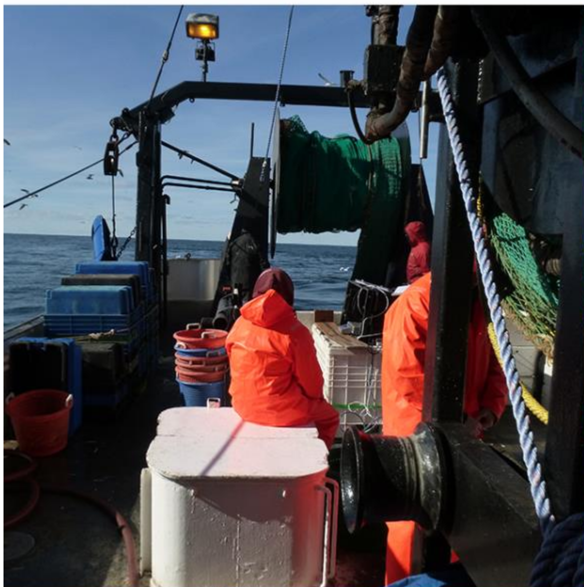
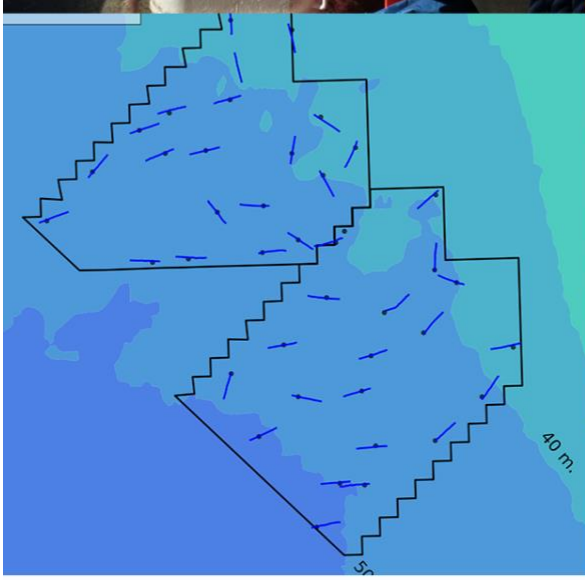
VINEYARD WIND

Vineyard Wind Demersal Trawl Survey





Quarterly Report

501 North Study Area

Winter 2020 (January - March)

VINEYARD WIND DEMERSAL TRAWL SURVEY

Winter 2020 Seasonal Report

501 North Study Area

May 2020

Prepared for Vineyard Wind, LLC

VINEYARD
WIND

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Vineyard Wind Demersal Trawl Survey Winter 2020 Seasonal Report

501 North Study Area

Progress Report #4

January 1 – March 31, 2020

Project title: Vineyard Wind Demersal Trawl Survey Winter 2020 Seasonal Report – 501 North Study Area

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SMAST-CE-REP-2020-085

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1. Introduction

In 2015, Vineyard Wind LLC leased a 675 km^2 area for renewable energy development on the Outer Continental Shelf, Lease Area OCS-A 0501, located approximately 14 miles south of Martha's Vineyard off the south coast of Massachusetts. Vineyard Wind is developing the northern portion of Lease Area OCS-A 0501 and fisheries studies are being conducted in a 250 km^2 area referred to as the "501 North (501N) Study Area," which is the focus of this report. Vineyard Wind is also conducting fisheries studies within the southern portion of Lease Area OCS-A 0501 (the "501 South Study Area") and within Lease Area OCS-A 0522; these studies are reported separately.

The Bureau of Ocean Energy Management (BOEM) has statutory obligations under the National Environmental Policy Act (NEPA) to evaluate environmental, social and economic impacts of a potential project. Additionally, BOEM has statutory obligations under the Outer Continental Shelf Lands Act to ensure any on-lease activities "protect the environment, conserve natural resources, prevent interference with reasonable use of the U.S. Exclusive Economic Zone, and consider the use of the sea as a fishery."

To address the potential impacts, Vineyard Wind LLC, in collaboration with the University of Massachusetts Dartmouth's School for Marine Science and Technology (SMAST), has developed a monitoring plan to assess the potential environmental impacts of the proposed development on marine fish and invertebrate communities. The impact of the development will be evaluated using the Before-After-Control-Impact (BACI) framework. This framework is commonly used to assess the environmental impact of an activity (i.e. wind farm development and operation). Under this framework, monitoring will occur prior to development (Before), and then during construction and operation (After). During these periods, changes in the ecosystem will be compared between the development site (Impact) and a control site (Control). The control site will be in the general vicinity with similar characteristics to the impact areas (i.e. depth, habitat type, seabed characteristics, etc.). The goal of the monitoring plan is to assess the impact that wind farm construction and operation has on the ecosystem within an everchanging ocean.

The current monitoring plan incorporates multiple surveys utilizing a range of survey methods to assess different facets of the regional ecology. The trawl survey is one component of the overall survey plan. A demersal otter trawl, further referred to as a trawl, is a net that is towed behind a vessel along the seafloor expanded horizontally by a pair of otter boards or trawl doors (Figure

1). Trawls tend to be relatively indiscriminate in the fish and invertebrates they collect; hence trawls are a general tool for assessing the biological communities along the seafloor and are widely used by institutions worldwide for ecological monitoring. Since they are actively towed behind a vessel, they are less biased by fish activity and behavior like passive fishing gear (i.e. gillnets, longlines, traps, etc.), which rely on animals moving to the gear. As such, state and federal fisheries management agencies heavily rely on trawl surveys to evaluate ecosystem changes and to assess fishery resources. The current trawl survey closely emulates the Northeast Area Monitoring and Assessment Program (NEAMAP) survey protocol. In doing so, the goal was to ensure compatibility with other regional surveys, including the National Marine Fisheries Service (NMFS) annual spring and fall trawl survey, the annual NEAMAP spring and fall trawl survey, and state trawl surveys including the Massachusetts Division of Marine Fisheries (MADMF) trawl survey.

The primary goal of this survey was to provide data related to fish abundance, distribution, and population structure in and around Vineyard Wind's 501N Study Area. The data will serve as a baseline to be used in a future analysis under the BACI framework. This progress report documents survey methodology, survey effort, and data collected during the winter of 2020.

2. Methodology

The methodology for the survey was adapted from the Atlantic States Marine Fisheries Commission's (ASMFC) NEAMAP nearshore trawl survey. Initiated in 2006, NEAMAP conducts annual spring and fall trawl surveys from Cape Hatteras to Cape Cod. The NEAMAP protocol has gone through extensive peer review and is currently implemented near the Lease Area using a commercial fishing vessel (Bonzek et al., 2008). The current NEAMAP protocol samples at a resolution of ~100 sq. kilometers, which is inadequate to provide scientific information related to potential changes on a smaller scale. Adapting existing methods with increased resolution (see Section 2.1) will enable the survey to fulfill the primary goal of evaluating the impact of windfarm development while improving the consistency between survey platforms. This should facilitate easier sharing and integration of the data with state and federal agencies and allow the data from this survey to be incorporated into existing datasets to enhance our understanding of the region's ecosystem dynamics. Additionally, the methodology is consistent with other ongoing surveys of nearby study areas (Vineyard Wind's 501S Study Area and 522 Lease Area).

2.1 Survey Design

The current survey is designed to provide baseline data on catch rates, population structure, and community structure for a future environmental assessment using the BACI framework as recommended by BOEM (BOEM, 2013). Tow locations within the Vineyard Wind 501N Study Area were selected using a systematic random sampling design. The 501N Study Area (249.3 km^2) was sub-divided into 20 sub-areas (each ~12.5 km^2), and one trawl tow was made in each of the 20 sub-areas. This was designed to ensure adequate spatial coverage throughout the survey area. The starting location within each area were randomly selected (Figure 2).

An area located to the east of the 501N Study Area was established as a control region (306 km^2). The selected region has similar depth contours, bottom types, and benthic habitats to the 501N Study Area. An additional 20 tows were completed in the Control Area. Tow locations were selected in the same manner as the 501N Study Area, using the systematic random sampling design.

The selection of 20 tows in each area was based on a preliminary power analysis conducted using catch data from a scoping survey (Stokesbury and Lowery, 2018). The results indicated that 20 tows within the 501N Study Area and a similar number in the Control Area would allow for a 95% chance of detecting a 25% change in the population of the most abundant species (i.e. scup, butterfish, silver hake, and summer flounder). When distributing the survey effort, randomly selecting multiple tow locations across the Study Area and Control Area accounts for spatial variations in fish populations. Alternatively, multiple tows could be sampled from a single tow track, which would assume that the tow track is representative of the larger ecosystem. The distributed approach, applied here, assumed that the catch characteristics across each area represents the ecosystem. Additionally, surveying each site seasonally accounts for temporal variations in fish populations. Accounting for spatial and temporal variations in fish assemblages reduces the assumptions of the population dynamics while increasing the power to detect changes due to the impacting activities. This methodology is commonly referred to in the scientific literature as the “beyond-BACI” approach (Underwood, 1991)

The survey will have a sampling density of 1 station per 12.5 km^2 (3.6 sq. nautical miles) in the 501N Study Area and 1 station per 15.3 km^2 (4.5 sq. nautical miles) in the Control Area. As previously mentioned, the NEAMAP nearshore survey samples at a density of one station per ~100 km^2 (30 sq. nautical miles).

2.2 Trawl Net

To ensure standardization and compatibility between these surveys and ongoing regional surveys, and to take advantage of the well-established survey protocol, the otter trawl used in this survey has an identical design to the trawl used for the NEAMAP surveys, including otter boards, ground cables and sweeps. This trawl was designed by the Mid-Atlantic and New England Fisheries Management Council's Trawl Advisory Panel (NTAP). As a result, the net design has been accepted by management authorities, the scientific community, and the commercial fishing industry in the region.

The survey trawl is a three-bridle four-seam bottom trawl (Figure 3). This net style allows for a high vertical opening (~5 m.) relative to the size of the net and consistent trawl geometry. These features make it a suitable net to sample a wide diversity of species with varying life history characteristics (i.e. demersal, pelagic, benthic, etc.). To effectively capture benthic organisms, a "flat sweep" was used (Figure 4). A "flat sweep" contains tightly packed rubber disks and lead weights, which ensures close contact with the substrate and minimizes the escape of fish under the net. This is permissible due to the soft bottom (i.e. sand, mud) in the survey area. To ensure the retention of small individuals, a 1" mesh size knotless liner was used within a 12 cm diamond mesh codend. Thyboron Type IV 66" trawl doors were used to horizontally open the net. The trawl doors were connected to the trawl by a series of steel wire bridles. See Figures 5 and 6 for a diagram of the trawl's rigging during the surveys. For a detailed description of the trawl design see Bonzek et al. (2008).

2.3 Trawl Geometry and Acoustic Monitoring Equipment

To ensure standardization between tows, the net geometry was required to be within pre-specified tolerances (±10%) for each of the geometry metrics (i.e. door spread, wing spread, and headline height). These metrics were developed by the NTAP and are part of the operational criteria in the NEAMAP survey protocol. Headline height was targeted to be between 5.0 and 5.5 m with acceptable deviations between 4.5 and 6.1 m. Wingspread was targeted between 13.0 and 14.0 meters (acceptable range: 11.7 – 15.4 m). Door spread was targeted between 32.0 and 33.0 meters (acceptable range: 28.8 – 37.4 m).

The Simrad PX net mensuration system (Kongsberg Group, Kongsberg, Norway) was used to monitor the net geometry (Figure 1). Two sensors were placed in the doors, one in each, to measure the distance between the doors, referred to as door spread. Two sensors placed on the center wingends measured the horizontal spread of the net, commonly referred to as the wing spread. A sensor with a sonar transducer was placed on the top of the net (headrope) to measure the vertical net opening, referred to as headline height. The headline sensor also measured bottom water temperature. To ensure the net was on the bottom a sensor was placed behind the footrope in the belly of the net. That sensor was equipped with a tilt sensor which reported the angle of the net belly. An angle around 0^{o} indicated the net was on the seafloor. A towed hydrophone was placed over the side of the vessel to receive the acoustic signals from the net sensors. A processing unit, located in the wheelhouse and running the TV80 software, was used to monitor and log the data during tows (Figure 7).

2.4 Survey Operations

The survey was conducted on the F/V Heather Lynn, an 84' stern trawler operating out of Point Judith, RI. The F/V Heather Lynn is a commercial fishing vessel currently operating in the industry. Three trips to the survey area were made (Trip 1: February 3 - 6, 2020; Trip 2: February 10 – 13, 2020; Trip 3: February 14 - 17, 2020), during which all planned tows were completed.

Surveys were alternated daily between the Control Area and 501N Study Area. Tows were only conducted during daylight hours. All tows started at least 30 minutes after sunrise and ended 30 minutes before sunset. This was intended to reduce the variability commonly observed during crepuscular periods. Tow duration was 20 minutes at a target tow speed of 3.0 knots (range: 2.8-3.2 knots). Timing of the tow duration was initiated when the wire drums were locked and ended at the beginning of the haulback (i.e. net retrieval). The trawl was towed behind the fishing vessel from steel wires, commonly referred to as trawl warp. The trawl warp ratio (trawl warp: seafloor depth) was set to ~4:1. This decision was based on the net geometry data obtained from the spring and summer surveys indicating that the 4:1 ratio constrained the horizontal spreading of the net increasing the headline height. Trawl warp was set to 100 fathoms (183 m.) for tows in 20 to 27 fathoms (36 to 50 m) and 125 fathoms (229 m) in depths between 28 and 30 fathoms (51 to 55 m). Compared to the spring and summer surveys, the trawl warp was increased in shallower tows (20-23 fm.) to simplify operations by reducing the number of trawl warp groupings.

In addition to monitoring the net geometry to ensure acceptable performance (as described in Section 2.3 above), the following environmental and operational data were collected:

- Cloud cover (i.e. clear, partly cloudy, overcast, fog, etc.)
- Wind speed (Beaufort scale)
- Wind direction
- Sea state (Douglas Sea Scale)
- Start and end position (Latitude and Longitude)
- Start and end depth
- Tow speed
- Bottom temperature

Tow paths and tow speed were continuously logged using the OpenCPN charting software (opencpn.org) running on a computer with a USB GPS unit (GlobalSat BU-353-S4).

2.5 Catch Processing

The catch from each tow was sorted by species. Aggregated weight from each species was weighed on a motion-compensated scale (M1100, Marel Corp., Gardabaer, Iceland). Individual fish length (to the nearest centimeter) and weight (to the nearest gram) were collected. Efforts were made to process all animals; however, during large catches sub-sampling was used for some abundant species. The straight sub-sampling by weight was the only sub-sampling strategy which was used during this survey. In this method the catch was sorted by species. An aggregated species weight was measured and then a sub-sample (50-100 individuals) was made for individual length and weight measurements. The ratio of the sub-sample weight to the total species weight was then used to extrapolate the length-frequency estimates.

Lengths were collected during every tow. Individual fish weights were collected during every tow for low abundance species (<20 individuals/tow) or during alternating tows for abundant common species (>20 individuals/tow). The result from each tow was a measurement of aggregated weight, length-frequency curves, and length-weight curves for each species except crabs, lobsters, and some non-commercial species. For these species, aggregated weight and counts were collected. Any observation of squid eggs was documented. All data was manually recorded and entered into a Microsoft Access database.

3. Results

3.1 Operational Data, Environmental Data and Trawl Performance

Twenty tows were successfully completed in both the 501N Study Area and the Control Area (Figure 2, Table 1). Operational parameters were similar between these two areas (Table 2). Tow durations averaged 20.0 ± 0.4 minutes (mean ± one standard deviation) in the 501N Study Area and 20.0 ± 0.4 minutes in the Control Area. Tow distances averaged 1.0 ± 0.04 nautical miles in the 501N Study Area giving an average tow speed of 3.0 ± 0.1 knots. Similarly tow distance averaged 1.0 ± 0.04 nautical miles in the Control Area giving an average tow speed of 3.0 ± 0.1 knots.

The seafloor in both areas follows a northeast to southwest depth gradient with the shallowest tow along the northeast edge (~35 meters). Depth increased to a maximum of 50 meters along the southwest boundary. Bottom water temperature decreased as the survey progressed. During the first day (February 4th), bottom water temperature averaged 6.2°C, decreasing to 4.8 °C on the last day (February 15th; Table 2).

The trawl geometry data indicated that the trawl took about 2 to 3 minutes to open and stabilize. Once open, readings were stable through the duration of the tow. Door spread averaged 35.0 ± 1.3 m (range: 31.4 – 37.8 m.) for tows in the 501N Study Area and 36.1 ± 1.6 (range: 33.3 – 39.0 m.) in the Control Area. The doorspread was largely within the acceptable tolerance limits except for 4 tow which were ~0.4 – 1.6 m above the tolerance limits. These tows were all conducted in deeper water which required additional trawl warp. The additional trawl warp allowed the doors to spread. While the door spread measurements are higher than the acceptable tolerance limits, we do not believe this affected the catch because the wing spread measurements are within the appropriate range indicating that the net had the appropriate geometry. Wing spread averaged 14.2 ± 0.4 m for tows in the 501N Study Area (range: 13.4 – 15.3 m) and 14.3 ± 0.5 m for tows in the Control Area (range: 13.6 – 15.4 m). All tows were within the acceptable tolerance limits for wingspread. Headline height averaged 4.8 ± 0.2 m for tows in the study area (range: 4.3 – 5.3 m) and 4.5 ± 0.2 m for tows in the control area (range: 3.9 – 4.9). Headline height was targeted to be between 5.0 and 5.5 m with acceptable deviations between 4.5 and 6.1 m. While wing spread data indicated the net was within acceptable tolerances, during nine tows the headline height was lower than desired. All of these tows, except one, were only 0.1-0.3 m lower than the acceptable range. While additional improvements are needed, we do not believe this significantly impacted the representation of species in the catch composition. The majority of species are demersal and are well represented in the catch. Additionally, this survey caught a significant volume of herring and other pelagic species which traditionally require a high vertical opening in the net. As a result, we believe that the survey results are representative of the fish community in the area, however additional testing is being conducted to increase the headline height to within the acceptable range.

3.2 Catch Data

3.2.1 501N Study Area

In the 501N Study Area, a total of 21 species were caught over the duration of the survey (Table 3). Catch volume ranged from 4.6 kg/tow to 77.4 kg/tow with an average of 32.1 kg/tow. The majority of the catch was primarily comprised of a small subset of the observed species. The five most abundant species (Atlantic herring, alewife, silver hake, butterfish, and little skate) accounted for 86% of the total catch weight. Data collected from this area included the catch of both adults and juveniles of most species observed.

Atlantic herring (*Clupea harengus*) was the predominate species observed accounting for 30% of the total catch weight. Individuals ranged in size from 10 to 26 cm with a bimodal distribution consisting of peaks at 15 and 19 cm (Figure 8). Atlantic herring were observed in all 20 tows. Catch rates averaged 9.7 ± 3.4 kg/tow (mean ± SEM, range: 0.1 – 69.7 kg/tow). Atlantic herring were observed throughout the 501N Study Area (Figure 9).

Alewife (*Alosa pseudoharengus*) was the second most abundant species. Alewife ranged in size from 9 to 25 cm with a bimodal size distribution consisting of peaks at 14 and 19 cm (Figure 10). Alewife were observed in every tow at an average catch rate of 8.2 ± 2.4 kg/tow (range: 0.1 – 31.7 kg/tow). Alewife were caught throughout the 501N Study Area with the highest catches aggregated along the eastern side of the study area (Figure 11).

Silver hake (*Merluccius bilinearis*), also commonly referred to as whiting, was the third most abundant species observed. Silver hake ranged in length from 3 to 32 cm. Silver hake had a unimodal size distribution consisting of a peak at 13 cm (Figure 12). Silver hake were observed in every tow at an average catch rate of 6.1 ± 1.0 kg/tow (range: 1.1 – 14.2 kg/tow). Silver hake were caught throughout the 501N Study Area with the highest catches aggregated along the eastern side of the study area (Figure 13).

Butterfish (*Peprilus triacanthus*) was the fourth most abundant species observed. Butterfish ranged in length from 4 to 18 cm with a unimodal size distribution consisting of a peak at 12 cm (Figure 14). Butterfish were observed in 14 of the 20 tows at an average catch rate of 1.9 ± 0.5 kg/tow (range: 0 – 8.0 kg/tow). Butterfish were caught throughout the 501N Study Area (Figure 15).

Little skate (*Leucoraja erinacea*) was the fifth most abundant species observed and the most abundant elasmobranch. Little skates ranged in length from 9 to 33 cm (disk width) with a broad size distribution (Figure 16). Little skates were observed in 19 of the 20 tows at an average catch rate of 1.8 ± 0.3 kg/tow (range: 0 – 5.0 kg/tow). Little skates were caught throughout the 501N Study Area with the highest catches aggregated along the eastern side of the study area (Figure 17).

Additional species commonly observed at low abundances included blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), longhorn sculpin (*Myoxocephalus octodecemspinosus*) and red hake (*Urophycis chuss*).

Blueback herring were caught in 14 of the 20 tows with individuals ranging in size from 7 to 25 cm. Blueback herring had a bimodal size distribution with peaks at 14 and 18 cm (Figure 18). The average catch of blueback herring was 1.0 ± 0.3 kg/tow (range: 0 – 4.5 kg/tow). Blueback herring were observed throughout the 501N Study Area (Figure 19).

American shad were caught in 15 of the 20 tows with individuals ranging in size from 7 to 26 cm. Shad had a bimodal size distribution with peaks at 14 to 23 cm (Figure 20). The average catch of shad was 1.0 ± 0.3 kg/tow (range: 0 – 4.9 kg/tow). Shad were observed throughout the 501N Study Area (Figure 21).

Longhorn sculpin were caught in every tows with individuals ranging in size from 11 to 36 cm with the majority of animals between 22 and 31 cm (Figure 22). The average catch of sculpin was 1.0 ± 0.1 kg/tow (range: 0.3 – 2.2 kg/tow). Sculpin were observed throughout the 501N Study Area (Figure 23).

Red hake were caught in 14 of the 20 tows with individuals ranging in size from 7 to 25 cm. Red hake had a broad size distribution with most animals between 7 and 17 cm (Figure 24). The average catch of red hake was 0.1 ± 0.03 kg/tow (range: 0 – 0.4 kg/tow). Red hake were observed primarily clustered in the southern portion of the 501N Study Area (Figure 25).

Longfin squid, a commercially important species, was caught in low abundances in 5 of the 20 tows. Individuals ranging in size from 8 to 15 cm (Figure 26). The catch rate averaged 0.03 ± 0.01 kg/tow (range: 0 – 0.2 kg/tow) and was distributed around the 501N Study Area (Figure 27). No squid eggs were observed during the survey.

Less common recreational and commercial species observed included 31 Atlantic sea scallops (*Placopecten* magellanicus), 9 Atlantic cod (*Gadus morhua*, size range: 20 - 61 cm), 9 windowpane flounder (*Scophthalmus aquosus,* size range: 9 – 29 cm), 6 yellowtail flounder (*Limanda ferruginea*, size range: 22 – 28 cm), 1 winter flounder (*Pseudopleuronectes americanus,* size: 33 cm), and 1 summer flounder (*Paralichthys dentatus*, size: 33 cm).

3.2.2 Control Area

In the Control Area, a total of 22 species were caught over the duration of the survey (Table 4). Catch volume ranged from 6.8 kg/tow to 209.3 kg/tow with an average of 45.8 kg/tow. The majority of the catch was primarily comprised of a small subset of the observed species. The six most abundant species (Atlantic herring, American shad, little skate, alewife, silver hake, and longhorn sculpin) accounted for 94% of the total catch weight. The species assemblage and catch rates were similar between the Control Area and 501N Study Area. Data collected from this area included the catch of both adults and juveniles of most species observed.

Atlantic herring was the predominate species observed accounting for 59% of the total catch weight. Individuals ranged in size from 12 to 24 cm with a bimodal size distribution consisting of peaks at 15 and 20 cm (Figure 8). Atlantic herring were observed in all 20 tows. Catch rates averaged 27.0 ± 9.9 kg/tow (range: 1.2 – 195.3 kg/tow). Atlantic herring were observed throughout the Control Area (Figure 9).

American shad was the second most abundant species caught in 14 of the 20 tows. Individuals ranging in size from 13 to 25 cm. Shad had a unimodal size distribution with a peak at 23 cm (Figure 20). The average catch of shad was 6.0 ± 3.9 kg/tow (range: 0 – 77.7 kg/tow). Shad were observed throughout the Control Area with the highest catch in the center of the area (Figure 21).

Little skate was the third most abundant species observed and the most abundant elasmobranch. Little skates ranged in length from 9 to 36 cm (disk width) with a broad size distribution (Figure 16). Little skates were observed in 19 of the 20 tows at an average catch rate of 3.5 ± 0.6 kg/tow (range: 0 – 9.5 kg/tow). Little skates were caught throughout the Control Area (Figure 17).

Alewife was the fourth most abundant species. Alewife ranged in size from 9 to 25 cm with a bimodal size distribution consisting of peaks at 8 and 27 cm (Figure 10). Alewife were observed in 19 of the 20 tows at an average catch rate of 2.8 ± 1.5 kg/tow (range: 0 – 30.4 kg/tow). Alewife were caught throughout the Control Area with the highest catch in the middle (Figure 11).

Silver hake was the fifth most abundant species observed. Silver hake ranged in length from 8 to 27 cm. Silver hake had a unimodal size distribution consisting of a peak at 12 cm (Figure 12). Silver hake were observed in 19 of the 20 tows at an average catch rate of 2.1 ± 0.8 kg/tow (range: 0 – 13.4 kg/tow). Silver hake were caught throughout the Control Area with the highest catches aggregated along the western side of the Control Area (Figure 13).

Additional species commonly observed at low abundances included longhorn sculpin, butterfish, and red hake. Longhorn sculpin were caught in 19 of the 20 tows. Individuals ranged in size from 11 to 35 cm with the majority of animals between 22 and 34 cm (Figure 22). The average catch of sculpin was 1.4 ± 0.3 kg/tow (range: 0 – 6.2 kg/tow). Sculpin were observed throughout the Control Area (Figure 23).

Butterfish were observed in 10 of the 20 tows. Individuals ranged in length from 8 to 18 cm with a unimodal peak at 12 cm (Figure 14). The average catch rate of butterfish was 0.7 ± 0.4 kg/tow (range: 0 – 7.3 kg/tow). The catch of butterfish was aggregated in the southwest section of the Control Area (Figure 15).

Red hake were caught in 12 of the 20 tows with individuals ranging in size from 6 to 24 cm. Red hake had a broad size distribution with most animals between 8 and 16 cm (Figure 24). The average catch of red hake was 0.1 ± 0.03 kg/tow (range: 0 – 0.5 kg/tow). Red hake were aggregated in the southwest section of the Control Area (Figure 25).

Longfin squid, a commercially important species, was caught in low abundances in 3 of the 20 tows. Individuals ranging in size from 4 to 27 cm (Figure 26). The catch rate averaged 0.02 ± 0.01 kg/tow (range: 0 – 0.2 kg/tow) and was scattered around the Control Area (Figure 27). No squid eggs were observed during the survey.

Less common recreational and commercial species observed included 13 Atlantic cod (size range: 20 - 47 cm), 7 windowpane flounder (size range: 8 – 31 cm), 2 yellowtail flounder (sizes: 18 and 27 cm), and 2 winter flounder (sizes: 20 and 24 cm).

4. Acknowledgements

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Table 1: Operational and environmental conditions for each survey tow.

Tow Number	Tow Area	Date	Sky Condition	Wind State (Knots)	Wind Direction	Sea State (m.)	Start Time	Start Latitude	Start Longitude	Start Depth (fm)	End Time	End Latitude	End Longitude	End Depth (fm)	Trawl Warp (fm)
1	501N	2/4/2020	Partly Cloudy	7-10	S	0.5-1.25	8:12	N 41° 08.502	W 70° 28.691	20	8:32	N 41° 07.481	W 70° 28.599	21	100
2	501N	2/4/2020	Partly Cloudy	7-10	S	0.5-1.25	8:48	N 41° 06.779	W 70° 28.453	21	9:08	N 41° 05.772	W 70° 28.154	21	100
3	501N	2/4/2020	Overcast	7-10	S	0.5-1.25	9:34	N 41° 05.026	W 70° 29.408	22	9:54	N 41° 05.281	W 70° 28.229	22	100
4	501N	2/4/2020	Overcast	7-10	S	0.5-1.25	10:24	N 41° 03.455	W 70° 29.274	24	10:44	N 41° 03.225	W 70° 30.602	24	100
5	501N	2/4/2020	Rain	7-10	S	0.5-1.25	11:16	N 41° 03.406	W 70° 31.423	23	11:36	N 41° 03.018	W 70° 32.673	25	100
6	501N	2/4/2020	Overcast	7-10	S	0.5-1.25	12:06	N 41° 04.688	W 70° 32.050	24	12:26	N 41° 04.917	W 70° 30.813	25	100
7	501N	2/4/2020	Overcast	7-10	S	0.5-1.25	12:53	N 41° 04.319	W 70° 32.096	24	13:13	N 41° 03.995	W 70° 33.392	24	100
8	501N	2/4/2020	Overcast	7-10	S	0.5-1.25	13:36	N 41° 03.220	W 70° 34.503	24	13:56	N 41° 02.458	W 70° 35.363	24	100
9	501N	2/4/2020	Overcast	7-10	S	0.5-1.25	14:22	N 41° 01.217	W 70° 36.390	25	14:42	N 41° 00.859	W 70° 37.675	29	100
10	501N	2/4/2020	Overcast	7-10	S	0.5-1.25	15:20	N 40° 59.479	W 70° 33.417	27	15:40	N 40° 59.436	W 70° 32.114	26	100
11	501N	2/4/2020	Mostly Cloudy	7-10	S	0.5-1.25	16:06	N 40° 59.594	W 70° 31.278	26	16:26	N 40° 59.543	W 70° 29.921	25	125
12	Control	2/5/2020	Overcast	16-20	N	1.25-2.5	7:06	N 40° 50.086	W 70° 23.865	27	7:26	N 40° 49.902	W 70° 25.109	28	125
13	Control	2/5/2020	Overcast	16-20	N	1.25-2.5	8:14	N 40° 51.532	W 70° 23.579	27	8:34	N 40° 51.457	W 70° 24.645	28	125
14	Control	2/5/2020	Overcast	16-20	N	1.25-2.5	8:55	N 40° 51.352	W 70° 23.741	27	9:15	N 40° 51.437	W 70° 22.434	27	125
15	Control	2/5/2020	Overcast	16-20	N	1.25-2.5	9:49	N 40° 52.772	W 70° 21.619	25	10:09	N 40° 52.695	W 70° 22.959	25	100
16	Control	2/5/2020	Mostly Cloudy	16-20	N	1.25-2.5	10:49	N 40° 54.561	W 70° 23.518	25	11:09	N 40° 54.825	W 70° 22.332	24	100
17	Control	2/5/2020	Mostly Cloudy	16-20	N	1.25-2.5	11:35	N 40° 55.893	W 70° 22.773	24	11:55	N 40° 56.177	W 70° 21.543	23	100
18	Control	2/5/2020	Mostly Cloudy	16-20	N	1.25-2.5	12:37	N 40° 57.591	W 70° 21.501	23	12:57	N 40° 58.136	W 70° 20.463	24	100
19	Control	2/5/2020	Mostly Cloudy	11-15	N	1.25-2.5	13:43	N 40° 58.016	W 70° 23.757	24	14:03	N 40° 58.149	W 70° 25.166	24	100
20	Control	2/5/2020	Mostly Cloudy	11-15	N	1.25-2.5	14:40	N 40° 56.484	W 70° 25.787	25	15:00	N 40° 56.314	W 70° 27.038	25	100
21	Control	2/5/2020	Mostly Cloudy	11-15	N	1.25-2.5	15:33	N 40° 54.612	W 70° 25.934	26	15:53	N 40° 24.633	W 70° 24.633	26	125
22	Control	2/5/2020	Mostly Cloudy	11-15	N	1.25-2.5	16:20	N 40° 53.456	W 70° 26.762	27	16:40	N 40° 53.048	W 70° 27.950	28	125
33	Control	2/12/2020	Clear	27-33	NW	1.25-2.5	7:03	N 41° 00.178	W 70° 23.573	22	7:23	N 40° 59.915	W 70° 24.804	23	100
34	501N	2/12/2020	Clear	27-33	NW	1.25-2.5	8:17	N 40° 59.814	W 70° 24.954	23	8:37	N 41° 00.386	W 70° 26.057	24	100
35	501N	2/12/2020	Clear	27-33	NW	1.25-2.5	9:22	N 40° 59.758	W 70° 26.222	23	9:42	N 40° 59.679	W 70° 27.420	24	100
36	501N	2/12/2020	Clear	21-26	NW	1.25-2.5	10:39	N 41° 00.776	W 70° 28.999	24	10:59	N 41° 01.551	W 70° 29.779	25	100
37	501N	2/12/2020	Clear	16-20	NW	1.25-2.5	11:29	N 41° 01.419	W 70° 28.244	24	11:49	N 41° 01.362	W 70° 26.957	24	100
38	501N	2/12/2020	Clear	11-15	NW	1.25-2.5	12:25	N 41° 02.872	W 70° 25.903	22	12:45	N 41° 03.805	W 70° 25.686	23	100
39	501N	2/12/2020	Clear	7-10	SW	1.25-2.5	13:22	N 41° 02.555	W 70° 24.531	21	13:42	N 41° 01.690	W 70° 25.922	22	100
40	501N	2/12/2020	Clear	7-10	SW	0.5-1.25	14:16	N 41° 02.722	W 70° 23.335	22	14:36	N 41° 03.606	W 70° 22.789	20	100
41	501N	2/12/2020	Clear	7-10	SW	0.5-1.25	15:07	N 41° 03.985	W 70° 23.629	21	15:27	N 41° 04.571	W 70° 24.762	21	100
42	501N	2/12/2020	Mostly Cloudy	7-10	SW	0.5-1.25	16:04	N 41° 06.821	W 70° 25.641	21	16:24	N 41° 07.794	W 70° 25.929	20	100
43	Control	2/15/2020	Mostly Cloudy	3-6	N	0.5-1.25	7:13	N 40° 54.550	W 70° 29.154	27	7:33	N 40° 55.449	W 70° 28.805	26	125
44	Control	2/15/2020	Partly Cloudy	3-6	N	0.5-1.25	8:59	N 41° 01.215	W 70° 19.953	22	9:19	N 41° 01.810	W 70° 19.034	22	100
45	Control	2/15/2020	Partly Cloudy	3-6	N	0.5-1.25	9:46	N 40° 59.927	W 70° 19.139	22	10:06	N 40° 58.967	W 70° 19.210	23	100
46	Control	2/15/2020	Partly Cloudy	3-6	N	0.5-1.25	10:25	N 40° 58.805	W 70° 19.028	23	10:45	N 40° 58.482	W 70° 17.893	22	100
47	Control	2/15/2020	Partly Cloudy	3-6	N	0.5-1.25	11:07	N 40° 57.483	W 70° 18.897	22	11:27	N 40° 56.768	W 70° 19.743	23	100
48	Control	2/15/2020	Partly Cloudy	3-6	N	0.5-1.25	11:59	N 40° 56.168	W 70° 16.609	21	12:19	N 40° 56.363	W 70° 15.203	20	100
49	Control	2/15/2020	Partly Cloudy	3-6	N	0.5-1.25	12:43	N 40° 55.181	W 70° 16.342	22	13:03	N 40° 54.403	W 70° 17.084	23	100
50	Control	2/15/2020	Partly Cloudy	3-6	N	0.5-1.25	13:28	N 40° 53.551	W 70° 18.403	24	13:48	N 40° 52.950	W 70° 19.275	25	100

Table 2: Tow parameters for each survey tow.

Tow Number	Tow Area	Tow Duration (min.)	Tow Speed (knots)	Tow Distance (nm.)	Bottom Temperature (^oC)	Headline Height (m.)	Wing Spread (m.)	Spread Door (m.)
1	501N	19.4	3.0	1.0	6.2	5.0	13.4	33.3
2	501N	19.9	3.1	1.0	6.3	4.6	14.1	35.5
3	501N	19.6	2.9	0.9	6.2	4.5	14.3	35.2
4	501N	20.5	3.0	1.0	6.1	4.7	14.1	35.0
5	501N	20.3	3.0	1.0	6.3	4.8	14.1	35.0
6	501N	20.0	3.0	1.0	6.1	4.7	14.1	35.8
7	501N	20.9	3.0	1.0	6.0	4.8	14.1	35.3
8	501N	19.8	3.1	1.0	5.9	4.6	14.2	35.5
9	501N	20.5	3.1	1.1	6.2	5.0	13.9	35.1
10	501N	20.0	3.1	1.0	6.2	5.3	13.8	31.4
11	501N	19.8	3.2	1.1	6.2	4.3	14.8	37.8
12	Control	20.0	3.0	1.0	5.0	4.4	15.1	37.2
13	Control	19.9	3.0	1.0	5.6	4.4	14.9	38.0
14	Control	20.3	3.0	1.0	5.3	4.5	14.6	37.4
15	Control	20.4	3.1	1.0	5.0	4.6	14.3	35.6
16	Control	19.8	2.9	1.0	5.0	4.4	14.2	37.1
17	Control	20.7	2.9	1.0	5.3	4.5	14.1	37.1
18	Control	20.4	3.0	1.0	5.9	4.4	13.9	36.5
19	Control	19.8	3.3	1.1	6.0	3.9	14.2	37.0
20	Control	19.6	3.0	1.0	5.8	4.3	14.4	35.9
21	Control	19.7	3.1	1.0	5.2	4.2	14.9	38.1
22	Control	19.8	3.1	1.0	5.8	4.4	14.7	37.1
23	Control	20.3	3.0	1.0	5.5	4.6	13.6	33.3
24	501N	20.0	3.1	1.0	5.8	4.7	14.2	35.2
25	501N	20.1	2.8	0.9	5.9	4.9	14.2	35.5
26	501N	20.0	3.1	1.0	5.8	4.7	14.4	36.7
27	501N	19.4	3.1	1.0	5.7	5.0	13.5	33.2
28	501N	19.6	2.9	1.0	5.4	4.9	13.9	34.4
29	501N	19.6	3.1	1.0	5.6	4.7	14.0	34.8
30	501N	19.9	3.0	1.0	5.4	4.5	15.3	35.3
31	501N	20.3	3.1	1.1	4.9	4.6	14.1	35.0
32	501N	20.6	3.0	1.0	4.6	4.6	14.3	34.8
33	Control	19.4	3.0	1.0	5.8		15.4	39.0
34	Control	20.3	2.8	0.9	4.6	4.5	14.2	35.1
35	Control	20.4	2.9	1.0	4.7	4.7	13.9	34.1
36	Control	19.8	2.9	0.9	4.5	4.9	13.9	34.5
37	Control	20.3	2.9	1.0	4.6	4.7	14.1	34.7
38	Control	20.3	3.2	1.1	4.6	4.6	14.0	34.8
39	Control	20.2	2.9	1.0	4.8	4.9	13.9	34.5
40	Control	19.6	2.8	0.9	4.9	4.6	13.9	34.6
Summary Statistics								
Control	Minimum	19.4	2.8	0.9	4.5	3.9	13.6	33.3
	Maximum	20.7	3.3	1.1	6.0	4.9	15.4	39.0
	Average	20.0	3.0	1.0	5.2	4.5	14.3	36.1
	St. Dev	0.4	0.1	0.04	0.5	0.2	0.5	1.6
501N	Minimum	19.4	2.8	0.9	4.6	4.3	13.4	31.4
	Maximum	20.9	3.2	1.1	6.3	5.3	15.3	37.8
	Average	20.0	3.0	1.0	5.9	4.8	14.2	35.0
	St. Dev.	0.4	0.1	0.04	0.5	0.2	0.4	1.3

Table 3: Total and average catch weights observed within the 501N Study Area.

Species Name	Scientific Name	Total Weight (Kg)	Catch/Tow (Kg)		% of Total Catch	Tows with Species Present
			Mean	SEM*		
Herring, Atlantic	*Clupea harengus*	193.1	9.7	3.35	30.1	20
Alewife	*Alosa pseudoharengus*	163.0	8.2	2.38	25.4	20
Hake, Silver	*Merluccius bilinearis*	122.1	6.1	0.96	19.0	20
Butterfish	*Peprilus triacanthus*	37.8	1.9	0.54	5.9	14
Skate, Little	*Leucoraja erinacea*	35.0	1.8	0.30	5.5	19
Herring, Blueback	*Alosa aestivalis*	20.9	1.0	0.30	3.3	14
Shad, American	*Alosa sapidissima*	20.4	1.0	0.31	3.2	15
Sculpin, Longhorn	*Myoxocephalus octodecemspinosus*	20.3	1.0	0.12	3.2	20
Crab, Rock	*Cancer sp.*	11.8	0.6	0.09	1.8	17
Atlantic Cod	*Gadus morhua*	6.0	0.3	0.15	0.9	5
Sea Scallop	*Placopecten magellanicus*	3.2	0.2	0.07	0.5	8
Hake, Red	*Urophycis chuss*	2.5	0.1	0.03	0.4	14
Flounder, Windowpane	*Scophthalmus aquosus*	1.6	0.1	0.03	0.2	7
Hake, Spotted	*Urophycis regius*	1.0	0.1	0.02	0.2	8
Flounder, Yellowtail	*Limanda ferruginea*	0.8	0.0	0.02	0.1	6
Squid, Atlantic Longfin	*Doryteuthis pealeii*	0.6	0.0	0.01	0.1	5
Mackerel, Atlantic	*Scomber scombrus*	0.4	0.0	0.01	0.1	3
Flounder, Winter	*Pseudopleuronectes americanus*	0.4	0.0	0.02	0.1	1
Flounder, Summer (Fluke)	*Paralichthys dentatus*	0.3	0.0	0.02	0.0	1
Flounder, Gulfstream	*Citharichthys arctifrons*	0.2	0.0	0.01	0.0	2
Sea Raven	*Hemitripterus americanus*	0.1	0.0	0.01	0.0	1
Total		641.6				

*SEM is an acronym for Standard Error of the Mean

Table 4: Total and average catch weights observed within the Control Area.

Species Name	Scientific Name	Total Weight (Kg)	Catch/Tow (Kg) Mean	Catch/Tow (Kg) SEM*	% of Total Catch	Tows with Species Present
Herring, Atlantic	*Clupea harengus*	540.1	27.0	9.86	59.0	20
Shad, American	*Alosa sapidissima*	120.9	6.0	3.92	13.2	14
Skate, Little	*Leucoraja erinacea*	70.3	3.5	0.62	7.7	19
Alewife	*Alosa pseudoharengus*	55.3	2.8	1.53	6.0	19
Hake, Silver	*Merluccius bilinearis*	42.9	2.1	0.81	4.7	19
Sculpin, Longhorn	*Myoxocephalus octodecemspinosus*	27.2	1.4	0.31	3.0	19
Crab, Rock	*Cancer sp.*	16.0	0.8	0.25	1.7	11
Butterfish	*Peprilus triacanthus*	13.9	0.7	0.39	1.5	10
Herring, Blueback	*Alosa aestivalis*	7.8	0.4	0.21	0.9	6
Atlantic Cod	*Gadus morhua*	6.3	0.3	0.10	0.7	10
Dogfish, Spiny	*Squalus acanthias*	4.3	0.2	0.15	0.5	2
Skate, Winter	*Leucoraja ocellata*	3.2	0.2	0.11	0.3	2
Mackerel, Atlantic	*Scomber scombrus*	2.2	0.1	0.04	0.2	7
Hake, Red	*Urophycis chuss*	1.8	0.1	0.03	0.2	12
Flounder, Windowpane	*Scophthalmus aquosus*	1.2	0.1	0.03	0.1	5
Hake, Spotted	*Urophycis regius*	1.1	0.1	0.02	0.1	7
Squid, Atlantic Longfin	*Doryteuthis pealeii*	0.4	0.0	0.01	0.0	3
Sea Raven	*Hemitripterus americanus*	0.3	0.0	0.02	0.0	1
Flounder, Winter	*Pseudopleuronectes americanus*	0.3	0.0	0.02	0.0	1
Flounder, Yellowtail	*Limanda ferruginea*	0.2	0.0	0.01	0.0	2
Skate, Barndoor	*Dipturus laevis*	0.1	0.0	0.01	0.0	1
Flounder, Gulfstream	*Citharichthys arctifrons*	0.1	0.0	0.01	0.0	1
Total		915.8				

*SEM is an acronym for Standard Error of the Mean

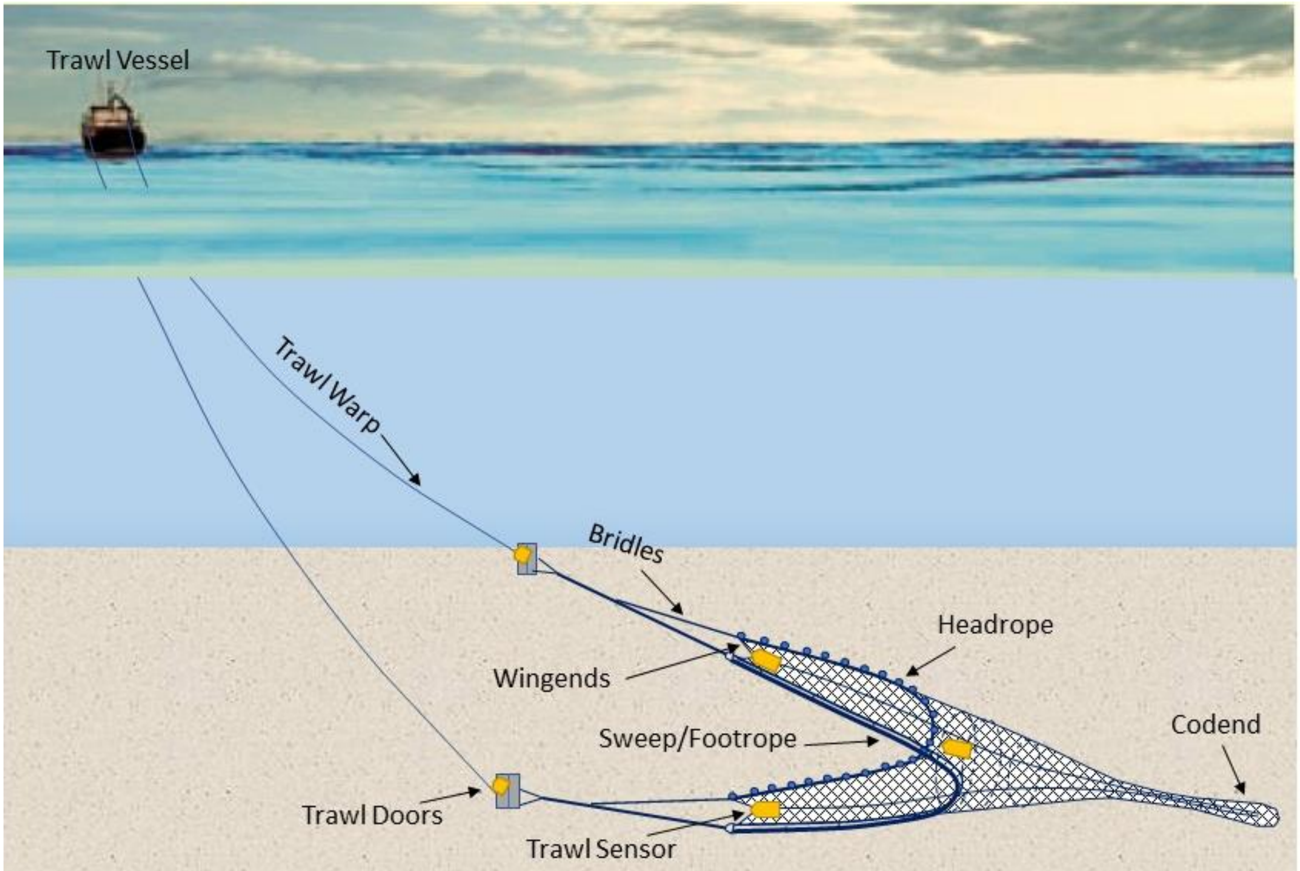


Figure 1: General schematic (not to scale) of a demersal otter trawl. Yellow rectangles indicate geometry sensors.

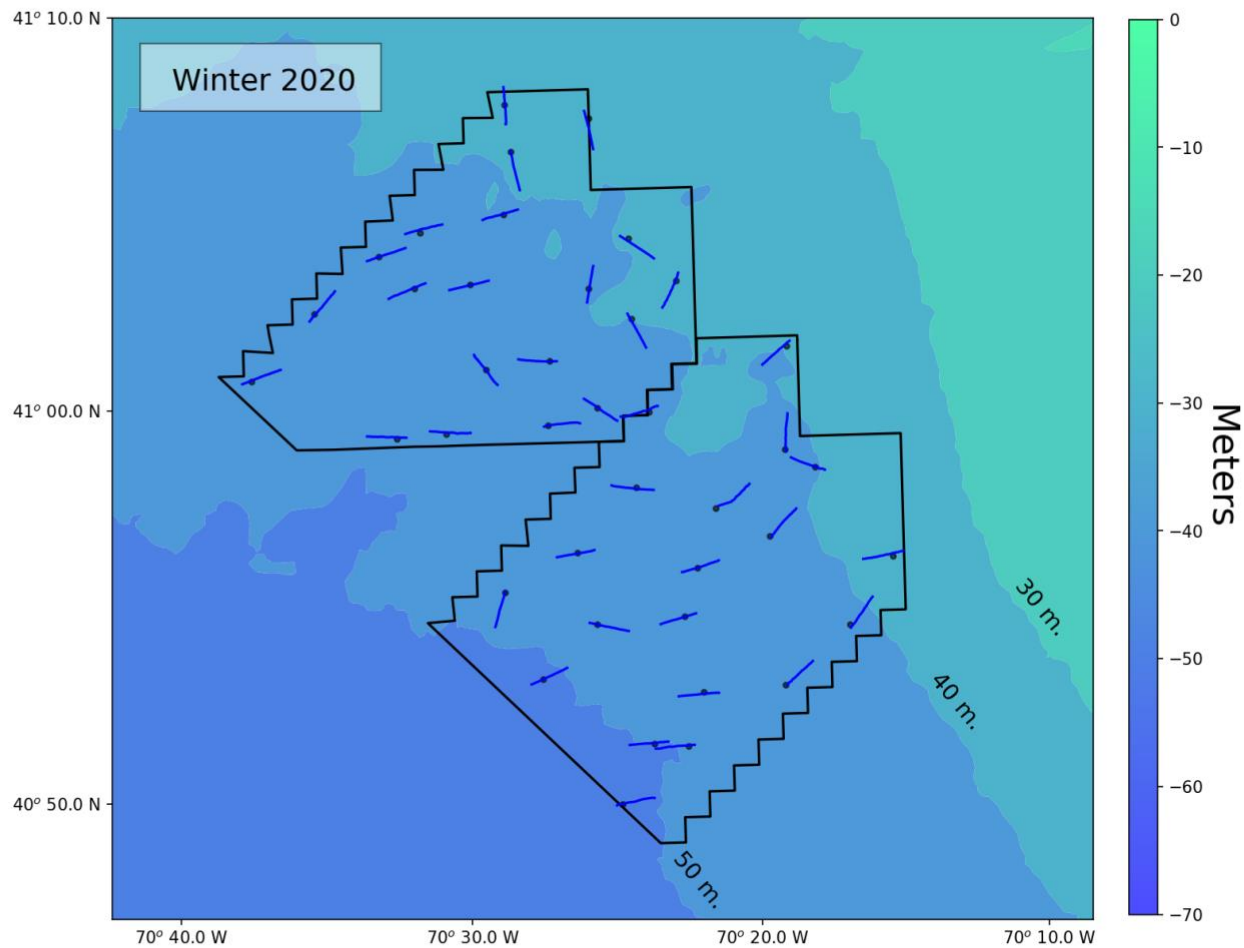


Figure 2: Tow locations (black dots) and trawl tracks (blue lines) from the 501N Study Area (left) and the Control Area (right).

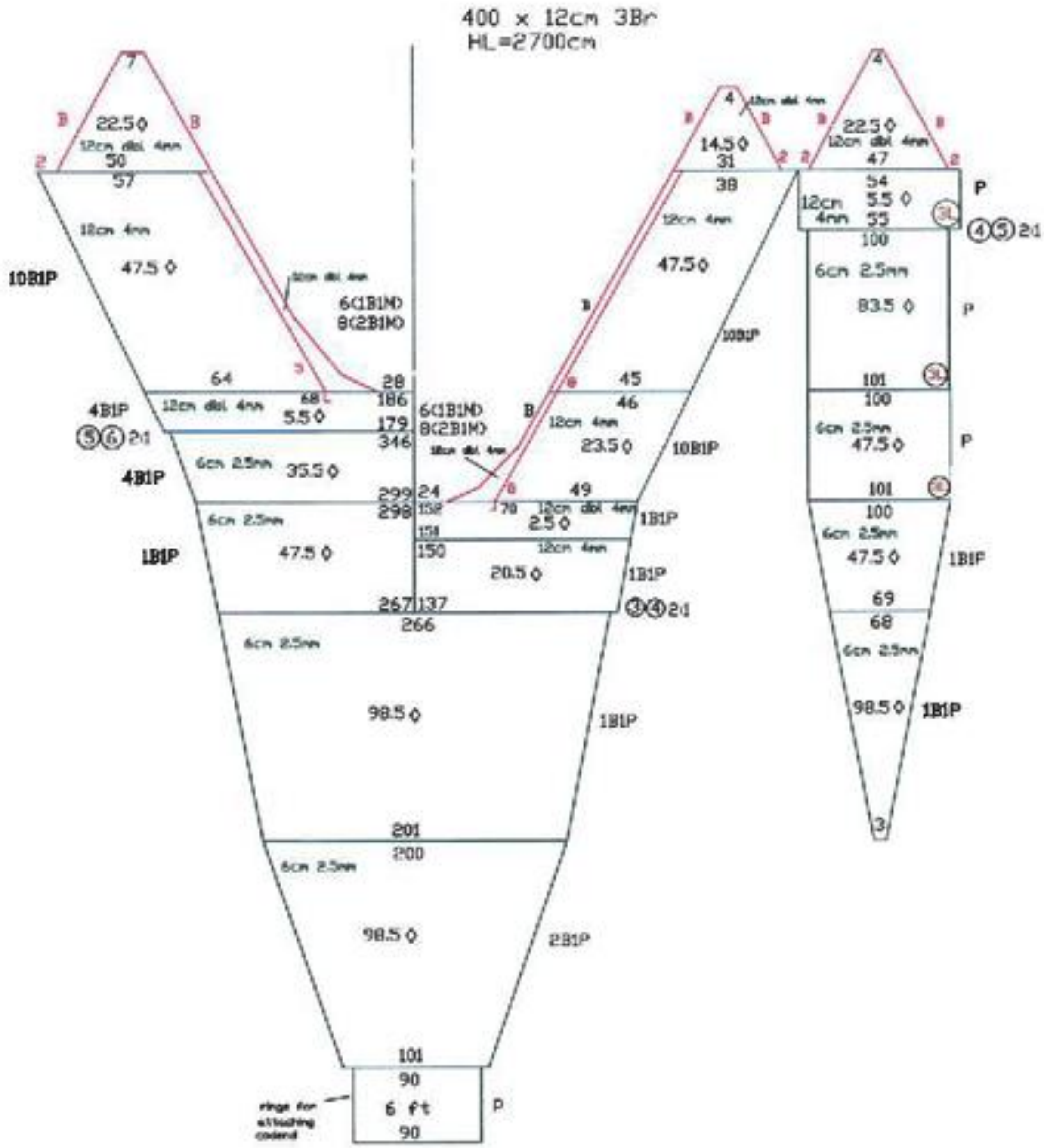


Figure 3: Schematic net plan for the NEAMAP trawl (Bonzek et al. 2008).

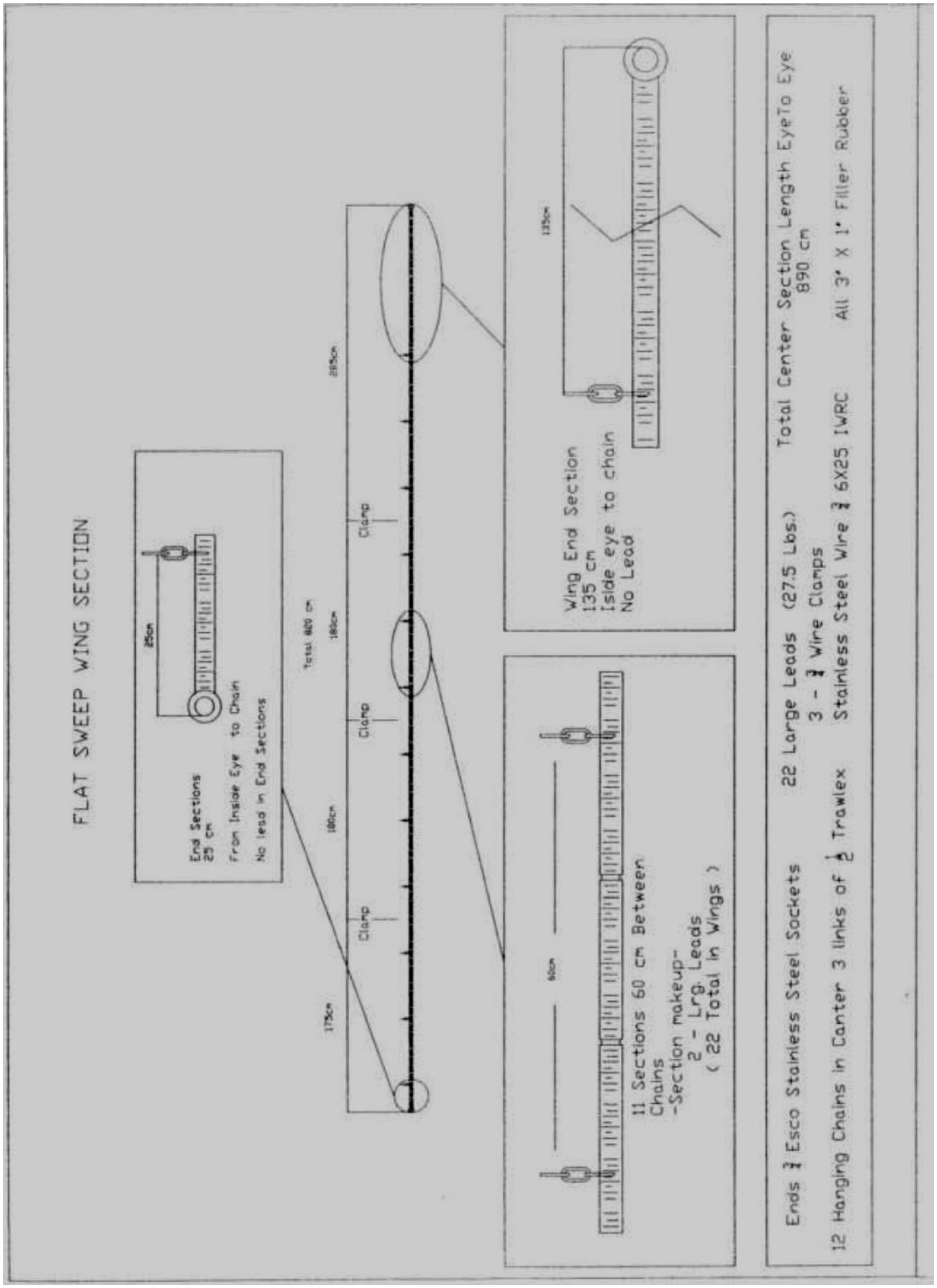


Figure 4: Sweep diagram for the survey trawl (Bonzek et al. 2008).

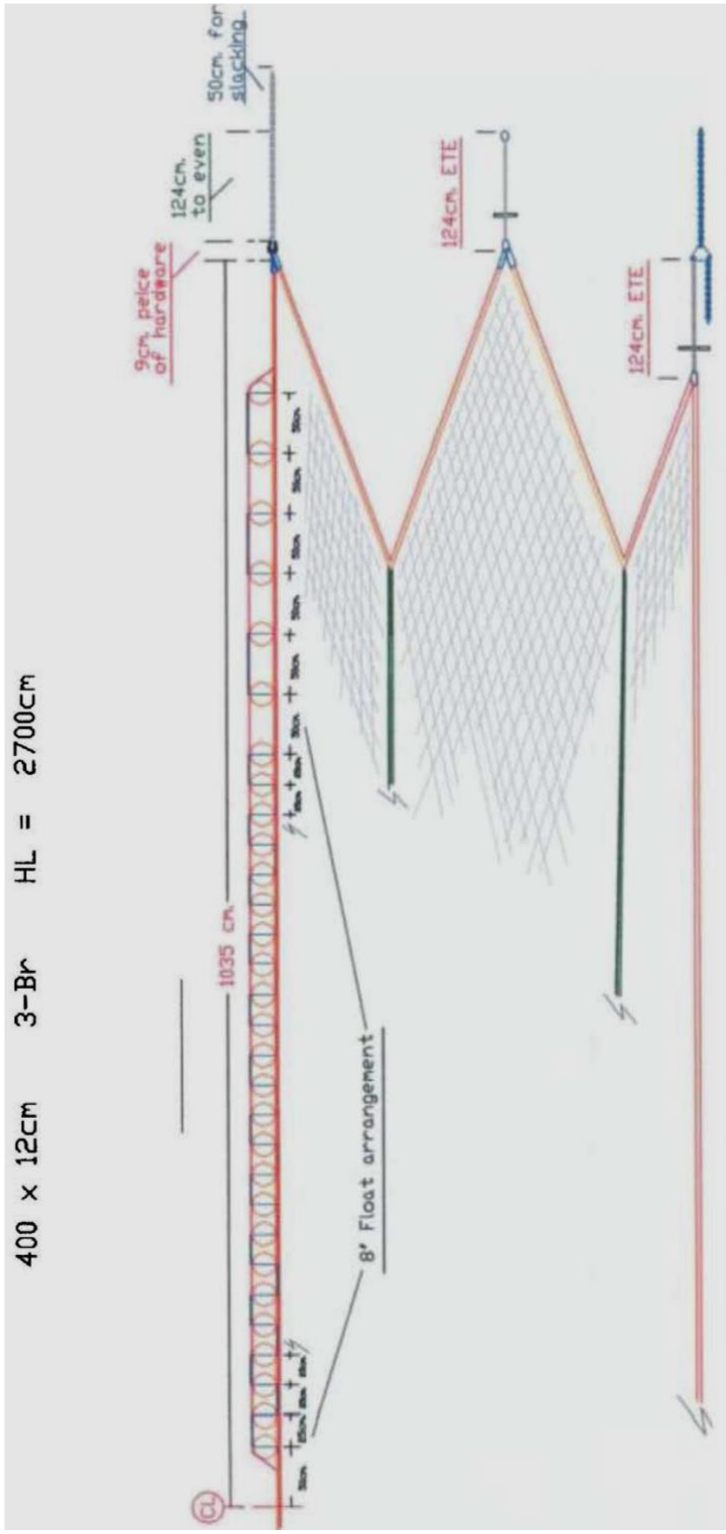


Figure 5: Headrope and rigging plan for the survey trawl (Bonzek et al. 2008).

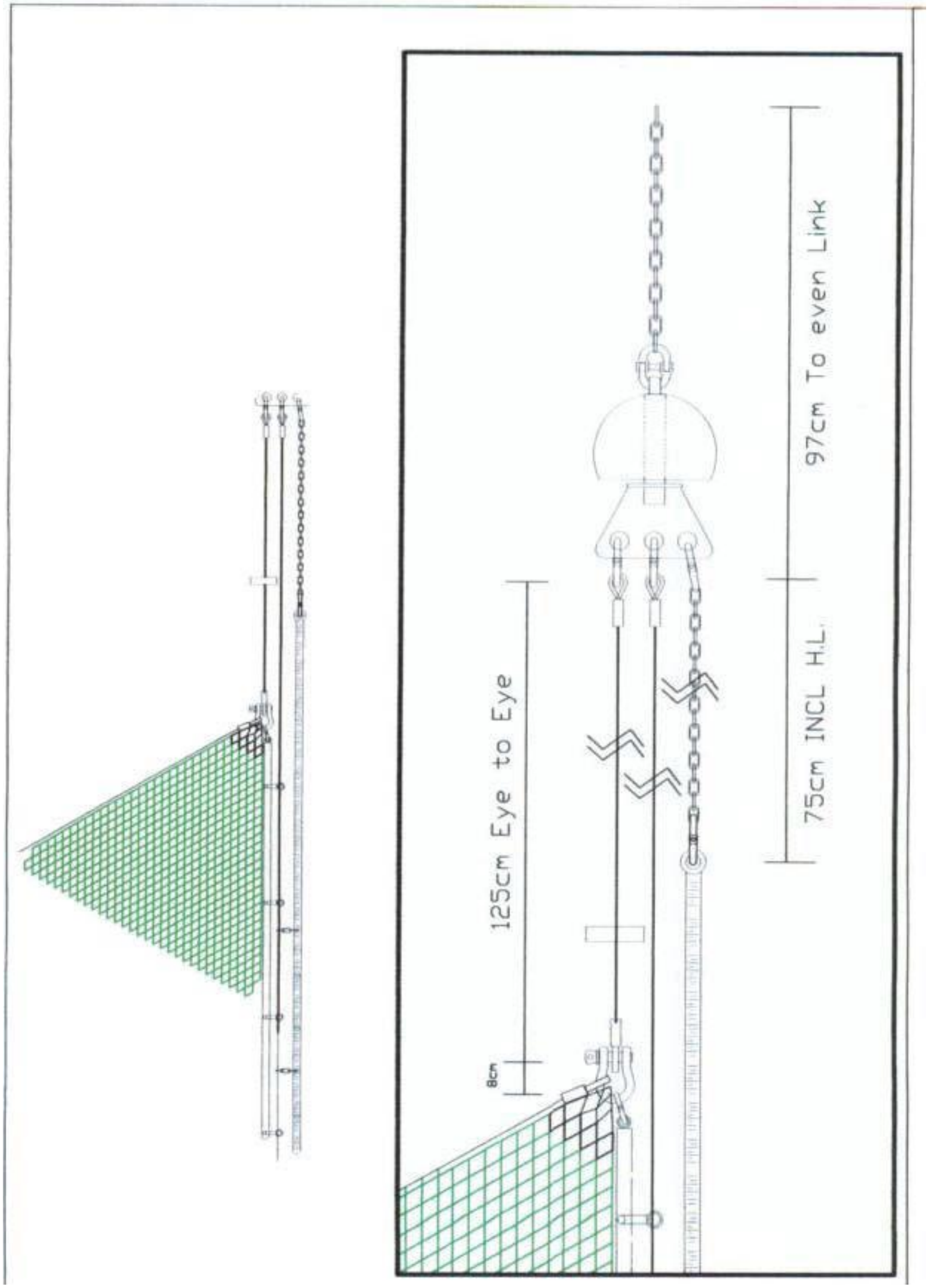


Figure 6: Lower wing and bobbin schematic for the survey trawl (Bonzek et al. 2008).

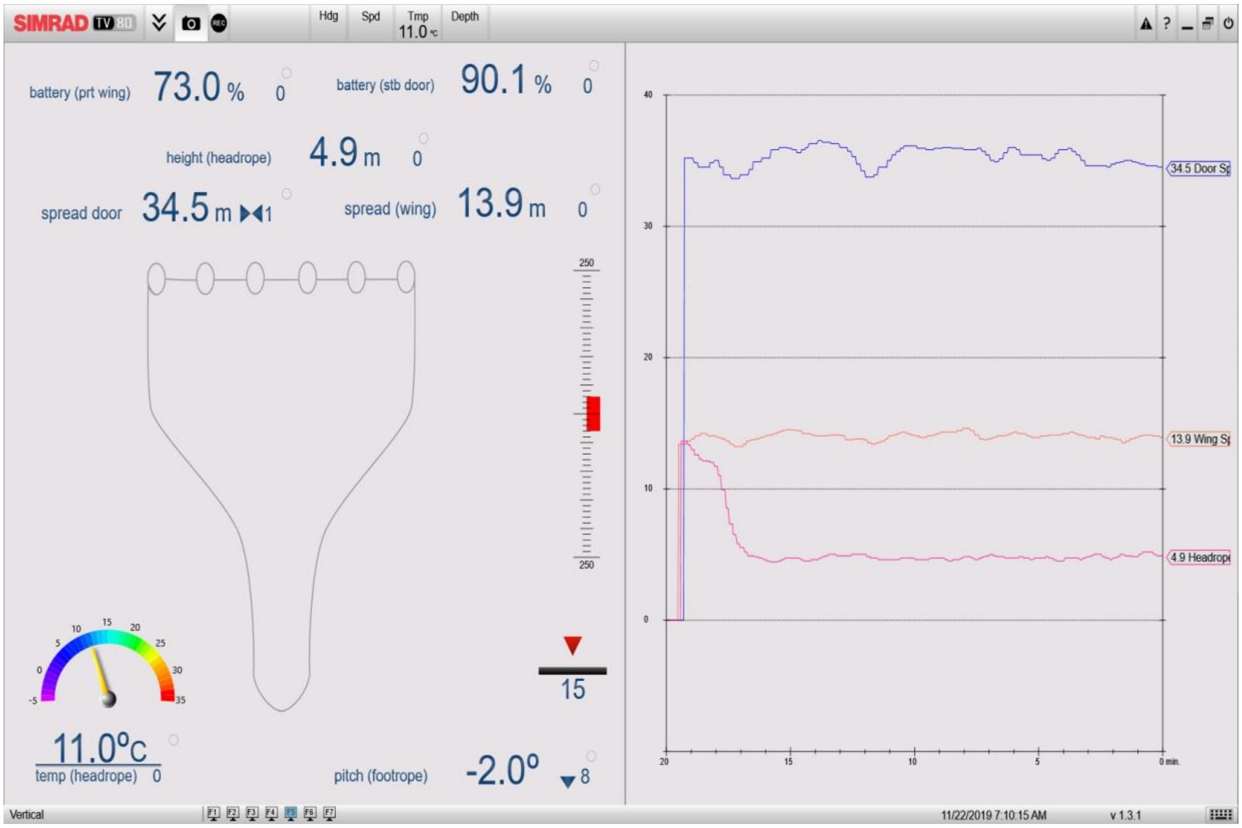


Figure 7: Screenshot of the SIMRAD TV80 software monitoring the trawl parameters.

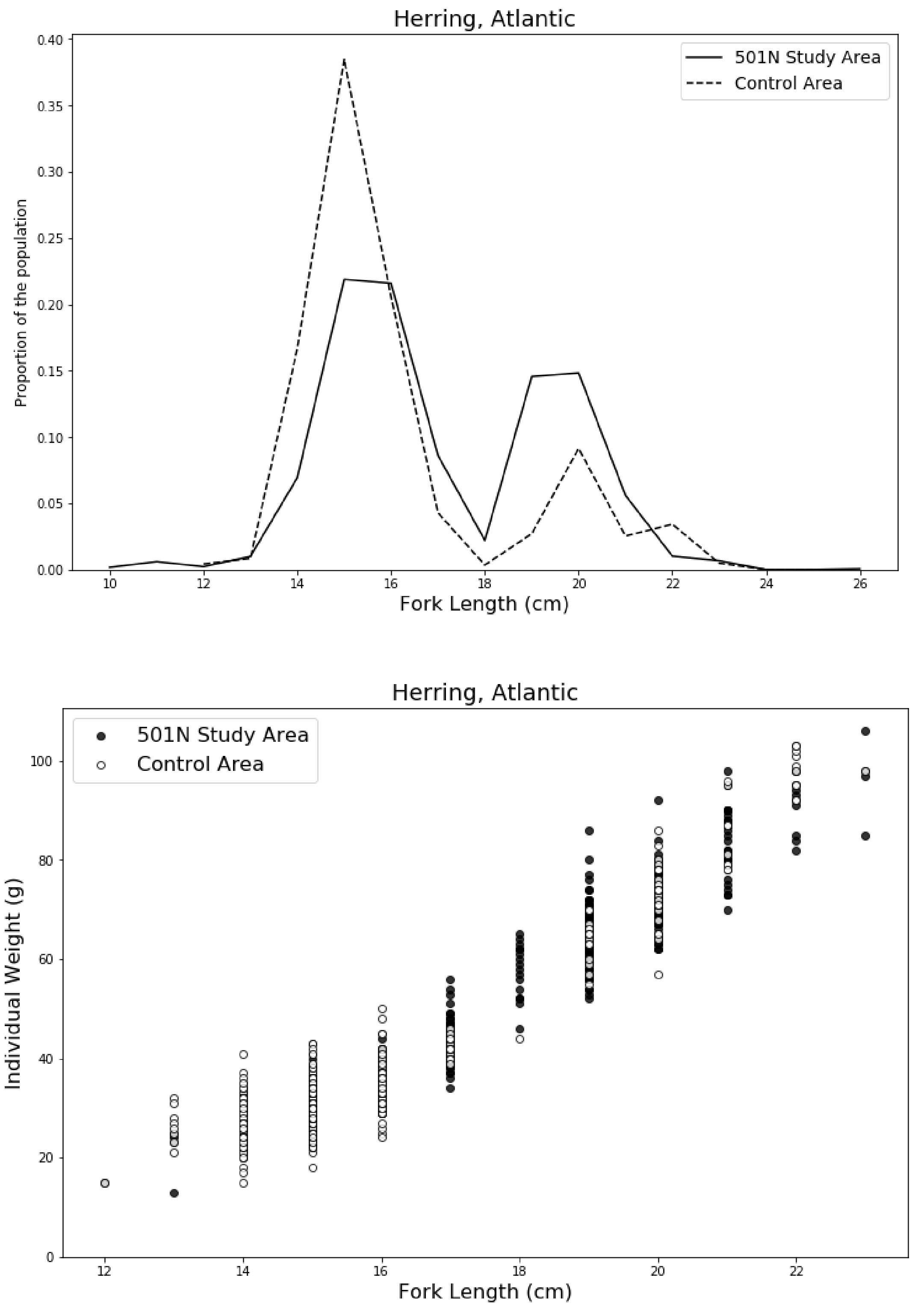


Figure 8: Population structure of Atlantic herring in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

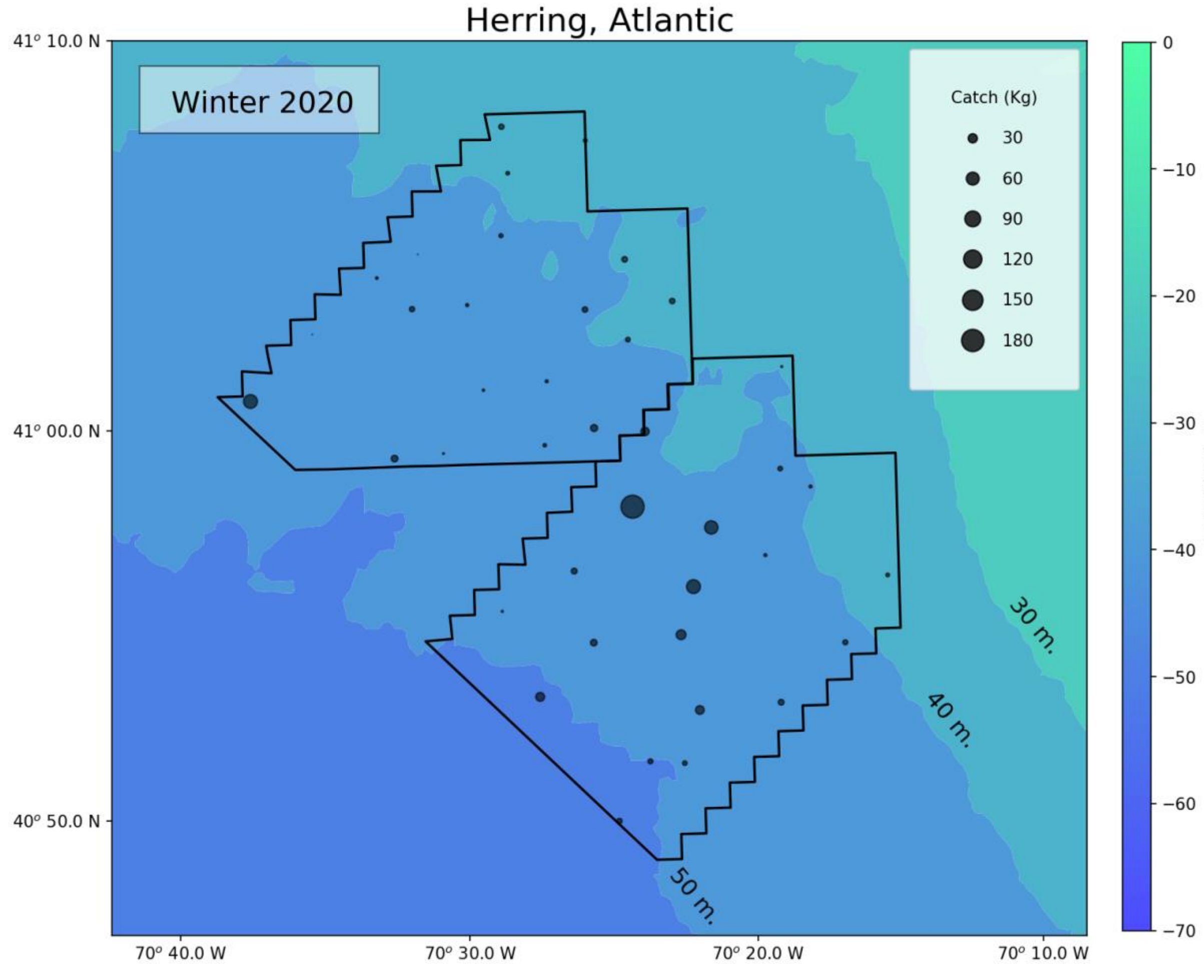
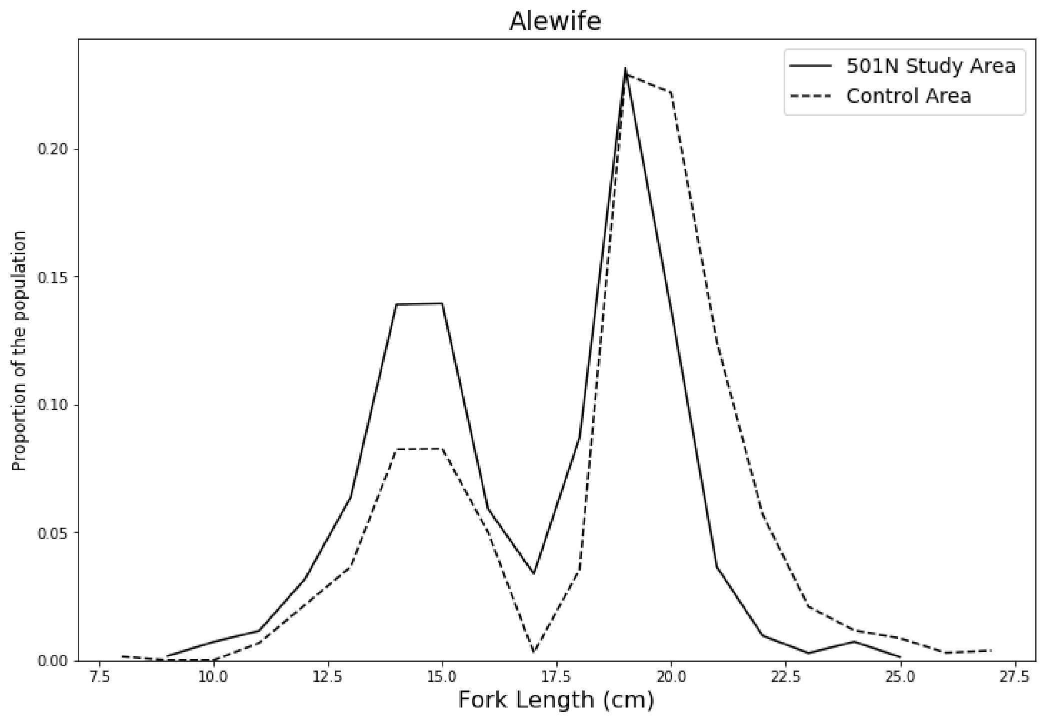


Figure 9: Distribution of the catch of Atlantic herring in the 501N Study Area (left) and Control Area (right).



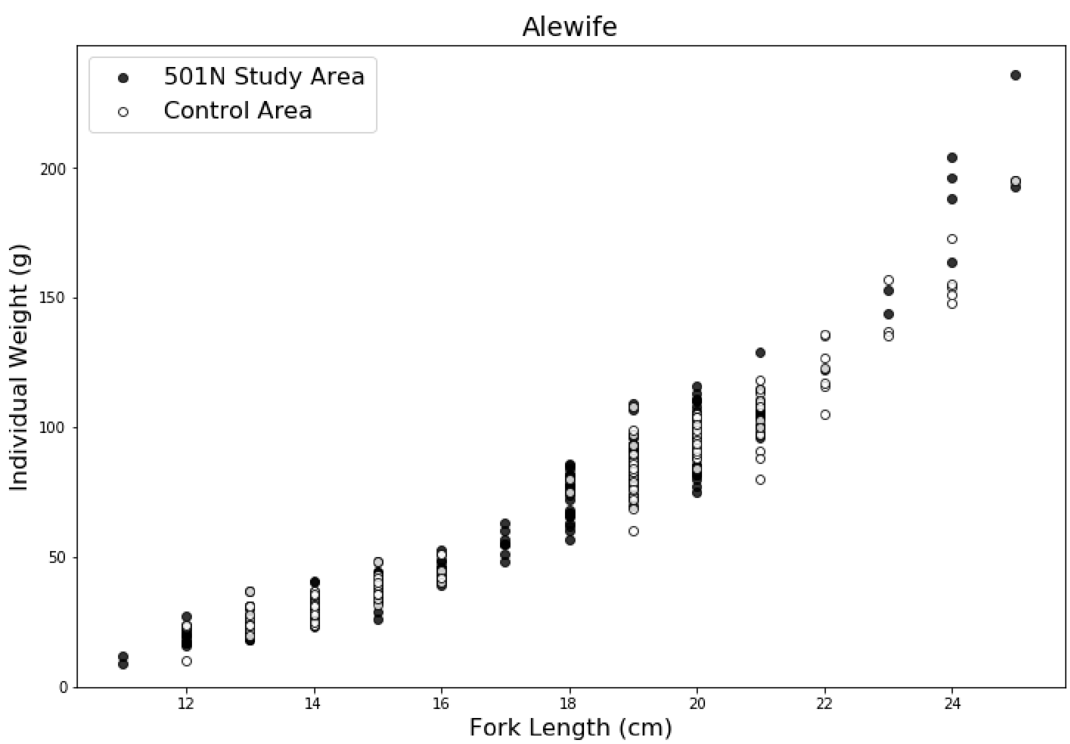


Figure 10: Population structure of alewife in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

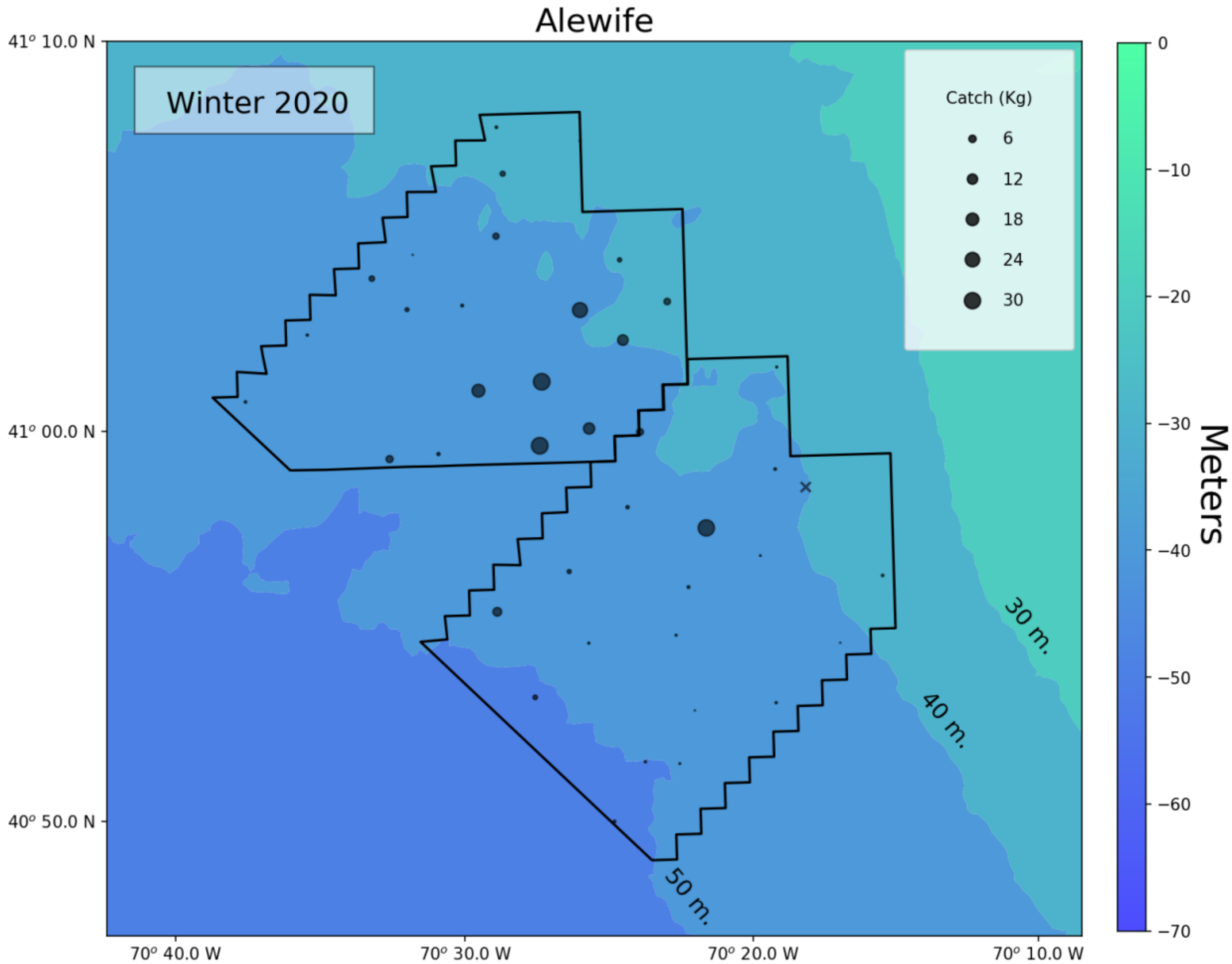
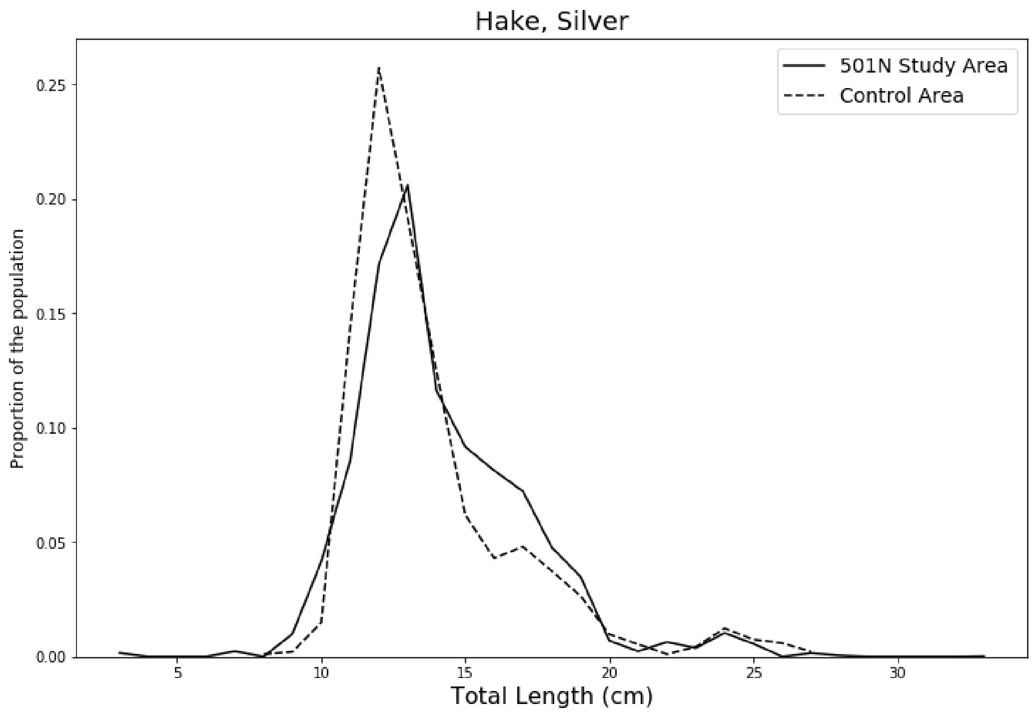


Figure 11: Distribution of the catch of alewife in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



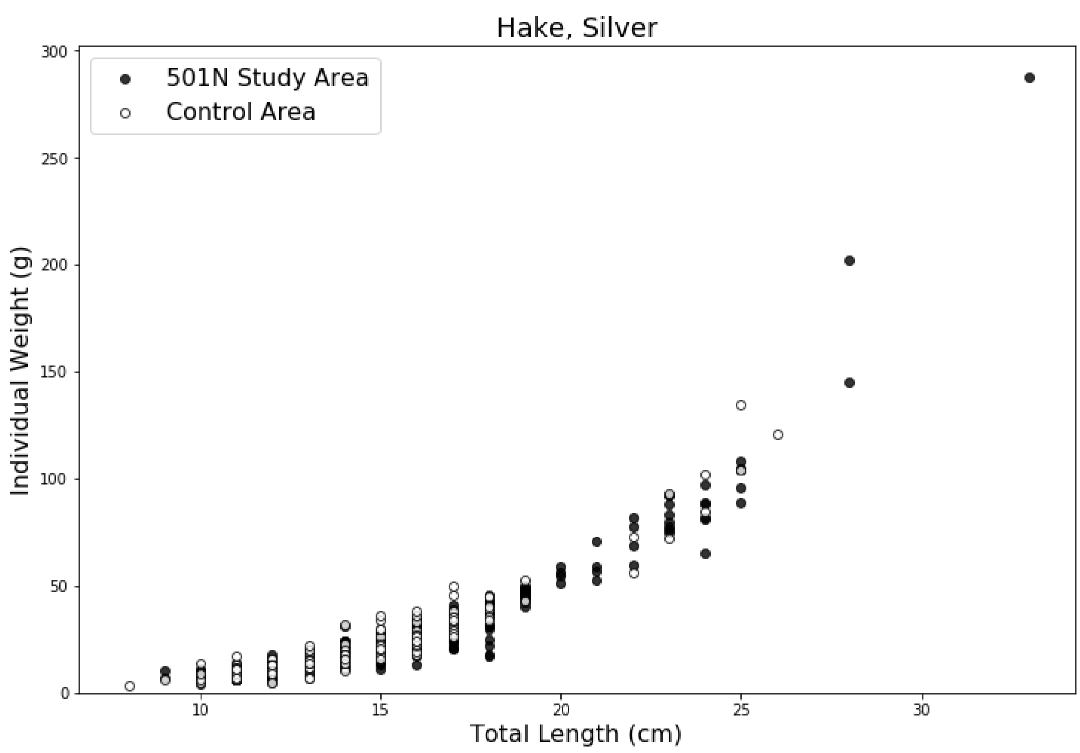


Figure 12: Population structure of silver hake in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

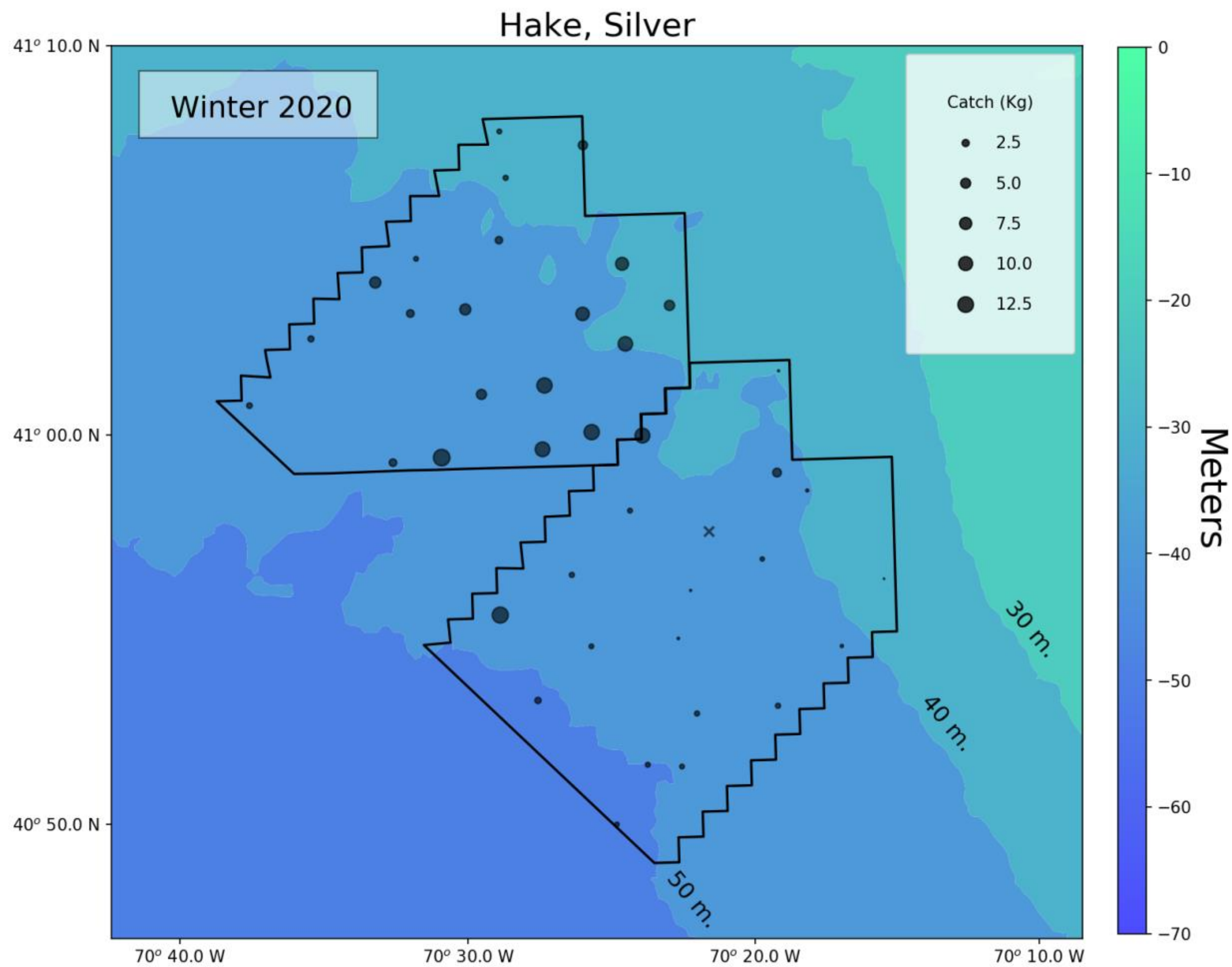
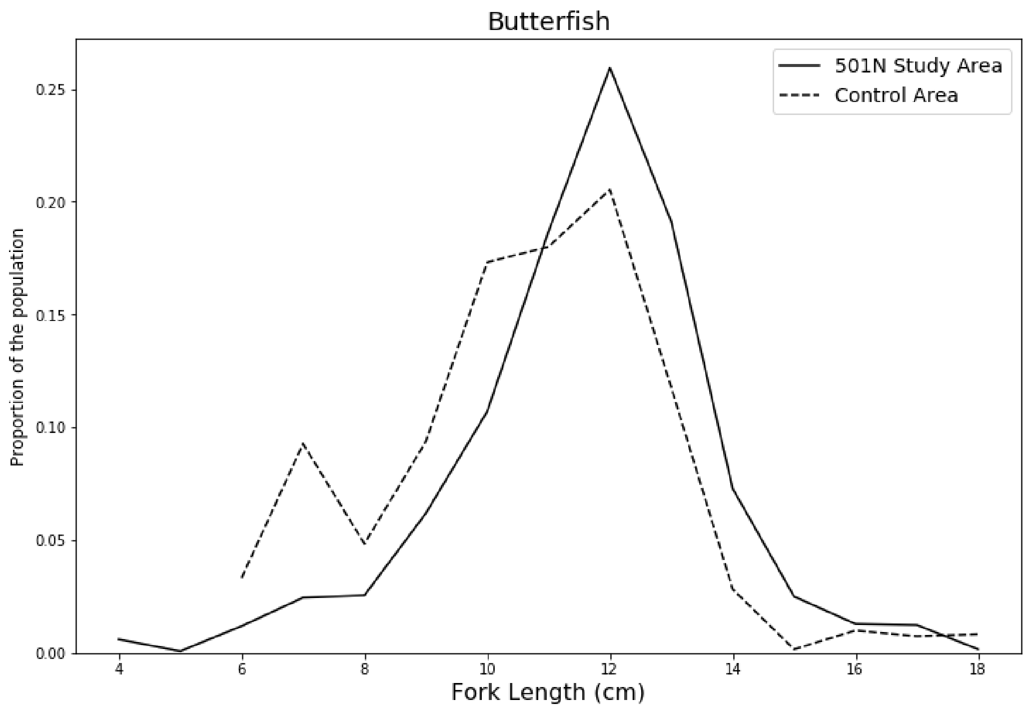


Figure 13: Distribution of the catch of silver hake in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



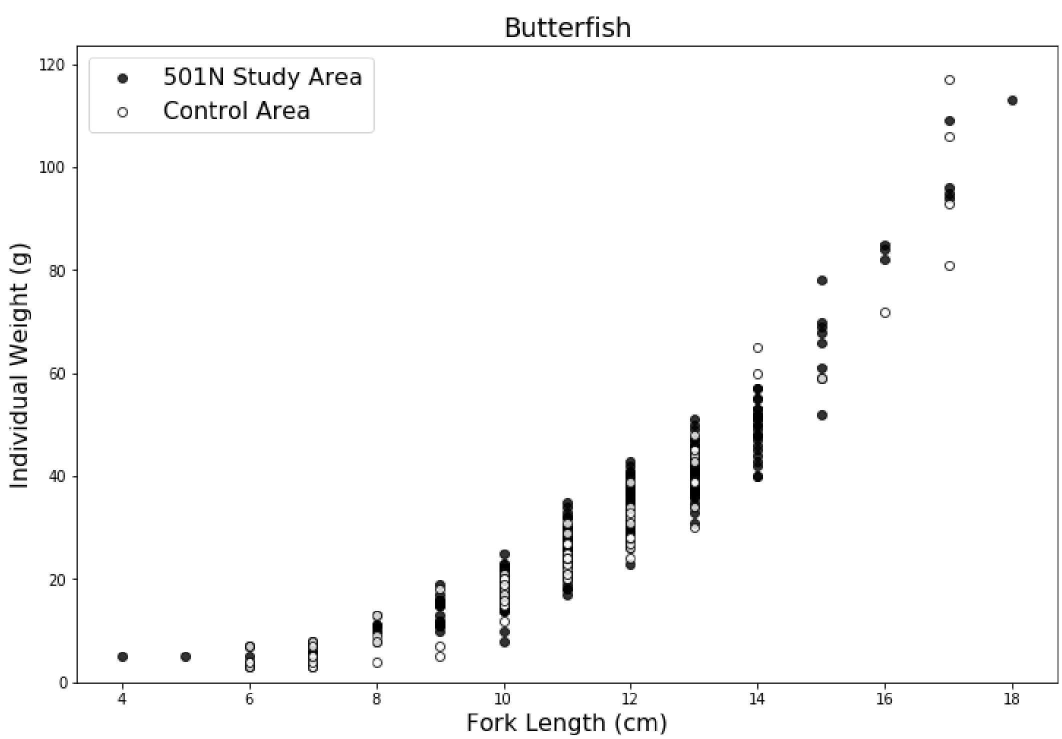


Figure 14: Population structure of butterfish in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

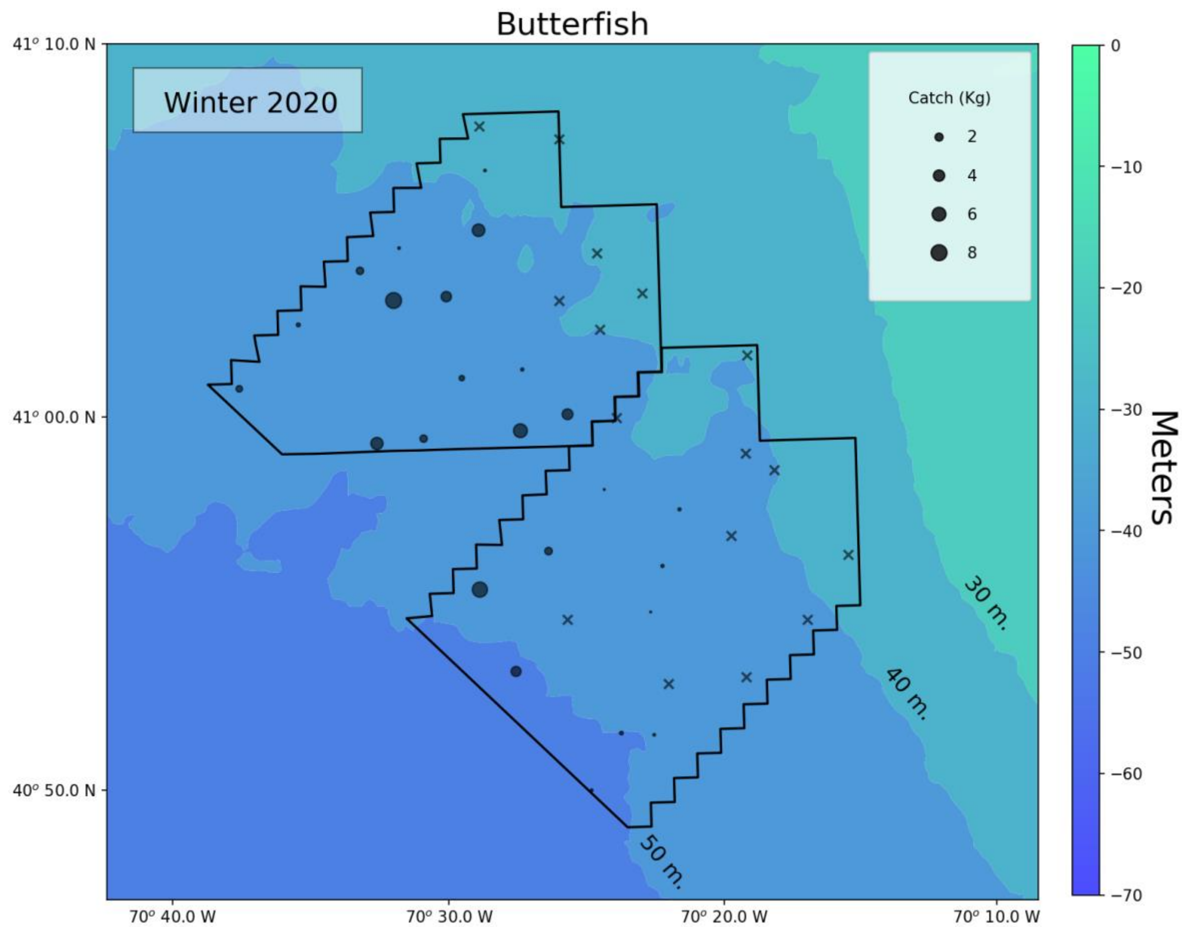
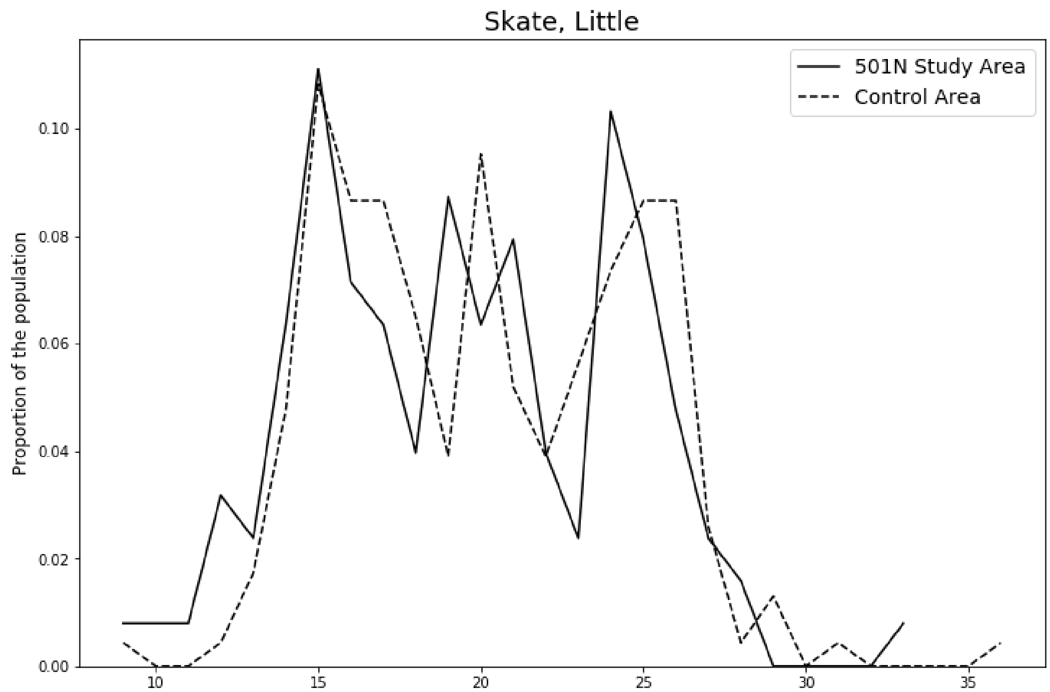


Figure 15: Distribution of the catch of butterfish in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



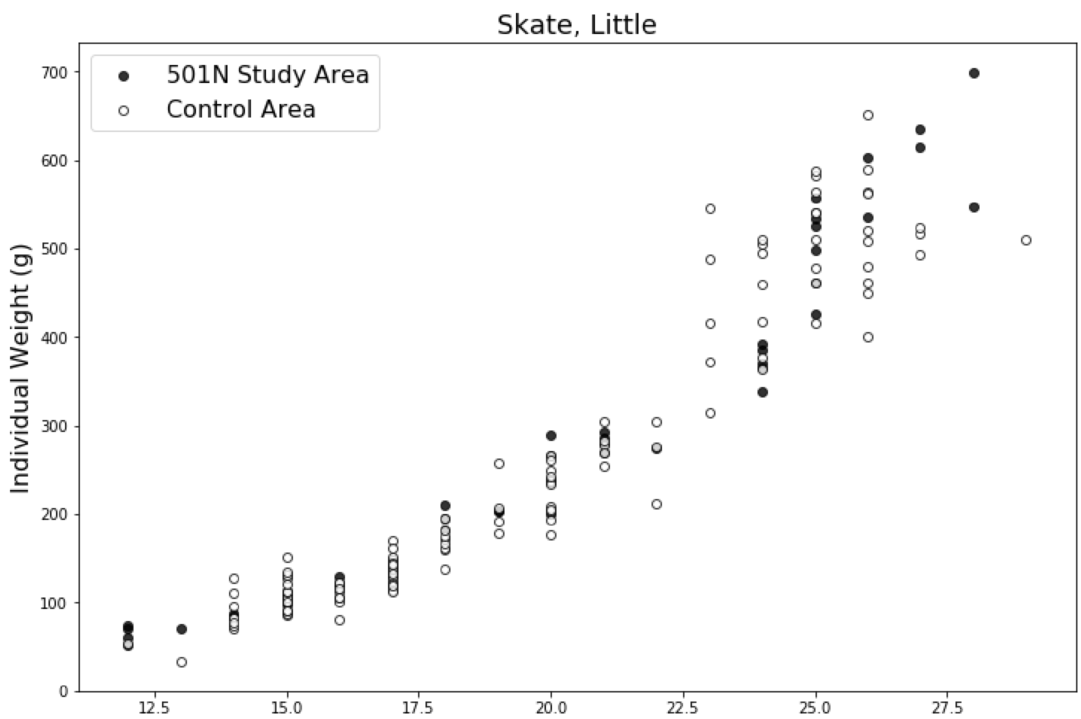


Figure 16: Population structure of little skate in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

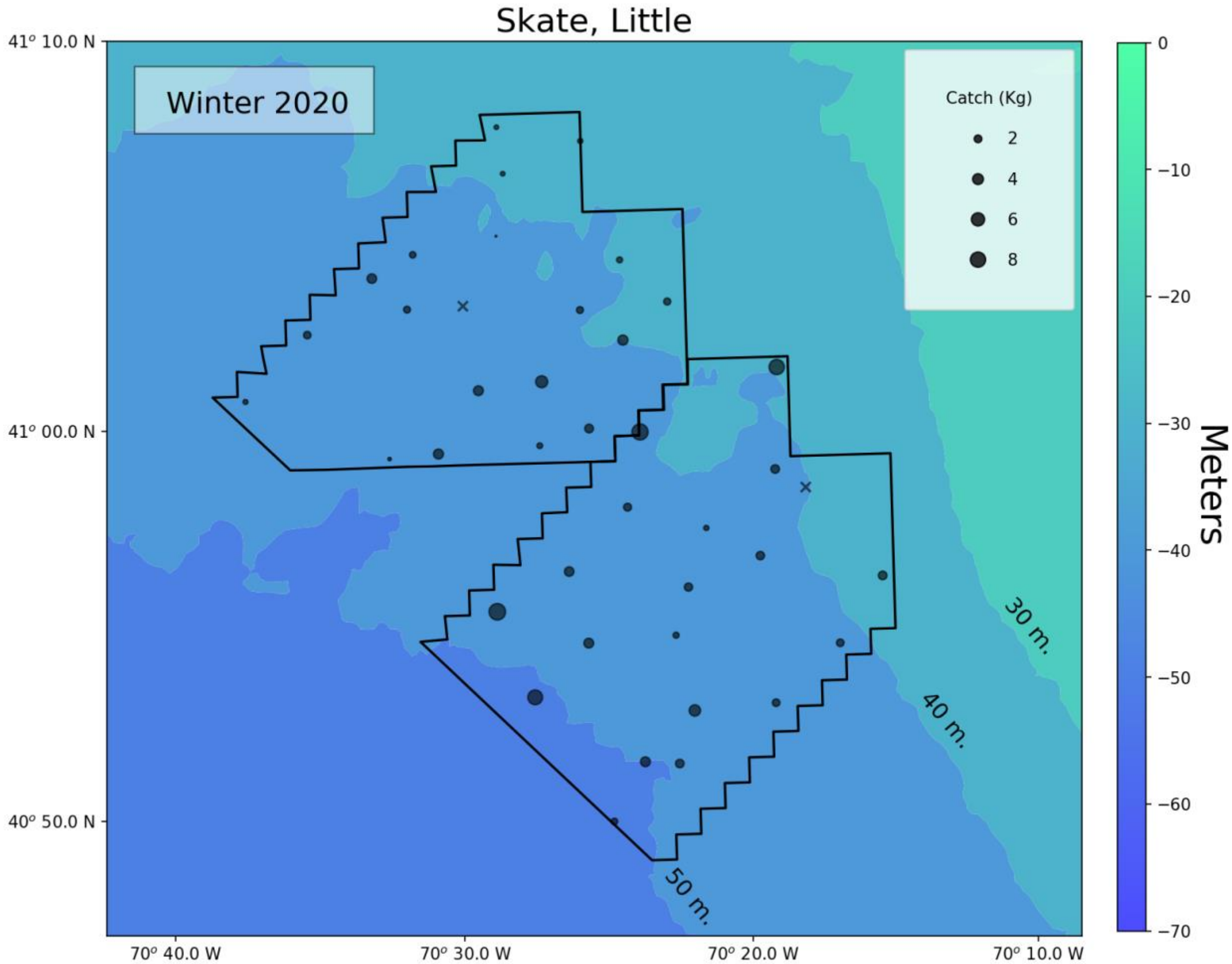
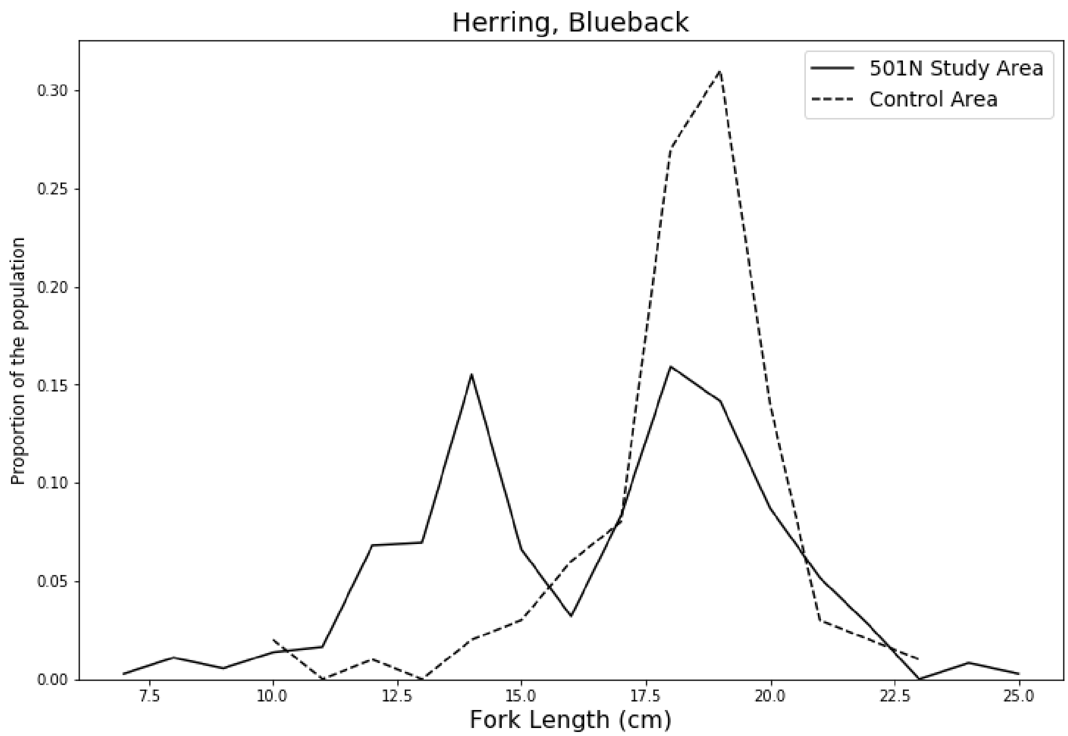


Figure 17: Distribution of the catch of little skate in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



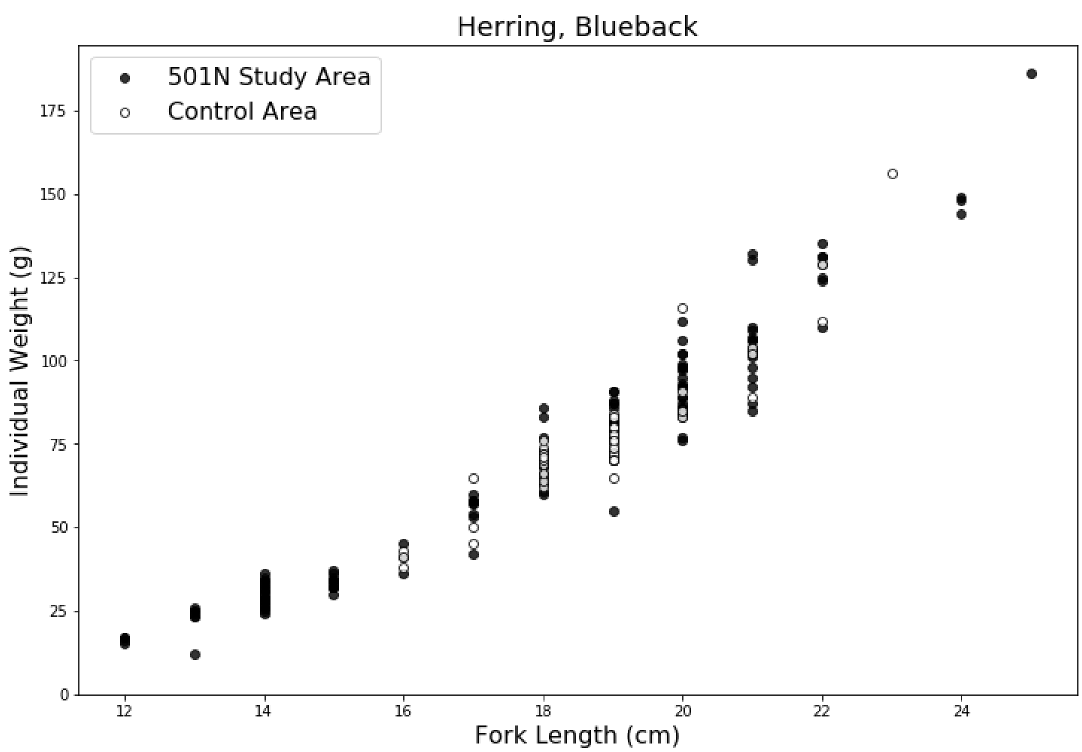


Figure 18: Population structure of blueback herring in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

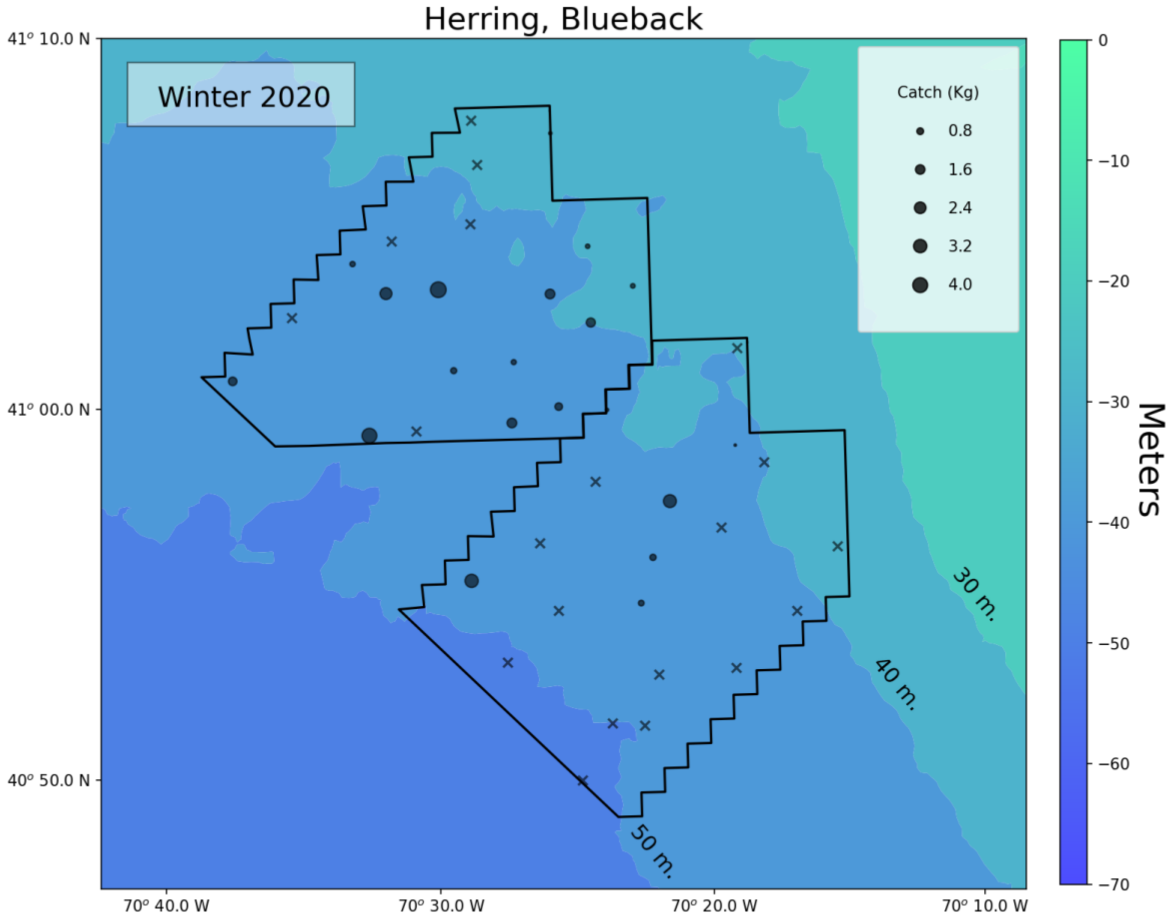
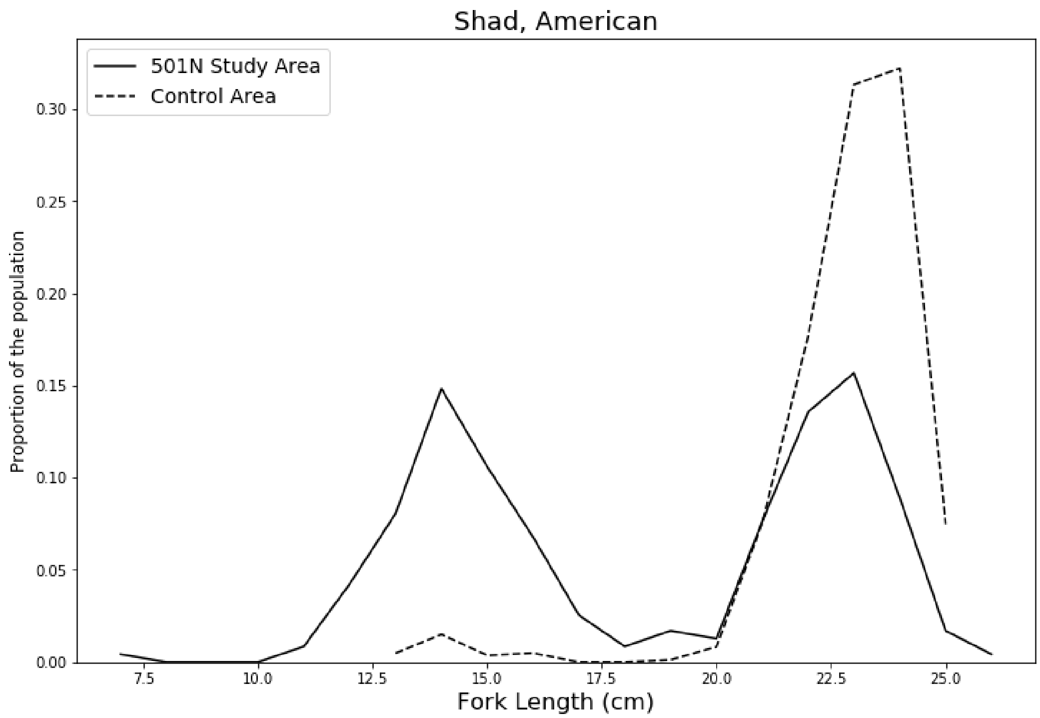


Figure 19: Distribution of the catch of blueback herring in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



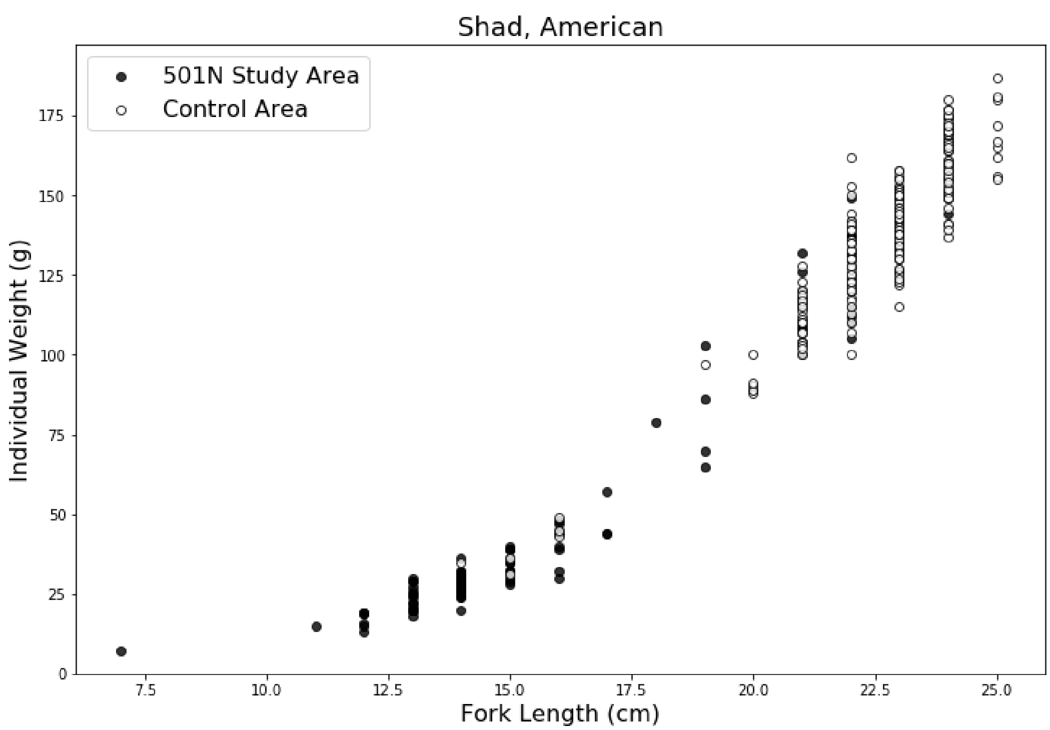


Figure 20: Population structure of American shad in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

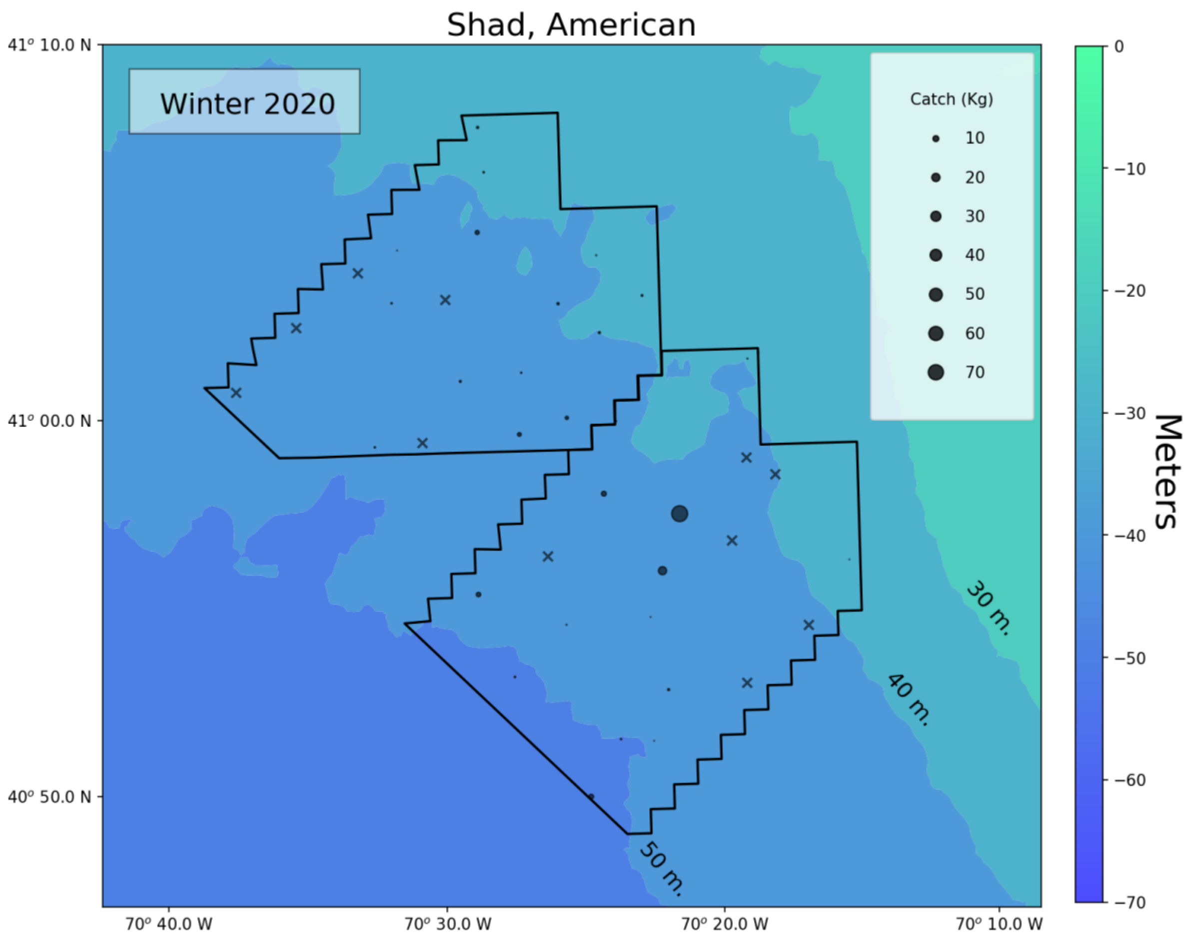
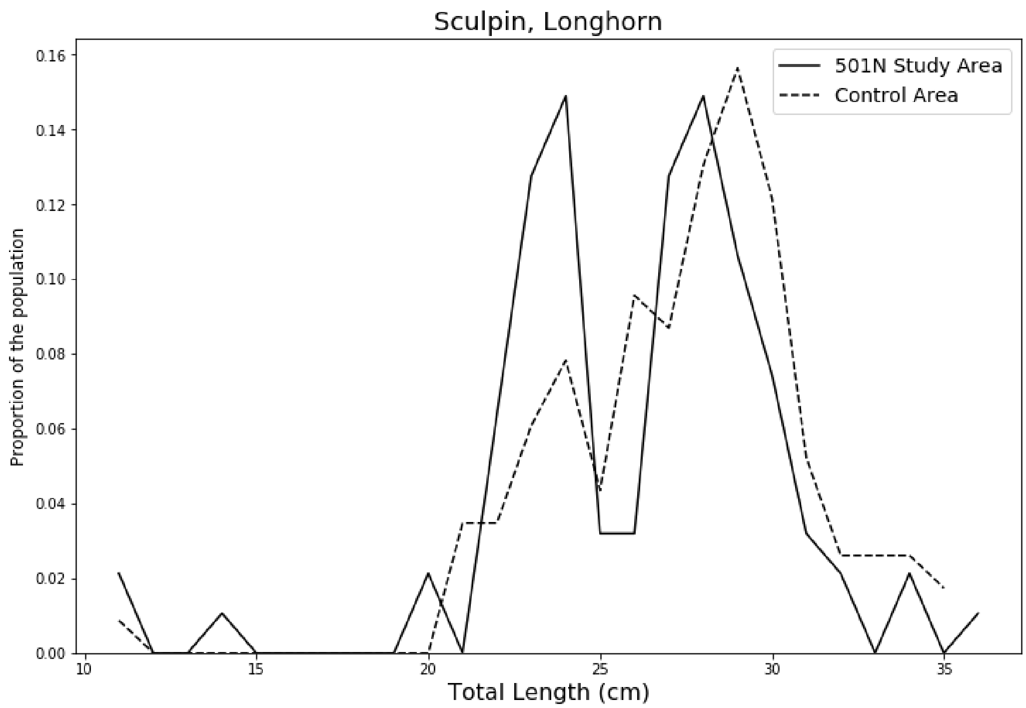


Figure 21: Distribution of the catch of American shad in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



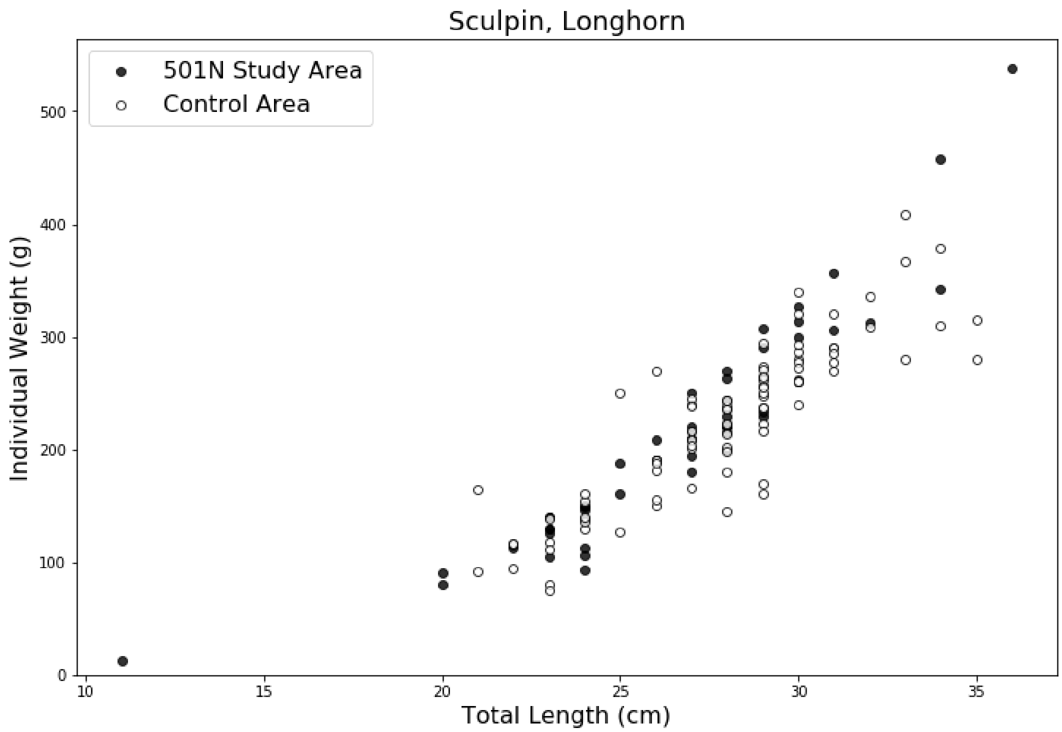


Figure 22: Population structure of longhorn sculpin in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

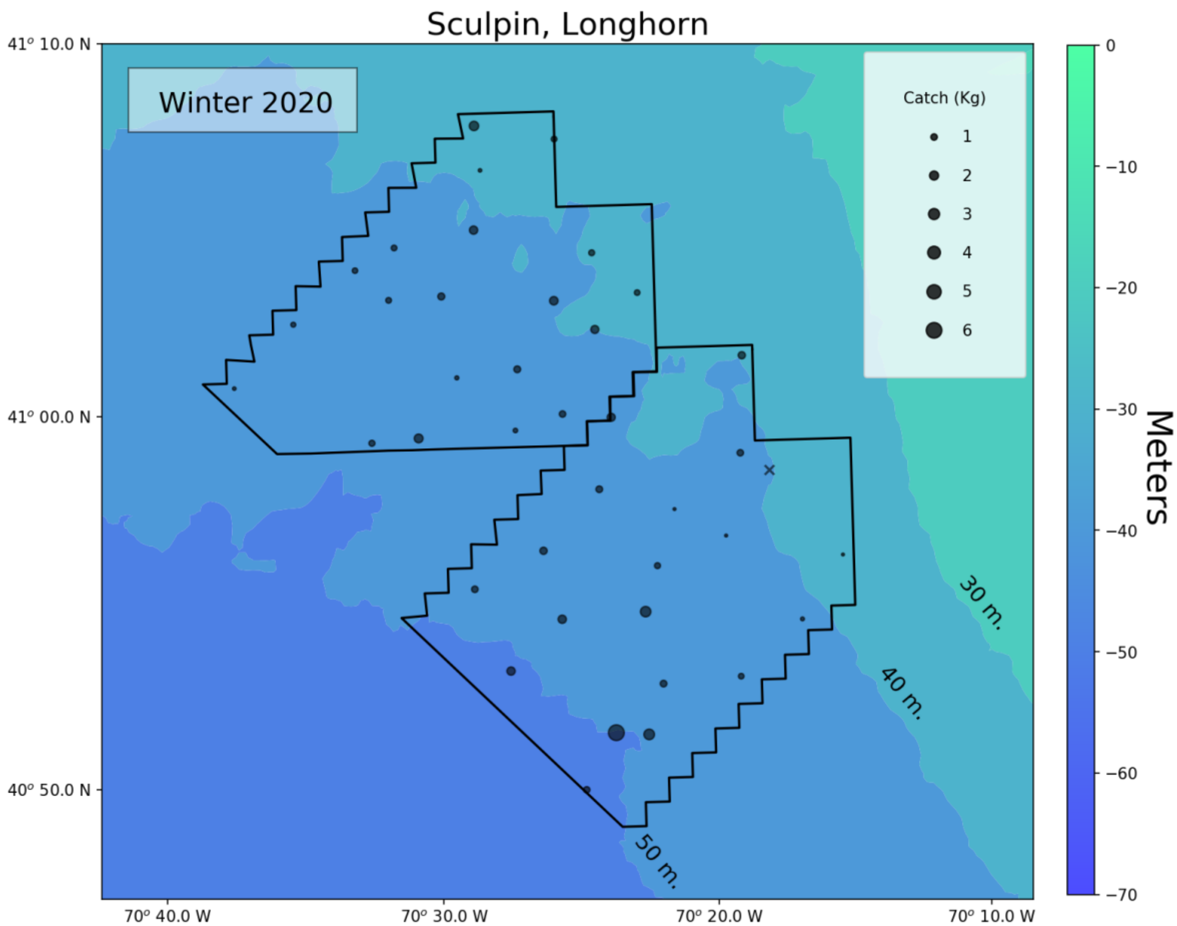
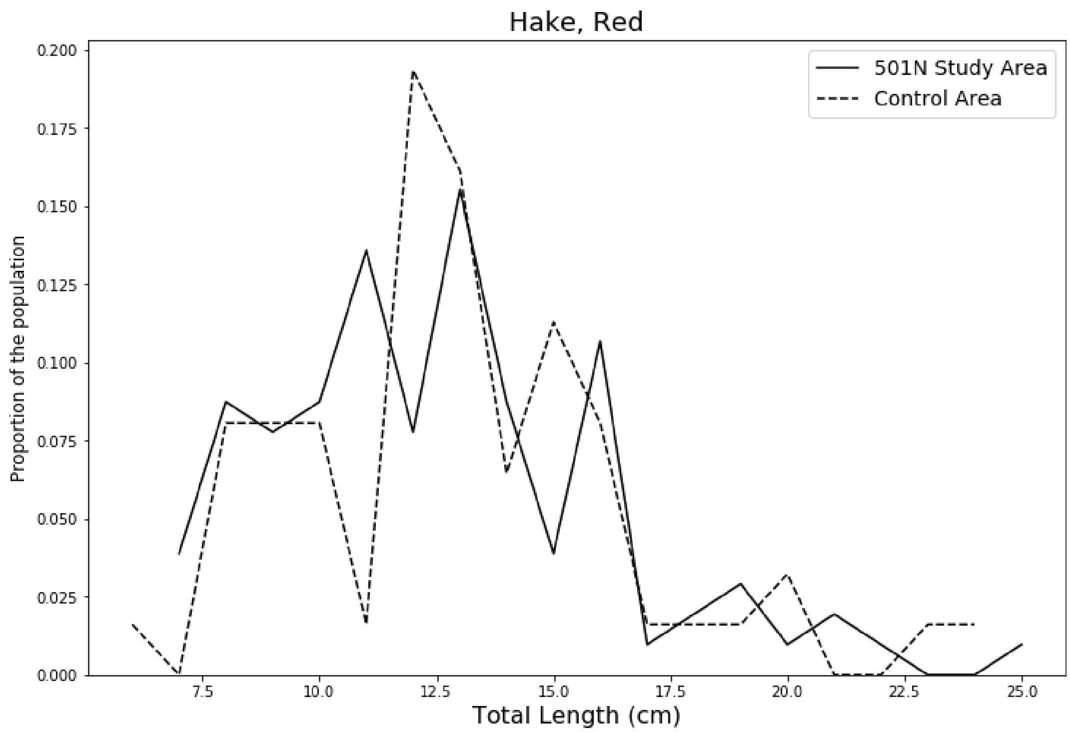


Figure 23: Distribution of the catch of longhorn sculpin in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



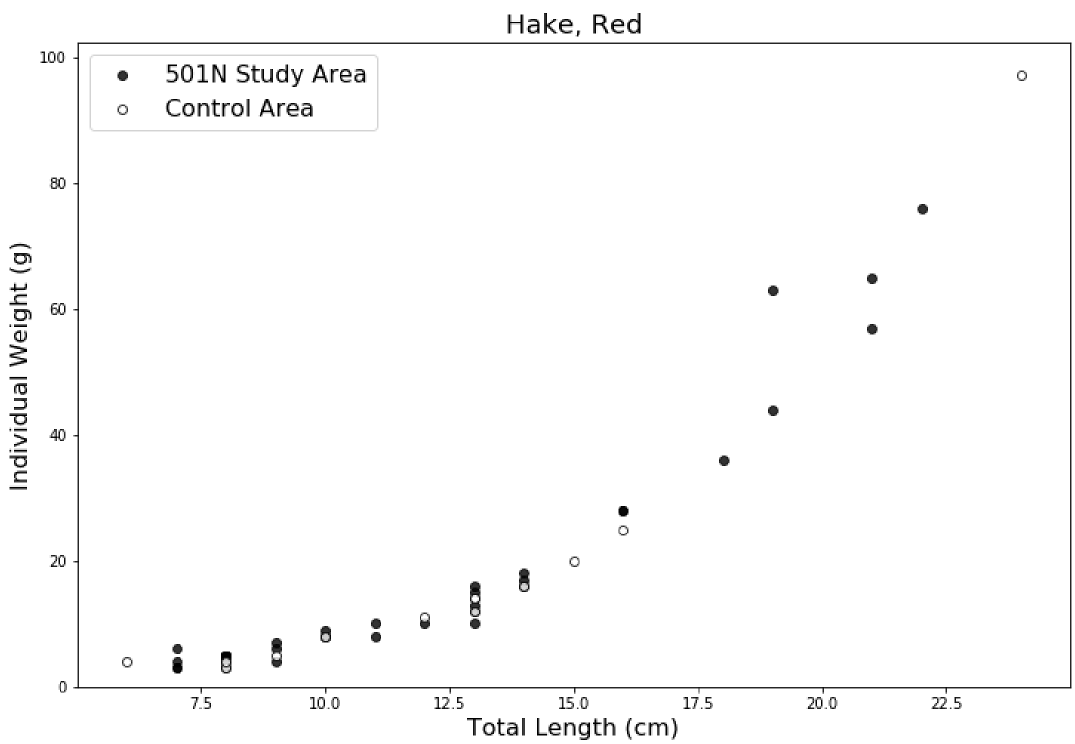


Figure 24: Population structure of red hake in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

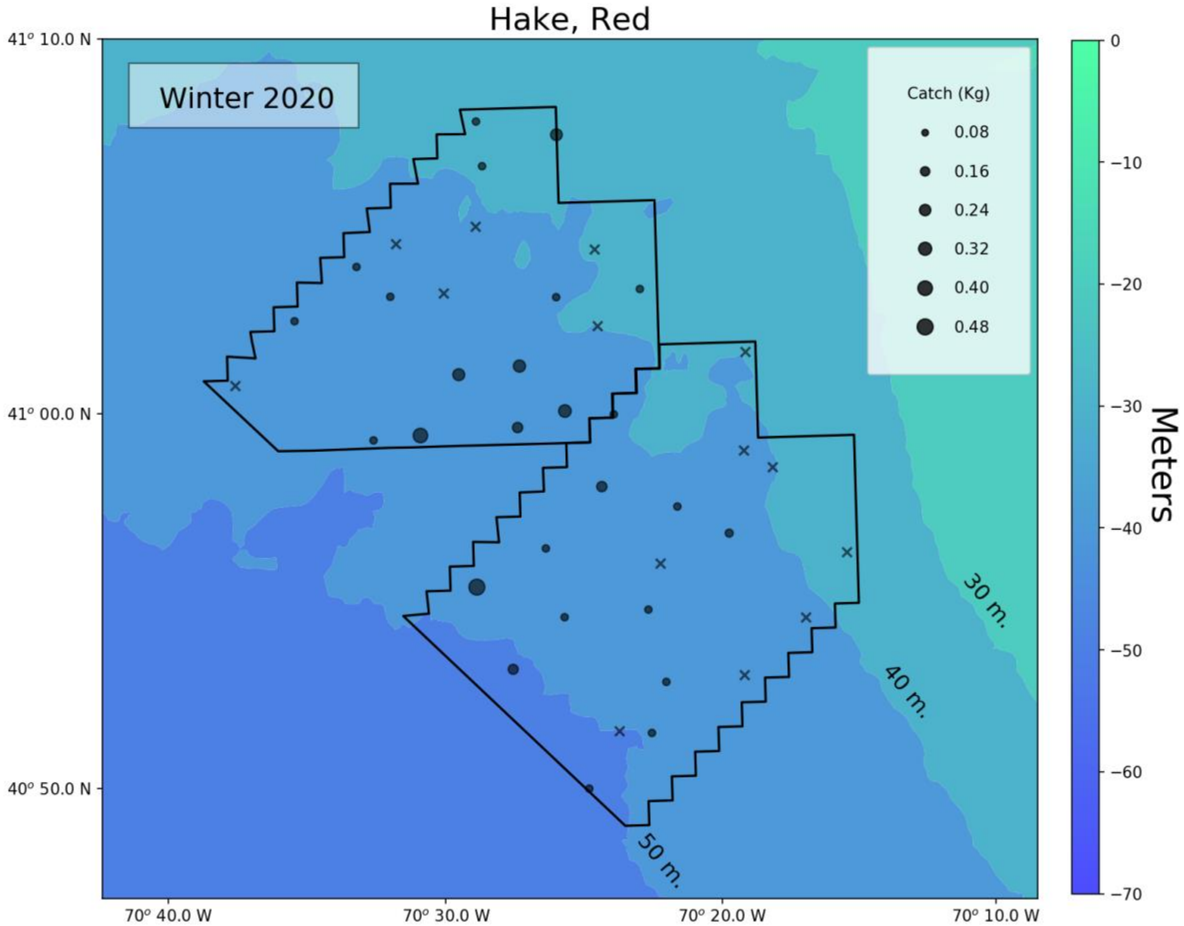
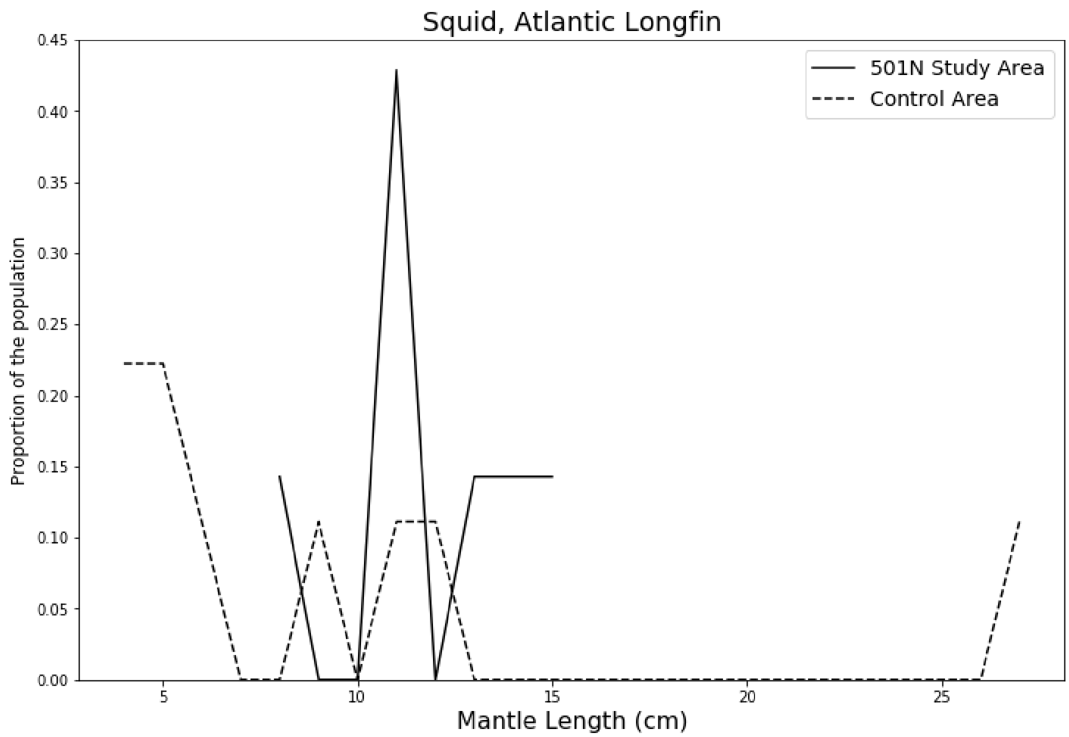


Figure 25: Distribution of the catch of red hake in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



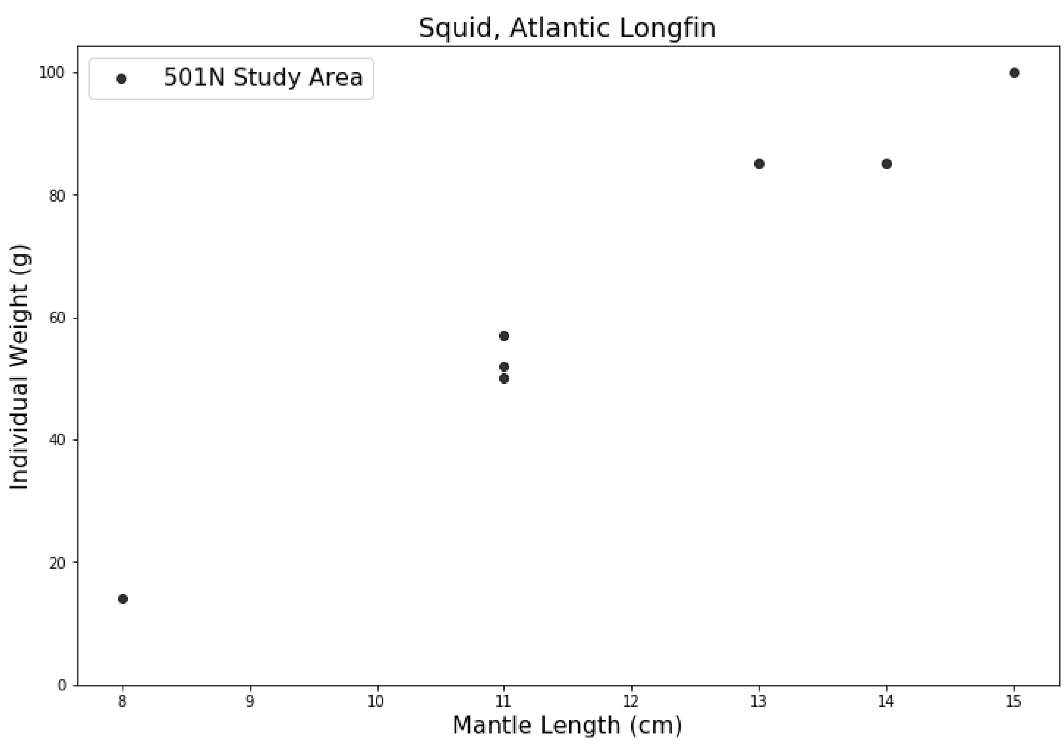


Figure 26: Population structure of longfin squid in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

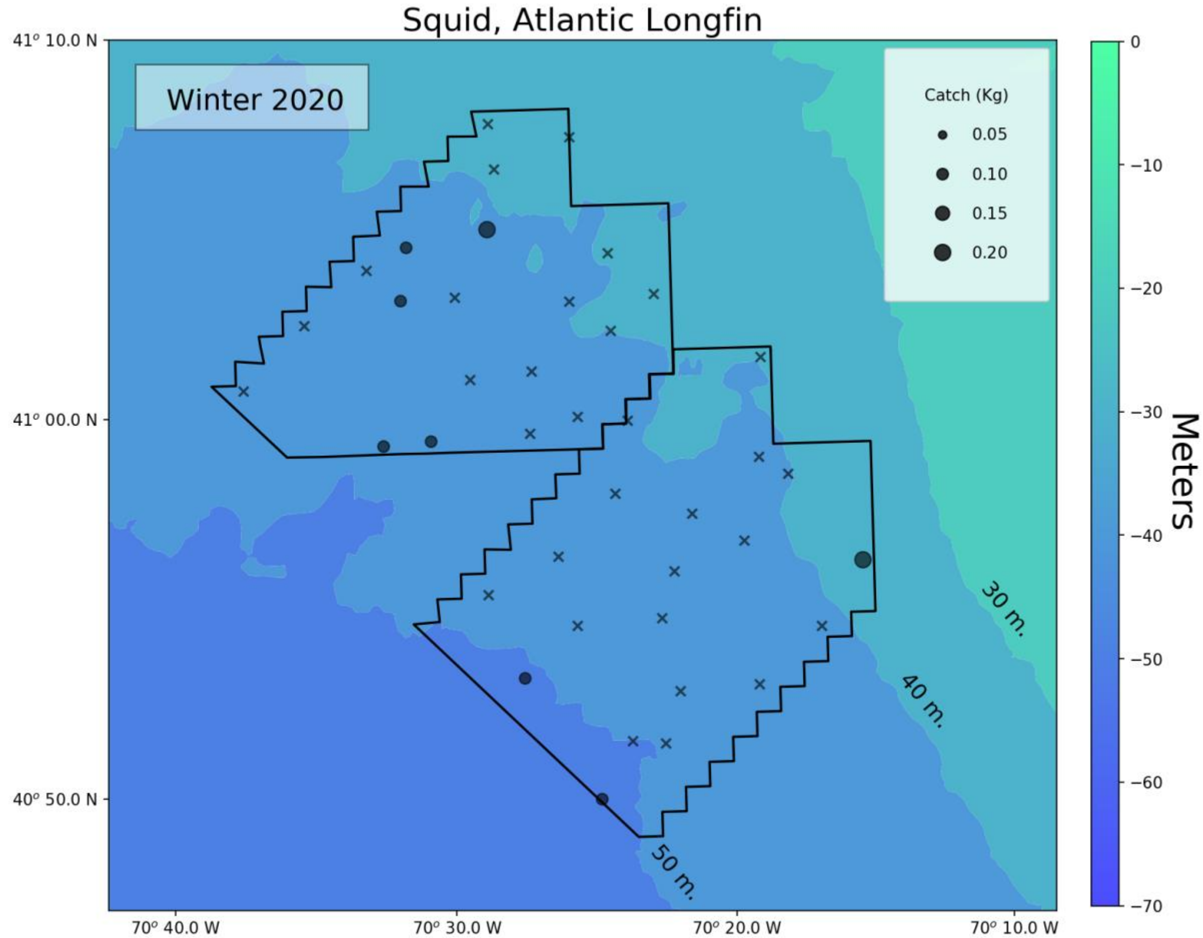


Figure 27: Distribution of the catch of longfin squid in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.