NOAA Technical Memorandum NMFS-SEFSC-636

CHARACTERIZATION OF THE U.S. GULF OF MEXICO SKIMMER TRAWL FISHERY BASED ON OBSERVER DATA

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Introduction

The skimmer trawl fishery in the northern Gulf of Mexico primarily targets inshore areas to harvest penaeid shrimp (Family Penaeidae). Skimmer trawls were first developed in the early 1980's in Louisiana and have become more widely used since that time (Hein and Meier, 1995). From 1992 to 2000, the number of skimmer trawl licenses acquired in Louisiana almost doubled from 1,836 to 3,655 (Epperly et al., 2002). In 2011, based on state penaeid shrimp trips obtained from the National Marine Fisheries Service (NMFS) Gulf Shrimp System (GSS) database there were 10,502 skimmer trawl trips in the state of Louisiana. In recent years, skimmer trawl gear has also been documented in other Gulf coast states including Alabama and Mississippi[1,2]. Hein and Meier (1995) and Hines et al. (1993) described in detail skimmer trawl operations in coastal Louisiana and North Carolina.

The typical layout of a skimmer trawl vessel is illustrated in Figure l. Skimmer trawls use nets attached to rigid frames on each side of the vessel instead of the traditional otter trawl rig used by the majority of the shrimp fishery. Vessels commonly push the nets through the water column, but they can also be passively fished by relying on tidal flow to catch shrimp. By having the nets fixed to the vessel, the bags (cod ends) can be retrieved while the nets fish continuously. Coale et al. (1994) examined skimmer trawl catch rates in North

[1] Alabama Marine Resource Division. 2012. P.O. Drawer 458, Gulf Shores, Alabama.
[2] Mississippi Department of Marine Resources. 2012. 1141 Bayview Ave., Biloxi, Mississippi.

Carolina and found them to be highly effective for targeting white shrimp, *Litopenaeus setiferus*, with a lower bycatch rate than otter trawl gear.

In the northern Gulf of Mexico skimmer trawl fishery, data collection of sea turtle interactions is critical to our understanding of potential sea turtle mortality. Sea turtle mortality may result from interactions with the commercial shrimp fishery in the Gulf of Mexico (Magnuson et al., 1990; Epperly et al., 2002). The five species of sea turtles potentially affected are as follows: leatherback, *Dermochelys coriacea*; Kemp's ridley, *Lepidochelys kempii*; hawksbill, *Eretmochelys imbricata*; loggerhead, *Caretta caretta*; and green, *Chelonia mydas*. All of these species are currently listed as threatened or endangered under the Endangered Species Act (ESA) of 1973 as amended (16 U.S.C. 1536 et seq.). Bycatch mitigation in the otter trawl fishery requires the use of turtle excluder devices (TEDs).

Skimmer trawls are currently exempt from the use of TEDs, but are required to adhere to seasonal tow-time restrictions of less than 55 min from April 1 to October 31 and no more than 75 min for the rest of the year[3]. In May 2012, a proposed rule to implement the use of TEDs in the skimmer trawl fisheries was published by the NMFS Southeast Regional Office[4]. The purpose of this rule was

[3] Federal Register. 1992. Final rule establishing limited tow-times as an alternative to turtle excluder devices. 57 FR 57348.
[4] Federal Register. 2012. Proposed rule to withdraw the alternative tow-time restriction and require all skimmer trawls, and wing nets (butterfly trawls) rigged for fishing to use turtle excluder devices in their nets. 77 FR 27411.

to reduce the incidental bycatch and mortality of sea turtles potentially associated with the fishery.

Due to the increased interest in the potential for sea turtle interactions in the fishery, from May to August 2012 mandatory observer coverage was initiated for skimmer trawl vessels operating in the northern Gulf of Mexico. NMFS-approved observers had been previously placed on a voluntary basis aboard skimmer vessels during 2004 and 2005 in coastal Louisiana. Scott-Denton et al. (2007) describes in detail the catch rates of target and non-target species, including sea turtles, encountered during this initial study. From 2008 through 2010, observers were placed aboard skimmer vessels in the northern Gulf of Mexico and North Carolina for TED evaluations through a voluntary observer program. Price and Gearhart (2011) describe the results from these studies that focus on bycatch reduction and shrimp loss associated with TED use.

The primary objectives of our recent study were to: 1) document interactions with threatened or endangered sea turtles during commercial shrimping operations and; 2) quantify both target and nontarget species by area.

The specific objectives of this paper are to: 1) summarize trip, vessel, environmental, and gear characteristics; 2) quantify fish and protected species capture; and 3) estimate catch per unit of effort (CPUE) trends and spatial distribution for target and nontarget species, excluding protected species.

Methods

Methods used in this investigation were similar to those described for the voluntary coastal Louisiana skimmer trawl observer program in 2004-2005 (Scott-Denton et al., 2007), and for the current mandatory Federal shrimp observer program operating in the U.S. Gulf of Mexico and along the U.S. southeastern Atlantic coast (Scott-Denton et al., 2012). For this investigation, NMFS-approved observers were placed on selected skimmer trawl vessels fishing primarily for brown shrimp off Louisiana, Mississippi and Alabama during May to August 2012.

The authority to place observers falls under the under the Endangered Species Act of 1973 as amended. In addition, pursuant to Magnuson- Stevens Fishery Conservation and Management Act (MSFCMA; 16 USC 1801), fishery permit or license holders are required to carry an observer if selected for Federal mandatory coverage. Among the several provisions promulgated under MSFCMA § 303(b)(8) is a mandate for vessel owners to obtain a current Commercial Fishing Vessel Safety Examination decal prior to the selection period for Federal mandatory observer coverage.

A mandatory selection process was used in this investigation. Selection was based on 2011 state penaeid shrimp trips obtained from the GSS database. Observer effort allocation for a particular area was determined from the previous year of effort reported in the GSS database, stratified by state (LA, MS, AL), and

month (March to July). All gear types were used in the selection process since specific gear type data (e.g. skimmer) were not available from all states. However, the majority (63%) of trips from the GSS database were skimmer trawl, 31% otter trawl, and 6% other gear combined. All 2011 penaeid shrimp trips were used to yield percent effort (total trips) and the subsequent number of vessels to select from each state (LA, MS, AL) based on the allocated funding level for 750 sea days. State license files provided by each state included owner names, contact information, and vessel size. The state license files were randomized by computer-generated lists and the required number of vessels were selected (e.g., the first 151).

Due to work and safety considerations, vessels less than 23 feet in length were removed from the selection pool. Consequently, the three-state universe of 2,495 vessels, was reduced by 531 (21%) due to the size of vessel. From the reduced universe, 376 permit holders were selected and notified by certified mail. Upon receipt of the letter, vessel owners were required to contact program staff within 24 hours to make arrangements to carry an observer. Selections were without replacement.

Initially, only one selection period was designed to yield approximately 750 sea days of coverage (151 vessels @ 5 sea days) during the April to July period. Most of the selected vessels were from Louisiana (89%), followed by Alabama (7%), and Mississippi (4%). A second selection (150 vessels) was made

after a substantial number of selected vessels were reported as having been sold, were inactive, were using otter instead of skimmer trawl gear (29%), or did not contact program staff (50%). A third selection (75 vessels) was made for June to July for Alabama and Mississippi after areas of Louisiana inshore waters were closed to the shrimp fishery.

Although most trips were typically two days in duration, a minimum sea day requirement of 5 days was established to augment logistical considerations and minimize travel costs. This often resulted in more than one trip on a selected vessel. One vessel with a current safety decal was granted an exemption during the study due to observer safety concerns (i.e., space limitation).

For each observed trip, vessel length, hull construction material, gross tonnage, engine horsepower, and crew size information were recorded. Gear characteristics related to bycatch reduction device (BRD), TED, net type and other associated gear were recorded at the start of each trip, and updated if changes were made during the trip. Tow time, vessel speed, and operational aspects relative to each net were also documented for each tow.

Skimmer trawl vessels use two framed nets (port and starboard) during fishing operations. For the entire duration of the trip, both nets were monitored for protected species interactions. For sampling finfish and shrimp, the observer randomly (coin flip) picked a net to start sampling, i.e. port or starboard. The observer continued to sample that net until a break in fishing operations or the end

of the trip, whichever came first. At that point, the observer sampled the other net. The net being sampled was alternated back and forth until the observer coverage was completed on the vessel.

For the net being sampled, tow time in and out was defined as when the cod end (bag) was deployed in the water and when the cod end was brought onboard the vessel (i.e., bag in - bag out). All tow times were recorded to the nearest whole minute. Cod ends may be periodically brought up to the surface without being brought onboard (remaining in the water) to determine the size of the catch and check for protected species interactions. During this study, one vessel regularly brought the cod ends to the surface without being brought onboard (within ~ 10 feet of the vessel), whereas other vessels brought the cod ends to the surface farther away from the vessel. This did not effect the tow times in our study, as tow time out was not recorded until the cod ends were brought fully onboard the vessel.

Skimmer trawl operations allow the nets to fish continuously while retrieving only the cod end. For tows when the frames remained in the water between tows, the subsequent tow's start time was recorded as the next whole minute after the previous tow's end time. This accounted for the time when frames remained in the water while dumping the catch and redeploying the cod end. If both the frames and cod ends were picked up, the next tow's start time

was recorded when the frames and cod ends were redeployed, as both are deployed simultaneously.

On the majority of vessels (78%), both cod ends were picked up at the same time. Thus tow times are known for both nets. However, on some vessels the cod ends were not picked up at the same time. For these vessels, the observer only recorded the time in and out for the net being sampled.

For the net being sampled, the observer attempted to obtain a total weight of the catch and total shrimp weight. Depending on the vessel layout and fishing operations, observers made an effort to characterize a portion or subsample of the catch for species grouping. A detailed description of at-sea collection methods and data requirements are presented in the Galveston Laboratory's observer manual entitled "Characterization of the U.S. Gulf of Mexico and Southeastern Atlantic Otter Trawl and Bottom Reef Fish Fisheries"[5].

Extrapolation, CPUE, and variance estimates are the same as described by Scott-Denton et al. (2011) and Scott-Denton et al. (2012). To identify patterns in CPUE for species of interest, a local spatial statistic, the Getis-Ord Gi* (Gi*), was calculated using the Hot Spot Analysis tool in ArcGIS[6,7] to locate clusters of

[5] NMFS. 2010. Characterization of the U.S. Gulf of Mexico and southeastern Atlantic otter trawl and bottom reef fish fisheries. Observer Training Manual. NMFS, Southeast Fisheries Science Center, Galveston Laboratory, Galveston, Texas. (available at http://galveston.ssp.nmfs.gov/research/fisherymanagement).

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

[7] ArcGIS 10.0 Computer Software. 380 New York Street, Redlands, California 92373 (available at http://www.esri.com/software/arcgis/index.html).

features with similarly high or low values. A detailed description of the Hot Spot Analysis tool is given in Scott-Denton et al. (2011) and Scott-Denton et al. (2012). For the skimmer trawl fishery, the search radius was based on the maximum tow length (15 km) from tow start to tow end.

Sea Turtle data were reported on a modified Southeast Fisheries Science Center (SEFSC) Sea Turtle Life History Form (Belskis et al. 2009, revised 2011) and sampled following SEFSC protocols (NMFS, 2008). The Sea Turtle Life History forms were transmitted to the SEFSC in Miami where the data were entered into the Sea Turtle Life History database for the Center's use.

All fishery data were entered into the southeast regional shrimp trawl bycatch database. This database is housed at the SEFSC Galveston Laboratory and was developed in 1992 through cooperation with commercial fishing interests, state fishery management agencies, and universities.

Results

Fishing Characteristics

From May through August 2012, data from 796 tows were collected during 58 trips (119 sea days) aboard 26 unique skimmer trawl vessels. Trip, vessel, tow and environmental characteristics are summarized (Table 1)[8]. Trip length averaged 2.1 days with an average of 13.7 tows per trip. Vessel length ranged from 26 to 55 ft, with a mean of 37 ft. The majority (≥ 80%) of vessels were fiberglass construction. Average tow time was 0.95 h (56.9 min) with a range of 0.05 to 2.65. Average fishing depth was 1.6 fm. Most tows (≥ 87%) occurred in seas <2 ft in wave height. Based on total hours towed the highest concentration of effort occurred off southeastern Louisiana (Figure 2).

Net characteristics for observed skimmer trawl vessels are given (Table 2). Headrope length ranged from 14 to 25 ft with an average of 17.9. Several dominant trawl characteristics included trawl body and cod end material (polyethylene), extension (none), and lazy line rigging (choke). Trawl body mesh size ranged from 1.3 to 2.1 in. with a mean of 1.6 in. The majority of nets (Table 3) were not equipped with TEDs or BRDs.

Catch Composition

Based on actual weight (i.e., nonextrapolated) data, 26,965.8 kg of total catch was documented from 716 nets (towing for 695 h). For nets that had an

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

effort value and an associated total catch and shrimp weight recorded, 26,755.0 kg of total catch were documented from 711 nets (690 h). Penaeid shrimp comprised 9,861.7 kg (heads-on) or 37% of the total weight. Average retained penaeid shrimp CPUE was 14.3 kg/h.

Extrapolated Species Composition

Weight extrapolations from species characterization data collected from 274 nets (269 h) were placed into major categories. In terms of percent composition and CPUE, finfishes dominated the catch at 47% (17.1 kg/h), followed closely by penaeid shrimp at 45% (16.4 kg/h), crustaceans at 7% (2.4 kg/h), debris at 2% (0.4 kg/h), invertebrates at 1% (0.2 kg/h), and discarded penaeid shrimp at <0.1%. Overall (total catch) CPUE was 36.7 kg/h.

A total of 21 species (or species groupings) were identified (Table 4). Two species comprised > 74% of total catch: brown shrimp, *Farfantepenaeus aztecus*, at 38% and grouped finfish species at 36%.

CPUE and variance estimates for selected species collected from all sampled nets from May through August 2012 depict very good (<0.3) CV estimates for penaeid shrimp and grouped finfish (Table 4). CVs were higher for several species of sharks, mackerel, *Scomberomorus* spp., and sciaenids (Family Sciaenidae), and in some instances equal to 1.0.

Based on weight extrapolations from species composition samples, the bycatch to penaeid shrimp ratio was 1.24. The finfish to penaeid shrimp ratio was 1.05.

A statistically significant clustering of high CPUE for penaeid shrimp was most pronounced in southeastern Louisiana, specifically in the Barataria Bay region (Figure 3). A clustering of high CPUE for bycatch, excluding protected species, was detected in areas in Lake Pontchartrain and Lake Borgne (Figure 4). The areas that showed the highest CPUE for shrimp had no significant clustering of CPUE for bycatch.

Protected Species

Twenty-four sea turtles were captured on observed trips using skimmer trawl gear (Figure 5). The highest concentration of sea turtle captures occurred off southeastern Louisiana. Twenty-three sea turtle captures were identified as Kemp's ridley species, with one as an unidentified hardshell. All sea turtles were released alive. Epperly and Stokes (2012) provide a detailed analysis on sea turtle takes in the skimmer trawl fishery. Mean sea turtle CPUE was calculated by the SEFSC at 0.03 sea turtles per tow hour[9].

Figure 6 depicts observed tow times in minutes and the seasonal legal maximum tow time (55 minutes). Approximately, 35.3% of the tows were below

[9] Southeast Fisheries Science Center's Analysis on Skimmer Trawl Observer Data. 2012. (available at http://sero.nmfs.noaa.gov/pr/ShrimpFishery_SeaTurtle.htm).

the seasonal 55-minute limit based on calculated tow times. While not specifically listed as protected species, three seabirds were captured during the study; all were laughing gulls, *Leucophaeus atricilla*, released dead.

Discussion

In July 2007, mandatory observer coverage was implemented for Federal permit holders in the Gulf of Mexico otter trawl penaeid shrimp fishery. This program was expanded in 2008 to include the South Atlantic otter trawl penaeid and rock shrimp, *Sicyonia* spp., fisheries. Data from the otter trawl mandatory observer program from 2007 through 2010 were reported by Scott-Denton et al. (2012). Based on actual weights, penaeid and rock shrimp comprised 27% of the catch with an average shrimp CPUE of 9.6 kg/h. In this current study, we found penaeid shrimp comprised 37% of the catch with an average shrimp CPUE of 14.3 kg/h. While higher than the latest offshore otter trawl study, percentage of catch and CPUE were lower than results reported by Scott-Denton et al. (2007) from the voluntary skimmer trawl observer program, with shrimp comprising 61.4% of the catch and a CPUE of 20.2 kg/h.

One reason for the differences between the earlier voluntary skimmer trawl observer coverage and the present study may be that the results were gathered from 26 unique vessels, while data were only obtained from 3 vessels in

the earlier study. Observer coverage for the present study was concentrated during the brown shrimp season, which typically occurs from May through August. The earlier study included data from both the brown shrimp and the white shrimp season, typically September through December. Coale et al. (1994) reported significant difference in skimmer trawl biomass when targeting white shrimp (23.3%) compared with brown shrimp (6.1%). In addition, none of the vessels in the earlier study were equipped with BRDs or TEDs; however, in this study 47% of vessel were equipped with BRDs and 5% with TEDs.

Concerns regarding sea turtle captures in the skimmer trawl fishery initially surfaced after a mass-stranding event in 2010 off the Mississippi coast. The proposal by the NMFS Southeast Regional Office in 2012 to require TEDs in the fishery prompted this study[10]. Scott-Denton et al. (2007) reported no sea turtle captures from voluntary observer coverage in 2004 and 2005. Price and Gearhart (2011) reported no captures in 2008 and 2009, but 3 captures in 2010 by skimmer nets not equipped with TEDs from North Carolina. Price and Gearhart (2011) reported an average of 5% shrimp loss associated with TED usage and bycatch reduction of greater than 27%. Additional TED testing studies by the SEFSC Harvesting Systems Unit in the fishery have since been accomplished in 2011 and are continuing in 2012.

[10] Federal Register. 2012. Proposed rule to withdraw the alternative tow-time restriction and require all skimmer trawls, and wing nets (butterfly trawls) rigged for fishing to use turtle excluder devices in their nets. 77 FR 27411.

For future consideration, continued research would provide more accurate estimates of protected species interactions in the skimmer trawl fishery. Observer programs remain a vital component in addressing concerns associated with commercial fishing operations.

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Table 1. —Trip, vessel, tow, and environmental characteristics based on mandatory observer coverage in the U.S. Gulf of Mexico skimmer trawl fishery from May through August 2012.

Trip	**Vessel**	**Tow**	**Environmental**
119 Sea days 58 trips aboard 26 vessels 796 tows	Length: Avg: 37 ft Range: 26 to 55 ft (± 8.2 s.d.).	Tow time: Avg: 0.95 hrs (± 0.38 s.d.) Range: 0.05 to 2.65 hours	Water depth: Avg: 1.6 fathoms (± 1.0 s.d.) Range: 0.5 to 6.7
Tows per trip: Avg: 13.7 (± 9.9 s.d.) Range: 4 to 48	Age: Avg: 18 yrs Range: 1 – 33 yrs		
Trip length (days): Avg: 2.1 (± 1.0 s.d.) Range: 1 to 6	Hull construction: Fiberglass: 80% Steel: 12% Fiberglass/wood: 8%	Vessel speed: Avg: 1.97 knots (± 0.54 s.d.) Range: 0.1 to 3.4 knots	Sea state: 0 to 2 foot seas: 87% 3 to 5 foot seas: 11% 6 to 8 foot seas: 2%
Trips per vessel: Avg: 2.2 (± 1.1 s.d.) Range: 1 to 4	Type: Ice boat: 96% Freezer: 4%		
Crew size: 0 to 3 individuals (excluding captain)	Engine horsepower: Avg: 376 hp (± 138 s.d.) Range: 200 to 700 hp		

Table 2.—Net characteristics based on mandatory observer coverage of the U.S. Gulf of Mexico skimmer trawl fishery from May through August 2012.

Item		n = 188 nets
Main net headrope length (ft)		
Mean		17.9
Range		14.0 - 25.0
s.d.		3.6
Main net footrope length (ft)		
Mean		28.2
Range		23.0 - 35.0
s.d.		2.9
Trawl body (%)	Poly	80
	Spectra	9
	Sapphire	7
	Nylon	5
Trawl body mesh size (in)		
Mean		1.6
Range		1.3 - 2.1
s.d.		0.2
Cod end (%)	Poly	54
	Nylon	40
	Sapphire	4
	Spectra	2
Cod end mesh size (in)		
Mean		1.4
Range		1.3 - 1.8
s.d.		0.2

Trawl extension type (%)	None	53
	Poly	28
	Nylon	12
	Sapphire	7
Lazy line rigging (%)	Choke	70
	Elephant ears	31
Tickler chain length (ft)		
Mean		28.9
Range		23.5 - 40.0
s.d.		4.4

Table 3.—Bycatch reduction device (BRD) and turtle excluder device (TED) characteristics based on mandatory observer coverage of the U.S. Gulf of Mexico skimmer trawl fishery from May through August 2012.

Item		
BRD type (%)	None	57
	Fisheye	43
BRD fisheye position (%)	None	57
	Top	36
	Offset	8
BRD escape shape (%)	None	57
	Cat eye	21
	Half moon	14
	Oval	9
TED type (%)	None	95
	Hard	5

Table 4.—Species documented from bycatch characterization samples based on mandatory observer coverage of the U.S. Gulf of Mexico skimmer trawl fishery from May through August 2012.

Common name	Scientific name	Extrapolated weight (kg)	Kg/h	Percent total	CV
Brown shrimp	*Farfantepenaeus aztecus*	3,781.9	14.1	38.3	<0.1
Fish (superclass)	*Pisces*	3,529.5	13.1	35.8	0.1
Atlantic croaker	*Micropogonias undulatus*	798.3	3.0	8.1	0.1
Crustacean	*Crustacean*	640.1	2.4	6.5	0.1
White shrimp	*Litopenaeus setiferus*	622.1	2.3	6.3	0.1
Debris (rocks, logs, etc.)	*Debris*	144.2	0.5	1.5	0.4
Seatrout (genus)	*Cynoscion sp*	128.2	0.5	1.3	0.1
Invertebrate	*Invertebrate*	53.3	0.2	0.5	0.2
Spanish mackerel	*Scomberomorus maculatus*	32.1	0.1	0.3	0.4
Black drum	*Pogonias cromis*	26.6	0.1	0.3	0.7
Blacktip shark	*Carcharhinus limbatus*	25.1	0.1	0.3	0.6
Spotted seatrout	*Cynoscion nebulosus*	19.7	0.1	0.2	0.2
Southern flounder	*Paralichthys lethostigma*	18.9	0.1	0.2	0.2
Atlantic sharpnose shark	*Rhizoprionodon terraenovae*	16.7	0.1	0.2	0.5
Shrimp disards (brown,white, pink)	*Penaeus Discard*	11.9	0.0	0.1	0.8
Bull shark	*Carcharhinus leucas*	6.4	0.0	0.1	0.7
Lane snapper	*Lutjanus synagris*	3.8	0.0	0.0	1.0
Red drum	*Sciaenops ocellatus*	1.9	0.0	0.0	0.5
Bonnethead shark	*Sphyrna tiburo*	0.6	0.0	0.0	1.0
Cobia	*Rachycentron canadum*	0.2	0.0	0.0	0.9
King mackerel	*Scomberomorus cavalla*	0.1	0.0	0.0	1.0
Total		9,861.59		100.0	

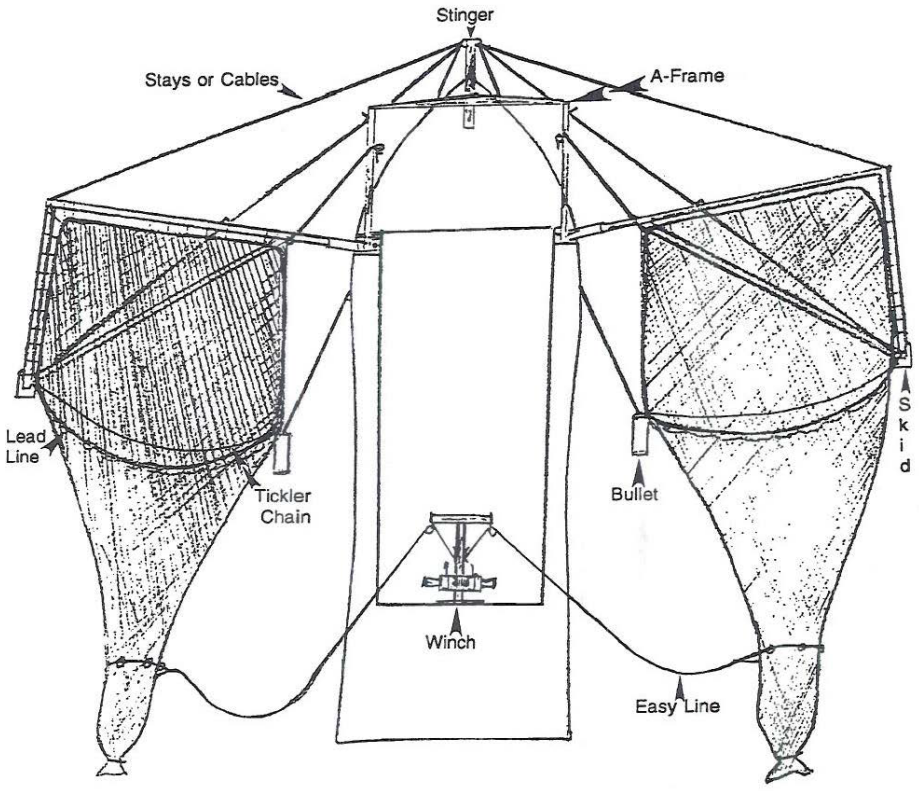

Figure 1.— Overhead view of a typical skimmer trawl vessel. Source: Hein and Meier 1995.

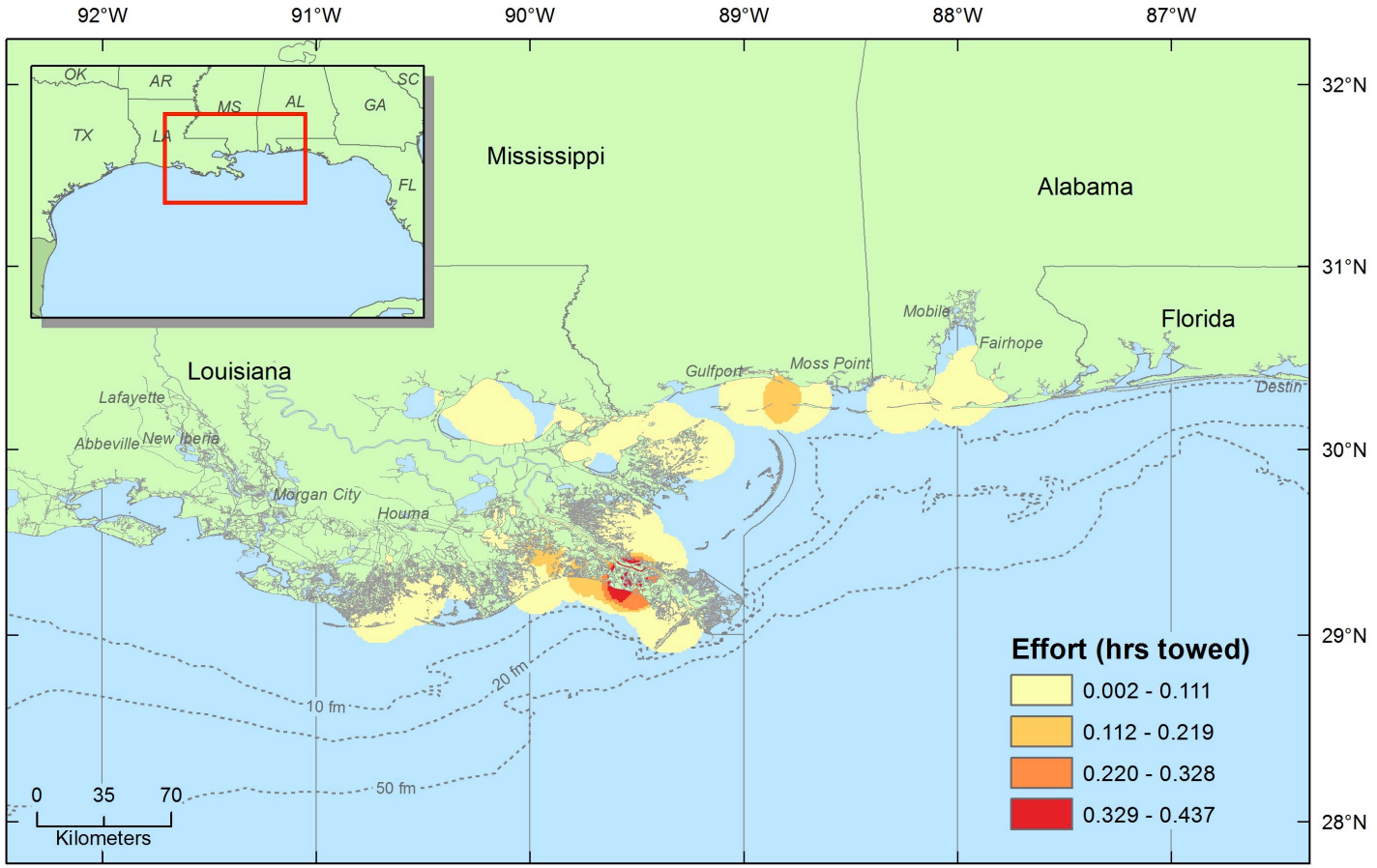

Figure 2.—Skimmer trawl effort by hours towed based on mandatory observer coverage of the U.S. Gulf of Mexico skimmer trawl fishery from May through August 2012.

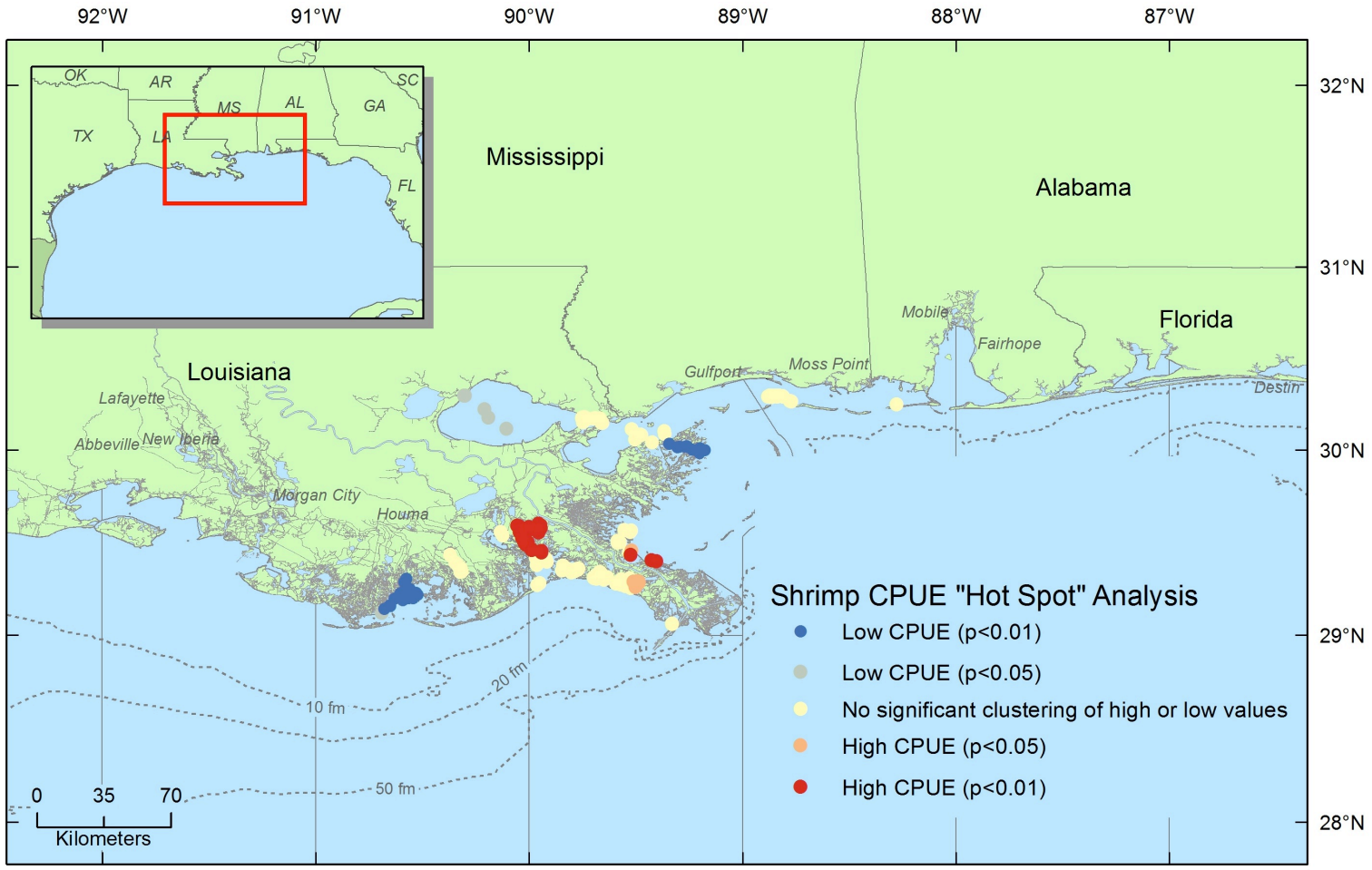

Figure 3.—Shrimp CPUE "Hot Spot" analysis based on mandatory observer coverage of the U.S. Gulf of Mexico skimmer trawl fishery from May through August 2012.

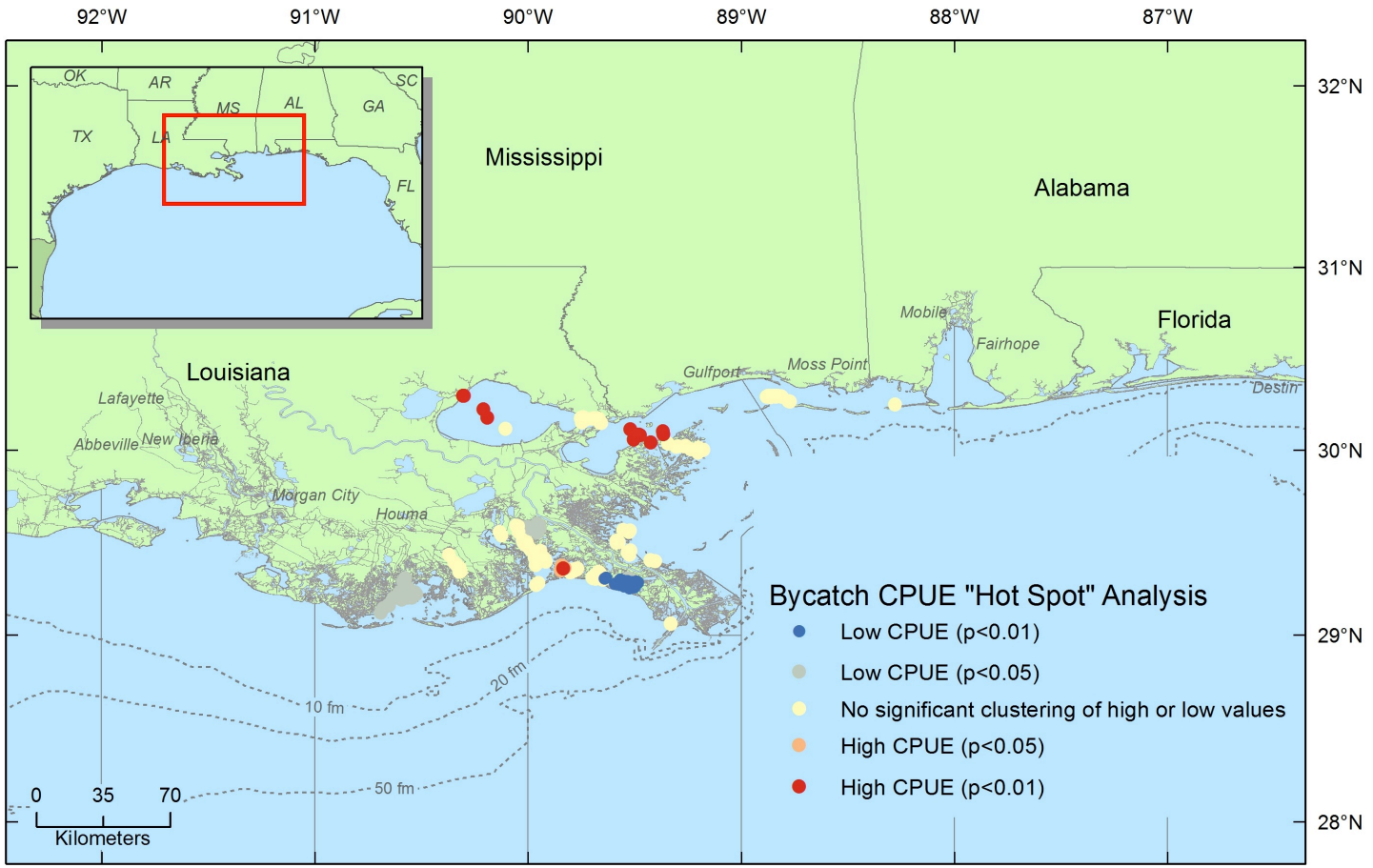

Figure 4.— Bycatch CPUE, excluding protected species, "Hot Spot" analysis based on mandatory observer coverage of the U.S. Gulf of Mexico skimmer trawl fishery from May through August 2012.

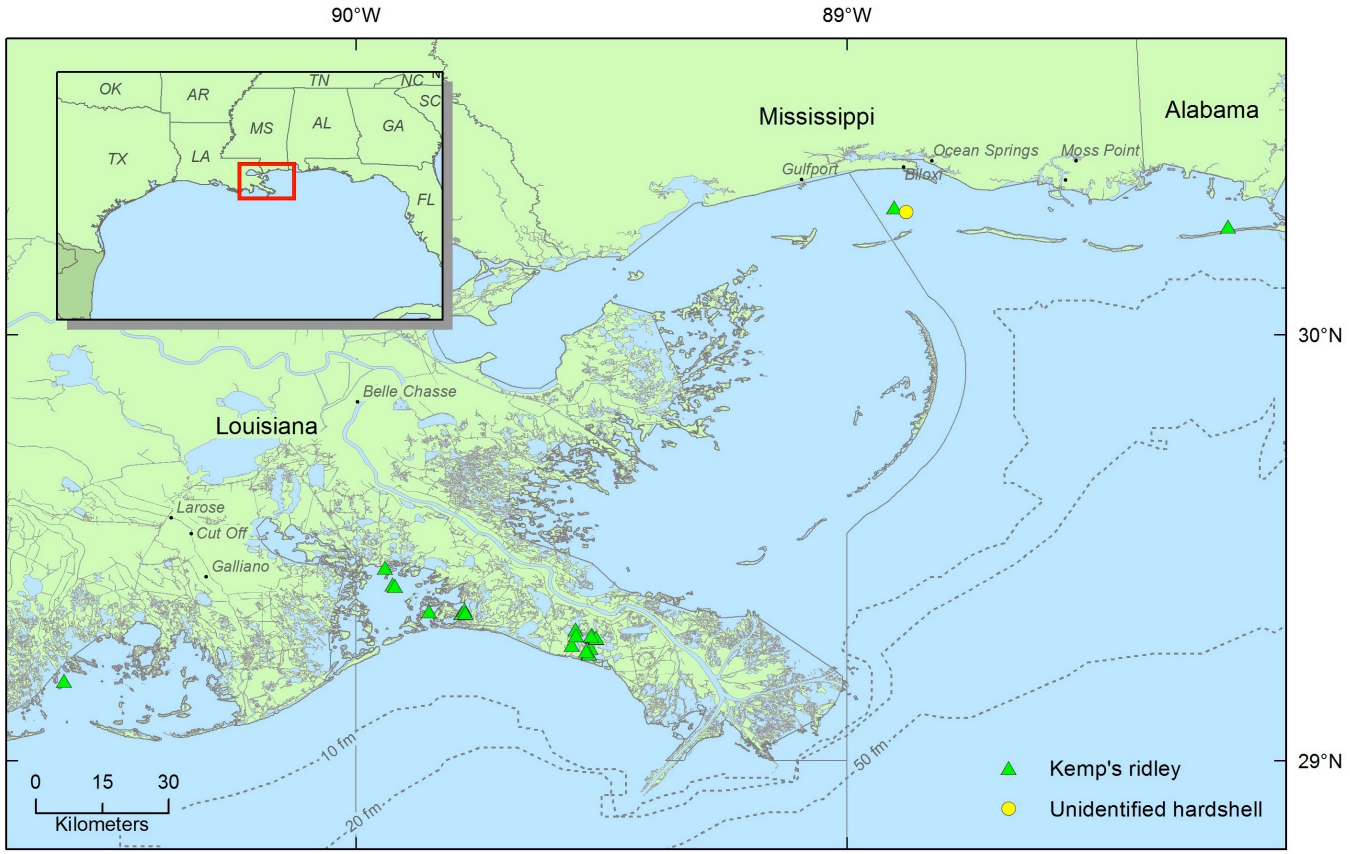

Figure 5.—Sea turtle capture locations based on mandatory observer coverage of the U.S. Gulf of Mexico skimmer trawl fishery from May through August 2012.

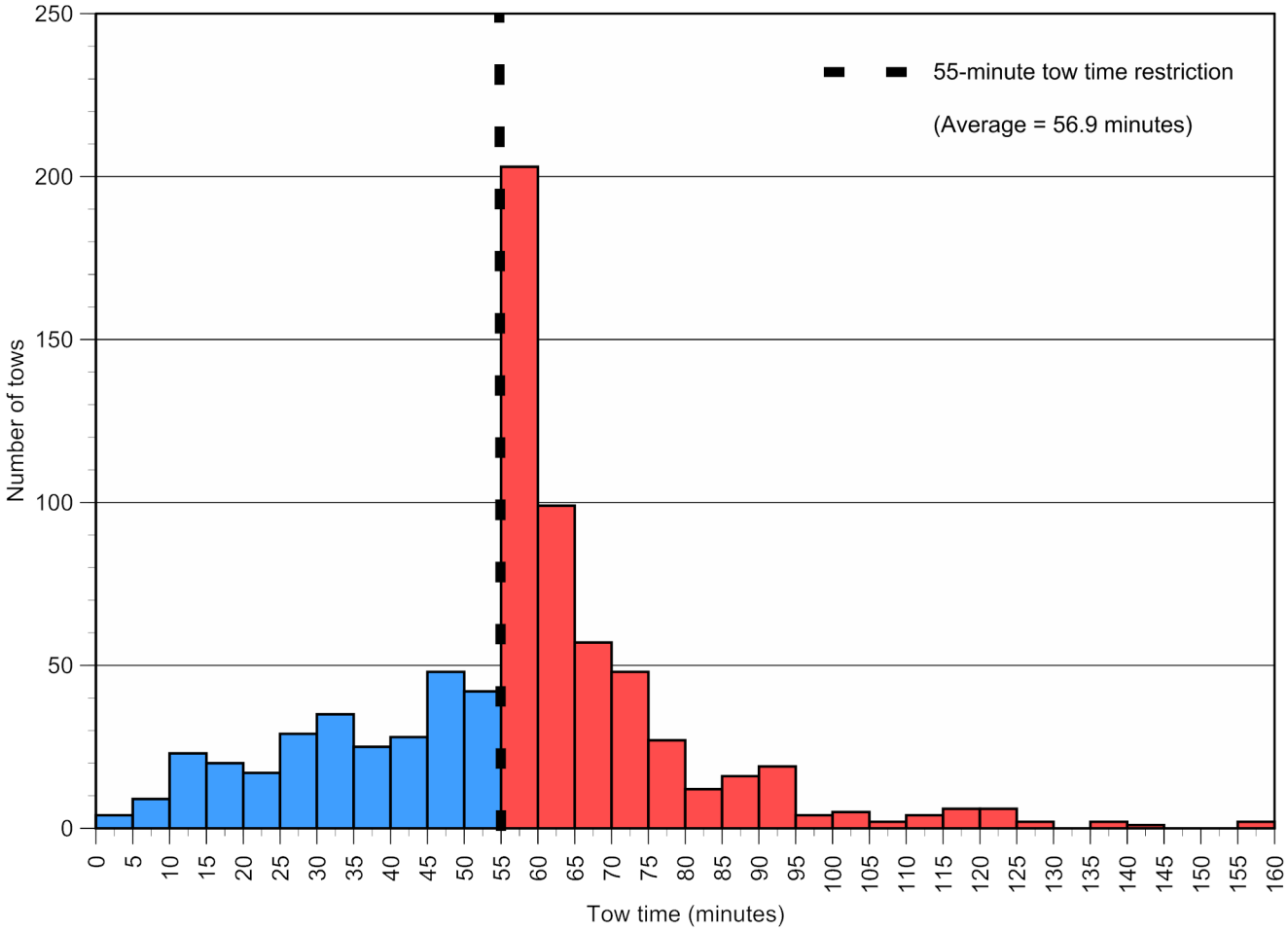

Figure 6.—Skimmer tow times relative to seasonal tow time restriction based on mandatory observer coverage of the U.S. Gulf of Mexico skimmer trawl fishery from May through August 2012.