NOAA-NMFS Saltonstall-Kennedy Grant Program

Final Report

Conservation engineering within the Monkfish Gillnet Fishery: Reducing negative fishery interaction through gear modifications and assessing post release mortality and behavior of the endangered Atlantic sturgeon

Award NA14NMF4270036

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Project Summary: This project represents a collaborative effort developed with industry leaders from the sink-gillnet Monkfish (Goosefish) fishery in NJ (Captain Kevin Wark; F/V Dana Christine II) and NY (Captain Tim Froehlich: F/V Liberty). Our project had several objectives including field trials of experimental and control gillnets, examination of Atlantic Sturgeon behavior in the presence of sink gillnets, and an examination of the post-release mortality of incidentally landed Atlantic Sturgeon. A total of 31 Atlantic Sturgeon were encountered during the fall 2016 sampling season resulting in 18 mortalities and 13 live releases. The industry standard (control) gillnet encountered the vast majority 25 (80.6%) of Atlantic Sturgeon while the modified reduced by a ratio of 4.2:1. Landings of Monkfish in control nets were slightly albeit significantly greater in NY while there was no difference in net performance in NJ. Landings of Spiny Dogfish and Winter Skate did not vary by gear type in either NY or NJ suggesting the experimental nets show much promise as a conservation measure. Of the 31, incidentally encountered Atlantic Sturgeon 18 mortalities took place. The remaining 13 individuals were released alive after being outfitted with a p-sat transmitter. Of the 13 transmitters deployed through this project, nine (69.2%) reported and four were physically recovered. Of the recovered transmitters there appears to have been two events that caused a premature release of tags caused by the constant depth release function. These releases could have been a result of either the individual succumbing to the stress of incidental capture (i.e. mortality) or as the result of the sturgeon remaining in an area of consistent depth for a prolonged period of time.

Background

Globally, sturgeons (family Acipenseridae) have suffered dramatic population declines with 85% of species at risk of extinction according to the findings of a recent IUCN report. As such, the IUCN noted that sturgeon were more critically endangered than any other species group on their on their Red List (IUCN 2010). The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), which ranges from the St. Johns River, Florida (Vladykov and Greeley 1963) north to the Hamilton Inlet, Labrador, Canada (Backus 1951), typifies this pattern. The Delaware River currently supports fewer than 300 spawning individuals (ASSRT 2007); representing ≈ 0.08% of the historical abundance of what was once the largest population (Secor and Waldman 1999) of Atlantic sturgeon. A recent examination of coast-wide genetic structure and population demographics estimated an effective population size (*Ne*) of 40 for the Delaware River which may suggest the relationship between a genetic artifact of large historical abundance and a current relict population (Waldman et al. 2018).

In 1990, the Atlantic States Marine Fisheries Commission (ASMFC) created a Fishery Management Plan (FMP) for Atlantic sturgeon with a goal of restoring a fishable population that could sustain annual removals equal to 10% of historic landings (Taub 1990). Shortly thereafter, the FMP was followed with an amendment implementing a coast-wide moratorium on harvest of Atlantic sturgeon (ASMFC, 1998). In 2005, the Atlantic Sturgeon Status Review Team (ASSRT) was created to determine if protection was warranted under the Endangered Species Act. The ASSRT published its findings in 2007, identifying five Distinct Population Segments (DPSs), which were distinctly separated by their biological traits and genetic composition, occupied unique ecological settings, and would create a large gap in the species' range if extirpated (ASSRT 2007).

On February 6, 2012, NMFS published a notice in the Federal Register proposing to list four of the Atlantic sturgeon DPSs, including the New York Bight and Chesapeake Bay DPSs, as endangered, and the Gulf of Maine DPS as threatened (U.S. Office of the Federal Register 2012a, U.S. Office of the Federal Register 2012b). On April 6, 2012, the final ruling to list five Distinct Population Segments (DPSs) of Atlantic sturgeon under the Endangered Species Act became effective. The decision to list Atlantic sturgeon was based on a number of factors including degradation and loss of habitat, vessel strikes, and bycatch in commercial fisheries. The ASMFC just completed the first benchmark stock assessment of Atlantic Sturgeon on almost two decades (ASMFC 2017). The results of this assessment suggest that all populations are depleted compared to historic levels although in roughly 2/3 of the systems mortality rates are at levels that should support recovery and populations are beginning to rebound compared to the 1998 benchmark stock assessment.

Atlantic sturgeons are anadromous, spending much of their life in the marine environment. In both the Status Review and FMP, documents there are calls for more directed research on the marine phase of Atlantic sturgeon life history, which has been underrepresented in the scientific literature (Stein et al. 2004a). The general lack of biological information causes problems for fisheries professionals working within the confines of state jurisdictional boundaries, and it is especially problematic for Atlantic Sturgeon, as they are known to suffer from interactions with coastal marine fisheries, including gillnets (Stein et al. 2004b, ASMFC 2007). Both fisheries-dependent (Stein et al. 2004a) and fisheries-independent (Dunton et al. 2010; Erickson et al. 2011; Oliver et al. 2013; Breece et al. 2016) studies assert that adult Atlantic Sturgeon primarily occupy shallow near-shore areas while also aggregating at key coastal features for improved foraging opportunities (Dovel and Berggren 1983; Johnson et al.

1997; Kynard et al. 2000). The congregation of Atlantic Sturgeon in nearshore areas of high productivity places the species at risk of many fisheries; however, Dunton et al. (2015) indicate that Summer Flounder (*Paralichthys dentatus*) bottom trawl and Goosefish (regionally known as Monkfish) (*Lophius americana*) gill-net surveys record the highest chances of bycatch.

In addition to coastal aggregations, the large coastal movements exhibited by sturgeon make them more vulnerable to bycatch in commercial fisheries along the coast (Collins et al. 2000). Bycatch, caused by a variety of gear types, is considered one of the primary threats within the ESA listing determination as well as one of the largest impediments to the recovery of both juvenile and adult Atlantic Sturgeon (Collins et al. 2000; ASSRT 2007).

The use of gillnets to capture fish dates back over 3,000 years, although relatively recent advances in technology including synthetic materials and hydraulic haulers have led to increased use of this methodology (Potter and Pawson 1991, He 2006). Unfortunately our understanding of the mechanisms influencing bycatch in gillnets has lagged behind technological advances in the fishing industry, leading to increased concerns over the incidental take of birds, fishes, and mammals (He and Pol 2010). Gillnets are generally selective and although somewhat limited information is available, it appears that gillnet configuration plays an important role in the retention of Atlantic sturgeon (Trencia et al. 2002, Sweka et al 2007, Fox et al. 2013). With the recent listing of Atlantic sturgeon under the Endangered Species Act, resource managers are under increased pressure to reduce incidental bycatch and corresponding mortality mortality rates of sturgeon

In the mid-Atlantic and northeast U.S., monkfish support a lucrative commercial fishery out to the edge of the continental shelf. Monkfish are targeted primarily with trawls in the northern management area and sink-gillnets in the mid-Atlantic. The sink-gillnets employed in the Monkfish fishery have been identified as a significant source of bycatch mortality for Atlantic sturgeon during the marine phase of their life history (Stein et al. 2004b, ASMFC 2007). As such, changes in fishing practices in the Monkfish fishery may have the potential to decrease the bycatch of Atlantic sturgeon. Unfortunately, data on potential bycatch reduction approaches in the Monkfish gillnet fishery (e.g. net profile and tie-downs) are generally lacking, although mesh size, tie downs, and soak times are thought to be mitigating factors in Atlantic sturgeon bycatch mortality (Fox et al. 2013). Through this project, we examined four objectives centered on improving both the recovery prospects of Atlantic Sturgeon and the sustainability of the mid-Atlantic Monkfish fishery. The specific objectives of the project were:

1. Compare the bycatch rates of Atlantic sturgeon for each of two net configurations
2. Compare the catch rates of the target species (monkfish and winter skate) for each net configuration
3. Assess post-release mortality of Atlantic sturgeon landed incidentally in both control and experimental gillnets via satellite and acoustic transmitters
4. Conduct in-situ experimental trials of sink gillnets to understand how Atlantic sturgeon interact with gillnets.

Methods

A total of 20 fishing trips were conducted on each collaborating fishing vessel in NY and NJ. Two net configurations were fished in two (NJ) or three (NY) replicated pairs: (1) An industry standard sink-gillnet with 12-inch mesh, 0.90mm twine, 12 ft. in height net with 4ft tie downs spaced out at 24 ft. intervals, (2) an experimental lower-profile sink-gillnet with 13-inch mesh, 0.81mm twine, 8 ft. in height with 2 ft. tie-downs spaced every 12 ft. (Figure 1). All other characteristics of the nets (e.g., .50 hanging ratio, 300 ft. long, and Chatham green webbing) were the same. The nets were tied together in either eight (NY) or 12 panel strings (NJ) (800 or 1,200 yards) which represent industry standards in the respective regional monkfish fisheries. The shorter string length in the NY monkfish fishery was a result of strong tidal currents, which require shorter lengths to prevent twisting of the nets.

Strings of gillnets were comprised of one net treatment (control vs. experimental) and were fished as pairs with each pair being fished in close proximity (<.5 miles) to minimize environmental variability. We employed between two - three replicates (four-six strings) representing 48 shots (4,800 yards) of netting at each location. The gear was maintained and tears or damage that could affect the performance of the gear were repaired or replaced prior to each set of the gear.

All hauls was observed by NOAA-NMFS Certified Observers (MRAG Americas Inc.) using standard observer logs replicating the data collection techniques used by Fox et al. 2013,. Catch of the targeted species as well as Atlantic sturgeon and other bycatch were recorded. All gear and haul characteristics including location, soak duration, and depth were recorded as per standard NEFSC protocols.

The experimental gillnet strings will consist of 12 net panels per string of the same net configuration (i.e. treatment vs. control. Sampling consisted of setting both net configurations (control and experimental) in a similar location and keeping all aspects of the operation (e.g. soak time, set direction, haul speed) standardized between the sets. During the course of the study, the sequence of gear deployment was randomly chosen. Each of the experimental strings was paired with control strings and set 20 times.

To examine the relative retention success of external transmitters (shedding rate) conducted an independent double acoustic tag study using a sub-set (n=40) of Atlantic sturgeon which were captured during directed sampling efforts in the spring of 2015 off the coast of Delaware. Atlantic sturgeon landed in this sub-project will have a transmitter surgically implanted (Fox et al. 2000, Damon-Randall et al. 2010) in addition to having an external tag affixed to the base of the dorsal fin (Sulak et al. 2009) with VEMCO V16-4H acoustic transmitters. The rationale behind this dual tagging effort was due to the relatively low cost of acoustic transmitters (\$330) vs. p-sat tags (>\$2,000) and the need for an independent assessment of tag shedding rates in our planned approach to understanding chronic mortality events. Unfortunately, due to low rates of incidentally caught Atlantic Sturgeon during commercial trials in the fall of 2016 we were unable to put out our planned external acoustic transmitters.

For this study, live Atlantic sturgeon incidentally captured within commercial gillnets were externally tagged with a Lotek PSATs (by trained onboard observers (MRAG Americas Inc.) to examine the acute effects of post release mortality and survivorship on Atlantic sturgeon. Sturgeon were tagged by tethering the PSAT's onto 180kg monofilament that was passed through the dorsal musculature at the base of the dorsal fin using a tagging needle (Erickson et al. 2012; Erickson and Hightower 2007).

We employed a 28 receiver VEMCO Ltd. VR2W Positioning System (VPS) in nearshore coastal waters that contain large numbers of migratory Atlantic Sturgeon which coincided with our spring 2016 sampling program. Within this VPS array we fished two sets of replicate gillnet strings comprised in a 3x3 random block design with each system comprised of 9 x 91.4 m net panels. Prior to the construction of the net, we randomized the order of treatments within a block. Since it was not feasible to do this every net set we also alternated the direction on gillnet sets to minimize potential biases. A total of three net configurations comprised of a control (standard monkfish net (30.5cm stretch, 12 mesh in height, .90mm twine, tied down to 1.2 m every 7.3 m and two treatment nets Treatment 1- 30.5 cm stretch, 8 mesh in height, .90 mm twine, tied down to .6 m every 3.65m and Treatment 2- similar to Treatment 1 with the exception that it will be constructed from lighter twine (e.g. .81mm) in hopes of decreasing retention of large individuals. These net configurations were fished during the spring months off the coast of Delaware in a relatively sturgeon rich environment and allowed up to examine how sturgeon act in the presence of fishing operations.

Results and Discussion

Comparative gillnet study (Objectives 1 and 2)

Between November 15 and December 23, 2016 40 sink-gillnet trials split equally between New Jersey (F/V Dana Christine II, Barnegat Light, NJ) and New York (F/V Liberty, Shinnecock Inlet, NY) were conducted. A NOAA-NMFS approved observer (MRAG Inc.) was on board to record data on net performance on bycatch of Atlantic Sturgeon as well as the landing rates of target species (e.g. Monkfish and Winter Skate).

Objective 1. Compare the bycatch rates of Atlantic sturgeon for each of two net configurations.

In total, 31 Atlantic Sturgeon were encountered during the fall 2016 sampling season resulting in 18 mortalities and 13 live releases (Table 1). Each live release was also fitted with an external pop-off satellite (p-sat) transmitter (Table 2). The industry standard (control) gillnet encountered the vast majority 25 (80.6%) of Atlantic Sturgeon. The modified gillnet utilized in this study reduced Atlantic Sturgeon bycatch by a ratio of 4.2:1 and shows much promise for the overall reduction of bycatch rates. Overall, the total number of Atlantic Sturgeon encountered in our sampling was much lower than anticipated. Although the marine movements of Atlantic Sturgeon are poorly understood, there is a growing body of evidence to suggest that their habitat use varies markedly between years and may be closely linked to water masses (Breece et al.2017, Breece et al. 2017). Conversations with our industry partners suggested that the bulk of Atlantic Sturgeon might have migrated prior to the start of the Monkfish season in the fall of 2016 resulting in fewer encounters than anticipated. An examination of telemetry data off the coast of Delaware indicated that Atlantic Sturgeon telemetered in other projects initiated their migration somewhat earlier in the fall of 2016 thereby reducing the likelihood of encounters in the NY and NJ sink gillnet fisheries during this year.

Objective 2. Compare the catch rates of the target species (monkfish and winter skate) for each net configuration

A total of 19 species (including Atlantic Sturgeon) were encountered during the conduction of our cooperative gillnet trials (Table 3). The total weights for the top three species landed were: Winter Skate - 35,010 lb., Monkfish - 32,333 lb., and Little Skate - 1,733 lb. followed by Spiny Dogfish at 1,379.7 lb. Overall landings of the primary target species were greater in NY (Monkfish- 23,654lb; Winter Skate 24,801) compared to NJ (Monkfish- 8,679lb; Winter Skate 10,201).

Soak times varied by states with our NJ cooperating partner soaking his nets an average of 32.1 h (range 18-51) compared to our NY cooperating fisherman who's average time was 48.0 h (range 24-120). Soak times can vary greatly both between and within regions because of numerous factors including weather, catch rates and market conditions, estimated haul time, fishing location, and vessel operations. Although we initially hoped to keep, our soak times below 96h there were weather conditions in the NY fishery that precluded our partner from getting to his nets for five days (120h) at one period. When questioned about this, our partner conveyed that he was surprised by the weather and by the time he realized conditions were deteriorating he was unable to get his gear out of the water resulting in the prolonged long soak time.

In an attempt to compare the performance of our experimental and control nets we examined state-specific catch rates (pounds landed/net/hour) for the three most abundant commercial species in our study; Monkfish, Winter Skate, and Spiny Dogfish. Overall landings of Monkfish were greater in NY during the 2016-fishing season and our results fit into the general pattern observed by our commercial partners. Historically under similar conditions our partner in NJ has fished in the same general area as our NY partner representing a one-way transit of approximately 90 miles. Our commercial partner in NJ stayed in his home waters in 2016 in part to meet the objectives of our study. As a result, we are able to provide insights in gear performance under periods of high and modest catches. The experimental nets landed significantly fewer Monkfish in NY ($p= 0.0440$) (Figure 2) while there was no significant difference in catch rates of Monkfish between gear types in NJ ($p= 0.3854$) (Figure 3). Catch rates of Winter Skate were similar across fishing locations and did not vary significantly by gear type (NY; $p= 0.1000$, NJ; $p=0.0593$) (Figures 4 and 5). Overall landings of Spiny Dogfish were modest in both locations and a similar pattern was documented with no significant differences in catch rates by gear type in either location (NY; $p= 0.5110$, NJ; $p=0.3509$) (Figures 6 and 7)

Objective 3. Assess post-release mortality of Atlantic sturgeon landed incidentally in both control and experimental gillnets via satellite and acoustic transmitters

Of the 31 incidentally encountered Atlantic Sturgeon 18 direct mortalities were recorded. The remaining 13 individuals were released alive after being outfitted with a Lotek p-sat transmitter (Table 5). All transmitters were programmed to pop-off and/or begin transmitting in 30 days. Of the 13 transmitters deployed through this project, nine (69.2%) have reported including four (44.4%) that we were able to physically recover. The recovered tags were provided by a commercial fisherman from Point Pleasant (NJ) who incidentally captured the animal (L-330-1349) in a sink-gillnet while targeting Monkfish and Winter Skate, a citizen who recovered a transmitter (L-330-1366) on a beach in Kill Devil Hills (NC), a transmitter (L-330-1371) that washed up on Long Beach Island (NJ) in April, 2017 that was collected by co-PI Keith Dunton, and a transmitter (L330-1350) that was recovered by a beachcomber on the Island of Santa Maria (Azores) in the fall of 2017 and returned to Lotek on January 18, 2018. The transmitter batteries were expired in all recovered tags and the Lotek data recovery specialist was able to recover the data in all but one instance.

An examination of the data from the p-sat tags provides insights into the post-capture behavior of Atlantic Sturgeon. Tag ID # 1349 was deployed on 12-13-2016 and tag # 1371 deployed on 12-11-2016 both recorded 11 days of information (Figure 4; Figure 5). The constant depth profiles achieved with fish #1372 after approximately four days at large and #1371 after 11 days is indicative of the fish maintaining a constant profile enabling the constant depth function causing the tag to release from the study animal if it sinks to the bottom or floats to the surface to allow data transmission. It is possible that a sturgeon could have been recovering sitting or maintaining a constant depth, or the animal died. An examination of the condition at time of incidental capture and release suggests that both individuals were in relatively good condition at the time of release. Tag ID # 1350 remained on the animal for 28 days and based on depth profiles this animal moved into deeper water on December 10 and continued to remain active for the duration of the tag deployment (Figure 6). Based on our limited sample sizes of fully workable p-sat data we speculate that one (25%) of our individuals possibly suffered a mortality post-release. Tag #1366, which was recovered from Kill Devil Hills, downloaded with unrecoverable data files.

Sub-project: Assessment of Transmitter Retention and Post-Release Survival- As proposed, the deployment of external acoustic tags to examine long-term (chronic) mortality was to follow the deployment of all p-sat transmitters. Due to low encounter rates of sturgeon, we were not able to deploy all p-sat transmitters thereby precluding the planned deployment of external acoustic transmitters in bycaught sturgeon. The double tagging of 40 individuals during our 2015 experimental trials, which ran from April 6 to May 8, allowed us to evaluate the effectiveness of external tagging (Figure 1). Captured fish, were double tagged by surgically implanting a VEMCO V-16 6H acoustic transmitter into the body cavity, as well as, externally attaching a VEMCO V-16 4H transmitter at the base of the dorsal fin. The overall goal of using both tags was to evaluate the shedding rates and effectiveness of externally attaching a tag by comparing the detectability of proven long term internal tagging. External attachment of tags was preferred to decrease the overall stress induced on the animal and reduces the confounding negative effects generally caused by surgical complications/healing, increased handling time, and anesthesia.

The forty fish (80 tags; 40 internal and 40 external) were detected at 198 different VEMCO VR-2W receivers located along the coast by our arrays as well as cooperating partners in the Atlantic Cooperative Tagging (ACT) Network , in NC, MD, NJ, and NY. To evaluate the effectiveness of external tags; the total percentage of both tags being active and detected together by acoustic receivers were compared against each other (Figure 2). In total, The 80 tags resulted in 79,076 unique detections (Table 4). Table 4, shows the individual fish tagged with the total number of detections for both the internal and external tags. When the acoustic tags are compared against each other (total % of both tags being active) both internal/external tags had a high rate of agreement within the first 3 months, with 97% of the animals reporting both their internal and external tags simultaneously on receivers, indicating a high retention of external transmitters (Figure 8.). This agreement amongst the two tagging types remained high, at 95% through 6 months of deployment but then drastically decreased after month 9 with only 76% in agreement (Figure 8). In all cases, the cause in the decline of the two tags being actively recorded together is due to the external tag not being detected. This loss of signal of the external tag likely indicated either loss or shedding of the tag or biofouling hindering the signal transmission, The overall high rate of retention of the external tags compared to internal acoustic tags for the first 6 months supported the use of external tags (acoustic and PSAT) for short deployment times such as the ones used in this study. The results of our dual tagging project show promise on minimally invasive external tagging on survival studies or short-term movement studies. On June 8, 2017 a New York State Department of Environmental Conservation Hudson River Fisheries Unit field crew captured one of our dual tagged individuals (Figure 9). This fish was originally tagged off the coast of Delaware on April 17, 2015 and the external transmitter was still well attached and showed minimal irritation (tissue reaction) or bio-fouling after 783 days at liberty.

Objective 4. Conduct in-situ experimental trials of sink gillnets to understand how Atlantic sturgeon interact with gillnets.

A 28-receiver VEMCO VR2W array was successfully deployed by the start of fishing activities on April 1, 2015 and recovered in mid-June 2015 (Figure 1). One receiver within the array was lost, but was not essential in determining the fine scale position estimates. All associated metadata for this study were compiled and sent to for VEMCO Ltd. to provide position estimates on fish that have swam through the array. Results indicate that the VEMCO VPS portion of this study detected seven telemetered species, which included 552 unique transmitters over the 71 d operational period. Cooperative data sharing agreements were obtained from 15 different agencies representing the vast majority (88.4%) of transmitters including 462 Atlantic Sturgeon, 15 Sand Tigers, 3 Striped Bass, 4 Horseshoe Crab, and 1 White Shark.

We have examined the trajectories of telemetered Atlantic Sturgeon, which were provided through the VPS array. In total 360 Atlantic Sturgeon provided sufficient data to provide position estimates. Of these 360 individuals 30 telemetered Atlantic Sturgeon were positioned during periods of directed sampling and came within close proximity of our gillnets (Table 6). The most promising encounters are plotted herein and one instance depicts an Atlantic Sturgeon exhibiting probable avoidance behavior (Figure 13). The remainder of the plots (Figures 14-18) depict Atlantic Sturgeon moving through our low-profile experimental nets. It is important to note that none of these previously telemetered Atlantic Sturgeon were captured in directed sampling as the individuals either swam over of through the nets. Our data also strongly suggest that Atlantic Sturgeon exhibit crepuscular behavior between roughly 04:00-07:00 and 17:00-19:00 during their spring migration. Given the size of most individuals, the vast majority of tagged animals would have been vulnerable to our gear. In general, Atlantic Sturgeon appear to be making slow directed movements along the nearshore coastal waters of Delaware in the spring.

Anticipated Work Products- We anticipate at least two full publications and a note arising from this effort. The first publication will be focused on merging the results of the field trials from this effort with those previously funded by the Office of Protected Resources (Fox et al. 2013) as a synoptic paper on the potential for reducing incidental bycatch of Atlantic Sturgeon in large mesh sink gillnets. The second publication will examine the behavior of Atlantic Sturgeon in the presence of sink gillnets. A masters student working with D. Fox has recently developed code and worked out the analyses as part of his thesis on Atlantic Sturgeon behavioral changes in the presence of commercial shipping. We plan to employ his methods to our question. We also plan to publish a note with the results of the dual-tagging study of Atlantic Sturgeon to address the question of the short-term external transmitter retention as this issue is of concern to the NOAA-NMFS Office of Permitting as well as the general research community.

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Vladykov, V.D., and J.R. Greely. 1963. Fishes of the Western North Atlantic 1:24-6.

Waldman, J., S. E. Alter, D. Peterson, L. Lorraine Maceda. N. Roy, and I. Wirgin. 2018. Contemporary and historical effective population sizes of Atlantic sturgeon *Acipenser* *oxyrinchus oxyrinchus*. Conservation Genetics. https://doi.org/10.1007/s10592-018-1121-4

Table 1: Atlantic Sturgeon encountered in cooperative trials of sink gillnets during November-December 2016 in New Jersey and New York. This table only represents the dates when Atlantic Sturgeon were encountered and includes information on the number of mortalities, total transmitters deployed, and the net configuration employed.

Date	Location (State)	# Atlantic Sturgeon Caught	# Atlantic Sturgeon Mortalities	# Atlantic Sturgeon Telemetered	# Atlantic Sturgeon in Control	# of Atlantic Sturgeon in Treatment
11/18/2016	NJ	1	0	1	1	0
11/25/2016	NJ	3	1	2	3	0
11/28/2016	NJ	1	0	1	1	0
11/30/2016	NJ	2	2	0	1	1
12/6/2016	NJ	2	1	1	2	0
12/8/2016	NJ	4	2	2	3	1
12/10/2016	NJ	3	3	0	2	1
12/13/2016	NJ	1	1	0	0	1
12/14/2016	NJ	1	0	1	1	0
12/20/2016	NJ	2	1	1	2	0
12/21/2016	NJ	1	1	0	1	0
12/22/2016	NJ	2	1	1	2	0
12/23/2016	NJ	1	1	0	1	0
11/19/2016	NY	1	1	0	1	0
11/27/2016	NY	1	1	0	1	0
12/4/2016	NY	1	1	0	1	0
12/7/2016	NY	1	0	1	1	0
12/10/2016	NY	1	1	0	0	1
12/11/2016	NY	1	0	1	0	1
12/13/2016	NY	1	0	1	1	0
TOTALS		31	18	13	25	6

Table 2: Incidentally encountered Atlantic Sturgeon that were externally tagged with a P-Sat transmitters by location, date, net type, and transmitter reporting statistics during our winter 2016 directed sampling efforts in NY and NJ.

Location	Date	Transmitter Number	Net Type	Transmitter Reported	Transmitter Recovered	Pop-off Date	Days At Large
NJ	11/18/2016	1331	CONTROL	Yes	No	12/16/2016	28
NJ	11/26/2016	1363	CONTROL	Yes	No	12/27/2016	31
NJ	11/26/2016	1350	CONTROL	Yes	Yes	12/27/2016	31
NJ	11/28/2016	1361	CONTROL	No	No	DID NOT REPORT	0
NJ	12/6/2016	1352	CONTROL	No	No	DID NOT REPORT	0
NJ	12/8/2016	1343	TREATMENT	No	No	DID NOT REPORT	0
NJ	12/8/2016	1366	CONTROL	Yes	Yes	1/5/2017	28
NJ	12/14/2016	1114	CONTROL	No	No	1/11/2017	28
NJ	12/20/2016	1337	CONTROL	Yes	No	1/17/2017	28
NJ	12/22/2016	1370	CONTROL	Yes	No	1/19/2017	28
NY	12/7/2016	1346	CONTROL	No	No	DID NOT REPORT	0
NY	12/11/2016	1371	TREATMENT	Yes	Yes	1/8/2017	28
NY	12/13/2016	1349	TREATMENT	Yes	Yes	1/14/2017	32

Table 3: Total landings by species encountered in cooperative trials of sink gillnets during November-December 2016 in New Jersey and New York.

Common Name	Pounds Landed NJ	Pounds Landed NY	Total Pounds Landed
Atlantic Menhaden	23	0	23
Atlantic Sturgeon	298	0	298
Atlantic Torpedo Ray	0	17	17
Barndoor Skate	89	50	139
Bluefish	51	39	91
Clearnose Skate	179	56	235
Horseshoe Crab	910	371	1281
Little Skate	591	1141	1733
Monkfish	8679	23654	32333
Northern Stargazer	19	0	19
Sea Robin	0	2	2
Smooth Dogfish	2	0	2
Spiny Dogfish	693	687	1380
Summer Flounder	0	117	117
Winter Skate	10210	24801	35010
Wolf Fish	17	0	17
Grand Total	21761	50934	72696

Table 4: Acoustic detections by transmitter type for dual acoustically tagged sturgeon caught off the coast of Delaware in the spring of 2015 for the first 24 months post-release.

		# of Months Post Release																									
Fish ID #	Tag type	0	1	2	3	4	5	6	7	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total # of detections
DSU AS 2015-017	External	4	85	13	11	25	53	2								1	146											340
	Internal	3	67	8	14	23	71									3	179											368
DSU AS 2015-018	External	50	57	682	34	39	573														3							1,438
	Internal	46	39	571	40	60	651														3							1,410
DSU AS 2015-019	External	2	6838	1102	1101	582	445																					10,070
	Internal	1	5918	919	774	479	204		28		25						5	7					11				6	8,377
DSU AS 2015-020	External	150	199	16			85	30																				480
	Internal	152	238	20			105	36							4	49	9				2							615
DSU AS 2015-021	External	162	27		51		12																					252
	Internal	161	24		55		13	1																				254
DSU AS 2015-022	External	2	737	1254	82			5	15		45					1					16							2,157
	Internal	2	700	1031	101				15		56					3					18	4	7					1,937
DSU AS 2015-023	External	9	26					1	21							5						2						64
	Internal	8	30					6	29							8						7						88
DSU AS 2015-024	External	91	148	934	15	22		18		8																		1,236
	Internal	79	148	863	16	23		26		12						7	110								8			1,292
DSU AS 2015-025	External	193	221	64							1					13												492
	Internal	172	170	38							2					13												395
DSU AS 2015-026	External	2	59	55	15	269	49					253	641	84	8	14	4											1,453
	Internal	1	63	46	20	253	66					275	654	73	9	16	8											1,484
DSU AS 2015-027	External	7	33	84			5									1	10	84			2							226
	Internal	6	32	80			10									4	11	86			1							230
DSU AS 2015-028	External	3	10																									13
	Internal	4	12																									16
DSU AS 2015-029	External	85	35	320	9	7	33	1								4				16								510
	Internal	64	24	130	10		33	2								5				10								278
DSU AS 2015-030	External	22	322	555					2	12						1	1				16	11						942
	Internal	23	241	437					3	17						2	2				11	4	15					755
DSU AS 2015-031	External	55	145	35						7						4												246
	Internal	48	116	33						7	1					7					4							216
DSU AS 2015-032	External	2	29	4	62		4								8	2	10				169							290
	Internal	2	43	8	62	4	17								13	5	9				151							314
DSU AS 2015-033	External	17	44	6	6		325										61		8	3	2							472
	Internal	14	33	9	10		384										41		12	3	1							507
DSU AS 2015-034	External	29	146	46	20	7	15														7							270
	Internal	20	122	46	24	3	22														8							245
DSU AS 2015-035	External	16	623	211				2		2185	1767						24			5	1	5						4,839
	Internal	17	493	152				3		2009	1693						22			14	3	5	7					4,418
DSU AS 2015-036	External	20																										20
	Internal	22	16		4	60	38										2											142
DSU AS 2015-037	External	5	32		32	11	48	7								2												137
	Internal	4	36		31	9	62	8																				150
DSU AS 2015-038	External	26	139	1424	1589	941	93	50	24	18	3	11																4,318
	Internal	24	127	1286	1371	985	96	62	25	20	4	11							1	429	82	9			7			4,539
DSU AS 2015-039	External	48	51	19	15	1	28	2														3						167
	Internal	54	56	16	16	8	36	4														5						195
DSU AS 2015-040	External	56		2	8			14								4					2							86
	Internal	64		3	9			24								5					6					23		134
DSU AS 2015-041	External	12	553	777							10																	1,352
	Internal	13	510	610							10						17		8									1,168
DSU AS 2015-042	External	7	138	257	31			12			148										3							596
	Internal	7	124	255	31			10			161										8		22	10		7		635
DSU AS 2015-043	External	25	94	143	270	204	12	11		1																		760
	Internal	23	90	183	209	148	15	12		1										12	3	8						704
DSU AS 2015-044	External	6	17	20	10		71	25	13																			162
	Internal	1	16	21	9		77	20	15											1								160
DSU AS 2015-045	External		87	39				13			12						11			5		7						174
	Internal		86	34			1	13			13						14			15		11		17				204
DSU AS 2015-047	External	40	109		1	9	15																					174
	Internal	40	117		2	9	16															2						186
DSU AS 2015-048	External	10	10	12	15		14										3											64
	Internal	9	12	5	17		13										2					15						73
DSU AS 2015-049	External	5	18		1	9	11	11												1								56
	Internal	4	21		2	11	19	14																				71
DSU AS 2015-050	External	8	196	1962	98												1											2,265
	Internal	6	152	1369	75			1									1				2	3						1,609
DSU AS 2015-051	External	53	168	348	19			103		1							2		3									697
	Internal	65	333	546	34			177		5							6		5			1						1,172
DSU AS 2015-052	External	33	303	273						838	1527					3			18									2,995
	Internal	35	317	223						789	1410					2			21			23						2,820
DSU AS 2015-053	External	42	32	22	59		10								11	4	16											196
	Internal	42	21	18	52		7								6	1	8											155
DSU AS 2015-054	External	11	74	4	29		3																					121
	Internal	12	61	6	42		7	2																				130
DSU AS 2015-055	External	69	184		13	21	29										2											318
	Internal	58	213		17	25	33										2				2							350
DSU AS 2015-056	External	47	36		46		34									1												164
	Internal	40	20		49		42									1				5								157
DSU AS 2015-057	External	42	34	34	86	28	42																					266
	Internal	42	30	36	64	26	37										3				7							245
	Grand Total	2854	22930	19719	6888	4301	4084	728	190	5930	6888	550	1295	157	59	191	742	177	76	519	533	125	62	27	15	30	6	79,076

Table 5: Incidentally encountered Atlantic Sturgeon that were externally tagged with P-Sat transmitters by location, date, net type, transmitter reporting/recovery, pop-off date, and days at large.

Location	Date	Transmitter Number	Net Type	Transmitter Reported	Transmitter Recovered	Pop-off Date	Days At Large
NJ	11/18/2016	1331	CONTROL	Yes	No	12/16/2016	28
NJ	11/26/2016	1363	CONTROL	Yes	No	12/27/2016	31
NJ	11/26/2016	1350	CONTROL	Yes	Yes	12/27/2016	31
NJ	11/28/2016	1361	CONTROL	No	No	DID NOT REPORT	0
NJ	12/6/2016	1352	CONTROL	No	No	DID NOT REPORT	0
NJ	12/8/2016	1343	TREATMENT	No	No	DID NOT REPORT	0
NJ	12/8/2016	1366	CONTROL	Yes	Yes	1/5/2017	28
NJ	12/14/2016	1114	CONTROL	No	No	1/11/2017	28
NJ	12/20/2016	1337	CONTROL	Yes	No	1/17/2017	28
NJ	12/22/2016	1370	CONTROL	Yes	No	1/19/2017	28
NY	12/7/2016	1346	CONTROL	No	No	DID NOT REPORT	0
NY	12/11/2016	1371	TREATMENT	Yes	Yes	1/8/2017	28
NY	12/13/2016	1349	TREATMENT	Yes	Yes	1/14/2017	32

Table 6: Potential interactions between previously telemetered Atlantic Sturgeon and sink gillnets off the coast of Delaware in 2015 including transmitter number, timing of interaction, net location, encounter type, encounter location, net configuration, and transmitter owner.

Tag	Date	Sturgeon Start UTC	Sturgeon End UTC	Amount ofTime	Net ID	Net Start UTC	Net End UTC	Net Location	Encounter	Where at net	Net Order	Net Type	Type	Direction	Net Location	Owner
A69-1303-20442	05/06/2015	11:07:36 AM	11:40:18 AM	0:32:42	2015 116/02	8:46:00 AM	11:53:00 AM	Off shore	Edge	West	RBY		Between	South to North	Offshore	DSU
A69-1303-20450	04/14/2015	3:48:26 PM	5:06:13 PM	1:17:47	2015 039/05	3:10:00 PM	7:38:00 PM	Off shore	Parallel	Center	YRB	Red	Experimental 1	West to East	Offshore	DSU
A69-1303-20457	05/04/2015	3:41:36 PM	4:52:58 PM	1:11:22	2015 106/04	1:53:00 PM	5:43:00 PM	In shore	Through	Center-West	BRY	Red	Experimental 1	South to North	Inshore	DSU
A69-1303-48147	04/29/2015	2:51:40 PM	3:49:03 PM	0:57:23	2015 094/04	2:16:00 PM	6:09:00 PM	In shore	Through	Center-West	BRY	Blue	Control	South to North	Inshore	DEDFW
A69-1303-48772	05/08/2015	2:23:00 PM	2:59:49 PM	0:36:49	2015 128/02	1:46:00 PM	5:01:00 PM	Off shore	Through	West	BRY	Yellow	Experimental 2	South to North	Offshore	DSU
A69-1601-23354	04/25/2015	6:31:41 PM	7:15:01 PM	0:43:20	2015 070/04	1:59:00 PM	6:33:00 PM	In shore	Edge	West	BRY		west of nets	South to North	Inshore	VIMS
A69-1601-27720	04/17/2015	6:13:25 PM	8:38:22 PM	2:24:57	2015 044/05	3:13:00 PM	8:50:00 PM	Off shore	Through	Center-West	BRY	Blue	Control	South to North	Offshore	DSU
A69-9001-22475	04/26/2015	8:18:45 AM	9:24:49 AM	1:06:04	2015 073/02	8:27:00 AM	12:38:00 PM	In shore	Edge	West	BRY		west of nets	North to South	Inshore	DSU
A69-9001-22479	04/26/2015	1:16:53 PM	5:14:50 PM	3:57:57	2015 076/05	1:22:00 PM	5:53:00 PM	In shore	Through	West	BRY	Blue	Control	Varying	Inshore	DSU
A69-9001-22482	04/26/2015	8:08:09 AM	6:23:19 PM	10:15:10	2015 077/06	2:09:00 PM	6:52:00 PM	Off shore	Parallel	Center-East	RBY	Yellow	Experimental 2	Varying	Offshore	DSU
A69-9001-22485	04/26/2015	1:12:27 PM	3:11:45 PM	1:59:18	2015 076/05	1:22:00 PM	5:53:00 PM	In shore	Parallel	West	BRY		Between	Varying	Offshore to Inshore	DSU
A69-9001-22486	04/29/2015	4:55:43 PM	7:31:32 PM	2:35:49	2015 094/04	2:16:00 PM	6:09:00 PM	In shore	Through	East	BRY	Yellow	Experimental 2	Varying	Inshore	DSU
A69-9001-22486	04/27/2015	4:15:34 PM	5:22:13 PM	1:06:39				In shore	Parallel	West			parallel	Varying	Inshore to Offshore	DSU
A69-9001-22487	04/27/2015	3:39:07 PM	5:24:53 PM	1:45:46	2015 082/04	12:12:00 PM	4:00:00 PM	In shore	Edge	West	YBR		parallel and west	Varying	Offshore to I	DSU
A69-9001-22488	04/28/2015	11:39:10 AM	6:25:37 PM	6:46:27				In shore	Edge	West			west of nets	Varying	Inshore	DSU
A69-9001-22489	04/27/2015	3:26:03 PM	5:25:02 PM	1:58:59	2015 083/05			Off shore	Edge	West			Control	South to North	Offshore	DSU
A69-9001-22489	04/28/2015	11:56:39 AM	9:00:55 PM	9:04:16	2015 86/02 & 2015 89/05			In shore	Edge	West			Control	Varying	Inshore	DSU
A69-9001-22490	04/27/2015	3:12:18 PM	5:23:08 PM	2:10:50	2015 083/05	1:01:00 PM	4:43:00 PM	Off shore	Through	Center-East	BRY	Red	Experimental 1	Varying	Offshore	DSU
A69-9001-22491	04/26/2015	5:33:57 PM	6:50:06 PM	1:16:09	2015 077/06	2:09:00 PM	6:52:00 PM	Off shore	Through	Center-West	RBY	Red	Experimental 1	South to North	Offshore	DSU
A69-9001-26405	04/25/2015	5:15:40 PM	5:59:32 PM	0:43:52				In shore	Edge	West			west of nets	South to North	Inshore	VIMS
A69-9001-27531	04/26/2015	4:39:39 PM	6:02:14 PM	1:22:35	2015 076/05	1:22:00 PM	5:53:00 PM	In shore	Through	Center-East	BRY	Yellow	Experimental 2	South to North	Inshore	DSU

Table 6 continued: Potential interactions between previously telemetered Atlantic Sturgeon and sink gillnets off the coast of Delaware in 2015 including transmitter number, timing of interaction, net location, encounter type, encounter location, net configuration, and transmitter owner.

Tag	Date	Sturgeon Start UTC	Sturgeon End UTC	Amount ofTime	Net ID	Net Start UTC	Net End UTC	Net Location	Encounter	Where at net	Net Order	Net Type	Type	Direction	Net Location	Owner
A69-9001-28853	04/11/2015	6:21:40 PM	7:49:31 PM	1:27:51	2015 019/04	2:34:00 PM	8:11:00 PM	Off shore	Through	Center	RBY	Blue	Control	South to North	Offshore	Stony Brook
A69-9001-29175	04/25/2015	4:53:57 PM	5:47:47 PM	0:53:50	2015 070/04	1:59:00 PM	6:33:00 PM	In shore	Through	West	BRY	Blue	Control	South to North	Inshore	CTDEEP
A69-9001-30017	04/29/2015	3:53:27 PM	4:26:37 PM	0:33:10	2015 094/04	2:16:00 PM	6:09:00 PM	In shore	Through	West	BRY	Blue	Control	South to North	Inshore	Stony Brook
A69-9001-30079	04/29/2015	3:52:19 PM	4:48:34 PM	0:56:15	2015 095/05	3:19:00 PM	6:54:00 PM	Off shore	Through	West	YBR	Yellow	Experimental 2	South to North	Offshore	Stony Brook
A69-9001-30106	05/06/2015	10:02:02 AM	11:13:08 AM	1:11:06	2015 115/01	8:31:00 AM	11:07:00 AM	In shore	Through	West	BRY	Blue	Control	North to South	Inshore	Stony Brook
A69-9001-30152	05/05/2015	6:17:01 PM	7:12:02 PM	0:55:01	2015 113/05	3:19:00 PM	7:33:00 PM	In shore	Through	Center-East	YBR	Red	Experimental 1	South to North	Inshore	Stony Brook
A69-9001-30259	05/07/2015	3:40:22 PM	5:18:56 PM	1:38:34	2015 125/05	2:17:00 PM	6:50:00 PM	In shore	Through	West	YRB	Yellow	Experimental 2	South to North	Inshore	Stony Brook
A69-9001-30289	04/25/2015	5:25:35 PM	6:06:12 PM	0:40:37	2015 071/05	2:51:00 PM	7:19:00 PM	Off shore	Through	Center-East	BRY	Red/ Yellow	Experimental 1/2	South to North	Offshore	Stony Brook
A69-9001-32473	04/18/2015	7:27:24 AM	8:02:08 AM	0:34:44	2015 046/01	7:26:00 AM	10:35:00 AM	In shore	Through	Center-West	BRY	Blue	Control	South to North	Inshore	Stony Brook

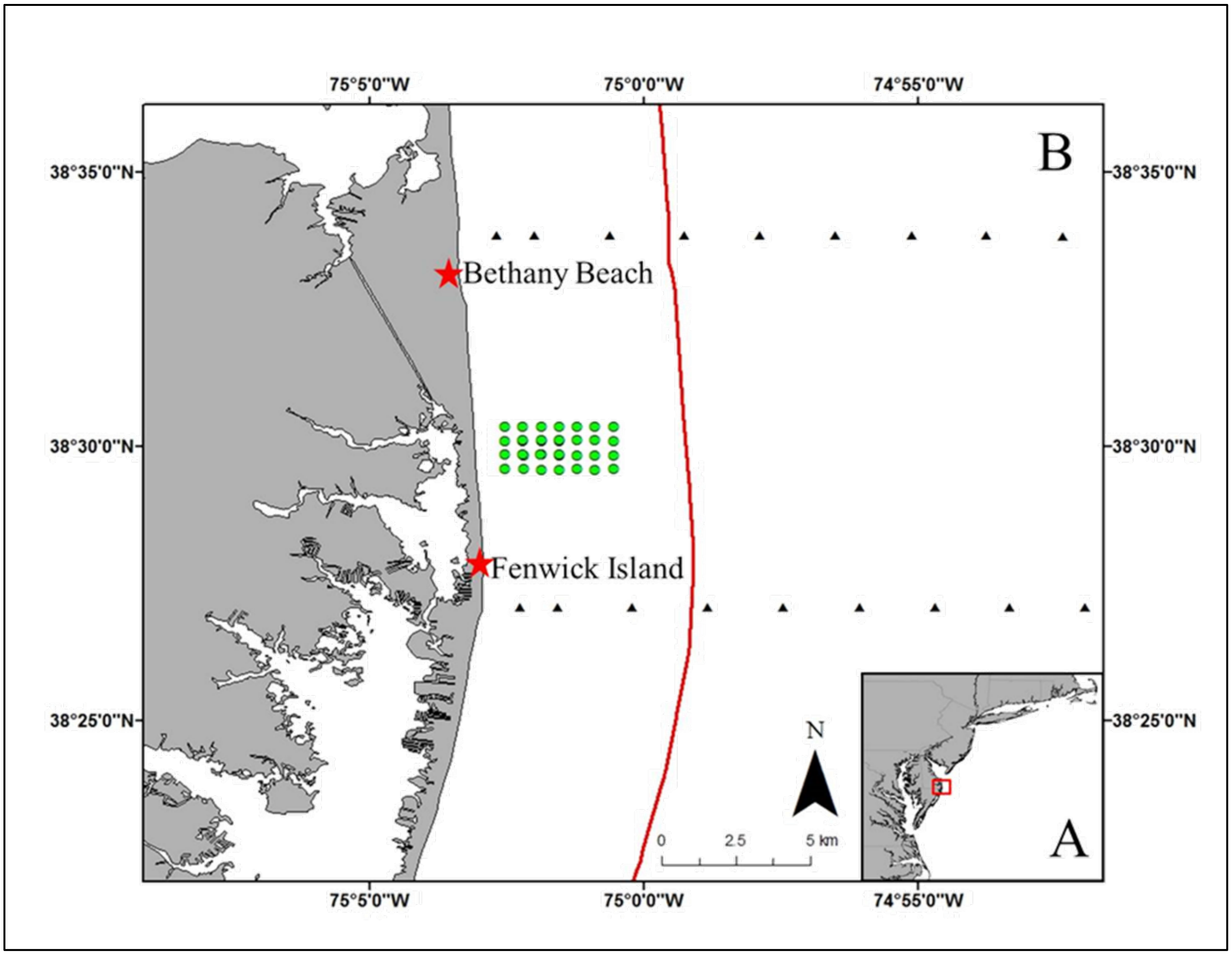

Figure 1. (A) Location of study area and (B) deployment of VEMCO VPS Array (green dots). Red line indicates Federal-State boundary, and black triangles are non-VPS deployed receivers for field trials completed in the spring of 2015.

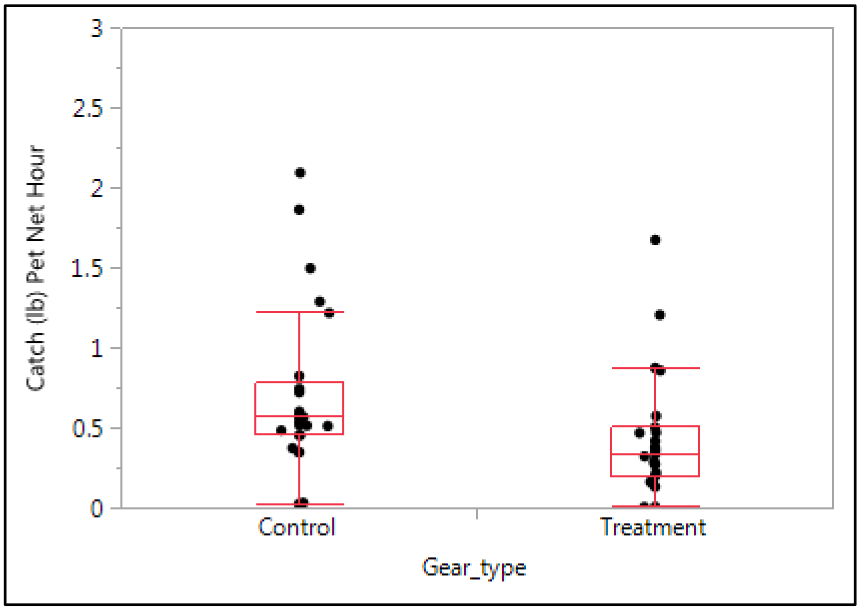

Figure 2- Landings of Monkfish (lb.) per gillnet hour by net type for targeted sampling conducted in NY waters in 2016. Box plots represent the median and 25-75th quartiles.

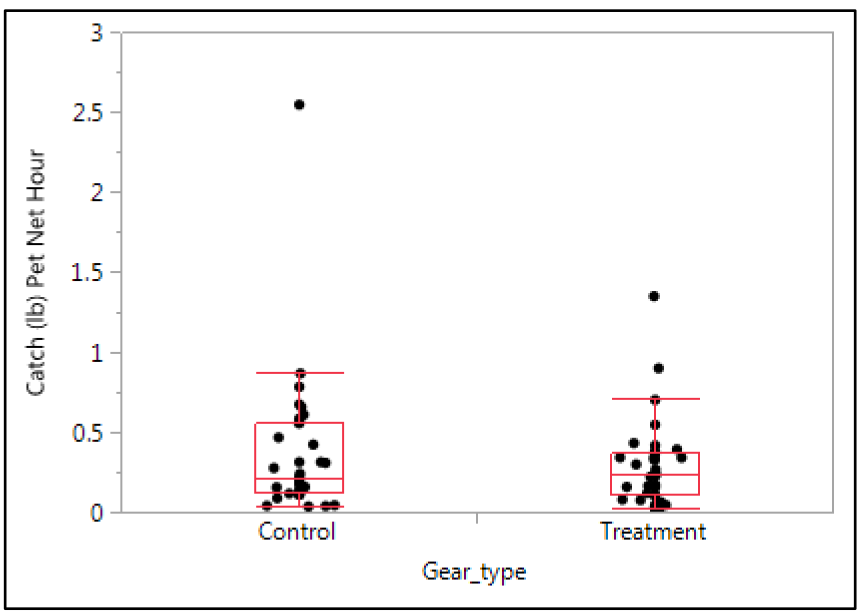

Figure 3- Landings of Monkfish (lb.) per gillnet hour by net type for targeted sampling conducted in NJ waters in 2016. Box plots represent the median and 25-75th quartiles.

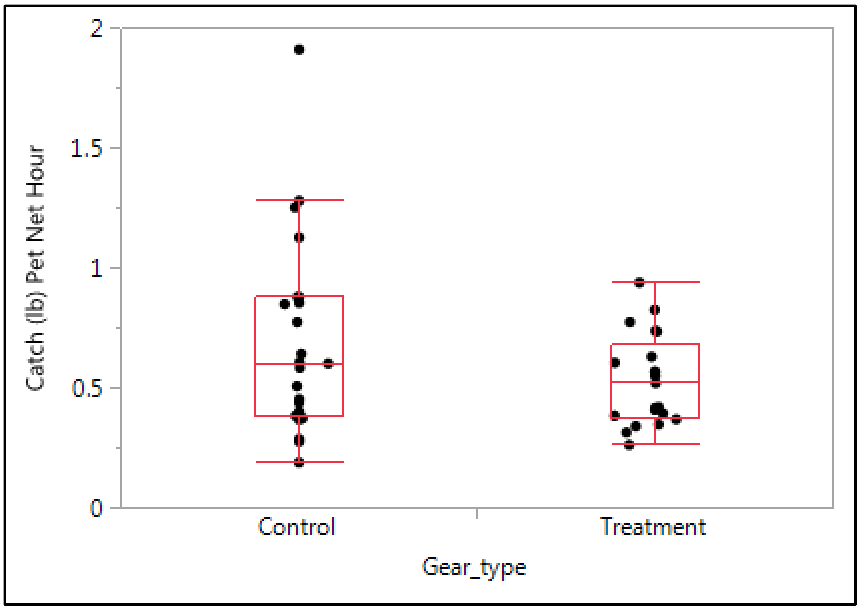

Figure 4- Landings of Winter Skate (lb.) per gillnet hour by net type for targeted sampling conducted in NY waters in 2016. Box plots represent the median and 25-75th quartiles.

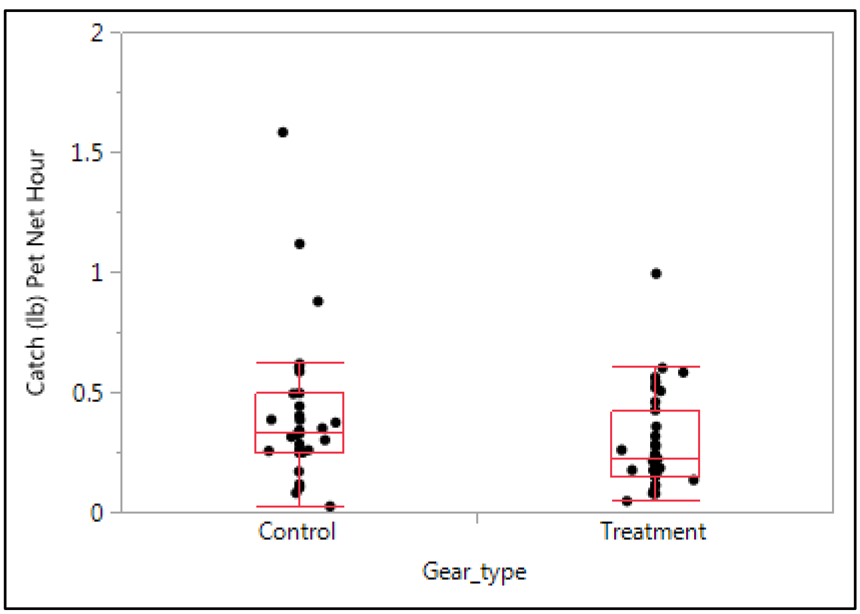

Figure 5- Landings of Winter Skate (lb.) per gillnet hour by net type for targeted sampling conducted in NJ waters in 2016. Box plots represent the median and 25-75th quartiles.

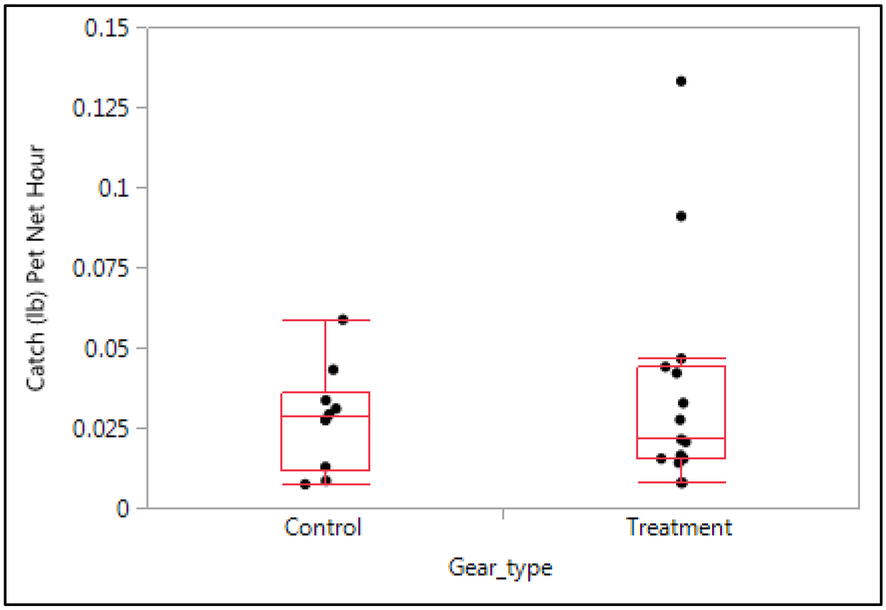

Figure 6- Landings of Spiny Dogfish (lb.) per gillnet hour by net type for targeted sampling conducted in NY waters in 2016. Box plots represent the median and 25-75th quartiles.

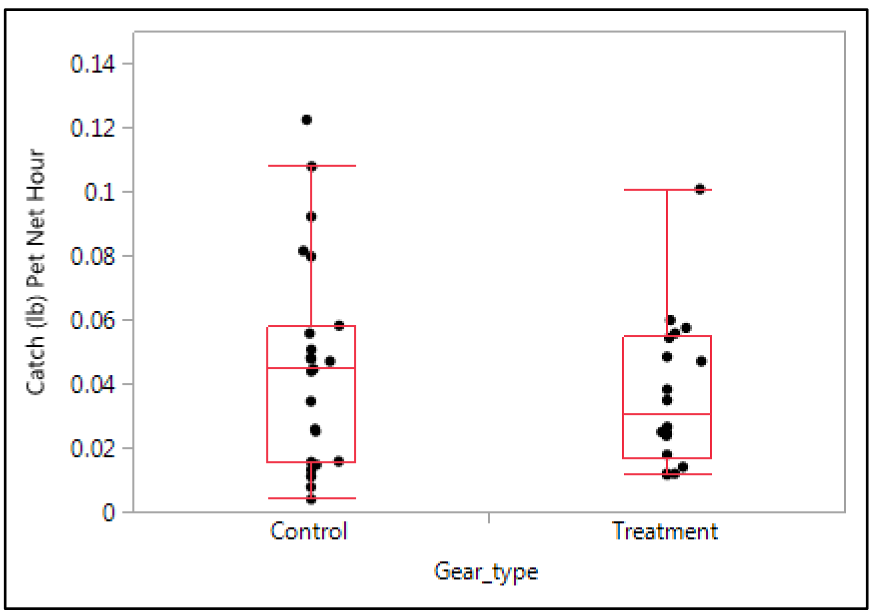

Figure 7- Landings of Spiny Dogfish (lb.) per gillnet hour by net type for targeted sampling conducted in NJ waters in 2016. Box plots represent the median and 25-75th quartiles.

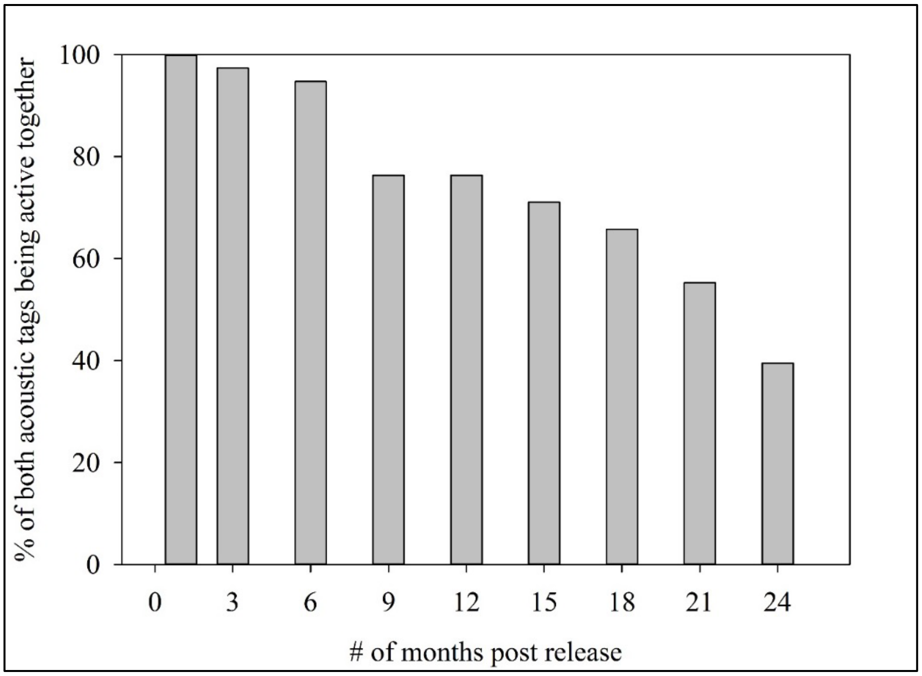

Figure 8. Proportion of both internal and externally attached VEMCO transmitters deployed on Atlantic Sturgeon off the coast of Delaware in the spring of 2015 that were detected on passive acoustic receivers ranging from NC to NY.

Figure 9- Photo of dorsal fin region of an adult Atlantic Sturgeon recaptured on June 18, 2017 in the Hyde Park River Reach, NY showing location of external VEMCO attachment after 783 days at liberty.

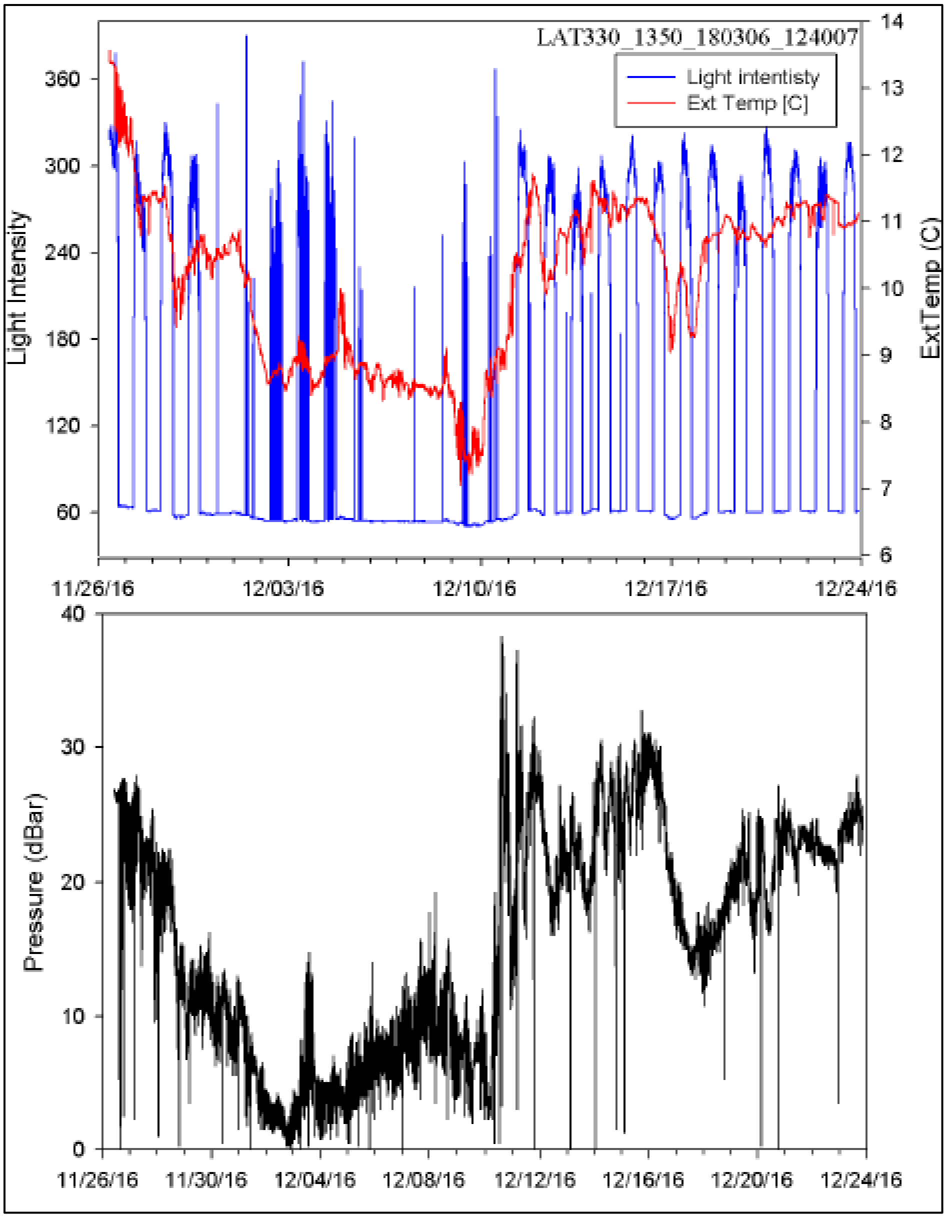

Figure 10: Light, temperature, and pressure data recovered from Atlantic Sturgeon #1350 for a 31-day period between November 26 and December 27, 2016.

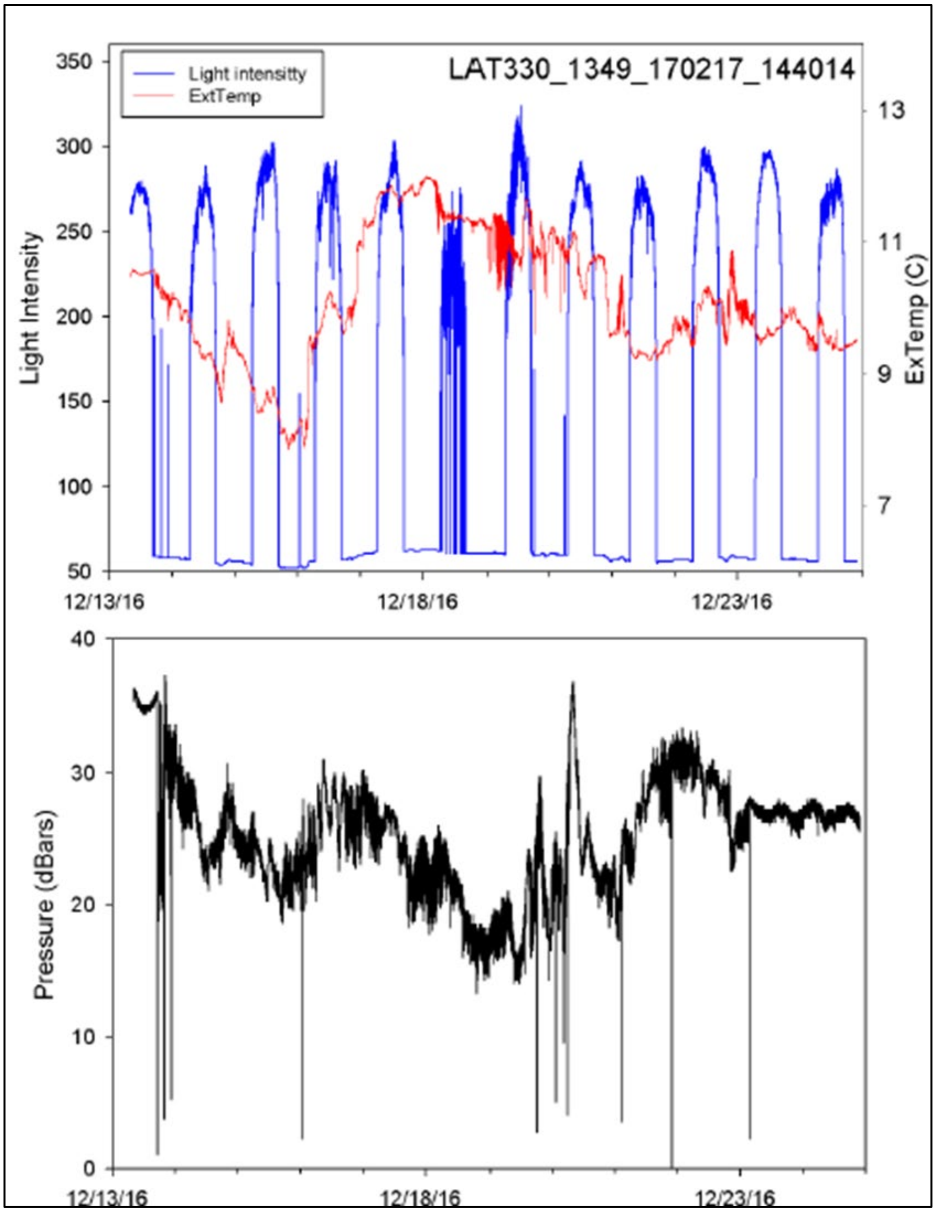

Figure 11: Light, temperature, and pressure data recovered from Atlantic Sturgeon #1349 for a 32-day period between December 13, 2016 and January 14, 2017.

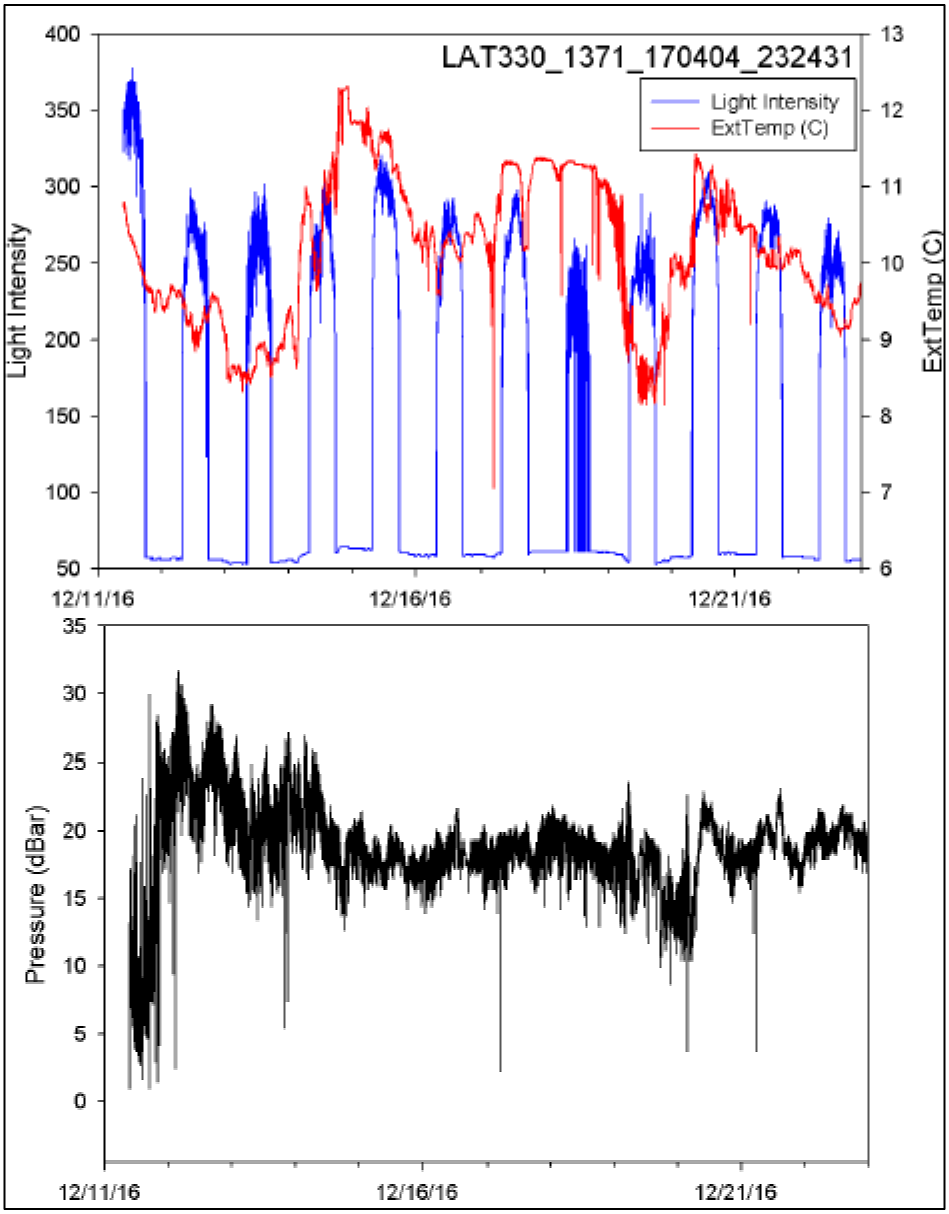

Figure 12: Light, temperature, and pressure data recovered from Atlantic Sturgeon #1371 for a 28-day period between December 11, 2016 and January 8, 2017.

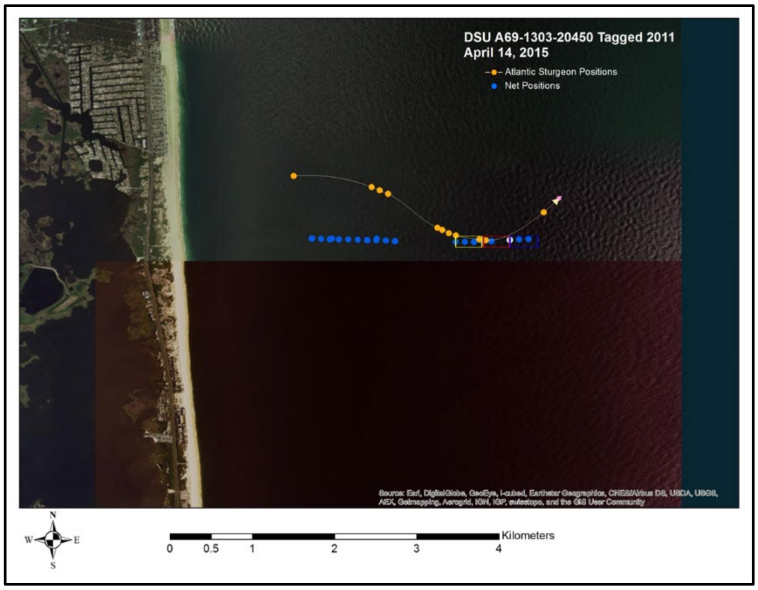

Figure 13: Potential gillnet interaction where Atlantic Sturgeon encountered the gillnet but continued to swim east. Yellow dots are Atlantic Sturgeon position estimates; yellow/orange dots are gillnet position estimates; gray line is the estimated swim path. This individual was in the vicinity of the experimental net for 1:17:47 (h:m:s)

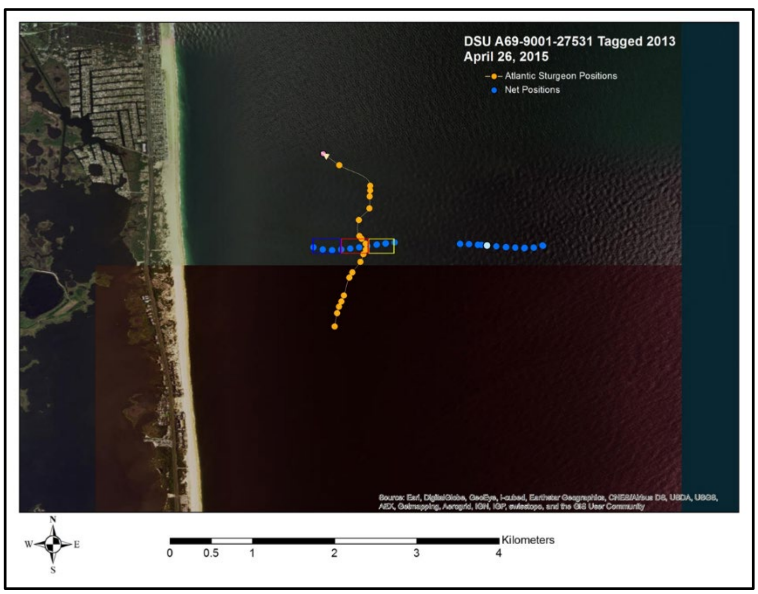

Figure 14: Potential gillnet interaction where Atlantic Sturgeon encountered the gillnet but continued to swim north. Yellow dots are Atlantic Sturgeon position estimates; yellow/orange dots are gillnet position estimates; gray line is the estimated swim path. This individual was in the vicinity of the experimental net for 1:22:35 (h:m:s)

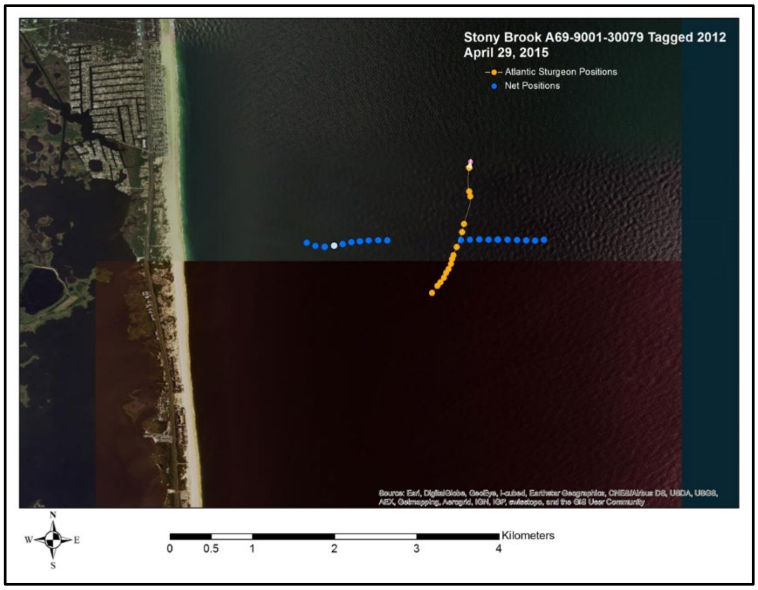

Figure 15: Potential gillnet interaction where Atlantic Sturgeon encountered the gillnet but continued to swim north. Yellow dots are Atlantic Sturgeon position estimates; yellow/orange dots are gillnet position estimates; gray line is the estimated swim path. This individual was in the vicinity of the experimental net for 0:56:15 (h:m:s)

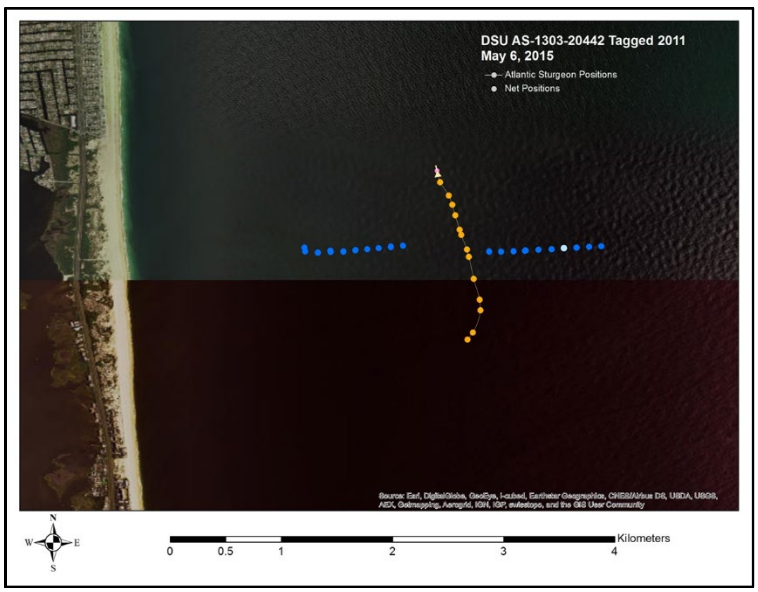

Figure 16: Potential gillnet interaction where Atlantic Sturgeon went between two gillnets and continued to swim north. Yellow dots are Atlantic Sturgeon position estimates; yellow/orange dots are gillnet position estimates; gray line is the estimated swim path. This individual was in the vicinity of the experimental net for : 0:32:42 (h:m:s)

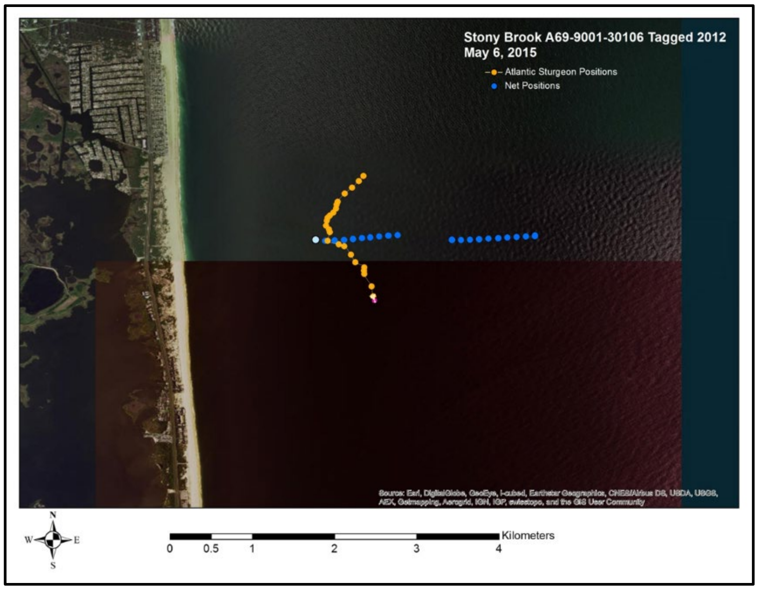

Figure 17: Potential gillnet interaction where Atlantic Sturgeon encountered an experimental gillnet and continued to swim north. Yellow dots are Atlantic Sturgeon position estimates; yellow/orange dots are gillnet position estimates; gray line is the estimated swim path. This individual was in the vicinity of the experimental net for: 1:11:06 (h:m:s)

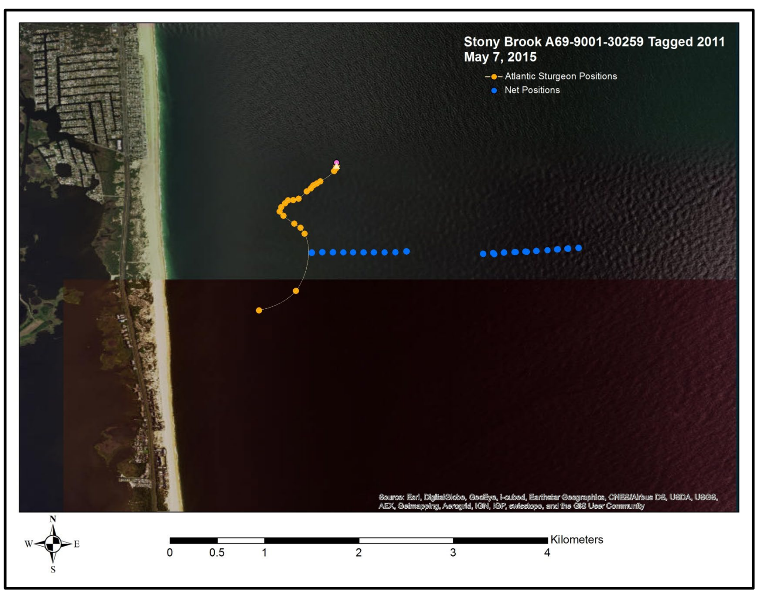

Figure 18: Potential gillnet interaction where Atlantic Sturgeon encountered the edge of an experimental gillnet and continued to swim north. Yellow dots are Atlantic Sturgeon position estimates; yellow/orange dots are gillnet position estimates; gray line is the estimated swim path. This individual was in the vicinity of the experimental net for: 1:38:34 (h:m:s)

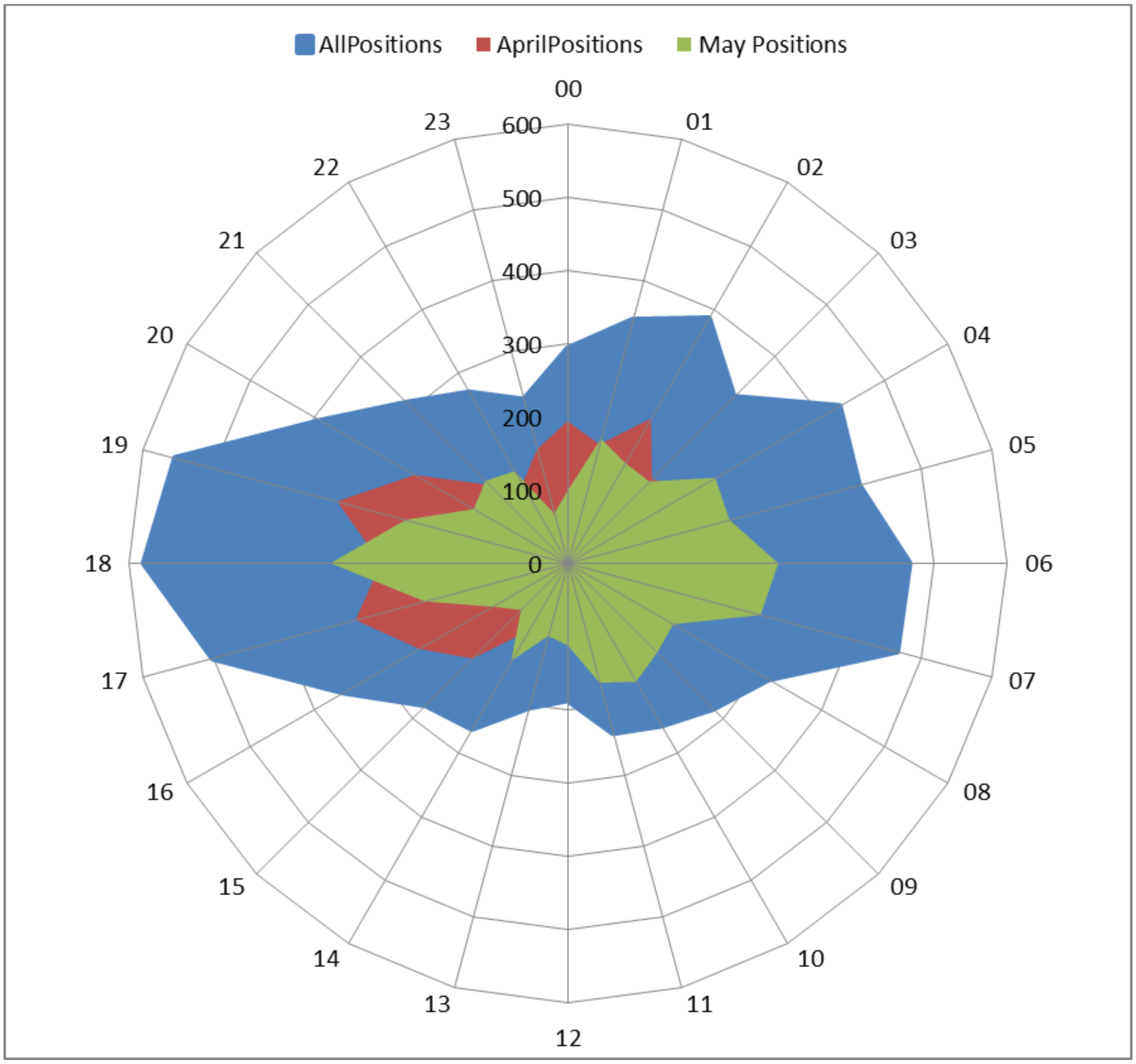

Figure 19: Radial plot for summed Atlantic Sturgeon positions by hour. Blue represents the overall study period during April and May 2015 while red indicates April and green indicates May.

Completion Report

for

Sturgeon Gillnet Study (EA-133F-12-RQ-0697)

Year Three, the Influence of Sink Gillnet Profile on Bycatch of Atlantic Sturgeon in the Mid-Atlantic Monkfish Fishery

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Summary

In 2012, five Distinct Population Segments of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) were listed under the Endangered Species Act. A preceding Status Review concluded that bycatch in sink-gillnets was a significant hurdle to Atlantic sturgeon recovery. Over three field seasons (2010-2012), we worked collaboratively with commercial harvesters to modify sink gillnet configurations to reduce Atlantic sturgeon bycatch while still achieving adequate catches of monkfish (*Lophius americanus*) and winter skate (*Leucoraja ocellata*), which were the primary target species. In 2010, we fished paired replicates of gillnets (12 meshes x 12 in (30.5 cm) stretch) with and without tie-downs, and, although Atlantic sturgeon bycatch did not differ significantly, target species catches were reduced in nets without tie-downs. In 2011, we subjected two different tie-down configurations: standard (12 meshes with 48 in (1.2 m) tie-downs) and low profile (six meshes with 24 in (0.6 m) tie-downs) to the same experimental protocol. Bycatch of Atlantic sturgeon and landings of targeted species were both significantly reduced in the low profile tie-down gillnets. During 2012 we compared another low profile net configuration (eight meshes tied-down to two) which reduced Atlantic sturgeon bycatch with minimal impact on the landings of targeted species. Our findings suggest that the use of tie-downs is important for maintaining adequate catches of target species, and that certain tie-down configurations can reduce Atlantic sturgeon bycatch. Additionally, experimental testing of gear developed by harvesters allows for the identification of gear configurations that both address conservation objectives and are realistic for use in commercial harvest. This model of collaborative research may prove useful in the recovery of other imperiled sturgeons.

Background

Globally, sturgeons (family Acipenseridae) have suffered dramatic population declines with 85% of species at risk of extinction according to the findings of a recent IUCN report. As such, the IUCN noted that sturgeon were more critically endangered than any other species group on their Red List (IUCN 2010). The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), which ranges from the St. Johns River, Florida (Vladykov and Greeley 1963) north to the Hamilton Inlet, Labrador, Canada (Backus 1951), typifies this pattern. The Delaware River currently supports fewer than 300 spawning individuals (ASSRT 2007); representing < 0.1% of the historical abundance of what was once the largest population (Secor and Waldman 1999) of Atlantic sturgeon.

In 1990, the Atlantic States Marine Fisheries Commission (ASMFC) created a Fishery Management Plan (FMP) for Atlantic sturgeon with a goal of restoring a fishable population that could sustain annual removals equal to 10% of historic landings (Taub 1990). Shortly thereafter, the FMP was followed with an amendment implementing a coast-wide moratorium on harvest of Atlantic sturgeon (ASMFC, 1998). In 2005, the Atlantic Sturgeon Status Review Team (ASSRT) was created to determine if protection was warranted under the Endangered Species Act. The ASSRT published its findings in 2007, identifying five Distinct Population Segments (DPSs), which were distinctly separated by their biological traits and genetic composition, occupied unique ecological settings, and would create a large gap in the species' range if extirpated (ASSRT 2007).

On February 6, 2012 NMFS published a notice in the Federal Register proposing to list four of the Atlantic sturgeon DPSs, including the New York Bight and Chesapeake Bay DPSs, as endangered, and the Gulf of Maine DPS as threatened (U.S. Office of the Federal Register

2012a, U.S. Office of the Federal Register 2012b). On April 6, 2012, the final ruling to list five Distinct Population Segments (DPSs) of Atlantic sturgeon under the Endangered Species Act became effective. The decision to list Atlantic sturgeon was based on a number of factors including degradation and loss of habitat, vessel strikes, and bycatch in commercial fisheries.

Atlantic sturgeons are anadromous, spending much of their life in the marine environment. In both the Status Review and FMP documents there are calls for more directed research on the marine phase of Atlantic sturgeon life history, which has been underrepresented in the scientific literature (Stein et al. 2004a). The general lack of biological information causes problems for fisheries professionals working within the confines of state jurisdictional boundaries, and it is especially problematic for Atlantic sturgeon as they are known to suffer from interactions with coastal marine fisheries, including gillnets (Stein et al. 2004b, ASMFC 2007).

The use of gillnets to capture fish dates back over 3,000 years, although relatively recent advances in technology including synthetic materials and hydraulic haulers have led to increased use of this methodology (Potter and Pawson 1991, He 2006a). Unfortunately our understanding of the mechanisms influencing bycatch in gillnets has lagged behind technological advances in the fishing industry, leading to increased concerns over the incidental take of birds, fishes, and mammals (He and Pol 2010). In the mid-Atlantic and northeast U.S., monkfish (*Lophius americanus*) support a lucrative commercial fishery out to the edge of the continental shelf. Monkfish are targeted primarily with trawls in the northern management area and sink-gillnets in the mid-Atlantic. The sink-gillnets employed in the monkfish fishery have been identified as a significant source of bycatch mortality for Atlantic sturgeon during the marine phase of their life history (Stein et al. 2004b, ASMFC 2007). As such, it is believed that changes in fishing practices in the monkfish fishery may have the potential to decrease the bycatch of Atlantic sturgeon. Unfortunately, data on potential bycatch reduction approaches in the monkfish gillnet fishery (e.g. net profile and tie-downs) are lacking, although mesh size, tie downs, and soak times are thought to be mitigating factors in Atlantic sturgeon bycatch mortality, which ranged from 14% (ASMFC 2007) to 22% (Stein et al. 2004) over the period 1989 to 2006 .

Objectives

The objectives of the study were as follows: 1) compare the bycatch rates of Atlantic sturgeon encountered in both control and experimental gillnets in NMFS Statistical Area 615; 2) compare the catch rates of the target species (monkfish and winter skate) in each gillnet configuration; and 3) record the bycatch of other NMFS regulated or protected species.

Methods

Field Studies: Through cooperative agreements with participating commercial harvesters, we examined catch rates of targeted species (e.g. monkfish and winter skate (*Leucoraja ocellata*)) and bycatch of Atlantic sturgeon for two gillnet configurations fished in a paired replicate design. We utilized NMFS supplied gillnets which were 300 ft (91.4 m) in length and consisted of two configurations that varied in vertical profile. The control nets were comprised of 12 meshes x 12 in (30.5 cm) stretch mesh with four 48 in (1.2 m) mesh tie-downs spaced 24 ft (7.3 m) apart on alternating corks on the float line. The lower profile treatment nets were constructed of 8 meshes x 12 in (30.5 cm) stretch mesh with 24 in (0.6 m) tie-downs spaced every 12 ft (3.65 m) apart, which corresponded to the location of corks in the float line. Panels were constructed using Chatham green webbing (0.90mm) with a 0.50 hanging ratio, 0.375 in

(9.5 mm) poly float line that contained five spliced 1,100 lb (500 kg) weak links per panel, and a 75 lb (34.1 kg) leadline (75 lb (34.1kg)/600 ft (182.8 m) spool). Each vessel deployed 40 panels of gillnet configured in 10 panel strings totaling 3,000 ft (914 m). Each string comprised either control (standard profile) or treatment (low profile) nets. Cooperating monkfish harvesters fished the strings of gillnets as paired replicates, with the pair including both the control and treatment gillnets strings set in a similar location, at a similar depth, and fished for a similar amount of time. A total of 120 hauls of 60 replicates were completed, with hauls split evenly between vessels, and the set sequence for net strings randomly selected at the start of the study. A copy of the haul schedule was kept on board each vessel and confirmed by the vessel master and NMFS trained observer.

Two monkfish fishing vessels (F/V Dana Christine and F/V Traveller II) employed normal gillnetting operations with soak times dependent upon fishing and weather conditions. Sampling operations took place in November and December of 2012 off the coast of New Jersey in waters that historically supported commercial monkfish operations (Statistical Area 615) (Figure 1) and where the vessel captains believed they would encounter Atlantic sturgeon. In the event of snags or tears, gillnet panels were repaired on site. Both fishing vessels operated in the same general vicinity, fishing inshore waters less than 100 m in depth. Effort was standardized to net days, which were defined as ten 100 yard (91.4 m) panels fished for a 24h period.

Fishing operations were monitored by NMFS trained observers (MRAG Americas) who recorded total weight and length measurements for all monkfish and other commercially landed species. In instances where the number of individuals per net string exceeded 100, a sub-sample (n=100) was randomly selected, and the total weight recorded. Atlantic sturgeon brought aboard the vessel were measured, weighed, a small tissue sample was recovered, and, in the case of mortalities, the pectoral girdles were removed for future age and growth studies. Atlantic sturgeon were scanned for the presence of a passive integrated transponder (PIT) tag. If no PIT tag was found in live individuals, a 12 mm 134.2 kHz PIT tag was implanted on the left side at the base of the dorsal fin and the fish were immediately released at the site of capture. In these instances the disposition (i.e., live vs. mortality) was recorded as was the vertical and horizontal location of the sturgeon capture in the net panel. In the case of the low profile nets vertical location in the net panel was often impossible to ascertain as the entire profile of the net was frequently bunched together.

If an Atlantic sturgeon carcass was salvageable (i.e. not mostly consumed or falling apart from scavenger foraging) it was brought ashore, outfitted with a tail tag, and placed in a commercial freezer at Viking Village Inc. (Barnegat Light, NJ). The carcasses were transferred to Burris Logistics (Harrington, DE), where they were individually wrapped in plastic and stored in a commercial freezer. At a later date, an announcement will be sent to sturgeon researchers with appropriate NOAA-NMFS permits and the carcasses will be made available for additional tissue sampling. The carcasses will then be placed back in storage for later use in a planned project to examine reporting rate of Atlantic sturgeon vessel strike mortalities in the Delaware River (pending funding from NOAA-NMFS-Species Recoveries Grants to States (Section 6)).

Original data sheets (available upon request) were signed by both the vessel captain and fishery observer and then scanned to ensure quick data entry and to provide a secure back up of the data. Data sheets were then entered into a relational database for generation of tables to facilitate report writing and statistical analyses. All statistical analyses were conducted with JMP Version 10.0 (2013) using a paired comparison to test for differences in soak times and catch rates between gear types. We examined the role of soak times and Atlantic sturgeon size (FL) in influencing status (live/dead) at the time of capture through a logistic regression model for the current sampling season and all (2010-2012) seasons combined. Catch-per-unit-effort (CPUE) was defined as weight (kg) landed per net day per 1000 yards of net, except for Atlantic sturgeon where numbers encountered were utilized. Statistical significance was inferred at $p \leq 0.05$.

Results and Discussion

All field sampling was conducted in NMFS Statistical Area 615 (Figure 1) and was initiated on Nov. 26, 2012 by the commercial fishing vessels F/V Dana Christine and F/V Traveller II. Operations were concluded on Dec. 18, 2011 at the completion of 120 net hauls (Table 1). Soak times for control gillnets averaged 32.06 hours (range = 21.1-74.2h), while the soak times for the lower profile treatment gillnets averaged 32.16 hours (range = 20.0-75.0h). There was no significant difference in the duration of soak time of control and treatment gillnets based on a paired comparison t-test (p = 0.9677).

A total of 16 identified species (12 fishes and four invertebrates) were encountered in the course of sampling, totaling 11,951 kg (Table 2). The vast majority of landings (79.7%) were of monkfish (5,004 kg) and winter skate (4521 kg). The next species of importance as measured by weight was Atlantic sturgeon with an estimated total weight of 1,000kg. After Atlantic sturgeon, there was a marked drop in total landings to little skate (*Raja erinacea*) (579 kg) and spiny dogfish (*Squalus acanthias*) (433 kg). Discards of regulated species (e.g. monkfish, winter skate, and spiny dogfish) were limited by market conditions and quotas. During the course of this work, no marine mammals were caught in either control or treatment nets.

In total, 35 adult and juvenile Atlantic sturgeon with a mean size of 149.4 cm FL (range = 102-181 cm) were encountered during the course of the project (Figure 2). Although Atlantic sturgeon in the control gillnets were larger (151.1 cm FL) than those captured in the low profile gillnets (146.8 cm FL), it did not appear that sturgeon length was significantly influenced by gear type (p= .4872). Capture rates of Atlantic sturgeon did not differ significantly (p = 0.3577) by gillnet type, with 21 (60.0%) captured in control gillnets and the remaining 14 (40.0%) captured in the lower profile treatment nets. A retrospective power analysis determined that the probability of rejecting the null hypothesis when the null hypothesis was false was 0.1189. The results of the power analysis suggest that our ability detect a difference when one existed may have been influenced by the low sample size of Atlantic sturgeon. We were able to attain length measurements on a total of 32 Atlantic sturgeon, the vast majority (93.8%) of which were above the minimum size of maturity (130 cm FL) for Atlantic sturgeon (Van Eenennaam et al. 1996) (Table 3). We were unable to measure the remaining individuals because three of them either escaped from gillnets as the gear was being hauled from the water or fell out and sank prior to being hauled on board. Of the 21 Atlantic sturgeon captured in the control nets; we were able to assess the vertical placement of 20 in the net: 70% of sturgeon were entangled in the top half of the net with the remaining individuals located in the bottom. In the instances when we could accurately determine the vertical placement of Atlantic sturgeon in the low profile treatment nets we found a similar pattern with 62% of individuals entangled in the top half of the net. It should be noted that our ability to accurately assess the entanglement position of Atlantic sturgeon in the low profile treatment nets may be diminished by the tendency of the entire net collapsing on the sturgeon. Although sample sizes are limited, these results appear to indicate Atlantic sturgeon catch rates are lowest at the bottom of the net. Sturgeons are traditionally referred to as benthic cruisers (Findeis 1997) though there is a growing body of evidence to suggest that they commonly are in the water column (Sulak et al. 2002, Erickson and Hightower 2007). Although we did not detect a significant difference in Atlantic sturgeon capture rates between net types, the decreased capture rates of sturgeon in the low profile nets coupled with the entanglement of sturgeon in the upper portions of both nets suggests that Atlantic sturgeon may be higher off the bottom than previously thought.

The disposition of Atlantic sturgeon was almost equally split between live (17) and dead (18) encounters during this study. Of the 21 Atlantic sturgeon encountered in the control gillnets, 10 were alive and 11 were dead. The 14 Atlantic sturgeon encountered in the treatment gillnet configuration were equally split between live and dead sturgeon. Due to low capture rates, we pooled across gillnet treatment types to examine the influence of soak time on Atlantic sturgeon disposition (i.e. live/dead) upon landing. The results of a logistic regression analysis of pooled Atlantic sturgeon encounters by soak time indicated that mortality rate was not significantly correlated with soak time ($p = 0.8862$) (Figure 3). Although it is intuitive that soak time could play a role in mediating survival risk in entangled individuals, the difficulty in assigning the actual timing of entanglement for individuals leads to much uncertainty, which can be further compounded when dealing with small sample sizes. In an attempt to further examine this relationship, we pooled the results of our 2012 sampling season with data collected in 2010 ($n=23$) and 2011 ($n=37$) to develop a more robust examination of the role that soak time plays in Atlantic sturgeon bycatch mortality rates. The results of this pooled analysis, which incorporated 95 events, suggests that Atlantic sturgeon mortality rate increased significantly ($p=.0343$) with soak time (Figure 4). These pooled results add to the growing body of evidence which suggests that the soak time of anchored gillnets may be positively correlated with mortality risk, especially in cases where soak times exceed 24h (Stein et al. 2004b, ASMFC 2007). In the present study, Atlantic sturgeon mortality rates increased marginally between 24-48h, and

Atlantic sturgeon encounters in longer soak times were limited to two dead individuals encountered after approximately 72h. Our pooled results indicated that Atlantic sturgeon mortality rates increased from approximately 54% at 24h to 65% at 48h, 76% at 72h, and reached 84% with a soak time of 96h.

Through our sampling efforts, a total of 800 monkfish weighing 5,004 kg of were landed (Table 2). Slightly more than half (52.3%) of monkfish were landed in control nets. In total, monkfish landings in the treatment gear (2,389 kg) were 4.5% lower than landings in control gear (2,615 kg). Catch rates of monkfish (CPUE) were not significantly different between the gear types ($p = 0.3274$). The mean size of monkfish landed in the control gillnets was 71.7 cm TL (median = 72cm TL) while the mean size of monkfish landed in the lower profile treatments (71.5 cm TL) (median = 72cm TL) was slightly, although not significantly ($p = 0.7171$), smaller (Figure 5).

A total of 947 Winter skate were landed, representing the second most dominant species by weight (4521 kg); catch rates did not vary significantly ($p = 0.4212$) by gear type, but the majority (53.5%) of landings were in the control gillnets. Lengths of winter skate landed in the control gillnets (mean = 84.4 cm TL) were significantly smaller ($p = 0.0230$) than those landed in the lower profile treatment nets (mean = 85.5cm TL) (Figure 6). Spiny dogfish, which represented the species with the lowest landings (433 kg) still considered commercially viable, were landed at significantly ($p < 0.0001$) lower rates (30.7%) in the low profile treatment nets compared to the control gear (69.3%). We documented no significant difference ($p = .3365$) in the lengths of dogfish landed in the control gear (mean = 85.9 cm TL) and those landed in the low profile treatment nets (mean = 85.1 cm TL) (Figure 7).

Through this study we have provided insights that although not significant, suggest that decreasing the profile of sink gillnets may reduce the capture rates of critically imperiled Atlantic sturgeon. Although the new net configuration did not significantly reduce Atlantic sturgeon encounters, it still provided landings of targeted species (i.e. monkfish and winter skate) at levels close to the control configuration while reducing sturgeon encounter rates by 20%. It should be noted that although our findings suggest that the lower profile nets may reduce the encounter rates of Atlantic sturgeon they represent a point estimate with correspondingly high levels of uncertainty. We recommend that additional controlled studies be conducted to expand the scope of our findings. Our results provide hope that through continued modification and testing we can increase the levels of monkfish landed in the low profile treatment gillnets in ways that would result in landings similar to those in traditional control nets. The use of modified net profiles has been examined in other systems (He 2006b) with mixed success, nevertheless providing hope for a technological solution to the issue surrounding Atlantic sturgeon bycatch in large mesh sink gillnets (ASMFC 2007). At the conclusion of the present study, both vessel captains suggest that continued refinement of the sink gillnets should focus on altering the mesh size and or twine configuration in an attempt to develop a conservation engineering approach that will both further Atlantic sturgeon conservation and recovery efforts and retain the economic viability of the existing commercial fishery.

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Table 1: Sample locations (decimal degrees) and haul information for F.Vs. Dana Christine and Traveller II.

Haul Number	Pair	Vessel Name	Gear Type	Set Date	Set Latitude Start	Set Longitude Start	Set Latitude End	Set Latitude End	Haul Date	Haul Latitude Start	Haul Longitude Start	Haul Latitude End	Haul Longitude End	Soak Time (hours)	Depth (m)
1	T01	Traveller II	Treatment	26-Nov-12	39.8333	-73.9003	39.8333	-73.9000	27-Nov-12	39.8169	-73.9002	39.8169	73.9000	23.5	23.8
2	T01	Traveller II	Control	26-Nov-12	39.8334	-73.9169	39.8334	-73.9167	27-Nov-12	39.8334	-73.9169	39.8334	-73.9167	24.9	23.8
3	T02	Traveller II	Treatment	26-Nov-12	39.8334	-73.9500	39.8334	-73.9500	27-Nov-12	39.8334	-73.9500	39.8334	-73.9335	25.3	21.9
4	T02	Traveller II	Control	26-Nov-12	39.8334	-73.9503	39.8334	-73.9500	27-Nov-12	39.8334	-73.9503	39.8334	-73.9501	26.6	21.9
5	D01	Dana Christine	Control	26-Nov-12	39.8764	-73.8964	39.8764	-73.9100	27-Nov-12	39.8668	-73.9002	39.8668	-73.8836	23.5	25.6
6	D01	Dana Christine	Treatment	26-Nov-12	39.8794	-73.9097	39.8789	-73.9225	27-Nov-12	39.8669	73.9168	39.8669	-73.9002	24.3	25.6
7	D02	Dana Christine	Treatment	26-Nov-12	39.8794	-73.9097	39.8789	-73.9225	27-Nov-12	39.8669	-73.9168	39.8669	-73.9002	25.0	25.6
8	D02	Dana Christine	Control	26-Nov-12	39.8781	-73.9358	39.8769	-73.9489	27-Nov-12	39.8767	-73.9483	39.8783	-73.9367	25.5	25.6
9	T03	Traveller II	Control	27-Nov-12	39.8400	-73.9567	39.8383	-73.9667	29-Nov-12	39.8400	-73.9533	39.8383	-73.9650	46.1	21.9
10	T03	Traveller II	Treatment	27-Nov-12	39.8383	-73.9417	39.8383	-73.9533	29-Nov-12	39.8383	-73.9400	39.8383	-73.9517	47.5	23.8
11	T04	Traveller II	Treatment	27-Nov-12	39.8317	-73.9033	39.8317	-73.9033	29-Nov-12	39.8317	-73.9000	39.8317	-73.9133	49.8	23.8
12	T04	Traveller II	Control	27-Nov-12	39.8367	-73.9200	39.8350	-73.9317	29-Nov-12	39.8350	-73.9183	39.8350	-73.9300	50.0	25.6
13	D03	Dana Christine	Treatment	27-Nov-12	39.8750	-73.9350	39.8767	-73.9250	29-Nov-12	39.8767	-73.9350	39.8767	-73.9350	44.6	25.6
14	D03	Dana Christine	Control	27-Nov-12	39.8783	-73.9367	39.8767	-73.9483	29-Nov-12	39.8783	-73.9350	39.8767	-73.9483	45.7	23.8
15	D04	Dana Christine	Control	27-Nov-12	39.8668	-73.8836	39.8668	-73.9002	29-Nov-12	39.8668	-73.8836	39.8668	-73.9001	48.5	25.6
16	D04	Dana Christine	Treatment	27-Nov-12	39.8800	-73.9117	39.8783	-73.9250	29-Nov-12	39.8800	-73.9100	39.8800	-73.9217	49.5	25.6
17	D05	Dana Christine	Control	29-Nov-12	39.8800	-73.9100	39.8800	-73.9233	30-Nov-12	39.8783	-73.9100	39.8800	-73.9217	21.8	25.6
18	D05	Dana Christine	Treatment	29-Nov-12	39.7867	-73.9100	39.8767	-73.8950	30-Nov-12	39.8767	-73.8967	39.8767	-73.9083	23.2	25.6
19	D06	Dana Christine	Control	29-Nov-12	39.8767	-73.9350	39.8767	-73.9217	30-Nov-12	39.8767	-73.9233	39.8767	-73.9350	25.8	25.6
20	D06	Dana Christine	Treatment	29-Nov-12	39.8783	-73.9367	39.8767	-73.9483	30-Nov-12	39.8783	-73.9350	39.8783	-73.9467	26.1	21.9
21	T05	Traveller II	Control	29-Nov-12	39.8400	-73.9650	39.8383	-73.9650	30-Nov-12	39.8400	-73.9533	39.8383	-73.9650	23.7	21.9
22	T05	Traveller II	Treatment	29-Nov-12	39.8383	-73.9517	39.8383	-73.9400	30-Nov-12	39.8383	-73.9400	39.8393	-73.9500	23.6	23.8
23	T06	Traveller II	Control	29-Nov-12	39.8350	-73.9283	39.8350	-73.9167	30-Nov-12	39.8367	-73.9167	39.8350	-73.9300	22.5	25.6
24	T06	Traveller II	Treatment	29-Nov-12	39.8317	-73.9133	39.8300	-73.9133	30-Nov-12	39.8317	-73.9017	39.8317	-73.9133	25.2	23.8
25	D07	Dana Christine	Control	30-Nov-12	39.8800	-73.9100	39.8800	-73.9217	02-Dec-12	39.8783	-73.9217	39.8783	-73.9100	44.8	25.6
26	D07	Dana Christine	Treatment	30-Nov-12	39.8668	-73.9001	39.8668	-73.8836	02-Dec-12	39.8668	-73.9002	39.8668	-73.8836	46.0	25.6
27	D08	Dana Christine	Treatment	30-Nov-12	39.8668	-73.9334	39.8668	-73.9168	02-Dec-12	39.8668	-73.9168	39.8668	-73.9334	45.4	25.6
28	D08	Dana Christine	Control	30-Nov-12	39.8669	-73.9334	39.8669	-73.9336	02-Dec-12	39.8669	-73.9336	39.8668	-73.9336	45.8	23.8
29	T07	Traveller II	Treatment	29-Nov-12	39.8334	-73.9002	39.8333	-73.9002	02-Dec-12	39.8169	-73.9002	39.8169	-73.9000	74.1	23.8
30	T07	Traveller II	Control	29-Nov-12	39.8334	-73.9169	39.8334	-73.9167	02-Dec-12	39.8334	-73.9169	39.8334	-73.9167	71.6	23.8

Table 1 continued: Sample locations (decimal degrees) and haul information for F.Vs. Dana Christine and Traveller II.

Haul Number	Pair	Vessel Name	Gear Type	Set Date	Set Latitude Start	Set Longitude Start	Set Latitude End	Set Latitude End	Haul Date	Haul Latitude Start	Haul Longitude Start	Haul Latitude End	Haul Longitude End	Soak Time (hours)	Depth (m)
31	T08	Traveller II	Control	29-Nov-12	39.8668	-73.9502	39.8334	-73.9500	02-Dec-12	39.8334	-73.9503	39.8334	-73.9501	74.2	23.8
32	T08	Traveller II	Treatment	29-Nov-12	39.8334	-73.9500	39.8334	-73.9334	02-Dec-12	39.8334	-73.9334	39.8334	-73.9500	75.0	23.8
33	T09	Traveller II	Treatment	02-Dec-12	39.8334	-73.9500	39.8334	-73.9334	03-Dec-12	39.8334	-73.9334	39.8334	-73.9500	20.0	23.8
34	T09	Traveller II	Control	02-Dec-12	39.8334	-73.9501	39.8334	-73.9667	03-Dec-12	39.8334	-73.9501	39.8334	-73.9667	21.6	21.9
35	T10	Traveller II	Treatment	02-Dec-12	39.8169	-73.9000	39.8169	-73.9000	03-Dec-12	39.8333	-73.9000	39.8169	-73.9002	24.9	25.6
36	T10	Traveller II	Control	02-Dec-12	39.8334	-73.9167	39.8334	-73.9169	03-Dec-12	39.8334	-73.9167	39.8334	-73.9169	24.7	25.6
37	D09	Dana Christine	Control	02-Dec-12	39.8669	-73.9002	39.8669	-73.9168	03-Dec-12	39.8669	-73.9002	39.8669	-73.9168	22.0	25.6
38	D09	Dana Christine	Treatment	02-Dec-12	39.8668	-73.8836	39.8668	-73.9002	03-Dec-12	39.8668	-73.8836	39.8668	-73.9001	23.0	25.6
39	D10	Dana Christine	Treatment	02-Dec-12	39.8668	-73.9336	39.8668	-73.9168	03-Dec-12	39.8668	-73.9168	39.8668	-73.9334	21.9	25.6
40	D10	Dana Christine	Control	02-Dec-12	39.8668	-73.9336	39.8669	-73.9334	03-Dec-12	39.8668	-73.9334	39.8668	-73.9336	22.7	23.8
41	D11	Dana Christine	Control	03-Dec-12	39.8669	-73.9001	39.8669	-73.9167	03-Dec-12	39.8669	-73.9167	39.8669	-73.9001	22.2	25.6
42	D11	Dana Christine	Treatment	03-Dec-12	39.9502	-73.8835	39.8668	-73.9001	04-Dec-12	39.8668	-73.9001	39.8668	-73.8835	23.0	25.6
43	D12	Dana Christine	Treatment	03-Dec-12	39.8668	-73.9333	39.8668	-73.9168	04-Dec-12	39.8668	-73.9334	39.8668	-73.9168	22.2	23.8
44	D12	Dana Christine	Control	03-Dec-12	39.8669	-73.9335	39.8669	-73.9169	04-Dec-12	39.8669	-73.9335	39.8669	-73.9333	22.3	25.6
45	T11	Traveller II	Control	03-Dec-12	39.8334	-73.9000	39.8334	-73.8834	04-Dec-12	39.8334	-73.9000	39.8334	-73.8834	22.9	23.8
46	T11	Traveller II	Treatment	03-Dec-12	39.8169	-73.9002	39.8169	-73.9000	04-Dec-12	39.8169	-73.9002	39.8169	-73.9000	23.1	23.8
47	T12	Traveller II	Treatment	03-Dec-12	39.8334	-73.9500	39.8334	-73.9334	04-Dec-12	39.8334	-73.9501	39.8334	-73.9334	25.6	21.9
48	T12	Traveller II	Control	03-Dec-12	39.8334	-73.9169	39.8333	-73.9167	04-Dec-12	39.8333	-73.9333	39.8333	-73.9167	23.5	23.8
49	T13	Traveller II	Control	04-Dec-12	39.8334	-73.8834	39.8333	-73.9000	05-Dec-12	39.8334	-73.8834	39.8333	-73.8836	21.9	25.6
50	T13	Traveller II	Treatment	04-Dec-12	39.8169	-73.9000	39.8169	-73.9003	05-Dec-12	39.8169	-73.9000	39.8169	-73.9002	21.9	23.8
51	T14	Traveller II	Treatment	04-Dec-12	39.8334	-73.9334	39.8334	-73.9501	05-Dec-12	39.8333	-73.9334	39.8334	-73.9500	21.9	23.8
52	T14	Traveller II	Control	04-Dec-12	39.8333	-73.9167	39.8333	-73.9169	05-Dec-12	39.8333	-73.9167	39.8333	-73.9169	22.0	23.8
53	D13	Dana Christine	Treatment	04-Dec-12	39.8668	-73.8835	39.8668	-73.9001	05-Dec-12	39.8668	-73.8835	39.8668	-73.9001	23.6	25.6
54	D13	Dana Christine	Control	04-Dec-12	39.8669	-73.9001	39.8669	-73.9167	05-Dec-12	39.8669	-73.9001	39.8669	-73.9167	23.5	25.6
55	D14	Dana Christine	Treatment	04-Dec-12	39.8668	-73.8668	39.8668	-73.9168	05-Dec-12	39.8668	-73.9168	39.8668	-73.9333	23.7	25.6
56	D14	Dana Christine	Control	04-Dec-12	39.8669	-73.9333	39.8669	-73.9333	05-Dec-12	39.8669	-73.9169	39.8669	-73.9335	23.3	23.8
57	T15	Traveller II	Control	05-Dec-12	39.8333	-73.9169	39.8333	-73.9167	07-Dec-12	39.8169	-73.9169	39.8333	-73.9167	44.8	23.8
58	T15	Traveller II	Treatment	05-Dec-12	39.8169	-73.9336	39.8169	-73.9336	07-Dec-12	39.8169	-73.9336	39.8169	-73.9334	46.3	21.9
59	T16	Traveller II	Treatment	05-Dec-12	39.8169	-73.9002	39.8169	-73.9000	07-Dec-12	39.8169	-73.9003	39.8169	-73.7501	48.0	23.8
60	T16	Traveller II	Control	05-Dec-12	39.8333	-73.8836	39.8333	-73.8834	07-Dec-12	39.8333	-73.9000	39.8333	-73.8834	49.4	23.8

Table 1 continued: Sample locations (decimal degrees) and haul information for F.Vs. Dana Christine and Traveller II.

Haul Number	Pair	Vessel Name	Gear Type	Set Date	Set Latitude Start	Set Longitude Start	Set Latitude End	Set Latitude End	Haul Date	Haul Latitude Start	Haul Longitude Start	Haul Latitude End	Haul Longitude End	Soak Time (hours)	Depth (m)
61	D15	Dana Christine	Treatment	05-Dec-12	39.8668	-73.9001	39.8668	-73.8835	07-Dec-12	39.8668	-73.8835	39.8668	-73.9001	46.3	23.8
62	D15	Dana Christine	Control	05-Dec-12	39.8669	-73.9167	39.8669	-73.9001	07-Dec-12	39.8669	-73.9001	39.8669	-73.8833	47.1	25.6
63	D16	Dana Christine	Treatment	05-Dec-12	39.8668	-73.9333	39.8668	-73.9333	07-Dec-12	39.8668	-73.9168	39.8668	-73.9333	46.3	25.6
64	D16	Dana Christine	Control	05-Dec-12	39.8669	-73.9333	39.8835	-73.9336	07-Dec-12	39.8669	-73.9333	39.8669	-73.9335	46.8	23.8
65	D17	Dana Christine	Control	07-Dec-12	39.5335	-73.8833	39.8669	-73.9001	08-Dec-12	39.8669	-73.9001	39.8669	-73.9167	22.9	23.8
66	D17	Dana Christine	Treatment	07-Dec-12	39.8668	-73.9001	39.8668	-73.8835	08-Dec-12	39.8668	-73.8835	39.8668	-73.9001	23.3	23.8
67	D18	Dana Christine	Control	07-Dec-12	39.8669	-73.9335	39.8669	-73.9169	08-Dec-12	39.8669	-73.8333	39.8669	-73.9335	22.7	25.6
68	D18	Dana Christine	Treatment	07-Dec-12	39.8668	-73.9333	39.8668	-73.9168	08-Dec-12	39.8668	-73.9168	39.8668	-73.9333	23.1	25.6
69	T17	Traveller II	Control	07-Dec-12	39.8333	-73.9167	39.8333	-73.9333	08-Dec-12	39.8333	-73.9167	39.8333	-73.9169	24.5	23.8
70	T17	Traveller II	Treatment	07-Dec-12	39.8169	-73.9334	39.8169	-73.9336	08-Dec-12	39.8169	-73.9334	39.8169	-73.9336	24.3	23.8
71	T18	Traveller II	Control	07-Dec-12	39.8333	-73.8834	39.8334	-73.9000	08-Dec-12	39.8333	-73.8834	39.8334	-73.8836	23.5	25.6
72	T18	Traveller II	Treatment	07-Dec-12	39.8169	-73.9001	39.8169	-73.9003	08-Dec-12	39.8169	-73.9000	39.8169	-73.9002	25.0	23.8
73	D19	Dana Christine	Treatment	08-Dec-12	39.8668	-73.9001	39.8668	-73.8835	09-Dec-12	39.8668	-73.9001	39.8668	-73.8835	23.7	25.6
74	D19	Dana Christine	Control	08-Dec-12	39.8669	-73.9001	39.8669	-73.9169	09-Dec-12	39.8669	-73.9001	39.8669	-73.9167	22.9	25.6
75	D20	Dana Christine	Control	08-Dec-12	39.8669	-73.9335	39.8669	-73.9333	09-Dec-12	39.8669	-73.9333	39.8669	-73.9335	21.9	23.8
76	D20	Dana Christine	Treatment	08-Dec-12	39.8668	-73.9333	39.8668	-73.9168	09-Dec-12	39.8668	-73.9334	39.8668	-73.9168	22.6	23.8
77	T19	Traveller II	Treatment	08-Dec-12	39.8333	-73.8834	39.8333	-73.8668	09-Dec-12	39.8169	-73.8668	39.8333	-73.8833	21.3	25.6
78	T19	Traveller II	Control	08-Dec-12	39.8334	-73.8836	39.8334	-73.8834	09-Dec-12	39.8333	-73.9000	39.8334	-73.8834	21.1	23.8
79	T20	Traveller II	Treatment	08-Dec-12	39.8169	-73.9002	39.8169	-73.9000	09-Dec-12	39.8169	-73.9000	39.8169	-73.9002	20.5	23.8
80	T20	Traveller II	Control	08-Dec-12	39.8333	-73.9169	39.8334	-73.9167	09-Dec-12	39.8334	-73.9167	39.8333	-73.9167	23.6	23.8
81	D21	Dana Christine	Control	11-Dec-12					12-Dec-12	39.8669	-73.9167	39.9002	-73.9001	23.0	25.6
82	D21	Dana Christine	Treatment	11-Dec-12					12-Dec-12	39.8668	-73.9001	39.8668	-73.8835	23.9	25.6
83	D22	Dana Christine	Control	11-Dec-12					12-Dec-12	39.8669	-73.9333	39.8668	-73.9336	24.3	21.9
84	D22	Dana Christine	Treatment	11-Dec-12					12-Dec-12	39.8668	-73.9333	39.8668	-73.9167	24.9	23.8
85	T21	Traveller II	Control	11-Dec-12	39.8334	-73.9502	39.8334	-73.9336	12-Dec-12	39.8334	-73.9502	39.8334	-73.9336	23.3	23.8
86	T21	Traveller II	Treatment	11-Dec-12	39.8334	-73.9335	39.8334	-73.9169	12-Dec-12	39.8334	-73.9335	39.8334	-73.9169	23.9	21.9
87	T22	Traveller II	Treatment	11-Dec-12	39.8169	-73.9001	39.8169	-73.8836	12-Dec-12	39.8169	-73.9002	39.8169	-73.8836	24.0	21.9
88	T22	Traveller II	Control	11-Dec-12	39.8334	-73.9168	39.8334	-73.9002	12-Dec-12	39.8333	-73.9168	39.8169	-73.9003	24.9	23.8
89	D23	Dana Christine	Control	12-Dec-12	39.8669	-73.9001	39.8669	-73.9167	14-Dec-12	39.8669	-73.9001	39.8669	-73.9167	46.6	25.6
90	D23	Dana Christine	Treatment	12-Dec-12	39.8668	-73.8835	39.8668	-73.9001	14-Dec-12	39.8668	-73.8835	39.8668	-73.9001	47.6	25.6

Table 1 continued: Sample locations (decimal degrees) and haul information for F.Vs. Dana Christine and Traveller II.

Haul Number	Pair	Vessel Name	Gear Type	Set Date	Set Latitude Start	Set Longitude Start	Set Latitude End	Set Latitude End	Haul Date	Haul Latitude Start	Haul Longitude Start	Haul Latitude End	Haul Longitude End	Soak Time (hours)	Depth (m)
91	D24	Dana Christine	Treatment	12-Dec-12	39.8668	-73.9168	39.8668	-73.9333	14-Dec-12	39.8668	-73.9167	39.8668	-73.9333	46.9	25.6
92	D24	Dana Christine	Control	12-Dec-12	39.8669	-73.9333	39.8669	-73.9335	14-Dec-12	39.8669	-73.9169	39.8669	-73.9335	47.3	23.8
93	T23	Traveller II	Control	12-Dec-12	39.8169	-73.9003	39.8333	-73.9168	14-Dec-12	39.8333	-73.9002	39.8333	-73.9168	43.9	23.8
94	T23	Traveller II	Treatment	12-Dec-12	39.8169	-73.8836	39.8169	-73.9002	14-Dec-12	39.8169	-73.8836	39.8169	-73.9001	45.4	25.6
95	T24	Traveller II	Treatment	12-Dec-12	39.8334	-73.9169	39.8334	-73.9335	14-Dec-12	39.8334	-73.9169	39.8334	-73.9335	46.9	23.8
96	T24	Traveller II	Control	12-Dec-12	39.8334	-73.9336	39.8334	-73.9502	14-Dec-12	39.8334	-73.9336	39.8334	-73.9502	48.3	23.8
97	T25	Traveller II	Control	14-Dec-12	39.8334	-73.8833	39.8334	-73.8667	15-Dec-12	39.8334	-73.8667	39.8334	-73.8669	21.6	25.6
98	T25	Traveller II	Treatment	14-Dec-12	39.8334	-73.8836	39.8334	-73.8833	15-Dec-12	39.8334	-73.8836	39.8334	-73.8834	21.2	25.6
99	T26	Traveller II	Control	14-Dec-12	39.8333	-73.9168	39.8334	-73.9002	15-Dec-12	39.8334	-73.9168	39.8334	-73.9002	26.0	25.6
100	T26	Traveller II	Treatment	14-Dec-12	39.8169	-73.9001	39.8333	-73.8835	15-Dec-12	39.8169	-73.9001	39.8333	-73.8836	26.0	23.8
101	D25	Dana Christine	Treatment	14-Dec-12	39.8668	-73.9001	39.8668	-73.8835	15-Dec-12	39.8668	-73.8835	39.8668	-73.9001	23.6	25.6
102	D25	Dana Christine	Control	14-Dec-12	39.8669	-73.9001	39.7502	-73.9167	15-Dec-12	39.8669	-73.9001	39.8669	-73.9167	23.8	25.6
103	D26	Dana Christine	Treatment	14-Dec-12	39.8668	-73.9334	39.8668	-73.9168	15-Dec-12	39.8668	-73.9334	39.8668	-73.9168	23.1	23.8
104	D26	Dana Christine	Control	14-Dec-12	39.8669	-73.9335	39.8669	-73.9169	15-Dec-12	39.8668	-73.9335	39.8668	-73.9333	23.9	21.9
105	D27	Dana Christine	Control	15-Dec-12	39.8669	-73.9167	39.8669	-73.9001	16-Dec-12	39.8669	-73.9167	39.8669	-73.9001	23.2	25.6
106	D27	Dana Christine	Treatment	15-Dec-12	39.8668	-73.9001	39.8668	-73.8835	16-Dec-12	39.8668	-73.9001	39.8668	-73.8835	23.7	25.6
107	D28	Dana Christine	Control	15-Dec-12	39.8668	-73.9333	39.8668	-73.9335	16-Dec-12	39.8668	-73.9335	39.8669	-73.9168	23.2	21.9
108	D28	Dana Christine	Treatment	15-Dec-12	39.8668	-73.9333	39.8668	-73.9167	16-Dec-12	39.8668	-73.9333	39.8668	-73.9168	23.6	25.6
109	T27	Traveller II	Control	15-Dec-12	39.8334	-73.8667	39.8334	-73.8833	16-Dec-12	39.8334	-73.8669	39.8334	-73.8667	22.6	25.6
110	T27	Traveller II	Treatment	15-Dec-12	39.8334	-73.8834	39.8334	-73.8836	16-Dec-12	39.8334	-73.8836	39.8334	-73.8834	22.6	25.6
111	T28	Traveller II	Treatment	15-Dec-12	39.8333	-73.8836	39.8169	-73.9001	16-Dec-12	39.8169	-73.9001	39.8333	-73.8836	21.7	23.8
112	T28	Traveller II	Control	15-Dec-12	39.8334	-73.9002	39.8334	-73.9168	16-Dec-12	39.8334	-73.9168	39.8334	-73.9002	23.1	25.6
113	D29	Dana Christine	Treatment	16-Dec-12	39.8668	-73.8835	39.8668	-73.9001	18-Dec-12	39.8668	-73.9001	39.8668	-73.9335	45.5	25.6
114	D29	Dana Christine	Control	16-Dec-12	39.8669	-73.9001	39.8669	-73.9167	18-Dec-12	39.8669	-73.9001	39.8669	-73.9167	46.0	25.6
115	D30	Dana Christine	Treatment	16-Dec-12	39.8668	-73.9168	39.8668	-73.9334	18-Dec-12	39.8668	-73.9168	39.8668	-73.9333	45.3	25.6
116	D30	Dana Christine	Control	16-Dec-12	39.8669	-73.9333	39.8669	-73.9335	18-Dec-12	39.8669	-73.9333	39.8669	-73.9335	45.8	23.8
117	T29	Traveller II	Treatment	16-Dec-12	39.8334	-73.8834	39.8334	-73.8836	18-Dec-12	39.8334	-73.8833	39.8334	-73.8835	47.3	25.6
118	T29	Traveller II	Control	16-Dec-12	39.8334	-73.8667	39.8334	-73.8669	18-Dec-12	39.8334	-73.8667	39.8334	-73.9502	49.0	25.6
119	T30	Traveller II	Treatment	16-Dec-12	39.8333	-73.8836	39.8333	-73.9001	18-Dec-12	39.8333	-73.8836	39.8334	-73.9001	48.6	25.6
120	T30	Traveller II	Control	16-Dec-12	39.8334	-73.9002	39.8334	-73.9168	18-Dec-12	39.8333	-73.9002	39.8334	-73.9168	48.8	23.8

Table 2: Summary of catch weight (kg) for identified and weighed species by both vessel and gear type. Note: table does not include Atlantic sturgeon weights that were estimated visually when fish escaped near the vessel.

Vessel Name	Gear Type	American Lobster (kg)	Atlantic Sturgeon (kg)	Barndoor Skate (kg)	Bluefish (kg)	Clearnose Skate (kg)	Horseshoe Crab (kg)	Jonah Crab (kg)	Lady Crab (kg)	Little Skate (kg)	Monkfish (kg)	Rock Crab (kg)	Sea Robin (kg)	Smooth Dogfish (kg)	Spiny Dogfish (kg)	Summer Flounder (kg)	Winter Skate (kg)
Dana Christine	Control	2.0	306.6	20.5	18.6	4.2	91.9	0.0	0.0	214.1	1480.1	0.0	0.0	1.5	206.0	8.3	1493.7
Dana Christine	Treatment	0.9	132.9	0.0	5.0	7.6	97.7	0.0	0.1	152.3	1372.0	0.0	0.0	0.0	82.8	4.0	1224.5
Traveller II	Control	0.0	291.4	4.1	6.8	0.0	47.4	0.5	0.0	121.7	1135.3	0.6	0.2	0.0	94.4	2.4	923.9
Traveller II	Treatment	1.4	272.6	0.0	4.9	7.3	69.3	0.0	0.0	91.3	1016.7	0.0	0.0	0.0	50.2	2.3	878.7
Total by Treatment	*Control*	*2.0*	*598.0*	*24.6*	*25.4*	*4.2*	*139.4*	*0.5*	*0.0*	*335.8*	*2615.5*	*0.6*	*0.2*	*1.5*	*300.4*	*10.7*	*2417.6*
	Treatment	*2.3*	*405.5*	*0.0*	*9.9*	*14.8*	*166.9*	*0.0*	*0.1*	*243.6*	*2388.7*	*0.0*	*0.0*	*0.0*	*133.0*	*6.3*	*2103.2*
Grand Total		**4.2**	**1003.4**	**24.6**	**35.2**	**19.0**	**306.3**	**0.5**	**0.1**	**579.4**	**5004.2**	**0.6**	**0.2**	**1.5**	**433.4**	**16.9**	**4520.9**

Table 3: Summary of Atlantic sturgeon captures by haul number, with information on vessel, gear type, dates, soak times, weight, fork length, net number, and individual status. Missing values were not recorded due to escapement. Weights estimated by vessel captains in pounds prior to escapement are noted in weight estimated column after conversion to kilograms.

Haul Number	Vessel Name	Set Date	Haul Date	Soak Time	Gear Type	Sturgeon Status	Fork Length	Total Length	Weight kg	Weight Estimated
8	Dana Christine	26-Nov-12	27-Nov-12	25.5	Control	dead	163	184	39.0	no
9	Traveller II	27-Nov-12	29-Nov-12	46.1	Control	dead			29.5	yes
10	Traveller II	27-Nov-12	29-Nov-12	47.5	Treatment	alive			45.4	yes
14	Dana Christine	27-Nov-12	29-Nov-12	45.7	Control	alive	142	167	29.5	yes
15	Dana Christine	27-Nov-12	29-Nov-12	48.5	Control	dead	154	171	28.1	no
16	Dana Christine	27-Nov-12	29-Nov-12	49.5	Treatment	alive	155	170	27.2	yes
20	Dana Christine	29-Nov-12	30-Nov-12	26.1	Treatment	alive	147	158	22.7	yes
20	Dana Christine	29-Nov-12	30-Nov-12	26.1	Treatment	dead	165	186	34.0	no
22	Traveller II	29-Nov-12	30-Nov-12	23.6	Treatment	alive	157	179	40.8	yes
25	Dana Christine	30-Nov-12	02-Dec-12	44.8	Control	alive	147	165	24.9	yes
28	Dana Christine	30-Nov-12	02-Dec-12	45.8	Control	dead	168	185	37.2	no
29	Traveller II	29-Nov-12	02-Dec-12	74.1	Treatment	dead	102	113	7.3	no
31	Traveller II	29-Nov-12	02-Dec-12	74.2	Control	dead	154	184	31.7	yes
33	Traveller II	02-Dec-12	03-Dec-12	20	Treatment	dead	160	181	27.2	yes
36	Traveller II	02-Dec-12	03-Dec-12	24.7	Control	alive	138	164	27.2	yes
36	Traveller II	02-Dec-12	03-Dec-12	24.7	Control	alive	164	187	43.1	yes
36	Traveller II	02-Dec-12	03-Dec-12	24.7	Control	dead	164	193	31.7	yes
37	Dana Christine	02-Dec-12	03-Dec-12	22	Control	alive	165	181	29.5	yes
37	Dana Christine	02-Dec-12	03-Dec-12	22	Control	dead	177	191	39.9	no
38	Dana Christine	02-Dec-12	03-Dec-12	23	Treatment	dead	181	201	49.0	no
41	Dana Christine	03-Dec-12	03-Dec-12	22.2	Control	dead	152	165	30.4	no
45	Traveller II	03-Dec-12	04-Dec-12	22.9	Control	alive	147	166	34.0	yes
47	Traveller II	03-Dec-12	04-Dec-12	25.6	Treatment	dead	150	170	31.7	yes
48	Traveller II	03-Dec-12	04-Dec-12	23.5	Control	alive	141	157	22.7	yes
49	Traveller II	04-Dec-12	05-Dec-12	21.9	Control	dead	139	162	18.1	yes
56	Dana Christine	04-Dec-12	05-Dec-12	23.3	Control	dead	171	186	23.1	no
59	Traveller II	05-Dec-12	07-Dec-12	48	Treatment	alive	139	161	34.0	yes
62	Dana Christine	05-Dec-12	07-Dec-12	47.1	Control	alive	131	144	15.9	yes
72	Traveller II	07-Dec-12	08-Dec-12	25	Treatment	dead	139	162	34.0	yes

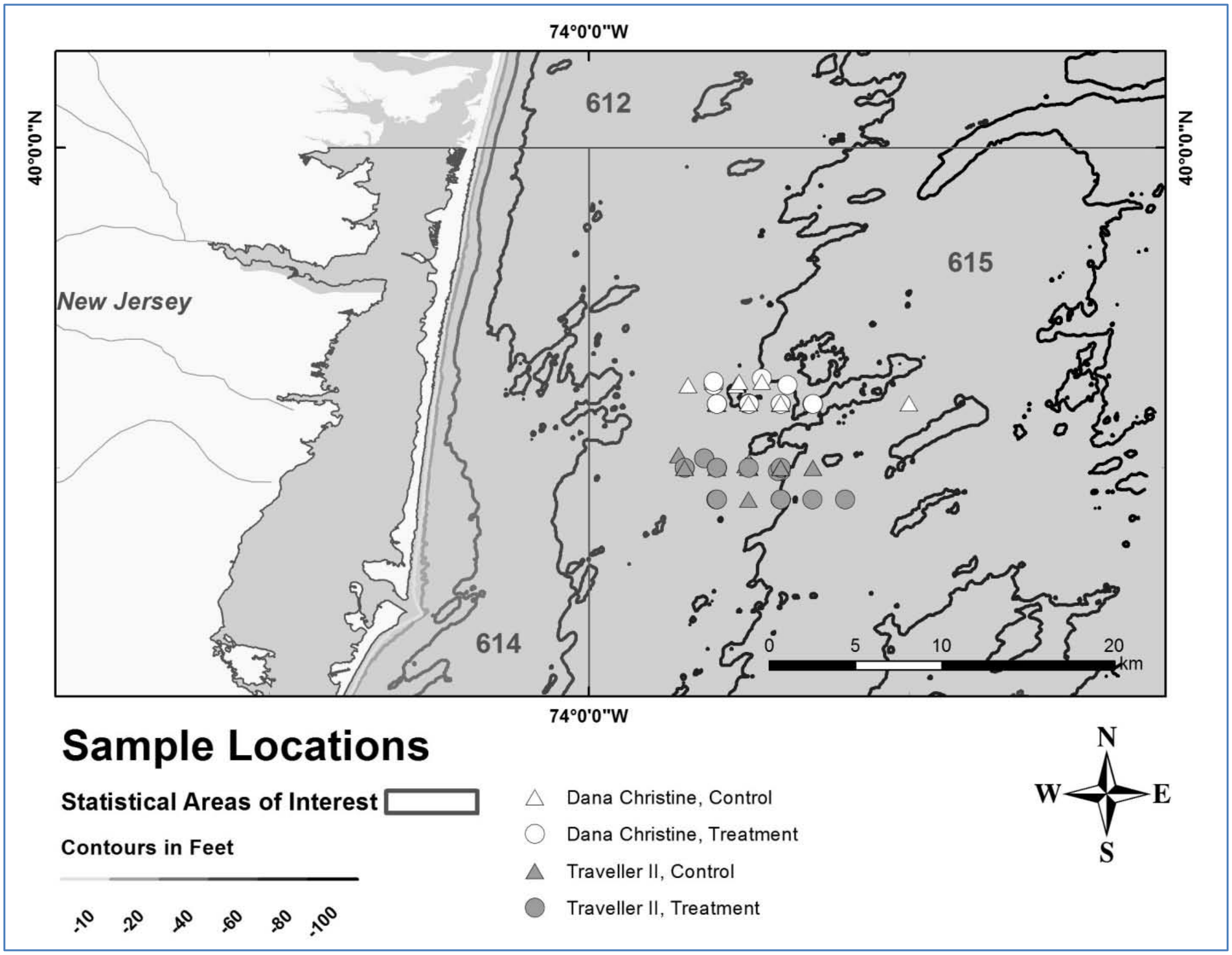

Figure 1: Location of gillnet sampling areas within NMFS Statistical Area 615 (inset) plotted by net type (triangle= control, circles = treatment) and vessel (white symbols = F/V Dana Christine, gray symbols = F/V Traveller II).

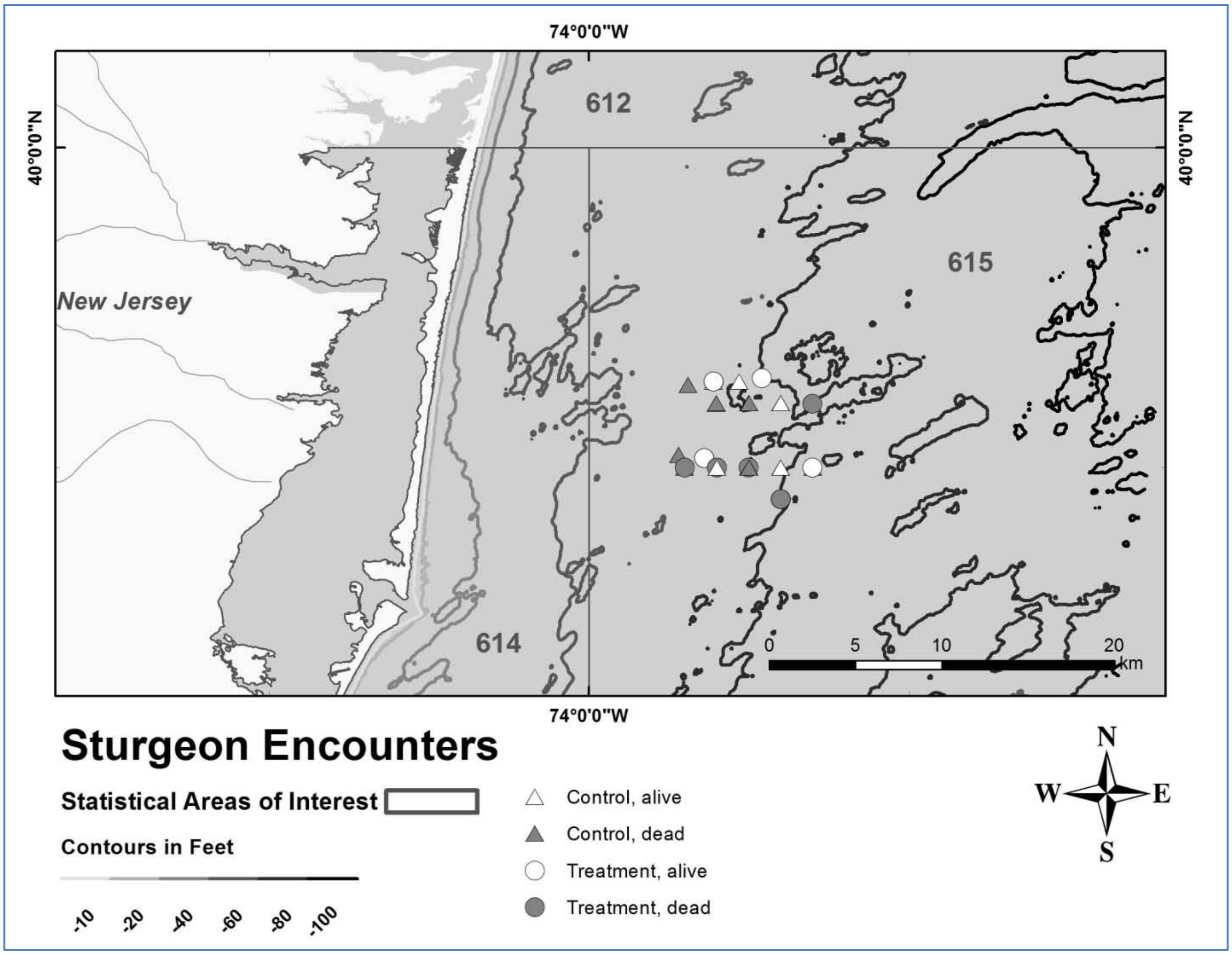

Figure 2: Location of Atlantic sturgeon encounters by mortality status (alive = white symbols; dead= gray symbols) and gear type (control = triangles; treatment= circles) within NMFS Statistical Area 615 during the 2012 field season.

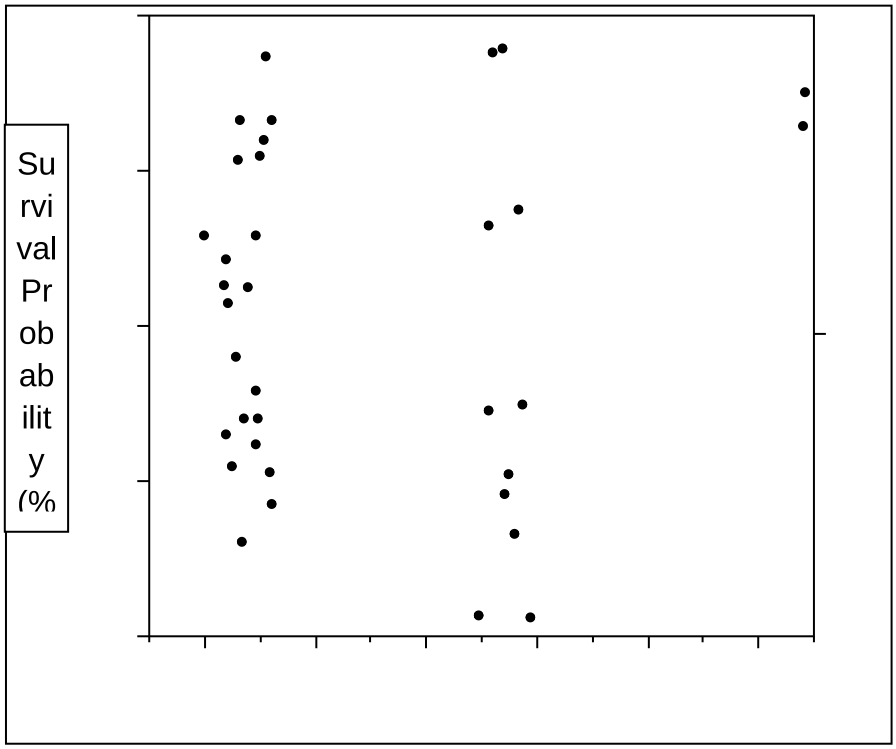

Figure 3: Results of logistic regression fit of Atlantic sturgeon survival probability by soak time for gillnet encounters in 2012. Points plotted above the solid line represent Atlantic sturgeon mortalities at the time of the encounter with the corresponding survival probability. At each soak time value, the probability scale for Atlantic sturgeon status is partitioned into probabilities for live/dead categories. The probabilities are measured as the vertical distance along the Y axis.

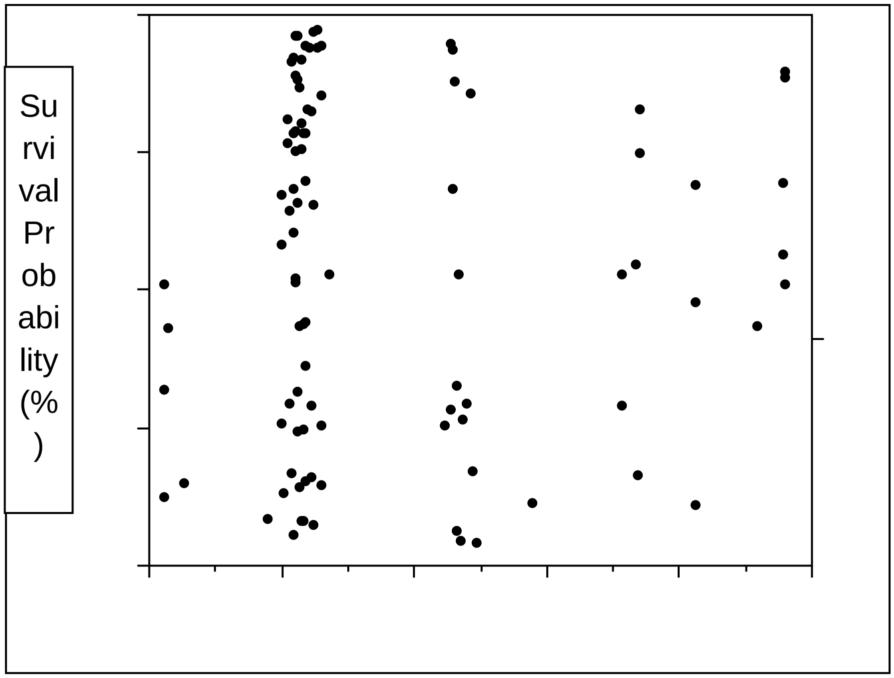

Figure 4: Figure 3: Results of logistic regression fit of Atlantic sturgeon survival probability by soak time for combined gillnet encounters in 2010-2012. Points plotted above the solid line represent Atlantic sturgeon mortalities at the time of the encounter with the corresponding survival probability. At each soak time value, the probability scale for Atlantic sturgeon status is partitioned into probabilities for live/dead categories. The probabilities are measured as the vertical distance along the Y axis.

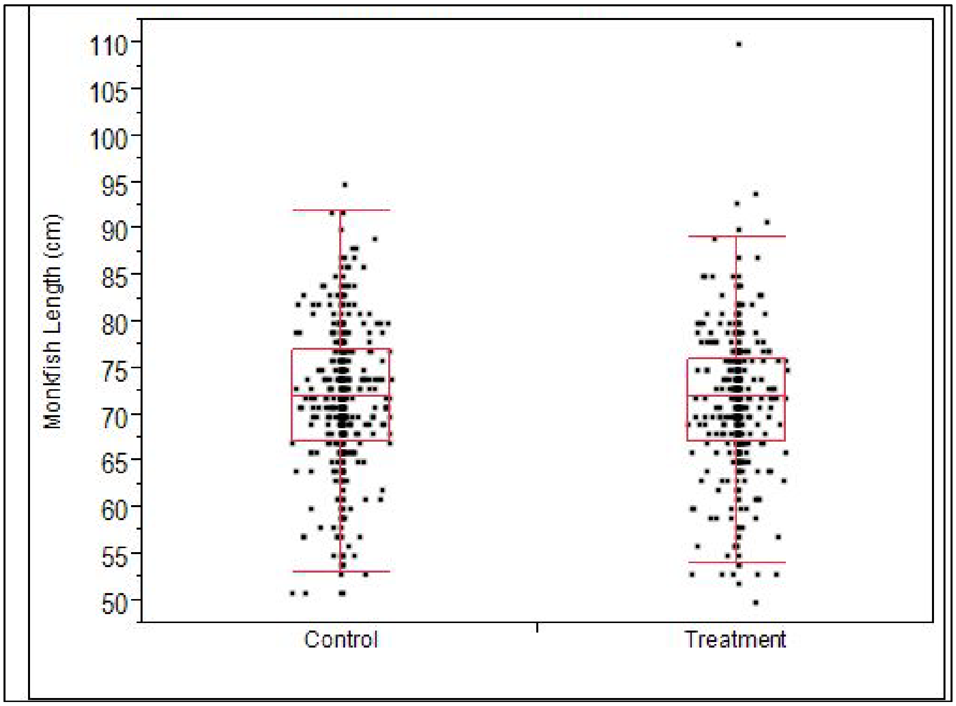

Figure 5: Length (cm) of monkfish landed by gillnet configuration. Box plots represent median and 25-75th percentiles.

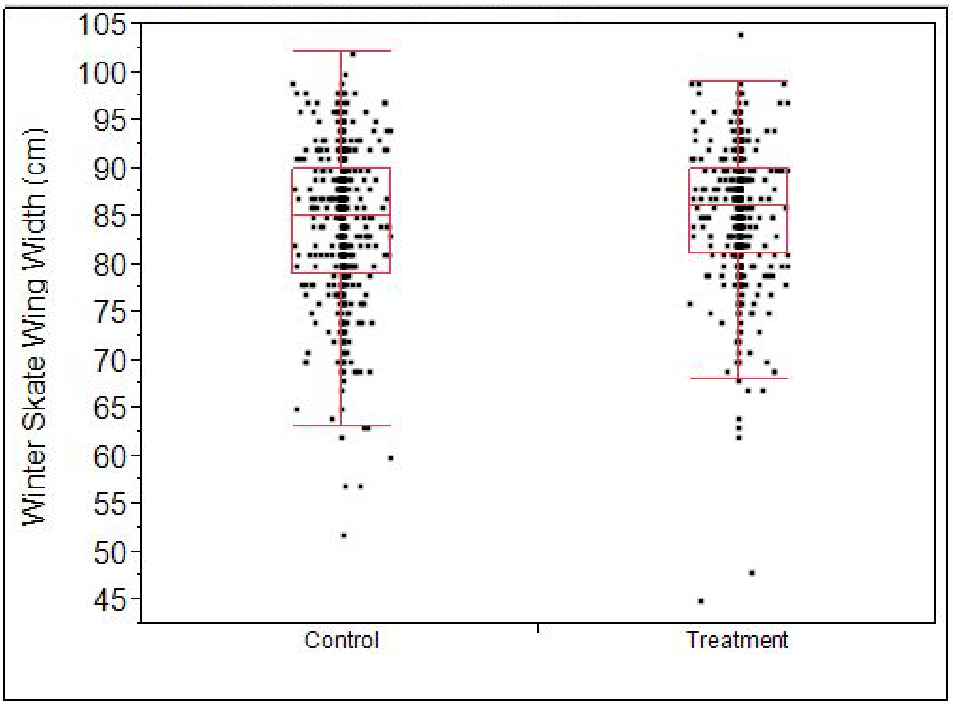

Figure 6: Width (cm) of winter skate landed by gillnet configuration. Box plots represent median and 25-75th percentiles.

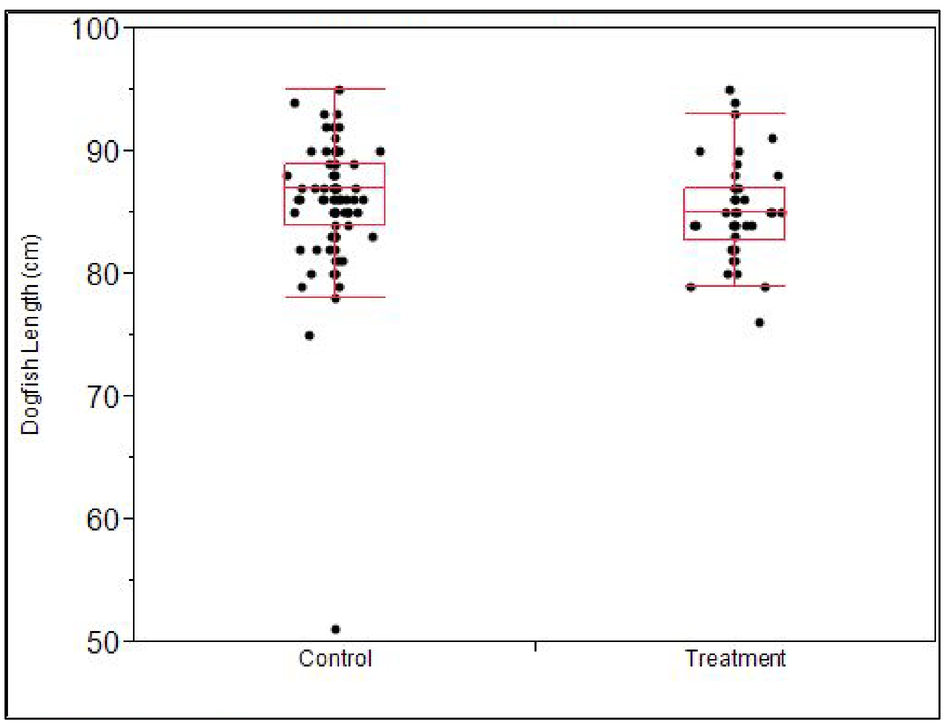

Figure 7: Length (cm) of spiny dogfish landed by gillnet configuration. Box plots represent median and 25-75th percentiles.

Completion Report

for

Sturgeon Gillnet Study (number EA133F-10-SE-3358)

The Influence of Sink Gillnet Profile on Bycatch of Atlantic Sturgeon in the Mid-Atlantic Monkfish Fishery

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Summary

On April 6th 2012, the final ruling to list five Distinct Population Segments (DPSs) of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) under the Endangered Species Act was implemented. This decision to list Atlantic sturgeon was based on a number of factors including degradation and loss of habitat, vessel strikes, and bycatch in commercial fisheries. The preceding Status Review concluded that bycatch in sink-gillnets was a significant hurdle to Atlantic sturgeon recovery. The Status Review specifically mentioned landings in the monkfish (*Lophius americanus*) gillnet fishery, which provides economic benefits to fishing communities in the mid-Atlantic and northeast U.S. The manner in which gillnets are fished, including net configuration (e.g. use of tie downs and net profile) and soak duration is believed to influence both Atlantic sturgeon encounter and mortality rates.

Cooperating monkfish harvesters' fished paired replicates of two gillnet configurations (control and treatment (low profile)) totaling 120 hauls in accordance with normal monkfish fishing operations. Atlantic sturgeon bycatch (CPUE) was significantly different (p=.0118) between gillnet configurations, with treatment nets encountering fewer individuals. With the exception of spiny dogfish (*Squalus acanthias*), we documented no significant differences in the landings of target species although overall catch rates were lower with the treatment gillnets. Our findings suggest that future modifications of gillnets may provide technological solutions to the problem of Atlantic sturgeon bycatch in large mesh sink gillnets in the mid-Atlantic and northeast U.S.

Background

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is one of 27 species within the family Acipenseridae and one of nine species/subspecies native to North American waters (Cech and Doroshov 2004). Characterized by a mostly cartilaginous skeleton, sturgeons can be traced back more than 200 million years and are recognizable in their present day form beginning approximately 85 million years ago (Bemis and Kynard 1997). Atlantic sturgeon historically occupied all major river systems along the Atlantic coast between the St.

Lawrence River, Canada (Bachus 1951) and the St. Johns River, Florida (Vladykov and Greely 1963). Additionally, Atlantic sturgeon were believed to have once co-occurred with native European sturgeon (*A. sturio*) in the Baltic Sea (500-1,500 years ago) before anthropogenic influences led to their extirpation from Europe (Ludwig et al. 2002).

Commercial harvest of sturgeon for roe (caviar) started during the 17th century and began in the U.S. in the late 1800's (Saffron 2002). In the mid-Atlantic, small scale fisheries that were directed predominantly at flesh rapidly transformed into the leaders of global caviar production (Townsend 1900). The US commercial caviar fishery was started in the Delaware River, which historically supported the largest Atlantic sturgeon population (Secor and Waldman 1999) and rapidly expanded to other river systems in the mid-Atlantic Bight before collapsing after just over a decade of high fishing effort (Cobb 1900). The success of the U.S. Atlantic sturgeon fishery was short-lived, and by 1900 the total catch was less than 10% of the peak harvest totals (Borodin 1925).

Following nearly a century of lack of recovery, the Atlantic States Marine Fisheries Commission (ASMFC) produced a Fishery Management Plan (FMP) for Atlantic sturgeon with a goal of restoring a sustainable fishery throughout its range (ASMFC 1998). The FMP implemented a coast-wide ban on harvest in state waters, which was followed shortly by a National Marine Fisheries Service (NMFS) ban in federal waters. In 2005, the NMFS established an Atlantic Sturgeon Status Review Team (ASSRT) which recommended that three of the five distinct population segments (DPS) of Atlantic sturgeon be listed as threatened under the Endangered Species Act (ESA), including the New York Bight and Chesapeake Bay DPSs (ASSRT 2007). On October 6, 2010, NMFS published a notice in the Federal Register proposing to list four of the Atlantic sturgeon DPSs, including the New York Bight and Chesapeake Bay DPSs, as endangered, and the Gulf of Maine DPS as threatened (U.S. Office of the Federal Register 2010). On April 6th 2012, the final ruling to list five Distinct Population Segments (DPSs) of Atlantic sturgeon under the Endangered Species Act was implemented. The decision to list Atlantic sturgeon was based on a number of factors including degradation and loss of habitat, vessel strikes, and bycatch in commercial fisheries.

Atlantic sturgeons are anadromous spending much of their life in the marine environment. In both the Status Review and FMP documents there are calls for more directed research on the marine phase of Atlantic sturgeon life history, which has been underrepresented in the scientific literature (Stein et al. 2004a). The general lack of biological information causes problems for fisheries professionals working within the confines of state jurisdictional boundaries, and it is especially problematic for Atlantic sturgeon as they are known to suffer from interactions with coastal marine fisheries including gillnets (Stein et al. 2004b, ASMFC 2007).

The use of gillnets to capture fish dates back over 3,000 years although relatively recent advances in technology including synthetic materials and hydraulic haulers has led to increased use of this methodology (Potter and Pawson 1991, He 2006a). Unfortunately our understanding of the mechanisms influencing bycatch in gillnets has lagged behind technological advances in the fishing industry, leading to increased concerns over the incidental take of imperiled birds, fishes, and mammals (He and Pol 2010). In the mid-Atlantic and northeast U.S., monkfish (*Lophius americanus*) support a lucrative commercial fishery out to the edge of the continental shelf. Monkfish are targeted primarily with trawls in the northern management area and sink-gillnets in the mid-Atlantic. The sink-gillnets employed in the monkfish fishery have been identified as a significant source of bycatch mortality for Atlantic sturgeon during their marine phase of their life history (Stein et al. 2004b, ASMFC 2007). As such, it is believed that changes in fishing practices in the monkfish fishery may have the potential to decrease the bycatch of Atlantic sturgeon. Unfortunately, data on bycatch reduction technologies in the monkfish gillnet fishery (e.g. net profile and tie-downs) are lacking although mesh size, tie downs, and soak times are thought to be mitigating factors in Atlantic sturgeon bycatch mortality, which ranges from 14% (ASMFC 2007) to 22.% (Stein et al. 2004).

Objectives

The objectives of the study were as follows: 1) compare the bycatch rates of Atlantic sturgeon encountered in both control and experimental gillnets in NMFS Statistical Area 614 and 615; 2) compare the catch rates of the target species (monkfish) in each gillnet configuration; and 3) record the bycatch of other NMFS regulated or protected species.

Methods

Field Studies: Through cooperative agreements with participating commercial harvesters, we examined catch rates of targeted species (e.g. monkfish and winter skate (*Leucoraja ocellata*) and bycatch of Atlantic sturgeon for two gillnet configurations. We utilized NMFS supplied gillnets which were 300 ft (91.4 m) in length and consisted of two configurations that varied in vertical profile. The control nets were comprised of 12 meshes x 12 in (30.5 cm) stretch mesh with four 48 in (1.2 m) mesh tie-downs spaced 24 ft (7.3 m) apart on alternating corks on the float line. The lower profile treatment nets were constructed of 6 meshes x 12 in (30.5 cm) stretch mesh with 24 in (0.6 m) tie-downs spaced every 12 ft (3.65 m) apart, which corresponded to the location of corks in the float line. Panels were constructed using Chatham green webbing (0.90mm) with a 0.50 hanging ratio, 0.375 in (9.5 mm) poly float line with five 1,100 lb (500 kg) weak links per panel spliced into a 0.31 in (7.9 mm) float line, and a 75 lb (34.1 kg) leadline (75 lb (34.1kg)/600 ft (182.8 m) spool). Each vessel deployed 40 panels of gillnet configured in 10 panel strings totaling 3,000 ft (914m). Each string comprised either control (standard profile) or treatment (low profile) nets. Cooperating monkfish harvesters fished the strings of gillnets as paired replicates, with the pair including both the control and treatment gillnets strings set in a similar location, at a similar depth, and fished for a similar amount of time. A total of 120 hauls of 60 replicates were completed, with hauls split evenly between vessels and the set sequence for net strings randomly selected at the start of the study. A copy of the haul schedule was kept on board each vessel and confirmed by the vessel master and NMFS trained observer.

Two monkfish fishing vessels (F/V Dana Christine and F/V Traveller II) employed normal gillnetting operations with soak times dependent upon fishing and weather conditions. Sampling operations took place in November and December of 2011 off the coast of New Jersey in waters which have historically supported commercial monkfish operations (Statistical Areas 614 and 615) (Figure 1) and where the vessel captains believed they would encounter Atlantic sturgeon. In the event of snags or tears, gillnet panels were either replaced entirely (if available), repaired on site if damage was minimal, or hauled and repaired on land if damage was sufficient to not allow at-sea repairs. Both fishing vessels operated in the same general vicinity, fishing inshore waters less than 100 m in depth. Effort was standardized to net days which were defined as 10 strings fished for a 24h period.

Fishing operations were monitored by NMFS trained observers (AIS Inc.) who recorded total weight and length measurements for all monkfish and other commercially landed species. In instances where the number of individuals per net string exceeded 100, a sub-sample (n=100) was randomly selected, and the total weight recorded. Atlantic sturgeon brought aboard the vessel were measured, weighed, a small tissue sample was recovered, and, in the case of mortalities, the pectoral girdles were removed for future age and growth studies. Atlantic sturgeon were scanned for the presence of a passive integrated transponder (PIT) tag. If no PIT tag was found in live individuals, a 12 mm 134.2 kHz PIT tag was implanted on the left side at the base of the dorsal fin and the fish were immediately released at the site of capture. In these instances the disposition (i.e., live vs. mortality) was recorded as was the vertical and horizontal location of the sturgeon capture in the net panel. In the case of the low-profile nets vertical location in the net panel was difficult to ascertain as the entire profile of the net was often bunched together.

Original data sheets (available upon request) were signed by both the vessel captain and fishery observer and then scanned to ensure quick data entry and secure back up of the data. Data sheets were then entered into a relational database for generation of tables to facilitate report writing and statistical analyses. All statistical analyses were conducted using JMP Version 9.0 (2011) using a paired comparison to test for differences in soak times and catch rates between gear types. We examined the role of soak times and Atlantic sturgeon size (FL) in influencing status (live/dead) at the time of capture through a logistic regression model. Catch-per-unit-effort (CPUE) was defined as weight (kg) landed per net day per 1000 yards of net, except for Atlantic sturgeon where numbers encountered were utilized. Statistical significance was inferred at $p \leq 0.05$.

Results and Discussion

All field sampling was conducted in NMFS Statistical Area 614 and 615 (Figure 1) and was initiated on Nov. 22, 2011 by the commercial fishing vessels F/V Dana Christine and F/V Traveller II. Operations were concluded on Dec. 14, 2011 at the completion of 120 net hauls (Table 1). Soak times for control gillnets averaged 32.24 hours (range = 5.4-97.4h), while the soak times for the lower profile treatment gillnets averaged 32.48 hours (range = 6.6-95.9h). There was no significant difference in the duration of soak time of control and treatment gillnets based on a paired comparison t-test (p = 0.7209).

A total of 11 identified species were encountered in the course of sampling, totaling 32,085 kg (Table 2). The vast majority of landings (95.1%) were of monkfish (7,687 kg), winter skate (21,655 kg) and spiny dogfish (*Squalus acanthias*) (1,175 kg). Discards of regulated species (i.e., monkfish, winter skate, and spiny dogfish) were limited by market conditions and quotas. During the course of this work, no marine mammals were caught in either control or treatment nets.

In total, 37 adult and juvenile Atlantic sturgeon with a mean size of 152.3 cm FL (range = 117-217 cm) were encountered during the course of the project ranging (Figure 2). Capture rates of Atlantic sturgeon varied significantly (p = 0.0079) by gillnet type (Figure 3), with 28 (75.7%) captured in control gillnets and the remaining nine (24.3%) captured in the lower profile treatment nets. During the first sampling event (Haul 1- F/V Dana Christine) an Atlantic sturgeon was captured during a short soak of the control gear, which doubled as an observer training trip. We have included this sampling event because it took place in the same general area as later sampling events although the soak time was markedly shorter. We were able to attain length measurements on a total of 33 Atlantic sturgeon, the vast majority (87.9%) of which were above the minimum size of maturity (130 cm FL) for Atlantic sturgeon (Van Eenennaam et al. 1996) (Table 3). We were unable to measure the remaining individuals because three of them escaped from the gillnets as the gear was being hauled from the water, and the final Atlantic sturgeon (Haul 81; 12-9-12) was dead and slid out of the net prior to coming aboard the vessel. Of the 28 Atlantic sturgeon captured in the control nets, we were able to assess the vertical placement of 10 in the net: five (50%) were located in the upper quarter of the net, four in the 2nd quarter, and the remaining individual was located in the 3rd quarter of the net. In the low profile treatment nets, Atlantic sturgeon tended to collapse the entire net which prohibited us from assigning vertical placement in all but four individuals. These four Atlantic sturgeon were distributed with one individual in the upper quarter, two in the 2nd quarter, and one in the 3rd quarter of the net. Although sample sizes are limited, these results appear to indicate Atlantic sturgeon catch rates are lowest at the bottom of the net. Sturgeons are traditionally referred to as benthic cruisers (Findeis 1997) though there is a growing body of evidence to suggest that they commonly are in the water column (Sulak et al. 2002, Erickson and Hightower 2007). Our limited results support the idea that sturgeons may occupy portions of the water column more frequently than previously thought.

Of the 37 Atlantic sturgeon observed through our sampling, a total of 25 (67.6%) were dead when landed, while the remaining 12 (32.4%) were released alive. A contingency analysis of Atlantic sturgeon mortalities between control and treatment captures was suggestive of a potential relationship ($p = 0.0606$), although the mortality rate appeared to be lower in the control gear (60.7%) than in the low profile treatment nets (88.9%). Due to low capture rates, we pooled across gillnet treatment types to examine the influence of soak time on Atlantic sturgeon disposition (i.e. live/dead) upon landing. The results of a logistic regression analysis of pooled Atlantic sturgeon encounters by soak time indicated that mortality rate was not significantly correlated with soak time ($p = 0.1608$) (Figure 4). Although it is intuitive that soak time plays a role in mediating survival risk in entangled individuals, the difficulty in assigning the actual timing of entanglement for individuals leads to much uncertainty. Although our results were not significant, they do appear to add to the growing body of evidence which suggests that the soak time of anchored gillnets may be positively correlated with mortality risk, especially in cases where soak times exceed 24h (Stein et al. 2004b, ASMFC 2007). In the present study, Atlantic sturgeon mortality rates increase from approximately 60% at 24h to almost 90% when soak times of 96h are reached.

Through our sampling efforts for this study, a total of 7,687 kg of monkfish were landed (Table 2). Slightly more than half (56.5%) of monkfish were landed in control nets. In total, landings in the treatment gear (3.341 kg) were 23.1% lower than landings in control gear (4,435 kg). The mean haul rate of monkfish for control gillnets was 70.1 kg/haul (95% CI 54.5 - 84.7) compared to a rate of 53.0 kg/haul (95% CI 41.4 – 64.7) for treatment gillnets. An examination of landings by gear type indicated that the vast majority of hauls landed monkfish at rates less than 150 kg/haul although there were six hauls (four control and two treatment gillnets) where monkfish landings exceeded 200kg/haul. Catch rates of monkfish (CPUE) were not significantly different between the gear types ($p = 0.1166$) (Figure 5), although the monkfish CPUE did differ significantly between vessels ($p = 0.0004$), reflecting the greater landings recorded on the F.V. Dana Christine (Table 4). Monkfish catch rates did not vary significantly by gear type for either fishing vessel indicated that both were still non-significant (Traveller II $p = .2766$; Dana Christine $p = .0734$) although there were marked differences in the probability estimates further suggesting differences between fishing vessels. The mean size of monkfish landed in the control gillnets was 71.3 cm TL (median = 71cm TL) while the mean size of monkfish landed in the lower profile treatments (72.1 cm TL) (median = 71cm TL) was slightly, although not significantly, larger ($p = 0.0817$) (Figure 6).

Winter skate, the dominant species landed by weight (21,655 kg), catch rates did not vary significantly ($p = 0.4212$) by gear type although the majority (55.1%) of landings were in the control gillnets (Figure 7). The landings of winter skate were significantly between vessels ($p = 0.0154$) with landings greatest on the F.V. Dana Christine (Table 5). Lengths of winter skate landed in the control gillnets (mean = 81.8 cm TL) were not significantly different ($p = 0.1616$) than those landed in the lower profile treatment nets (mean = 82.1cm TL) (Figure 8). Spiny dogfish which represented the species with the lowest landings considered commercially viable were landed at significantly lower levels ($p < 0.0001$) in the low profile treatment nets compared to the control gear (Figure 9). Similar to the other species, we also documented a significant difference in spiny dogfish landings between vessels, with the F.V. Dana Christine landing greater numbers (Table 5). Similar to our findings with monkfish and winter skate, we found no significant difference ($p = 0.8429$) between the lengths of spiny dogfish landed in the control gear (mean = 83.3 cm TL) and those landed in the lower profile treatment nets (mean = 83.1 cm TL).

Through this study we have provided quantifiable results suggesting that decreasing the net profile can significantly reduce the capture rates of critically imperiled Atlantic sturgeon. This finding provides hope that through continued modification and testing we can increase the levels of monkfish landed in the lower profile treatment gillnets to begin to approximate landings in traditional control nets. The use of modified net profiles has been examined in other systems (He 2006b) with mixed success; nevertheless providing hope for a technological solution to the issue surrounding Atlantic sturgeon bycatch in large mesh sink gillnets (ASMFC 2007). At the conclusion of the present study, both vessel captains felt strongly that modifying the treatment gear design to maintain the lowered profile but increasing the bag may help increase the landings of target species in future studies. We hope that these recommendations can be tested in further rigorous field trials.

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Table 1: Sample locations (decimal degrees) and haul information for F.Vs. Dana Christine and Traveller II.

Haul Number	Pair	Vessel Name	Gear Type	Set Date	Latitude	Longitude	Haul Date	Soak Time (hours)
1	1	Dana	Control	11/22/2011	39.7835	-74.0335	11/22/2011	5.4
2	1	Dana	Treatment	11/22/2011	39.78356	-74.01692	11/22/2011	6.6
3	2	Dana	Control	11/22/2011	39.80017	-74.00022	11/22/2011	6.1
4	2	Dana	Treatment	11/22/2011	39.80019	-74	11/22/2011	6.8
5	3	Traveler II	Treatment	11/24/2011	39.83339	-73.95006	11/25/2011	20.1
6	3	Traveler II	Control	11/24/2011	39.83336	-73.93344	11/25/2011	21.1
7	4	Traveler II	Treatment	11/24/2011	39.81692	-73.91678	11/25/2011	22
8	4	Traveler II	Control	11/24/2011	39.81692	-73.90014	11/25/2011	22.8
9	5	Dana	Treatment	11/24/2011	39.85	-73.88347	11/25/2011	20.1
10	5	Dana	Control	11/24/2011	39.83358	-73.86686	11/25/2011	21
11	6	Dana	Treatment	11/24/2011	39.90019	-73.85025	11/25/2011	22.8
12	6	Dana	Control	11/24/2011	39.8335	-73.85006	11/25/2011	22.9
13	7	Dana	Control	11/25/2011	39.83358	-73.86686	11/26/2011	22.1
14	7	Dana	Treatment	11/25/2011	39.85	-73.88347	11/26/2011	22.3
15	8	Dana	Control	11/25/2011	39.8335	-73.85025	11/26/2011	21.7
16	8	Dana	Treatment	11/25/2011	39.8335	-73.85025	11/26/2011	22.6
17	9	Traveler II	Control	11/25/2011	39.83336	-73.93342	11/26/2011	21.8
18	9	Traveler II	Treatment	11/25/2011	39.81692	-73.91678	11/26/2011	21.8
19	10	Traveler II	Control	11/25/2011	39.83333	-73.90014	11/26/2011	22.5
20	10	Traveler II	Treatment	11/25/2011	39.83342	-73.95003	11/26/2011	26.3
21	11	Dana	Control	11/26/2011	39.83358	-73.86686	11/27/2011	21.8
22	11	Dana	Treatment	11/26/2011	39.85	-73.88347	11/27/2011	22.9
23	12	Dana	Treatment	11/26/2011	39.83342	-73.81692	11/27/2011	21.9
24	12	Dana	Control	11/26/2011	39.83336	-73.81669	11/27/2011	22.5
25	13	Traveler II	Control	11/26/2011	39.83333	-73.90011	11/27/2011	21.8
26	13	Traveler II	Treatment	11/26/2011	39.81692	-73.91678	11/27/2011	32.9
27	14	Traveler II	Treatment	11/26/2011	39.83342	-73.95006	11/27/2011	23.7
28	14	Traveler II	Control	11/26/2011	39.83336	-73.93342	11/27/2011	27.2
29	15	Dana	Treatment	11/27/2011	39.83342	-73.81692	11/28/2011	21.9
30	15	Dana	Control	11/27/2011	39.83336	-73.81692	11/28/2011	21.7
31	16	Dana	Control	11/27/2011	39.83358	-73.85025	11/28/2011	25
32	16	Dana	Treatment	11/27/2011	39.85008	-73.88344	11/28/2011	22.5
33	17	Traveler II	Control	11/27/2011	39.83333	-73.90014	11/28/2011	23.6
34	17	Traveler II	Treatment	11/27/2011	39.83333	-73.91678	11/28/2011	23
35	18	Traveler II	Control	11/27/2011	39.83336	-73.93342	11/28/2011	21.6
36	18	Traveler II	Treatment	11/27/2011	39.83342	-73.95	11/28/2011	23.7
37	19	Dana	Control	11/28/2011	39.85	-73.86686	12/2/2011	91.8
38	19	Dana	Treatment	11/28/2011	39.85008	-73.88344	12/2/2011	93.5
39	20	Dana	Treatment	11/28/2011	39.83347	-73.81692	12/2/2011	95.1
40	20	Dana	Control	11/28/2011	39.83342	-73.81669	12/2/2011	97.4
41	21	Traveler II	Control	11/28/2011	39.83333	-73.90014	12/2/2011	82.6
42	21	Traveler II	Treatment	11/28/2011	39.83333	-73.91678	12/2/2011	95.8
43	22	Traveler II	Control	11/28/2011	39.83339	-73.91683	12/2/2011	96.2
44	22	Traveler II	Treatment	11/28/2011	39.83342	-73.93347	12/2/2011	95.9
45	23	Dana	Treatment	12/2/2011	39.85006	-73.90011	12/4/2011	46
46	23	Dana	Control	12/2/2011	39.85	-73.86686	12/4/2011	46.6
47	24	Dana	Treatment	12/2/2011	39.83347	-73.81692	12/4/2011	44.5
48	24	Dana	Control	12/2/2011	39.83339	-73.81667	12/4/2011	46.5
49	25	Traveler II	Control	12/2/2011	39.83333	-73.88358	12/4/2011	47.3
50	25	Traveler II	Treatment	12/2/2011	39.81692	-73.91678	12/4/2011	47.5
51	26	Traveler II	Control	12/2/2011	39.83336	-73.93342	12/4/2011	46.4
52	26	Traveler II	Treatment	12/2/2011	39.83344	-73.93347	12/4/2011	45.9
53	27	Dana	Treatment	12/4/2011	39.85006	-73.88344	12/5/2011	22.7
54	27	Dana	Control	12/4/2011	39.85	-73.86692	12/5/2011	23.6
55	28	Dana	Control	12/4/2011	39.83347	-73.81692	12/5/2011	22.5
56	28	Dana	Treatment	12/4/2011	39.83339	-73.80025	12/5/2011	23
57	29	Traveler II	Control	12/4/2011	39.83333	-73.88358	12/5/2011	23.7
58	29	Traveler II	Treatment	12/4/2011	39.83344	-73.9335	12/5/2011	22.2
59	30	Traveler II	Treatment	12/4/2011	39.83333	-73.90022	12/5/2011	24.8

Table 1 continued: Sample locations (decimal degrees) and haul information for F.Vs. Dana Christine and Traveller II.

Haul Number	PAIR	Vessel Name	Gear Type	Set Date	Latitude	Longitude	Haul Date	Soak Time (hours)
60	30	Traveler II	Control	12/4/2011	39.83342	-73.91686	12/5/2011	26
61	31	Dana Christine	Treatment	12/5/2011	39.85014	-73.88347	12/6/2011	22.9
62	31	Dana Christine	Control	12/5/2011	39.85003	-73.86689	12/6/2011	23.3
63	32	Dana Christine	Control	12/5/2011	39.83347	-73.81692	12/6/2011	22.8
64	32	Dana Christine	Treatment	12/5/2011	39.83339	-73.80025	12/6/2011	23.7
65	33	Traveler II	Treatment	12/5/2011	39.83342	-73.95006	12/6/2011	22.6
66	33	Traveler II	Control	12/5/2011	39.83342	-73.93344	12/6/2011	20.1
67	34	Traveler II	Control	12/5/2011	39.83333	-73.88358	12/6/2011	24.9
68	34	Traveler II	Treatment	12/5/2011	39.83333	-73.91678	12/6/2011	24.2
69	35	Dana Christine	Control	12/6/2011	39.85011	-73.8835	12/7/2011	22
70	35	Dana Christine	Treatment	12/6/2011	39.85003	-73.86692	12/7/2011	22.8
71	36	Dana Christine	Control	12/6/2011	39.8335	-73.81692	12/7/2011	22.3
72	36	Dana Christine	Treatment	12/6/2011	39.83342	-73.81669	12/7/2011	22.8
73	37	Traveler II	Control	12/6/2011	39.83342	-73.93344	12/7/2011	22.5
74	37	Traveler II	Treatment	12/6/2011	39.83344	-73.9335	12/7/2011	24.2
75	38	Traveler II	Treatment	12/6/2011	39.83333	-73.91678	12/7/2011	22.5
76	38	Traveler II	Control	12/6/2011	39.83333	-73.90014	12/7/2011	23.9
77	39	Dana Christine	Control	12/7/2011	39.85014	-73.88342	12/9/2011	46
78	39	Dana Christine	Treatment	12/7/2011	39.85003	-73.86675	12/9/2011	47.3
79	40	Dana Christine	Treatment	12/7/2011	39.86675	-73.90025	12/9/2011	44.2
80	40	Dana Christine	Control	12/7/2011	39.86692	-73.91678	12/9/2011	43.2
81	41	Traveler II	Treatment	12/7/2011	39.83342	-73.95006	12/9/2011	45.6
82	41	Traveler II	Control	12/7/2011	39.83342	-73.93342	12/9/2011	47.1
83	42	Traveler II	Control	12/7/2011	39.83333	-73.90014	12/9/2011	46
84	42	Traveler II	Treatment	12/7/2011	39.83336	-73.91675	12/9/2011	47.9
85	43	Traveler II	Treatment	12/9/2011	39.83342	-73.95006	12/11/2011	48.5
86	43	Traveler II	Control	12/9/2011	39.83333	-73.90014	12/11/2011	47.6
87	44	Traveler II	Treatment	12/9/2011	39.83336	-73.91672	12/11/2011	47.7
88	44	Traveler II	Control	12/9/2011	39.83342	-73.93342	12/11/2011	50.3
89	45	Dana Christine	Treatment	12/9/2011	39.86686	-73.90011	12/11/2011	20.1
90	45	Dana Christine	Control	12/9/2011	39.88336	-73.93339	12/11/2011	21.3
91	46	Dana Christine	Treatment	12/9/2011	39.85011	-73.86692	12/11/2011	25.1
92	46	Dana Christine	Control	12/9/2011	39.85014	-73.86692	12/11/2011	26
93	47	Dana Christine	Control	12/11/2011	39.88336	-73.93336	12/12/2011	21.9
94	47	Dana Christine	Treatment	12/11/2011	39.86692	-73.91669	12/12/2011	22.5
95	48	Dana Christine	Control	12/11/2011	39.86692	-73.93358	12/12/2011	21.6
96	48	Dana Christine	Treatment	12/11/2011	39.86692	-73.95025	12/12/2011	22.4
97	49	Traveler II	Control	12/11/2011	39.83333	-73.88356	12/12/2011	20.3
98	49	Traveler II	Treatment	12/11/2011	39.83336	-73.90022	12/12/2011	21.3
99	50	Traveler II	Control	12/11/2011	39.83339	-73.91681	12/12/2011	20.9
100	50	Traveler II	Treatment	12/11/2011	39.81681	-73.9	12/12/2011	25
101	51	Traveler II	Control	12/12/2011	39.83333	-73.90014	12/13/2011	23.5
102	51	Traveler II	Treatment	12/12/2011	39.81692	-73.95022	12/13/2011	20.3
103	52	Traveler II	Control	12/12/2011	39.83344	-73.93342	12/13/2011	23.7
104	52	Traveler II	Treatment	12/12/2011	39.83336	-73.91678	12/13/2011	25.2
105	53	Dana Christine	Control	12/12/2011	39.86683	-73.93339	12/13/2011	22.4
106	53	Dana Christine	Treatment	12/12/2011	39.95017	-73.91675	12/13/2011	23.5
107	54	Dana Christine	Control	12/12/2011	39.86686	-73.95	12/13/2011	22.3
108	54	Dana Christine	Treatment	12/12/2011	39.86689	-73.95022	12/13/2011	23.5
109	55	Dana Christine	Control	12/13/2011	39.86683	-73.93339	12/14/2011	22.4
110	55	Dana Christine	Treatment	12/13/2011	39.86683	-73.91675	12/14/2011	23.4
111	56	Dana Christine	Treatment	12/13/2011	39.86689	-73.95022	12/14/2011	22.1
112	56	Dana Christine	Control	12/13/2011	39.86683	-73.93358	12/14/2011	22.8
113	57	Traveler II	Control	12/13/2011	39.83333	-73.93344	12/14/2011	23.7
114	57	Traveler II	Treatment	12/13/2011	39.81689	-73.96675	12/14/2011	23.8
115	58	Traveler II	Treatment	12/13/2011	39.83339	-73.91678	12/14/2011	22.9
116	58	Traveler II	Control	12/13/2011	39.83344	-73.93339	12/14/2011	24.6
117	59	Traveler II	Treatment	12/14/2011	39.83339	-73.91678	12/17/2011	57.7
118	59	Traveler II	Control	12/14/2011	39.83344	-73.93339	12/17/2011	58.1
119	60	Traveler II	Control	12/14/2011	39.75	-73.95003	12/17/2011	73.8
120	60	Traveler II	Treatment	12/14/2011	39.81689	-73.96678	12/17/2011	62.1

Table 2: Summary of catch weight (kg) for identified and weighed species by both vessel and gear type. Note: table does not include Atlantic sturgeon where weights were estimated due to escapement at the vessel where interactions were recorded.

Vessel Name	Gear Type	Atlantic Sturgeon	Bluefish	Clearnose Skate	Horseshoe Crab	Little Skate	Monkfish	Unknown Seastar	Unknown Skate	Spiny Dogfish	Summer Flounder	Weakfish	Winter Skate
Dana Christine	Control	383	11	8	41	29	2208	2	0	634	11	2	6127
Dana Christine	Treatment	113	7	4	45	6	1381	6	0	156	0	0	4482
Traveler II	Control	496	13	2	34	0	2138	0	93	307	14	0	5794
Traveler II	Treatment	120	12	6	48	0	1961	0	61	78	0	0	5252
	Control	879	24	10	75	29	4345	2	93	941	24	2	11921
	Treatment	234	19	10	93	6	3341	6	61	235	0	0	9734
	Total Weights	1113	43	20	168	36	7687	8	154	1175	24	2	21655

Table 3: Summary of Atlantic sturgeon captures by haul number, with information on vessel, gear type, dates, soak times, weight, fork length, and individual status. Missing values were not recorded due to escapement. Weights estimated by vessel captains prior to escapement are noted by *.

Haul Number	Vessel Name	Gear Type	Set Date	Haul Date	Soak Time (hours)	Weight (kg)	Fork Length (cm)	Status
1	Dana Christine	Control 2	11/22/2011	11/22/2011	5.4	40*	NA	alive
6	Traveler II	Control 2	11/24/2011	11/25/2011	21.1	23	144	dead
8	Traveler II	Control 2	11/24/2011	11/25/2011	22.8	50	217	dead
9	Dana Christine	Treatment 2	11/24/2011	11/25/2011	20.1	23	156	dead
13	Dana Christine	Control 2	11/25/2011	11/26/2011	22.1	23	145	dead
15	Dana Christine	Control 2	11/25/2011	11/26/2011	21.7	66	185	alive
15	Dana Christine	Control 2	11/25/2011	11/26/2011	21.7	66	145	dead
18	Traveler II	Treatment 2	11/25/2011	11/26/2011	21.8	12	124	dead
19	Traveler II	Control 2	11/25/2011	11/26/2011	22.5	45	191	alive
27	Traveler II	Treatment 2	11/26/2011	11/27/2011	23.7	36	160	alive
28	Traveler II	Control 2	11/26/2011	11/27/2011	27.2	20	134	dead
29	Dana Christine	Treatment 2	11/27/2011	11/28/2011	21.9	68	187	dead
31	Dana Christine	Control 2	11/27/2011	11/28/2011	25	63	166	dead
37	Dana Christine	Control 2	11/28/2011	12/2/2011	91.8	18	136	dead
41	Traveler II	Control 2	11/28/2011	12/2/2011	82.6	73	174	dead
41	Traveler II	Control 2	11/28/2011	12/2/2011	82.6	73	164	dead
41	Traveler II	Control 2	11/28/2011	12/2/2011	82.6	73	144	alive
42	Traveler II	Treatment 2	11/28/2011	12/2/2011	95.8	10	122	dead
43	Traveler II	Control 2	11/28/2011	12/2/2011	96.2	79	154	dead
43	Traveler II	Control 2	11/28/2011	12/2/2011	96.2	79	154	dead
43	Traveler II	Control 2	11/28/2011	12/2/2011	96.2	79	170	dead
44	Traveler II	Treatment 2	11/28/2011	12/2/2011	95.9	32	152	dead
45	Dana Christine	Treatment 2	12/2/2011	12/4/2011	46	23	139	dead
46	Dana Christine	Control 2	12/2/2011	12/4/2011	46.6	27	117	alive
51	Traveler II	Control 2	12/2/2011	12/4/2011	46.4	25	135	alive
57	Traveler II	Control 2	12/4/2011	12/5/2011	23.7	29	144	alive
60	Traveler II	Control 2	12/4/2011	12/5/2011	26	43	173	dead
62	Dana Christine	Control 2	12/5/2011	12/6/2011	23.3	27	134	alive
66	Traveler II	Control 2	12/5/2011	12/6/2011	20.1	45*	NA	alive
68	Traveler II	Treatment 2	12/5/2011	12/6/2011	24.2	29	141	dead
71	Dana Christine	Control 2	12/6/2011	12/7/2011	22.3	23	135	dead
73	Traveler II	Control 2	12/6/2011	12/7/2011	22.5	41	163	dead
81	Traveler II	Treatment 2	12/7/2011	12/9/2011	45.6	NA	NA	dead
90	Dana Christine	Control 2	12/9/2011	12/11/2011	21.3	77*	NA	alive
90	Dana Christine	Control 2	12/9/2011	12/11/2011	21.3	77	152	dead
107	Dana Christine	Control 2	12/12/2011	12/13/2011	22.3	18	128	dead
118	Traveler II	Control 2	12/14/2011	12/17/2011	58.1	23	142	alive

Table 4: Catch information for monkfish (target species). Table includes kept fish only.

Haul	Vessel	Set Date	Haul Date	Soak Time (hours)	Gear	Monkfish Landed	Total Weight of Monkfish (kg)	Median Total Length (cm)
1	Dana Christine	11/22/11	11/22/11	5.4	Control	0	0.0	NA
2	Dana Christine	11/22/11	11/22/11	6.6	Treatment	1	7.3	73
3	Dana Christine	11/22/11	11/22/11	6.1	Control	1	6.8	71
4	Dana Christine	11/22/11	11/22/11	6.8	Treatment	0	0.0	NA
5	Traveler II	11/24/11	11/25/11	20.1	Treatment	9	579.6	72
6	Traveler II	11/24/11	11/25/11	21.1	Control	12	1235.4	68
7	Traveler II	11/24/11	11/25/11	22	Treatment	10	666.7	74
8	Traveler II	11/24/11	11/25/11	22.8	Control	7	387.3	73
9	Dana Christine	11/24/11	11/25/11	20.1	Treatment	9	449.0	74
10	Dana Christine	11/24/11	11/25/11	21	Control	9	483.7	73
11	Dana Christine	11/24/11	11/25/11	22.8	Treatment	4	75.3	68
12	Dana Christine	11/24/11	11/25/11	22.9	Control	14	1368.3	70
13	Dana Christine	11/25/11	11/26/11	22.1	Control	7	288.9	75
14	Dana Christine	11/25/11	11/26/11	22.3	Treatment	6	274.8	78
15	Dana Christine	11/25/11	11/26/11	21.7	Control	8	321.1	69
16	Dana Christine	11/25/11	11/26/11	22.6	Treatment	1	5.4	62
17	Traveler II	11/25/11	11/26/11	21.8	Control	1	7.3	80
18	Traveler II	11/25/11	11/26/11	21.8	Treatment	5	158.7	71
19	Traveler II	11/25/11	11/26/11	22.5	Control	6	302.0	63
20	Traveler II	11/25/11	11/26/11	26.3	Treatment	3	76.2	80
21	Dana Christine	11/26/11	11/27/11	21.8	Control	13	1016.0	75
22	Dana Christine	11/26/11	11/27/11	22.9	Treatment	18	1534.7	70.5
23	Dana Christine	11/26/11	11/27/11	21.9	Treatment	13	1214.5	76
24	Dana Christine	11/26/11	11/27/11	22.5	Control	9	487.8	71
25	Traveler II	11/26/11	11/27/11	21.8	Control	12	810.9	66
26	Traveler II	11/26/11	11/27/11	32.9	Treatment	14	1644.4	72.5
27	Traveler II	11/26/11	11/27/11	23.7	Treatment	17	2243.5	68
28	Traveler II	11/26/11	11/27/11	27.2	Control	16	1850.3	69.5
29	Dana Christine	11/27/11	11/28/11	21.9	Treatment	15	104.5	74
30	Dana Christine	11/27/11	11/28/11	21.7	Control	6	370.1	65
31	Dana Christine	11/27/11	11/28/11	25	Control	16	1542.0	69.5
32	Dana Christine	11/27/11	11/28/11	22.5	Treatment	6	217.7	75
33	Traveler II	11/27/11	11/28/11	23.6	Control	15	1449.0	73
34	Traveler II	11/27/11	11/28/11	23	Treatment	5	170.1	89
35	Traveler II	11/27/11	11/28/11	21.6	Control	17	1842.6	75
36	Traveler II	11/27/11	11/28/11	23.7	Treatment	15	1251.7	70
37	Dana Christine	11/28/11	12/2/11	91.8	Control	45	11142.9	72
38	Dana Christine	11/28/11	12/2/11	93.5	Treatment	29	4313.8	73
39	Dana Christine	11/28/11	12/2/11	95.1	Treatment	15	1517.0	71
40	Dana Christine	11/28/11	12/2/11	97.4	Control	42	8304.8	70
41	Traveler II	11/28/11	12/2/11	82.6	Control	21	2695.2	69
42	Traveler II	11/28/11	12/2/11	95.8	Treatment	36	9142.9	70.5
43	Traveler II	11/28/11	12/2/11	96.2	Control	39	10523.8	70
44	Traveler II	11/28/11	12/2/11	95.9	Treatment	24	4767.3	70.5
45	Dana Christine	12/2/11	12/4/11	46	Treatment	7	279.4	75
46	Dana Christine	12/2/11	12/4/11	46.6	Control	14	730.2	72
47	Dana Christine	12/2/11	12/4/11	44.5	Treatment	5	146.3	69
48	Dana Christine	12/2/11	12/4/11	46.5	Control	23	3040.6	72
49	Traveler II	12/2/11	12/4/11	47.3	Control	12	876.2	67.5
50	Traveler II	12/2/11	12/4/11	47.5	Treatment	8	475.3	73
51	Traveler II	12/2/11	12/4/11	46.4	Control	19	2386.8	70
52	Traveler II	12/2/11	12/4/11	45.9	Treatment	10	734.7	74
53	Dana Christine	12/4/11	12/5/11	22.7	Treatment	5	189.3	78
54	Dana Christine	12/4/11	12/5/11	23.6	Control	2	15.4	65.5
55	Dana Christine	12/4/11	12/5/11	22.5	Control	2	40.8	68.5
56	Dana Christine	12/4/11	12/5/11	23	Treatment	0	0.0	NA
57	Traveler II	12/4/11	12/5/11	23.7	Control	5	208.6	73
58	Traveler II	12/4/11	12/5/11	22.2	Treatment	5	163.3	66
59	Traveler II	12/4/11	12/5/11	24.8	Treatment	6	166.0	67

Table 4 (continued): Catch information for monkfish (target species). Table includes kept fish only.

Haul	Vessel	Set Date	Haul Date	Soak Time (hours)	Gear	Monkfish Landed	Total Weight of Monkfish (kg)	Median Total Length (cm)
60	Traveler II	12/4/11	12/5/11	26	Control	4	42.2	69
61	Dana Christine	12/5/11	12/6/11	22.9	Treatment	7	290.5	68
62	Dana Christine	12/5/11	12/6/11	23.3	Control	0	0.0	NA
63	Dana Christine	12/5/11	12/6/11	22.8	Control	13	834.2	69
64	Dana Christine	12/5/11	12/6/11	23.7	Treatment	14	1507.9	72
65	Traveler II	12/5/11	12/6/11	22.6	Treatment	6	223.1	71.5
66	Traveler II	12/5/11	12/6/11	20.1	Control	4	154.2	73.5
67	Traveler II	12/5/11	12/6/11	24.9	Control	4	90.7	67
68	Traveler II	12/5/11	12/6/11	24.2	Treatment	7	251.7	74
69	Dana Christine	12/6/11	12/7/11	22	Control	8	288.4	67.5
70	Dana Christine	12/6/11	12/7/11	22.8	Treatment	5	185.9	74
71	Dana Christine	12/6/11	12/7/11	22.3	Control	12	955.1	73
72	Dana Christine	12/6/11	12/7/11	22.8	Treatment	3	65.3	85
73	Traveler II	12/6/11	12/7/11	22.5	Control	8	446.3	68
74	Traveler II	12/6/11	12/7/11	24.2	Treatment	0	0.0	NA
75	Traveler II	12/6/11	12/7/11	22.5	Treatment	6	190.5	70.5
76	Traveler II	12/6/11	12/7/11	23.9	Control	3	59.9	69
77	Dana Christine	12/7/11	12/9/11	46	Control	17	1534.2	73
78	Dana Christine	12/7/11	12/9/11	47.3	Treatment	17	1133.3	70
79	Dana Christine	12/7/11	12/9/11	44.2	Treatment	11	725.9	71
80	Dana Christine	12/7/11	12/9/11	43.2	Control	14	676.2	73
81	Traveler II	12/7/11	12/9/11	45.6	Treatment	7	393.7	72
82	Traveler II	12/7/11	12/9/11	47.1	Control	23	3390.0	73
83	Traveler II	12/7/11	12/9/11	46	Control	19	2455.8	73
84	Traveler II	12/7/11	12/9/11	47.9	Treatment	11	713.4	71
85	Traveler II	12/9/11	12/11/11	48.5	Treatment	9	506.1	70
86	Traveler II	12/9/11	12/11/11	47.6	Control	11	793.2	70
87	Traveler II	12/9/11	12/11/11	47.7	Treatment	14	1415.9	72
88	Traveler II	12/9/11	12/11/11	50.3	Control	12	995.9	70.5
89	Dana Christine	12/9/11	12/11/11	20.1	Treatment	19	2115.4	72
90	Dana Christine	12/9/11	12/11/11	21.3	Control	30	6966.0	79
91	Dana Christine	12/9/11	12/11/11	25.1	Treatment	8	495.2	76
92	Dana Christine	12/9/11	12/11/11	26	Control	19	1826.8	71
93	Dana Christine	12/11/11	12/12/11	21.9	Control	6	306.1	77.5
94	Dana Christine	12/11/11	12/12/11	22.5	Treatment	4	67.1	73
95	Dana Christine	12/11/11	12/12/11	21.6	Control	6	247.6	68
96	Dana Christine	12/11/11	12/12/11	22.4	Treatment	5	248.3	80
97	Traveler II	12/11/11	12/12/11	20.3	Control	7	298.4	69
98	Traveler II	12/11/11	12/12/11	21.3	Treatment	6	239.5	74.5
99	Traveler II	12/11/11	12/12/11	20.9	Control	5	197.3	74
100	Traveler II	12/11/11	12/12/11	25	Treatment	4	107.0	71
101	Traveler II	12/12/11	12/13/11	23.5	Control	2	37.2	73.5
102	Traveler II	12/12/11	12/13/11	20.3	Treatment	4	99.8	71
103	Traveler II	12/12/11	12/13/11	23.7	Control	3	65.3	70
104	Traveler II	12/12/11	12/13/11	25.2	Treatment	2	28.1	77.5
105	Dana Christine	12/12/11	12/13/11	22.4	Control	5	111.1	65
106	Dana Christine	12/12/11	12/13/11	23.5	Treatment	1	10.2	85
107	Dana Christine	12/12/11	12/13/11	22.3	Control	5	196.1	75
108	Dana Christine	12/12/11	12/13/11	23.5	Treatment	3	56.5	67
109	Dana Christine	12/13/11	12/14/11	22.4	Control	10	532.9	70.5
110	Dana Christine	12/13/11	12/14/11	23.4	Treatment	6	231.3	75
111	Dana Christine	12/13/11	12/14/11	22.1	Treatment	3	54.4	75
112	Dana Christine	12/13/11	12/14/11	22.8	Control	13	1241.0	75
113	Traveler II	12/13/11	12/14/11	23.7	Control	4	85.3	66.5
114	Traveler II	12/13/11	12/14/11	23.8	Treatment	8	413.6	72
115	Traveler II	12/13/11	12/14/11	22.9	Treatment	6	291.2	79
116	Traveler II	12/13/11	12/14/11	24.6	Control	1	89.8	62
117	Traveler II	12/14/11	12/17/11	57.7	Treatment	12	903.4	68
118	Traveler II	12/14/11	12/17/11	58.1	Control	8	410.0	69
119	Traveler II	12/14/11	12/17/11	73.8	Control	2	28.1	74
120	Traveler II	12/14/11	12/17/11	62.1	Treatment	6	326.5	71.5

Table 5: Catch information for winter skate and spiny dogfish (target species). Missing values represent no landings or that a variable was not recorded on the vessel.

Haul Numbers	Vessel	Geat Type	Set Date	Haul Date	Soak Time (hour)	Winter Skate Weight (kg)	Winter Skate Mean Length (cm)	Spiny Dogfish Weight (kg)	Spiny Dogfish Mean Length (cm)
1	Dana Christine	Control 2	11/22/2011	11/22/2011	5.4	433	80		
2	Dana Christine	Treatment 2	11/22/2011	11/22/2011	6.6	410	80	11	87
3	Dana Christine	Control 2	11/22/2011	11/22/2011	6.1	210	81		
4	Dana Christine	Treatment 2	11/22/2011	11/22/2011	6.8	221	83		
5	Traveler II	Treatment 2	11/24/2011	11/25/2011	20.1	259	83		
6	Traveler II	Control 2	11/24/2011	11/25/2011	21.1	231	82	5	
7	Traveler II	Treatment 2	11/24/2011	11/25/2011	22	188	82		
8	Traveler II	Control 2	11/24/2011	11/25/2011	22.8	304	81	2	
9	Dana Christine	Treatment 2	11/24/2011	11/25/2011	20.1	201	84		
10	Dana Christine	Control 2	11/24/2011	11/25/2011	21	398	81	15	
11	Dana Christine	Treatment 2	11/24/2011	11/25/2011	22.8	260	80		
12	Dana Christine	Control 2	11/24/2011	11/25/2011	22.9	349	82		
13	Dana Christine	Control 2	11/25/2011	11/26/2011	22.1	319	80	17	88
14	Dana Christine	Treatment 2	11/25/2011	11/26/2011	22.3	209	82		86
15	Dana Christine	Control 2	11/25/2011	11/26/2011	21.7	153	82	9	87
16	Dana Christine	Treatment 2	11/25/2011	11/26/2011	22.6	227	82	8	84
17	Traveler II	Control 2	11/25/2011	11/26/2011	21.8	278	83	5	
18	Traveler II	Treatment 2	11/25/2011	11/26/2011	21.8	266	83		
19	Traveler II	Control 2	11/25/2011	11/26/2011	22.5	218	80		
20	Traveler II	Treatment 2	11/25/2011	11/26/2011	26.3	237	81		
21	Dana Christine	Control 2	11/26/2011	11/27/2011	21.8	159	84	23	90
22	Dana Christine	Treatment 2	11/26/2011	11/27/2011	22.9	87	82		
23	Dana Christine	Treatment 2	11/26/2011	11/27/2011	21.9	99	83	3	76
24	Dana Christine	Control 2	11/26/2011	11/27/2011	22.5	59	85	13	89
25	Traveler II	Control 2	11/26/2011	11/27/2011	21.8	171	82	5	
26	Traveler II	Treatment 2	11/26/2011	11/27/2011	32.9	160	84		
27	Traveler II	Treatment 2	11/26/2011	11/27/2011	23.7	118	83	5	
28	Traveler II	Control 2	11/26/2011	11/27/2011	27.2	127	85		
29	Dana Christine	Treatment 2	11/27/2011	11/28/2011	21.9	29	86		
30	Dana Christine	Control 2	11/27/2011	11/28/2011	21.7	74	87	6	93
31	Dana Christine	Control 2	11/27/2011	11/28/2011	25	115	85	9	87
32	Dana Christine	Treatment 2	11/27/2011	11/28/2011	22.5	73	81	8	87
33	Traveler II	Control 2	11/27/2011	11/28/2011	23.6	100	82	13	74
34	Traveler II	Treatment 2	11/27/2011	11/28/2011	23	75	86	2	73
35	Traveler II	Control 2	11/27/2011	11/28/2011	21.6	71	84	2	76
36	Traveler II	Treatment 2	11/27/2011	11/28/2011	23.7	43	81	6	84
37	Dana Christine	Control 2	11/28/2011	12/2/2011	91.8	389	82	196	88
38	Dana Christine	Treatment 2	11/28/2011	12/2/2011	93.5	338	83	16	88
39	Dana Christine	Treatment 2	11/28/2011	12/2/2011	95.1	348	84	10	86
40	Dana Christine	Control 2	11/28/2011	12/2/2011	97.4	336	86	34	86
41	Traveler II	Control 2	11/28/2011	12/2/2011	82.6	413	85	11	
42	Traveler II	Treatment 2	11/28/2011	12/2/2011	95.8	257	85		
43	Traveler II	Control 2	11/28/2011	12/2/2011	96.2	331	81		
44	Traveler II	Treatment 2	11/28/2011	12/2/2011	95.9	343	83	7	
45	Dana Christine	Treatment 2	12/2/2011	12/4/2011	46	145	82	10	86
46	Dana Christine	Control 2	12/2/2011	12/4/2011	46.6	164	84	22	87
47	Dana Christine	Treatment 2	12/2/2011	12/4/2011	44.5	257	84	5	87
48	Dana Christine	Control 2	12/2/2011	12/4/2011	46.5	350	84	11	84
49	Traveler II	Control 2	12/2/2011	12/4/2011	47.3	166	82	24	80
50	Traveler II	Treatment 2	12/2/2011	12/4/2011	47.5	103	82	5	75
51	Traveler II	Control 2	12/2/2011	12/4/2011	46.4	116	83	14	76
52	Traveler II	Treatment 2	12/2/2011	12/4/2011	45.9	59	81	9	75
53	Dana Christine	Treatment 2	12/4/2011	12/5/2011	22.7	71	83	2	84
54	Dana Christine	Control 2	12/4/2011	12/5/2011	23.6	56	81	41	86
55	Dana Christine	Control 2	12/4/2011	12/5/2011	22.5	180	83	29	85
56	Dana Christine	Treatment 2	12/4/2011	12/5/2011	23	43	84	1	
57	Traveler II	Control 2	12/4/2011	12/5/2011	23.7	78	81	16	77
58	Traveler II	Treatment 2	12/4/2011	12/5/2011	22.2	62	84	5	76

Table 5 (continued): Catch information for winter skate and spiny dogfish (target species). Missing values represent no landings or that a variable was not recorded on the vessel.

Haul Numbers	Vessel	Geat Type	Set Date	Haul Date	Soak Time (hour)	Winter Skate Weight (kg)	Winter Skate Mean Length (cm)	Spiny Dogfish Weight (kg)	Spiny Dogfish Mean Length (cm)
59	Traveler II	Treatment 2	12/4/2011	12/5/2011	24.8	56	84		
60	Traveler II	Control 2	12/4/2011	12/5/2011	26	81	85	26	76
61	Dana Christine	Treatment 2	12/5/2011	12/6/2011	22.9	62	81	5	87
62	Dana Christine	Control 2	12/5/2011	12/6/2011	23.3	73	78	14	85
63	Dana Christine	Control 2	12/5/2011	12/6/2011	22.8	100	83	35	87
64	Dana Christine	Treatment 2	12/5/2011	12/6/2011	23.7	30	83	4	79
65	Traveler II	Treatment 2	12/5/2011	12/6/2011	22.6	22	84	5	72
66	Traveler II	Control 2	12/5/2011	12/6/2011	20.1	79	82	22	78
67	Traveler II	Control 2	12/5/2011	12/6/2011	24.9	80	79	47	77
68	Traveler II	Treatment 2	12/5/2011	12/6/2011	24.2	61	83		
69	Dana Christine	Control 2	12/6/2011	12/7/2011	22	111	85	23	86
70	Dana Christine	Treatment 2	12/6/2011	12/7/2011	22.8	53	84	7	86
71	Dana Christine	Control 2	12/6/2011	12/7/2011	22.3	113	85	6	92
72	Dana Christine	Treatment 2	12/6/2011	12/7/2011	22.8	22	83	5	84
73	Traveler II	Control 2	12/6/2011	12/7/2011	22.5	125	84	2	77
74	Traveler II	Treatment 2	12/6/2011	12/7/2011	24.2	94	82	2	74
75	Traveler II	Treatment 2	12/6/2011	12/7/2011	22.5	128	85	3	71
76	Traveler II	Control 2	12/6/2011	12/7/2011	23.9	148	85	9	77
77	Dana Christine	Control 2	12/7/2011	12/9/2011	46	255	76	21	85
78	Dana Christine	Treatment 2	12/7/2011	12/9/2011	47.3	212	83	6	90
79	Dana Christine	Treatment 2	12/7/2011	12/9/2011	44.2	129	84	13	89
80	Dana Christine	Control 2	12/7/2011	12/9/2011	43.2	134	83	8	87
81	Traveler II	Treatment 2	12/7/2011	12/9/2011	45.6	216	82	5	75
82	Traveler II	Control 2	12/7/2011	12/9/2011	47.1	278	82	10	79
83	Traveler II	Control 2	12/7/2011	12/9/2011	46	408	79	20	75
84	Traveler II	Treatment 2	12/7/2011	12/9/2011	47.9	204	80	6	74
85	Traveler II	Treatment 2	12/9/2011	12/11/2011	48.5	99	82	7	
86	Traveler II	Control 2	12/9/2011	12/11/2011	47.6	269	81	14	
87	Traveler II	Treatment 2	12/9/2011	12/11/2011	47.7	195	81		
88	Traveler II	Control 2	12/9/2011	12/11/2011	50.3	205	85	16	
89	Dana Christine	Treatment 2	12/9/2011	12/11/2011	20.1	196	82	11	86
90	Dana Christine	Control 2	12/9/2011	12/11/2011	21.3	460	83	27	87
91	Dana Christine	Treatment 2	12/9/2011	12/11/2011	25.1	103	82	5	82
92	Dana Christine	Control 2	12/9/2011	12/11/2011	26	187	80	6	87
93	Dana Christine	Control 2	12/11/2011	12/12/2011	21.9	177	82	10	87
94	Dana Christine	Treatment 2	12/11/2011	12/12/2011	22.5	139	85	4	100
95	Dana Christine	Control 2	12/11/2011	12/12/2011	21.6	345	82	6	89
96	Dana Christine	Treatment 2	12/11/2011	12/12/2011	22.4	251	81		
97	Traveler II	Control 2	12/11/2011	12/12/2011	20.3	259	79		
98	Traveler II	Treatment 2	12/11/2011	12/12/2011	21.3	204	81		
99	Traveler II	Control 2	12/11/2011	12/12/2011	20.9	236	79	7	59
100	Traveler II	Treatment 2	12/11/2011	12/12/2011	25	327	78		
101	Traveler II	Control 2	12/12/2011	12/13/2011	23.5	29	76	7	80
102	Traveler II	Treatment 2	12/12/2011	12/13/2011	20.3	149	79		
103	Traveler II	Control 2	12/12/2011	12/13/2011	23.7	81	78	7	78
104	Traveler II	Treatment 2	12/12/2011	12/13/2011	25.2	66	82		
105	Dana Christine	Control 2	12/12/2011	12/13/2011	22.4	108	81	23	88
106	Dana Christine	Treatment 2	12/12/2011	12/13/2011	23.5	83	83	9	81
107	Dana Christine	Control 2	12/12/2011	12/13/2011	22.3	111	82	13	91
108	Dana Christine	Treatment 2	12/12/2011	12/13/2011	23.5	46	81	2	84
109	Dana Christine	Control 2	12/13/2011	12/14/2011	22.4	68	82	6	85
110	Dana Christine	Treatment 2	12/13/2011	12/14/2011	23.4	64	85	2	82
111	Dana Christine	Treatment 2	12/13/2011	12/14/2011	22.1	76	82	7	88
112	Dana Christine	Control 2	12/13/2011	12/14/2011	22.8	141	84	9	88
113	Traveler II	Control 2	12/13/2011	12/14/2011	23.7	133	80	2	68
114	Traveler II	Treatment 2	12/13/2011	12/14/2011	23.8	93	79	4	82
115	Traveler II	Treatment 2	12/13/2011	12/14/2011	22.9	78	80		
116	Traveler II	Control 2	12/13/2011	12/14/2011	24.6	94	80	17	75
117	Traveler II	Treatment 2	12/14/2011	12/17/2011	57.7	551	79	5	
118	Traveler II	Control 2	12/14/2011	12/17/2011	58.1	299	80		
119	Traveler II	Control 2	12/14/2011	12/17/2011	73.8	388	78	6	
120	Traveler II	Treatment 2	12/14/2011	12/17/2011	62.1	540	81	3	

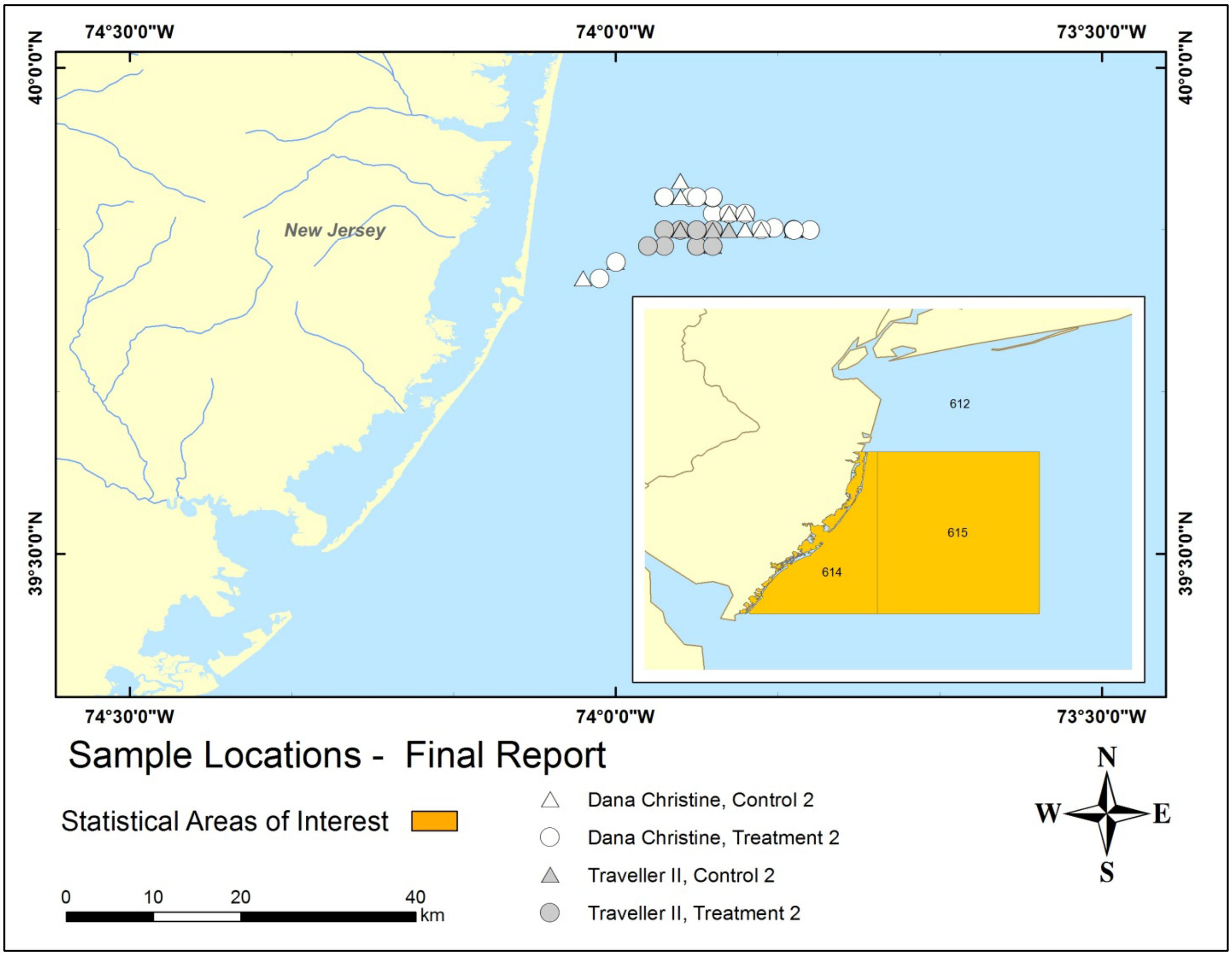


Figure 1: Location of gillnet sampling areas within NMFS Statistical Area 614 and 615 (inset) plotted by net type (triangle= control, circles = treatment) and vessel (white symbols = F.V. Dana Christine, gray symbols = F/V Traveller II).

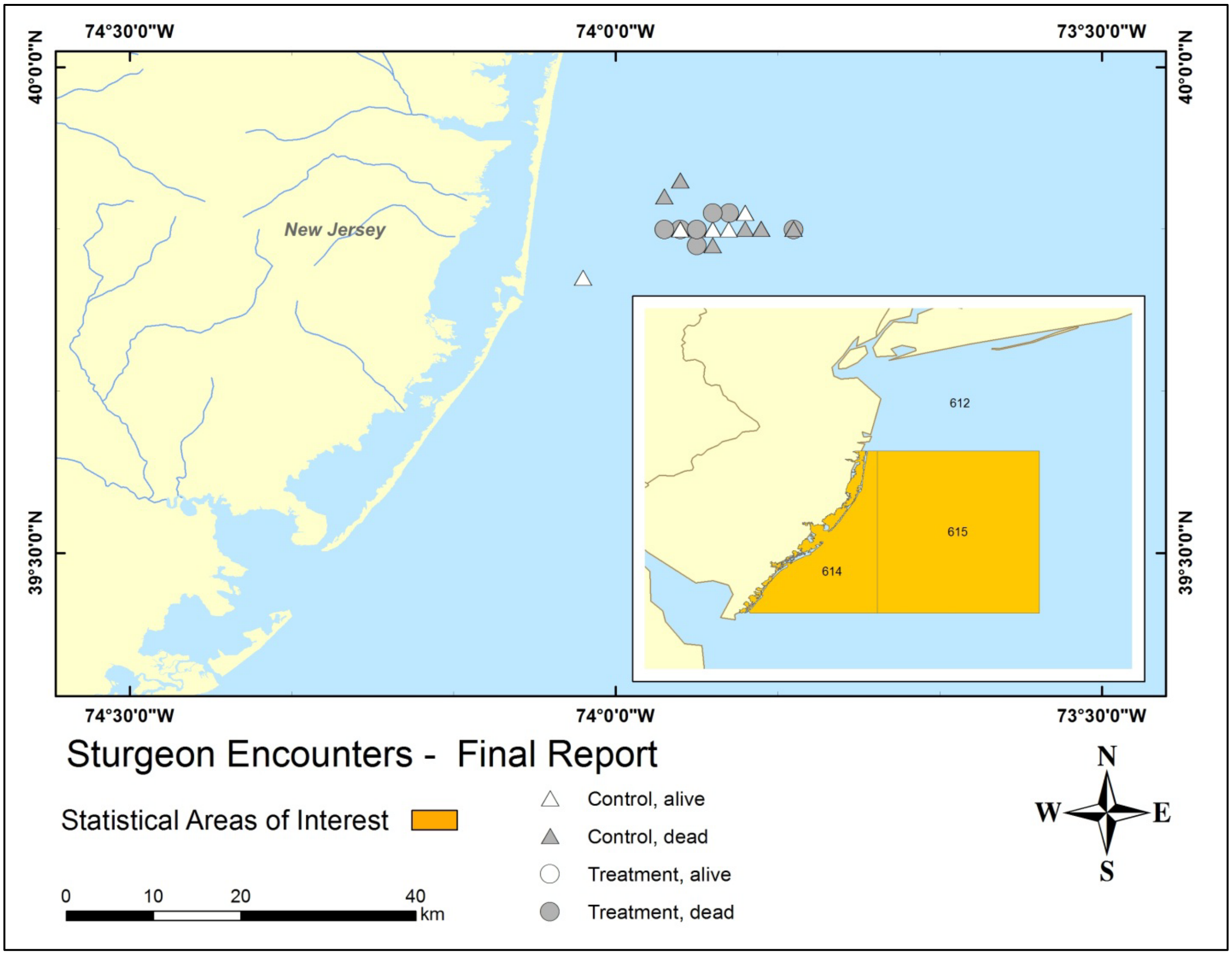


Figure 2: Location of Atlantic sturgeon encounters by mortality status (alive = white symbols; dead= gray symbols) and gear type (control = triangles; treatment= circles) within NMFS Statistical Areas 614 and 615 during the 2011 field season.

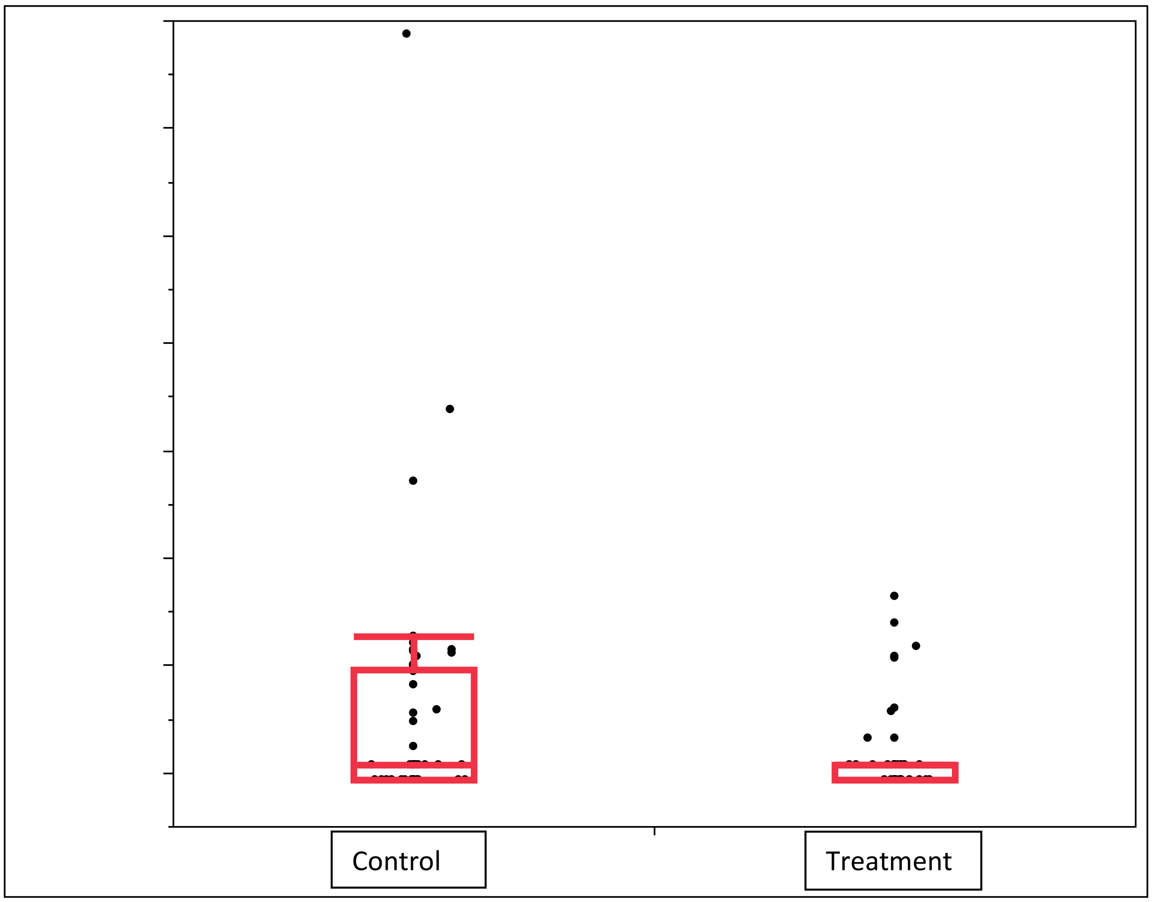


Figure 3: Atlantic sturgeon capture rates by gear type for the 2011 sampling season. Box plots represent median with 25th and 75th percentiles.

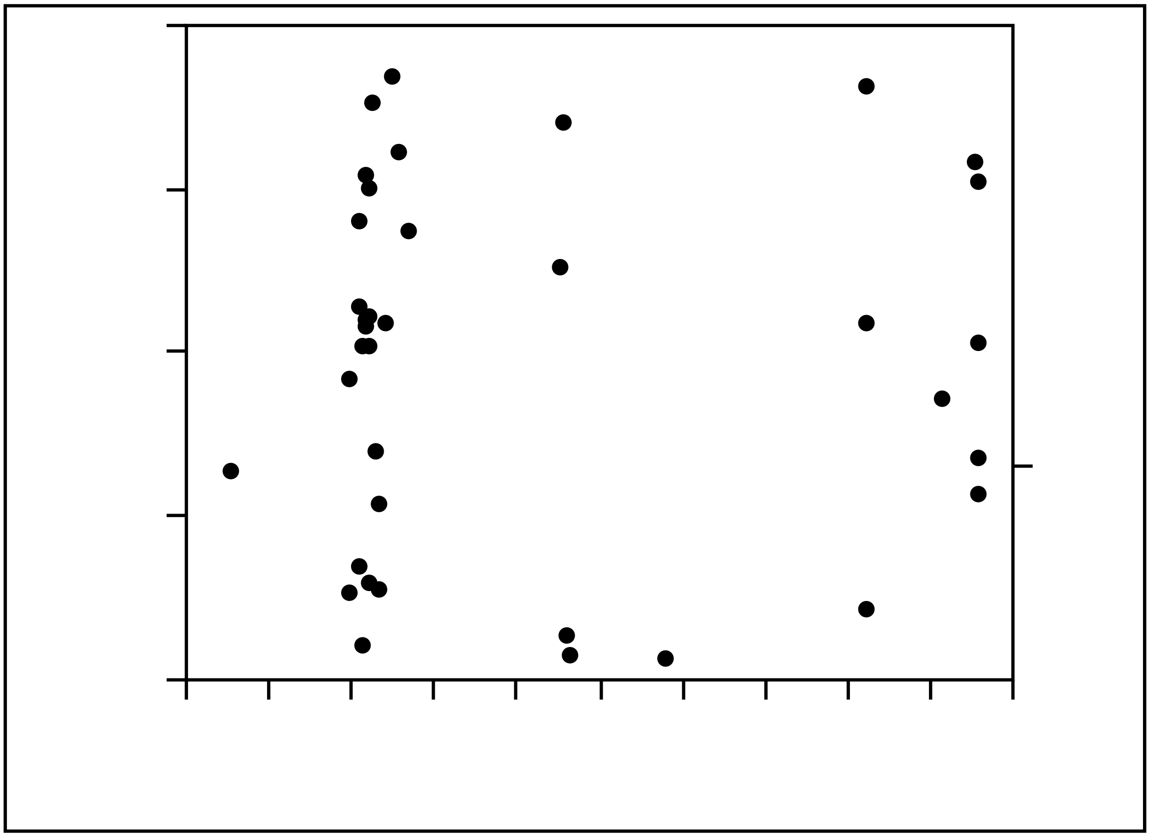
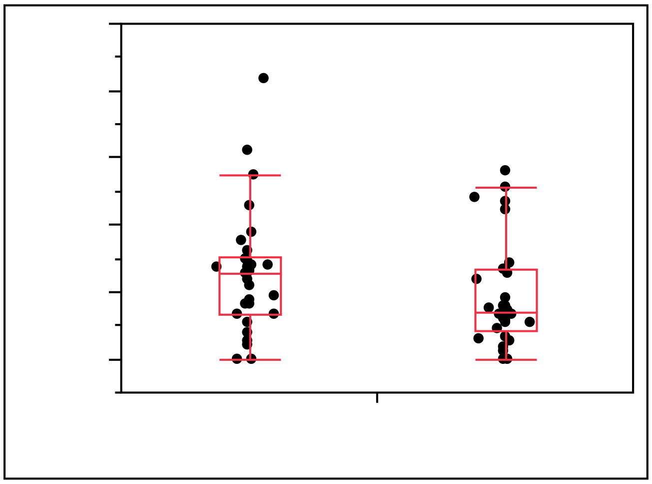
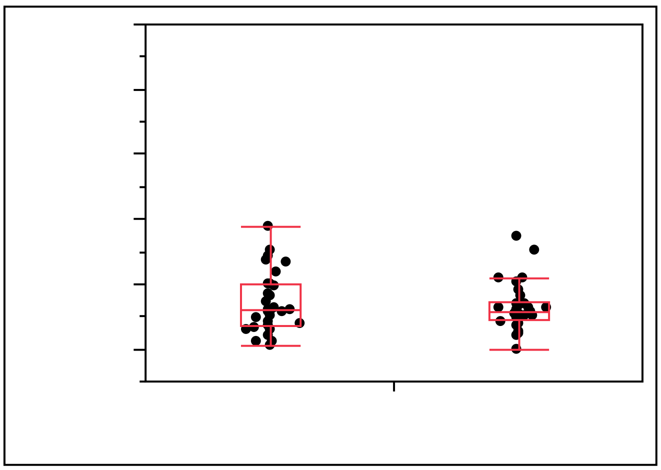


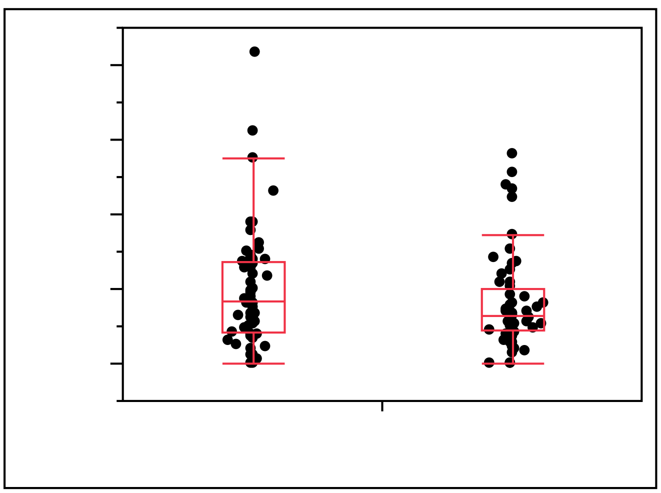
Figure 4: Results of logistic regression fit of Atlantic sturgeon status (alive vs. dead) by soak time for gillnet encounters. Points plotted above the solid line represent Atlantic sturgeon dead at the time of the encounter. At each soak time value, the probability scale for Atlantic sturgeon status is partitioned into probabilities for live/dead categories. The probabilities are measured as the vertical distance between the curves (Total Y = 1.0).



Panel A



Panel B



Panel C

Figure 5: Monkfish catch rates by gear type for the 2011 sampling season. Box plots represent median with 25th and 75th percentiles. Panel A represents F/V Dana Christine, Panel B represents F/V Traveller II, and Panel C represents combined landings (note change in Y axis).

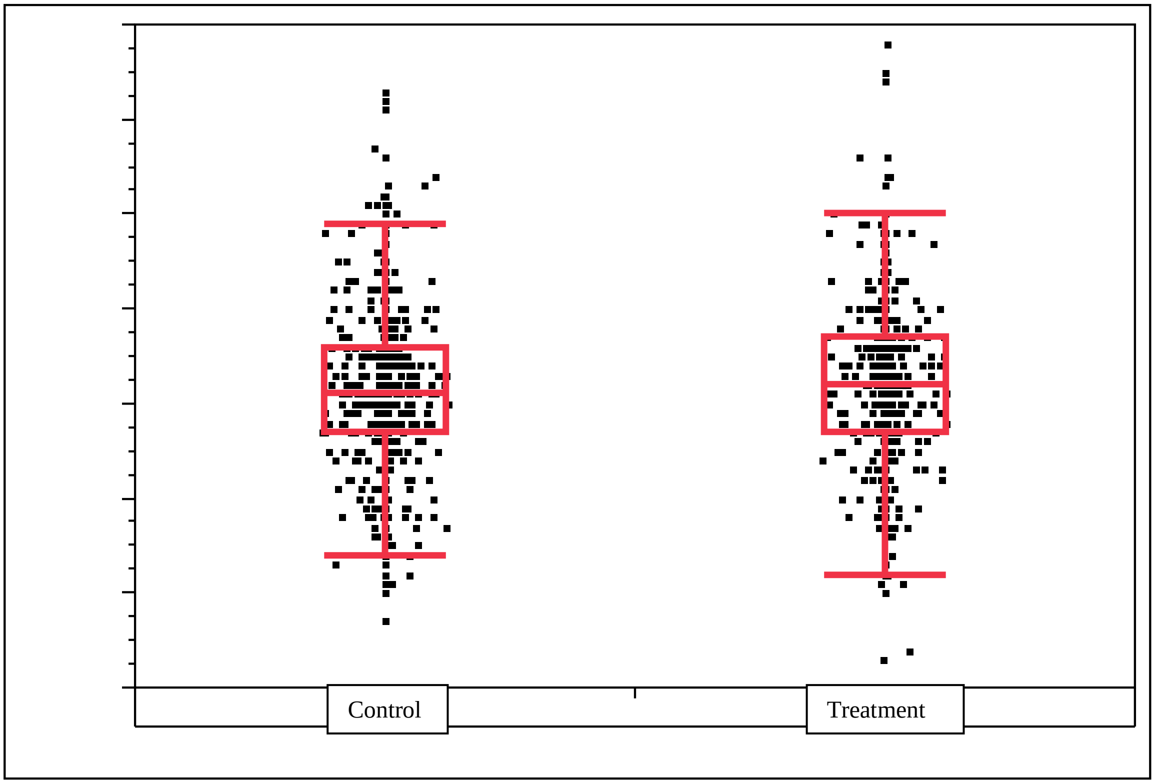


Figure 6: Length (cm) of monkfish landed by gillnet configuration. Box plots represent median and 25-75th quartiles.

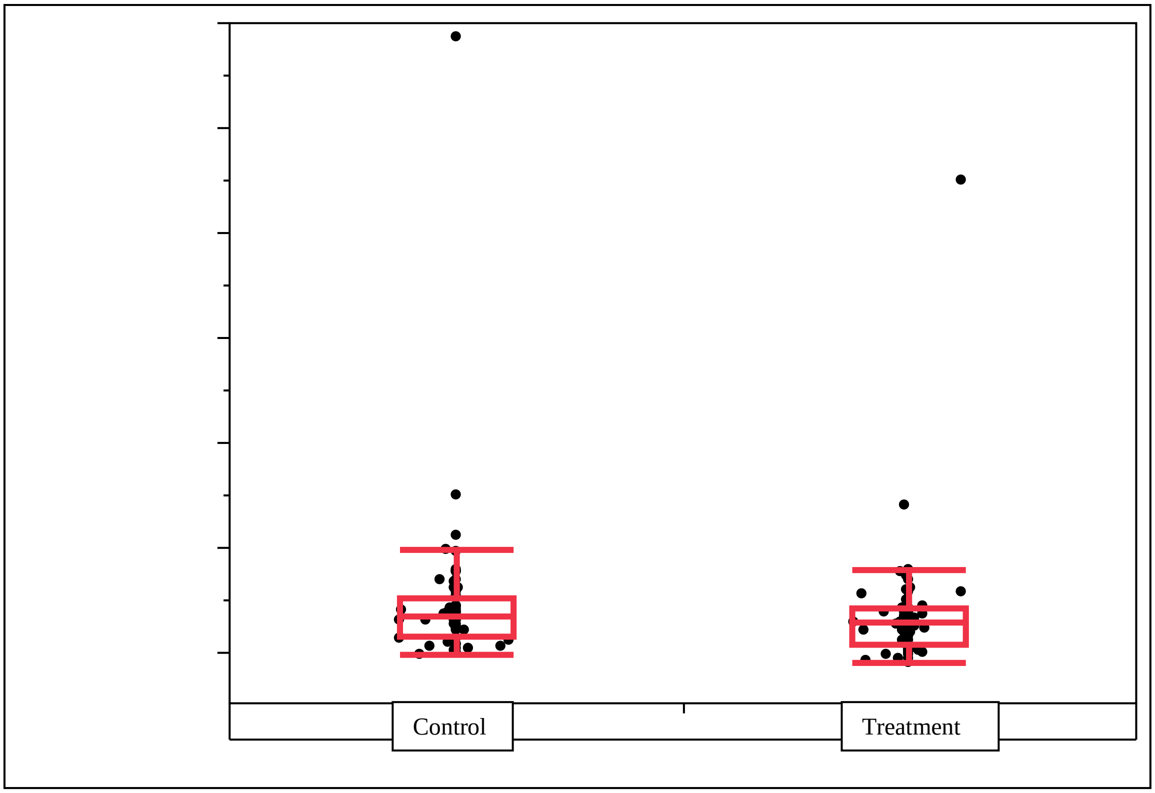


Figure 7: Winter skate catch rates by gear type for the 2011 sampling season. Box plots represent median with 25th and 75th percentiles.

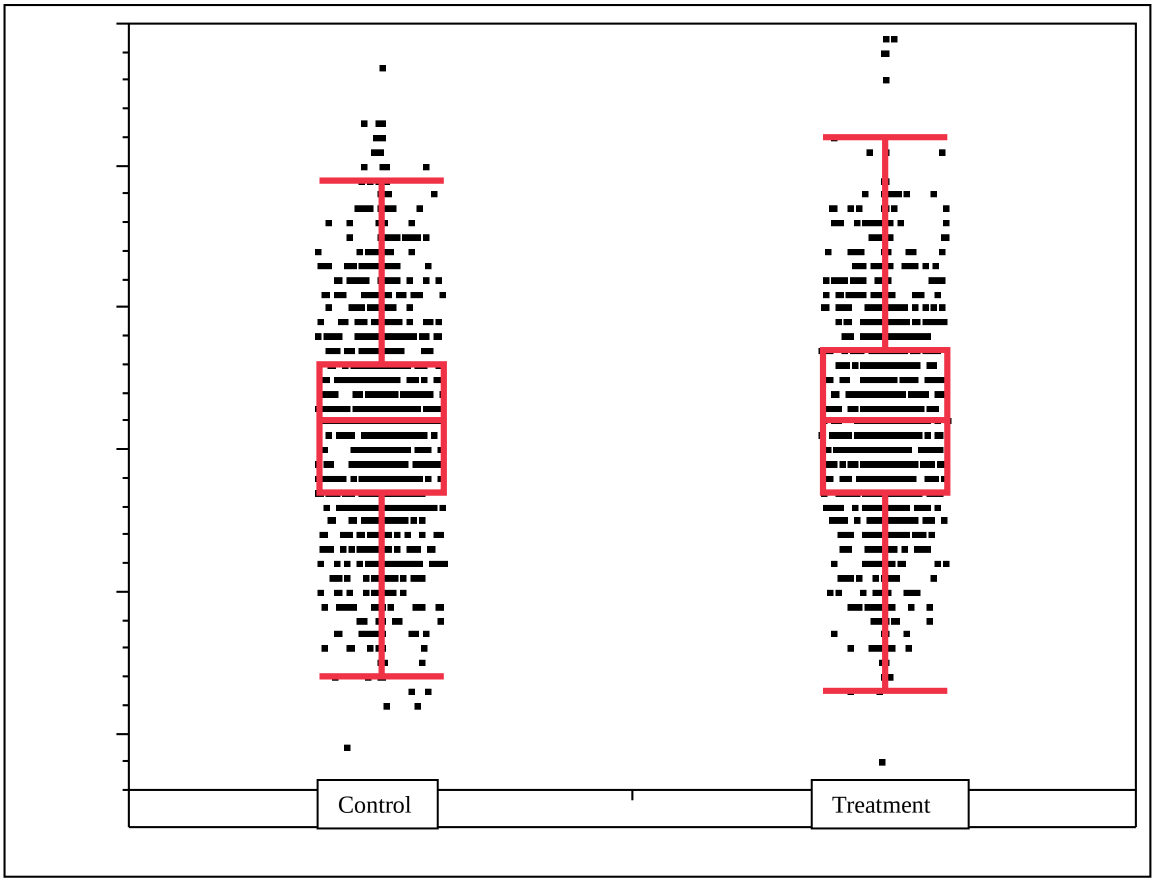


Figure 8: Width (cm) of winter skate landed by gillnet configuration. Box plots represent median and 25-75th quartiles.

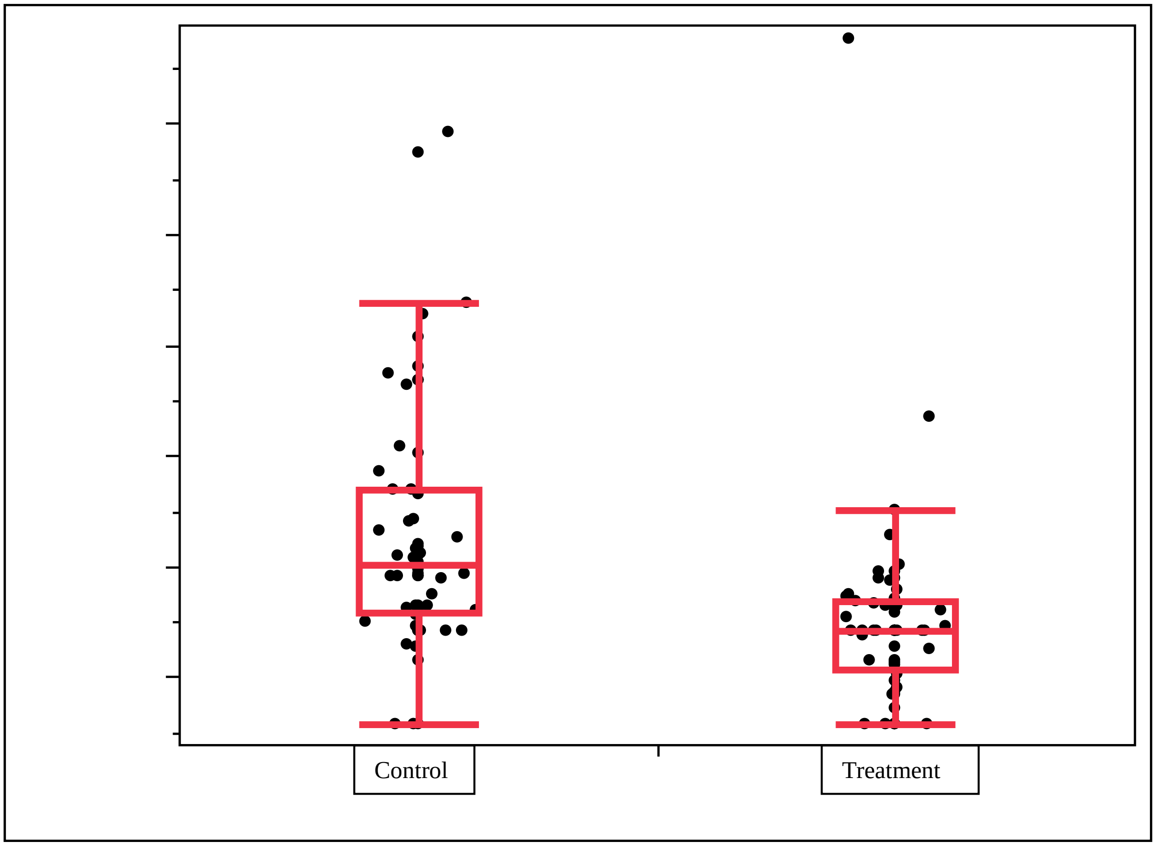


Figure 9: Spiny dogfish catch rates by gear type for the 2011 sampling season. Box plots represent median with 25th and 75th percentiles.

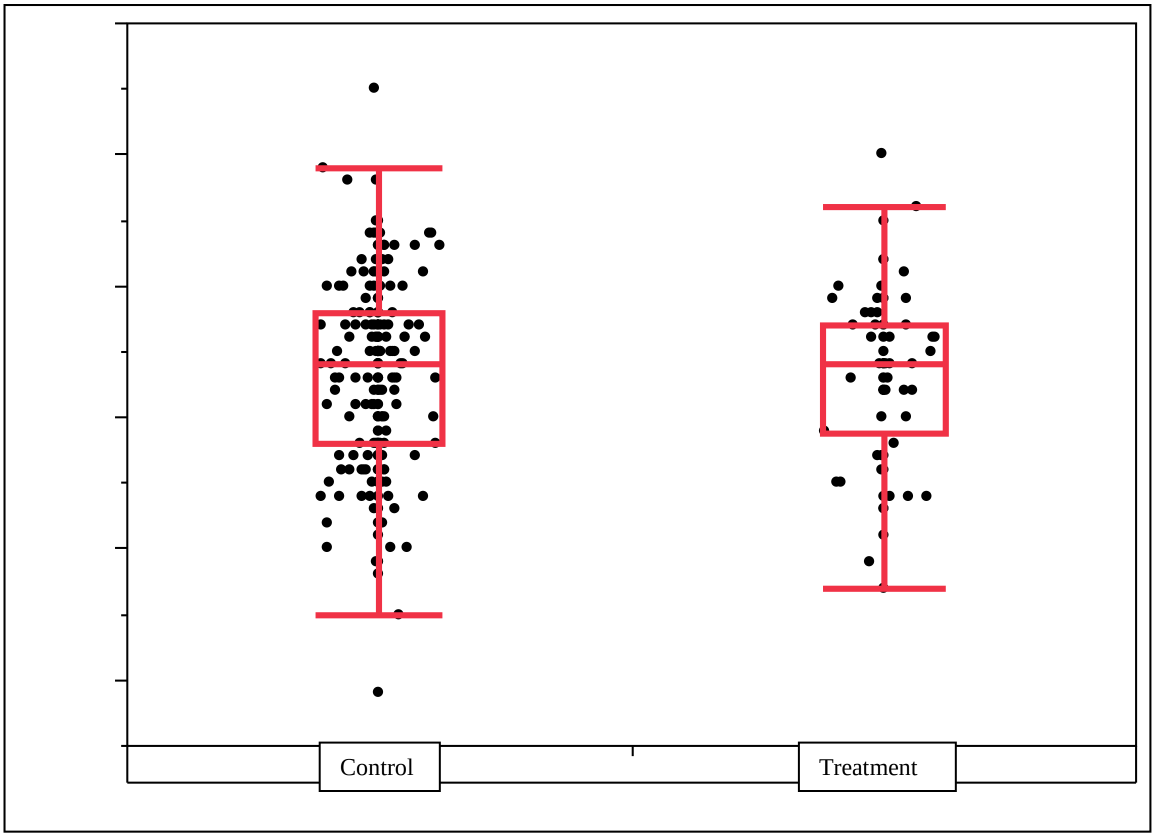


Figure 10: Length (cm) of spiny dogfish landed by gillnet configuration. Box plots represent median and 25-75th quartiles.

Final Report

GILLNET CONFIGURATIONS AND THEIR IMPACT ON ATLANTIC STURGEON AND MARINE MAMMAL BYCATCH IN THE NEW JERSEY MONKFISH FISHERY: YEAR 1

December 19, 2011

D. A. Fox, K. Wark, J. L. Armstrong, L. M. Brown

Report submitted in partial fulfillment of
NOAA NMFS Contract Number: (number EA133F-10-RQ-1160)

Recipient Name: Endeavor Fisheries Inc.

Summary

Monkfish (*Lophius americanus*) support a lucrative fishery primarily centered in the waters of the mid-Atlantic and northeast US. Monkfish are targeted primarily through trawls and sink-gillnets. Overharvest coupled with habitat loss and alteration led to a decline of Atlantic sturgeon *(Acipenser oxyrinchus oxyrinchus)* in the early 1900s. Atlantic sturgeon is currently being considered for listing under the Endangered Species Act. A formal status review concluded that bycatch in otter trawls and sink-gillnets including those used in the monkfish fishery are a significant hurdle to Atlantic sturgeon conservation and recovery. The manner in which gillnets are fished including the use of tie-downs, as well as long soak durations, is believed to be influencing how Atlantic sturgeon interactions. Additionally, tie-downs on large mesh (17.8-45.7 cm) gillnet gear are seasonally required in the mid-Atlantic region under the Harbor Porpoise Take Reduction Plan (HPTRP) as one component within a suite of gear modifications designed to reduce interactions between harbor porpoises and commercial gillnet gear in this area.

In an attempt to provide resource managers information on the influence of tie-downs employed in the monkfish fishery on Atlantic sturgeon and marine mammal bycatch we employed two gillnet configurations (control: 12 meshes x 30.5cm stretch mesh with four mesh tie-downs, experimental: 12 meshes x 30.5cm stretch mesh without tie-downs) in an experiment off northern New Jersey during November and December of 2010. Cooperating monkfish harvesters fished paired replicates of each gillnet configuration totaling 120 hauls in accordance to normal monkfish fishing operations. Atlantic sturgeon bycatch (CPUE) did not differ significantly (p=.1158) between gillnet configurations, likely due to relatively low statistical power (.1708) in the current study. The experimental nets (without tie-downs) significantly

decreased ($p<.0001$) landings of the target species, monkfish and resulted in a number of marine mammal (e.g. common dolphin (*Delphinus delphis*)) mortalities, which were not encountered in tied-down nets. Our findings provide much needed information to managers on the role that net configuration plays in targeted landings and bycatch of Atlantic sturgeon and marine mammals in the sink-gillnet monkfish fishery. Although there was no significant difference in Atlantic sturgeon encounter rates for experimental nets, they did result in significantly lower catch rates of targeted species and unacceptable levels of marine mammal mortalities. However, due to the low statistical power, additional control and experimental hauls need be observed in the future to provide a confident conclusion.

Background

In the late 1800s Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) became the target of fisheries primarily focused on spawning adults in all large river systems along the Atlantic Coast (Ryder 1890). This fishery originated in the Delaware River which historically supported the largest Atlantic sturgeon population (Secor and Waldman 1999) and rapidly expanded to other river systems in the mid-Atlantic Bight before collapsing after just over a decade of high fishing effort (Cobb 1900). Following almost a century most noted by the lack of recovery in Atlantic sturgeon populations, the Atlantic States Marine Fisheries Commission (ASMFC) produced a Fishery Management Plan (FMP) for Atlantic sturgeon with a goal of restoring a sustainable fishery throughout its range (ASMFC 1998). At the same time, a coast-wide ban on harvest in state waters was implemented and followed shortly by a National Marine Fisheries Service (NMFS) ban in federal waters. In 2005, the NMFS established a status review team consisting of NMFS, FWS, and U.S. Geological Survey (USGS) scientists. The team completed their status review of Atlantic sturgeon and released their recommendations in February 2007. The review team recommended that three of the five distinct population segments (DPS)s of Atlantic sturgeon be listed as threatened under the ESA, including the New York Bight and Chesapeake Bay DPSs (ASSRT 2007). On October 6, 2010, NMFS published notice in the Federal Register proposing to list four of the Atlantic sturgeon DPSs, including the New York Bight and Chesapeake Bay DPSs, as endangered, and the Gulf of Maine DPS as threatened (75 FR 61872 and 75 FR 61904). A final listing determination for each DPS is due in the fall of 2011.

Atlantic sturgeons are anadromous and spend a large proportion of their life in the marine environment. In both the status review and FMP documents there are calls for more directed research on the marine phase of Atlantic sturgeon life history which has been underrepresented in the scientific literature (Stein et al. 2004a). The lack of information for management causes problems for fisheries professionals working within the confines of state jurisdictional boundaries, and is especially problematic for Atlantic sturgeon as they are known to suffer from interactions with coastal marine fisheries (Stein et al. 2004b, ASMFC 2007).

Harbor porpoise (*Phocoena phocoena*) co-occur with Atlantic sturgeon in marine and estuarine waters and are a protected species under the Marine Mammal Protection Act (MMPA). Due to high rates of incidental take in commercial fisheries, NMFS was required to reduce the number of harbor porpoise deaths in accordance with the MMPA. NMFS convened a group of federal, state, academic, and industry representatives and developed the Harbor Porpoise Take Reduction Plan (HPTRP), which was implemented in December 1998. The HPTRP mandates spatial and temporal modifications to commercial gillnets in the Gulf of Maine, southern New England, and the mid-Atlantic during periods of time when harvesters are likely to encounter harbor porpoises. One such modification required in the mid-Atlantic gillnet fishery is the use of tie-downs in the large mesh (17.8-63.7 cm stretch mesh) gillnet fishery in an attempt to lower the net profile thus decreasing the probability of harbor porpoise entanglement.

Monkfish (*Lophius americanus*) support a lucrative commercial fishery primarily centered in the waters of the mid-Atlantic and northeast US. Monkfish are targeted primarily through trawls in the northern management area and sink-gillnets in the mid-Atlantic. Sink gillnets, which include the monkfish fishery have been identified as a source of bycatch mortality for Atlantic sturgeon during their marine phase of their life history (Stein et al. 2004b, ASMFC 2007). As such, it is believed that changes in fishing practices in the monkfish fishery may have the potential to decrease the overall bycatch of Atlantic sturgeon. Unfortunately, data on the influence of monkfish specific practices (e.g. tie-downs) on Atlantic sturgeon bycatch are lacking resulting in the need for field studies to examine the influence of gillnet configuration on sturgeon bycatch.

Objectives

As outlined in the contract solicitation the objectives of our study were as follows 1) compare the bycatch rates of Atlantic sturgeon encountered in both control and experimental gillnets in NMFS Statistical Area 612, 2)[1] interrogate the NEFOP data to examine the effects of tie-downs on harbor porpoise bycatch, 3) compare the catch rates of the target species (monkfish) in each gillnet configuration, and 4) record the bycatch of other NMFS regulated or protected species.

Methods

Field Studies: The recent ASMFC (ASMFC 2007) report on bycatch of Atlantic sturgeon in coastal commercial fisheries of New England and the mid-Atlantic identified the

[1] This work was provided and is available in a separate report upon request.

NMFS Statistical Area 612 as a region which supports robust landings of monkfish that has been identified as a potential problem area for Atlantic sturgeon bycatch (Stein et al. 2004, ASMFC 2007). Through cooperative agreements with participating commercial harvesters, we examined catch rates of targeted species (e.g. monkfish) and bycatch of Atlantic sturgeon for two gillnet configurations. We utilized NMFS supplied gillnets which were 91.4m in length and consisted of 12 meshes x 30.5 cm stretch mesh with four mesh tie-downs (control) and 12 meshes x 30.5cm stretch mesh without tie-downs (experimental). Panels were constructed using Chatham green webbing (0.90mm) with a 0.50 hanging ratio, 9.5 mm poly float line with five 463.6 kg weak links per panel spliced into a 7.9 mm float line, and a 34.1 kg leadline (34.1kg/182.8m spool). If required, tie-downs were placed every 7.3m. In total, each vessel deployed 40 panels of gillnet configured in 10 panel strings (914m). Each string was comprised of either tie-downs present (control) or tie-downs absent (treatment) strings. Cooperating monkfish harvesters fished the strings of gillnets as paired replicates, where the pair was set of both the control and treatment gillnets strings set in a similar location, at a similar depth, and for a similar amount of time. A total of 120 hauls with the control and treatment net strings randomly selected at the start of the study was completed. A copy of the haul schedule was kept on board each vessel and confirmed by the vessel master and NMFS trained observer.

Monkfish harvesters employed normal gillnetting operations with soak times dependent upon fishing and weather conditions. Sampling operations were initiated in mid-November and ran through mid-December, thus the probability of encountering other protected resources (e.g. harbor porpoises and sea turtles) were thought to be low while the possibility of encountering migrating Atlantic sturgeon still existed. During periods of poor weather and/or poor fishing (i.e. low catch rates) harvesters could opt to leave their nets soaking for longer periods. Harvesters may also reduce soak times because of external factors including high catch rates or concerns over large amounts of bycatch or increased processing times when winter skate (*Leucoraja ocellata*) are encountered. In the event of snags or tears gillnet panels were either replaced entirely or repaired on site.

The harvesters were also allowed freedom to sample in regions of Statistical Area 612 that have historically supported the monkfish fishery. Captain Kevin Wark (F.V. Dana Christine) fished primarily inshore waters (depth range 20-40m) in an area that supported large monkfish landings as recent as 2008. Captain Wark selected these inshore waters not to maximize monkfish encounters as information gained from the fishing fleet suggested this area supporting a large biomass of winter skate. Instead, Captain Wark selected these inshore waters as he thought the probability of fishing in deeper waters, where the 2010 monkfish fishery in Area 612 was centered, would severely limit our chances for encountering Atlantic sturgeon. The Fishing Vessels Eliza and Endeavor were operated by Michael Karch and he fished in depths ranging from 21-100m of depth and sought to maximize monkfish landings.

Fishing operations were monitored by NMFS trained observers (AIS Inc.) who recorded total weight and length measurements for all monkfish and other commercially landed species. In instances where the number of individuals per net string exceeded 100, a sub-sample (n=100) was randomly selected and the total weight recorded. Due to problems securing an Exempted Fishing Permit for retention of prohibited species, all Atlantic sturgeon and other prohibited species (e.g. marine mammals) were quickly photographed and immediately released at the site of capture. In these instances the disposition (i.e. live/mortality) was recorded in addition to vertical and horizontal placement in the net panel although these data are not reported here.

Raw data sheets were signed by both the vessel captain and fishery observer and then scanned to ensure quick data entry and secure back up of raw data (available upon request). Data sheets were then entered into a relational database for generation of tables to facilitate report writing and statistical analyses. All statistical analyses were conducted using JMP Version 9.0 (2011) using ANOVA to test for differences between gear types except for the analyses of Atlantic sturgeon bycatch (CPUE) when a non-parametric analog was used. Statistical significance was inferred at $\alpha \leq 05$.

Results and Discussion

All field sampling was conducted in NMFS Statistical Area 612 (Figure 1) and was initiated on Nov. 14, 2010 by the commercial fishing vessels F.V. Endeavor, and the F.V. Dana Christine. On Nov. 16 2010, the F.V. Eliza started fishing operations. Operations were concluded on Dec. 18, 2010 at the completion of 120 net hauls (Table 1). Soak times for control (tie-down) gillnets averaged 38.3h (range= 2.5-143.0h) while the soak times for treatment gillnets averaged 37.4h (range 3.0-143.8h). There was no significant difference in the duration of soak time of control and treatment gillnets based on a one-way ANOVA (p=0.4467).

A total of 16 identified species were encountered, although due to permitting restrictions we were not able to handle (i.e. measure or weigh) Atlantic sturgeon or marine mammals. A total of 25,119 kg was landed with monkfish (11,044 kg) and winter skate (11,831 kg) dominating the catches followed by barndoor skate (*Dipturus laevis*) (914.7 kg) and spiny dogfish (*Squalus acanthias*) (501.6 kg) (Table 2). Discards of regulated species (i.e. monkfish, winter skate, and spiny dogfish) were limited by market conditions and quotas. In the vast majority of incidents vessel trip quotas were filled before these species were discarded. Other captured species accounted for 827.2 kg of the landings.

In total 23 adult and juvenile Atlantic sturgeon were encountered during the course of the project although we were unable to partition between adults and juveniles (Van Eenennaam et al. 1996) since we were not permitted to handle/measure any protected resources that were encountered(Table 3; Figure 2). Catch rates (i.e. CPUE: # Atlantic sturgeon/1000m net/h) of Atlantic sturgeon did not vary significantly ($p=0.1158$) by gillnet type based on a non-parametric ANOVA (Wilcoxon Test) (Figure 3). The vast majority ($n=104$) of gillnet sets did not encounter any Atlantic sturgeon while encounter rates in the remaining sets ranged from 0.32 to 28.8 individuals per net day. Our results were likely influenced by the large range in encounter rates. A retrospective power analyses indicated that with $\alpha=0.05$ and sigma (σ) = 2.7522 (derived from current study) the power of the current study to detect a significant difference when one existed was .1708. To raise the power of the study to 0.50 it was estimated that a sample size of 453 hauls would be required as a result of the low encounter probability we experienced with Atlantic sturgeon.

From April 2 through May 13, 2011 an additional 50 hauls of a single 10 shot gillnet constructed to the same specifications as the nets used in the present study with the exception of alternating treatment/control panels was fished as part of a directed sampling effort for Atlantic sturgeon in Delaware's coastal waters by researchers at Delaware State University. Over the course of the entire sampling period a total of 67 Atlantic sturgeon were landed in this net configuration. The encounter rates of Atlantic sturgeon in control ($n=34$) and treatment ($n=33$) were almost identical between gear types. Although conducted outside the bounds of the current study, these findings strongly suggest that tie-downs may not have much of a role in mediating

Atlantic sturgeon bycatch.   Also of interest in the companion study was the fact that the control gillnets captured Atlantic sturgeon at a significantly (p=0.0146) smaller size (mean = 146.2 cm) compared to treatment nets (mean = 158.9). The apparent difference in the size selectivity whereby control nets are selecting for smaller Atlantic sturgeon may play a role in the encounter rates noted in the current study and could change if the size range of sturgeon were different. Although we were not able to show a significant difference in the likelihood of encounter rates by gillnet type the ratio of sturgeon encounters suggested that the control gear had a greater probability of retaining sturgeon. A potential reason for this disparity may lie in the fact that fewer larger Atlantic sturgeon were in our sampling area and thus were not vulnerable to capture in the treatment nets during the period of sampling. Results based on passive acoustic telemetry suggest that adult and large juvenile Atlantic sturgeon begin to depart Delaware Bay (approximately 100km south of Statistical Area 612) in early/mid-September with the median departure date of early November with the last individual leaving on December 1st, 2010 presumptively on their way south (Erickson et al. 2010) (Fox and Breece 2010).

Though the sturgeon encounter rates were not statistically different, the majority (n=18) of Atlantic sturgeon encounters took place in control gillnets (net with tie-downs) with hauls 1, 18, and 102 each entangling three sturgeon to account for half of all encounters in the control gillnets. Of the Atlantic sturgeon encountered in the control gillnets, 10 were released alive while eight suffered mortality because of entanglement (Figure 4). The experimental gillnets encountered five Atlantic sturgeon of which two were alive and three were dead upon landing. Due to low encounter rates we pooled across gillnet treatment types to examine the influence of soak time on Atlantic sturgeon disposition (i.e. live/dead) upon landing. The results of a logistic regression analysis of pooled Atlantic sturgeon encounters by soak time indicated that deposition was not significantly impacted by soak time (p=0.0832) (Figure 5). The results of this retrospective analysis were likely influenced by the live encounter of an Atlantic sturgeon entangled in a gillnet soaked 74 hours. Although it is intuitive that longer soak times likely result in increased risk of mortality we are unable to assign the timing of entanglement for individual Atlantic sturgeon.

We recorded nine marine mammal encounters, all of which took place in the treatment gillnets (no tie-downs) (Table 4; Figure 6). The majority (6/9) of marine mammals encountered were short-beaked common dolphin (*Delphinus delphis*). The remaining four animals were identified as "unknown dolphin" due to state of decomposition (N = 3). The relatively high encounter rate of short-beaked common dolphins in the experimental gillnets was surprising since this species is not typically encountered in tie-down gillnetting operations based on interviews with participants in the monkfish fishery and a cursory review of the NEFOP data. In fact, interviews with the captains of the cooperating fishing vessels indicate that neither short-beaked, common, or Atlantic white sided dolphins have been caught in over two decades of fishing for monkfish, although short-beaked common dolphins are regularly observed foraging in heavily fished areas.

The tie-downs utilized in today's monkfish fishery were originally developed as a result of Atlantic sturgeon harvesters noticing "slime" (mucous) marks indicative of monkfish presence during the NJ coastal intercept Atlantic sturgeon fishery (Kevin Wark, F.V. Dana Christine, personal communication). In traditional Atlantic sturgeon gillnets, monkfish were not landed in large numbers due to escapement in the nets leaving a telltale mucous mark. After some experimentation, commercial harvesters were able to develop the tie-down methodology in addition to proper strategies for hauling and deployment, which helped contribute to the large-scale development of the monkfish fishery in the late 1980s and early 1990s.

Through our sampling efforts for this study a total of 11,044 kg of monkfish were landed (Table 2). The vast majority (66.2%) of monkfish were landed in control nets (with tie-downs) which represented a statistically significant difference ($p<0.0001$) in CPUE (# monkfish/1000m gillnet/h) based on the results of a paired t-test. In addition to catching monkfish at higher rates, the control gillnet configuration also landed significantly ($p<0.0001$) larger (mean= 69.6cm) monkfish when compared to monkfish landed in the experimental gillnets (mean= 67.7 cm) (Figure 7). Winter skate, the dominant species landed by weight (11,831kg) was heavily skewed with 84.9% landed in the control gillnets. Unlike monkfish, winter skate landed in the control gillnets (mean= 81.8cm) were significantly ($p<.0001$) smaller than those landed in the experimental net configuration (mean= 84.1cm) (Figure 8).

The results of this study suggest a complex problem surrounding the issue of tie-downs in the New Jersey monkfish fishery, which is somewhat reflective of the larger protected resource-commercial fishery interactions along the US east coast (Zollett 2009). The use of tie-downs clearly enhances the catch rates of both monkfish and winter skate while at the same time selecting for larger monkfish, which can translate into increased landings values for the targeted species. At the same time, the use of tie downs appears to have been successful in decreasing the take of harbor porpoise, which was a stated goal of the HPTRP. At the same time, our study shows equivocal results on the impact of tie-downs on the rate of Atlantic sturgeon bycatch. Although we found no significant difference in the rate of Atlantic sturgeon encounter, it should be noted that the overall power of our test statistic was low likely a result of the rarity of encounter events.

We did not find any significant difference in Atlantic sturgeon encounter rates by gillnet configuration, and the results of a companion study conducted in the spring of 2001 indicate that tie-downs play little, if any, role in mediating bycatch rates of sturgeon. At the same time our companion study may shed some light on the potential for tie-downs to select for smaller Atlantic sturgeon suggesting that future study efforts be conducted when a broad segment of Atlantic sturgeon are in the region and vulnerable to the fishing gear.

The modification of gillnet configuration as well as fishing practices (e.g. soak times) are areas that shows much promise for the reduction of Atlantic sturgeon bycatch. Gessner and Ardnt (2006) reconfigured gillnets through the creation of a gap between the lead line and the bottom meshes to allow Siberian sturgeon (*Acipenser baerii*) passage while still retaining most target species at levels similar to control gillnets. Our results suggest that removal of tie-downs will likely decrease the landings of targeted species, increased take of marine mammals, and may not decrease Atlantic sturgeon encounters to levels that are acceptable to resource managers. However, it is only through field trials under normal fishing conditions that we will be able to adequately assess the impacts of future gear modifications on the landings of targeted species as well as the bycatch of protected resources.

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Table 1: Sample locations (decimal degrees) and haul information for F.V. Dana Christine, F.V. Endeavor, and F.V. Eliza.

Haul Pairing	Haul Number	Vessel	Gear Type	Set Date	Set Latitude Start	Set Longitude Start	Haul Date	Soak Time (hours)	Depth (m)
1	1	Dana Christine	Control	11/14/2010	40.14278	-73.85389	11/14/2010	2.50	27.43
1	2	Dana Christine	Treatment	11/14/2010	40.14167	-73.86778	11/14/2010	3.00	23.77
2	3	Dana Christine	Control	11/14/2010	40.15139	-73.82444	11/14/2010	4.00	32.92
2	4	Dana Christine	Treatment	11/14/2010	40.14694	-73.83917	11/14/2010	4.75	27.43
3	5	Endeavor	Treatment	11/14/2010	40.00025	-73.10006	11/15/2010	23.50	45.72
3	6	Endeavor	Control	11/14/2010	40.01667	-73.11669	11/15/2010	24.25	46.63
4	7	Endeavor	Treatment	11/14/2010	40.01672	-73.11692	11/15/2010	25.50	46.27
4	8	Endeavor	Control	11/14/2010	40.01678	-73.13356	11/15/2010	26.00	47.18
5	9	Dana Christine	Treatment	11/14/2010	40.14778	-73.83000	11/14/2010	18.00	29.26
5	10	Dana Christine	Control	11/14/2010	40.15306	-73.82389	11/15/2010	19.00	32.92
6	11	Dana Christine	Treatment	11/14/2010	40.15000	-73.84250	11/15/2010	21.00	27.43
6	12	Dana Christine	Control	11/14/2010	40.15222	-73.85750	11/15/2010	22.50	27.43
7	13	Endeavor	Control	11/15/2010	40.01675	-73.11678	11/16/2010	22.75	46.27
7	14	Endeavor	Treatment	11/15/2010	40.01667	-73.10008	11/16/2010	23.00	44.81
8	15	Endeavor	Treatment	11/15/2010	40.01681	-73.13339	11/16/2010	22.25	46.63
8	16	Endeavor	Control	11/15/2010	40.01681	-73.15003	11/16/2010	22.75	46.63
9	17	Dana Christine	Treatment	11/15/2010	40.14778	-73.82778	11/16/2010	22.00	32.92
9	18	Dana Christine	Control	11/15/2010	40.15389	-73.81472	11/16/2010	23.20	32.92
10	19	Dana Christine	Treatment	11/16/2010	40.15750	-73.78667	11/16/2010	5.10	34.75
10	20	Dana Christine	Control	11/16/2010	40.15472	-73.80083	11/16/2010	5.90	34.75
11	21	Eliza	Control	11/16/2010	40.01678	-73.15000	11/19/2010	70.75	38.40
11	22	Eliza	Treatment	11/16/2010	40.01681	-73.13336	11/19/2010	71.25	47.18
12	23	Eliza	Control	11/16/2010	40.01667	-73.10017	11/19/2010	73.50	45.72
12	24	Eliza	Treatment	11/16/2010	40.01667	-73.08356	11/19/2010	75.50	45.35
13	25	Dana Christine	Control	11/21/2010	40.14833	-73.84306	11/21/2010	3.20	27.43
13	26	Dana Christine	Treatment	11/21/2010	40.15222	-73.85750	11/21/2010	3.70	27.43
14	27	Dana Christine	Control	11/21/2010	40.15139	-73.82444	11/21/2010	5.00	31.09
14	28	Dana Christine	Treatment	11/21/2010	40.14806	-73.82528	11/21/2010	5.20	29.26
15	29	Eliza	Treatment	11/19/2010	40.01681	-73.11675	11/22/2010	69.75	43.71
15	30	Eliza	Control	11/19/2010	40.01678	-73.13339	11/22/2010	70.25	47.73
16	31	Eliza	Treatment	11/19/2010	40.01678	-73.08353	11/22/2010	70.00	46.82
16	32	Eliza	Control	11/19/2010	40.00003	-73.10014	11/22/2010	70.50	46.45
17	33	Dana Christine	Control	11/21/2010	40.17250	-73.78639	11/22/2010	17.00	31.09
17	34	Dana Christine	Treatment	11/21/2010	40.16639	-73.79944	11/22/2010	21.03	25.60
18	35	Dana Christine	Control	11/21/2010	40.15139	-73.82444	11/22/2010	19.60	32.92
18	36	Dana Christine	Treatment	11/21/2010	40.14778	-73.82778	11/22/2010	21.30	27.43
19	37	Endeavor	Treatment	11/22/2010	40.01672	-73.10014	11/23/2010	20.75	47.55
19	38	Endeavor	Control	11/22/2010	40.01669	-73.11678	11/22/2010	21.50	47.00
20	39	Endeavor	Treatment	11/22/2010	40.01678	-73.13339	11/23/2010	24.25	48.10
20	40	Endeavor	Control	11/22/2010	40.01678	-73.15000	11/23/2010	24.00	47.55
21	41	Dana Christine	Control	11/22/2010	40.15139	-73.82667	11/23/2010	20.60	27.43
21	42	Dana Christine	Treatment	11/22/2010	40.14778	-73.82778	11/23/2010	21.20	27.43
22	43	Dana Christine	Control	11/22/2010	40.17361	-73.77278	11/23/2010	24.20	29.26
22	44	Dana Christine	Treatment	11/22/2010	40.16750	-73.78806	11/23/2010	24.30	31.09
23	45	Dana Christine	Treatment	11/23/2010	40.14778	-73.82778	11/25/2010	20.50	29.26
23	46	Dana Christine	Control	11/23/2010	40.15139	-73.82667	11/25/2010	20.90	29.26
24	47	Dana Christine	Treatment	11/23/2010	40.13861	-73.70611	11/25/2010	20.80	38.40
24	48	Dana Christine	Control	11/23/2010	40.12944	-73.69306	11/25/2010	20.30	38.40
25	49	Eliza	Treatment	11/23/2010	40.01678	-73.13339	11/28/2010	116.50	46.45
25	50	Eliza	Control	11/23/2010	40.01678	-73.15000	11/28/2010	117.50	46.63
26	51	Eliza	Control	11/23/2010	40.01672	-73.11675	11/28/2010	120.25	100.58
26	52	Eliza	Treatment	11/23/2010	40.01672	-73.10008	11/28/2010	121.25	46.63
27	53	Dana Christine	Treatment	11/25/2010	40.17083	-73.78472	11/28/2010	72.80	29.26
27	54	Dana Christine	Control	11/25/2010	40.16639	-73.79944	11/28/2010	73.50	31.09
28	55	Dana Christine	Treatment	11/25/2010	40.13083	-73.69722	11/28/2010	73.20	31.09
28	56	Dana Christine	Control	11/25/2010	40.12500	-73.68556	11/28/2010	74.10	29.26
29	57	Eliza	Control	11/28/2010	40.01672	-73.10014	11/29/2010	20.00	45.72
29	58	Eliza	Treatment	11/28/2010	40.01672	-73.08353	11/29/2010	20.50	45.90
30	59	Eliza	Treatment	11/28/2010	40.01678	-73.13339	11/29/2010	23.25	46.63
30	60	Eliza	Control	11/28/2010	40.01678	-73.15000	11/29/2010	24.00	46.45

31	61	Dana Christine	Treatment	11/28/2010	40.17083	-73.78472	11/29/2010	21.80	31.09
31	62	Dana Christine	Control	11/28/2010	40.16833	-73.79889	11/29/2010	22.90	31.09
32	63	Dana Christine	Control	11/28/2010	40.12778	-73.69361	11/29/2010	21.70	31.09
32	64	Dana Christine	Treatment	11/28/2010	40.13083	-73.69722	11/29/2010	22.10	40.23
33	65	Endeavor	Control	11/29/2010	40.01678	-73.15000	11/30/2010	22.00	46.09
33	66	Endeavor	Treatment	11/29/2010	40.01678	-73.13339	11/30/2010	22.50	47.18
34	67	Endeavor	Control	11/29/2010	40.01672	-73.10014	11/30/2010	25.00	44.81
34	68	Endeavor	Treatment	11/29/2010	40.01672	-73.08350	11/30/2010	25.75	45.72
35	69	Dana Christine	Control	11/29/2010	40.12361	-73.68167	11/30/2010	19.70	40.23
35	70	Dana Christine	Treatment	11/29/2010	40.13083	-73.69722	11/30/2010	21.00	40.23
36	71	Dana Christine	Control	11/29/2010	40.10000	-73.70778	11/30/2010	20.90	40.23
36	72	Dana Christine	Treatment	11/29/2010	40.15111	-73.71556	11/30/2010	21.70	40.23
37	73	Eliza	Control	11/30/2010	40.01678	-73.13336	12/3/2010	71.25	47.55
37	74	Eliza	Treatment	11/30/2010	40.01678	-73.11672	12/3/2010	24.25	47.73
38	75	Eliza	Treatment	11/30/2010	40.01672	-73.08344	12/3/2010	71.50	46.63
38	76	Eliza	Control	11/30/2010	40.01672	-73.10008	12/3/2010	72.00	46.63
39	77	Dana Christine	Control	11/30/2010	40.14167	-73.70722	12/3/2010	71.40	40.23
39	78	Dana Christine	Treatment	11/30/2010	40.15278	-73.71722	12/3/2010	71.60	40.23
40	79	Dana Christine	Control	11/30/2010	40.12361	-73.68167	12/3/2010	74.00	40.23
40	80	Dana Christine	Treatment	11/30/2010	40.13083	-73.69722	12/3/2010	75.97	40.23
41	81	Dana Christine	Control	12/8/2010	39.98361	-74.00222	12/8/2010	3.80	20.12
41	82	Dana Christine	Treatment	12/8/2010	39.98278	-74.01417	12/8/2010	4.50	20.12
42	83	Dana Christine	Treatment	12/8/2010	39.99333	-73.99889	12/8/2010	4.80	21.95
42	84	Dana Christine	Control	12/8/2010	39.99667	-73.99778	12/8/2010	5.20	21.95
43	85	Endeavor	Control	12/3/2010	40.01678	-73.13333	12/9/2010	142.75	46.09
43	86	Endeavor	Treatment	12/3/2010	40.01675	-73.11672	12/9/2010	134.75	46.63
44	87	Endeavor	Control	12/3/2010	40.01669	-73.11675	12/9/2010	143.00	46.27
44	88	Endeavor	Treatment	12/3/2010	40.01672	-73.10014	12/9/2010	143.75	46.63
45	89	Dana Christine	Treatment	12/8/2010	39.98278	-74.01417	12/9/2010	19.50	21.95
45	90	Dana Christine	Control	12/8/2010	39.98361	-74.00222	12/9/2010	19.50	21.95
46	91	Dana Christine	Treatment	12/8/2010	39.99333	-73.99889	12/9/2010	19.00	21.95
46	92	Dana Christine	Control	12/8/2010	39.99778	-74.00917	12/9/2010	19.90	21.95
47	93	Dana Christine	Treatment	12/9/2010	39.98083	-73.98917	12/10/2010	22.30	21.95
47	94	Dana Christine	Control	12/9/2010	39.98361	-74.00000	12/10/2010	22.90	21.95
48	95	Dana Christine	Control	12/9/2010	39.99778	-74.00917	12/10/2010	22.30	21.95
48	96	Dana Christine	Treatment	12/9/2010	39.99333	-73.99889	12/10/2010	22.70	21.95
49	97	Endeavor	Treatment	12/9/2010	40.01675	-73.11669	12/10/2010	22.00	51.76
49	98	Endeavor	Control	12/9/2010	40.01678	-73.11692	12/10/2010	22.25	47.18
50	99	Endeavor	Control	12/9/2010	40.01672	-73.10008	12/10/2010	21.00	46.63
50	100	Endeavor	Treatment	12/9/2010	40.01672	-73.08347	12/10/2010	21.75	47.18
51	101	Dana Christine	Treatment	12/10/2010	39.97944	-73.98750	12/11/2010	22.70	21.95
51	102	Dana Christine	Control	12/10/2010	39.98361	-74.00000	12/11/2010	23.80	21.95
52	103	Dana Christine	Treatment	12/10/2010	39.99222	-73.98778	12/11/2010	23.20	21.95
52	104	Dana Christine	Control	12/10/2010	39.99639	-74.00028	12/11/2010	23.50	21.95
53	105	Endeavor	Treatment	12/10/2010	40.01678	-73.13336	12/11/2010	23.25	47.18
53	106	Endeavor	Control	12/10/2010	40.01678	-73.13358	12/11/2010	23.50	47.18
54	107	Endeavor	Control	12/10/2010	40.01672	-73.10014	12/11/2010	23.00	46.63
54	108	Endeavor	Treatment	12/10/2010	40.01672	-73.08350	12/11/2010	23.75	47.18
55	109	Endeavor	Control	12/11/2010	40.01672	-73.10014	12/16/2010	121.50	46.63
55	110	Endeavor	Treatment	12/11/2010	40.01672	-73.08350	12/16/2010	122.50	46.09
56	111	Endeavor	Treatment	12/11/2010	40.01678	-73.13339	12/16/2010	124.50	47.18
56	112	Endeavor	Control	12/11/2010	40.01678	-73.15000	12/16/2010	125.00	47.55
57	113	Endeavor	Treatment	12/17/2010	40.00006	-73.91689	12/17/2010	5.00	22.86
57	114	Endeavor	Control	12/17/2010	40.00006	-73.93353	12/17/2010	5.50	22.49
58	115	Endeavor	Control	12/17/2010	40.00011	-73.90000	12/17/2010	5.75	22.49
58	116	Endeavor	Treatment	12/17/2010	40.00011	-73.88336	12/17/2010	6.25	22.49
59	117	Endeavor	Control	12/17/2010	40.00006	-73.93356	12/18/2010	18.50	21.21
59	118	Endeavor	Treatment	12/17/2010	40.00006	-73.91689	12/18/2010	20.00	21.95
60	119	Endeavor	Treatment	12/17/2010	40.00011	-73.88339	12/18/2010	12.50	22.31
60	120	Endeavor	Control	12/17/2010	40.00011	-73.90000	12/18/2010	19.00	22.68

Table 2: Summary of catch weight (kg) for identified and weighed species by both vessel and gear type. Note: table does not include prohibited species which were not accurately measured.

Vessel	Gear Type	Barndoor Skate (kg)	Bluefish (kg)	Clearnose Skate (kg)	Horseshoe Crab (kg)	Jonah Crab (kg)	Little Skate (kg)	Monkfish (kg)	Northern Stargazer (kg)	Sea Scallop (kg)	Spiny Dogfish (kg)	Summer Flounder (kg)	Tautog (kg)	Winter Skate (kg)	Total Weight (kg)
Dana Christine	Control	13.6	2.7	11.3	277.1	6.8	55.8	1623.8	5.0	0.7	101.6	1.6	3.6	8733.8	10837.4
Dana Christine	Treatment	0.0	130.6	2.3	70.3	0.0	9.1	684.4	0.0	0.0	198.6	0.0	0.0	1564.6	2659.9
Eliza	Control	258.5	0.0	7.3	4.5	0.0	72.1	3120.6	0.0	0.0	19.0	0.0	0.0	285.3	3767.3
Eliza	Treatment	83.0	0.0	0.0	0.0	0.0	3.2	1678.9	0.0	0.0	39.9	5.0	0.0	81.6	1891.6
Endeavor	Control	455.3	39.0	20.9	1.8	0.0	76.6	2561.9	0.0	0.0	58.0	4.5	0.0	1029.5	4247.6
Endeavor	Treatment	104.3	0.0	4.1	2.3	0.0	9.1	1374.6	0.0	0.0	84.4	0.0	0.0	136.1	1714.7
	Total Control	727.4	41.7	39.5	283.4	6.8	204.5	7306.3	5.0	0.7	178.7	6.1	3.6	10048.5	18852.4
	Total Treatment	187.3	130.6	6.3	72.6	0.0	21.3	3737.9	0.0	0.0	322.9	5.0	0.0	1782.3	6266.2
	Total Weights	914.7	172.3	45.8	356.0	6.8	225.9	11044.2	5.0	0.7	501.6	11.1	3.6	11830.8	25118.6

Table 3: Summary of Atlantic sturgeon encounters including haul information, gear type, individual status, and visually estimated weight.

Haul Number	Set Date	Haul Date	Soak Time	Gear Type	Sturgeon Status	Estimated Weight (kg)
1	11/14/2010	11/14/2010	2.50	Control	alive	41
1	11/14/2010	11/14/2010	2.50	Control	alive	36
1	11/14/2010	11/14/2010	2.50	Control	alive	34
2	11/14/2010	11/14/2010	3.00	Treatment	alive	32
9	11/14/2010	11/14/2010	18.00	Treatment	alive	32
11	11/14/2010	11/15/2010	21.00	Treatment	dead	36
12	11/14/2010	11/15/2010	22.50	Control	dead	34
12	11/14/2010	11/15/2010	22.50	Control	dead	36
18	11/15/2010	11/16/2010	23.20	Control	alive	18
18	11/15/2010	11/16/2010	23.20	Control	dead	18
18	11/15/2010	11/16/2010	23.20	Control	dead	23
48	11/23/2010	11/25/2010	20.30	Control	alive	36
54	11/25/2010	11/28/2010	73.50	Control	dead	36
62	11/28/2010	11/29/2010	22.90	Control	alive	43
77	11/30/2010	12/3/2010	71.40	Control	dead	27
78	11/30/2010	12/3/2010	71.60	Treatment	dead	45
79	11/30/2010	12/3/2010	74.00	Control	alive	27
93	12/9/2010	12/10/2010	22.30	Treatment	dead	23
95	12/9/2010	12/10/2010	22.30	Control	dead	14
102	12/10/2010	12/11/2010	23.80	Control	dead	23
102	12/10/2010	12/11/2010	23.80	Control	dead	29
102	12/10/2010	12/11/2010	23.80	Control	dead	45
104	12/10/2010	12/11/2010	23.50	Control	alive	34

Table 4: Marine mammal encounter information including haul number, gear type, soak time, estimated weight in kilograms if possible, and species if known. Unidentified (NK) dolphin in haul 61 is thought to be the same individual caught in haul 53.

Vessel Name	Set Date	Haul Date	Soak Time (Hour)	Estimated Weight	Gear Type	Species	Digital Images	Comments
Dana Christine	11/25/2010	11/28/2010	72.8	113	Treatment	Short Beaked Common Dolphin	042-043	
Dana Christine	11/28/2010	11/29/2010	21.8	18	Treatment	NK Dolphin		Potentially same individual caught in haul 53
Dana Christine	11/29/2010	11/30/2010	21.7	113	Treatment	Short Beaked Common Dolphin		
Eliza	11/30/2010	12/3/2010	24.25		Treatment	Short Beaked Common Dolphin	055-056	ID verified by NEFSC
Eliza	11/30/2010	12/3/2010	24.25		Treatment	NK Dolphin	056 only	
Dana Christine	11/30/2010	12/3/2010	71.6	68	Treatment	Short Beaked Common Dolphin	201030-201035	
Dana Christine	11/30/2010	12/3/2010	75.97	91	Treatment	Short Beaked Common Dolphin	201036-201039	
Endeavor	12/3/2010	12/9/2010	143.75		Treatment	NK Dolphin	201040-201044	
Dana Christine	12/8/2010	12/9/2010	19.5	91	Treatment	Short Beaked Common Dolphin	069-070	

Table 7: Catch information for monkfish (target species). Table includes kept fish only.

Haul Number	Vessel	Gear Type	Set Date	Haul Date	Soak Time (hour)	Weight (kg)	Mean Length (cm)
5	Endeavor	Treatment	11/14/2010	11/15/2010	23.50	104	67.61
6	Endeavor	Control	11/14/2010	11/15/2010	24.25	139	70.90
7	Endeavor	Treatment	11/14/2010	11/15/2010	25.50	22	71.20
8	Endeavor	Control	11/14/2010	11/15/2010	26.00	105	76.30
9	Dana Christine	Treatment	11/14/2010	11/14/2010	18.00	23	83.18
10	Dana Christine	Control	11/14/2010	11/15/2010	19.00	45	81.99
11	Dana Christine	Treatment	11/14/2010	11/15/2010	21.00	7	86.12
12	Dana Christine	Control	11/14/2010	11/15/2010	22.50	24	83.48
13	Endeavor	Control	11/15/2010	11/16/2010	22.75	109	68.30
14	Endeavor	Treatment	11/15/2010	11/16/2010	23.00	48	65.40
15	Endeavor	Treatment	11/15/2010	11/16/2010	22.25	47	65.27
16	Endeavor	Control	11/15/2010	11/16/2010	22.75	121	71.55
17	Dana Christine	Treatment	11/15/2010	11/16/2010	22.00	6	85.90
18	Dana Christine	Control	11/15/2010	11/16/2010	23.20	32	82.00
19	Dana Christine	Treatment	11/16/2010	11/16/2010	5.10	15	104.00
21	Eliza	Control	11/16/2010	11/19/2010	70.75	210	62.36
22	Eliza	Treatment	11/16/2010	11/19/2010	71.25	125	61.11
23	Eliza	Control	11/16/2010	11/19/2010	73.50	268	61.35
24	Eliza	Treatment	11/16/2010	11/19/2010	75.50	112	59.35
25	Dana Christine	Control	11/21/2010	11/21/2010	3.20	11	84.50
26	Dana Christine	Treatment	11/21/2010	11/21/2010	3.70	15	74.50
27	Dana Christine	Control	11/21/2010	11/21/2010	5.00	13	78.33
28	Dana Christine	Treatment	11/21/2010	11/21/2010	5.20	14	74.00
29	Eliza	Treatment	11/19/2010	11/22/2010	69.75	239	65.62
30	Eliza	Control	11/19/2010	11/22/2010	70.25	342	71.18
31	Eliza	Treatment	11/19/2010	11/22/2010	70.00	208	70.37
32	Eliza	Control	11/19/2010	11/22/2010	70.50	473	69.42
33	Dana Christine	Control	11/21/2010	11/22/2010	17.00	39	79.71
34	Dana Christine	Treatment	11/21/2010	11/22/2010	21.03	31	80.67
35	Dana Christine	Control	11/21/2010	11/22/2010	19.60	82	81.00
36	Dana Christine	Treatment	11/21/2010	11/22/2010	21.30	6	83.71
37	Endeavor	Treatment	11/22/2010	11/23/2010	20.75	184	69.09
38	Endeavor	Control	11/22/2010	11/22/2010	21.50	160	71.00
39	Endeavor	Treatment	11/22/2010	11/23/2010	24.25	101	66.77
40	Endeavor	Control	11/22/2010	11/23/2010	24.00	133	68.96
41	Dana Christine	Control	11/22/2010	11/23/2010	20.60	13	78.54
42	Dana Christine	Treatment	11/22/2010	11/23/2010	21.20	8	81.55
43	Dana Christine	Control	11/22/2010	11/23/2010	24.20	29	79.97
44	Dana Christine	Treatment	11/22/2010	11/23/2010	24.30	17	86.00
45	Dana Christine	Treatment	11/23/2010	11/25/2010	20.50	39	81.67
46	Dana Christine	Control	11/23/2010	11/25/2010	20.90	112	80.76
47	Dana Christine	Treatment	11/23/2010	11/25/2010	20.80	55	77.80
48	Dana Christine	Control	11/23/2010	11/25/2010	20.30	164	79.30
49	Eliza	Treatment	11/23/2010	11/28/2010	116.50	283	69.91
50	Eliza	Control	11/23/2010	11/28/2010	117.50	460	70.38
51	Eliza	Control	11/23/2010	11/28/2010	120.25	493	72.57
52	Eliza	Treatment	11/23/2010	11/28/2010	121.25	229	70.34
53	Dana Christine	Treatment	11/25/2010	11/28/2010	72.80	41	80.93
54	Dana Christine	Control	11/25/2010	11/28/2010	73.50	87	82.67
55	Dana Christine	Treatment	11/25/2010	11/28/2010	73.20	201	77.50
56	Dana Christine	Control	11/25/2010	11/28/2010	74.10	247	76.31
57	Eliza	Control	11/28/2010	11/29/2010	20.00	188	72.03

Table 7 (continued): Catch information for monkfish (target species). Table includes kept fish only.

Haul Number	Vessel	Gear Type	Set Date	Haul Date	Soak Time (hour)	Weight (kg)	Mean Length (cm)
58	Eliza	Treatment	11/28/2010	11/29/2010	20.50	136	71.88
59	Eliza	Treatment	11/28/2010	11/29/2010	23.25	125	67.29
60	Eliza	Control	11/28/2010	11/29/2010	24.00	181	68.42
61	Dana Christine	Treatment	11/28/2010	11/29/2010	21.80	7	84.86
62	Dana Christine	Control	11/28/2010	11/29/2010	22.90	21	80.87
63	Dana Christine	Control	11/28/2010	11/29/2010	21.70	61	79.13
64	Dana Christine	Treatment	11/28/2010	11/29/2010	22.10	10	71.40
65	Endeavor	Control	11/29/2010	11/30/2010	22.00	113	68.17
66	Endeavor	Treatment	11/29/2010	11/30/2010	22.50	117	64.33
67	Endeavor	Control	11/29/2010	11/30/2010	25.00	220	68.45
68	Endeavor	Treatment	11/29/2010	11/30/2010	25.75	123	68.36
69	Dana Christine	Control	11/29/2010	11/30/2010	19.70	25	81.36
70	Dana Christine	Treatment	11/29/2010	11/30/2010	21.00	10	64.00
71	Dana Christine	Control	11/29/2010	11/30/2010	20.90	57	79.00
72	Dana Christine	Treatment	11/29/2010	11/30/2010	21.70	28	74.86
73	Eliza	Control	11/30/2010	12/3/2010	71.25	186	71.38
74	Eliza	Treatment	11/30/2010	12/3/2010	24.25	94	70.60
75	Eliza	Treatment	11/30/2010	12/3/2010	71.50	110	72.05
76	Eliza	Control	11/30/2010	12/3/2010	72.00	287	69.80
77	Dana Christine	Control	11/30/2010	12/3/2010	71.40	201	80.07
78	Dana Christine	Treatment	11/30/2010	12/3/2010	71.60	38	84.27
79	Dana Christine	Control	11/30/2010	12/3/2010	74.00	142	81.91
80	Dana Christine	Treatment	11/30/2010	12/3/2010	75.97	35	84.46
85	Endeavor	Control	12/3/2010	12/9/2010	142.75	293	71.25
86	Endeavor	Treatment	12/3/2010	12/9/2010	134.75	120	69.89
87	Endeavor	Control	12/3/2010	12/9/2010	143.00	350	71.71
88	Endeavor	Treatment	12/3/2010	12/9/2010	143.75	100	74.88
89	Dana Christine	Treatment	12/8/2010	12/9/2010	19.50	18	83.11
91	Dana Christine	Treatment	12/8/2010	12/9/2010	19.00	5	83.40
92	Dana Christine	Control	12/8/2010	12/9/2010	19.90	70	81.83
93	Dana Christine	Treatment	12/9/2010	12/10/2010	22.30	7	79.89
95	Dana Christine	Control	12/9/2010	12/10/2010	22.30	60	82.43
96	Dana Christine	Treatment	12/9/2010	12/10/2010	22.70	31	82.23
97	Endeavor	Treatment	12/9/2010	12/10/2010	22.00	42	66.79
98	Endeavor	Control	12/9/2010	12/10/2010	22.25	98	72.74
99	Endeavor	Control	12/9/2010	12/10/2010	21.00	102	67.78
100	Endeavor	Treatment	12/9/2010	12/10/2010	21.75	29	65.67
101	Dana Christine	Treatment	12/10/2010	12/11/2010	22.70	17	83.44
102	Dana Christine	Control	12/10/2010	12/11/2010	23.80	16	83.20
104	Dana Christine	Control	12/10/2010	12/11/2010	23.50	73	79.36
105	Endeavor	Treatment	12/10/2010	12/11/2010	23.25	51	70.78
106	Endeavor	Control	12/10/2010	12/11/2010	23.50	143	69.52
107	Endeavor	Control	12/10/2010	12/11/2010	23.00	119	69.91
108	Endeavor	Treatment	12/10/2010	12/11/2010	23.75	95	67.95
109	Endeavor	Control	12/11/2010	12/16/2010	121.50	218	74.12
110	Endeavor	Treatment	12/11/2010	12/16/2010	122.50	87	72.39
111	Endeavor	Treatment	12/11/2010	12/16/2010	124.50	68	72.54
112	Endeavor	Control	12/11/2010	12/16/2010	125.00	98	77.02
116	Endeavor	Treatment	12/17/2010	12/17/2010	6.25	7	74.00
117	Endeavor	Control	12/17/2010	12/18/2010	18.50	9	79.10
118	Endeavor	Treatment	12/17/2010	12/18/2010	20.00	9	83.39
119	Endeavor	Treatment	12/17/2010	12/18/2010	12.50	5	81.33
120	Endeavor	Control	12/17/2010	12/18/2010	19.00	16	81.41

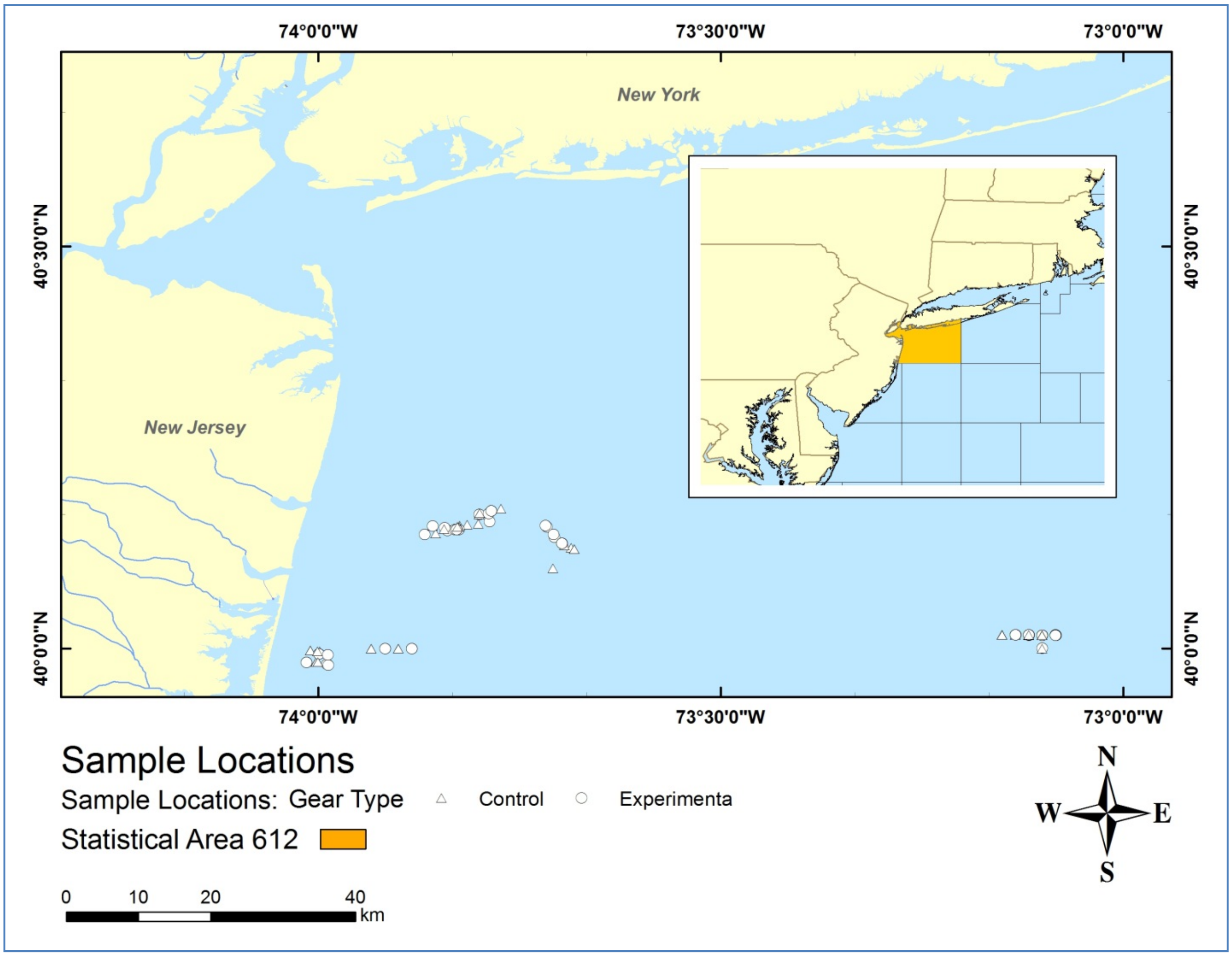

Figure 1: Location of gillnet sampling areas within NMFS Statistical Area 612 (inset) plotted by net type (triangle= control, open circles = experimental).

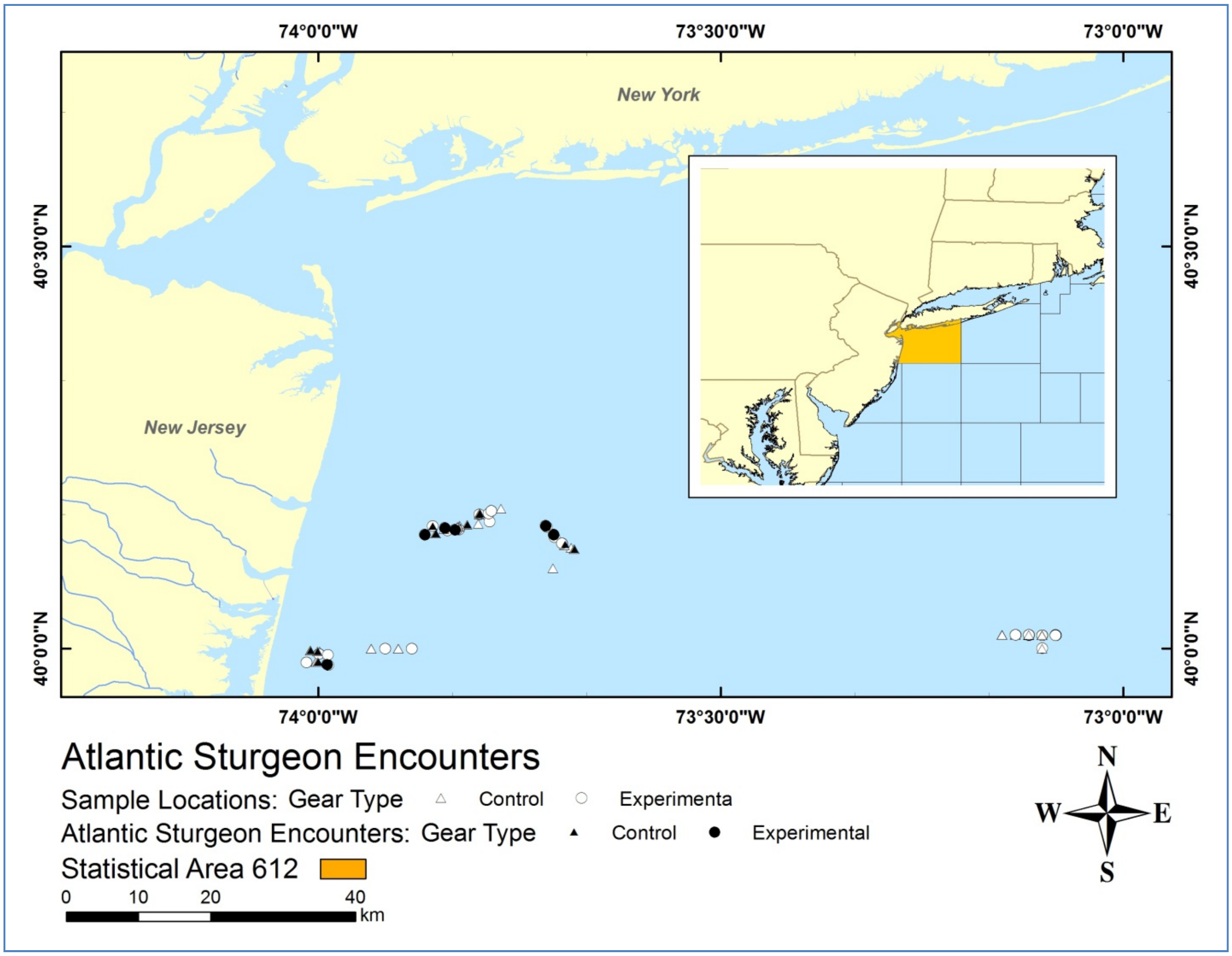

Figure 2: Location of gillnet activities by gear type (control = triangles; treatment= circles) within NMFS Statistical Area 612 with Atlantic sturgeon encounters (filled symbols). Figure is zoomed to represent the area that encompasses Atlantic sturgeon encounters. Gillnets fished further to the east are omitted from this figure due to the lack of encounter history.

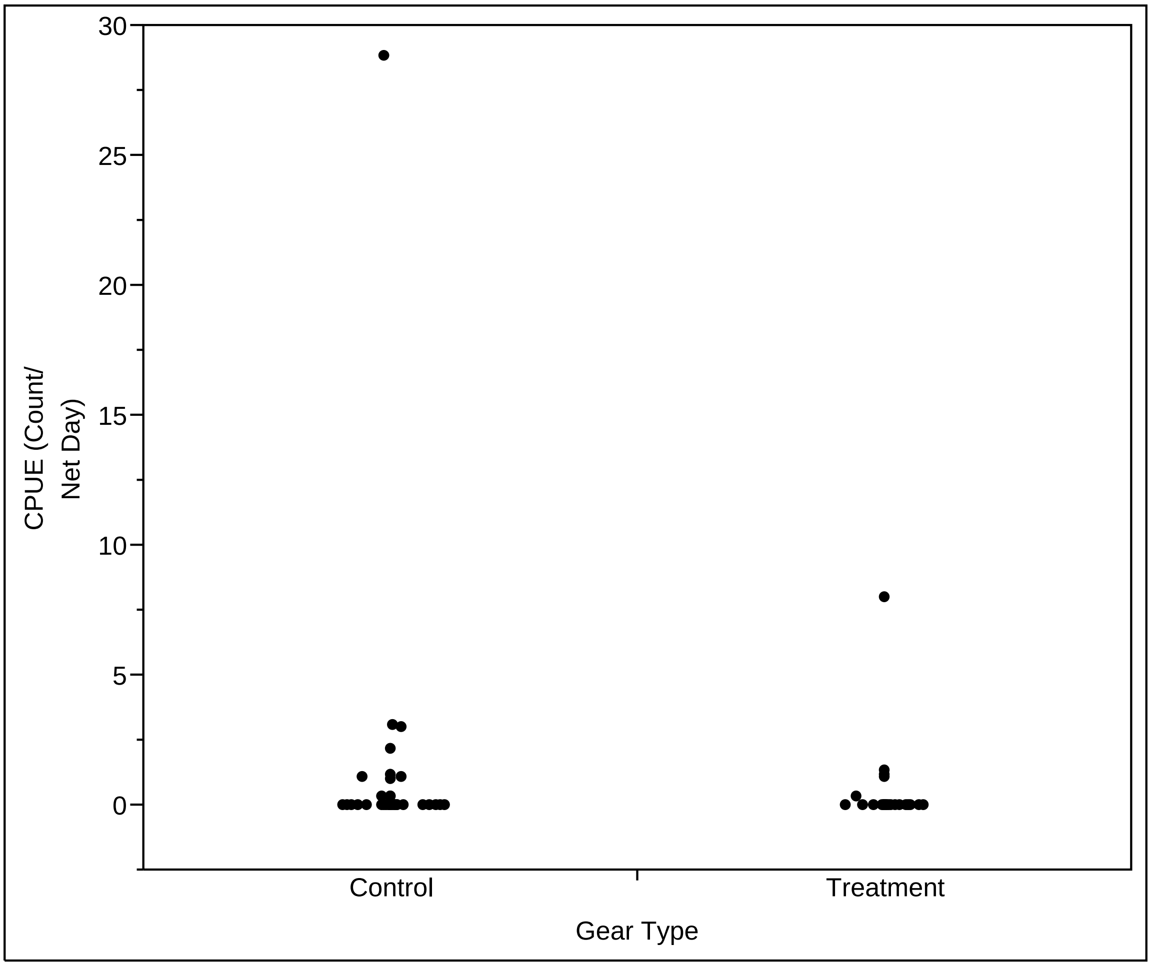

Figure 3: Atlantic sturgeon encounter rates by gear type for the 2010 sampling season.

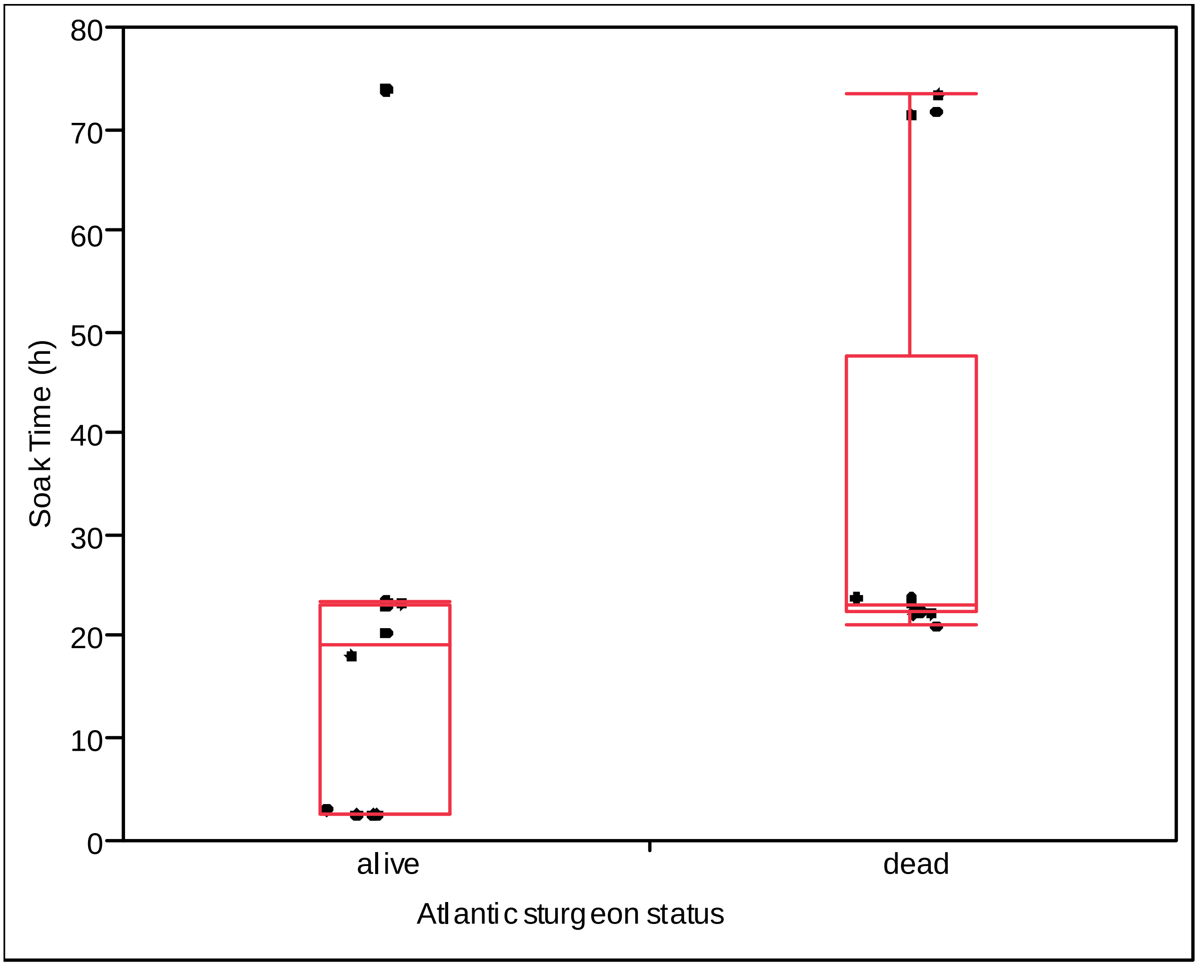

Figure 4: Atlantic sturgeon disposition at landing (alive vs. dead) plotted against gillnet soak time. Box plots represent median and 25-75th quartiles.

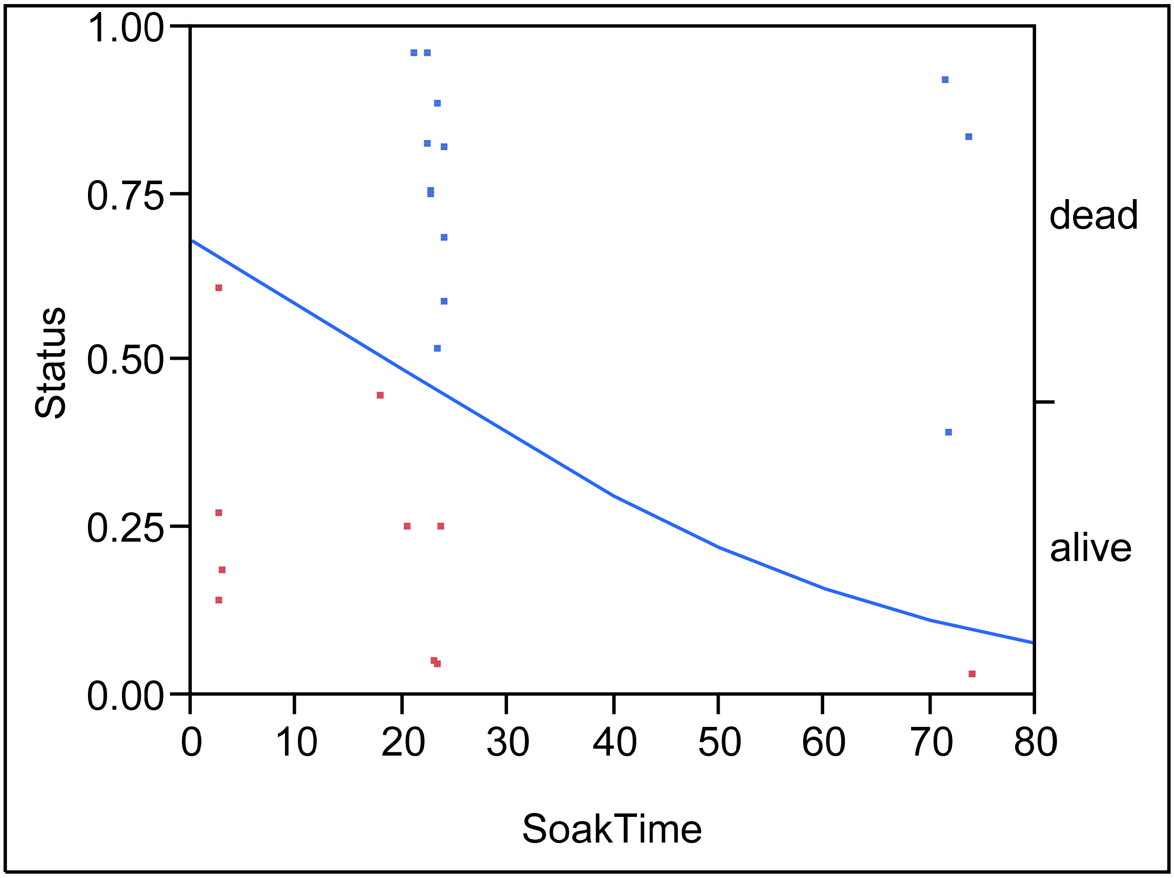

Figure 5: Results of logistic regression fit of Atlantic sturgeon status (alive vs. dead) by soak time for gillnet encounters. Points plotted above the line represent Atlantic sturgeon that were dead at the time of the encounter.

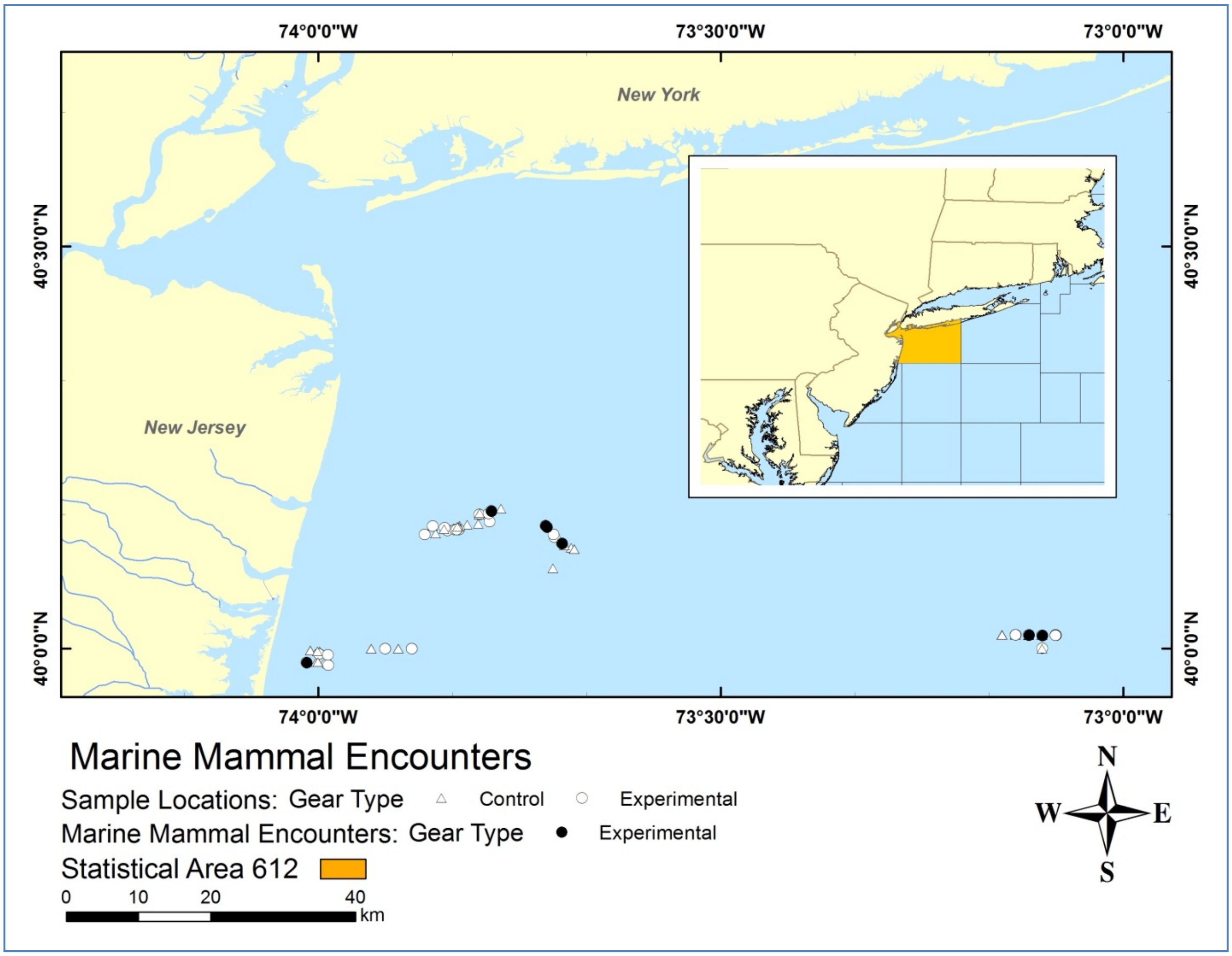

Figure 6: Location of gillnet activities by gear type (control = triangles; treatment= circles) within NMFS Statistical Area 612 with marine mammal encounters (filled symbols).

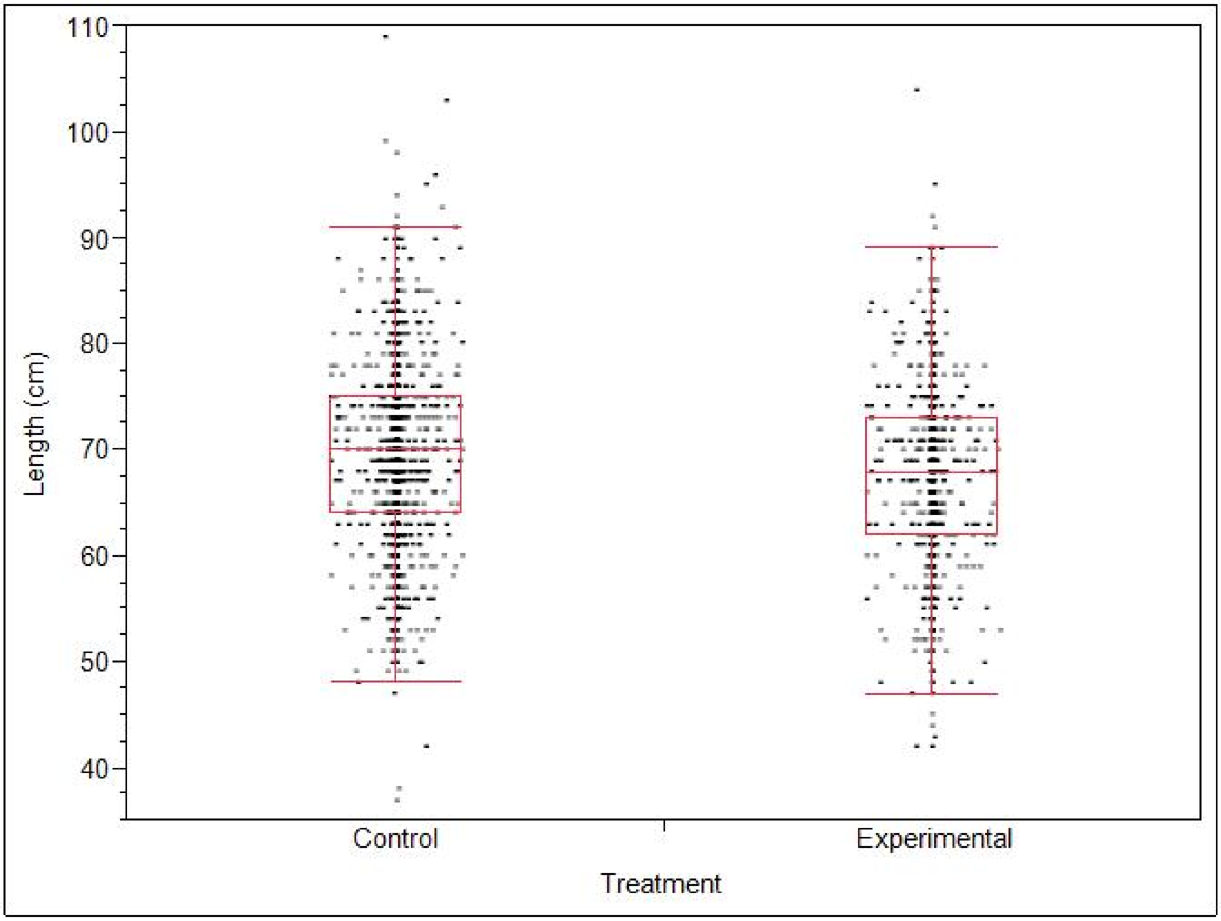

Figure 7: Length (cm) of monkfish landed by gillnet configuration. Box plots represent median and 25-75th quartiles.

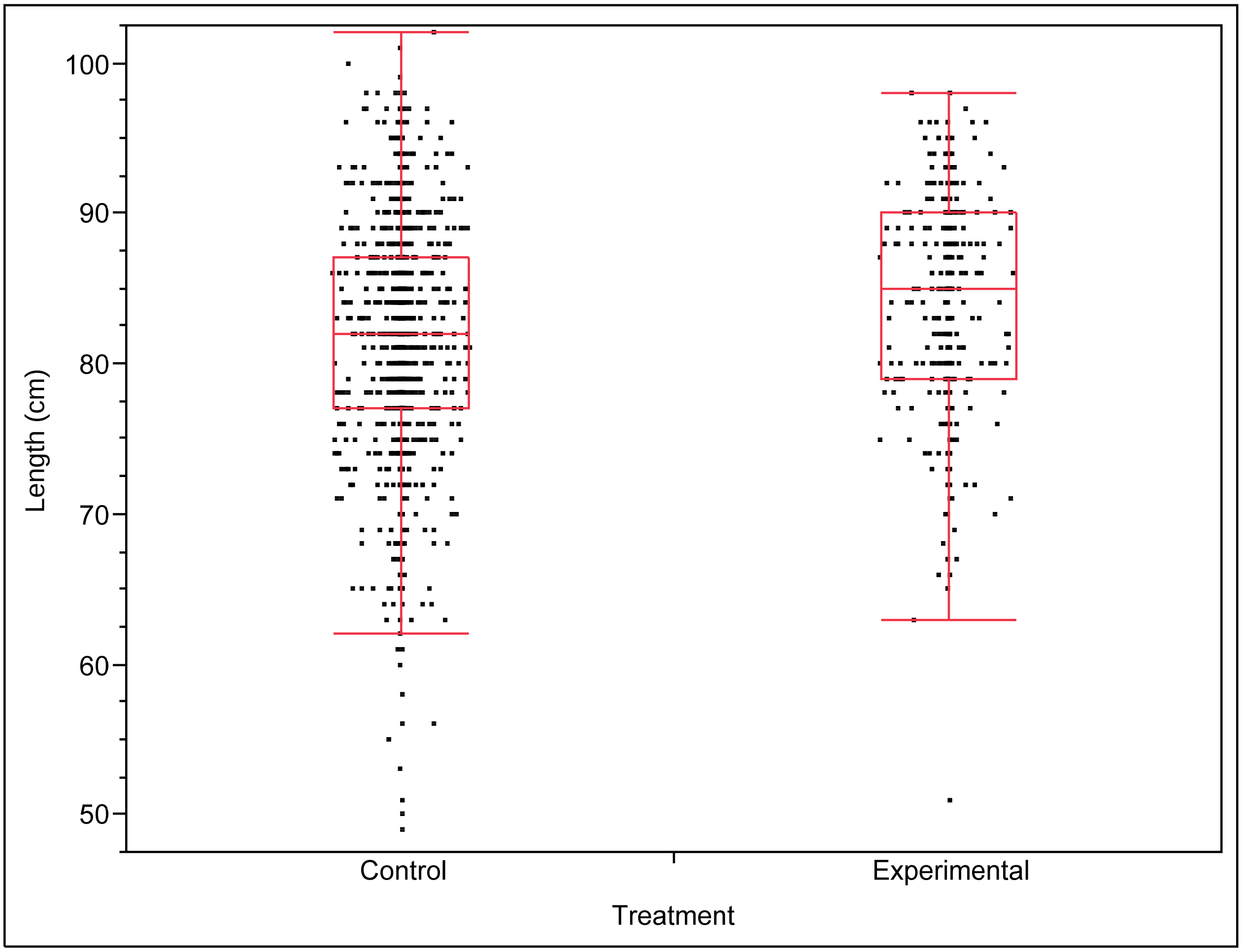

Figure 8: Length (cm) of winter skate landed by gillnet configuration. Box plots represent median and 25-75th quartiles.

Design and Test of a Low Profile Gillnet to Reduce Atlantic Sturgeon and Sea Turtle Bycatch in Mid-Atlantic Monkfish Fishery

Final Report

Report title:	Design and Test of a Low Profile Gillnet to reduce Atlantic Sturgeon and Sea Turtle By-catch in Mid-Atlantic Monkfish Fishery
Key project partners:	Rick Usher, A.I.S. Inc. Pingguo He, UMass Dartmouth – SMAST
Funding Agency:	NOAA Fisheries
NOAA Contract No.:	EA133F-12-SE-2094
Recipient name:	A.I.S. Inc. New Bedford, MA
NOAA COR:	Henry Milliken
Report by:	Pingguo He and Natalie Jones (SMAST)
Date:	August 15, 2013

This project was a collaboration of NOAA Fisheries Protected Species Branch (PSB), A.I.S Inc., the fishing industry, and UMass Dartmouth's School for Marine Science and Technology (SMAST). Henry Milliken of PSB provided general directions on the design of the experimental gillnets and the scope of the project. Rick Usher and his team at A.I.S. Inc. were responsible for vessel selection and contracting, observer coverage, at-sea data collection, and field logistics. Pingguo He and his team at SMAST provided advices on experimental designs and data collection, and were responsible for data entry, management, analysis, and drafting of this report. Sea trials were conducted on board two gillnet fishing vessels F/V "Landon Blake" and F/V "Risky Business" from the Mid-Atlantic region.

Design and Test of a Low Profile Gillnet to reduce Atlantic Sturgeon Bycatch in Mid-Atlantic Monkfish Fishery

Summary

This project was to test an experimental gillnet designed to reduce bycatch of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and sea turtles while targeting monkfish (*Lophius americanus)* and winter skate *(Leucoraja ocellata*) in the inshore Mid-Atlantic region off Virginia and Maryland. The Experimental gillnets were 8 meshes deep with 24" tie-downs compared with commercial gillnets (Control) that were 12 meshes deep with 48" tie-downs. Two commercial fishing vessels, F/V "Landon Blake" and F/V "Risky Business", were contracted to do sea trials during May of 2013 with an A.I.S. Inc. observer on board each vessel to collect operational and biological data. The nets were fished in pairs; each pair of nets consisted of one control string (10 nets, 50 fm each net) and one experimental string of the same number and length. A pair of nets is set close to each other in location, set and hauled one after the other, with the same soak time, sea floor type, net direction, and other fishing ground features. Each vessel completed 50 hauls, 25 hauls of Control gillnets, and 25 hauls of Experimental nets. This provided 25 pairs of comparable hauls for each vessel. Seven Atlantic sturgeons were captured, all from the Control nets. The Experimental net significantly reduced bycatch of Atlantic sturgeon for each vessel independently and when both vessels' data were combined. The catch efficiency of the experimental nets for monkfish was inconsistent between the two vessels. There were no significant differences between the two types of nets from "Landon Blake" ($p=0.60$, paired t-test, two-tailed, dof=25), but the Experimental nets caught significantly less monkfish on the fishing vessel "Risky Business" ($p=0.012$, paired t-test, two-tailed, dof=25) and when both vessels' data were combined. The catch differences between the nets were particularly large when the catch rates were high. Length frequency and GLMM modeling indicate that the reduction in monkfish catch in "Risky Business" primarily resulted from a reduction in catch of monkfish that were less than 75 cm. There were no statistical differences in the catch of winter skate between the Control and the Experimental nets for either vessel, or when data for both vessels are combined ($p>0.05$).

1. Introduction

Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is an anadromous subspecies of sturgeon, spawning in river systems but growing and maturing in the sea. In the Northwest Atlantic, the species is widely distributed along the coast from Labrador in northern Canada to Florida in the southeast US.

In the US, the Atlantic States Marine Fisheries Commission (ASMFC) had managed Atlantic sturgeon from 1990 until populations of sturgeon were listed as "Endangered" or "Threatened" in 2012. The Atlantic Sturgeon Status Review Team (ASSRT) identified five Distinct Population Segments (DPSs) for the sturgeon population along the Atlantic Coast based on their biological, ecological, genetic, and migration/homing characteristics (ASSRT, 2007): 1) Gulf of Maine, 2) New York Bight, 3) Chesapeake Bay, 4) Carolinas, and 5) South Atlantic. The Gulf of Maine DSP was listed as "Threatened" while the other four DSPs were listed as "Endangered" under the Endangered Species Act (FR, 2012 a & b). Significant risks to the population of the Atlantic Sturgeon include: commercial fishing by-catch, water quality, vessel strikes, dredging and habitat impediments including locks and dams.

Bottom-set gillnets are recognized as the gear type that results in the most bycatch of Atlantic sturgeon and subsequent mortality. Between 1989 and 2000, gillnets targeting monkfish (goosefish, *Lophius americanus)* are reported to result in the largest amount of sturgeon bycatch 2000 *(*Stein et al., 2004; ASSRT, 2007, Miller and Shepard, 2011). Along the coast, bottom gillnet vessels that land fish in New Jersey, Delaware and Maryland had the highest sturgeon takes in relation to target species landed, especially during spring months (*ibid*).

Monkfish are distributed widely throughout the Northwest Atlantic, from the northern Gulf of St. Lawrence and Grand Bank of Newfoundland in Canada to Florida in the US. The fish primarily stick close to the benthos of all water depths from the tide line to as deep as 900 m. In the US, monkfish are primarily landed by bottom trawls (73% during 2000-2011) in the Northern Fishery Management Area (NFMA) north of Cape Cod, and by bottom gillnets (72% during 2000-2011) in the Southern Fishery Management Area (SFMA) south of Cape Cod (NOAA, 2013).

Gillnetting is one of the oldest fishing methods in the northeast US, dating back to mid-1800s, but the widespread use of gillnets coincided with the introduction of synthetic materials, especially monofilament in 1950s and 60s (He, 2006a; He and Pol, 2010). Efficient, durable and almost maintenance-free monofilament gillnets are suitable for many fish species from surface to midwater and bottom fisheries with mesh sizes that change to match the target fish sizes. Monkfish gillnets have large mesh sizes in order to target large bottom-dwelling monkfish.

Typical monkfish gillnets in the Atlantic Coast use 12" (305 mm) mesh size, and large twine sizes (e.g. 0.9 mm) to land large monkfish in varying sea conditions (Figure 1). A "standard" net is 300 feet long and 12 meshes deep. The webbing is typically hung onto a polypropylene (PP) head rope with a hanging ratio of 0.50. Tie-down nets are used for monkfish in both southern and northern management areas. Tie-down line (48" long every 4 fm along the length) reduces vertical height and results in a vertically curved net shape with extra webbing near the bottom. During commercial monkfish gillnet fishing, 10 to 20 nets are typically tied together to form a string or a fleet. A fishing vessel may fish several strings depending on vessel size, the number of crew, catch rates, and deck machinery.

Monkfish are believed to stay very close to the seabed. In an experiment comparing gillnets of different heights, He (2006b) found that catch rates for monkfish were very similar when 25-mesh, 12-mesh, or 8-mesh groundfish gillnets (6.5" mesh size) were used; however, tie-down nets caught more monkfish than regular "stand-up" gillnets. This indicates that lower profile gillnets than currently employed commercially (12 meshes deep) might be used without affecting the catch rate of monkfish.

Fox et al. (2011; 2012; 2013) tested monkfish gillnets of different configurations to reduce the bycatch of Atlantic sturgeon in the New York Bight. The first year project (Fox et al., 2011) compared gillnets with and without tie-downs (tie-down nets vs. stand-up nets), and found that stand-up nets had much lower monkfish catch rates but did not reduce sturgeon bycatch. The second year project (Fox et al., 2012) compared a 6-mesh low profile net with 24" tie-downs and the standard monkfish net, and found that both catch rates of sturgeon and monkfish were significantly reduced when using the 6-mesh nets. The third year project (Fox et al., 2013) increased the low profile gillnet to 8 meshes deep and compared with the same standard monkfish net. They did not find significant differences in the catch rates of sturgeon, nor those of target species – monkfish and winter skate (*Leucoraja ocellata*). They did find that the majority of sturgeons entangled in the nets (70%), were entangled in the top half of the net, suggesting that a lower profile net might be an effective means of reducing sturgeon bycatch. The results of the low profile gillnets not significantly reducing targeted monkfish and winter skate, along with the location of sturgeons caught in the nets are encouraging and provide rationales for further studies on lower profile nets for the fishery, especially during different seasons.

2. Project Goals and Objectives

The goal of the research was to reduce bycatch of Atlantic sturgeon and sea turtles in the Mid-Atlantic monkfish fishery through design and tests of an experimental low profile gillnet. Specific objectives were to:

- Design a low profile gillnet and compare with the commercial nets that Mid-Atlantic fishermen normally use to harvest monkfish, and
- Conduct sea trials in the Mid-Atlantic waters to test the experimental gear's effectiveness in retaining catches of the target species and reducing bycatch of sturgeon and sea turtles.

3. Research Methods

3.1 Gear design

The control nets were regular commercial monkfish gillnets used in the Mid-Atlantic region. They were 50 fm long, and 12 meshes deep, made of 0.90 mm diameter, 12" mesh size green nylon monofilament netting. The headrope was made of 3/8" polypropylene (PP) ropes with standard gillnet floats spaced at 12'. The footrope was made of 75 lbs per 600' lead line. Tie-down lines (48" in length) were spaced at 24' (Figure 1). The experimental gillnet was the same as the control net in terms of netting materials, headrope and footrope, but was 8 meshes deep instead of 12 meshes. In addition, tie-down lines in the experimental nets were spaced at 12', and were 24" in length instead of 48" spread at 24' (Figure 1). Therefore, the tie-down lines were at every float in the experimental nets while they were on every other float in the control nets. Each string of gear contained 10 nets of the same type (Control or Experimental). Each pair of nets contained one string of control net and one string of experimental net. Each vessel fished two pairs of gears. All Control and Experimental gillnets (including spare nets) were supplied by NOAA Fisheries.

3.2 Sea trials

Two commercial fishing vessels, F/V "Landon Blake" owned and operated by Thomas Danchise, and F/V "Risky Business" owned and operated by James Wescott, were contracted to do sea trials during May of 2013. The goal was to complete 25 pairs of hauls for each vessel. Both vessels were equipped with adequate machinery, permits and allocations to fish in the Mid-Atlantic monkfish fishery. Prior to signing the contracts and sea trials, the A.I.S. Project Manager inspected the vessels and a Vessel Suitability Report (VSR) was submitted to NOAA Contracting Office Representative (COR). The VSR is attached as Appendix 1.

"Landon Blake" is a 43' fiberglass vessel equipped with a 375 horsepower Caterpillar 3208 engine and has a 14' beam and a 4' draft. It has a 30" Crosley gillnet lifter and two net reel style haulers. "Risky Business" is a 45' fiberglass vessel equipped with a 640 horsepower Caterpillar engine with a 15' beam and a 4' draft. It has a 24" Crosley gillnet lifter and two net reel style haulers.

Prior to the data collection period, a meeting was held with all project participants. At the meeting, the scope of the project was reviewed and it was verified that all participants clearly understood sampling protocols and procedures. This facilitated the onboard data collection process. A tentative deployment calendar was developed with possible sail dates and data collector assignments. Prior to the start of gear deployment, the Project Manager (PM) met with each captain at his vessel. A NEFOP Pre-Trip Vessel Safety Checklist was completed for each vessel and certified that all of the safety equipment remained valid for the duration of the study.

One string of control gear was fished comparably with one string of experimental gear in pairs. Each string in the pair was set close to the other in location, with the same or similar soak time, sea floor type, and other fishing ground features and set in a similar direction. Fishing trials were conducted off the coast of Virginia and Maryland at depths between 14 and 20 fm. Fishing vessel skippers were allowed to choose fishing locations and soak time (1 to 3 days), but they were advised that each pair of nets be set in close proximity and with the same soak time. The exact fishing locations for each string can be seen in Table 1 and also plotted in Figure 2.

Both vessels began fishing on 05/02/2013. Usually two pairs of gear were hauled each day, weather permitting. “Landon Blake” finished 50 hauls (25 pairs) in 13 trips by 05/19/2013, while “Risky Business” finished the planned number of hauls in 15 trips by 05/23/2013.

3.3 Sampling and data collection

A.I.S. supplied each vessel with an at-sea observer (data collector) to sample, measure and record operational and biological data. Weather and current sea conditions, GPS locations, time/date deployed and hauled, and photographic documentation of the fishing process were recorded. Water temperature was measured by a thermometer at the water surface.

Catch and bycatch were quantified from each haul (each string of netting). Monkfish and winter skate were the dominant species. The bycatch species of primary concern were Atlantic sturgeon (no sea turtles were caught). Animals landed on board are noted in two deposition categories: “Kept” and “Discarded”. Monkfish, and other kept and discarded species from each haul were weighed to the nearest 0.1 lb using a Marel marine scale. All “Kept” monkfish were measured for their total lengths to the nearest cm and no sub-samples were taken. Legal sized fish permitted to land and in marketable condition were kept while sublegal fish, non-permitted, and non-marketable species were discarded after obtaining weights.

Atlantic sturgeon were measured (fork length and total length) and weighed when possible. Individuals were scanned for tags and released immediately if alive and in good condition. DNA samples (fin clips) were obtained for two Atlantic sturgeons that were released alive and for one deceased sturgeon that was discarded. Four other deceased sturgeons were kept (whole animal) and frozen for sampling per NOAA Fisheries directive. The position in the gillnet where sturgeons were captured was noted if possible, in terms of “shot” – the net number from the hauling end, the horizontal and vertical quarter in each net, as illustrated in Figure 3.

3.4 Cruise report

Weekly progress reports containing a summary of fishing effort and catch were composed and submitted to NOAA COR after the completion of each week's sea trials. The weekly reports kept the NOAA COR up to date on the progress so that potential problems could be discussed and resolved. The weekly progress reports are enclosed as Appendix 2.

3.5 Data management

All data collected at sea were recorded in a NOAA-approved data sheet on a haul-by-haul basis. Upon completion of each trip, the data collectors reviewed their data for accuracy and comprehensiveness and then submitted to the PM. The PM reviewed the data for missing or unclear information and worked with the data collector to resolve any issues. Following the completion of the final trip all data sheets were delivered to SMAST for data entry and analysis. The filled sheets were then scanned and are attached as Appendix 3. The data were initially entered into a Microsoft Access database, and then exported to other formats for analysis and graphing. A copy of Access database containing original data is submitted together with this report.

3.6 Data analysis

Exploratory examination of data revealed that monkfish and winter skate occupied the majority of catch, with the remaining species sharing <15% of the total weight captured. Therefore, the catch analysis concentrated on monkfish and winter skate. The study's goal was to evaluate the effectiveness of the low profile gillnet on the bycatch of Atlantic sturgeon and sea turtles to determine if their capture rates were reduced. As no turtles were captured or observed, no further comments will be made on turtles.

As there were considerable variations in soak time during the course of research both within and between vessels (ranging between 18.0 to 72.3 h), and soak time is known to affect catch, the data used for analysis were adjusted to 24-h soak, i.e. the weight of catch for the species was divided by the soak time in hours and multiplied by 24 to represent the amount of catch per 24 hours of soak time.

We analyzed the data for each vessel, comparing the regular commercial gillnets (Control, or Ctrl) and the low profile nets (Experimental, or Exp). Paired t-test was used for continuous variables (weight) applicable to all target and discard species, except for sturgeon. For sturgeon analyses, we used Wilcoxon Signed-rank Test for discrete variables – the number of sturgeon captured by different nets.

We also explored whether the data from the two vessels could be combined to increase the number of pairs and statistical power. We used the paired t-test to compare catch weight of concerned species between the two vessels for the period both vessels were fishing, i.e., between 05/02/2013 and 05/19/2013. We used Wilcoxon Signed-rank Test to compare the catch of sturgeon between the two vessels. Only the data for Control nets were used for this comparison because no sturgeons were caught in the Experimental nets for either vessel. -

We tested Effect Size of the differences between the Control and Experimental gillnets. The Effect Size indicates big or important the differences are. The Effect Size is calculated as the mean difference between the groups divided by the standard deviation of the Control group. Typically the Effect Size is interpreted as follows:

Effect Size	<0.1	0.1 – 0.3	0.3 – 0.5	>0.5
Effect	trivial	small	moderate	large

We examined whether the difference of catch was related to the length of fish for monkfish. This was the only species with sufficient number of individuals with length measurements for analysis. We used Generalized Linear Mixed Model (GLMM) using R statistical package with the following procedures.

The proportion of monkfish (Φ) kept at length (L) by the Experimental nets can be expressed for each length and each pair as:

$$\Phi(L) = N_{L,Exp} / (N_{L,Exp} + N_{L,\ Ctrl})$$

where $N_{L,Exp}$ and $N_{L,\ Ctrl}$ are number of monkfish at length L measured for the Experiment net and the Control net respectively. A value of $\Phi = 0.5$ indicates that there are no differences in the catch in numbers between two types of nets at length L. The catch at length proportion Φ(L) for monkfish from two nets was analyzed using the Generalized Linear Mixed Model (GLMM) with L as the explanatory variable, Φ(L) as the response variable; and the individual pair, vessel, depth and location as random effects, following the method described in Holst and Revill (2009) and as applied by He and Balzano (2013). The GLMM was implemented using the glmmPQL function in MASS package of the R statistical software, which uses a penalized quasilikelihood approach. A random intercept polynomial regression GLMM was used to fit curves for the expected proportions of the catch retained by the experiment net, after logit transformation, as:

$$\text{logit}[\Phi(L)] = \beta_0 + \beta_1 L + \beta_2 L^2 + \beta_3 L^3$$

The analyses began by fitting the third order polynomials followed by subsequent reductions of terms until all terms showed statistical significance ($p<0.05$) based on the Wald's test, with removal of one level of the polynomial at a time to determine the best model fit (either constant, linear, 2nd order, and 3rd order).

4. Results

4.1 Operations

Vessels fished in close proximity, with "Risky Business" about 2-3 nautical miles north of "Landon Blake". The depth of the grounds fished by the vessels ranged from 14 to 20 fm, and there were no statistical differences between depths fished by two vessels ($p=0.279$, two-tailed t-test). "Risky Business" fished in waters about 1 °C colder than that of "Landon Blake" and the differences were statistically different ($p=0.018$, two-tailed t-test). This may be due to "Risky Business" fishing slightly north of "Landon Blake". While both vessels' soak time ranged from about 18 to 72 hours, "Risky Business" had longer soak time on average than "Landon Blake" (44.6 h vs. 32.9 h), and differed statistically ($p=0.004$). For each vessel, however, there were no statistical differences in fishing depth, water temperature and soak time between the control and the experimental nets ($p>0.1$, paired t-test).

4.2 Catch and bycatch – general descriptions

A total of 100 strings of nets were hauled, containing 50 pairs of data (25 pairs for each vessel), between 05/02/2013 and 05/23/2013. Overall, "Landon Blake" caught 23,407.7 lbs of fish with 9,858.7 lbs of Kept monkfish and 9,815.9 lbs of Kept winter skate (Table 2a). "Risky Business" caught substantially more fish in total, for Kept monkfish and for Kept winter skate (Total: 45,770.4 lbs, Kept monkfish: 17,305.0 lbs; Kept winter skate: 21,338.8 lbs, Table 2b). A total of seven Atlantic sturgeons were caught during the sea trials. No sea turtles were caught or observed. No marine mammals were caught or interacted with the control or experimental nets on either vessel.

A total of 13 identified species (excluding Atlantic sturgeon) were encountered during the sea trials totaling 69,178 lbs, 40.9% were monkfish (28,356.2 lbs), 45.2% were winter skate (31,303.8 lbs). They accounted for more than 85% of the total catch when combined. Their catches in different types of nets and by different vessels are analyzed in detail. Other species caught in some quantities included horseshoe crab (*Limulus polypyhemus*), little skate (*Leucoraja erinacea*), spiny dogfish (*Squalus acanthias*), smooth dogfish (*Mustelus canis)*, and angel shark (*Squatina dumeril*), as listed in Table 3. The remaining species, caught in small quantities, included clearnose skate (*Raja eglanteria*), bluefish (*Pomatomus saltatrix*), summer flounder (*Paralichthys dentatus*), northern stargazer (*Astroscopus guttatus),* Atlantic menhaden *(Brevoortia tyrannus),* American lobster (*Homarus americanus*), rock crab (*Cancer irroratus*)*,* and spider crab (unspecified). They are together listed in Table 3 as “All other”.

4.3 Atlantic sturgeon

Altogether seven Atlantic sturgeons were captured by the two vessels, four by “Landon Blake” and three by “Risky Business”, all from Control nets. No sturgeons were caught in the Experimental gillnets. The details of sturgeon captured are provided in Table 4.

Soak times of the gillnets by which sturgeons were caught ranged from 21.8 to 72 hours. Depth ranged from 15 to 18 fm. Five of the seven were hauled back dead, while two were released alive. Those two that were alive had soak times less than 24 hours. None of sturgeons that were from gillnets soaked for more than 24 hours were alive. Mean fork length was 147 cm ranging from 133 to 167.5 cm. Sturgeon that were alive were released as soon as possible. Three sturgeons were located in the 4th vertical quarter/3rd horizontal quarter, one was located in the 3rd vertically and 4th horizontally, and the rest did not have documented positions within the gillnet.

The number of sturgeons captured was analyzed using Wilcoxon Signed Rank Test. When analyzed separately for each vessel, the reduction in sturgeon catch was statistically significant for “Landon Blake” ($p<0.001$), but not for “Risky business” ($p>0.2$). Catch rates of the Control nets for sturgeon between the two vessels were also compared by the same method, and were found not statistically different (p>0.2). Therefore we pooled the data between the vessels and tested for a sample size of 50. The reduction in the catch rates for sturgeon by the low profile Experimental was statistically significant when compared with the Control net (p<0.001). The combined data produced and Effect Size of 0.400, indicating that the effect is "moderate". Table 5 provides details of statistical results for sturgeon.

4.4 Target species

4.4.1 Catch per string

Monkfish and winter skate were target species, and shared the majority of the catch for both vessels. A haul-by-haul plot of kept catch per string of net for each species is shown in Figure 4 for "Landon Blake" and in Figure 5 for "Risky Business".

For "Landon Blake", the mean catch rates per string between the Control and the Experimental nets were comparable for both monkfish (reduced by 5.1%,) and winter skate (increased by 16.5%). The differences between the nets were not statistically significant for either species (monkfish p=0.600; winter skate p=0.080), and their effect can be considered as "small" as indicated by the Effect Size (monkfish ES=0.140; winter skate ES=0.160). Table 6 listed details of statistical tests and results.

For "Risky Business", the mean catch rates of monkfish per string were 25.3% higher in Control nets compared with the Experimental nets but mean catch rates of winter skate were higher in the Experimental nets (3.3% increase). The differences between the nets were statistically significant for monkfish (p=0.012), but not statistically significant for winter skate (p=0.520). The reduction in monkfish catch can be considered as "moderate" as indicated by the Effect Size of 0.363, but the increase in the catch of winter skate was "trivial" as indicated by the Effect Size of 0.024 (Table 6).

4.4.2 Catch per string per 24-h soak

In light of wide variations in soak time for both vessels, catch per string was also standardized to a 24-h soak. The soak-corrected catch rates for major species are provided in Table 7 and also plotted in Figure 6 ("Landon Blake") and Figure 7 ("Risky Business"). There was a general trend of catch increase per 24-h soak as the study progressed (Figure 8). In Figure 8, the gillnet string from which a sturgeon was caught is indicated (square symbol).

For “Landon Blake”, the mean catch rates per string per 24-h soak between the Control and the Experimental nets was again comparable for both monkfish (reduced by 8.5%,) and winter skate (increased by 14.0%). The differences between the nets were not statistically significant for both species (monkfish p=0.334; winter skate p=0.221), and their effect can be considered as “small” as indicated by the Effect Size (monkfish ES=0.173; winter skate ES=0.135) (Table 6).

For “Risky Business”, the mean catch rates of monkfish per string per 24-h soak were 22.3% higher in Control nets compared with the Experimental net, but the catch rates were almost identical for winter skate (reduced by 0.5%). The differences in catch rates between the nets were statistically significant for monkfish (p=0.012), but not statistically significant for winter skate (p=0.914). Again, the reduction in monkfish can be considered as “moderate” as indicated by the Effect Size of 0.463, but the increase in the catch of winter skate was “trivial” as indicated by the Effect Size of 0.005 (Table 6).

We evaluated whether the data from two vessels could be pooled. As “Landon Blake” had completed all hauls by 05/19/2013, and “Risky Business” continued fishing on 05/20, 05/21, and 05/23, and because of the trend of increasing catch as the study progressed, we compared catch data between the two vessels for the period when both vessels were fishing, i.e., between 05/2 and 05/19. For both kept and total monkfish and winter skate, and for both Control and Experimental strings, there were no differences in the catch rates per string per 24-h soak between the two vessels. We therefore also analyzed the pooled data from the two vessels.

When both vessels’ data were combined, and for all 50 pairs including hauls that “Risky Business” fished alone on 05/20, 05/21 and 05/23, the Control strings produced 204.9 lbs on average of kept monkfish for a 24-h soak, while the experimental strings yielded 171.9 lbs, a mean reduction of 33 lbs or 16.1%. The differences were statistically different (p=0.010), and the effect can be considered as “moderate” (Table 6). For winter skate, the Control strings produced 163.8 lbs on average for a 24-h soak, while the experimental strings yielded 174.1 lbs, a mean increase of 10.3 lbs or 6.3%, but the differences were not statistically different (p=0.263), and the effect was “trivial” (Table 6).

4.4.3 Target species catch in relation to total catch

We analyzed the catch differences for monkfish (Control catch – Experimental catch) in relation to the total amount of catch in gillnets or the total amount of monkfish in the gillnet to examine if catch-related net deformation (collapse or rollup due to catch) or net saturation would affect the catch of monkfish. As the range of the total catch or the monkfish catch for "Landon Blake" was minimal, and there were no differences in the catch rates of monkfish between Control and Experimental nets, the analysis of monkfish catch differences in relation to total catch amount could not be done for this vessel. Monkfish catch differences in relation to catch amount were analyzed for "Risky Business" as there was a large range of total catch amount during the study for this vessel.

Generally, the total monkfish catch differences between the Control and the Experimental nets increased with either the total fish caught in the Control net or the total monkfish caught in the Control net (Figure 9). This illustrates that if more fish was caught in the net, the capture efficiency of the low profile Experimental net was reduced.

4.4.4 Monkfish length

Altogether 2,267 individuals of monkfish were measured for lengths, of which 824 were from "Landon Blake" and 1,443 were from "Risky Business".

The length frequency distribution of monkfish for "Landon Blake" is shown in Figure 10a, and GLMM results are shown in Figure 10b. GLMM analysis indicated that retention of monkfish by Control and Experimental nets was not length-related, and the logit-constant fit was the best fit for the data. The mean value of $N_{L,Exp} / (N_{L,Exp} + N_{L, Ctrl})$ did not differ from the expected 0.5 (p=0.497).

The length frequency distribution of monkfish for "Risky Business" is shown in Figure 11a, and GLMM results are shown in Figure 11b. GLMM analysis indicated that retention of monkfish could best be modeled by a logit-linear model, with p-value of 0.006 for intercept indicating the Experimental net caught significantly fewer monkfish, and a p-value of 0.033 for slope indicating the reduction is significantly length-related. The model indicated that the Experimental net caught fewer monkfish smaller than 75 cm compared to the Control net, but there were no differences between the nets in the number of monkfish caught above 75 cm in length.

When lengths from both vessels were combined (Figure 12a), GLMM analysis indicated that retention of monkfish could best be modeled by logit-linear model (Figure 12b). Similar to the results from “Risky Business”, the model indicated that the Experimental net caught fewer monkfish smaller than 75 cm when compared to the Control net, but there were no differences between nets for monkfish above 75 cm in length.

4.5 Other species

In addition to monkfish, winter skate and Atlantic sturgeon, 11 other species were caught in both types of nets and by both vessels. Among those bycatch species, horseshoe crab accounted for 40% to 88% by weight on average among different types of nets and vessels (Table 4). For both horseshoe crab and for the total bycatch species, “Risky Business” caught significantly more than “Landon Blake” both for the Control nets and for the Experimental nets ($p<0.01$).

For “Landon Blake”, Experimental nets caught significantly more horseshoe crab (48.5 lbs per string vs. 27.9 lbs per string, $p=0.005$) than Control nets. However, the total catch of the 11 bycatch species combined was not statistically different between the Control and Experimental nets for this vessel (70.0 lbs per string vs. 67.7 lbs per string, $p=0.825$) (Figure 13).

For “Risky Business”, Experimental nets caught significantly more horseshoe crab (116.6 lbs per string vs. 85.9 lbs per string, $p=0.009$) than Control nets. However, the total catch of the 11 bycatch species combined was not statistically different between the Control and Experimental nets for this vessel (110.2 lbs. per string vs. 132.9 lbs per string, $p=0.095$) (Figure 14).

5. Discussion

The results indicated that the experimental low profile net reduced the bycatch of Atlantic sturgeon in the monkfish gillnet fishery in the Mid-Atlantic. Of the seven individual sturgeons captured during the sea trials, none were captured by the low profile Experimental nets. While the result was statistically significant for one of the vessels, and when the data for both vessels were combined, the sample size was too small to draw firm conclusions. This result however does provide evidence that lowering the head rope height to gillnet can reduce sturgeon bycatch.

Fox et al. (2013) tested the same low profile net in the New York Bight in November 2012, and encountered a larger number of Atlantic sturgeons in both control and experimental gillnets. While their experimental net also caught fewer sturgeons, the difference was not statistically significant. In this study that was conducted in May, none of the sturgeons caught were from the low profile nets. It may be possible that there is a behavioral difference in sturgeon that might affect their potential for capture in bottom set gillnets (D. Fox, personal communication). While we did not measure visibility of water on the grounds, differing visibility due to location, freshwater run-off, and season conditions may alter the sturgeons' ability to avoid gillnets.

While the result of sturgeon by-catch reduction from this study is very promising, a reduction of monkfish catch was also observed in the experimental nets; especially during periods where catch rates were high. "Landon Blake" had relatively lower catch rates of monkfish, winter skate and total of all species during the entire period, therefore there were no significant differences in catch rates between the Control and the Experimental nets. On the other hand, "Risky Business" experienced higher catch rates for monkfish, winter skates and all species combined. When catch rates were high, a significant reduction in monkfish catch was observed in the experimental nets. When monkfish catch rates were less than 600 lbs, or the total catch for all species was less than 1,500 lbs per string in the Control nets, there were no differences in monkfish catch rates between the Control and Experimental nets (Figure 9). By comparison, the average catch rates of monkfish in the study Fox et al. (2013) was less than 50 lbs per string, and coincidently, no differences in monkfish catch rates were observed between the control and low profile experimental nets. It is conceivable that higher catch rates require a larger gillnet webbing area in order to continue catching or retaining the fish. When monkfish are abundant, low profile gillnets may result in reduced catch. The monkfish catch rates experienced by "Risky Business" during the last 5 strings of nets between 05/19 and 05/23 (600 to 1200 lbs.) represented "commercial" catch rates. Unfortunately, great reductions in monkfish catch were experienced in the Experimental nets during that period. Therefore future research should explore low headrope height nets with sufficient number of vertical meshes, for example 12-mesh webbing with 24" tie-downs.

Using the Generalized Linear Mixed Model technique, we noticed that reductions of the catch of monkfish on the F/V Risky Business was mostly a reduction in catch of smaller fish less than 75 cm in length. There were no differences in catch rates for fish greater than 75 cm. It is possible that smaller monkfish are higher off the seabed compared with larger monkfish, but this needs further verification.

No reductions in winter skate catch were observed for both vessels, and during the periods of low or high catch rates, either per string or standardized for soak time. Skates may be closer to the seabed, and may continued to be caught when the headrope of a gillnet sinks to the bottom due to other catches on the net.

In conclusion, the low profile gillnets (8-mesh deep with 24" tie-downs) caught significantly less sturgeon than the regular 12-mesh gillnets. In fact, no sturgeons were caught by the low profile nets during the 50 pairs of comparative fishing. Catch rates of monkfish were comparable between the two nets when the catch rates were low, but significant reductions were observed in the experimental nets when catch rates were high. Additionally there were no reductions in the catch of winter skate during the entire period of fishing and by both vessels. Future research may explore low headrope height nets with sufficient number of vertical meshes such as nets with 12-mesh webbing and 24" tie-downs.

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TABLES

Table 1. Operation details during gillnet sea trials, including dates, position of nets, water depth and soak time, and weather sea conditions at the time the nets were hauled. Pair No., Trip ID, and Haul Number can be used to identify fishing conditions in subsequent table.

Pair No.	Trip ID	Date hauled	Weather /Sea				Control								Experimental							
			Wind		Wave	Sky	Haul	Soak	Position haul start		Position haul end		Depth	Temp	Haul	Soak	Position haul start		Position haul end		Depth	Temp
			Dir.	Spd(kt)	Hgt (ft)	Condition	No.	time (h)	Lat	Long	Lat	Long	(fm)	(°C)	No.	time (h)	Lat.	Long.	Lat.	Long.	(fm)	(°C)
F/V "Landon Blake"																						
1	LB001	5/2/13	45	18	4	pt cloudy	1	72.0	37.8097	-74.9800	37.8106	-74.9686	16	11.1	2	72.0	37.8103	-74.9686	37.8096	-74.9558	17	10.6
2	LB001	5/2/13	45	18	4	pt cloudy	3	72.0	37.8097	-74.9547	37.8092	-74.9450	17	11.1	4	72.0	37.8092	-74.9917	37.8100	-74.9825	17	10.6
3	LB002	5/5/13	45	30	8	pt cloudy	6	70.4	37.8114	-74.9803	37.8103	-74.9694	17	11.1	5	69.1	37.8083	-74.9936	37.8100	-74.9822	16	10.6
4	LB002	5/5/13	45	30	8	pt cloudy	8	71.9	37.8094	-74.9558	37.8086	-74.9444	18	11.1	7	71.1	37.8097	-74.9678	37.8119	-74.9747	18	10.6
5	LB003	5/8/13	225	5	2	pt cloudy	9	70.0	37.8094	-74.9564	37.8097	-74.9431	17	11.1	10	70.4	37.8097	-74.9672	37.8094	-74.9564	18	10.6
6	LB004	5/9/13	225	6	2	pt cloudy	12	24.5	37.8097	-74.9803	37.8094	74.9683	17	11.7	11	23.2	37.8094	-74.9928	37.8094	-74.9083	16	11.1
7	LB004	5/9/13	225	6	2	pt cloudy	14	24.2	37.8097	-74.9556	37.8094	-74.9436	18	11.7	13	23.1	37.8097	-74.9669	37.8094	-74.9561	18	11.1
8	LB005	5/10/13	225	5	1	pt cloudy	15	21.8	37.8086	-74.9703	37.8086	-74.9817	18	13.9	16	22.0	37.8089	-74.9828	37.8092	-74.9922	17	13.3
9	LB005	5/10/13	225	5	1	pt cloudy	17	23.6	37.8094	-74.9447	37.8083	-74.9572	18	13.9	18	23.9	37.8083	-74.9578	37.8092	-74.9689	19	13.3
10	LB006	5/11/13	248	15	3	cloudy	20	23.3	37.8083	-74.9828	37.8078	-74.9939	17	14.4	19	23.1	37.8083	-74.9694	37.8078	-74.9806	18	13.9
11	LB006	5/11/13	248	15	3	cloudy	22	23.4	37.8097	-74.9567	37.8092	-74.9689	18	14.4	21	23.0	37.8097	-74.9447	37.8092	-74.9550	17	13.9
12	LB007	5/13/13	0	14	2	pt cloudy	23	23.1	37.8081	-74.9706	37.8081	-74.9814	18	15.0	24	23.4	37.8078	-74.9833	37.8086	-74.9942	16	14.4
13	LB007	5/13/13	0	14	2	pt cloudy	25	23.2	37.8097	-74.9439	37.8086	-74.9553	17	15.0	26	23.5	37.8089	-74.9572	37.8083	-74.9678	17	14.4
14	LB008	5/14/13	0	12	2	pt cloudy	28	23.9	37.8081	-74.9825	37.8081	-74.9939	17	14.4	27	24.7	37.8081	-74.9697	37.8078	-74.9806	18	13.9
15	LB008	5/14/13	0	12	2	pt cloudy	30	25.3	37.8078	-74.9925	37.8081	-75.0044	-	14.4	29	24.4	37.8078	-74.9967	37.8081	-75.0069	-	13.9
16	LB009	5/15/13	180	-	3	pt cloudy	31	21.2	37.8075	-74.9667	37.8075	-74.9908	18	15.0	32	21.4	37.8078	-74.9808	37.8075	-74.9908	16	14.4
17	LB009	5/15/13	180	-	3	pt cloudy	34	21.7	37.8083	-75.0067	37.8083	-75.0169	-	15.0	33	21.4	37.8078	-74.9928	37.8078	-75.0047	16	14.4
18	LB010	5/16/13	180	7	2	pt cloudy	36	21.3	37.8083	-75.0022	37.8086	-75.0139	16	15.6	35	21.0	37.8081	-74.9903	37.8083	-75.0011	16	15.0
19	LB010	5/16/13	180	7	2	pt cloudy	38	24.4	37.8072	-75.0303	37.8067	-75.0414	15	15.6	37	24.2	37.8078	-75.0181	37.8078	-75.0292	16	15.0
20	LB011	5/17/13	0	2	1	pt cloudy	39	23.1	37.8072	-74.9900	37.8069	-75.0017	17	16.7	40	23.6	37.8075	-75.0028	37.8083	-75.0139	16	16.1
21	LB011	5/17/13	0	2	1	pt cloudy	41	23.0	37.8069	-75.0147	37.8069	-75.0267	15	16.7	42	23.3	37.8064	-75.0283	37.8061	-75.0386	16	16.1
22	LB012	5/18/13	90	5	1-2	pt cloudy	44	23.7	37.8078	-75.0028	37.8086	-75.0142	17	16.7	43	23.6	37.8069	-74.9900	37.8072	-75.0008	17	16.1
23	LB012	5/18/13	90	5	1-2	pt cloudy	46	23.7	37.8058	-75.0292	37.8094	-75.0367	15	16.7	45	23.4	37.8078	-75.0161	37.8058	-75.0275	16	16.1
24	LB013	5/19/13	180	20	6	pt cloudy	48	23.3	37.8061	-75.0267	37.8075	-75.0147	16	16.7	47	23.1	37.8053	-75.0381	37.8056	-75.0272	16	16.1
25	LB013	5/19/13	180	20	6	pt cloudy	50	26.2	37.8072	-75.0019	37.8067	-74.9894	-	16.7	49	25.5	37.8075	-75.0142	37.8078	-75.0028	-	16.1
F/V "Risky Business"																						
1	RB001	5/2/13	45	15	6	pt cloudy	3	72.0	37.8661	-74.9600	37.8675	-74.9492	17	10.0	1	72.0	37.8683	-74.9475	37.8711	-74.9231	17	10.6
2	RB001	5/2/13	45	15	6	pt cloudy	4	72.0	37.8697	-74.9364	37.8703	-74.9256	17	10.0	2	72.0	37.8711	-74.9231	-	-	17	10.0
3	RB002	5/5/13	45	30	8	pt cloudy	5	72.0	37.8650	-74.9478	37.8669	-74.9367	17	10.0	6	72.0	37.8692	-74.9214	37.8689	-74.9125	15	10.0
4	RB002	5/5/13	45	30	8	pt cloudy	7	72.0	37.8669	-74.9339	37.8689	-74.9239	15	10.0	8	72.0	37.8714	-74.9094	37.8728	-74.8992	19	10.0
5	RB003	5/7/13	135	10	3	cloudy	10	47.8	37.8728	-74.9294	37.8717	-74.9378	16	10.0	9	47.5	37.8742	-74.9164	37.8728	-74.9281	18	10.0
6	RB003	5/7/13	135	10	3	cloudy	12	48.9	37.8664	-74.9553	37.8639	-74.9656	17	10.0	11	48.7	37.8706	-74.9428	37.8667	-74.9547	17	10.0
7	RB004	5/9/13	135	5	2	clear	13	43.9	37.8744	-74.9161	37.8731	-74.9281	18	11.1	14	44.2	37.8731	-74.9292	37.8717	-74.9397	17	11.1
8	RB004	5/9/13	135	5	2	clear	15	43.1	37.8717	-74.9414	37.8694	-74.9525	17	11.1	16	43.8	37.8697	-74.9536	37.8661	-74.9464	18	11.1
9	RB005	5/10/13	225	5	1	pt cloudy	18	24.4	37.8633	-74.9444	37.8647	-74.9319	16	12.2	17	24.1	37.8617	-74.9572	37.8633	-74.9453	17	12.2
10	RB005	5/10/13	225	5	1	pt cloudy	20	24.9	37.8656	-74.9181	37.8661	-74.9083	19	12.2	19	24.7	37.8644	-74.9311	37.8658	-74.9208	14	12.2
11	RB006	5/11/13	225	10	3	rain	21	18.5	37.8572	-74.9739	37.8606	-74.6333	15	13.6	22	18.8	37.8614	-74.9617	37.8644	-74.9514	17	13.9
12	RB006	5/11/13	225	10	3	rain	23	19.0	37.8650	-74.9497	37.8669	-74.9386	18	13.9	24	19.3	37.8678	-74.9367	37.8683	-74.9269	17	13.9
13	RB007	5/12/13	225	5	3	cloudy	26	22.4	37.8639	-74.9564	37.8664	-74.9456	17	13.9	25	22.1	37.8597	-74.9675	37.8633	-74.9564	17	13.9
14	RB007	5/12/13	225	5	3	cloudy	28	22.9	37.8692	-74.9325	37.8703	-74.9203	16	13.9	27	22.7	37.8669	-74.9444	37.8686	-74.9333	18	13.9
15	RB008	5/13/13	315	15	3	pt cloudy	30	24.2	37.8514	-74.8569	37.8536	-74.8461	18	12.8	29	23.5	37.8497	-74.8694	37.8508	-74.8586	19	12.8
16	RB008	5/13/13	315	15	3	pt cloudy	32	25.6	37.8556	-74.8317	37.8564	-74.8206	19	12.8	31	24.9	37.8536	-74.8442	37.8556	-74.8336	19	12.8
17	RB009	5/15/13	5	18	4	cloudy	33	44.0	37.8561	-74.8186	37.8556	-74.8311	19	13.1	34	44.3	37.8556	-74.8319	37.8539	-74.8419	18	13.1
18	RB009	5/15/13	5	18	4	cloudy	35	44.6	37.8539	-74.8439	37.8522	-74.8553	19	13.1	36	44.9	37.8522	-74.8561	37.8514	-74.8664	18	13.1
19	RB010	5/16/13	180	8	2	clear	38	18.3	37.8444	-74.9522	37.8439	-74.9622	14	13.9	37	18.0	37.8461	-74.9411	37.8450	-74.9511	14	13.9
20	RB011	5/17/13	0	2	2	pt cloudy	40	46.7	37.8558	-74.8500	37.8569	-74.8397	19	15.0	39	46.4	37.8533	-74.8614	37.8553	-74.8517	18	15.0
21	RB012	5/19/13	180	20	5	cloudy	41	71.5	37.8436	-74.9592	37.8467	-74.9464	14	15.0	42	71.9	37.8461	-74.9461	37.8483	-74.9367	15	15.0
22	RB013	5/20/13	180	10	3	pt cloudy	43	70.2	37.8569	-74.8353	37.8539	-74.8458	20	15.0	44	70.9	37.8536	-74.8486	37.8519	-74.8581	18	15.0
23	RB014	5/21/13	180	8	2	cloudy	45	45.9	37.8528	-74.9633	37.8494	-74.9750	17	16.1	46	46.8	37.8492	-74.9758	37.8489	-74.9853	19	16.1
24	RB015	5/23/13	225	20	5	pt cloudy	47	46.7	37.8528	-74.9494	37.8508	-74.9614	15	17.2	48	47.5	37.8503	-74.9619	37.8494	-74.9719	16	17.2
25	RB015	5/23/13	225	20	5	pt cloudy	50	72.3	37.8500	-74.8564	37.8483	-74.8661	18	16.7	49	71.6	37.8531	-74.8450	37.8519	-74.8608	19	16.7

Table 2a. Catch of major species by deposition and total catch for F/V “Landon Blake”. Details of “All other species” are listed in Table 3.

F/V "Landon Blake"																							
Pair No.	Control (weight in lbs)										Experimental (weight in lbs)										All nets (weight in lbs)		
	Monkfish			Winter skate			All other species			All species	Monkfish			Winter skate			All other species			All species	Kept	Kept	All species
	Kept	Discarded	Total	Kept	Discarded	Total	Kept	Discarded	Total	Total	Kept	Discarded	Total	Kept	Discarded	Total	Kept	Discarded	Total	Total	Monkfish	W. skate	Total
1	234.0		234.0	504.0		504.0		46.0	46.0	784.0	181.5	2.0	183.5	626.0		626.0	2.5	44.5	47.0	856.5	415.5	1130.0	1640.5
2	142.0	23.5	165.5	489.0		489.0		40.0	40.0	694.5	351.0	29.0	380.0	621.0		621.0		38.5	38.5	1039.5	493.0	1110.0	1734.0
3	164.0	18.5	182.5	226.5	4.5	231.0		53.0	53.0	466.5	36.0	4.5	40.5	339.5	4.0	343.5		83.0	83.0	467.0	200.0	566.0	933.5
4	58.0	17.5	75.5	171.0	5.5	176.5	12.5	36.0	48.5	300.5	177.0	17.0	194.0	230.0		230.0	13.5	52.0	65.5	489.5	235.0	401.0	790.0
5	266.6	5.5	272.1	187.8	3.6	191.4	4.5	25.7	30.2	493.7	353.4	13.5	366.9	205.3		205.3		61.5	61.5	633.7	620.0	393.1	1127.4
6	154.1		154.1	42.6		42.6		19.2	19.2	215.9	181.0		181.0	127.2	5.0	132.2		33.7	33.7	346.9	335.1	169.8	562.8
7	208.7	10.9	219.6	56.2	2.7	58.9		58.6	58.6	337.1	217.1		217.1	51.8	2.0	53.8	4.3	49.8	54.1	324.9	425.8	108.0	662.0
8	292.4		292.4	52.0		52.0		27.6	27.6	372.0	152.9		152.9	88.7	2.0	90.7		64.1	64.1	307.7	445.3	140.7	679.7
9	276.4	11.2	287.6	52.1		52.1		60.4	60.4	400.1	249.9	4.3	254.2	34.7		34.7	5.5	39.9	45.4	334.3	526.3	86.8	734.4
10	170.3		170.3	47.2		47.2		41.6	41.6	259.1	234.3	7.7	242.0	25.9		25.9	13.1	54.4	67.5	335.4	404.6	73.1	594.5
11	205.8		205.8	28.5		28.5		131.4	131.4	365.7	143.8	2.0	145.8	71.7		71.7		70.8	70.8	288.3	349.6	100.2	654.0
12	284.6		284.6	70.9		70.9	50.9	92.4	143.3	498.8	307.0	5.0	312.0	99.5		99.5		156.0	156.0	567.5	591.6	170.4	1066.3
13	259.0	14.0	273.0	156.5		156.5	19.0	139.5	158.5	588.0	243.0	5.0	248.0	116.0		116.0	25.0	99.5	124.5	488.5	502.0	272.5	1076.5
14	141.8		141.8	9.5		9.5	67.7	38.6	106.3	257.6	62.1		62.1	66.8		66.8	10.0	64.6	74.6	203.5	203.9	76.3	461.1
15	429.5		429.5	25.0		25.0		34.5	34.5	489.0	177.5	11.5	189.0	58.0		58.0		65.0	65.0	312.0	607.0	83.0	801.0
16	157.0		157.0	47.5		47.5		50.0	50.0	254.5	123.5		123.5	133.0	5.5	138.5	41.0	47.5	88.5	350.5	280.5	180.5	605.0
17	180.0	4.0	184.0	180.0		180.0	90.5	53.0	143.5	507.5	127.5		127.5	76.5		76.5		33.0	33.0	237.0	307.5	256.5	744.5
18	217.5		217.5	96.5		96.5	33.0	36.5	69.5	383.5	316.0		316.0	108.0		108.0	22.5	31.0	53.5	477.5	533.5	204.5	861.0
19	205.5	4.0	209.5	127.0	4.5	131.5	87.5	21.0	108.5	449.5	326.0	4.0	330.0	98.0		98.0	21.5	39.5	61.0	489.0	531.5	225.0	938.5
20	182.5		182.5	146.0		146.0	49.5	68.0	117.5	446.0	153.0	16.0	169.0	87.5	1.0	88.5	22.5	26.5	49.0	306.5	335.5	233.5	752.5
21	151.5		151.5	77.0		77.0		42.5	42.5	271.0	136.0		136.0	57.5		57.5	62.5	83.5	146.0	339.5	287.5	134.5	610.5
22	159.5		159.5	300.0	2.0	302.0	30.0	16.0	46.0	507.5	135.5	4.0	139.5	229.5		229.5		89.5	89.5	458.5	295.0	529.5	966.0
23	115.0		115.0	340.0		340.0		96.5	96.5	551.5	152.0		152.0	274.0		274.0		50.0	50.0	476.0	267.0	614.0	1027.5
24	231.0		231.0	427.0	3.0	430.0		7.5	7.5	668.5	110.0		110.0	708.0	6.0	714.0	21.5	42.5	64.0	888.0	341.0	1135.0	1556.5
25	172.0		172.0	675.0		675.0	42.5	23.5	66.0	913.0	153.0		153.0	748.0	6.0	754.0		8.0	8.0	915.0	325.0	1423.0	1828.0
Total	5058.7	109.1	5167.8	4534.8	25.8	4560.6	487.6	1259.0	1746.6	11475.0	4800.0	125.5	4925.5	5,282.1	31.5	5313.6	265.4	1,428.3	1693.7	11932.7	9858.7	9,816.9	23407.7
Mean	202.3	4.4	206.71	181.4	1.0	182.4	19.5	50.4	69.9	459.0	192.0	5.0	197.02	211.3	1.3	212.5	10.6	57.1	67.7	477.3	394.3	392.7	936.3
SE	14.74	1.4	14.50	35.6	0.2	35.64	5.7	6.7	8.6	34.8	17.25	1.5	17.94	44.4	0.4	44.56	3.3	5.9	6.7	45.2	25.50	78.8	76.0

Table 2ab Catch of major species by deposition and total catch for F/V “Risky Business”. Details of “All other species” are listed in Table 3.

F/V "Risky Business"																							
Pair No.	Control (weight in lbs)										Experimental (weight in lbs)										All nets (weight in lbs)		
	Monkfish			Winter skate			All other species			All species	Monkfish			Winter skate			All other species			All species	Kept	Kept	All species
	Kept	Discarded	Total	Kept	Discarded	Total	Kept	Discarded	Total	Total	Kept	Discarded	Total	Kept	Discarded	Total	Kept	Discarded	Total	Total	Monkfish	W. skate	Total
1	208.3	32.0	240.3	497.0		497.0	12.0	57.0	69.0	806.3	129.0		129.0	750.0		750.0		328.2	25.5	904.5	337.3	1247.0	1710.8
2	306.0	31.0	337.0	688.0	11.0	699.0		29.0	29.0	1065.0	113.3	19.0	132.3	659.0		659.0		33.5	33.5	824.8	419.3	1347.0	1889.8
3	229.3	34.0	263.3	217.0		217.0		49.5	49.5	529.8	61.5	36.3	97.8	442.0		442.0		77.5	77.5	617.3	290.8	659.0	1147.1
4	86.0	63.8	149.8	222.5	49.5	272.0	7.0	70.0	77.0	498.8	81.5	48.5	130.0	234.0		234.0		59.0	59.0	423.0	167.5	456.5	921.8
5	410.3		410.3	234.0		234.0	9.5	105.0	114.5	758.8	141.0	12.5	153.5	244.5		244.5		34.0	34.0	432.0	551.3	478.5	1190.8
6	358.5	10.8	369.3	182.0		182.0	9.0	84.0	93.0	644.3	223.0	26.0	249.0		8.5	8.5		74.8	74.8	332.3	581.5	182.0	976.6
7	390.5	32.3	422.8	245.0	11.5	256.5		108.8	108.8	788.1	486.5	7.5	494.0	145.5	3.3	148.8	14.0	250.0	264.0	906.8	877.0	390.5	1694.9
8	433.3		433.3	151.0		151.0	1.0	23.7	24.7	609.0	185.5	3.3	188.8	186.0		186.0	8.0	187.0	195.0	569.8	618.8	337.0	1178.8
9	388.0	28.5	416.5	156.0		156.0		91.0	91.0	663.5	241.3		241.3	73.5		73.5		152.0	152.0	466.8	629.3	229.5	1130.3
10	207.9	19.5	227.4	48.3		48.3		113.3	113.3	389.0	139.8	4.5	144.3	47.5		47.5		195.0	195.0	386.8	347.7	95.8	775.8
11	137.0		137.0	34.5		34.5	11.0	95.8	106.8	278.3	90.1		90.1	58.5		58.5		127.5	127.5	276.1	227.1	93.0	554.4
12	246.8		246.8	66.0		66.0		114.0	114.0	426.8	104.2		104.2	48.0		48.0		150.5	150.5	302.7	351.0	114.0	729.5
13	155.1		155.1	21.0		21.0	5.0	91.5	96.5	272.6	211.3		211.3	59.0		59.0		91.0	91.0	361.3	366.4	80.0	633.9
14	259.1	30.8	289.9	28.0		28.0	11.5	67.5	79.0	396.9	262.6		262.6	26.5		26.5	9.0	106.5	115.5	404.6	521.7	54.5	801.5
15	250.5	30.0	280.5	169.5		169.5	9.5	130.3	139.8	589.8	196.8	3.5	200.3	157.5		157.5		57.0	57.0	414.8	447.3	327.0	1004.6
16	243.0	23.3	266.3	149.0		149.0		79.5	79.5	494.8	341.5	19.0	360.5	159.5		159.5		111.8	111.8	631.8	584.5	308.5	1126.6
17	191.5	80.5	272.0	371.0		371.0		169.0	169.0	812.0	494.2	20.0	514.2	352.0	7.0	359.0		187.8	187.8	1061.0	685.7	723.0	1873.0
18	369.8	28.3	398.1	316.5		316.5		124.5	124.5	839.1	517.5	15.5	533.0	244.0		244.0		223.0	223.0	1000.0	887.3	560.5	1839.1
19	149.5	41.0	190.5	93.5		93.5		24.6	24.6	308.6	118.0	28.5	146.5	75.5		75.5	27.0	122.5	149.5	371.5	267.5	169.0	680.1
20	846.5	70.5	917.0	468.0		468.0		152.0	152.0	1537.0	598.8	63.5	662.3	373.0		373.0		190.0	190.0	1225.3	1445.3	841.0	2762.3
21	639.0	23.0	662.0	571.5		571.5	23.0	180.5	203.5	1437.0	674.0	13.0	687.0	812.5		812.5		144.5	144.5	1644.0	1313.0	1384.0	3081.0
22	765.0	13.0	778.0	2019.0		2019.0		77.0	77.0	2874.0	502.0	11.0	513.0	2082.5		2082.5		73.0	73.0	2668.5	1267.0	4101.5	5542.5
23	593.8		593.8	497.5		497.5		167.0	167.0	1258.3	356.1		356.1	564.0		564.0	25.0	148.5	173.5	1093.6	949.9	1061.5	2351.9
24	807.0		807.0	738.5		738.5	23.0	175.0	198.0	1743.5	507.3	5.0	512.3	838.5		838.5		182.0	182.0	1532.8	1314.3	1577.0	3276.3
25	1234.5	29.0	1263.5	2313.0		2313.0	25.0	229.0	254.0	3830.5	622.0		622.0	2208.5		2208.5		236.0	236.0	3066.5	1856.5	4521.5	6897.0
Total	9906.2	621.3	10527.5	10497.3	72.0	10569.3	146.5	2608.5	2755.0	23851.8	7398.8	336.6	7735.4	10841.5	18.8	10860.3	83.0	3542.6	3625.6	21918.6	17305.0	21338.8	45770.4
Mean	396.2	24.9	421.1	419.9	2.9	422.8	5.9	104.3	110.2	954.1	296.0	13.5	309.4	433.7	0.8	434.4	3.3	141.7	145.0	876.7	692.2	853.6	1830.8
SE	55.2	3.8	55.0	113.1	4.4	113.0	1.5	10.5	11.4	166.6	39.1	3.3	39.5	116.1	0.5	115.1	1.8	14.7	13.5	142.7	88.3	227.3	307.1

Table 3. Details of catch of less important (mostly discarded) species referred to as "All other species" in Table 2a and 2b.

F/V "Landon Blake"

Pair No.	Control (weight in lbs)							Experimental (weight in lbs)						
	Horseshoe crab	Spiny Dogfish	Little Skate	Smooth Dogfish	Angel Shark	All other	Total	Horseshoe crab	Spiny Dogfish	Little Skate	Smooth Dogfish	Angel Shark	All other	Total
1	35.0	1.5	4.5	0	0	5	46.0	33.5	0	4	0	0	9.5	47.0
2	15.5	15	6	0	0	3.5	40.0	31.5	0	7	0	0	0.0	38.5
3	24.0	17	8	0	0	4	53.0	48.0	7.5	14	13.5	0	0.0	83.0
4	12.0	21	3	0	0	12.5	48.5	36.0	0	11	4.5	0	14.0	65.5
5	6.3	6.8	3.4	0	0	13.7	30.2	44.1	0	5.6	8.6	0	3.2	61.5
6	9.8	0	3.5	0	0	5.9	19.2	33.7	0	0	0	0	0.0	33.7
7	34.7	9.6	1.8	0	0	12.5	58.6	49.8	0	3.75	0	0	0.5	54.1
8	19.9	0	1.2	0	6.5	0	27.6	60.7	0	0	0	0	3.4	64.1
9	47.3	4.9	3.1	0	0	5.1	60.4	38.1	0	1.8	0	0	5.5	45.4
10	39.1	0	2.5	0	0	0	41.6	52.9	0	0	0	0	14.6	67.5
11	93.7	35.5	2.2	0	0	0	131.4	48.5	0	0	22.3	0	0.0	70.8
12	27.4	7	2	0	0	106.9	143.3	138.0	0	0	0	18	0.0	156.0
13	72.0	0	1.5	0	11.5	73.5	158.5	97.0	0	2.5	0	0	25.0	124.5
14	25.8	6.3	4	0	0	70.2	106.3	56.7	0	0	0	7.9	10.0	74.6
15	6.5	27	1	0	0	0	34.5	61.5	0	3.5	0	0	0.0	65.0
16	29.0	7.5	2	0	11.5	0	50.0	46.5	0	1	41	0	0.0	88.5
17	19.5	0	5	117	0	2	143.5	33.0	0	0	0	0	0.0	33.0
18	35.0	0	1.5	33	0	0	69.5	31.0	0	0	22.5	0	0.0	53.5
19	11.0	0	0.5	87.5	0	9.5	108.5	18.5	0	1	21.5	11.5	8.5	61.0
20	54.5	8.5	5	49.5	0	0	117.5	24.0	0	2.5	22.5	0	0.0	49.0
21	23.0	0	4	0	15.5	0	42.5	70.0	0	0.5	62.5	13	0.0	146.0
22	6.5	5	1.5	31	0	2	46.0	87.5	0	2	0	0	0.0	89.5
23	44.5	23.5	6	0	21	1.5	96.5	25.0	5.5	7	0	12	0.5	50.0
24	0.0	0	1	0	6.5	0	7.5	41.5	0	1	21.5	0	0.0	64.0
25	5.5	0	5	42.5	12.5	0.5	66.0	6.5	0	1.5	0	0	0.0	8.0
Total	697.5	196.1	79.2	360.5	85.0	328.3	1746.6	1213.5	13.0	69.7	240.4	62.4	94.7	1693.7
Mean	27.9	7.8	3.2	14.4	3.4	13.1	69.9	48.5	0.5	2.8	9.6	2.5	3.8	67.7
SE	4.43	1.99	0.38	6.12	1.22	5.50	8.59	5.51	0.36	0.73	3.16	1.06	1.28	6.74

F/V "Risky Business"

Pair No.	Control (weight in lbs)							Experimental (weight in lbs)						
	Horseshoe crab	Spiny Dogfish	Little Skate	Smooth Dogfish	Angel Shark	All other	Total	Horseshoe crab	Spiny Dogfish	Little Skate	Smooth Dogfish	Angel Shark	All other	Total
1	14.0	25.5	9	8.5	0	12	69.0	14.0	3.5	8	0	0	0.0	25.5
2	14.0	6	3	0	0	6	29.0	18.0	8	0	0	7	0.5	33.5
3	32.0	5.5	6	0	0	6	49.5	71.5	0	6	0	0	0.0	77.5
4	51.0	4	0	0	0	22	77.0	59.0	0	0	0	0	0.0	59.0
5	87.0	13	5	0	0	9.5	114.5	25.5	0	2.5	6	0	0.0	34.0
6	65.5	8.5	10	0	0	9	93.0	53.0	0	1.5	13.5	0	6.8	74.8
7	97.5	3.3	0	0	8	0	108.8	237.5	0	5.5	0	7	14.0	264.0
8	13.2	6.5	2	0	0	3	24.7	162.0	10	2	13	0	8.0	195.0
9	79.0	12	0	0	0	0	91.0	152.0	0	0	0	0	0.0	152.0
10	108.5	0	4.8	0	0	0	113.3	194.0	0	1	0	0	0.0	195.0
11	46.0	28.5	0	0	21.3	11	106.8	127.5	0	0	0	0	0.0	127.5
12	91.0	23	0	0	0	0	114.0	109.5	15.5	0	0	0	25.5	150.5
13	90.5	0	1	0	0	5	96.5	91.0	0	0	0	0	0.0	91.0
14	67.5	0	0	0	0	11.5	79.0	106.5	0	0	0	0	9.0	115.5
15	121.5	0	0	0	0	18.3	139.8	44.5	0	3	0	0	9.5	57.0
16	58.0	0	1	0	20.5	0	79.5	90.5	0	0	17	0	4.3	111.8
17	166.0	0	3	0	0	0	169.0	180.5	0	0	0	0	7.3	187.8
18	105.5	9	5	0	5	0	124.5	208.0	0	0	0	9	6.0	223.0
19	21.8	0	1	0	0	1.8	24.6	84.5	0	0	57	8	0.0	149.5
20	144.0	0	0	0	8	0	152.0	190.0	0	0	0	0	0.0	190.0
21	132.0	6.5	0	65	0	0	203.5	133.5	0	0	0	11	0.0	144.5
22	72.0	5	0	0	0	0	77.0	51.0	0	14	0	8	0.0	73.0
23	103.0	5	0	17	42	0	167.0	103.5	7	0	18	38	7.0	173.5
24	152.0	7	0	16	16	7	198.0	176.0	0	6	0	0	0.0	182.0
25	216.0	0	0	25	13	0	254.0	232.0	0	0	0	4	0.0	236.0
Total	2148.5	168.3	50.8	131.5	133.8	122.1	2755.0	2915.0	44.0	49.5	124.5	92.0	97.9	3322.9
Mean	85.9	6.7	2.0	5.3	5.4	4.9	110.2	116.6	1.8	2.0	5.0	3.7	3.9	132.9
SE	10.3	1.6	0.6	2.8	2.0	1.26	11.42	13.5	0.8	0.7	2.5	1.6	1.2	13.54

Table 4. Details of Atlantic sturgeon encounter during sea trials.

Date Landed	5/2/13	5/5/13	5/7/13	5/10/13	5/14/13	5/19/13	5/19/13
Trip ID	RB001	RB002	RB003	LB005	LB008	LB013	LB013
Vessel	Risky Business	Risky Business	Risky Business	Landon Blake	Landon Blake	Landon Blake	Landon Blake
Haul#	3	7	12	15	28	48	50
Gear	Control	Control	Control	Control	Control	Control	Control
Latitude	37.86611	37.86694	37.86639	37.80861	37.80833	37.80667	37.80722
Longitude	-74.96000	-74.93389	-74.95528	-74.98111	-74.98778	-75.01778	-74.99333
Depth (fm)	17	15	17	18	17	16	-
Water temp (C)	10	10	10	13.3	13.9	16.1	16.1
Soak Time (h)	72	72	48.9	21.8	23.9	23.3	26.2
Condition	Dead	Dead	Dead	Dead	Alive	Alive	Dead
Sandflea/abrasion	No	No	No	No	Abrasion (2)	Abrasions (1)	Sandflea (1)
Deposition	Discarded	Kept	Kept	Kept	Released	Released	Kept
Weight (lbs)	-	38	65	68.9	75	-	51.6
Fork length (cm)	167.5	133	147	150	149	141	142.5
Total length (cm)	190.5	155	167	177	168	158	156
Disposition	0	0	0	0	2-abrasions	1-abrasions	2- sandfleas
Location in net	Shot 9	Shot 9	Shot 8 Horizontal 3	Shot 10 Horizontal 4 Vertical 3	Shot 4 Horizontal 3 Vertical 4	Shot 4 Horizontal 3 Vertical 4	Shot 7 Horizontal 3 Vertical 4
Notes:	Dead, but in good condition. No sandflea damage, but sandfleas were visible on gills. Completely wrapped in net from float line to lead line, but not gilled.	Completely wrapped in net from float line to lead line. Not gilled.	Not gilled, but wrapped in net parallel to lead and float lines	On the last 2 meshes of Shot 10 just before the end line	10 floats before the end of net. Gilled. Released live.	14 floats before the end of net. Gilled near lead line. Some abrasions near pectoral fin area. Blind in one eye from a previous injury as the eye socket area was covered with scar tissue. Release alive and appeared healthy. Swam away when put back in water.	12 floats from the end of the shot. Fresh dead with some sandflea damage and scavenging

Table 5. Statistical analysis of Atlantic sturgeon bycatch by different vessels and nets.

Vessel		Control	Experimental	Reduction (increase)		Significance	Effect size
		(N)	(N)	(N)	%	p	
Landon Blake							
	Number of animals	4	0	4	100	**<0.001**	
	Number of pairs	25	25				
	Mean (per string)	0.16	0	0.16	100		0.432
	SD	0.37					
Risky Business							
	Number of animals	3	0	3	100	>0.2	
	Number of pairs	25	25				
	Mean (per string)	0.12	0	0.12	100		0.364
	SD	0.33					
Both vessels combined							
	Number of animals	7	0	7	100	**<0.001**	
	Number of pairs	50	50				
	Mean (per string)	0.14	0	0.14	100		0.400
	SD	0.35					

Table 6. Statistical analysis of monkfish and winter skate catch by different vessels and different nets.

Vessel and species	Control	Experimental	Reduction (increase)		Significance	Effect Size
Landon Blake	lbs	lbs	lbs	%	p	
Kept monkfish						
Mean weight per string	202.3	192.0	10.3	5.1	0.600	0.140
SD	73.68	86.25				
Mean weight per string per 24 h	183.9	168.2	15.7	8.5	0.334	0.173
SD	90.77	85.85				
Kept winter skate						
Mean weight per string	181.4	211.3	(29.9)	(16.5)	0.080	0.160
SD	187.06	221.83				
Mean weight per string per 24 h	140.4	160	(19.6)	(14.0)	0.221	0.135
SD	145.51	179.82				
Risky Business						
Kept monkfish						
Mean weight per string	396.2	296	100.2	25.3	**0.012**	0.363
SD	276.05	195.63				
Mean weight per string per 24 h	225.8	175.5	50.3	22.3	**0.012**	0.463
SD	108.64	92.96				
Kept winter skate						
Mean weight per string	419.9	433.7	(13.8)	(3.3)	0.520	0.024
SD	565.53	575.64				
Mean weight per string per 24 h	187.2	188.2	(1.0)	(0.5)	0.914	0.005
SD	182.89	186.95				
Both vessels combined						
Kept monkfish						
Mean weight per string per 24 h	204.9	171.9	33.0	16.1	**0.010**	0.326
SD	101.31	88.64				
Kept winter skate						
Mean weight per string per 24 h	163.8	174.1	(10.3)	(6.3)	0.263	0.062
SD	165.27	182.09				

Table 7. Soak time corrected catch of monkfish and winter skate by "Landon Blake" and "Risky Business" and by Control and Experimental nets.

F/V "Landon Blake"

Pair No.	Control (weight in lbs/24h)										Experimental (weight in lbs/24)										All nets (weight in lbs/24h)		
	Monkfish			Winter skate			All other species			All species	Monkfish			Winter skate			All other species			All species	Kept	Kept	All species
	Kept	Discarded	Total	Kept	Discarded	Total	Kept	Discarded	Total	Total	Kept	Discarded	Total	Kept	Discarded	Total	Kept	Discarded	Total	Total	Monkfish	W. skate	Total
1	78.0	0.0	78.0	168.0	0.0	168.0	0.0	15.3	15.3	261.3	60.5	0.7	61.2	208.7	0.0	208.7	0.8	14.8	15.7	285.5	138.5	376.7	546.8
2	47.3	7.8	55.2	163.0	0.0	163.0	0.0	13.3	13.3	231.5	117.0	9.7	126.7	207.0	0.0	207.0	0.0	12.8	12.8	346.5	164.3	370.0	578.0
3	55.9	6.3	62.2	77.2	1.5	78.8	0.0	18.1	18.1	159.0	12.5	1.6	14.1	117.9	1.4	119.3	0.0	28.8	28.8	162.2	68.4	195.1	321.2
4	19.4	5.8	25.2	57.1	1.8	58.9	4.2	12.0	16.2	100.3	59.7	5.7	65.5	77.6	0.0	77.6	4.6	17.6	22.1	165.2	79.1	134.7	265.5
5	91.4	1.9	93.3	64.4	1.2	65.6	1.5	8.8	10.4	169.3	120.5	4.6	125.1	70.0	0.0	70.0	0.0	21.0	21.0	216.0	211.9	134.4	385.3
6	151.0	0.0	151.0	41.7	0.0	41.7	0.0	18.8	18.8	211.5	187.2	0.0	187.2	131.6	5.2	136.8	0.0	34.9	34.9	358.9	338.2	173.3	570.4
7	207.0	10.8	217.8	55.7	2.7	58.4	0.0	58.1	58.1	334.3	225.6	0.0	225.6	53.8	2.1	55.8	4.4	51.7	56.2	337.6	432.5	109.5	671.9
8	321.9	0.0	321.9	57.2	0.0	57.2	0.0	30.4	30.4	409.5	166.8	0.0	166.8	96.8	2.2	98.9	0.0	69.9	69.9	335.7	488.7	154.0	745.2
9	281.1	11.4	292.5	53.0	0.0	53.0	0.0	61.4	61.4	406.9	250.9	4.3	255.3	34.8	0.0	34.8	5.5	40.1	45.6	335.7	532.0	87.8	742.6
10	175.4	0.0	175.4	48.6	0.0	48.6	0.0	42.8	42.8	266.9	243.4	8.0	251.4	26.9	0.0	26.9	13.6	56.5	70.1	348.5	418.8	75.5	615.4
11	211.1	0.0	211.1	29.2	0.0	29.2	0.0	134.8	134.8	375.1	150.1	2.1	152.1	74.8	0.0	74.8	0.0	73.9	73.9	300.8	361.1	104.0	675.9
12	295.7	0.0	295.7	73.7	0.0	73.7	52.9	96.0	148.9	518.2	314.9	5.1	320.0	102.1	0.0	102.1	0.0	160.0	160.0	582.1	610.6	175.7	1100.3
13	267.9	14.5	282.4	161.9	0.0	161.9	19.7	144.3	164.0	608.3	248.2	5.1	253.3	118.5	0.0	118.5	25.5	101.6	127.1	498.9	516.1	280.4	1107.2
14	142.4	0.0	142.4	9.5	0.0	9.5	68.0	38.8	106.7	258.7	60.3	0.0	60.3	64.9	0.0	64.9	9.7	62.8	72.5	197.7	202.7	74.4	456.4
15	407.4	0.0	407.4	23.7	0.0	23.7	0.0	32.7	32.7	463.9	174.6	11.3	185.9	57.0	0.0	57.0	0.0	63.9	63.9	306.9	582.0	80.8	770.8
16	177.7	0.0	177.7	53.8	0.0	53.8	0.0	56.6	56.6	288.1	138.5	0.0	138.5	149.2	6.2	155.3	46.0	53.3	99.3	393.1	316.2	202.9	681.2
17	199.1	4.4	203.5	199.1	0.0	199.1	100.1	58.6	158.7	561.3	143.0	0.0	143.0	85.8	0.0	85.8	0.0	37.0	37.0	265.8	342.1	284.9	827.1
18	245.1	0.0	245.1	108.7	0.0	108.7	37.2	41.1	78.3	432.1	361.1	0.0	361.1	123.4	0.0	123.4	25.7	35.4	61.1	545.7	606.2	232.2	977.8
19	202.1	3.9	206.1	124.9	4.4	129.3	86.1	20.7	106.7	442.1	323.3	4.0	327.3	97.2	0.0	97.2	21.3	39.2	60.5	485.0	525.4	222.1	927.1
20	189.6	0.0	189.6	151.7	0.0	151.7	51.4	70.6	122.1	463.4	155.6	16.3	171.9	89.0	1.0	90.0	22.9	26.9	49.8	311.7	345.2	240.7	775.1
21	158.1	0.0	158.1	80.3	0.0	80.3	0.0	44.3	44.3	282.8	140.1	0.0	140.1	59.2	0.0	59.2	64.4	86.0	150.4	349.7	298.2	139.6	632.5
22	161.5	0.0	161.5	303.8	2.0	305.8	30.4	16.2	46.6	513.9	137.8	4.1	141.9	233.4	0.0	233.4	0.0	91.0	91.0	466.3	299.3	537.2	980.2
23	116.5	0.0	116.5	344.3	0.0	344.3	0.0	97.7	97.7	558.5	155.9	0.0	155.9	281.0	0.0	281.0	0.0	51.3	51.3	488.2	272.4	625.3	1046.7
24	237.9	0.0	237.9	439.8	3.1	442.9	0.0	7.7	7.7	688.6	114.3	0.0	114.3	735.6	6.2	741.8	22.3	44.2	66.5	922.6	352.2	1175.4	1611.2
25	157.6	0.0	157.6	618.3	0.0	618.3	38.9	21.5	60.5	836.3	144.0	0.0	144.0	704.0	5.6	709.6	0.0	7.5	7.5	861.2	301.6	1322.3	1697.5
Mean	183.9	2.7	186.6	140.4	0.7	141.0	19.6	46.4	66.0	393.7	168.2	3.3	171.5	160.0	1.2	161.2	10.7	51.3	62.0	394.7	352.2	300.4	788.4
SE	18.15	0.9	18.15	29.1	0.2	29.14	6.1	7.5	10.0	35.6	17.17	0.9	17.27	36.0	0.4	36.24	3.3	6.7	8.0	37.3	31.55	63.5	69.2

F/V "Risky Business"

Pair No.	Control (weight in lbs/24h)										Experimental (weight in lbs/24h)										All nets (weight in lbs/24h)		
	Monkfish			Winter skate			All other species			All species	Monkfish			Winter skate			All other species			All species	Kept	Kept	All species
	Kept	Discarded	Total	Kept	Discarded	Total	Kept	Discarded	Total	Total	Kept	Discarded	Total	Kept	Discarded	Total	Kept	Discarded	Total	Total	Monkfish	W. skate	Total
1	69.4	10.7	80.1	165.7	0.0	165.7	4.0	19.0	23.0	268.8	43.0	0.0	43.0	250.0	0.0	250.0	0.0	109.4	8.5	301.5	112.4	415.7	570.3
2	102.0	10.3	112.3	229.3	3.7	233.0	0.0	9.7	9.7	355.0	37.8	6.3	44.1	219.7	0.0	219.7	0.0	11.2	11.2	274.9	139.8	449.0	629.9
3	76.4	11.3	87.8	72.3	0.0	72.3	0.0	16.5	16.5	176.6	20.5	12.1	32.6	147.3	0.0	147.3	0.0	25.8	25.8	205.8	96.9	219.7	382.4
4	28.7	21.3	49.9	74.2	16.5	90.7	2.3	23.3	25.7	166.3	27.2	16.2	43.3	78.0	0.0	78.0	0.0	19.7	19.7	141.0	55.8	152.2	307.3
5	206.0	0.0	206.0	117.5	0.0	117.5	4.8	52.7	57.5	381.0	71.2	6.3	77.6	123.5	0.0	123.5	0.0	17.2	17.2	218.3	277.3	241.0	599.3
6	176.0	5.3	181.3	89.3	0.0	89.3	4.4	41.2	45.6	316.2	109.9	12.8	122.7	0.0	4.2	4.2	0.0	36.9	36.9	163.8	285.8	89.3	480.0
7	213.5	17.7	231.1	133.9	6.3	140.2	0.0	59.5	59.5	430.9	264.2	4.1	268.2	79.0	1.8	80.8	7.6	135.7	143.3	492.4	477.6	212.9	923.2
8	241.3	0.0	241.3	84.1	0.0	84.1	0.6	13.2	13.8	339.1	101.6	1.8	103.5	101.9	0.0	101.9	4.4	102.5	106.8	312.2	342.9	186.0	651.3
9	381.6	28.0	409.7	153.4	0.0	153.4	0.0	89.5	89.5	652.6	240.3	0.0	240.3	73.2	0.0	73.2	0.0	151.4	151.4	464.9	621.9	226.6	1117.5
10	200.4	18.8	219.2	46.6	0.0	46.6	0.0	109.2	109.2	374.9	135.8	4.4	140.2	46.2	0.0	46.2	0.0	189.5	189.5	375.8	336.2	92.7	750.8
11	177.7	0.0	177.7	44.8	0.0	44.8	14.3	124.3	138.6	361.0	115.0	0.0	115.0	74.7	0.0	74.7	0.0	162.8	162.8	352.5	292.8	119.4	713.5
12	311.7	0.0	311.7	83.4	0.0	83.4	0.0	144.0	144.0	539.1	129.6	0.0	129.6	59.7	0.0	59.7	0.0	187.2	187.2	376.4	441.3	143.1	915.5
13	166.2	0.0	166.2	22.5	0.0	22.5	5.4	98.0	103.4	292.1	229.5	0.0	229.5	64.1	0.0	64.1	0.0	98.8	98.8	392.4	395.6	86.6	684.4
14	271.5	32.3	303.8	29.3	0.0	29.3	12.1	70.7	82.8	416.0	277.6	0.0	277.6	28.0	0.0	28.0	9.5	112.6	122.1	427.8	549.2	57.4	843.7
15	248.4	29.8	278.2	168.1	0.0	168.1	9.4	129.2	138.6	584.9	201.0	3.6	204.6	160.9	0.0	160.9	0.0	58.2	58.2	423.6	449.4	329.0	1008.6
16	227.8	21.8	249.7	139.7	0.0	139.7	0.0	74.5	74.5	463.9	329.2	18.3	347.5	153.7	0.0	153.7	0.0	107.8	107.8	609.0	557.0	293.4	1072.8
17	104.5	43.9	148.4	202.4	0.0	202.4	0.0	92.2	92.2	442.9	267.7	10.8	278.6	190.7	3.8	194.5	0.0	101.7	101.7	574.8	372.2	393.1	1017.7
18	199.0	15.2	214.2	170.3	0.0	170.3	0.0	67.0	67.0	451.5	276.6	8.3	284.9	130.4	0.0	130.4	0.0	119.2	119.2	534.5	475.6	300.7	986.1
19	196.1	53.8	249.8	122.6	0.0	122.6	0.0	32.3	32.3	404.7	157.3	38.0	195.3	100.7	0.0	100.7	36.0	163.3	199.3	495.3	353.4	223.3	900.1
20	435.0	36.2	471.3	240.5	0.0	240.5	0.0	78.1	78.1	789.9	309.7	32.8	342.6	192.9	0.0	192.9	0.0	98.3	98.3	633.8	744.8	433.4	1423.7
21	214.5	7.7	222.2	191.8	0.0	191.8	7.7	60.6	68.3	482.3	225.0	4.3	229.3	271.2	0.0	271.2	0.0	48.2	48.2	548.8	439.5	463.0	1031.1
22	261.5	4.4	266.0	690.3	0.0	690.3	0.0	26.3	26.3	982.6	169.9	3.7	173.7	704.9	0.0	704.9	0.0	24.7	24.7	903.3	431.5	1395.2	1885.9
23	310.5	0.0	310.5	260.1	0.0	260.1	0.0	87.3	87.3	657.9	182.6	0.0	182.6	289.2	0.0	289.2	12.8	76.2	89.0	560.8	493.1	549.4	1218.8
24	414.7	0.0	414.7	379.5	0.0	379.5	11.8	89.9	101.8	896.0	256.3	2.5	258.8	423.7	0.0	423.7	0.0	92.0	92.0	774.5	671.1	803.2	1670.5
25	409.8	9.6	419.4	767.8	0.0	767.8	8.3	76.0	84.3	1271.5	208.5	0.0	208.5	740.3	0.0	740.3	0.0	79.1	79.1	1027.9	618.3	1508.1	2299.4
Mean	225.8	15.1	240.9	187.2	1.1	188.2	3.4	67.4	70.8	499.9	175.5	7.5	182.9	188.2	0.4	188.5	2.8	93.2	91.9	463.4	401.3	375.3	963.3
SE	21.7	3.0	21.9	36.6	0.7	36.5	0.9	7.6	8.0	51.6	18.6	2.0	18.9	37.4	0.2	37.3	1.5	10.7	11.8	43.5	35.9	73.4	92.8

FIGURES

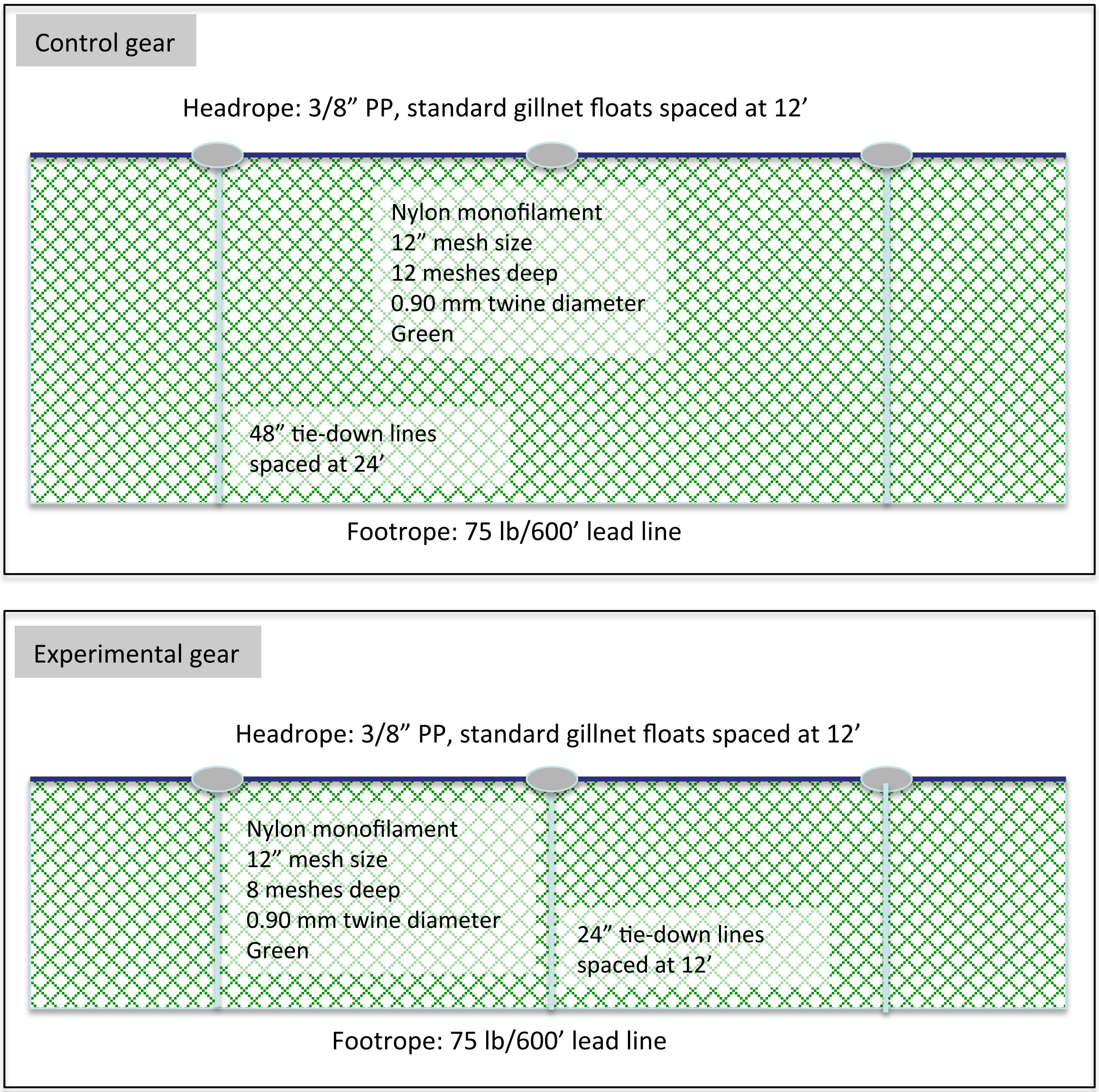


Figure 1. Specification and rigging of the Control and the Experimental gillnets.

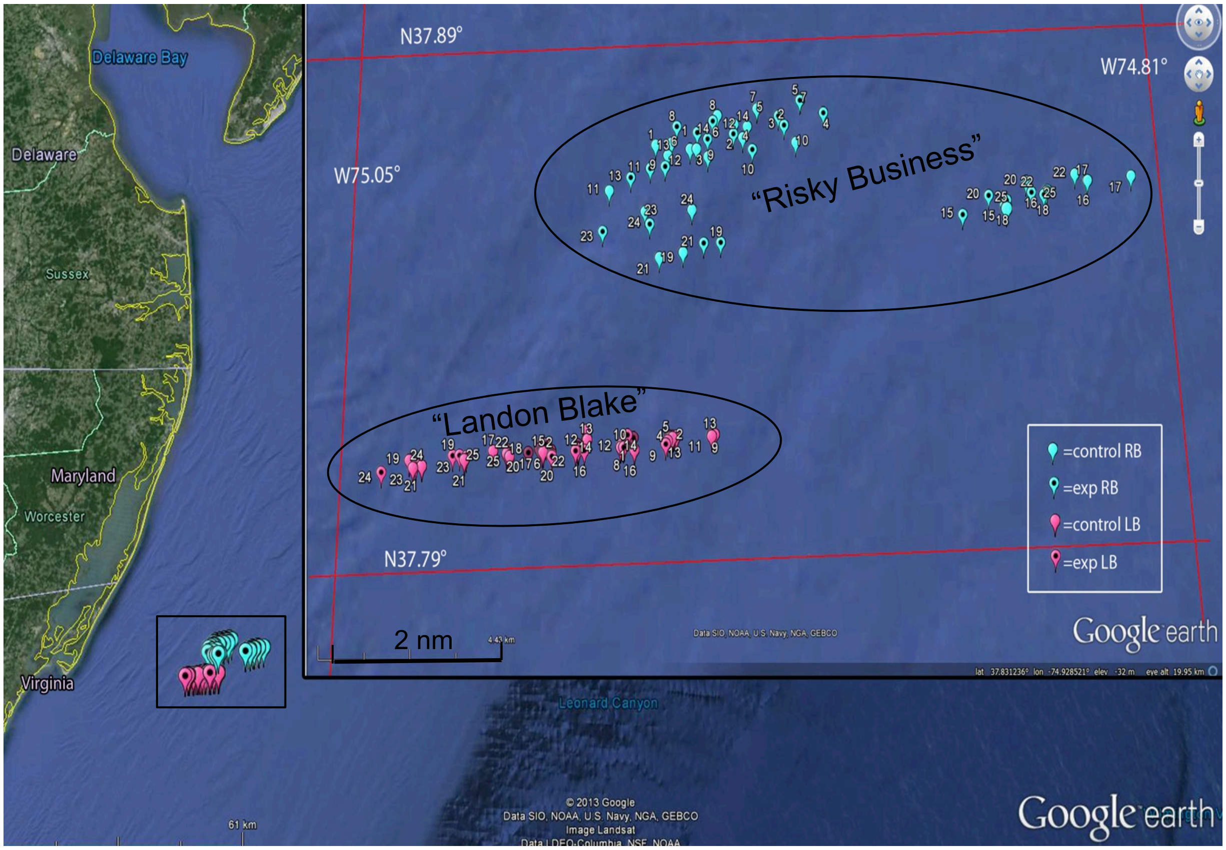
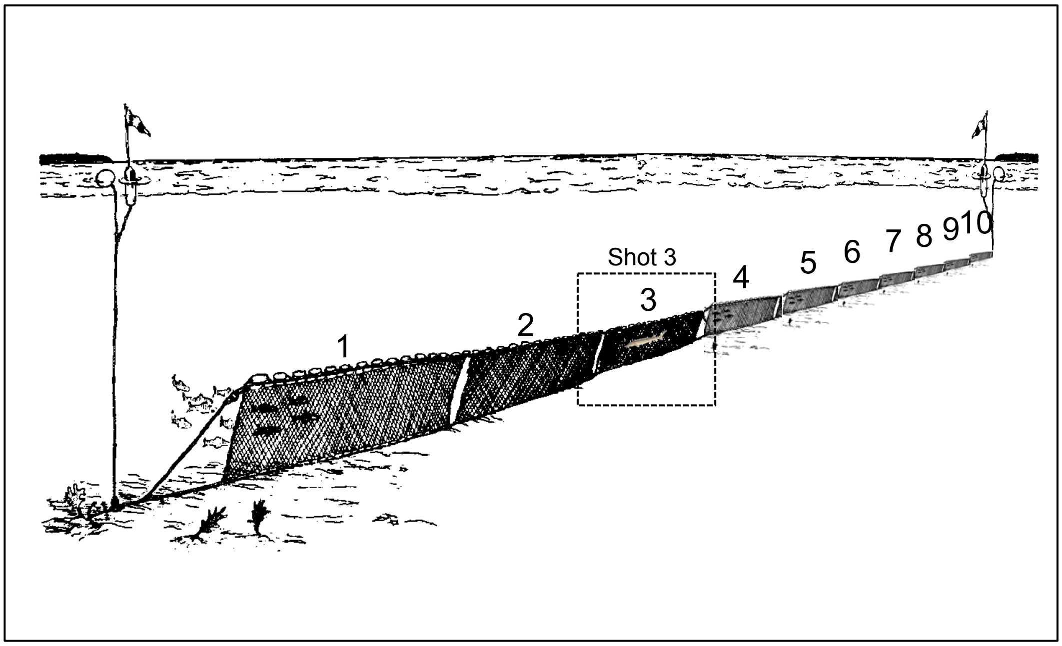


Figure 2. Location of Control and Experimental monkfish gillnets deployed and hauled by F/V "Landon Blake" and F/V "Risky Business" during May 2013.



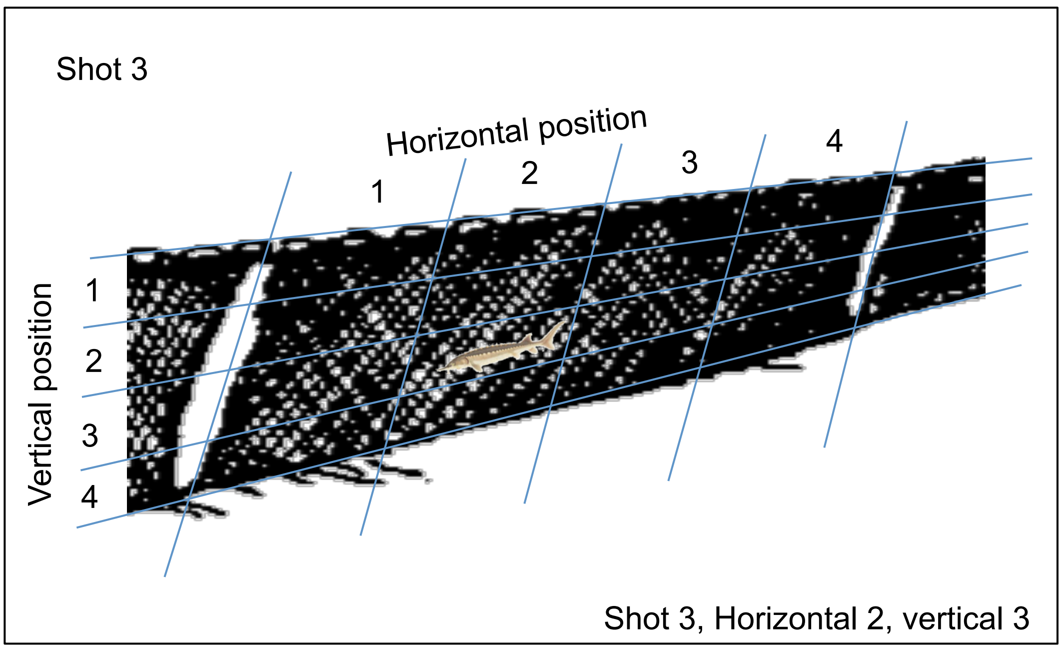


Figure 3. Illustration of identification of the location in the gillnet where an Atlantic sturgeon was caught. In this example, the sturgeon capture location is noted as "Shot 3, Horizontal 2, Vertical 3".

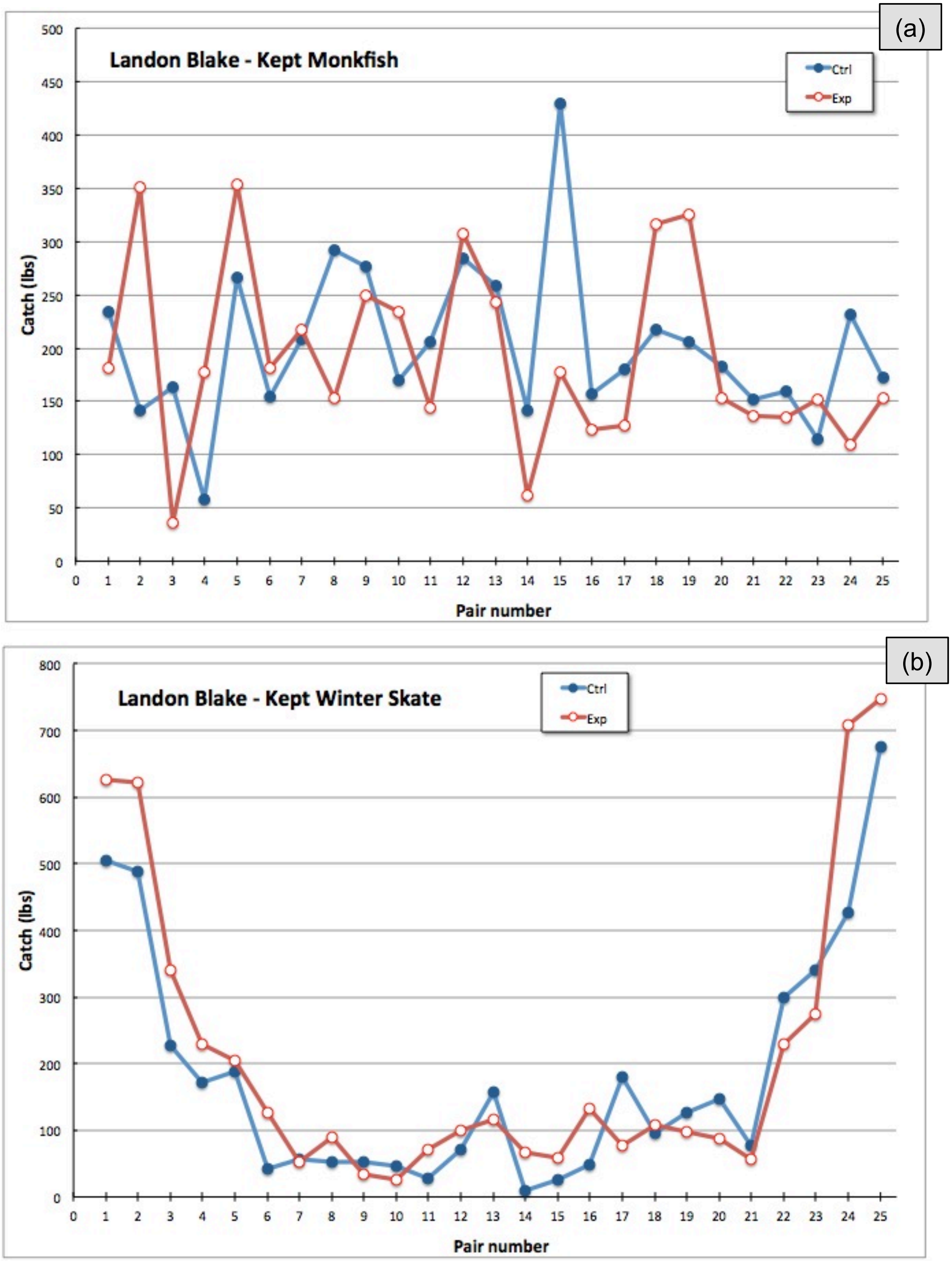


Figure 4. Haul-by-haul of "Kept" monkfish (a) and winter skate (b) per string by "Landon Blake". Ctrl – Control, Exp – Experimental.

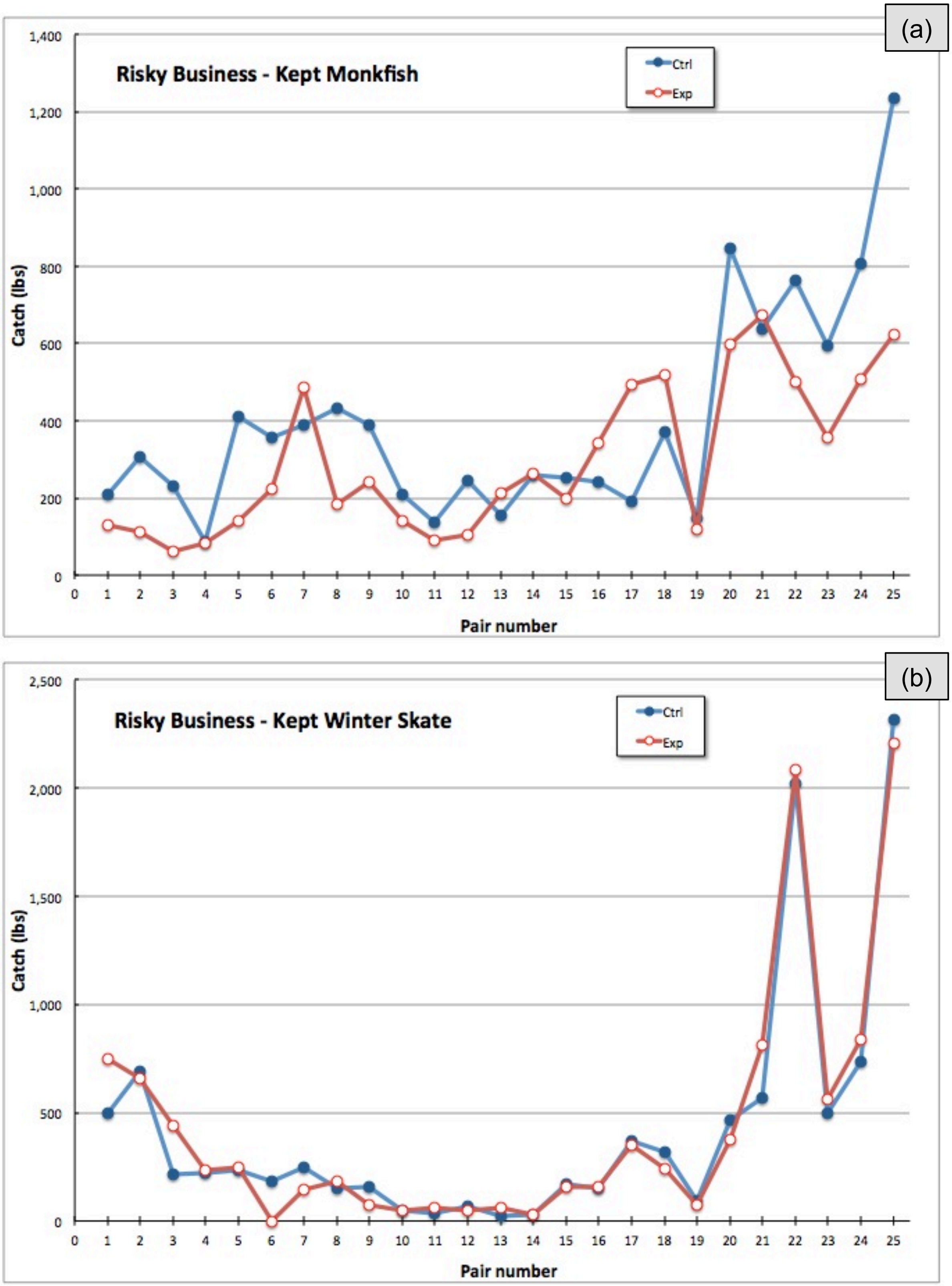
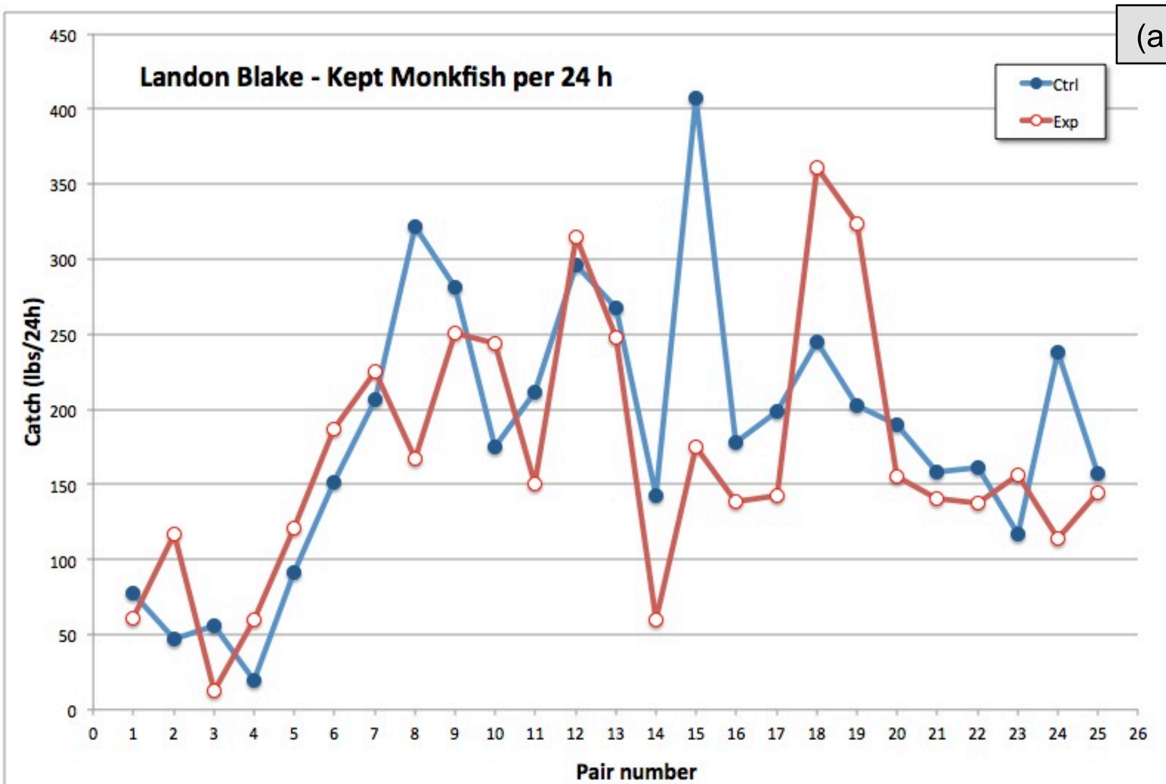


Figure 5. Haul-by-haul catch of "Kept" monkfish (a) and winter skate (b) per string by "Risky Business". Ctrl – Control, Exp – Experimental.

(a)



(b)

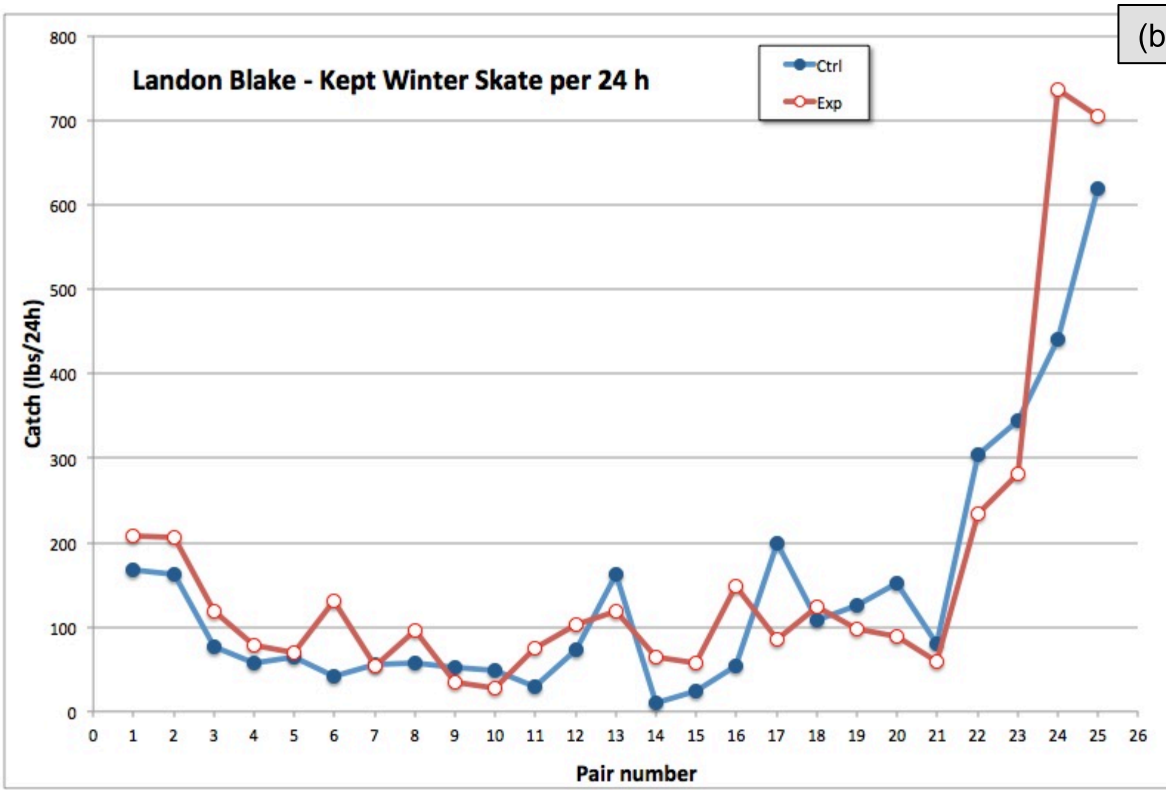
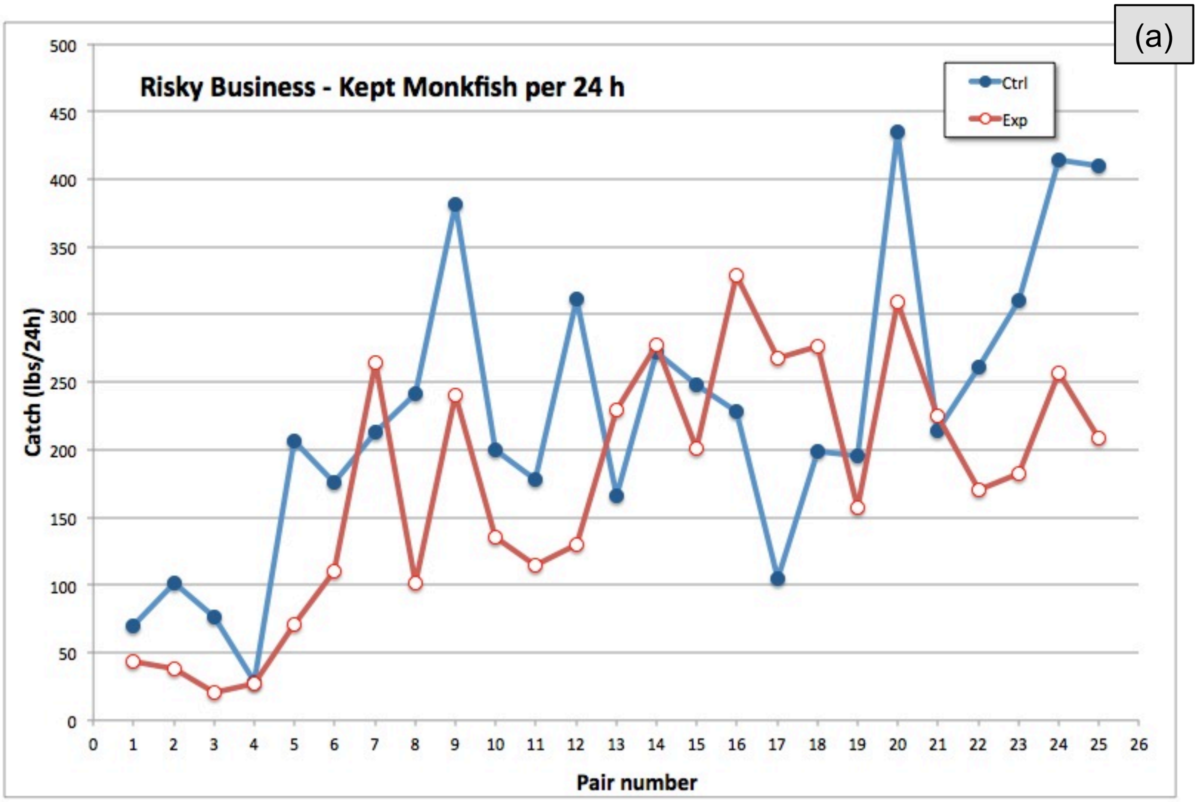


Figure 6. Haul-by-haul catch of “Kept” monkfish (a) and winter skate (b) per string per 24-h soak by “Landon Blake”. Ctrl – Control, Exp – Experimental.



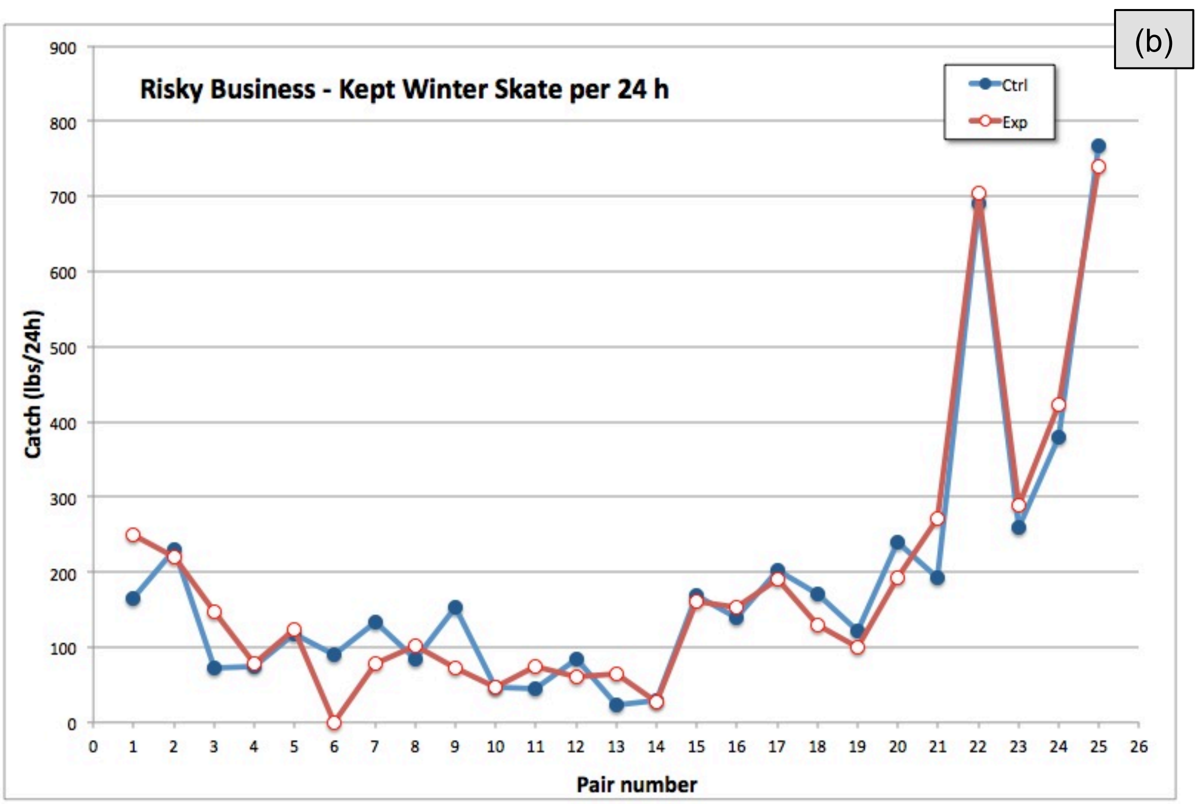


Figure 7. Haul-by-haul catch of "Kept" monkfish (a) and winter skate (b) per string per 24-h soak by "Risky Business". Ctrl – Control, Exp – Experimental.

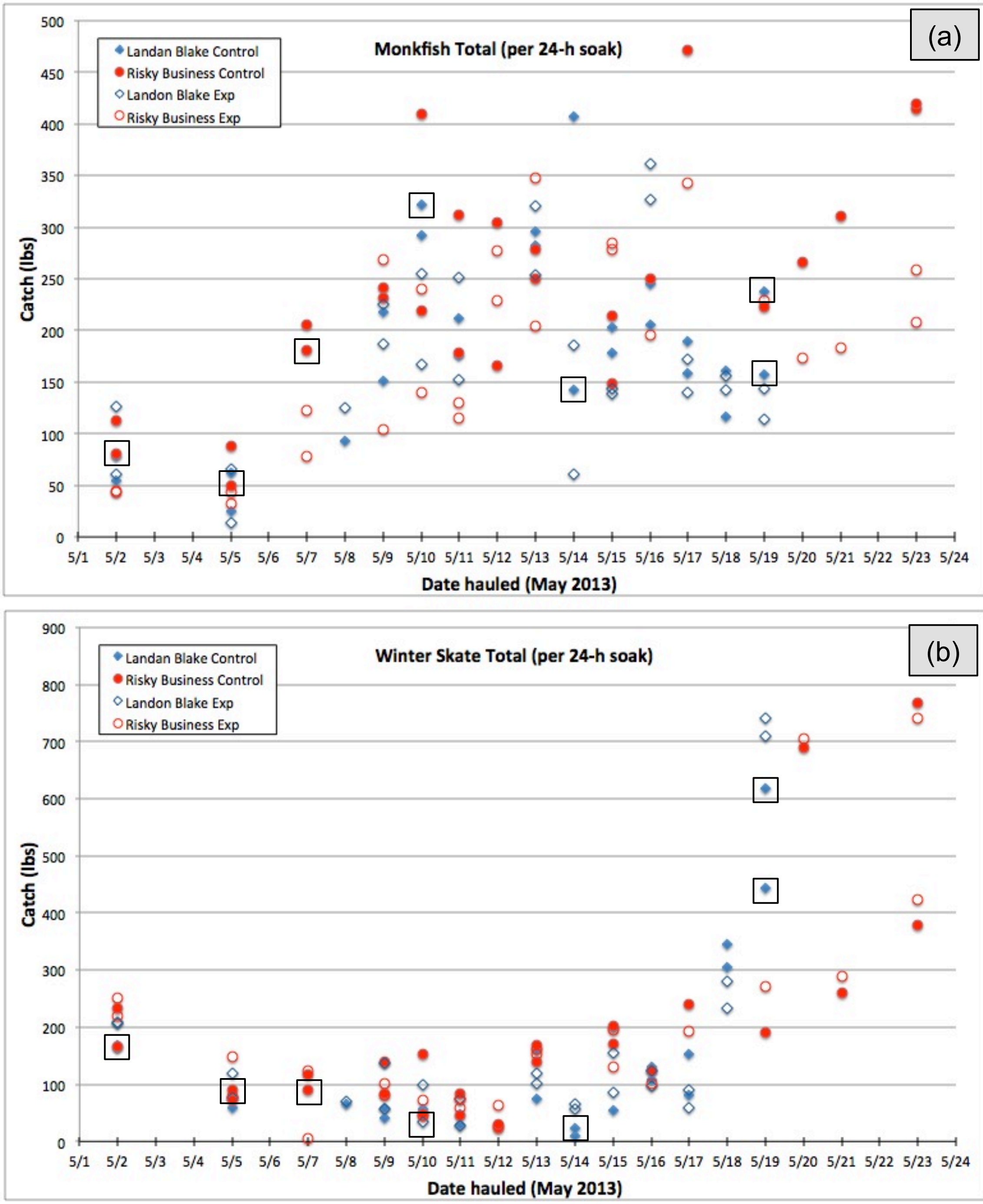


Figure 8. Catch of total monkfish (a) and winter skate (b) by two vessel by date illustrating increasing in catch as the season progressed. Squares indicate the string where a sturgeon was caught.

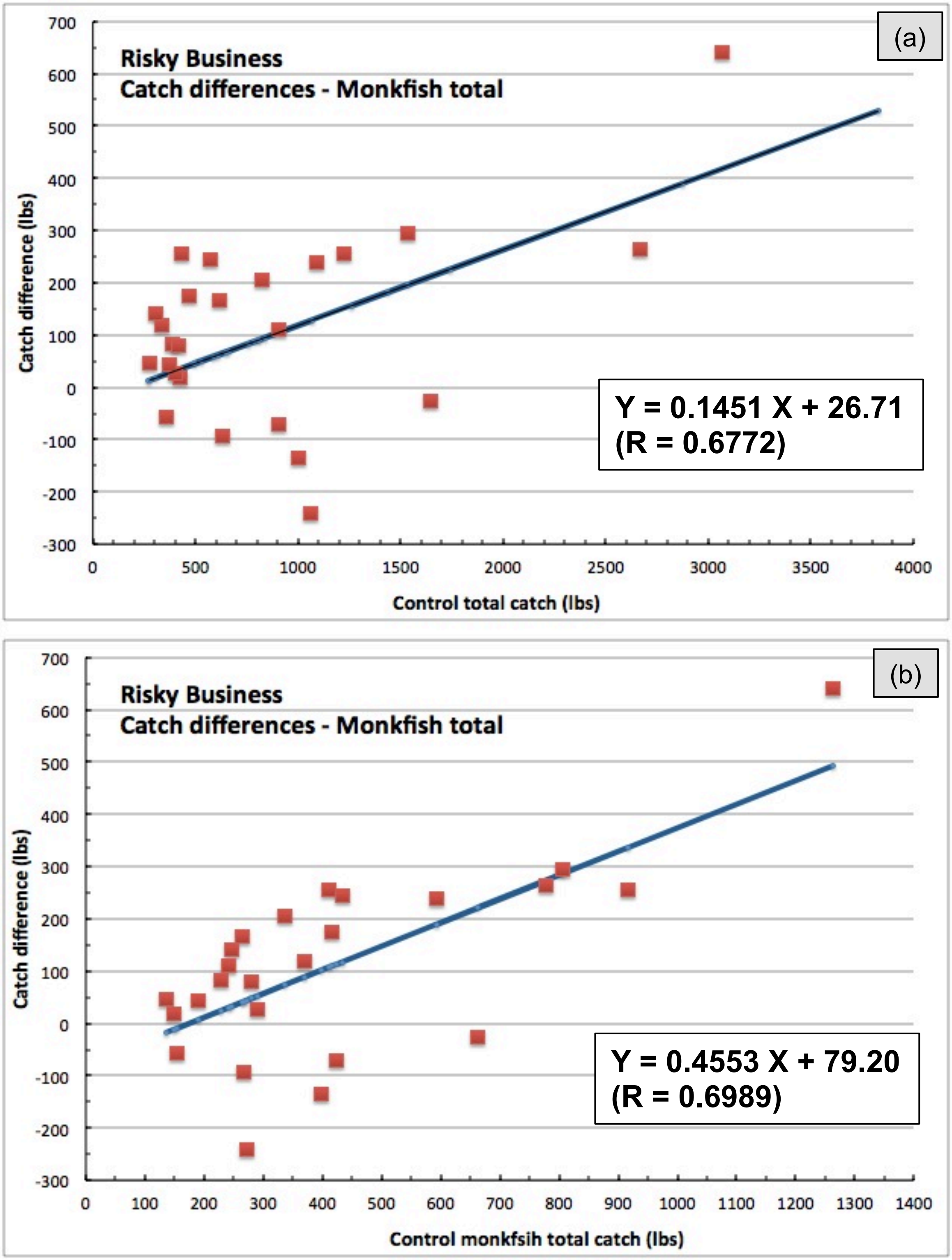


Figure 9. Catch differences between Control and Experimental nets for each pair of net for total monkfish (Kept + discarded) per string in relation to total catch weight of the Control net (top) and to the total monkfish catch in the Control (bottom). Blue lines are linear regression lines.

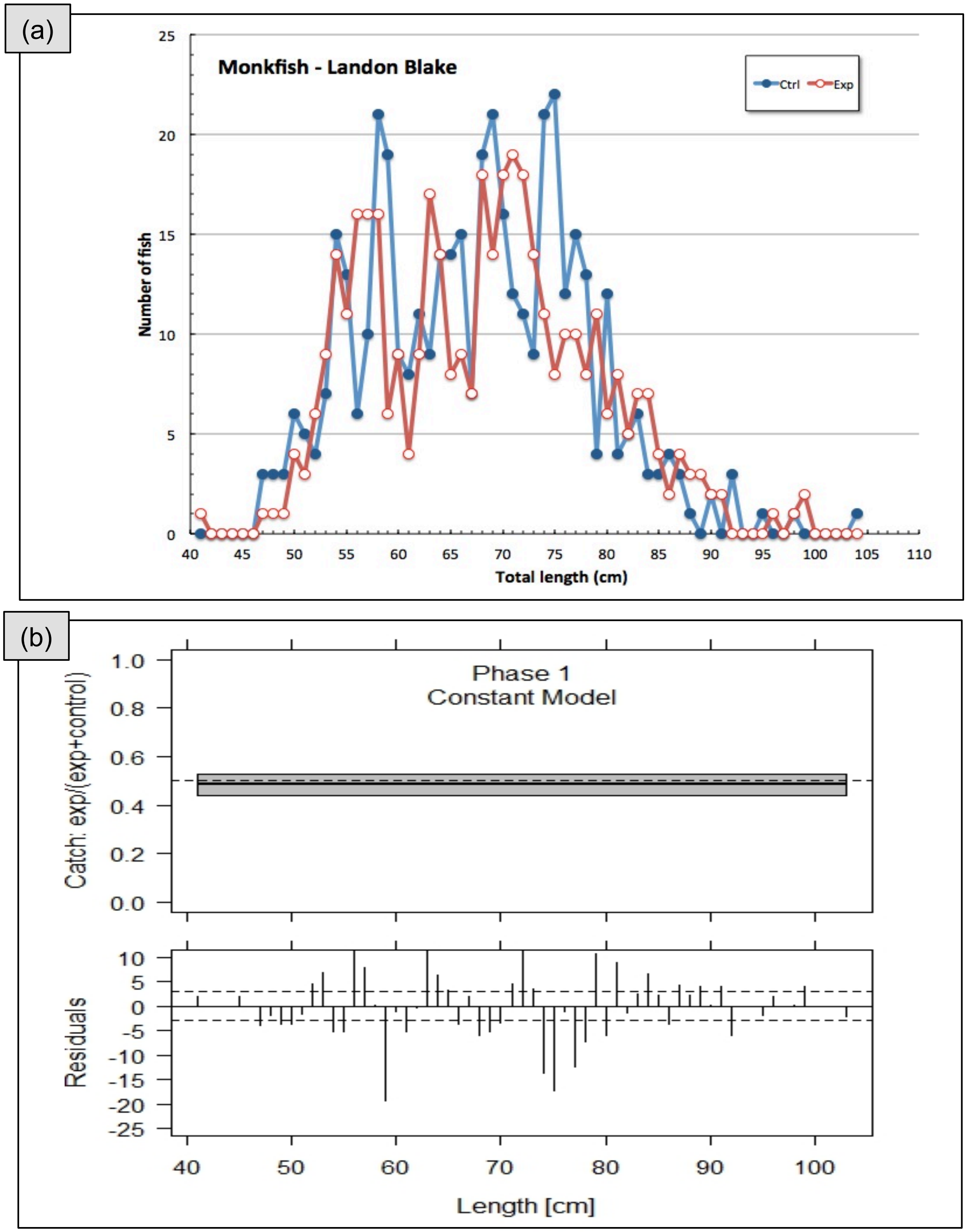


Figure 10. Length frequency distribution of monkfish from Control and Experimental nets (a) and GLMM modeling results (b) for "Landon Blake".

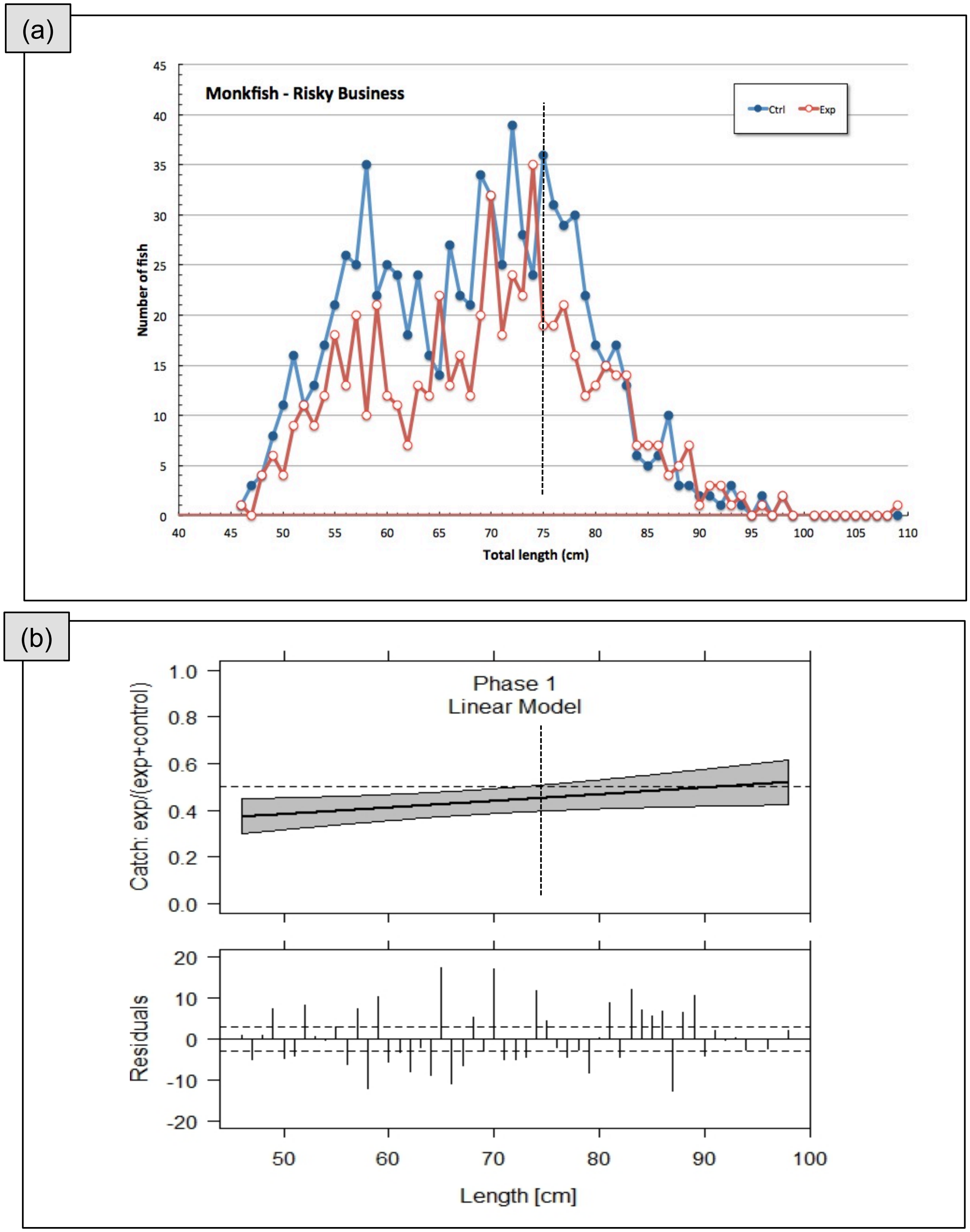


Figure 11. Length frequency distribution of monkfish from Control and Experimental nets (a) and GLMM modeling results (b) for "Risky Business". Vertical dashed lines indicate the length below which the Experimental net catch less number of fish than the Control net.

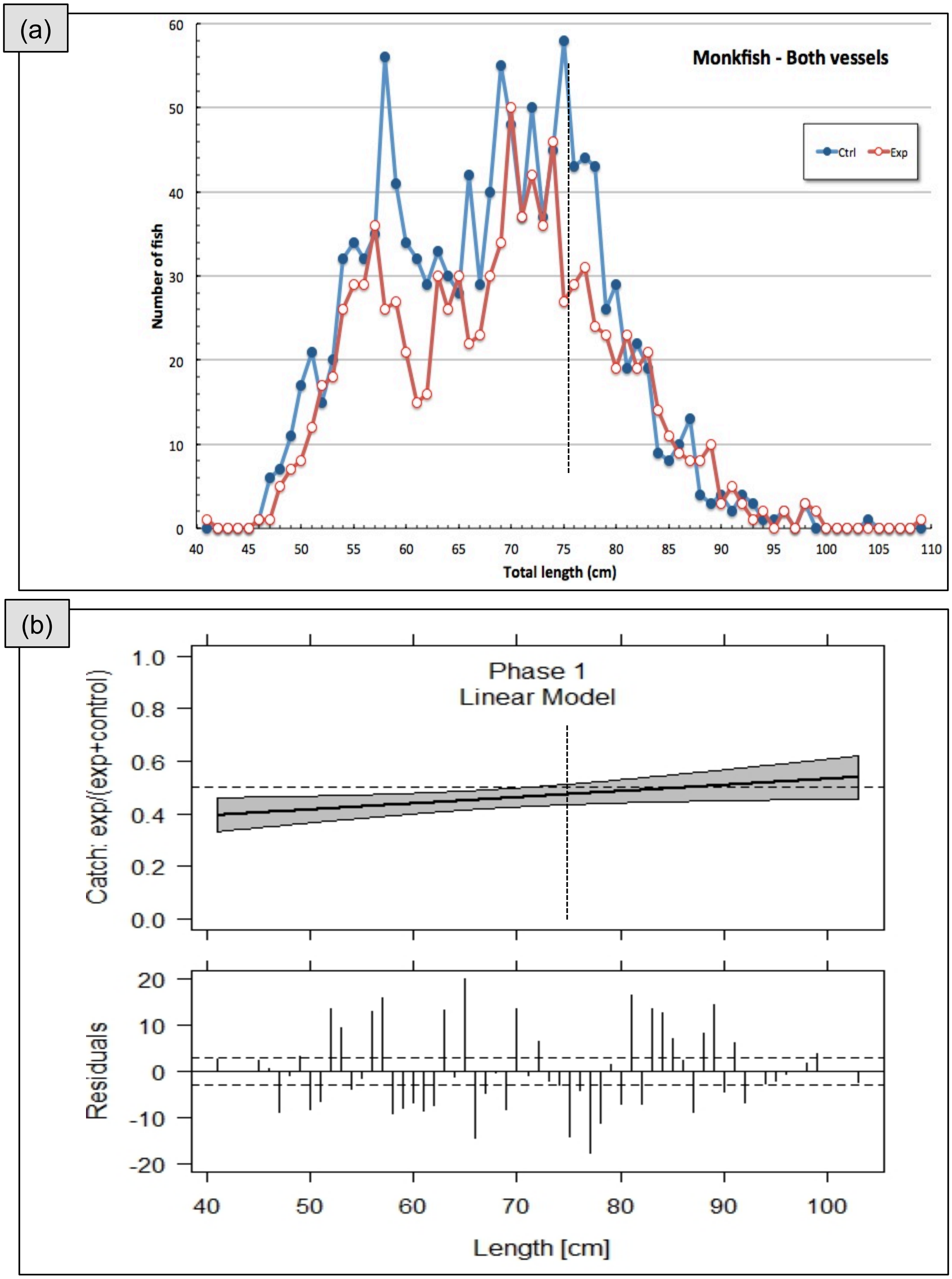
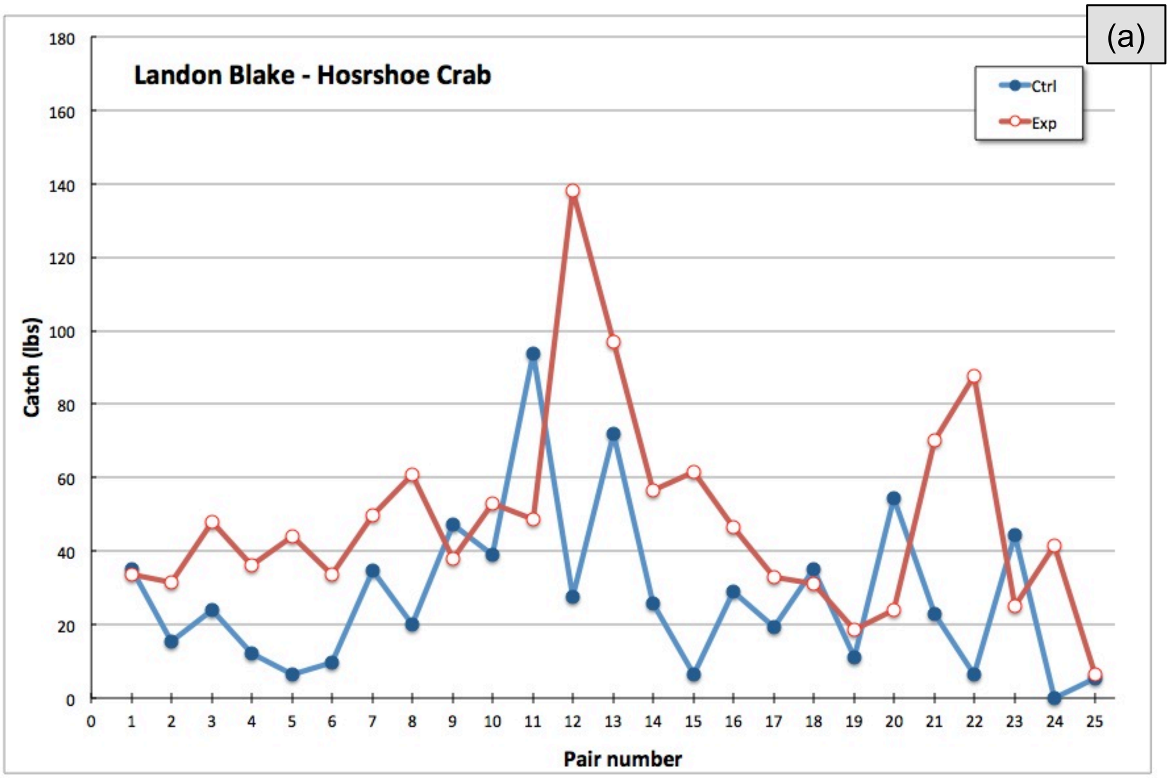


Figure 12. Length frequency distribution of monkfish from Control and Experimental nets (a) and GLMM modeling results (b) for both vessels combined. Vertical dashed lines indicate the length below which the Experimental net catch less number of fish than the Control net.



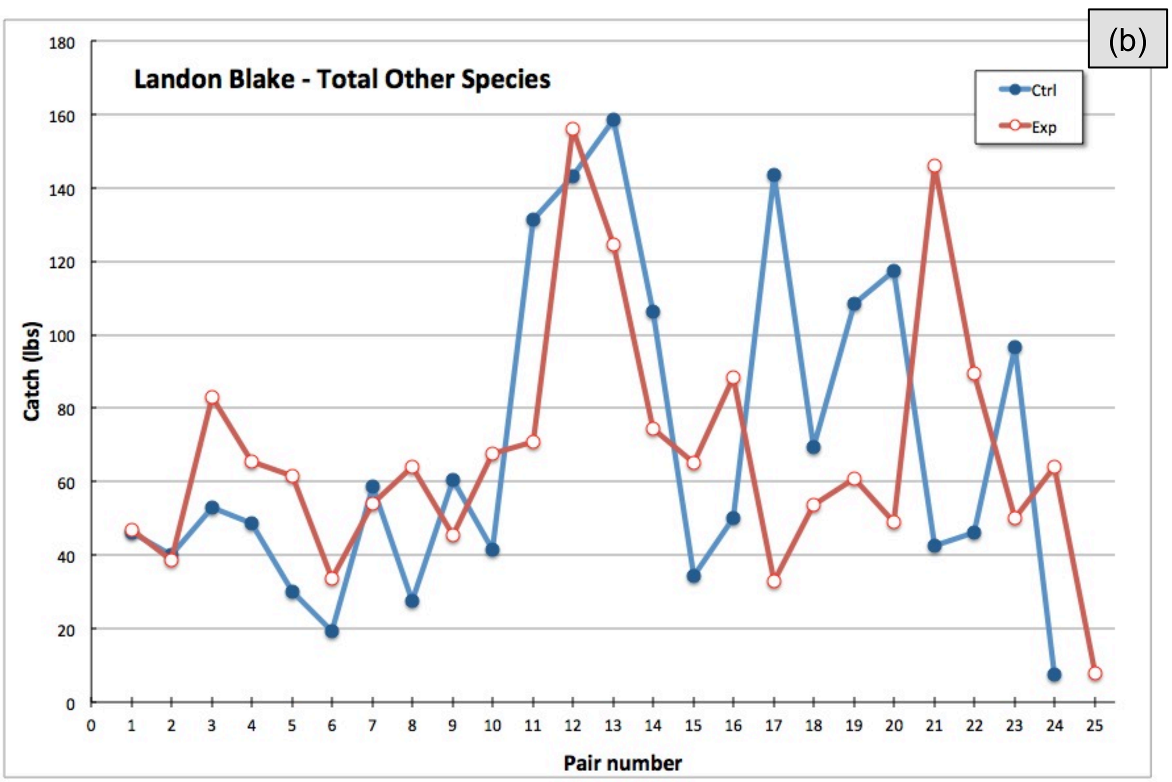
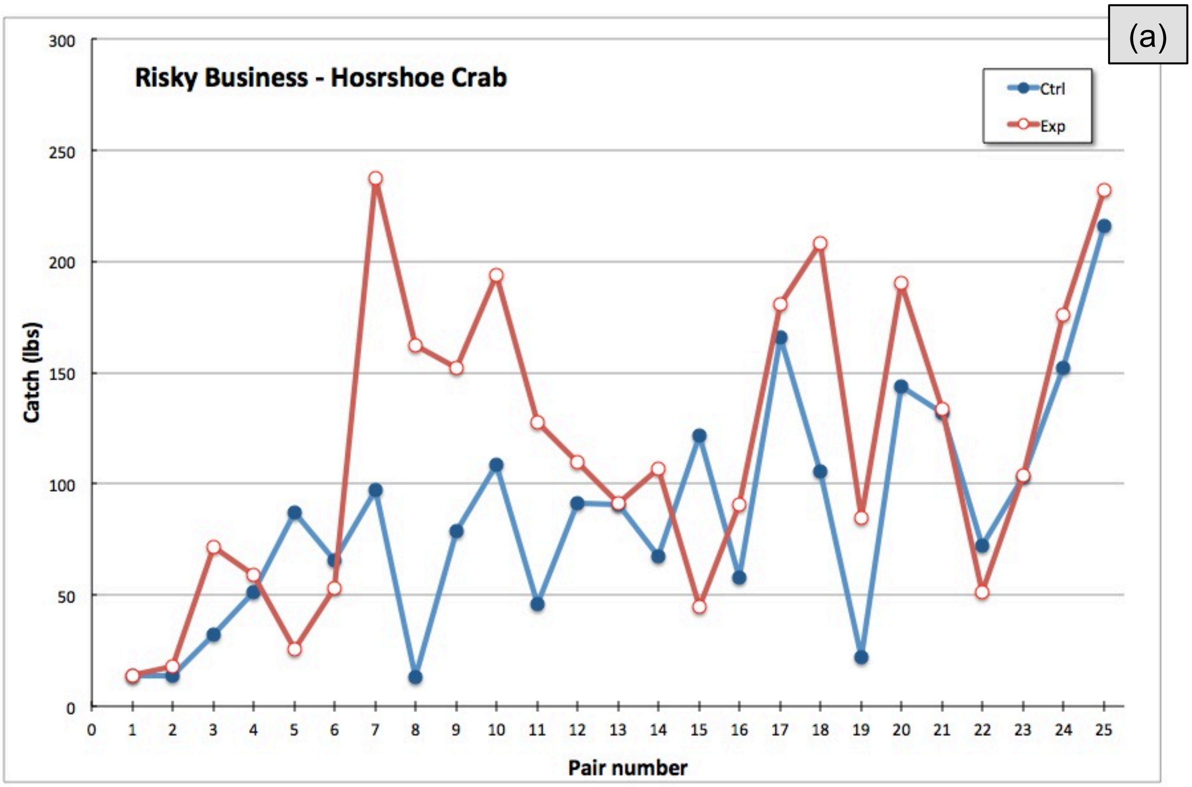


Figure 13. Haul-by-haul comparison of catch of horseshoe crab (a) and “total other species” (b) for “Landon Blake”.



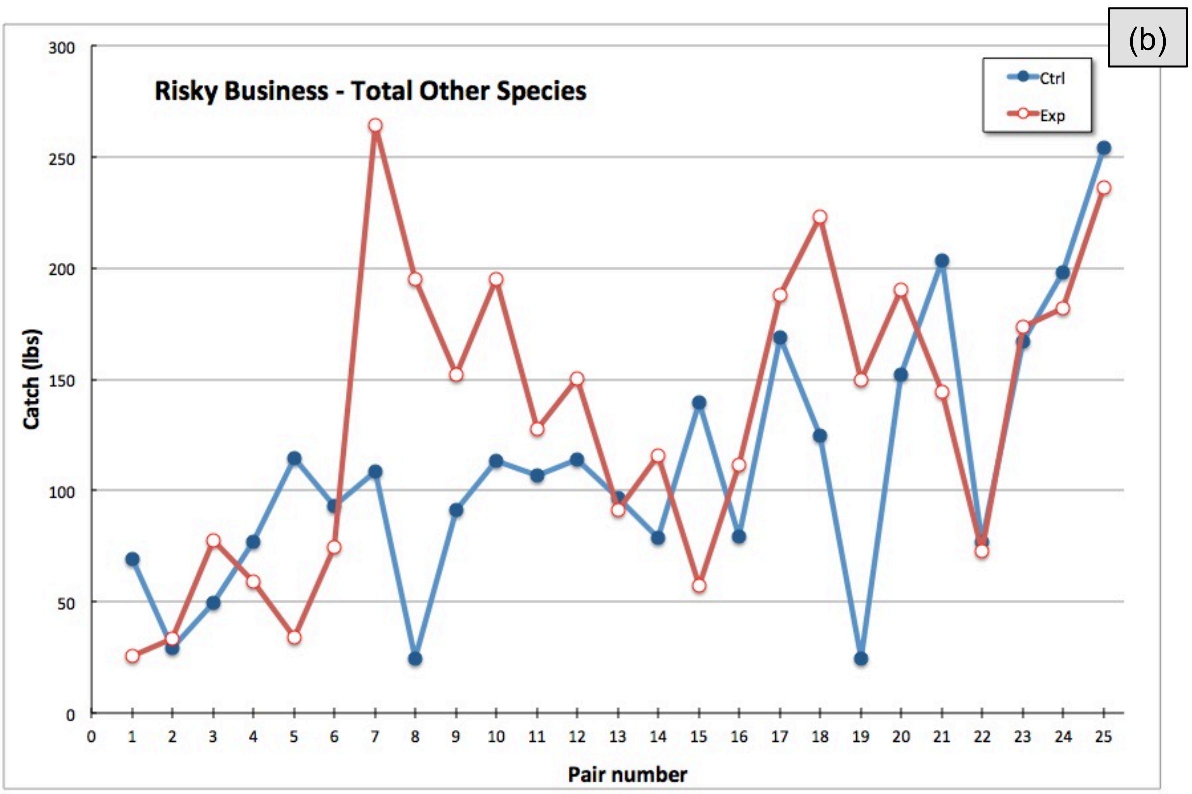


Figure 14. Haul-by-haul comparison of catch of horseshoe crab (a) and “total other species” (b) for “Risky business”.