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Evaluation of Commercial Shrimp Fishery Bycatch in Louisiana Waters

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Overview

Project Need

In 2010, a Fisheries Improvement Project (FIP) was initiated for the commercial shrimp fishery operating in Louisiana (LA) waters as a first step in the process of achieving a sustainability certification for the fishery. This was followed by an official improvement plan for the fishery in 2012. By 2015, the LA shrimp fishery met the goals outlined in the initial plan which allowed the fishery to progress into a comprehensive FIP that addresses all issues within the fishery to ensure the fishery is in compliance with the sustainability standards outlined by the certifying body.

Several action items were outlined in the comprehensive FIP, including the need for current bycatch data from the fishery to assess the main bycatch species per standards of the certifying body. The Louisiana Shrimp Task Force (LSTF) and involved members of the industry approached the Louisiana Department of Wildlife and Fisheries (LDWF) in 2016 and initiated discussions to conduct a study to characterize the current bycatch of the fishery in LA waters. In 2018, LDWF partnered with the LSTF and the American Shrimp Processors Association (ASPA) to fund a one-year observer study designed by the LDWF to focus exclusively on the bycatch of the shrimp fishery operating in LA waters, as the bycatch of the fishery operating in federal waters is monitored and reported by NOAA Fisheries.

Project Objectives

Objectives of this study were:

1. Characterize the current bycatch of the commercial shrimp fishery operating in LA waters.
2. Identify the main bycatch species of the fishery per standards of the Audubon Nature Institute (ANI) Gulf United for Lasting Fisheries (GULF) Responsible Fisheries Management (RFM) program (ANI 2020).
3. Assess the population resilience of the main bycatch species to fisheries exploitation.

Fishery Description

The commercial harvest of shrimp in LA dates back to the 1800s (LDWF 2016). As the popularity of shrimp as a food source grew in the early 1900s, the LA commercial shrimp industry expanded and

commercial landings began to increase above 20 million pounds annually. Continued expansion of the industry into current times has led to the most valuable commercial fishery operating in LA waters with landings averaging over 70 million pounds annually in the most recent decade.

In the early 1900s, the otter trawl was developed and became the primary fishing gear used by LA shrimp fishers. This was followed by introduction of the butterfly net in the 1950s that allowed stationary fishing in tidal passes. The introduction of skimmer nets in the 1980s, which allowed fishers to focus efforts in shallower water and fish the entire water column, was widely accepted by the LA shrimp fishery.

A shift in gear preference of the LA commercial shrimp fishery has occurred over time as well as an overall decrease in license sales (Table 1). Based on commercial gear license sales, the use of otter trawl and butterfly net gear has decreased since 2000 while the use of skimmer nets has increased. The overall number of commercial licenses sold has decreased by over 70% since 2000.

Commercial shrimp landings in LA waters and the corresponding number of fishery trips have also decreased since 2000 (Figure 1). Commercial landings have decreased over 30% since 2000 while the number of fishery trips has declined by over 65%. This disproportionate decrease is primarily due to the characteristics of the shrimp fishery operating in LA waters changing over time, where a noticeable decline occurred in the mid-2000's in the number of trips less than 1-day at sea.

Regulatory Authority

Regulatory authorities for the LA shrimp fishery are the Governor of Louisiana, the Louisiana Legislature, the Louisiana Wildlife and Fisheries Commission (LWFC), and the Secretary of LDWF. The Governor has the authority to issue executive orders, in limited instances, which are enforced in the same manner as statutes passed by the legislature. The LA Legislature has the authority to enact laws to protect, conserve, and replenish the natural resources of the state, such as gear regulations, licensing requirements, and entry limitations. Some of the authority of the legislature has been delegated to the LWFC, allowing regulatory authority of seasons, quotas, size limits, and possession limits.

Specific to commercial shrimping, the LWFC has the authority to open and close state outside waters, set the inshore shrimp season dates, and modify gear mesh sizes during the special shrimp seasons. The LWFC also has the authority to promulgate regulations regarding the use and configuration of excluder devices. Some authority of the LWFC is delegated to the Secretary of LDWF, including the ability to open or close special and regular shrimp seasons as well as open or close state outside waters.

Methods

Bycatch Characterization

In 2019, LDWF, along with the LSTF and ASPA, initiated an observer study of the commercial shrimp fishery operating in Louisiana waters to characterize bycatch of the fishery from July 2019 through June 2020. LGL Ecological Research Associates, Inc. (LGL) was contracted for this study to provide biological staff to act as observers onboard commercial shrimp fishing vessels operating in LA waters.

Fishery participants were solicited though the LSTF, social media, and LDWF news releases, and an online portal was developed for interested commercial fishers to enroll. All commercial fishers operating out of LA ports were eligible to participate in this study. Commercial vessels in which observers were placed were selected randomly from the pool of participating commercial fishers. Commercial fishers randomly drawn from this group were compensated $350 per day for each fishing trip where bycatch was observed by an LGL biologist. Fishing trips conducted with observers onboard were not to exceed 48 hours. Trips in which observers were placed were randomly assigned proportional to the recent fishery effort (number of trips) by fishing gear, LDWF Coastal Study Area (CSA), and fishing season (spring, fall, inshore closed).

Bycatch information was collected over the duration of each observed trip by sampling each tow. On vessels containing multiple nets, samples were collected by alternating which net the samples were collected from after each tow. Any observed interactions with sea turtles were to be documented, regardless of which net was sampled.

For each net sampled, the total weight of the tow was estimated through a volumetric approach as described in the NOAA Observer Training Manual (NOAA Fisheries 2010). Multiple fish baskets were equally filled with the entire catch of the sampled tow and then one fish basket was randomly chosen, weighed and used to extrapolate the weight of the entire tow's catch from the number of baskets filled. Catch of the randomly chosen basket was also characterized by sorting, enumerating, and weighing each species to the nearest gram with the exception of white and brown shrimp and jellyfish species where only weight measurements were recorded. The species weight composition of the subsample was then used to extrapolate the total catch weight of each tow.

Size measurements of up to thirty individuals per sampled tow were recorded for penaeid shrimp species and other selected species that are managed or commonly harvested. Large specimens that weren't included in the volumetric sampling method were identified by species, counted, released condition documented, and size or weight measurements recorded when possible. Tow times and locations were also recorded along with the position of the sampled net for each tow.

Main Bycatch Identification

The ANI GULF RFM program identifies relevant bycatch (non-target catches), whether discarded or retained, as managed non-target species (species regulated for commercial, bait, or recreational use) greater than 1% of total catch and non-managed non-target species greater than 10% of total catch (ANI 2020).

Resilience to Exploitation

Population resilience is a population's ability to withstand perturbation. Populations with higher resilience are at less risk of extinction due to fishery exploitation than populations with lower resilience. Productivity, which is a function of growth rates, fecundity, natural mortality, age at maturity, and longevity, can be a reasonable proxy for population resilience. Productivity classification indices were developed for each species identified as main bycatch from their life history characteristics based on a classification scheme developed at the Food and Agricultural Organization of the United Nations (FAO)

second technical consultation on the suitability of the Convention on International Trade in Endangered Species (CITES) criteria for listing commercially-exploited aquatic species (FAO 2001).

Results

Bycatch Characterization

Thirty-three shrimp fishing trips with 363 tows and 501 hours of tow time were observed from July 2019 through June 2020 from 12 individual commercial fishing vessels. Of the twelve participating vessels, 9 fished with skimmer nets, 2 with otter trawls, and 1 with butterfly net gear. The otter trawls were all equipped with bycatch reduction devices (BRDs) and turtle excluder devices, and two-thirds of the skimmer nets were equipped with BRDs.

Observer coverage of the fishery over the course of this study was approximately 0.1% (33 observed trips/37,203 fishery trips) and nearly proportional to the number of fishery trips by gear, CSA, and fishing season with the exception of CSA 6 and 7 due to the lack of fishery participation in those areas (Table 2, Figure 2).

From the 363 observed tows, 14,266 kg of total catch was observed consisting of 105 unique species or grouped species (Table 3). Four species of penaeid shrimp, 82 finfish species, 12 crustacean species (excluding penaeid shrimp), and 7 non-crustacean invertebrate species were observed. Penaeid shrimp species were the highest group caught by weight (48.1%), followed by finfish (40.2%), crustaceans other than penaeid shrimp (5.0%), and invertebrates (3.0%). Debris made up 3.7% of the total catch by weight.

The most abundant species caught consisting of >1% by weight of the total catch were white shrimp (44.3%), Gulf menhaden, (14.1%), Atlantic croaker (5.4%), blue crab (4.9%), brown shrimp (3.7%), spot (3.2%), jellyfish sp. (2.9%), sand seatrout (2.8%), hardhead catfish (2.2%), gafftopsail catfish (2.1%), and Atlantic cutlassfish (2.1%).

The bycatch to shrimp sample ratio error distribution was assumed lognormal and the corresponding sample ratio geometric mean in units of weight was 1.01 (Table 4). Size compositions and mean sizes of penaeid shrimp and the managed and commonly harvested species catches are presented in Table 5. Catch composition of large specimens not represented in the volumetric samples are presented in Table 6 along with released condition and corresponding size and weight measurements if available. Interactions with diamondback terrapins were observed in which all were released alive (Table 6). No interactions with sea turtles were observed.

Main Bycatch Identification

Gulf menhaden and blue crab were identified as the main bycatch species of the current LA commercial shrimp fishery per ANI standards. Both are managed species that are greater than 1% of the total catch by weight. The other non-target species consisting of greater than 1% of the total catch are non-managed species not regulated for recreational, bait, or commercial use. No non-managed non-target species was greater than 10% of the total catch by weight.

Resilience to Exploitation

Blue crab and Gulf menhaden were assigned productivity/resilience levels (high, medium, or low) based on each species life history characteristics (Table 7). Life history parameter values were taken from the most recent stock assessments if available (SEDAR 2018, West et al. 2019). Parameter values not available in the stock assessment reports were taken from FishBase (Froese and Pauly 2011) and SeaLifeBase (Palomares and Pauly 2020). Parameter values for each of the main bycatch species indicate overall high productivity/resilience.

Discussion

Historic Bycatch Ratios

The bycatch to penaeid shrimp sample ratio mean from this study (1.01) is less than an earlier LDWF shrimp bycatch study conducted in LA waters (Adkins 1993). The bycatch to penaeid shrimp sample ratio mean in that study, recalculated as a geometric mean, was 1.24, suggesting bycatch in the LA shrimp fishery has decreased through time. This decrease is likely due to the changing characteristics of the fishery where skimmer nets have become the preferred gear of the fishery, along with the use of BRDs. An earlier NOAA Fisheries bycatch study conducted in LA waters (Scott-Denton et al. 2006), which only characterized bycatch from the skimmer net fishery operating primarily in Vermilion Bay (CSA 6), reported an overall ratio of bycatch to penaeid shrimp of 0.63.

Management Implications

For managed species identified as main bycatch, the ANI standards require the effects of the fishery to be considered. Consideration of managed non-target species aims primarily at establishing whether the overall effects of fishing on the stock under consideration and all significant removals are accounted for; and that the management strategy and relative measures are effective in maintaining other managed species from experiencing overfishing and other impacts that are likely to be irreversible or very slowly reversible (ANI 2020).

The main bycatch species of the LA commercial shrimp fishery per ANI standards (Gulf menhaden and blue crab) are regulated species which undergo periodic stock assessments that output estimates used as metrics of stock status (SEDAR 2018, West et al. 2019) with fisheries that currently hold Global Sustainable Seafood Initiative (GSSI) accredited sustainability certifications. Removals of Gulf menhaden and blue crab as bycatch from the LA shrimp fishery have not been considered in the respective stock assessments. Bycatch from the offshore Gulf of Mexico shrimp fishery was considered in the most recent Gulf menhaden stock assessment (SEDAR 2018), but was ultimately not used as a model input by the assessment panelists due to the high uncertainty in the estimated time-series and the relatively insignificant level of bycatch when compared to the landings of the fishery.

Future LDWF blue crab and SEDAR Gulf menhaden stock assessments would be required to consider removals from the LA shrimp fishery per ANI standards. Time-series of bycatch removals could be estimated directly from annual LA shrimp landings from the mean bycatch to shrimp ratio from this study and the earlier LDWF study (Adkins 1993) along with the percent composition of blue crab and Gulf menhaden in the catches and assumptions of discard mortality. These time-series would unfortunately be

considered highly uncertain due to the few bycatch to shrimp ratio estimates available in LA waters over time coupled with the changing characteristics of the fishery, but would allow accurate estimation of the current bycatch removals of the LA shrimp fishery to determine their significance relative to the directed landings of each fishery.

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Tables

Table 1. Louisiana annual commercial shrimp gear license sales (percent by gear and total sales), 2000-2019.

Year	Trawl	Skimmer	Butterfly	Total
2000	54%	34%	12%	22,218
2001	52%	37%	10%	22,865
2002	51%	40%	9%	21,627
2003	48%	44%	8%	20,586
2004	48%	43%	8%	17,347
2005	46%	45%	9%	15,420
2006	44%	48%	9%	13,646
2007	43%	48%	9%	12,590
2008	42%	49%	10%	11,476
2009	40%	50%	10%	12,082
2010	38%	52%	10%	12,806
2011	37%	54%	9%	13,234
2012	38%	53%	8%	12,728
2013	29%	64%	7%	10,123
2014	42%	49%	9%	7,319
2015	41%	50%	9%	7,551
2016	41%	51%	9%	7,340
2017	41%	51%	8%	6,867
2018	41%	51%	8%	6,236
2019	40%	51%	8%	5,791

Table 2: Louisiana shrimp fishery trips and observer coverage (July 2019 – June 2020) by gear, CSA, and fishing season.

Fishery trips	37,203
Observed trips	33

	Fishery trips		Observed trips	
Gear	Frequency	Percent	Frequency	Percent
Butterfly net	2276	6.1%	3	9.1%
Otter trawl	6452	17.3%	6	18.2%
Skimmer net	28475	76.5%	24	72.7%

	Fishery trips		Observed trips	
CSA	Frequency	Percent	Frequency	Percent
1	6564	17.6%	7	21.2%
3	11136	29.9%	12	36.4%
5	14607	39.3%	14	42.4%
6	1108	3.0%	0	0.0%
7	3788	10.2%	0	0.0%

	Fishery trips		Observed trips	
Season	Frequency	Percent	Frequency	Percent
Spring	7823	21.0%	7	21.2%
Fall	24457	65.7%	24	72.7%
Inshore closed	4923	13.2%	2	6.1%

Table 3: Species total catch composition and corresponding mean weights. Species mean weights are calculated from the subsampled weights and counts.

Species	total kg	% kg	mean kg
WHITE SHRIMP	6321.765	44.313	--
GULF MENHADEN	2013.137	14.111	0.014
ATLANTIC CROAKER	768.736	5.389	0.011
BLUE CRAB	700.646	4.911	0.054
BROWN SHRIMP	527.423	3.697	--
DEBRIS	521.480	3.655	--
SPOT	449.081	3.148	0.030
JELLYFISH SP.	415.590	2.913	--
SAND SEATROUT	402.123	2.819	0.012
HARDHEAD CATFISH	314.820	2.207	0.018
GAFFTOPSAIL CATFISH	302.624	2.121	0.015
ATLANTIC CUTLASSFISH	299.163	2.097	0.021
ATLANTIC THREAD HERRING	117.899	0.826	0.015
BAY ANCHOVY	102.212	0.716	0.001
GIZZARD SHAD	94.846	0.665	0.019
THREADFIN SHAD	68.982	0.484	0.014
COWNOSE RAY	68.401	0.479	0.772
SPANISH MACKEREL	67.702	0.475	0.023
SPOTTED SEATROUT	66.077	0.463	0.080
ATLANTIC MOONFISH	62.295	0.437	0.008
CATFISH SP.	54.260	0.380	0.022
STRIPED MULLET	43.462	0.305	0.039
ATLANTIC STINGRAY	41.300	0.289	0.215
HARVESTFISH	36.490	0.256	0.025
PINFISH	31.478	0.221	0.039
STRIPED ANCHOVY	31.222	0.219	0.012
HOGCHOKER	25.958	0.182	0.016
SHEEPSHEAD	23.683	0.166	1.203
SOUTHERN FLOUNDER	23.201	0.163	0.337
SOUTHERN KINGFISH	20.237	0.142	0.032
SILVER PERCH	17.558	0.123	0.026
SEABOB	17.386	0.122	0.005
BLUE CATFISH	16.445	0.115	0.007
LEAST PUFFER	16.150	0.113	0.007
WHITE MULLET	16.042	0.112	0.023
ATLANTIC BRIEF SQUID	15.726	0.110	0.009
BAY WHIFF	15.136	0.106	0.009
SCALED SARDINE	14.126	0.099	0.007
LADYFISH	10.005	0.070	0.102
CREVALLE JACK	9.887	0.069	0.028
STAR DRUM	8.882	0.062	0.014
INSHORE LIZARDFISH	8.292	0.058	0.034
ATLANTIC SPADEFISH	7.770	0.054	0.013
HIGHFIN GOBY	7.558	0.053	0.027
ATLANTIC BUMPER	6.027	0.042	0.003
VIOLET GOBY	5.584	0.039	0.030
LOOKDOWN	4.889	0.034	0.015
FLORIDA POMPANO	4.535	0.032	0.092
BLUE RUNNER	4.382	0.031	0.045
BLACK DRUM	3.471	0.024	0.088
GRAY SNAPPER	3.053	0.021	0.044
HERMIT CRAB SP.	2.905	0.020	0.018

Table 3 (continued):

Species	total kg	% kg	mean kg
BANDED DRUM	2.866	0.020	0.006
ATLANTIC MIDSHIPMAN	2.304	0.016	0.022
GULF STONE CRAB	2.166	0.015	0.440
ATLANTIC NEEDLEFISH	2.048	0.014	0.026
BLACKTIP SHARK	1.970	0.014	0.200
ATLANTIC SILVERSTRIPE HALFBEAK	1.871	0.013	0.035
SPINY SEAROBIN	1.723	0.012	0.004
LEATHERJACKET	1.615	0.011	0.008
INLAND SILVERSIDE	1.600	0.011	0.004
BIGHEAD SEAROBIN	1.590	0.011	0.005
ROUGH SILVERSIDE	1.492	0.010	0.002
BLACKCHEEK TONGUEFISH	0.985	0.007	0.033
GULF TOADFISH	0.886	0.006	0.036
PIGFISH	0.886	0.006	0.060
STRIPED BURRFISH	0.886	0.006	0.180
GULF BUTTERFISH	0.768	0.005	0.005
NEEDLEFISH SP.	0.704	0.005	0.029
SNAIL SP.	0.689	0.005	0.016
NAKED SOLE	0.596	0.004	0.020
NORTHERN KINGFISH	0.596	0.004	0.040
SHARKSUCKER	0.566	0.004	0.038
ISOPODA SP.	0.502	0.004	0.034
BAYOU KILLIFISH	0.478	0.003	0.019
GIANT TIGER PRAWN	0.359	0.003	0.073
FALSE SILVERSTRIPE HALFBEAK	0.355	0.002	0.024
ATLANTIC MENHADEN	0.345	0.002	0.070
MOJARRA SP.	0.295	0.002	0.015
BLUNTNOSE JACK	0.251	0.002	0.009
FALSE SHARK EYE	0.246	0.002	0.013
CRESTED CUSK EEL	0.197	0.001	0.040
THINSTRIPE HERMIT CRAB	0.197	0.001	0.013
FAT SLEEPER	0.177	0.001	0.018
FRINGED FLOUNDER	0.158	0.001	0.004
FLORIDA ROCKSNAIL	0.148	0.001	0.015
OYSTER TOADFISH	0.148	0.001	0.030
RIVER SHRIMP	0.148	0.001	0.030
SPOTFIN MOJARRA	0.148	0.001	0.015
YELLOWFIN MOJARRA	0.148	0.001	0.008
PYGMY SEA BASS	0.108	0.001	0.022
SMOOTH PUFFER	0.103	0.001	0.011
AMERICAN PADDLEFISH	0.098	0.001	0.020
BIVALVE CLAM SP.	0.098	0.001	0.020
MANTIS SHRIMP	0.098	0.001	0.010
PINK PURSE CRAB	0.098	0.001	0.010
WHITE RIVER CRAWFISH	0.098	0.001	0.010
SILVER ANCHOVY	0.079	0.001	0.008
BIGCLAW SNAPPING SHRIMP	0.049	0.000	0.010
REDEAR SUNFISH	0.049	0.000	0.010
FLORIDA LADY CRAB	0.044	0.000	0.009
TIDEWATER MOJARRA	0.044	0.000	0.009
ESTUARINE MUD CRAB	0.015	0.000	0.001
BIGEYE ROBIN	0.005	0.000	0.001
GULF PIPEFISH	0.005	0.000	0.001
SPECKLED SWIMMING CRAB	0.005	0.000	0.001

Table 4: Bycatch to penaeid shrimp (brown, white, seabob) sample ratio summary statistics in units of weight. The sample ratio mean and error estimates are geometric.

Ratio (bycatch /shrimp)		
Bin	Frequency	Percent
0.0	163	50.309
1.0	55	16.975
2.0	39	12.037
3.0	18	5.556
4.0	16	4.938
5.0	12	3.704
6.0	5	1.543
7.0	4	1.235
8.0	2	0.617
9.0	--	--
10.0	2	0.617
11.0	--	--
12.0	--	--
13.0	1	0.309
14.0	--	--
15.0	1	0.309
16.0	2	0.617
17.0	--	--
18.0	--	--
19.0	2	0.617
--	--	--
51.0	1	0.309
--	--	--
111.0	1	0.309

Ratio (bycatch/shrimp)	
Mean	1.013
L95%CI	0.882
U95%CI	1.163
CV	1.986
Tows	324

Table 5: Bycatch size compositions of managed and commonly harvested species. Size measurements are fork length (finfish), total length (shrimp), and carapace width (crab).

Size bin (cm)	ATLANTIC CROAKER	BLACK DRUM	BLUE CRAB	BROWN SHRIMP	GRAY SNAPPER	GULF MENHADEN	SEABOB	SHEEPSHEAD	SOUTHERN FLOUNDER	SPOTTED SEATROUT	STRIPED MULLET	WHITE SHRIMP
0	2	--	--	--	--	--	--	--	--	--	--	--
1	1	--	30	1	--	--	--	--	--	--	--	--
2	--	--	96	1	2	1	--	--	--	--	--	1
3	3	--	291	--	1	6	--	--	--	--	--	6
4	1	--	358	15	--	64	--	--	--	--	--	14
5	39	--	285	91	--	302	--	--	--	--	--	74
6	284	--	177	419	--	627	1	--	--	--	1	263
7	485	--	139	1,087	--	1,074	6	--	--	--	2	700
8	748	1	111	1,246	--	970	28	--	--	--	4	1,039
9	632	--	91	635	--	579	34	--	--	5	9	1,043
10	618	--	94	260	1	742	15	--	--	9	24	788
11	988	--	123	112	1	830	1	--	--	12	39	1,035
12	822	--	116	20	--	330	--	--	--	18	25	1,395
13	513	--	89	4	1	156	--	--	--	11	30	1,562
14	261	--	82	1	--	172	--	--	--	6	27	1,021
15	120	--	99	--	--	126	--	--	--	6	16	336
16	55	--	124	--	--	53	--	--	--	6	12	78
17	24	2	71	--	--	11	--	--	--	8	6	9
18	10	--	24	1	--	5	--	--	--	1	8	2
19	3	3	6	--	--	1	--	--	--	4	6	2
20	1	1	--	--	--	1	--	--	1	8	3	--
21	3	1	--	--	--	--	--	--	1	12	2	--
22	--	--	--	--	--	1	--	--	--	13	1	--
23	--	--	--	--	--	--	--	--	1	5	2	--
24	--	--	--	--	--	--	--	--	1	6	--	--
25	--	--	--	--	--	--	--	--	--	8	--	--
26	--	--	--	--	--	--	--	--	1	3	--	--
27	--	--	--	--	--	--	--	--	--	5	--	--
28	--	--	--	--	--	--	--	--	1	4	--	--
29	--	--	--	--	--	--	--	--	1	2	--	--
30	--	--	--	--	--	--	--	1	1	2	--	--
31	--	--	--	--	--	--	--	--	--	--	--	--
32	--	--	--	--	--	--	--	1	--	--	--	--
33	--	--	--	--	--	--	--	--	--	2	--	--
34	--	--	--	--	--	--	--	1	--	3	--	--
35	--	--	--	--	--	--	--	--	2	--	--	--
36	--	--	--	--	--	--	--	--	1	1	--	--
37	--	--	--	--	--	--	--	--	1	--	--	--
38	--	--	--	--	--	--	--	--	--	--	--	--
39	--	--	--	--	--	--	--	--	--	--	--	--
40	--	--	--	--	--	--	--	--	--	--	--	--
41	--	--	--	--	--	--	--	--	--	--	--	--
42	--	--	--	--	--	--	--	--	--	--	--	--
43	--	--	--	--	--	--	--	1	--	--	--	--
Mean size (mm)	107	176	83	82	73	94	91	354	290	187	135	113
n	5613	8	2406	3893	6	6051	85	4	12	160	217	9368

Table 6: Large specimen catch composition. Size measurements are fork length.

Species	numbers	released condition			weight (kg)				size (mm)			
		alive	dead	unknown	mean	n	min	max	mean	n	min	max
Black Drum	33	20	2	11	7.67	2	6.98	8.35	905	1	905	905
Cownose Ray	27	5	--	22	0.81	5	0.60	0.96	323	4	136	410
Atlantic Stingray	25	10	11	4	0.86	3	0.41	1.16	146	1	146	146
Sheepshead	15	10	1	4	2.59	3	2.48	2.78	494	3	460	528
Longnose Gar	12	12	--	--	--	--	--	--	--	--	--	--
Diamondback Terrapin	5	5	--	--	--	--	--	--	--	--	--	--
Red Drum	5	5	--	--	--	--	--	--	--	--	--	--
Hardhead Catfish	5	5	--	--	--	--	--	--	--	--	--	--
Alligator Gar	4	4	--	--	--	--	--	--	1140	2	450	1829
Atlantic Tripletail	3	2	--	1	--	--	--	--	--	--	--	--
Bull shark	2	2	--	--	4.92	2	4.83	5.01	--	--	--	--
Spotted Seatrout	2	2	--	--	--	--	--	--	--	--	--	--
Bonnethead	1	1	--	--	--	--	--		--	--	--	--
Blacktip Shark	1	1	--	--	3.62	1	3.62	3.62	566	1	566	566

Table 7: FAO proposed guideline for indices of productivity/resilience for exploited aquatic species (top table) and corresponding productivity/resilience levels for blue crab and Gulf menhaden (bottom table). Parameter values are taken from the latest stock assessment reports (West et al. 2019, SEDAR 63) unless noted by an * where values are taken from FishBase (Froese and Pauly 2011) for Gulf menhaden and SeaLifeBase (Palomares and Pauly 2020) for blue crab.

Parameter	Productivity/Resilience		
	Low	Medium	High
Intrinsic rate of population growth (r per yr)	<0.14	0.14 - 0.35	>0.35
Natural mortality rate (M per yr)	<0.2	0.2 - 0.5	>0.5
Individual growth rate (K per yr)	<0.15	0.15 - 0.33	>0.33
Age at maturity (yrs)	>8	8 - 3.3	<3.3
Maximum age (yrs)	>25	14 - 25	<14
Generation time (yrs)	>10	10.0 - 5.0	<5

Parameter	Blue Crab		Gulf Menhaden	
	Value	Index	Value	Index
Intrinsic rate of population growth (r per yr)	0.6*	High	3.0*	High
Natural mortality rate (M per yr)	1.0	High	1.1	High
Individual growth rate (K per yr)	1.9	High	0.3	High
Age at maturity (yrs)	1.0	High	2.0	High
Maximum age (yrs)	3.0	High	6.0	High
Generation time (yrs)	<3.0	High	2.4*	High
Overall productivity /resilience level	High		High	

Figures

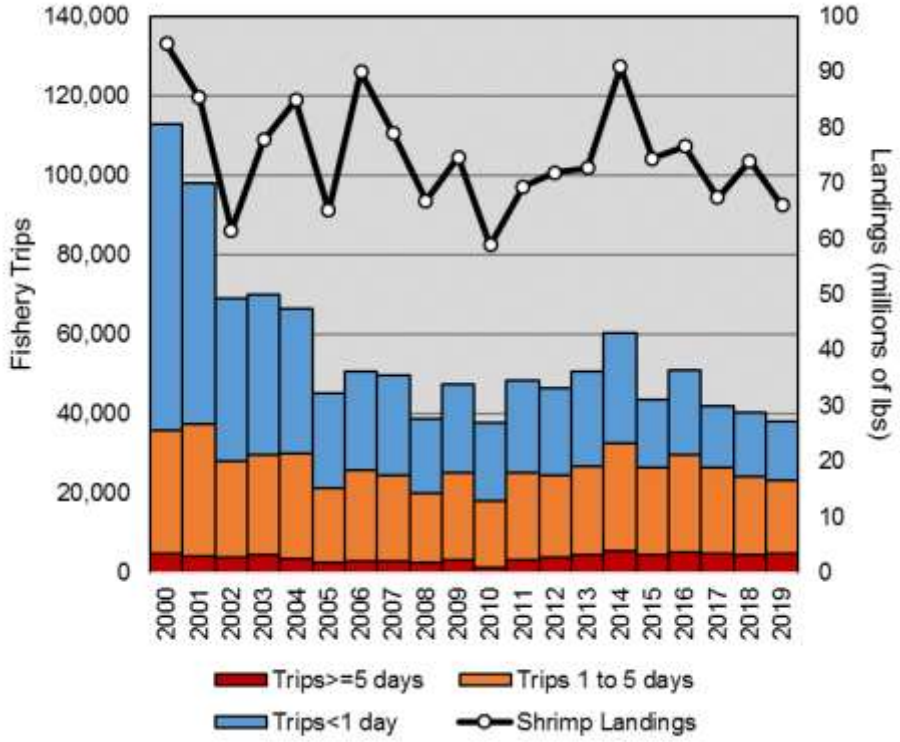

Figure 1: Shrimp fishery trips in LA waters by number of days at sea and corresponding total penaeid shrimp landings taken from the LDWF Trip Ticket program, 2000-2019. Note: Landings and fishery trips do not include records from out of state or federal waters.

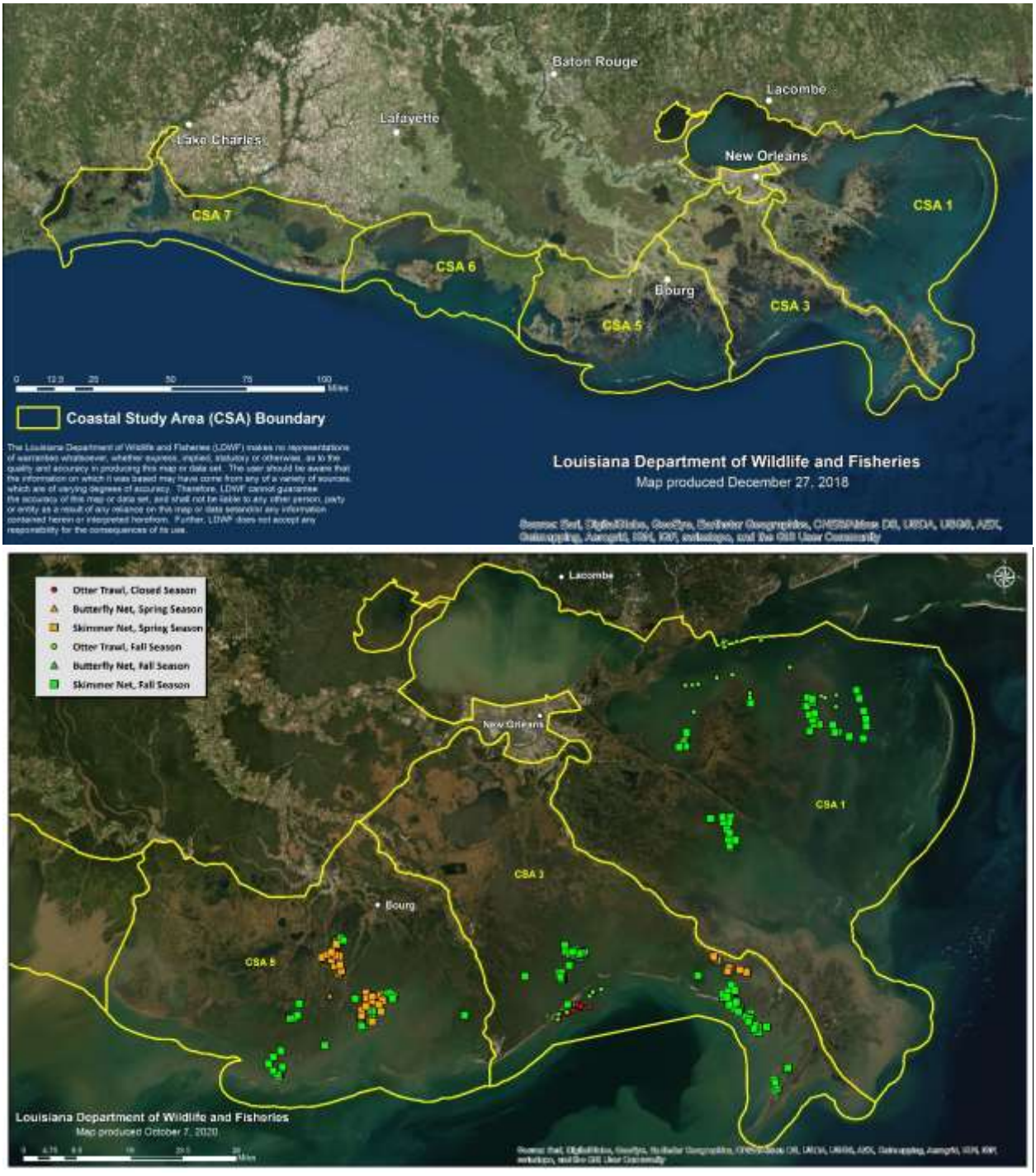

Figure 2: Louisiana state waters and LDWF Coastal Study Areas delineated by the yellow lines (top graphic) and locations of observed fishery tows (bottom graphic) by gear fished (otter trawl, skimmer net, butterfly net) and fishing season (spring, fall, inshore closed).