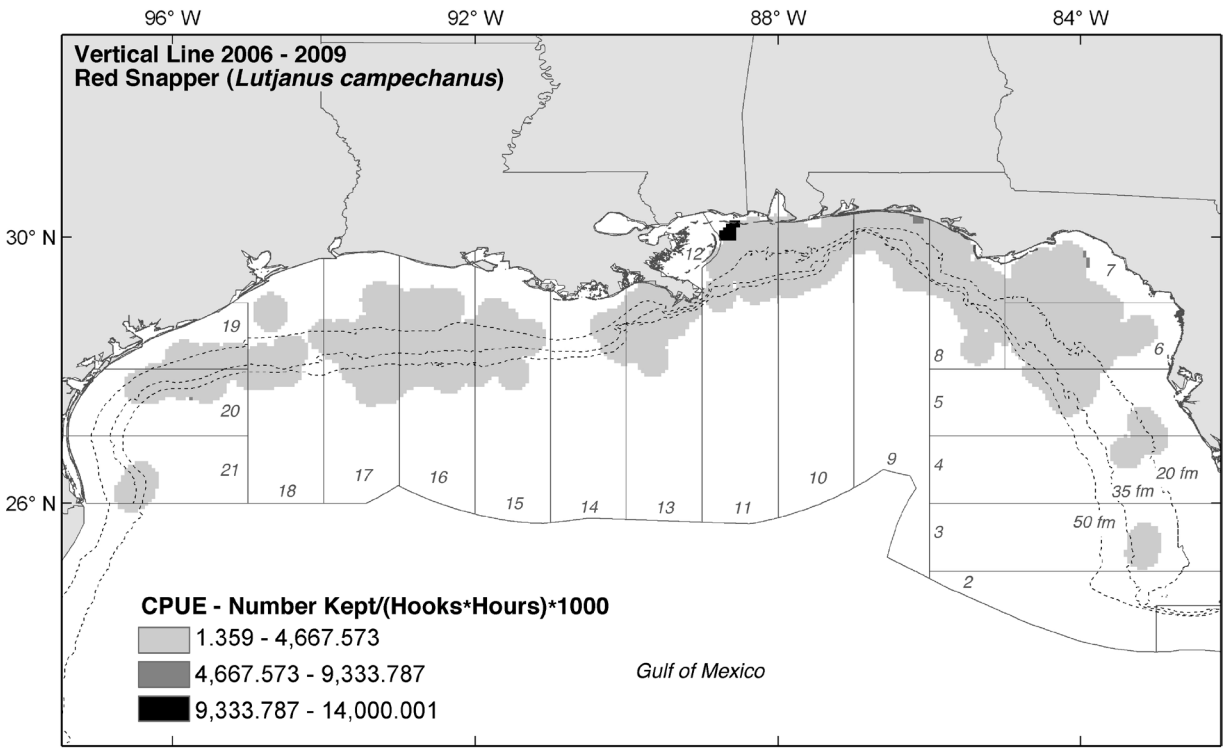

Figure 17.—CPUE density surface for red snapper kept in the vertical line fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from July 2006 through December 2009.

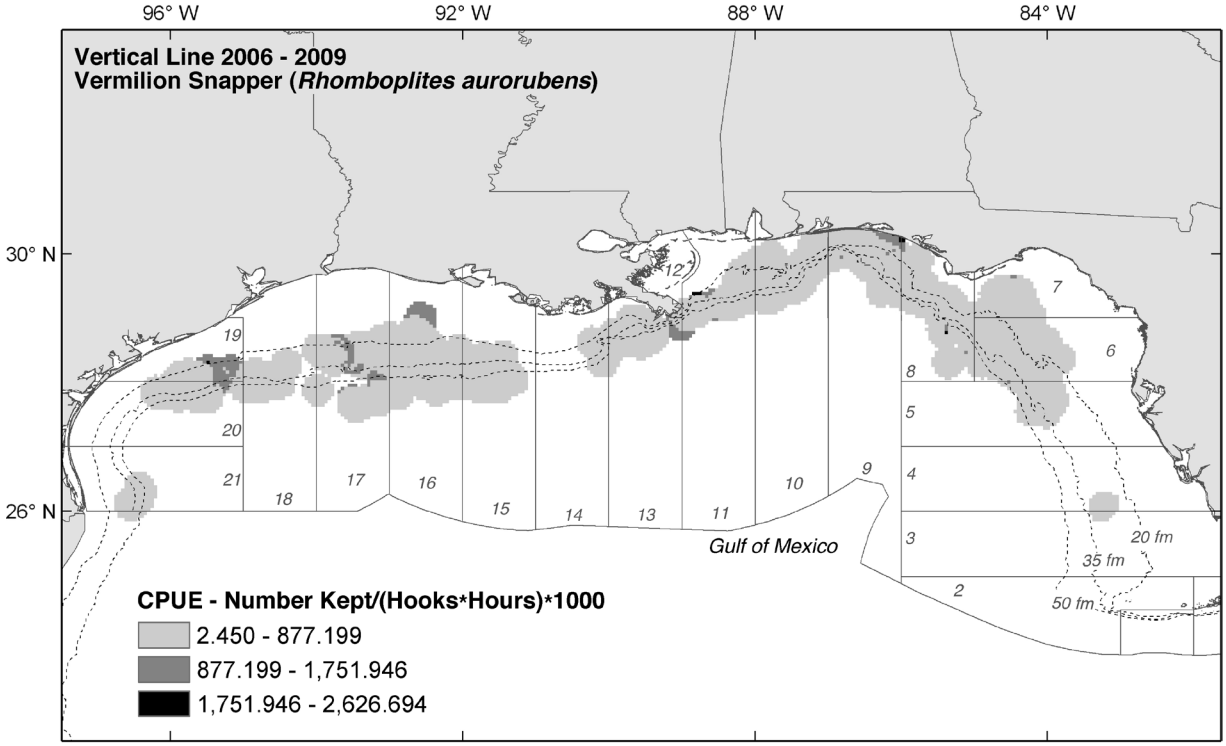

Figure 18.—CPUE density surface for vermilion snapper kept in the vertical line fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from July 2006 through December 2009.

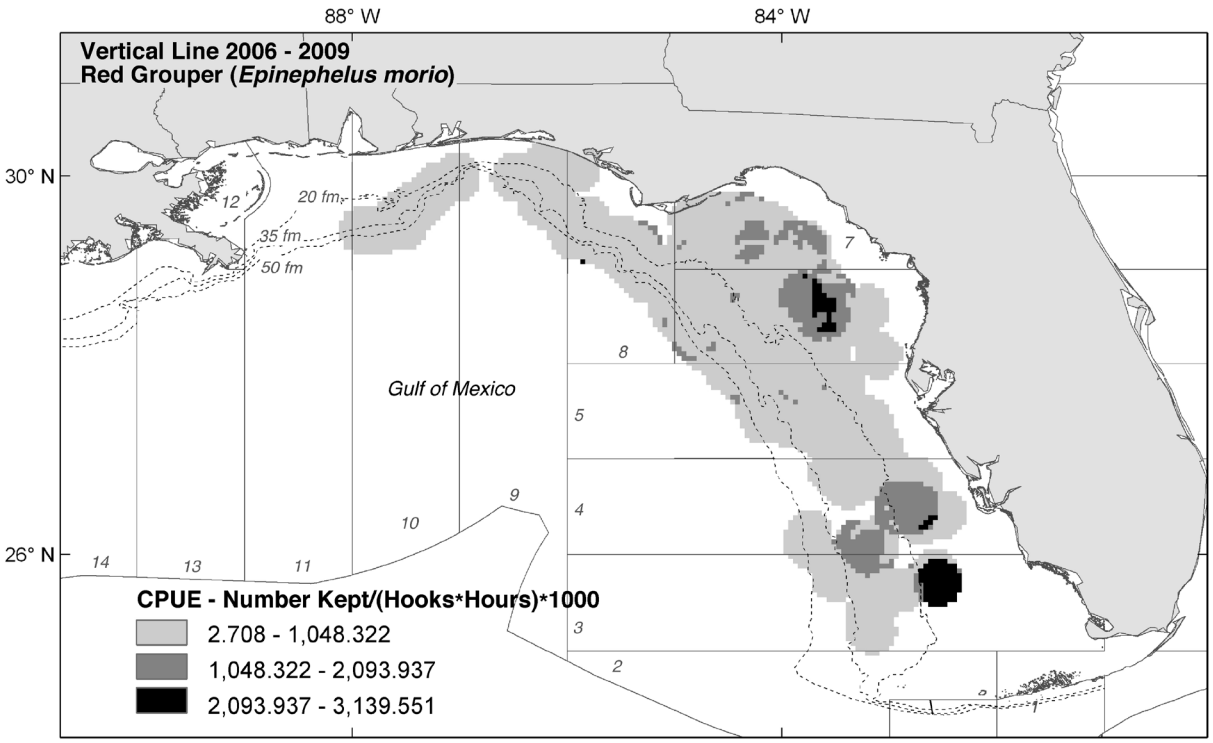

Figure 19.—CPUE density surface for red grouper kept in the vertical line fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from July 2006 through December 2009.

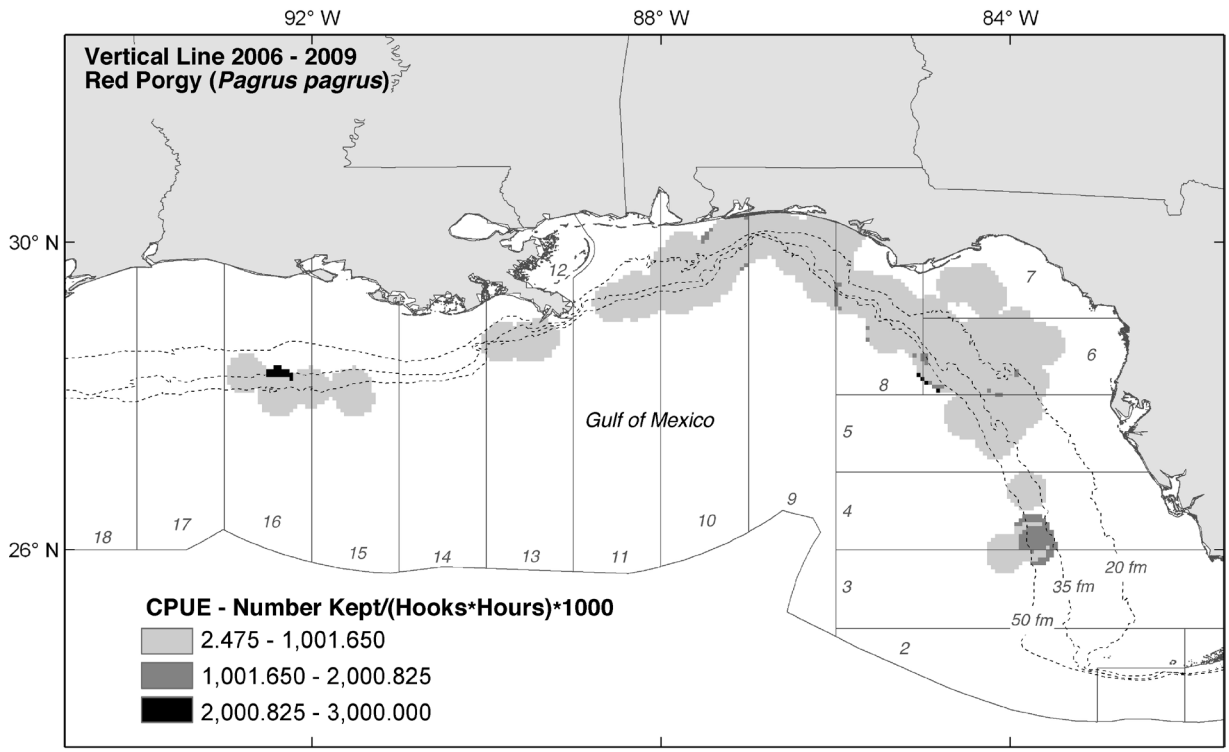

Figure 20.—CPUE density surface for red porgy kept in the vertical line fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from July 2006 through December 2009.

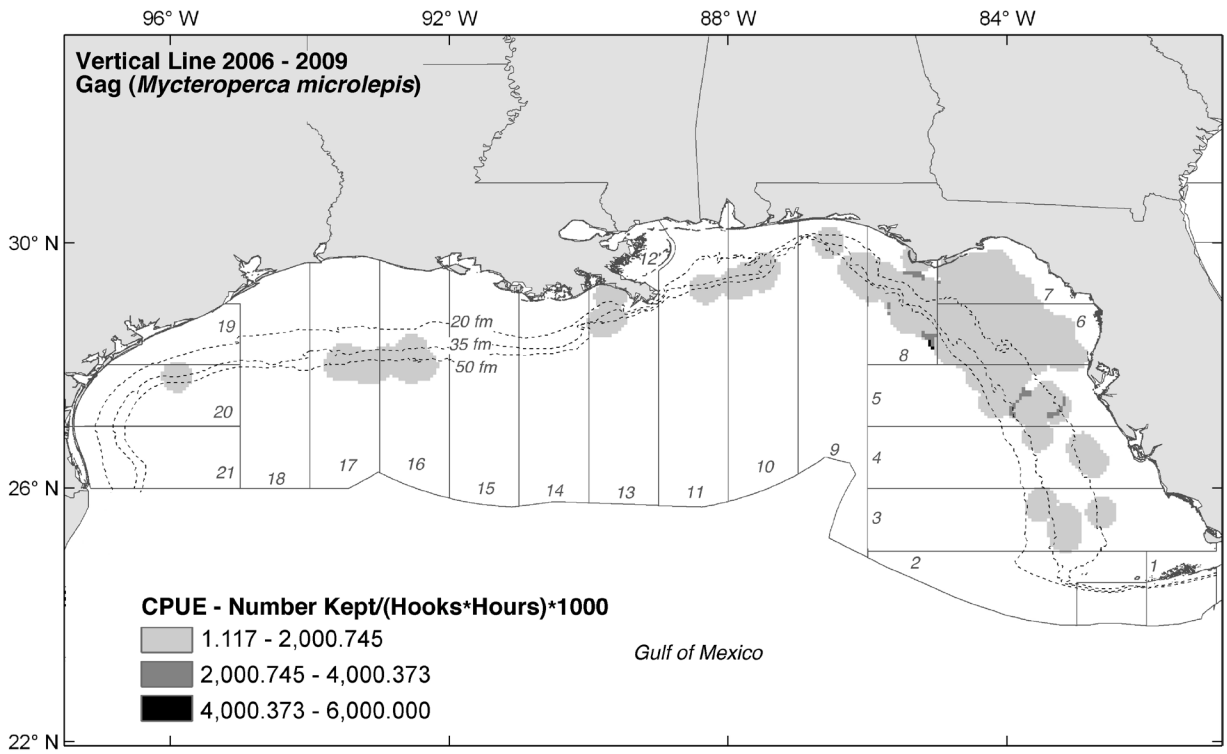

Figure 21.—CPUE density surface for gag kept in the vertical line fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from July 2006 through December 2009.

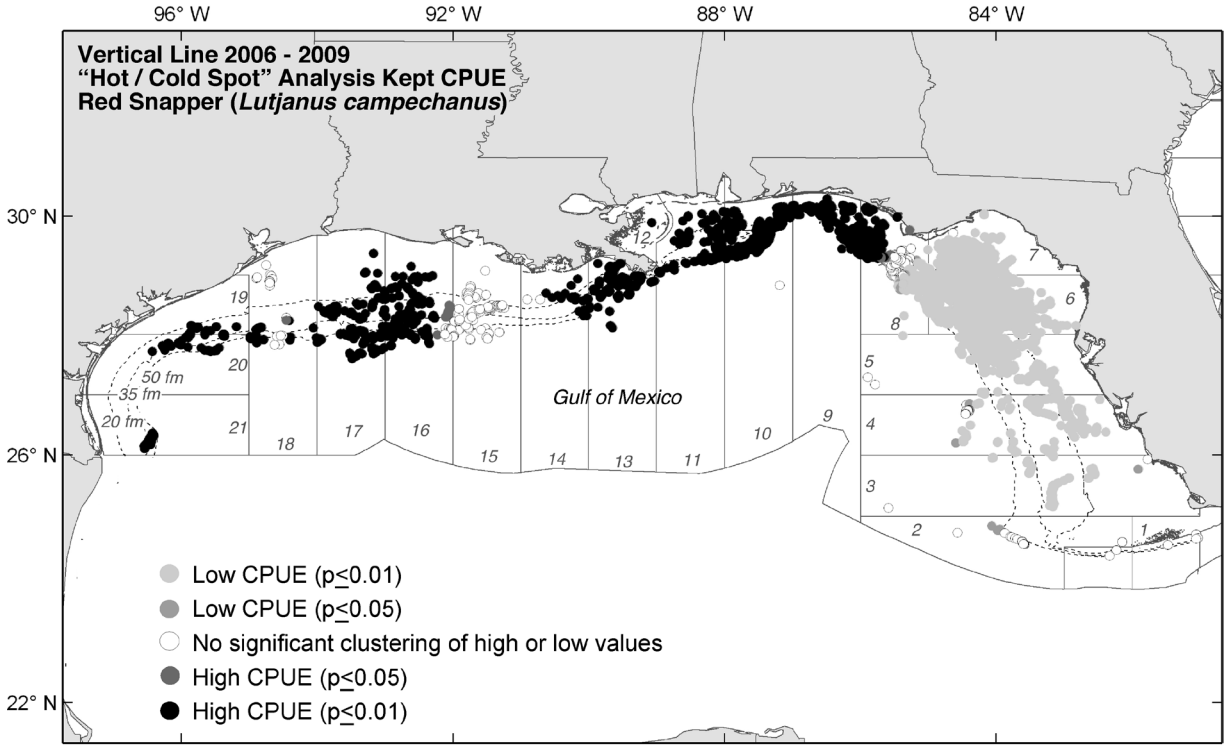

Figure 22.—Hot Spot Analysis for all kept red snapper in the vertical line fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from July 2006 through December 2009.

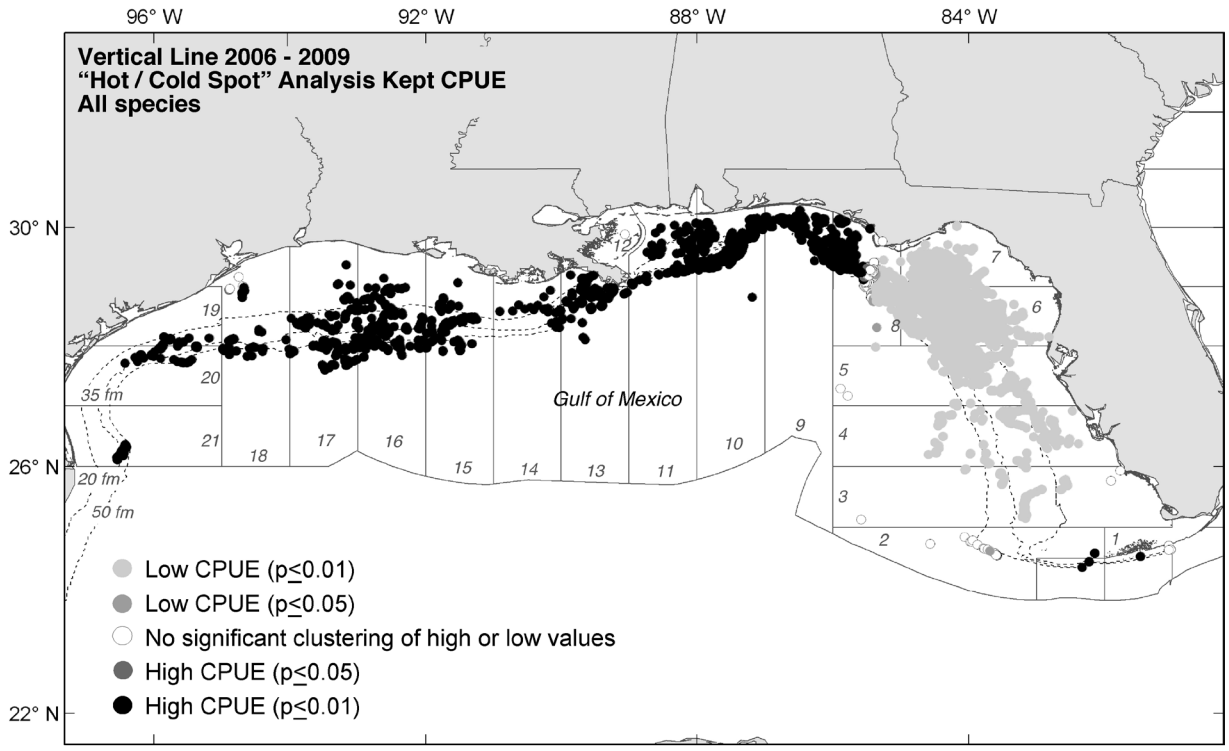

Figure 23.—Hot Spot Analysis for all kept species in the vertical line fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from July 2006 through December 2009.

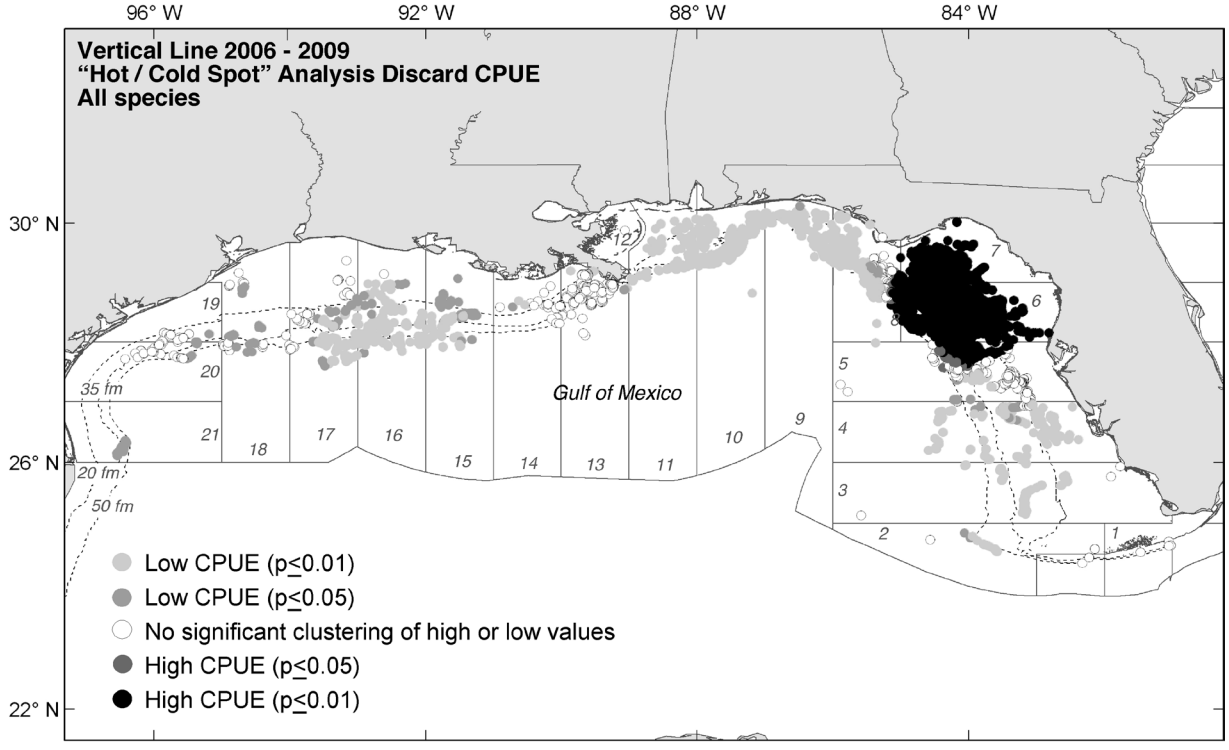

Figure 24.—Hot Spot Analysis for all discarded species in the vertical line fishery based on observer coverage of the U.S. Gulf of Mexico reef fish fishery from July 2006 through December 2009.

proportions may still adversely affect long-lived stocks.

Discard mortality rates are highly variable and influenced by a number of factors, including species-specific life history characteristics (Coleman et al., 2000; Patterson et al., 2002; Nieland et al., 2007), season (Render and Wilson, 1994) depth, and method of capture and release (Gitschlag and Renaud, 1994; Collins et al., 1999, Dorf, 2003; Rummer, 2007; Burns et al.[7]). Using the Marine Recreational Fishery Statistic Survey data from 1981–99 and findings from 53 release mortality studies, Bartholomew and Bohnsack (2005) found significant mortality factors related to hook location, bait removal, hook type, capture depth, water temperature, and handling time.

Through a tagging study conducted off the coast of Alabama, Patterson et al. (2002) indirectly estimated discard mortality of 13.5% for red snapper and <1% for gray triggerfish, based on surface release observations and recapture rates of fish caught with recreational gear. Red snapper (<18 in TL) comprised 93% of the released fish from a Texas headboat survey, of these 60.6% were released alive, 22.8% swam erratically, 15.2% floated, and 1.4% were discarded dead (Dorf, 2003). Diamond and Campbell (2009) examined red snapper caught on hook and line at three petroleum production platforms off south Texas and found immediate mortality at 17%; however, through the use of an injury status condition index, delayed mortality was estimated to be 64%.

Variable minimum assumed mortality rates and discard proportions may also be attributed to regulatory changes in minimum size limits and through implementation of IFQ requirements for several species, notably, red snapper, red grouper, and tilefish. Minimum assumed mortality (all discarded species combined) in this study was 24% in longline and 23% in vertical line. By species, immediate mortality for red grouper was 20% in longline and 11% in vertical line, with minimum assumed mortality for red snapper of 27% and 28%, in longline and in vertical line, respectively.

Table 9.—Coefficient of variation (CV) for Federally-managed discarded species caught aboard vertical line vessels in the Gulf of Mexico from July 2006 to December 2009.

Common name	Scientific name	*n*	CV
Red grouper	*Epinephelus morio*	6,597	<0.1
Red snapper	*Lutjanus campechanus*	19,227	<0.1
Vermilion snapper	*Rhomboplites aurorubens*	5,754	<0.1
Gag	*Mycteroperca microlepis*	1,096	<0.1
Greater amberjack	*Seriola dumerili*	621	<0.1
Lesser amberjack	*Seriola fasciata*	136	0.2
Gray triggerfish	*Balistes capriscus*	124	0.3
Warsaw grouper	*Epinephelus nigritus*	32	0.3
Snowy grouper	*Epinephelus niveatus*	32	0.3
King mackerel	*Scomberomorus cavalla*	20	0.3
Banded rudderfish	*Seriola zonata*	363	0.3
Scamp	*Mycteroperca phenax*	189	0.3
Cobia	*Rachycentron canadum*	24	0.3
Goliath grouper	*Epinephelus itajara*	12	0.4
Speckled hind	*Epinephelus drummondhayi*	24	0.4
Yellowedge grouper	*Epinephelus flavolimbatus*	28	0.4
Red drum	*Sciaenops ocellatus*	114	0.4
Lane snapper	*Lutjanus synagris*	79	0.4
Wenchman	*Pristipomoides aquilonaris*	52	0.4
Blueline tilefish	*Caulolatilus microps*	8	0.5
Red hind	*Epinephelus guttatus*	11	0.5
Rock hind	*Epinephelus adscensionis*	4	0.5
Yellowtail snapper	*Ocyurus chrysurus*	48	0.6
Gray snapper	*Lutjanus griseus*	49	0.6
Spanish mackerel	*Scomberomorus maculatus*	18	0.7
Black grouper	*Mycteroperca bonaci*	2	0.7
Queen snapper	*Etelis oculatus*	3	0.7
Silk snapper	*Lutjanus vivanus*	3	1.0
Tilefish	*Lopholatilus chamaeleonticeps*	1	1.0
Mutton snapper	*Lutjanus analis*	1	1.0
Yellowmouth grouper	*Mycteroperca interstitialis*	1	1.0

Stephen and Harris (2010) reported immediate mortality range of 33–100% for vertical line trips targeting vermilion snapper off South Carolina, with >90% mortality observed for gray triggerfish, greater amberjack, scamp, and red snapper. Nieland et al. (2007), using four release condition categories, similar but more detailed than that of this study, assessed the fate of red snapper regulatory discards aboard commercial vertical line vessels operating primarily off Louisiana and found 69% of discarded red snapper were either dying or dead when released.

Rudershausen et al. (2007) examined discard composition in the commercial snapper-grouper fishery in North Carolina and found low (<10%) immediate release morality for vermilion snapper, gag, and red grouper; moderate (14%) mortality for red porgy; and high (23%) immediate mortality for scamp.

In our study, red snapper ranged from 6–41 in TL with a mode of 15 in TL. Nieland et al. (2007), using specimens collected from commercial red snapper landings, described a similar unimodal distribution with the mode at 400 mm (15.7 in) TL, noting that 98% were less than 600 mm (23.6 in) TL. Red grouper length frequency data from NMFS bottom longline surveys in the Gulf of Mexico from 2000 through 2005 depicted a distribution range of approximately 10–34 in TL with a mode 18 in TL (Ingram et al.[19]); a similar range and mode as observed in this study.

Estimated CPUE for all species combined in the longline fishery was 0.0095 fish per hook-hour. Highest density CPUE (numbers of fish kept per 1,000 hook-hours) occurred in the eastern Gulf for red grouper and blueline tilefish, a similar distribution as reported by Ingram et al.[19] In deeper waters of the western Gulf, yellowedge grouper, tilefish, and scamp had high CPUE density values. For vertical line, the catch rate for all species was higher (0.0311 fish per hook-hour) than observed in longline. Highest CPUE for red snapper occurred in the western Gulf, consistent with SEDAR.[3] Density CPUE values

[19]Ingram, W., M. Grace, L. Lombardi-Carlson, and T. Henwood. 2006. Catch rates, distribution and size/age composition of red grouper, Epinephelus morio, collected during NOAA Fisheries Bottom Longline Surveys from the U.S. Gulf of Mexico. SEDAR-12-DW-05. Southeast Data Assessment and Review, South Atl. Fish. Manage. Counc., Charleston, SC (available at www.sefsc.noaa.gov/sedar/).

were higher and more dispersed in vertical line for other dominant species (vermilion snapper, red grouper, red porgy, and gag).

As prescribed by NMFS' National Bycatch Strategy addressing fishery bycatch on a national level, precision goals for bycatch estimates are defined in terms of CV estimates (NMFS, 2004). The precision of single species bycatch estimates is needed for population assessments; however, the reef fish fishery has bycatch from several stocks. In our study, CV estimates were low (0.1) for undersize target species, notably red grouper and red snapper. CV estimates for other species of commercial, recreational, and ecological importance, including several species of grouper and snapper, were relatively high and in some instances equal to 1.0.

In terms of areas of high bycatch, management measures to reduce bycatch should consider targets that include changes in fishing behaviors relative to avoidance of high bycatch areas, modifications of gear to reduce bycatch, and cooperative efforts to close areas with high bycatch. As illustrated by Hot/Cold Spot Analysis[15], areas of highly significant rates of discards were identified. In longline, discard CPUE density was significantly higher in statistical areas 3 through 6. For vertical line, discard catch rates were significantly higher and concentrated off Florida in statistical areas 5 through 7.

Prior to a mandatory observer program, self-reporting through logbook and discard supplementary data submission were used to estimate sea turtle take projections in the reef fish fishery and formed the basis of biological opinions pursuant to formal consultation under Section 7 of the ESA (NMFS[20]). Observers documented twenty sea turtle interactions, notably in the bottom longline component, during the study period (SEFSC[18]), resulting in important implications for management. In October 2009, a new biological opinion on the Gulf of Mexico reef fish fishery was completed with regulatory measures designed to minimize the impacts of future takes and monitor levels of incidental take (Fed. Regist.[21]).

Observer programs remain the most reliable means for monitoring fishery characteristics by not only providing insight on protected species interactions, but also for assessing quota and size restrictions, IFQ programs, CPUE, discard levels, gear effectiveness, and a wide array of other variables of interest to fishery managers, the fishing industry, academia, and the public.

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