Vineyard Wind Demersal Trawl Survey

Quarterly Report

Winter 2021 (January - March)

501 North Study Area

VINEYARD WIND DEMERSAL TRAWL SURVEY

Winter 2021 Seasonal Report

501N Study Area

March 2021

Prepared for Vineyard Wind, LLC

Prepared by:

Pingguo He and Chris Rillahan

University of Massachusetts Dartmouth
School for Marine Science and Technology

Vineyard Wind Demersal Trawl Survey Winter 2021 Seasonal Report

501N Study Area

Progress Report #7

January 1 – March 31, 2021

Project title:	Vineyard Wind Demersal Trawl Survey Winter 2021 Seasonal Report – 501N Study Area
Project leaders:	Pingguo He and Christopher Rillahan University of Massachusetts Dartmouth School for Marine Science and Technology 836 S. Rodney French Blvd., New Bedford, MA 02744 Tel. (508) 910-6323, Fax. (508) 999-8197 Email: phe@umassd.edu
Submitted to:	Vineyard Wind LLC 700 Pleasant St, Suite 510 New Bedford, MA 02740
Report by:	Christopher Rillahan and Pingguo He
Date:	March 1, 2021

You may cite this report as:
Rillahan, C., He, P. (2021). Vineyard Wind Demersal Trawl Survey Winter 2021 Seasonal Report – 501N Study Area. Progress report #7. University of Massachusetts Dartmouth - SMAST, New Bedford, MA. SMAST-CE-REP-2021-097. 38 pp.

SMAST-CE-REP-2021-097

Table of Contents

List of Tables

List of Figures

1. Introduction

In 2015, Vineyard Wind LLC (Vineyard Wind) leased a 675 square kilometer (km^2) area for renewable energy development on the Outer Continental Shelf, Lease Area OCS-A 0501, which is 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 306 km^2 area referred to as "501 North" or the 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 "501S Study Area") and within Lease Area OCS-A 0522 (the "522 Study Area"); these studies are reported separately.[1]

BOEM has statutory obligations under the National Environmental Policy Act to evaluate the 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, 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 have on the ecosystem within an ever-changing 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

[1] The Bureau of Ocean Energy Management (BOEM) segregated Lease Area OCS-A 0501 into two lease areas – OCS-A 0501 and OCS-A 0534 – in June 2021. The 501S Study Area is now located in the area designated as Lease Area OCS-A 0534 and referred to as the 501S Study Area in SMAST fisheries survey reports published prior to 2022.

survey plan. A demersal otter trawl, further referred to as a trawl, is a net that is towed behind a vessel along the seafloor and 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, bottom trawls are a generally accepted tool for assessing the biological communities along the seafloor and are widely used by institutions worldwide for ecosystem monitoring. Since they are actively towed behind a vessel, they are less biased by fish activity and behavior than passive fishing gear (i.e., gillnets, longlines, traps, etc.), which relies 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 the abundance of 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 annual spring and fall trawl surveys, the annual NEAMAP spring and fall trawl surveys, and state trawl surveys including the Massachusetts Division of Marine Fisheries trawl survey. The bottom trawl survey is complemented by the drop camera survey and lobster trap survey, both are also carried out by SMAST.

The primary goal of this survey was to provide data related to fish abundance, distribution, and population structure in and around the 501N Study Area. The data will serve as a baseline to be used in a future analysis under the BACI framework. The reports for the previous six seasons of surveys – conducted from spring 2019 to fall 2020 – have been submitted to the sponsoring organization. This progress report documents survey methodology, survey effort, and data collected during the winter of 2021.

2. Methodology

The methodology for the survey was adapted from the Atlantic States Marine Fisheries Commission's NEAMAP nearshore trawl survey. Initiated in 2006, NEAMAP conducts annual spring and fall trawl surveys from Cape Hatteras to Cape Cod. The NEAMAP survey 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 survey protocol samples at a resolution of ~100 km^2, 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 wind farm 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 (i.e., 501S Study Area and 522 Study 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 was modified from the 2019/2020 survey year due to boundary refinements of projects within Lease Area OCS-A 0501. The current 501N Study Area was increased from 249.3 km^2 to 306 km^2 by adding additional area to the southeastern corner. The current 501N Study Area was sub-divided into 20 sub-areas (each ~15.3 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 501N Study Area. The starting location within each sub-area was randomly selected (Figure 2).

An area located to the east of the 501N Study Area was established as a control region, further referred to as the Control Area. The selected region has similar depth contours, bottom types, and benthic habitats to the 501N Study Area. The Control Area was modified from the 2019/2020 survey year. The Control Area was shifted north with an additional area added to the north of the 501N Study Area. The change was due to differences in depths and catch rates observed in the 2019/2020 survey data. The goal was to increase the similarity between the 501N Study Area and Control Area. Additionally, shifting effort to the north reduces the area located in the easterly adjacent Lease Area OCS-A 0520 as well as increases the overlap with the lobster and drop camera surveys. These changes increase the Control Area from 306 km^2 to 324 km^2. An additional 20 tows were completed in the Control Area (each ~16.2km^2). Tow locations were selected in the same manner as the 501N Study Area, using the spatially balanced 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). This information was updated based on catch data from the 2019/2020 survey year (Rillahan and He, 2020). The results of the updated power analysis indicated that several species, including little skate, Atlantic longfin squid, silver hake, and fourspot flounder, had relatively low variability and therefore a high probability of detecting small to moderate effects (~25% change) under the current monitoring effort. Many of the common species observed, including winter skate, red hake, windowpane flounder, monkfish, summer flounder, scup, yellowtail flounder, winter flounder, and butterfish, had higher variability (Coefficient of Variation [CV]: 1.5 – 2.3). For these species, the current monitoring would have a high probability of detecting moderate effects (i.e., 30 – 50% change). For species exhibiting strong seasonality and high variability (CV: 2.5 – 4), large effects (i.e., 50 – 75% change) can be detected with a high probability under the current monitoring plan. For all species collected during the surveys, the current monitoring plan has the statistical power to detect a complete disappearance from either the 501N Study Area or Control Area (100% change). The updated power analysis showed that increasing survey effort would only result in small improvements in detectability. When distributing the survey effort, randomly selecting multiple tow locations across the 501N 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 survey area represent 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 one station per 15.3 km^2 (4.5 square nautical miles nmi^2) in the 501N Study Area and one station per 16.2 km^2 (4.7 nmi^2) in the Control Area. As previously mentioned, the NEAMAP nearshore survey samples at a density of one station per ~100 km^2 (30 nmi^2).

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 meters [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 areas. To ensure the retention of small individuals, a 1" mesh size knotless liner was used within a 12-centimeter (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. Wing spread was targeted between 13.0 and 14.0 m (acceptable range: 11.7 – 15.4 m). Door spread was targeted between 32.0 and 33.0 m (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 that reported the angle of the net belly. An angle around 0° 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, Rhode Island. The F/V *Heather Lynn* is a commercial fishing vessel currently operating in the industry. Two trips to the survey areas were made during which all planned tows were completed.

- Trip 1: February 3 – 6, 2021
- Trip 2: February 9 – 16, 2021

Surveys were alternated daily between the 501N Study Area and Control 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 2019 surveys indicating that the 4:1 ratio constrained the horizontal spreading of the net increasing the headline height.

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. Length data were collected using a digital measuring board (DCS-5, Big Fin Scientific LLC, Austin, Texas) and individual weights were measured using a motion-compensated digital scale (M1100, Marel Corp., Gardabaer, Iceland). An Android tablet (Samsung Active Tab 2) running DCSLinkStream (Big Fin Scientific LLC, Austin, Texas) served as the data collection platform. 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 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 the survey data were uploaded and stored in 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 survey areas (Table 2). Tow durations averaged 20.3 ± 0.3 minutes (mean ± one standard deviation) in the 501N Study Area and 20.2 ± 0.4 minutes in the Control Area. Tow distances averaged 1.0 ± 0.02 nautical miles (nmi) in the 501N Study Area giving an average tow speed of 2.9 ± 0.1 knots. Similarly, tow distances averaged 1.0 ± 0.04 nmi in the Control Area giving an average tow speed of 2.9 ± 0.1 knots.

The seafloor in both areas follows a northeast to southwest depth gradient with the shallowest tow along the northeastern edge (~30 meters). Depth increased to a maximum of 50 m along the southwestern boundary. Bottom water temperatures were relatively uniform throughout the survey areas with slightly warmer temperatures observed during the deeper tows. Bottom water temperature averaged 3.9 ± 0.2°C (39.0 ± 0.4°F, range: 3.5 – 4.2°C [38.3 – 39.6°F]) in the 501N Study Area and 4.2 ± 0.3°C (39.6 ± 0.5°F, range: 3.6 – 4.6°C [38.5 – 40.3°F]) in the Control Area (Table 2).

The trawl geometry data indicated that the trawl took about two to three minutes to open and stabilize. Once open, readings were stable throughout the duration of the tow. Door spread averaged 34.0 ± 0.9 m (range: 32.2 – 35.4 m) for tows in the 501N Study Area and 33.7 ± 1.2 (range: 30.1 – 35.6 m) for tows in the Control Area. Wing spread averaged 13.9 ± 0.3 m for tows in the 501N Study Area (range: 13.4 – 14.5 m) and 13.8 ± 0.3 m for tows in the Control Area (range: 13.3 – 14.2 m). Headline height averaged 5.1 ± 0.2 m for tows in the 501N Study Area (range: 4.8 – 5.6 m) and 5.0 ± 0.2 m for tows in the Control Area (range: 4.7 – 5.5). All tows were within the acceptable tolerance limits for door spread, wing spread, and headline height.

3.2 Catch Data

3.2.1 501N Study Area

In the 501N Study Area, a total of 20 species were caught over the duration of the survey (Table 3). Catch volume ranged from 5.4 kilograms per tow (kg/tow) to 148.7 kg/tow with an average of 29.9 kg/tow. The majority of the catch was primarily comprised of a small subset of the observed species. The four most abundant species (Atlantic herring, little skate, longhorn sculpin, and alewife) accounted for 95.0% 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 predominant species observed, accounting for 84% of the total catch weight. Individuals ranged in length from 17 to 26 cm with a unimodal size distribution peaking at 19 cm (Figure 8). Atlantic herring were observed in all 20 tows. Catch rates averaged 25.1 ± 7.8 kg/tow (mean ± Standard Error of the Mean [SEM], range: 1.3 – 145.3 kg/tow). Atlantic herring were observed throughout the 501N Study Area with the highest catches observed in the northern half of the 501N Study Area (Figure 9).

Little skate (*Leucoraja erinacea*) was the second most abundant species observed, accounting for 6.7% of the total catch weight. Individuals ranged in size from 5 to 30 cm (disk width) with a unimodal size distribution consisting of a peak at 26 cm (Figure 10). Little skate were observed in 15 of the 20 tows. Catch rates averaged 1.8 ± 0.5 kg/tow (range: 0 – 7.6 kg/tow). Little skate were observed throughout the 501N Study Area with higher catches observed in the southern half of the 501N Study Area (Figure 11).

Longhorn sculpin (*Myoxocephalus octodecimspinosus*) was the third most abundant species. Individuals ranged in length from 21 to 35 cm with a wide, dispersed size distribution (Figure 12). Longhorn sculpin were observed in 19 of the 20 tows at an average catch rate of 0.7 ± 0.1 kg/tow (range: 0 – 2.1 kg/tow). Longhorn sculpin were caught throughout the 501N Study Area (Figure 13).

Alewife (*Alosa pseudoharengus*) were commonly caught in the 501N Study Area. Individuals ranged in length from 9 to 31 cm with a bimodal distribution peaking at 14 cm and 19 cm (Figure 14). Alewife were observed in all 20 tows at an average catch rate of 0.6 ± 0.1 kg/tow (range: 0.1 – 2.5 kg/tow). Alewife were caught throughout the 501N Study Area (Figure 15).

Cancer crabs (*Cancer sp.*) were caught in 10 of the 20 tows in the 501N Study Area. The average catch rate of Cancer crab was 0.3 ± 0.1 kg/tow (range: 0 – 1.1 kg/tow). Cancer crabs were caught throughout the 501N Study Area (Figure 16).

Nine Atlantic cod (*Gadus morhua*) were caught in the 501N Study Area. Individuals ranged in length from 21 to 51 cm (Figure 17). Atlantic cod were observed in five of the 20 tows at an average catch rate of 0.3 ± 0.1 kg/tow (range: 0 – 2.3 kg/tow). Atlantic cod were primarily caught in the northern half of the 501N Study Area (Figure 18).

Silver hake (*Merluccius bilinearis*), a commercially important species also commonly referred to as whiting, was caught in the 501N Study Area. Individuals ranged in length from 7 to 28 cm. Silver hake had a bimodal size distribution consisting of peaks at 10 cm and 23 cm (Figure 19). Silver hake were observed in 13 of the 20 tows at an average catch rate of 0.2 ± 0.1 kg/tow (range: 0 – 1.3 kg/tow). The catch of silver hake was distributed across the 501N Study Area (Figure 20).

American shad (*Alosa sapidissima*) was observed in 13 of the 20 tows in the 501N Study Area. Individuals ranged in length from 9 to 27 cm with a bimodal size distribution peaking at 13 cm and 24 cm (Figure 21). The average catch rate of American shad was 0.2 ± 0.1 kg/tow (range: 0 – 1.1 kg/tow). American shad were caught throughout the 501N Study Area (Figure 22).

Less common recreational and commercial species observed included 13 Atlantic sea scallops (*Placopecten* magellanicus), three windowpane flounder (*Scophtalmus aquosus*, 19, 19, 25 cm), two haddock (*Melanogrammus aeglefinus*, 19, 20 cm), two winter flounder (*Pleuronectes americanus*, 14, 30 cm), and one monkfish (*Lophius americanus*, 9 cm).

3.2.2 Control Area

In the Control Area, a total of 20 species were caught over the duration of the survey (Table 4). Catch volume ranged from 0.4 kg/tow to 288.1 kg/tow with an average of 45.5 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, little skate, longhorn sculpin, American shad, and alewife) accounted for 95.3% of the total catch weight. Data collected from this area included the catch of both adults and juveniles of most species observed.

Atlantic herring was the predominant species observed accounting for 65.2% of the total catch weight in the Control Area. Individuals ranged in length from 18 to 25 cm with a unimodal size distribution peaking at 20 cm (Figure 8). Atlantic herring were observed in 17 of the 20 tows. Catch rates averaged 29.7 ± 14.3 kg/tow (range: 0 – 281.5 kg/tow). Atlantic herring were observed throughout the Control Area with the highest catches observed in the northern half of the Control Area (Figure 9).

Little skate was the second most abundant species observed in the Control Area accounting for 21.4% of the total catch weight. Individuals ranged in size from 8 to 31 cm (disk width) with a unimodal size distribution consisting of a peak at 24 cm (Figure 10). Little skate were observed in 18 of the 20 tows. Catch rates averaged 9.7 ± 3.0 kg/tow (range: 0 – 50.7 kg/tow). Little skate were observed throughout the Control Area with the catch increasing with water depth (Figure 11).

Longhorn sculpin was the third most abundant species in the Control Area. Individuals ranged in length from 19 to 35 cm with a wide, dispersed size distribution (Figure 12). Longhorn sculpin were observed in 15 of the 20 tows at an average catch rate of 1.9 ± 0.4 kg/tow (range: 0 – 5.0 kg/tow). Longhorn sculpin were caught throughout the Control Area with higher catches observed in the southern half of the Control Area (Figure 13).

American shad was observed in 13 of the 20 tows in the Control Area. Individuals ranged in length from 11 to 29 cm with a unimodal size distribution peaking at 22 cm (Figure 21). The average catch rate of American shad was 1.1 ± 0.4 kg/tow (range: 0 – 5.4 kg/tow). American Shad were caught throughout the Control Area with higher catch rates observed in the southern half of the Control Area (Figure 22).

Alewife was commonly caught in the Control Area. Individuals ranged in length from 9 to 27 cm with a unimodal distribution peaking at 18 cm (Figure 14). Alewife were observed in 18 of the 20 tows at an average catch rate of 1.0 ± 0.4 kg/tow (range: 0 – 6.0 kg/tow). Alewife were caught throughout the Control Area (Figure 15).

Twenty Atlantic cod were caught in the Control Area. Individuals ranged in length from 21 to 48 cm (Figure 17). Atlantic cod were observed in 14 of the 20 tows at an average catch rate of 0.7 ± 0.1 kg/tow (range: 0 – 1.7 kg/tow). Atlantic cod were primarily caught in the southern half of the Control Area (Figure 18).

Cancer crabs (*Cancer sp.*) were caught in 14 of the 20 tows in the Control Area. The average catch rate of Cancer crabs was 0.4 ± 0.1 kg/tow (range: 0 – 2.1 kg/tow). Cancer crabs were caught throughout the Control Area (Figure 16).

Silver hake was caught in the Control Area. Individuals ranged in length from 7 to 32 cm. Silver hake had a bimodal size distribution consisting of peaks at 10 cm and 23 cm (Figure 19). Silver hake were observed in nine of the 20 tows at an average catch rate of 0.2 ± 0.1 kg/tow (range: 0 – 1.7 kg/tow). The catch of silver hake was primarily associated with tows in the southern half of the Control Area (Figure 20).

Less common recreational and commercial species observed included 49 Atlantic sea scallops, five windowpane flounder (size range: 18 - 27 cm), two Atlantic longfin squid (*Dorytheuthis pealei*, 12, 14 cm [mantle length]), one winter flounder (36 cm), and one yellowtail flounder (*Pleuronectes ferrugineus*, 34 cm).

4. Acknowledgments

We would like to thank the owner (Stephen Follett), captain (Kevin Jones), and crew (Mark Bolster, Andrew Follett, and Matt Manchester) of the F/V *Heather Lynn* for their help sorting, processing, and measuring the catch. Additionally, we would like to thank Mike Coute (SMAST), Keith Hankowsky (SMAST), and Harrision Tobi (SMAST) for their help with data collection at sea.

5. References

BOEM (U.S. Department of the Interior, Bureau of Ocean Energy Management). 2013. Guidelines for Providing Information on Fisheries for Renewable Energy Development on the Atlantic Outer Continental Shelf Pursuant to 30 CFR Part 585.

Bonzek, C. F., Gartland, J., Johnson, R. A., & Lange Jr, J. D. (2008). NEAMAP Near Shore Trawl Survey: Peer Review Documentation. *A report to the Atlantic States Marine Fisheries Commission by the Virginia Institute of Marine Science, Gloucester Point, Virginia*.

Stokesbury, K.D.E. and Lowery, T. (2018). 2018 Vineyard Wind Groundfish Bottom Trawl Survey: Final Report.

Underwood, A. J. (1991). Beyond BACI: experimental designs for detecting human environmental impacts on temporal variations in natural populations. *Marine and Freshwater Research*, *42*(5), 569-587.

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)	Bottom Temp. (ºC)	Trawl Warp (fm)
1	501N	2/4/2021	Mostly Cloudy	11-15	NW	0.5-1.25	7:23	N 41º 03.307	W 70º 35.542	24	7:43	N 41º 03.845	W 70º 34.532	24	3.5	100
2	501N	2/4/2021	Mostly Cloudy	11-15	NW	0.5-1.25	8:11	N 41º 03.552	W 70º 33.796	23	8:31	N 41º 03.391	W 70º 32.530	26	3.6	95
3	501N	2/4/2021	Mostly Cloudy	11-15	NW	0.5-1.25	9:03	N 41º 01.675	W 70º 31.759	25	9:23	N 41º 01.425	W 70º 33.018	26	3.8	100
4	501N	2/4/2021	Mostly Cloudy	11-15	NW	0.5-1.25	10:00	N 41º 00.488	W 70º 30.441	26	10:20	N 41º 00.737	W 70º 29.261	25	3.8	100
5	501N	2/4/2021	Mostly Cloudy	11-15	NW	0.5-1.25	10:53	N 40º 59.034	W 70º 29.888	25	11:14	N 40º 58.802	W 70º 31.115	26	4.2	100
6	501N	2/4/2021	Mostly Cloudy	11-15	NW	0.5-1.25	11:52	N 40º 58.783	W 70º 27.242	25	12:12	N 40º 58.787	W 70º 25.887	24	4.0	100
7	501N	2/4/2021	Mostly Cloudy	11-15	NW	0.5-1.25	12:50	N 40º 57.603	W 70º 27.699	25	13:10	N 40º 57.081	W 70º 28.747	25	4.2	100
8	501N	2/4/2021	Mostly Cloudy	11-15	NW	0.5-1.25	13:39	N 40º 57.234	W 70º 30.039	25	13:59	N 40º 57.008	W 70º 31.277	26	4.2	100
9	501N	2/4/2021	Mostly Cloudy	11-15	NW	0.5-1.25	14:34	N 40º 58.131	W 70º 32.058	26	14:54	N 40º 58.196	W 70º 33.353	27	4.1	100
10	501N	2/4/2021	Partly Cloudy	11-15	NW	0.5-1.25	15:31	N 40º 59.343	W 70º 35.266	27	15:51	N 40º 59.468	W 70º 36.544	27	4.1	120
11	501N	2/4/2021	Partly Cloudy	7-10	NW	0.5-1.25	16:25	N 41º 01.052	W 70º 37.708	26	16:45	N 41º 01.824	W 70º 36.884	25		120
12	Control	2/5/2021	Partly Cloudy	7-10	SW	0.5-1.25	6:58	N 40º 56.476	W 70º 26.931	25	7:18	N 40º 56.274	W 70º 28.321	25	4.3	100
13	Control	2/5/2021	Overcast	7-10	SW	0.5-1.25	7:55	N 40º 54.283	W 70º 27.885	27	8:15	N 40º 53.341	W 70º 27.382	28	4.4	120
14	Control	2/5/2021	Overcast	11-15	SW	0.5-1.25	8:54	N 40º 52.656	W 70º 24.414	27	9:14	N 40º 53.477	W 70º 23.851	26	4.6	120
15	Control	2/5/2021	Rain	11-15	SW	0.5-1.25	9:41	N 40º 53.455	W 70º 23.255	26	10:01	N 40º 53.225	W 70º 22.094	26	4.4	120
16	Control	2/5/2021	Overcast	11-15	SW	0.5-1.25	10:34	N 40º 53.018	W 70º 21.940	26	10:54	N 40º 52.085	W 70º 21.995	26	4.5	120
17	Control	2/5/2021	Overcast	11-15	SW	1.25-2.5	11:28	N 40º 54.049	W 70º 21.818	25	11:48	N 40º 54.015	W 70º 21.530	24	4.6	100
18	Control	2/5/2021	Mostly Cloudy	11-15	SW	1.25-2.5	12:17	N 40º 55.093	W 70º 20.814	24	12:37	N 40º 54.730	W 70º 19.686	24	4.5	100
19	Control	2/5/2021	Overcast	11-15	SW	1.25-2.5	13:11	N 40º 55.755	W 70º 20.255	23	13:31	N 40º 56.577	W 70º 20.912	23	4.5	100
20	Control	2/5/2021	Rain	11-15	SW	1.25-2.5	14:09	N 40º 56.601	W 70º 23.334	24	14:29	N 40º 56.195	W 70º 24.387	24	4.4	100
21	Control	2/5/2021	Rain	11-15	SW	1.25-2.5	14:54	N 40º 57.046	W 70º 24.406	24	15:14	N 40º 57.007	W 70º 24.328	24	4.3	100
22	Control	2/5/2021	Rain	11-15	SW	1.25-2.5	15:40	N 40º 59.148	W 70º 23.446	22	16:00	N 40º 59.395	W 70º 24.635	23	4.2	95
23	501N	2/10/2021	Partly Cloudy	11-15	NW	0.5-1.25	7:05	N 41º 07.104	W 70º 26.726	21	7:25	N 41º 06.977	W 70º 27.992	22		95
24	501N	2/10/2021	Partly Cloudy	11-15	NW	0.5-1.25	8:00	N 41º 06.118	W 70º 30.243	23	8:20	N 41º 05.589	W 70º 31.313	23	3.6	100
25	501N	2/10/2021	Mostly Cloudy	11-15	NW	0.5-1.25	8:48	N 41º 03.729	W 70º 30.131	23	9:08	N 41º 02.795	W 70º 29.936	25	3.9	100
26	501N	2/10/2021	Partly Cloudy	16-20	NW	0.5-1.25	9:49	N 41º 04.018	W 70º 26.631	22	10:09	N 41º 04.612	W 70º 25.792	23	3.7	95
27	501N	2/10/2021	Partly Cloudy	16-20	NW	0.5-1.25	11:15	N 41º 04.916	W 70º 26.421	21	11:35	N 41º 04.024	W 70º 27.028	22	3.6	95
28	501N	2/10/2021	Partly Cloudy	16-20	NW	0.5-1.25	10:24	N 41º 04.764	W 70º 25.612	22	10:44	N 41º 05.752	W 70º 25.666	21	3.5	95
29	501N	2/10/2021	Partly Cloudy	16-20	NW	0.5-1.25	12:04	N 41º 02.120	W 70º 26.604	21	12:24	N 41º 01.156	W 70º 26.341	23	3.8	95
30	501N	2/10/2021	Partly Cloudy	16-20	NW	0.5-1.25	12:55	N 41º 01.273	W 70º 24.941	22	13:15	N 41º 01.058	W 70º 23.864	22	4.0	95
31	501N	2/10/2021	Partly Cloudy	16-20	NW	0.5-1.25	13:43	N 41º 02.374	W 70º 23.902	22	14:03	N 41º 03.323	W 70º 23.667	20	3.8	95
32	Control	2/10/2021	Partly Cloudy	16-20	NW	0.5-1.25	14:29	N 41º 04.350	W 70º 22.472	21	14:49	N 41º 04.012	W 70º 21.621	21	3.7	95
33	Control	2/10/2021	Partly Cloudy	11-15	NW	0.5-1.25	15:16	N 41º 03.508	W 70º 20.576	20	15:36	N 41º 02.903	W 70º 19.756	21	3.6	95
34	Control	2/10/2021	Partly Cloudy	11-15	NW	0.5-1.25	16:07	N 41º 02.765	W 70º 17.523	19	16:27	N 41º 02.662	W 70º 16.345	18		95
35	Control	2/12/2021	Clear	16-20	NW	1.25-2.5	7:13	N 41º 02.133	W 70º 14.263	17	7:33	N 41º 02.118	W 70º 15.435	18	3.7	75
36	Control	2/12/2021	Partly Cloudy	16-20	NW	1.25-2.5	8:25	N 40º 57.221	W 70º 15.549	19	8:45	N 40º 56.547	W 70º 16.125	20	3.9	95
37	Control	2/12/2021	Clear	16-20	NW	1.25-2.5	9:24	N 40º 57.782	W 70º 17.504	21	9:44	N 40º 58.371	W 70º 18.391	22	4.2	95
38	Control	2/12/2021	Clear	16-20	NW	1.25-2.5	10:23	N 41º 00.418	W 70º 18.197	21	10:43	N 41º 01.344	W 70º 18.387	21	4.0	95
39	Control	2/12/2021	Clear	11-15	NW	1.25-2.5	11:19	N 41º 00.524	W 70º 21.100	22	11:39	N 41º 00.291	W 70º 22.345	21		95
40	Control	2/12/2021	Clear	11-15	NW	1.25-2.5	12:10	N 40º 58.771	W 70º 22.458	22	12:30	N 40º 57.715	W 70º 22.609	23	4.3	100

Table 2: Tow parameters for each survey tow.

Tow Number	Tow Area	Tow Duration (min.)	Tow Distance (nmi.)	Tow Speed (knots)	Start Depth (fm)	Trawl Warp (fm)	Headline Height (m.)	Wing Spread (m.)	Spread Door (m.)
1	501N	20.2	1.0	2.9	24	100		14.2	33.9
2	501N	20.7	1.0	2.9	23	95	5.0	14.1	34.8
3	501N	20.1	1.0	3.0	25	100	5.4	13.8	33.3
4	501N	20.0	1.0	2.9	26	100	5.2	13.9	34.0
5	501N	21.0	1.0	2.8	25	100	5.2	13.9	33.7
6	501N	20.1	1.0	2.9	25	100	5.3	13.4	32.2
7	501N	20.2	1.0	2.9	25	100	5.2		34.9
8	501N	20.6	1.0	2.9	25	100	5.0	14.2	34.4
9	501N	20.6	1.0	2.9	26	100	5.6	13.9	34.8
10	501N	20.4	1.0	2.9	27	120	4.9	14.5	35.4
11	501N	20.5	1.0	3.0	26	120	4.8	14.1	33.6
12	Control	21.3	1.0	2.9	25	100	5.3	13.9	33.3
13	Control	20.6	1.0	3.0	27	120	5.1	14.0	34.0
14	Control	20.1	1.0	2.8	27	120	4.8	14.2	35.0
15	Control	20.0	0.9	2.8	26	120	5.0	13.9	35.6
16	Control	20.5	0.9	2.7	26	120	5.2	13.5	32.4
17	Control	20.2	1.0	3.0	25	100	5.0	13.6	34.1
18	Control	20.4	0.9	2.8	24	100	4.9	14.0	34.5
19	Control	20.0	1.0	2.9	23	100	5.3	13.6	32.9
20	Control	19.2	0.9	2.8	24	100	4.9	14.1	35.2
21	Control	20.0	1.0	3.0	24	100	5.2	14.0	33.6
22	Control	20.2	1.0	2.9	22	95	5.0	14.1	33.7
23	501N	20.5	1.0	2.9	21	95	4.8	14.1	34.0
24	501N	20.2	1.0	2.9	23	100	4.8	14.2	35.2
25	501N	20.5	1.0	3.0	23	100	5.1	14.0	33.8
26	501N	19.5	0.9	2.9	22	95	5.2	13.8	32.7
27	501N	20.4	1.0	3.0	21	95	5.4	13.4	32.3
28	501N	20.5	1.0	2.9	22	95	5.0	14.1	34.0
29	501N	19.8	1.0	3.0	21	95	5.1	13.6	33.4
30	501N	20.0	1.0	2.9	22	95	5.3	13.9	34.5
31	501N	20.2	1.0	2.9	22	95	4.8	14.1	34.1
32	Control	20.0	1.0	2.9	21	95	4.9	14.1	33.8
33	Control	20.3	1.0	2.8	20	95	5.2	13.5	32.2
34	Control	20.1	0.9	2.8	19	95	4.7	13.9	34.2
35	Control	19.8	0.9	2.8	17	75	5.5	13.6	33.6
36	Control	20.0	0.9	2.7	19	95	5.4	13.3	30.1
37	Control	20.2	0.9	2.7	21	95	5.0	13.7	34.5
38	Control	20.2	0.9	2.7	21	95	5.1	13.4	32.6
39	Control	20.0	0.9	2.8	22	95	4.7	14.1	34.2
40	Control	20.3	1.1	3.2	22	100	5.0	13.9	34.1
Summary Statistics									
Control	Minimum	19.2	0.9	2.7	17	75	4.7	13.3	30.1
	Maximum	21.3	1.1	3.2	27	120	5.5	14.2	35.6
	Average	20.2	1.0	2.9	22.8	101	5.0	13.8	33.7
	St. Dev	0.4	0.05	0.1	2.8	11	0.2	0.3	1.2
501N	Minimum	19.5	0.9	2.8	21	95	4.8	13.4	32.2
	Maximum	21.0	1.0	3.0	27	120	5.6	14.5	35.4
	Average	20.3	1.0	2.9	23.7	100	5.1	13.9	34.0
	St. Dev.	0.3	0.02	0.1	1.9	7	0.2	0.3	0.9

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*	508.8	25.1	7.8	84.0	20
Skate, Little	*Leucoraja erinacea*	40.3	2.0	0.5	6.7	15
Sculpin, Longhorn	*Myoxocephalus octodecimspinosus*	14.8	0.7	0.1	2.4	19
Alewife	*Alosa pseudoharengus*	11.8	0.6	0.1	1.9	20
Crab, Cancer	*Cancer sp.*	6.4	0.3	0.1	1.1	10
Atlantic Cod	*Gadus morhua*	5.0	0.3	0.1	0.8	5
Hake, Silver (Whiting)	*Merluccius bilinearis*	4.5	0.2	0.1	0.7	13
Shad, American	*Alosa sapidissima*	4.3	0.2	0.1	0.7	13
Skate, Winter	*Leucoraja ocellata*	3.4	0.2	0.2	0.6	1
Herring, Blueback	*Alosa aestivalis*	2.2	0.1	0.1	0.4	5
Sea Raven	*Hemitripterus americanus*	1.2	0.1	0.0	0.2	2
Sea Scallop	*Placopecten magellanicus*	0.8	0.04	0.02	0.1	4
Mackerel, Atlantic	*Scomber scombrus*	0.6	0.03	0.02	0.1	2
Hake, Spotted	*Urophycis regia*	0.4	0.02	0.01	0.1	3
Flounder, Windowpane	*Scophtalmus aquosus*	0.4	0.02	0.01	0.1	3
Hake, Red	*Urophycis chuss*	0.4	0.02	0.01	0.1	4
Flounder, Winter	*Pleuronectes americanus*	0.3	0.01	0.02	0.05	1
Haddock	*Melanogrammus aeglefinus*	0.2	0.01	0.01	0.03	2
Monkfish	*Lophius americanus*	0.1	0.00	0.01	0.02	1
Flounder, Gulfstream	*Citharichthys arctifrons*	0.1	0.00	0.01	0.02	1
Total		**606.0**				

*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)		% of Total Catch	Tows with Species Present
			Mean	SEM*		
Herring, Atlantic	*Clupea harengus*	600.9	29.7	14.3	65.2	17
Skate, Little	*Leucoraja erinacea*	197.3	9.7	3.0	21.4	18
Sculpin, Longhorn	*Myoxocephalus octodecimspinosus*	38.8	1.9	0.4	4.2	15
Shad, American	*Alosa sapidissima*	21.9	1.1	0.4	2.4	13
Alewife	*Alosa pseudoharengus*	19.8	1.0	0.4	2.1	18
Atlantic Cod	*Gadus morhua*	13.5	0.7	0.1	1.5	14
Crab, Cancer	*Cancer sp.*	8.3	0.4	0.1	0.9	14
Hake, Silver (Whiting)	*Merluccius bilinearis*	4.8	0.2	0.1	0.5	9
Mackerel, Atlantic	*Scomber scombrus*	3.9	0.2	0.1	0.4	8
Sea Scallop	*Placopecten magellanicus*	3.6	0.2	0.1	0.4	8
Skate, Winter	*Leucoraja ocellata*	2.5	0.1	0.1	0.3	2
Sea Raven	*Hemitripterus americanus*	2.3	0.1	0.1	0.2	4
Herring, Blueback	*Alosa aestivalis*	1.2	0.1	0.0	0.1	5
Flounder, Windowpane	*Scophtalmus aquosus*	0.9	0.04	0.02	0.1	5
Flounder, Winter	*Pleuronectes americanus*	0.8	0.04	0.04	0.1	1
Hake, Spotted	*Urophycis regia*	0.5	0.02	0.01	0.1	5
Flounder, Yellowtail	*Pleuronectes ferrugineus*	0.3	0.01	0.02	0.0	1
Hake, Red	*Urophycis chuss*	0.2	0.01	0.01	0.0	2
Flounder, Gulfstream	*Citharichthys arctifrons*	0.2	0.01	0.01	0.02	2
Squid, Atlantic Longfin	*Dorytheuthis pealei*	0.2	0.01	0.01	0.02	2
Total		**921.8**				

*SEM is an acronym for Standard Error of the Mean

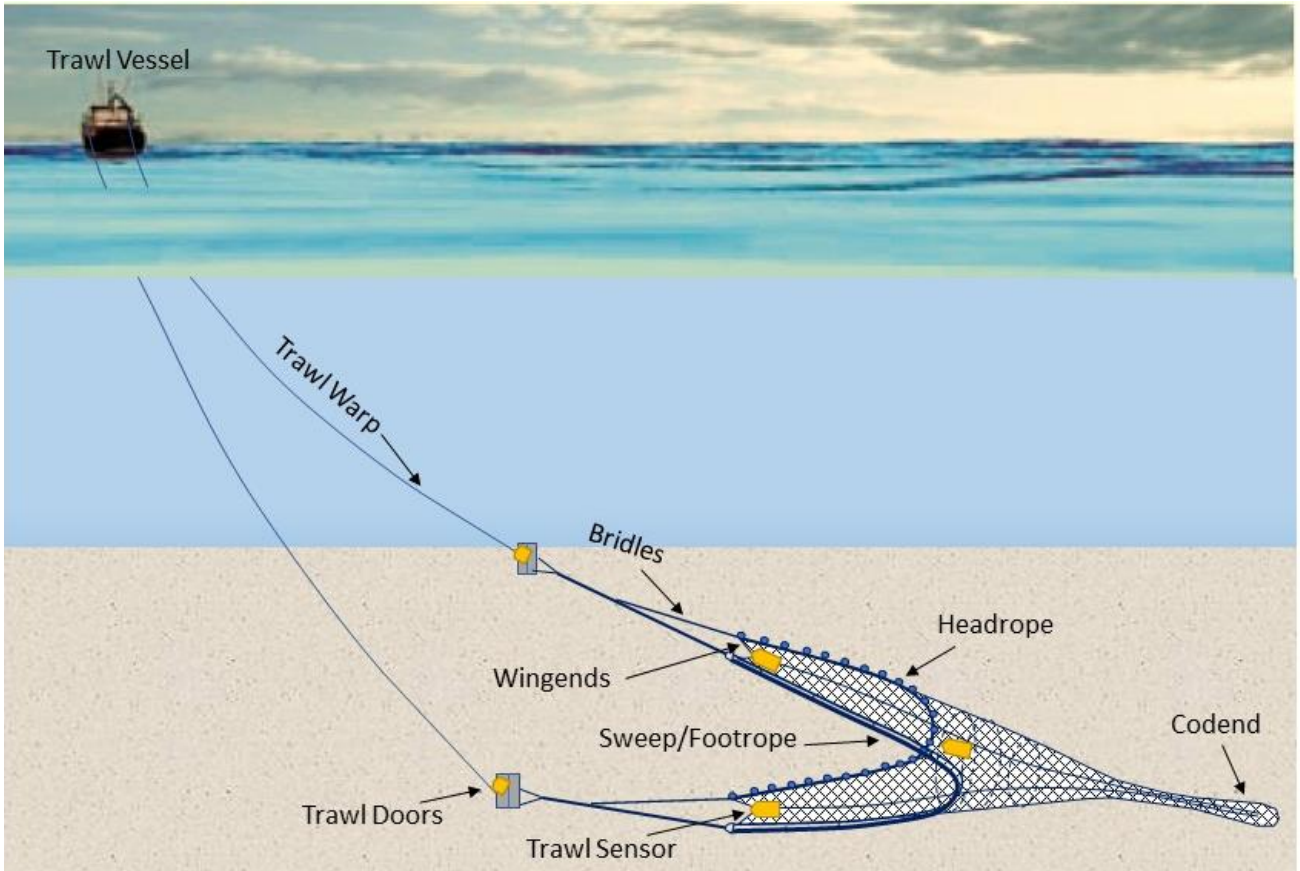


Figure 1: General schematic (not to scale) of a demersal otter trawl. Yellow rectangles indicate geometry sensors.

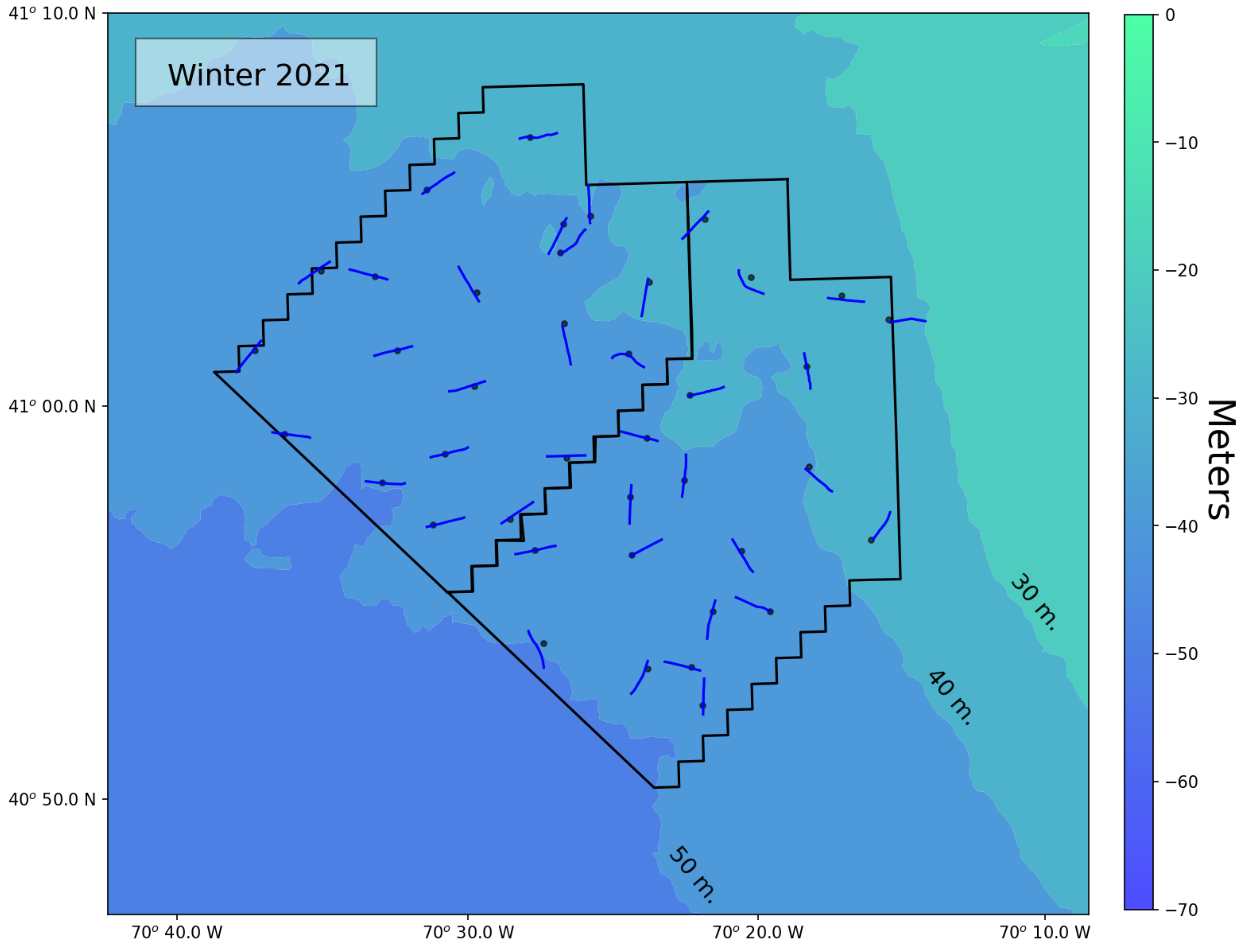


Figure 2: Tow locations (black dots) and trawl tracks (blue lines) from the 501N Study Area (left) and the Control Area (right).

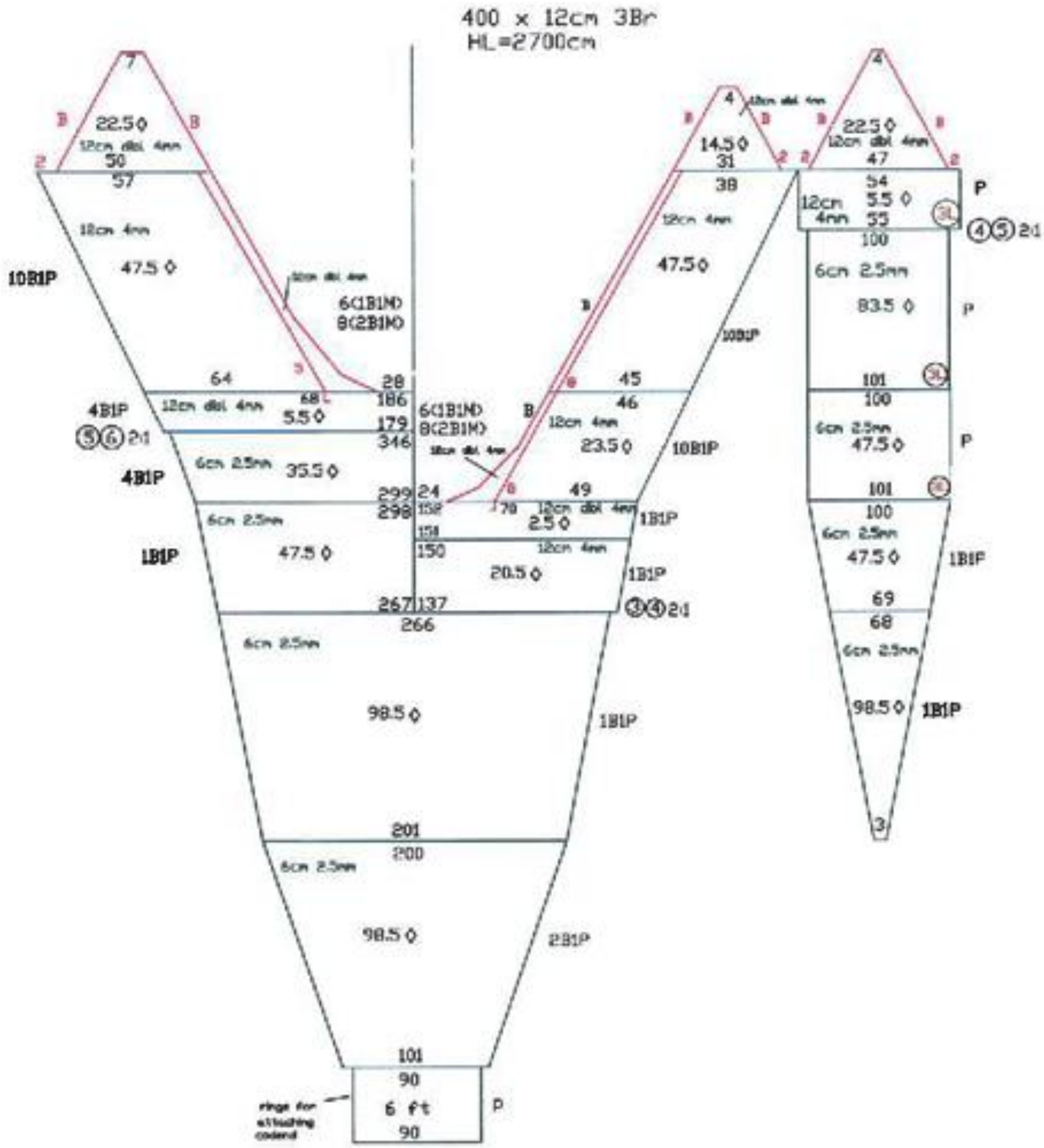


Figure 3: Schematic net plan for the NEAMAP trawl (Bonzek et al., 2008).

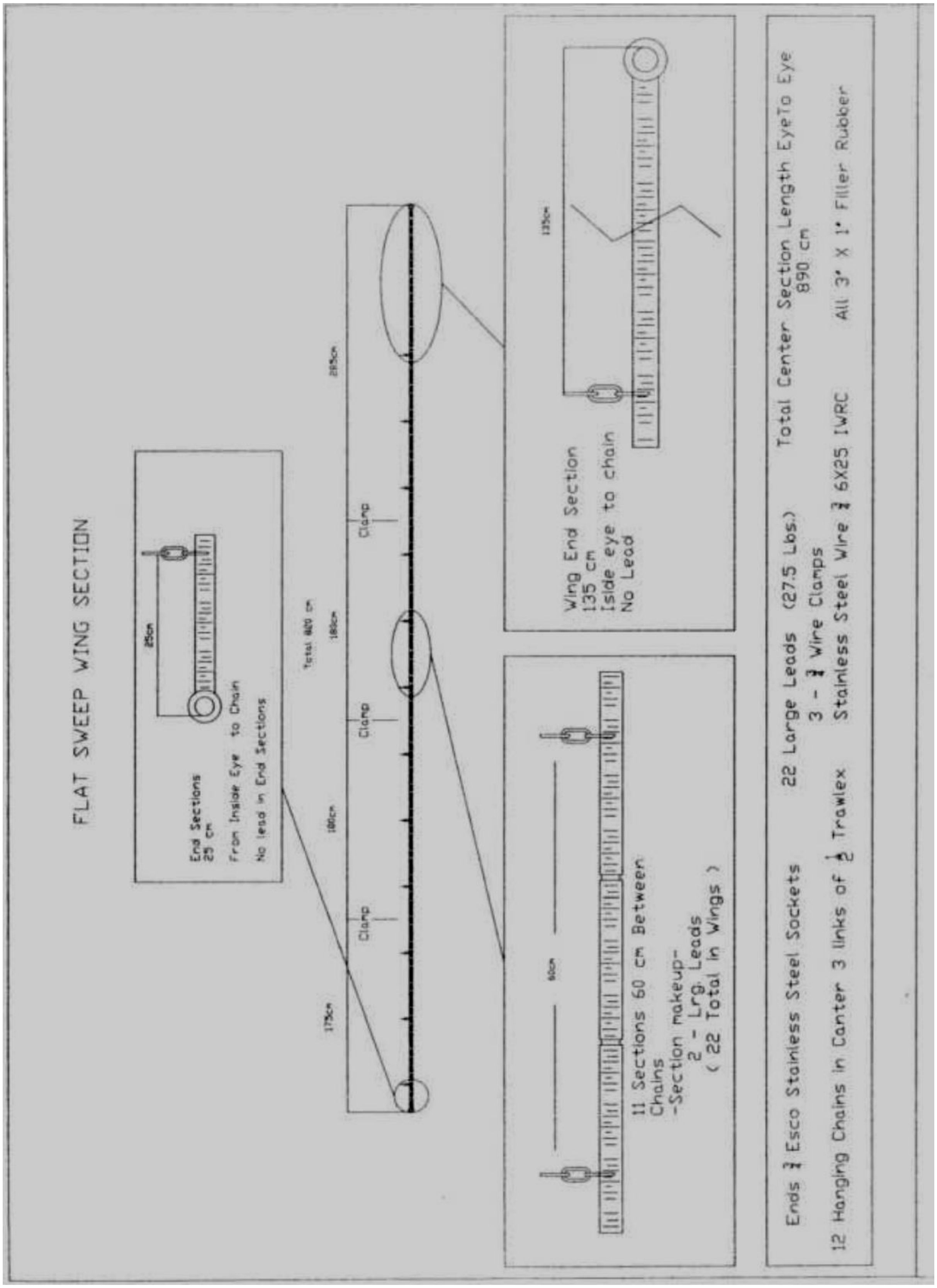


Figure 4: Sweep diagram for the survey trawl (Bonzek et al., 2008).

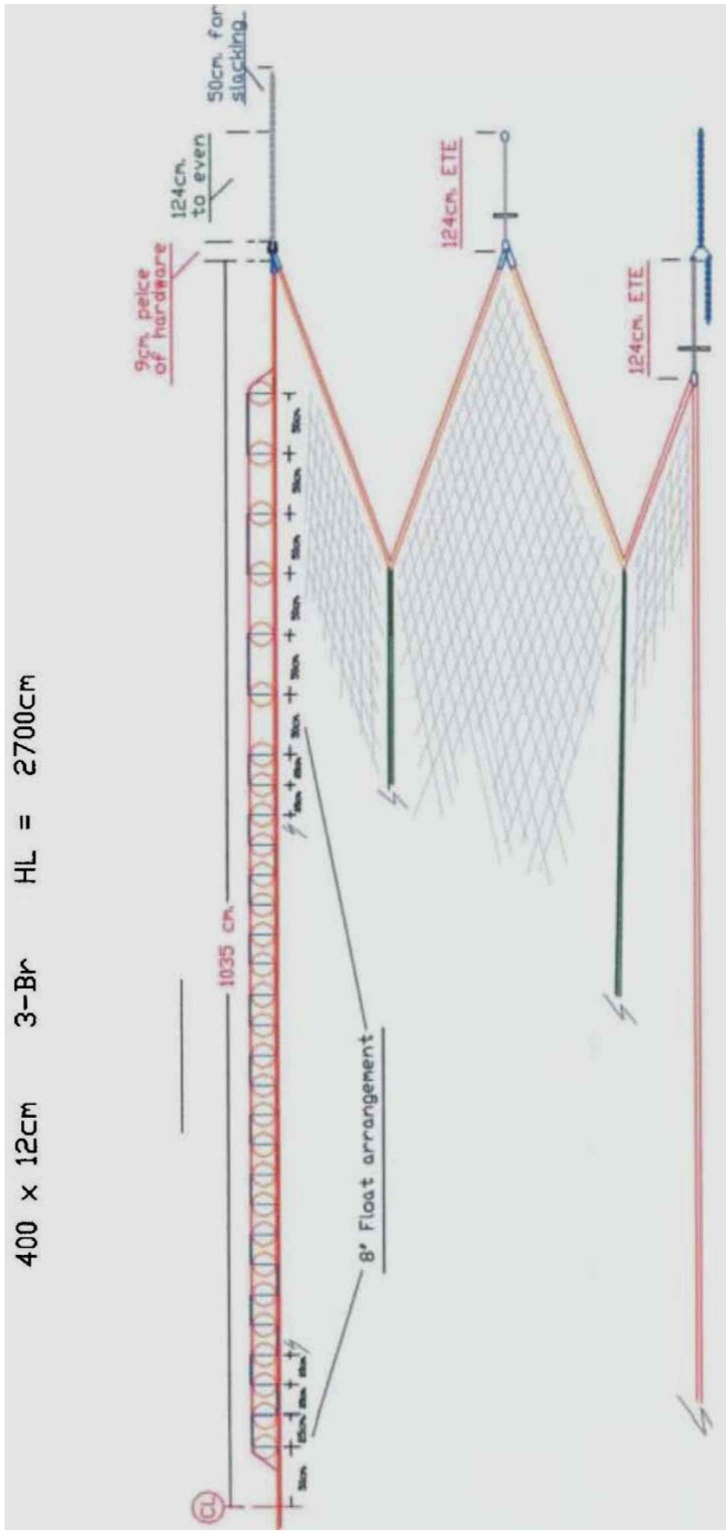


Figure 5: Headrope and rigging plan for the survey trawl (Bonzek et al., 2008).

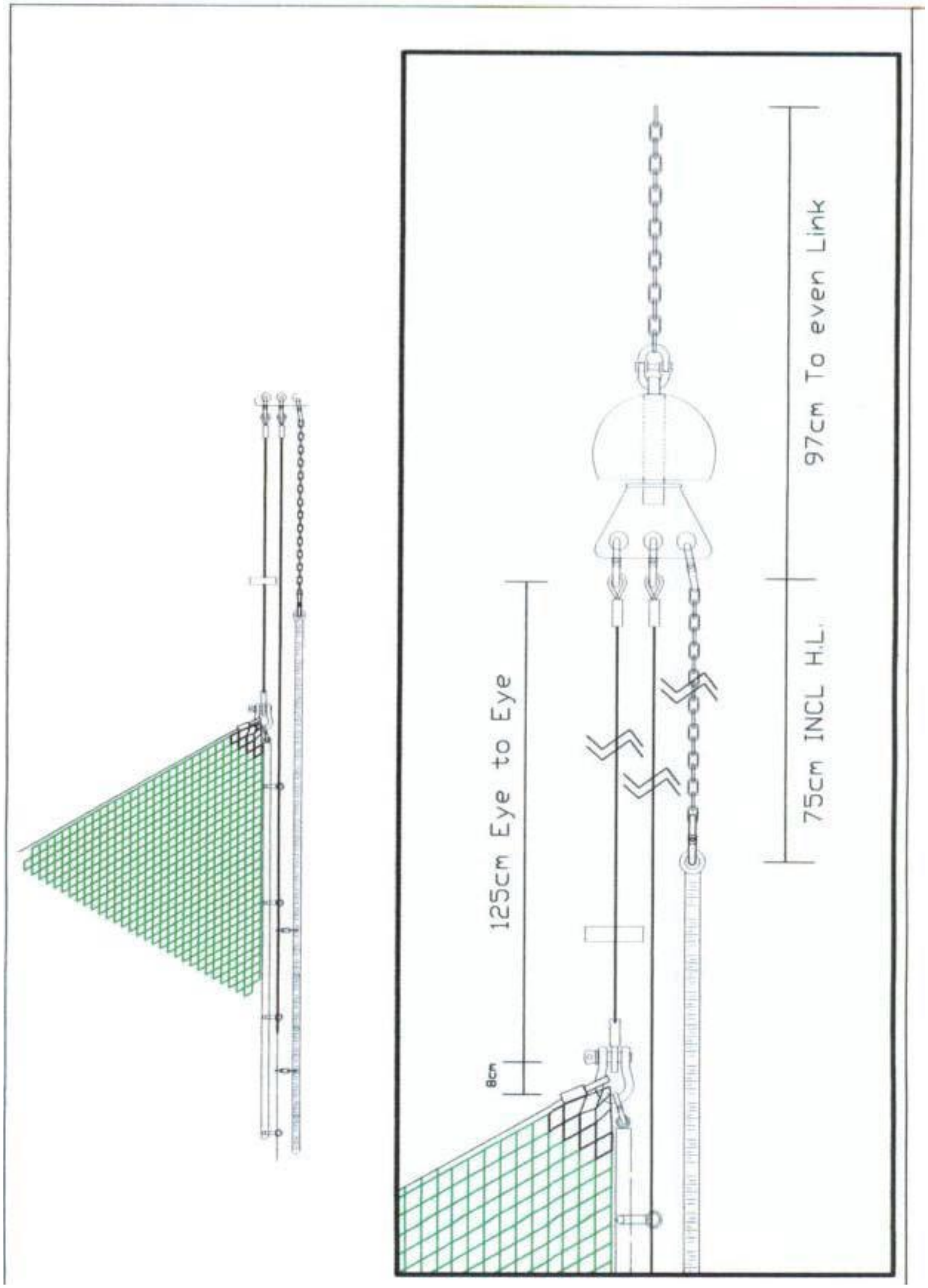


Figure 6: Lower wing and bobbin schematic for the survey trawl (Bonzek et al., 2008).

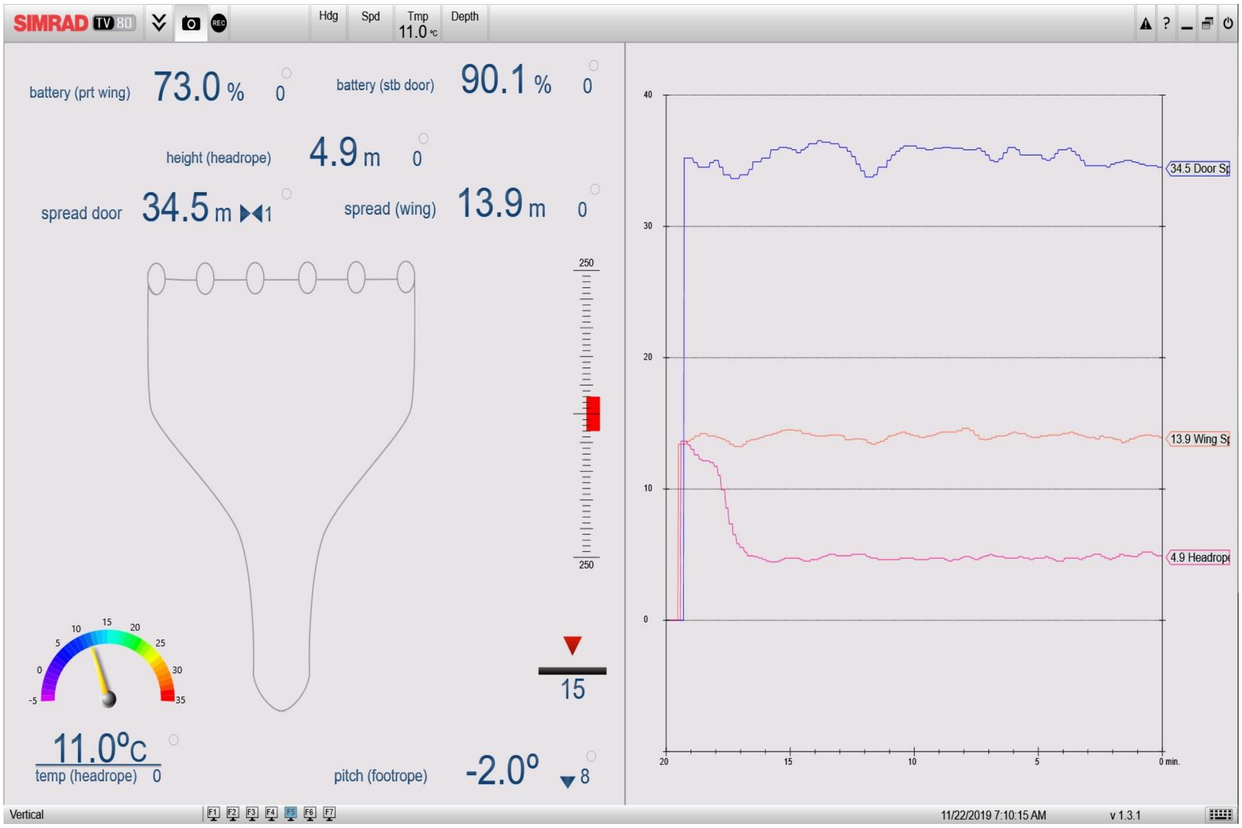
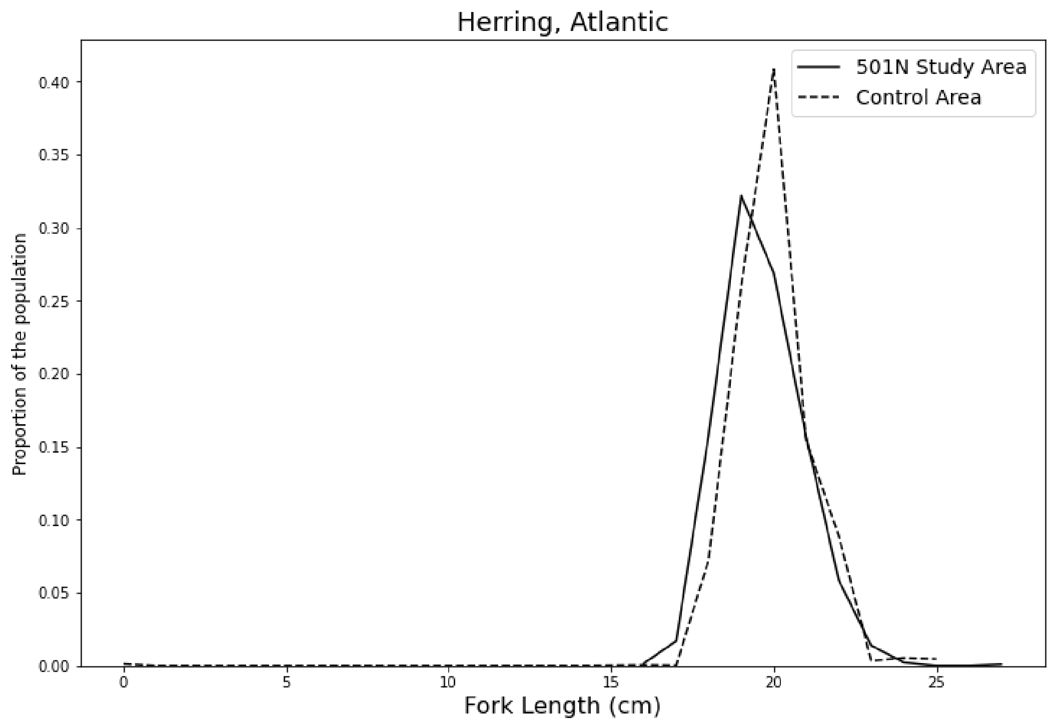


Figure 7: Screenshot of the SIMRAD TV80 software monitoring the trawl parameters.



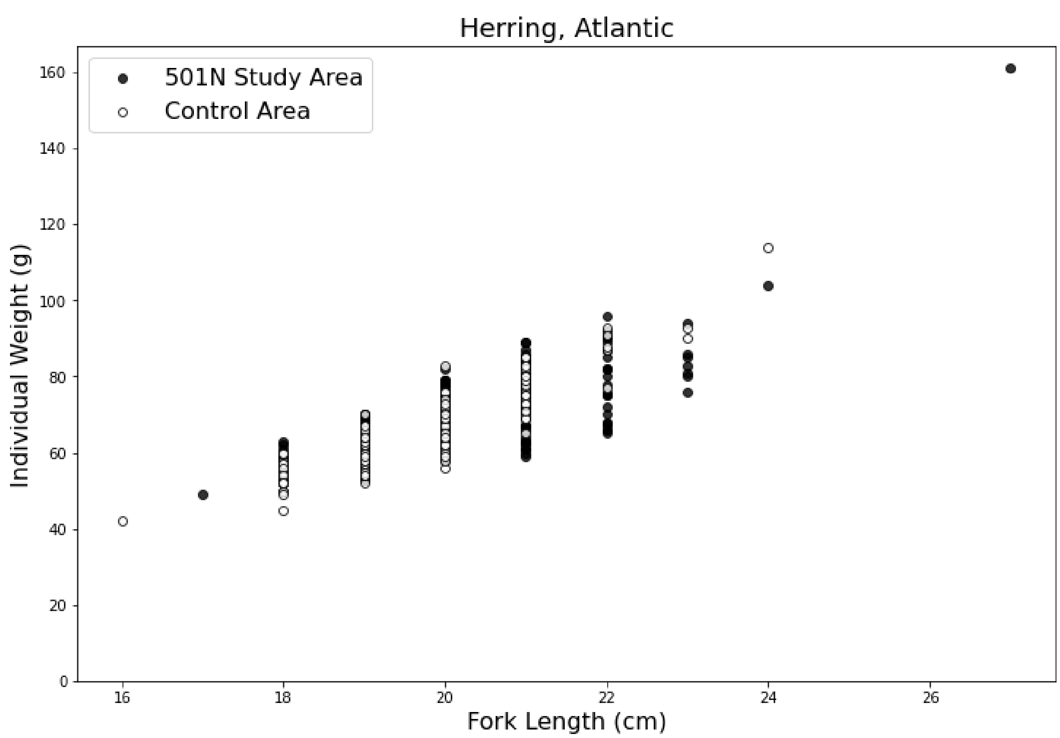


Figure 8: Population structure of Atlantic herring in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

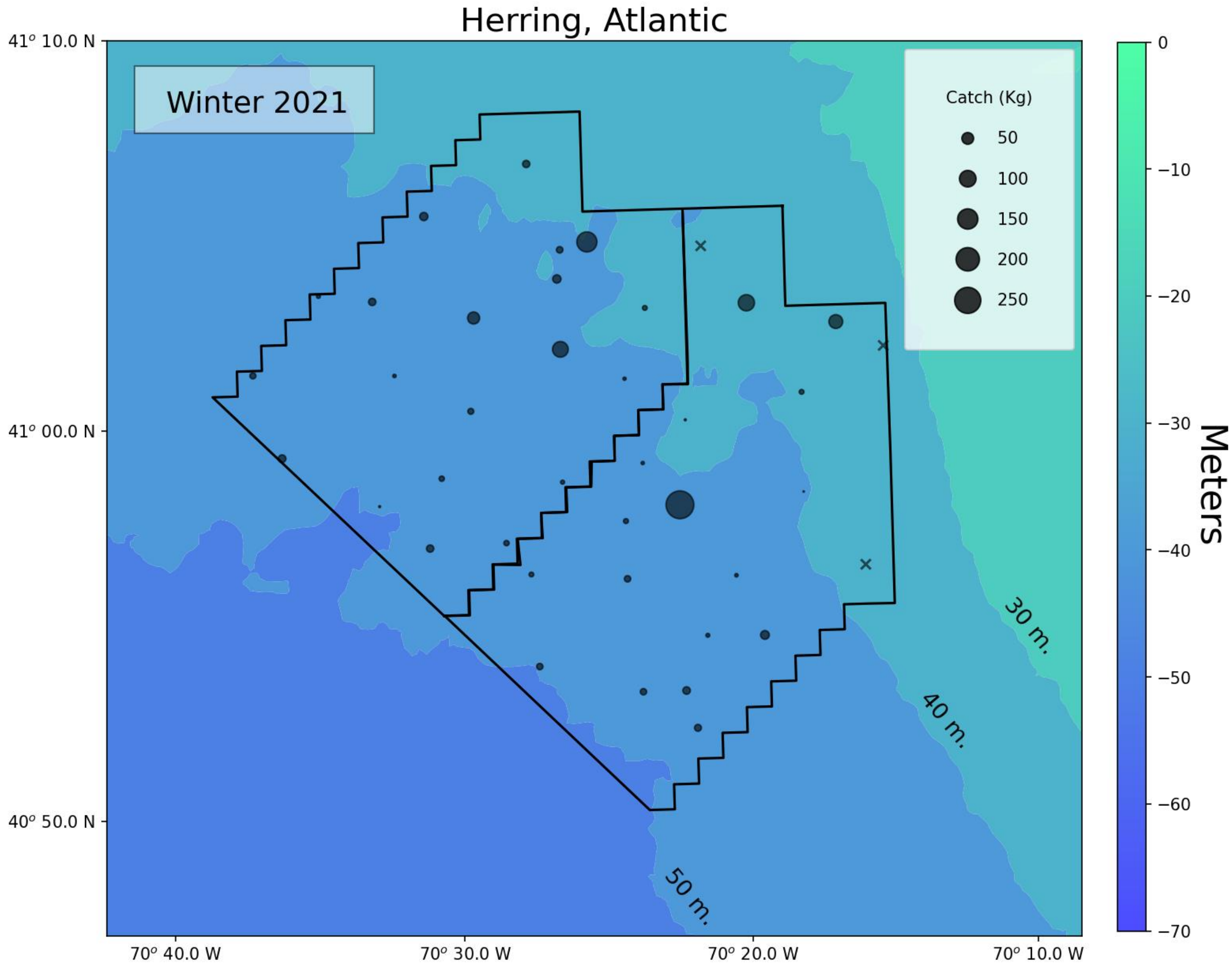
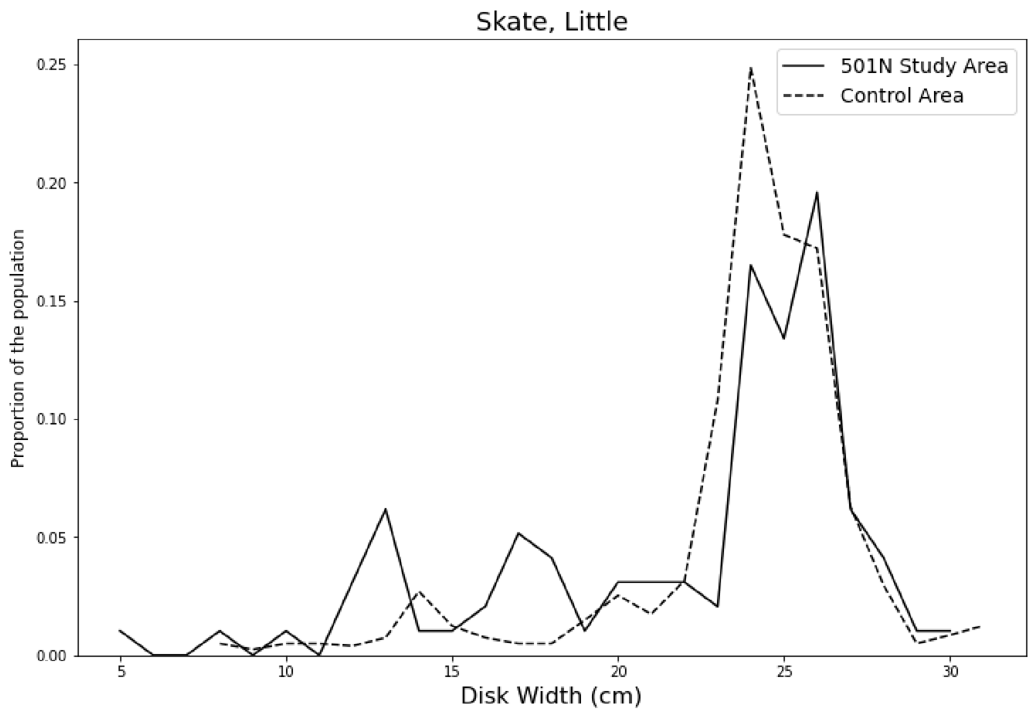


Figure 9: Distribution of the catch of Atlantic herring in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



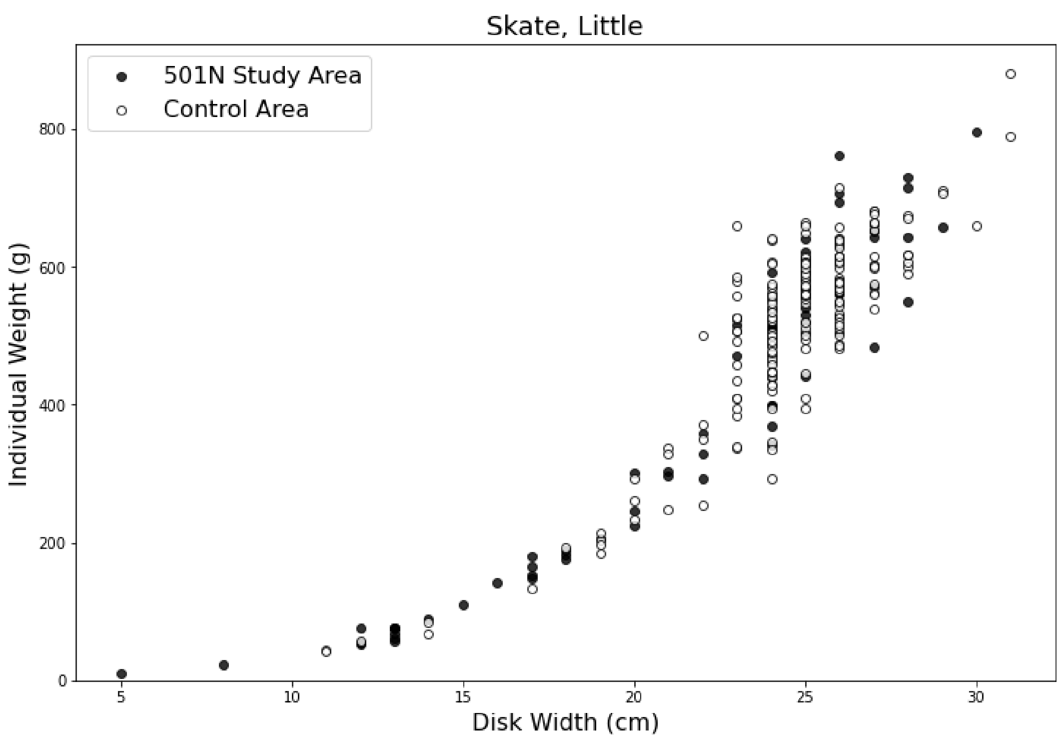


Figure 10: Population structure of little skate in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

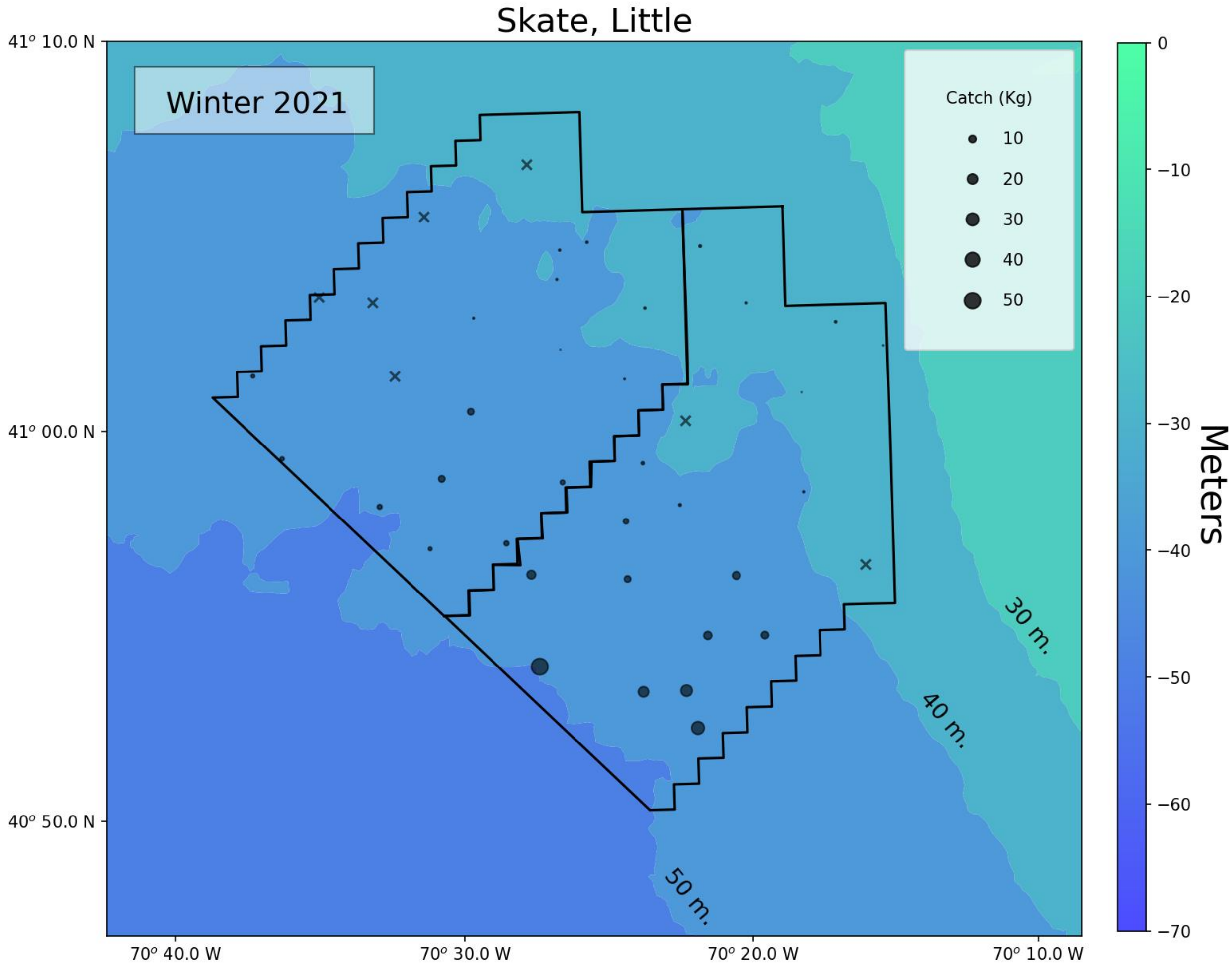
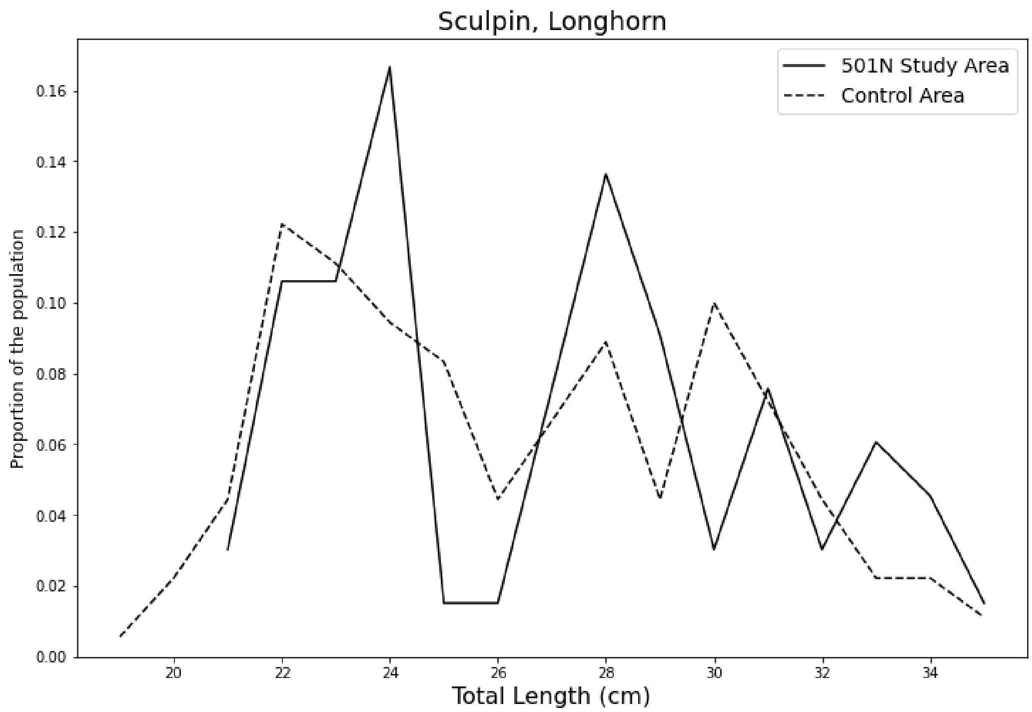


Figure 11: Distribution of the catch of little skate in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



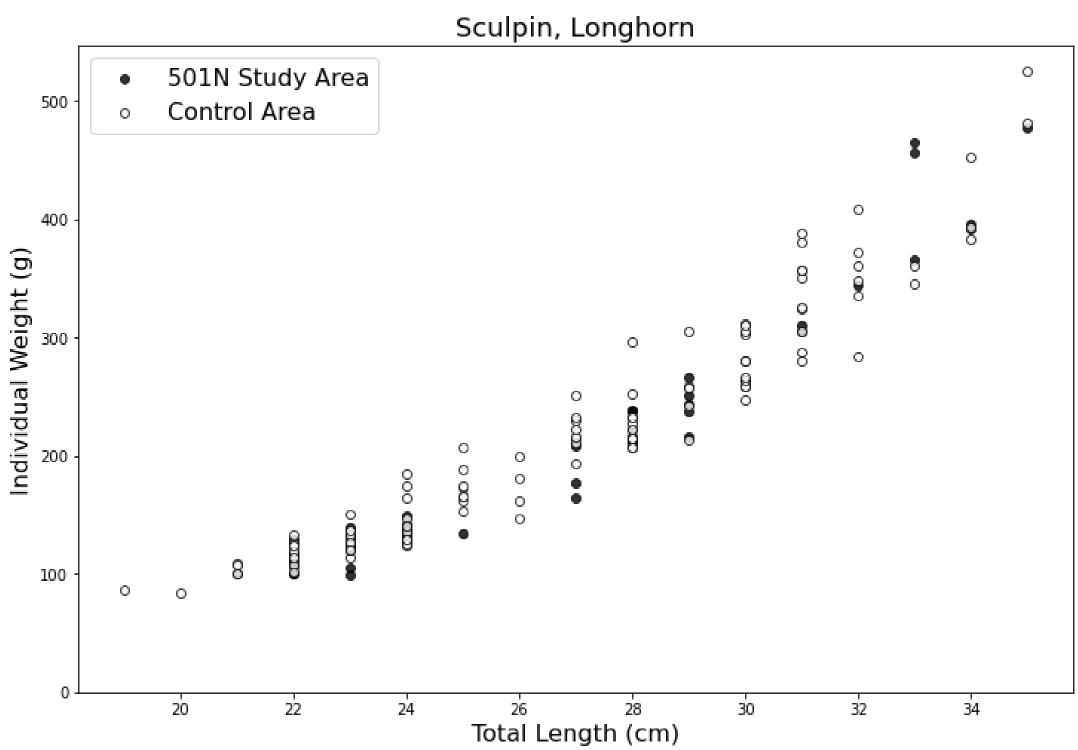


Figure 12: Population structure of longhorn sculpin in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

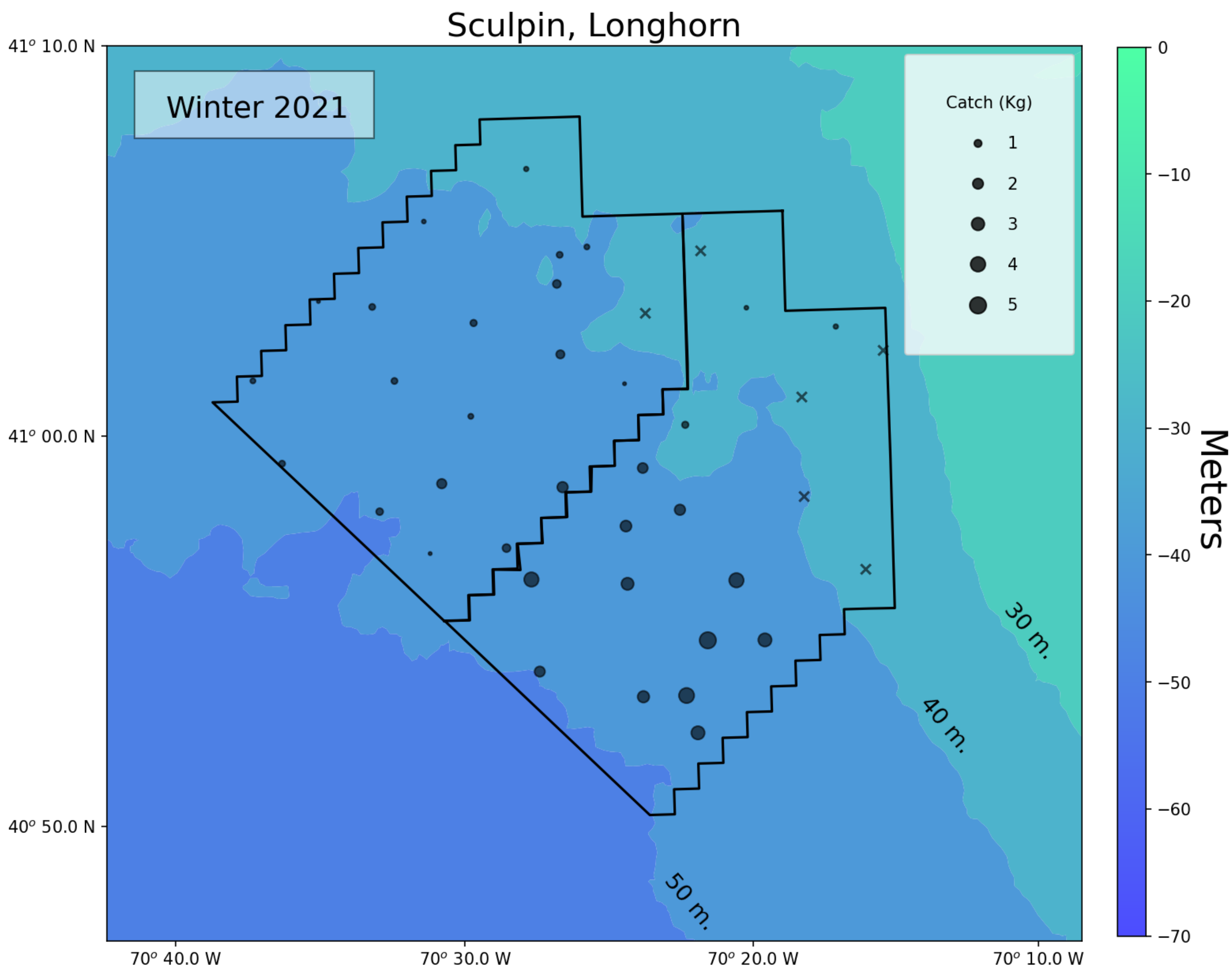
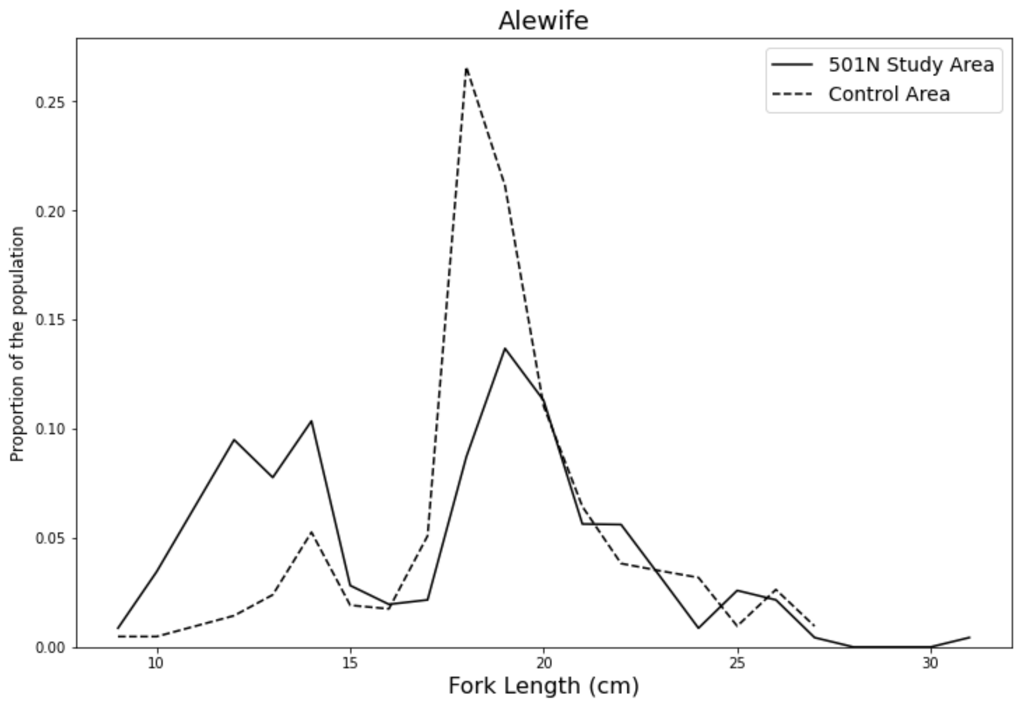


Figure 13: Distribution of the catch of longhorn sculpin in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



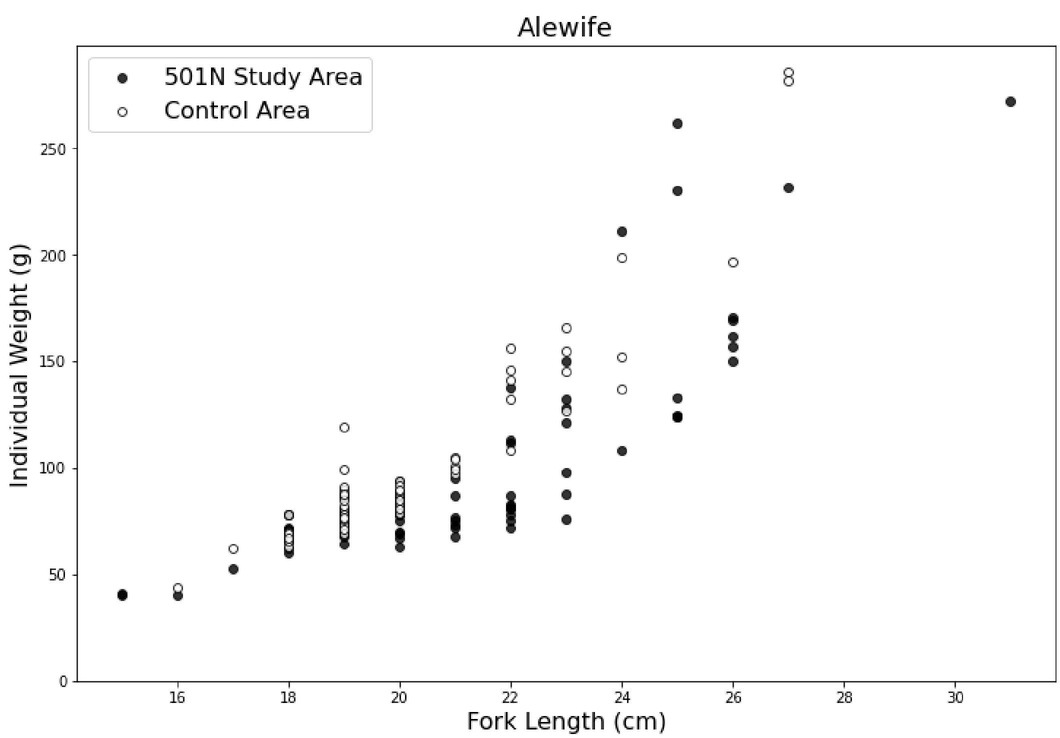


Figure 14: Population structure of alewife in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

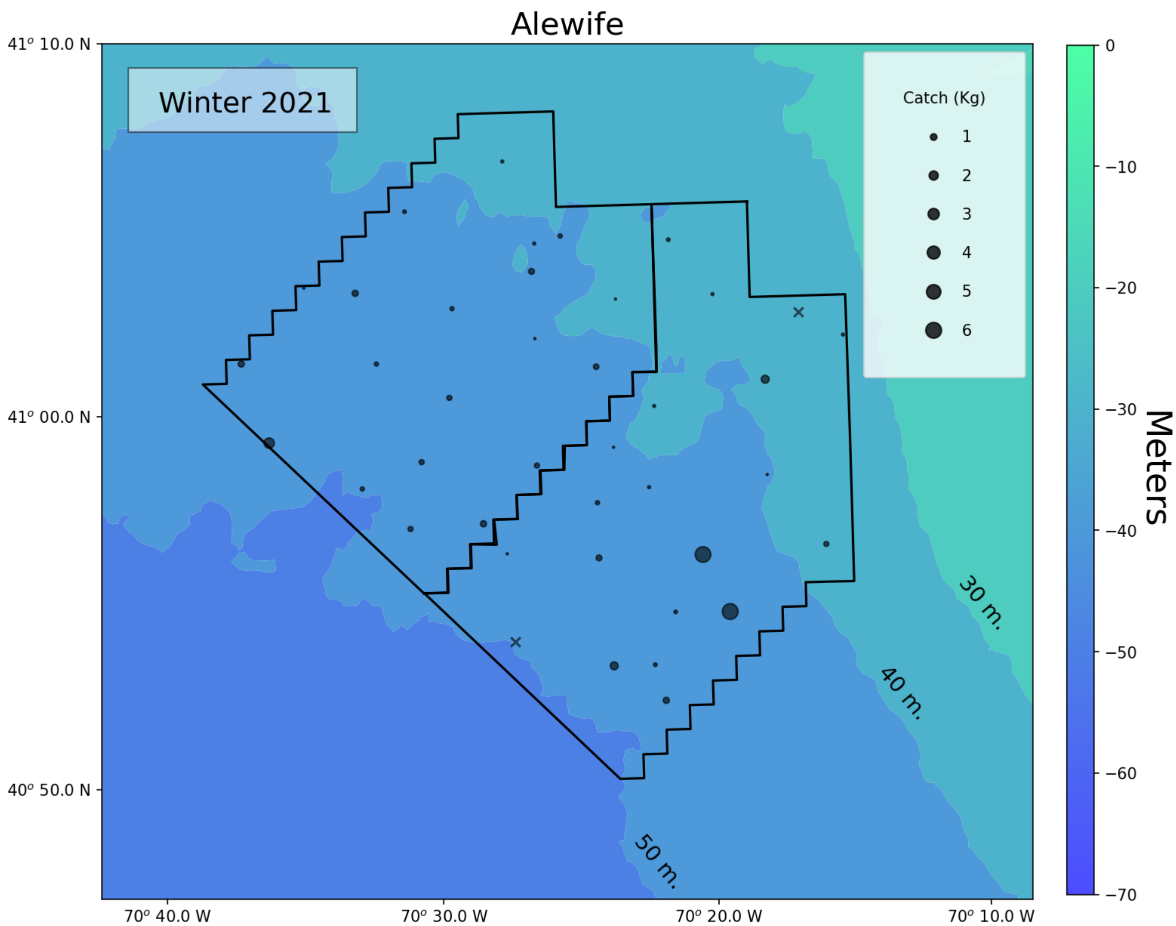


Figure 15: Distribution of the catch of alewife in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.

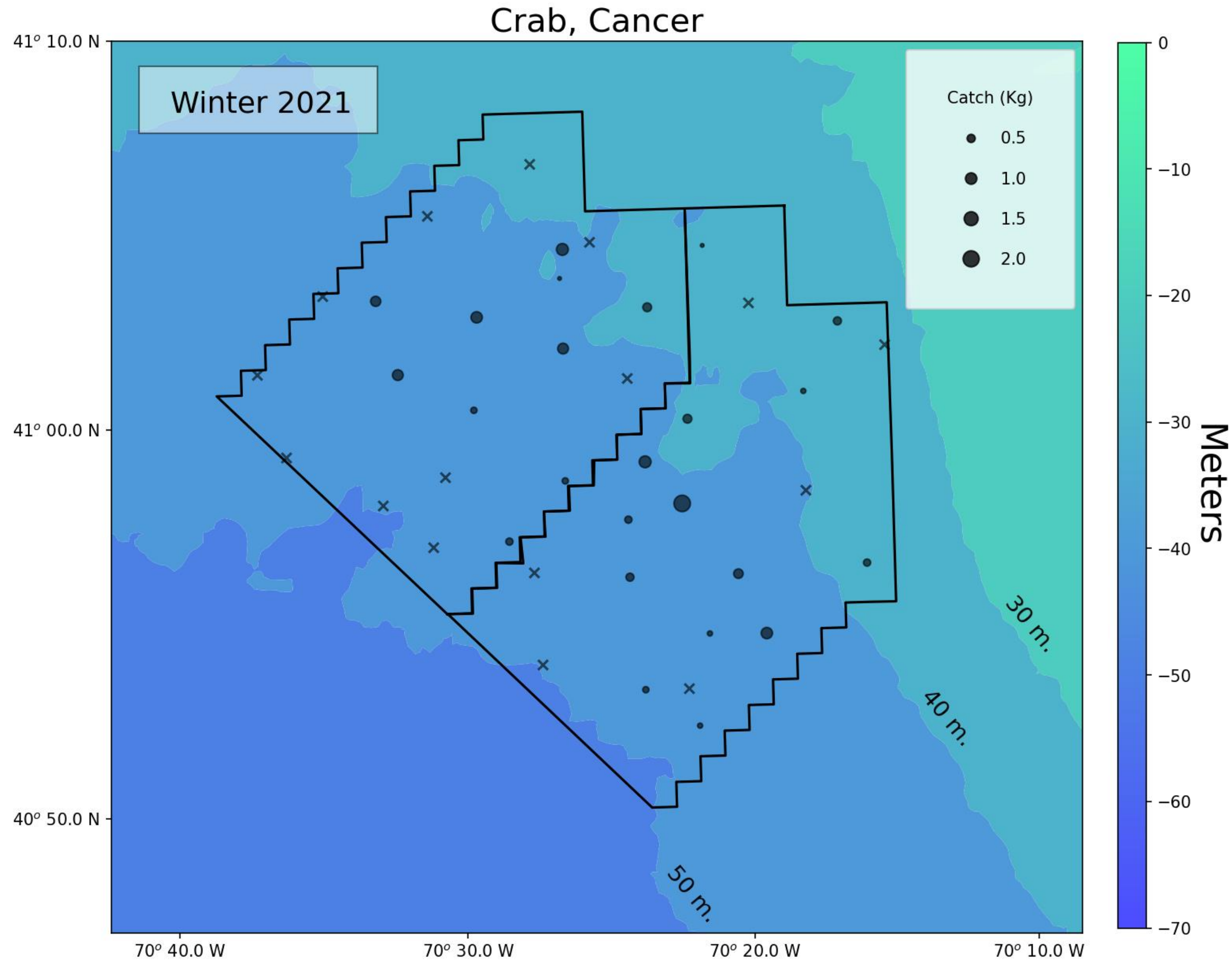
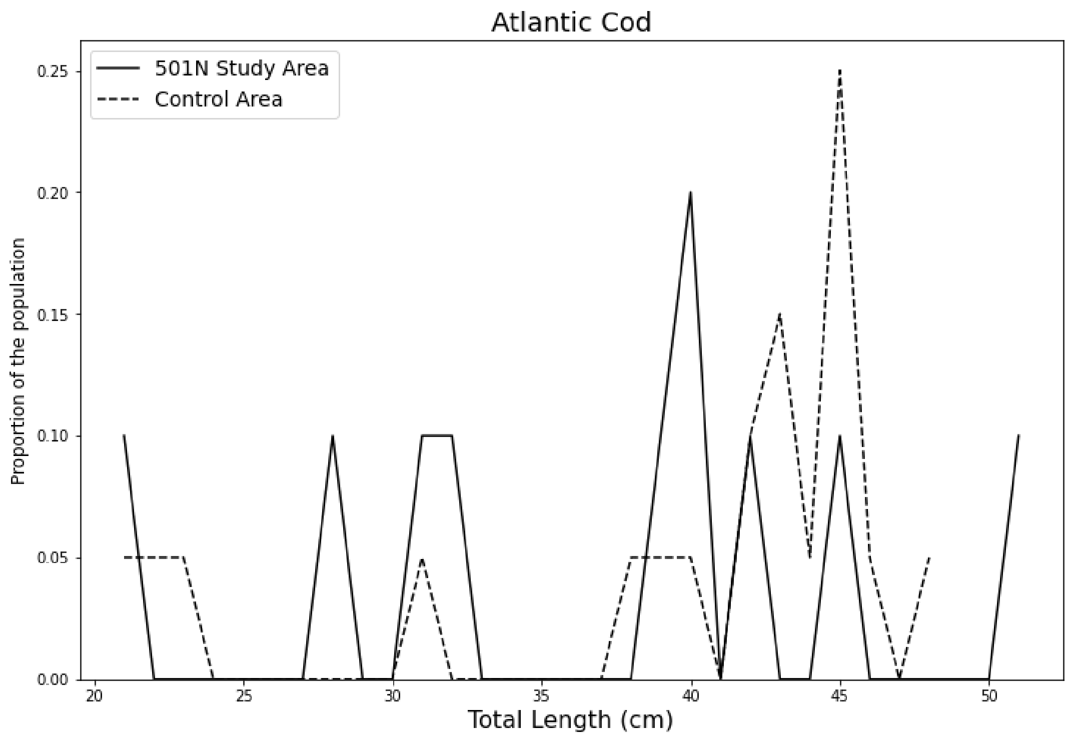


Figure 16: Distribution of the catch of cancer crab in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



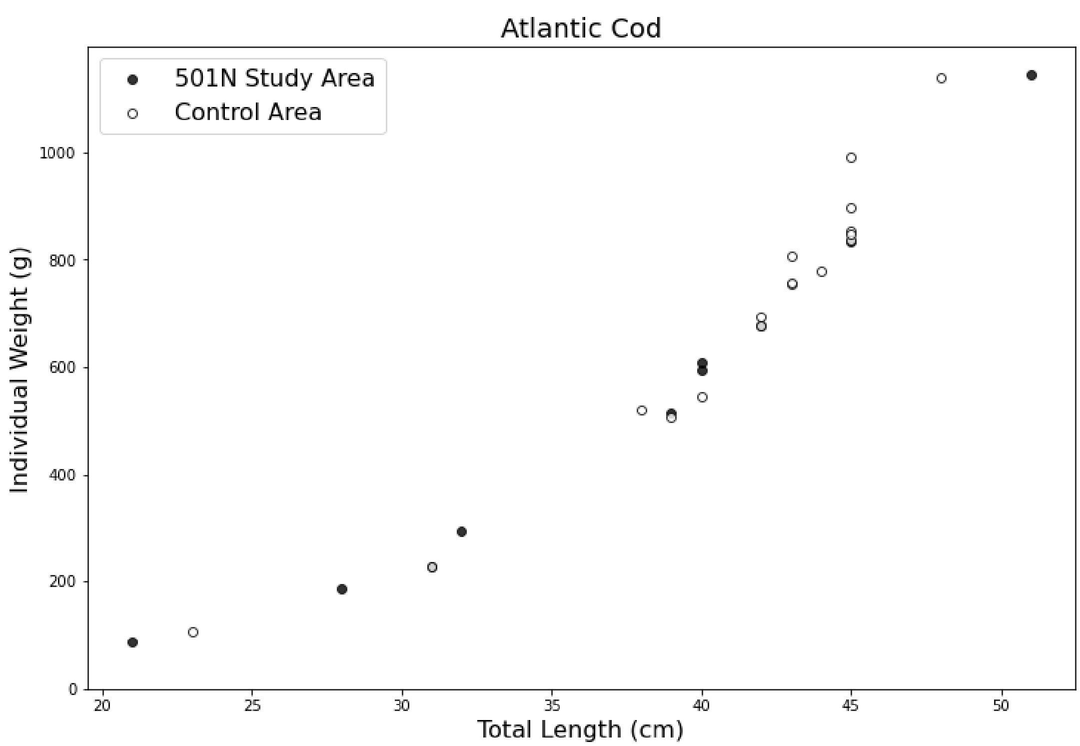


Figure 17: Population structure of Atlantic cod in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

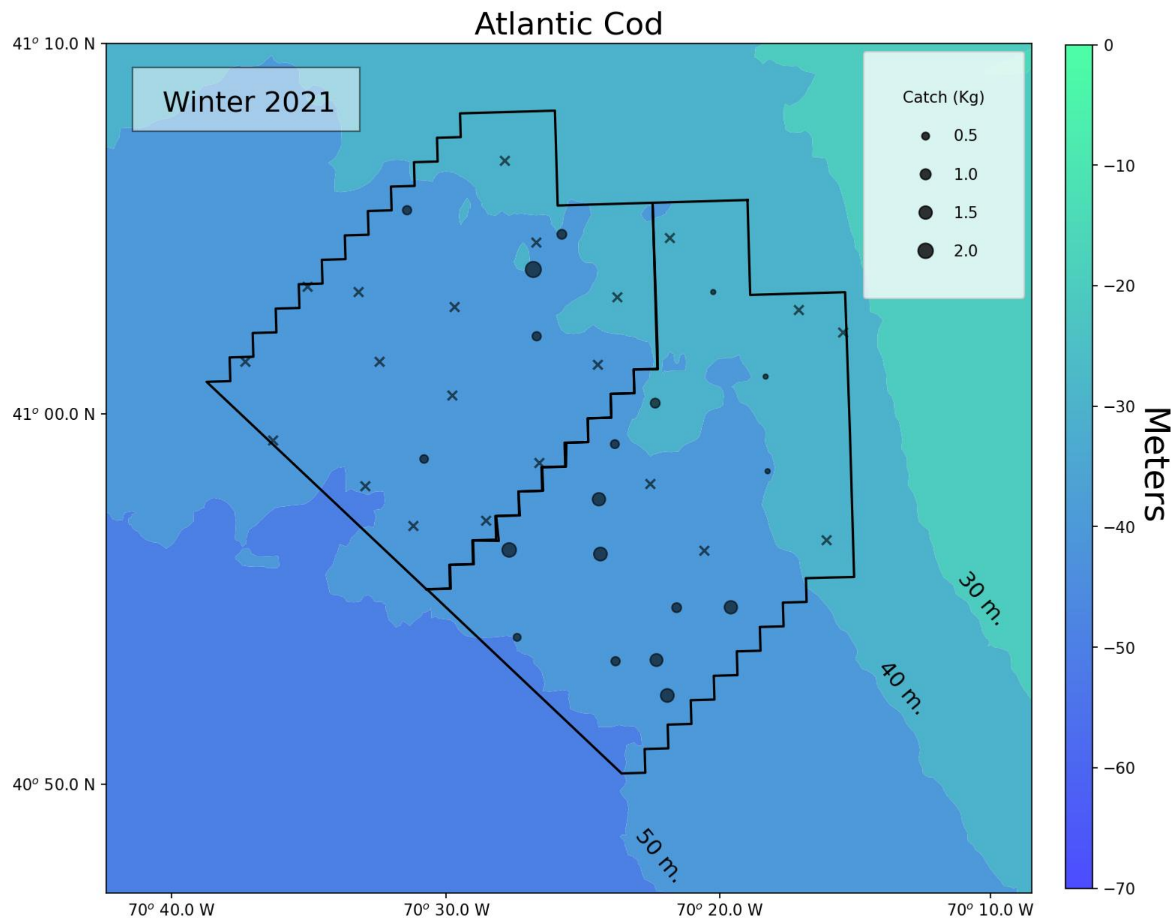
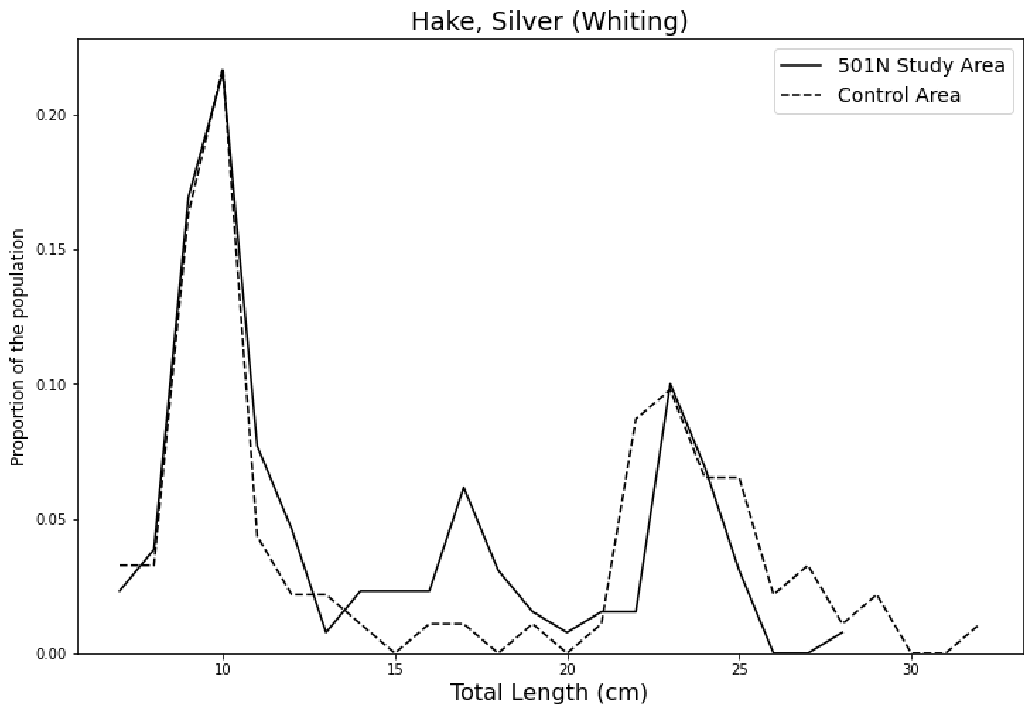


Figure 18: Distribution of the catch of Atlantic cod in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



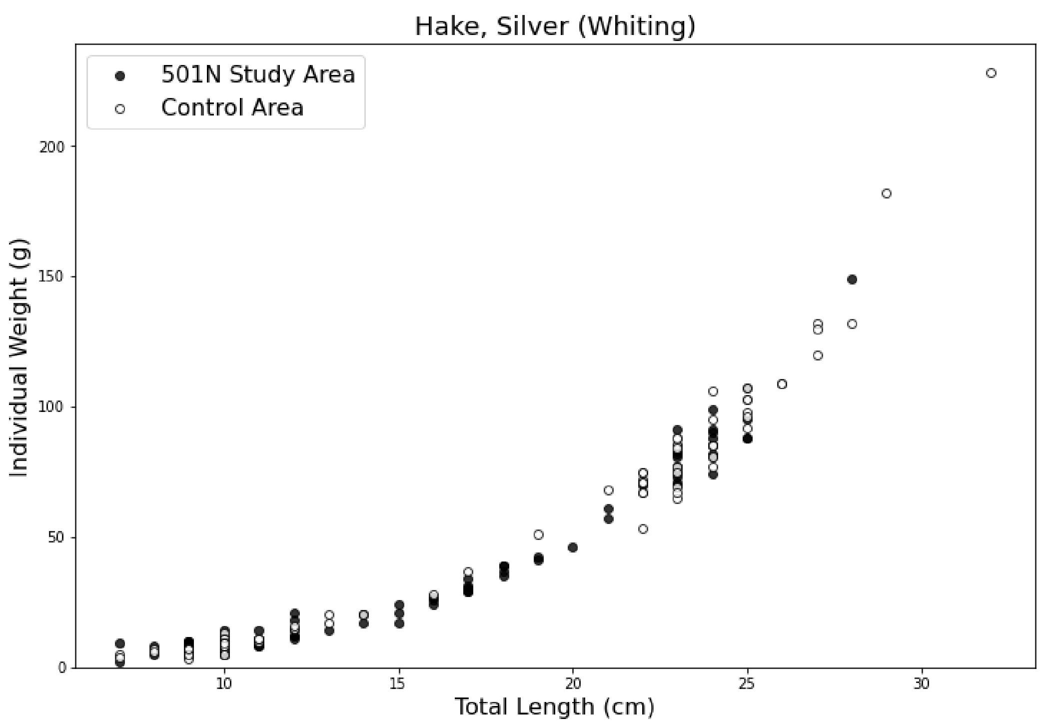


Figure 19: Population structure of silver hake in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

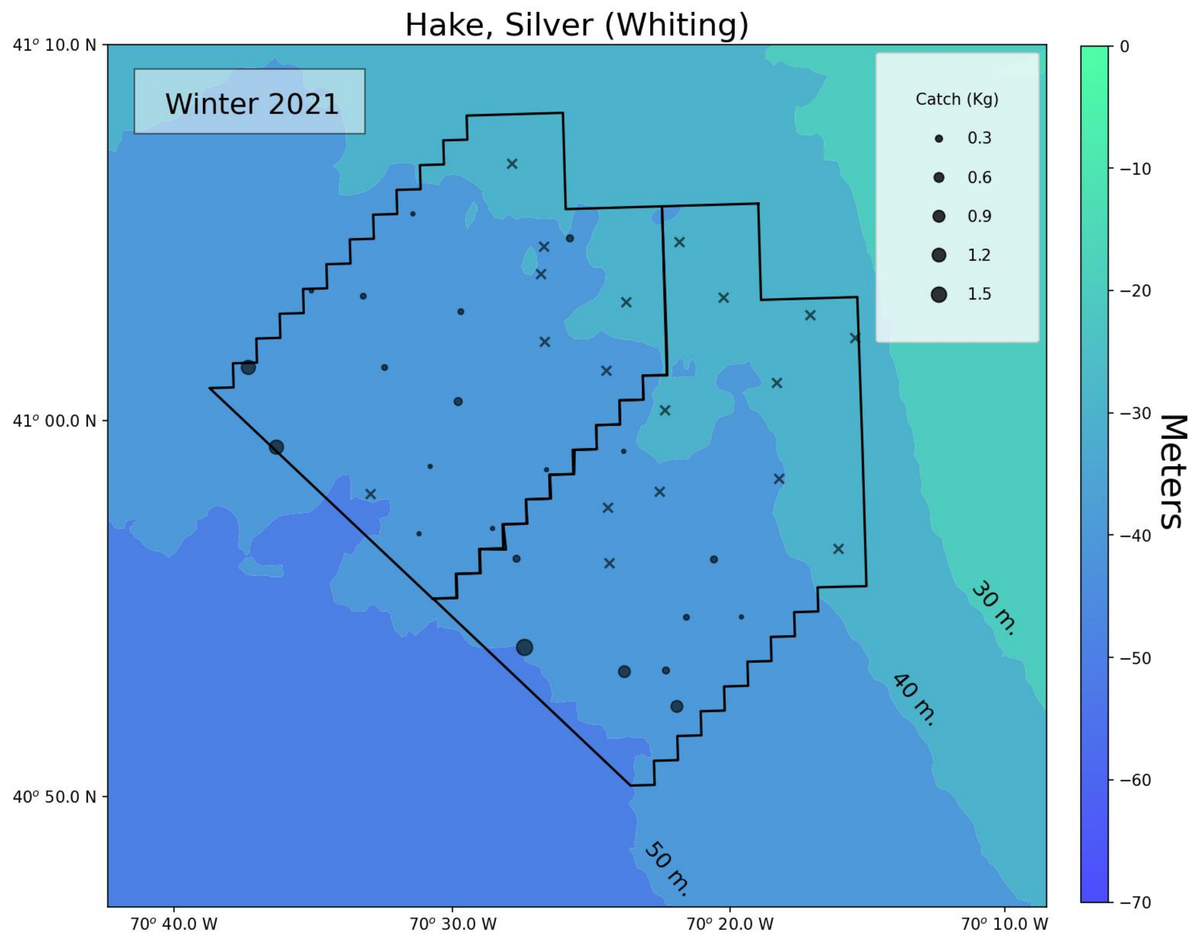


Figure 20: Distribution of the catch of silver hake in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.

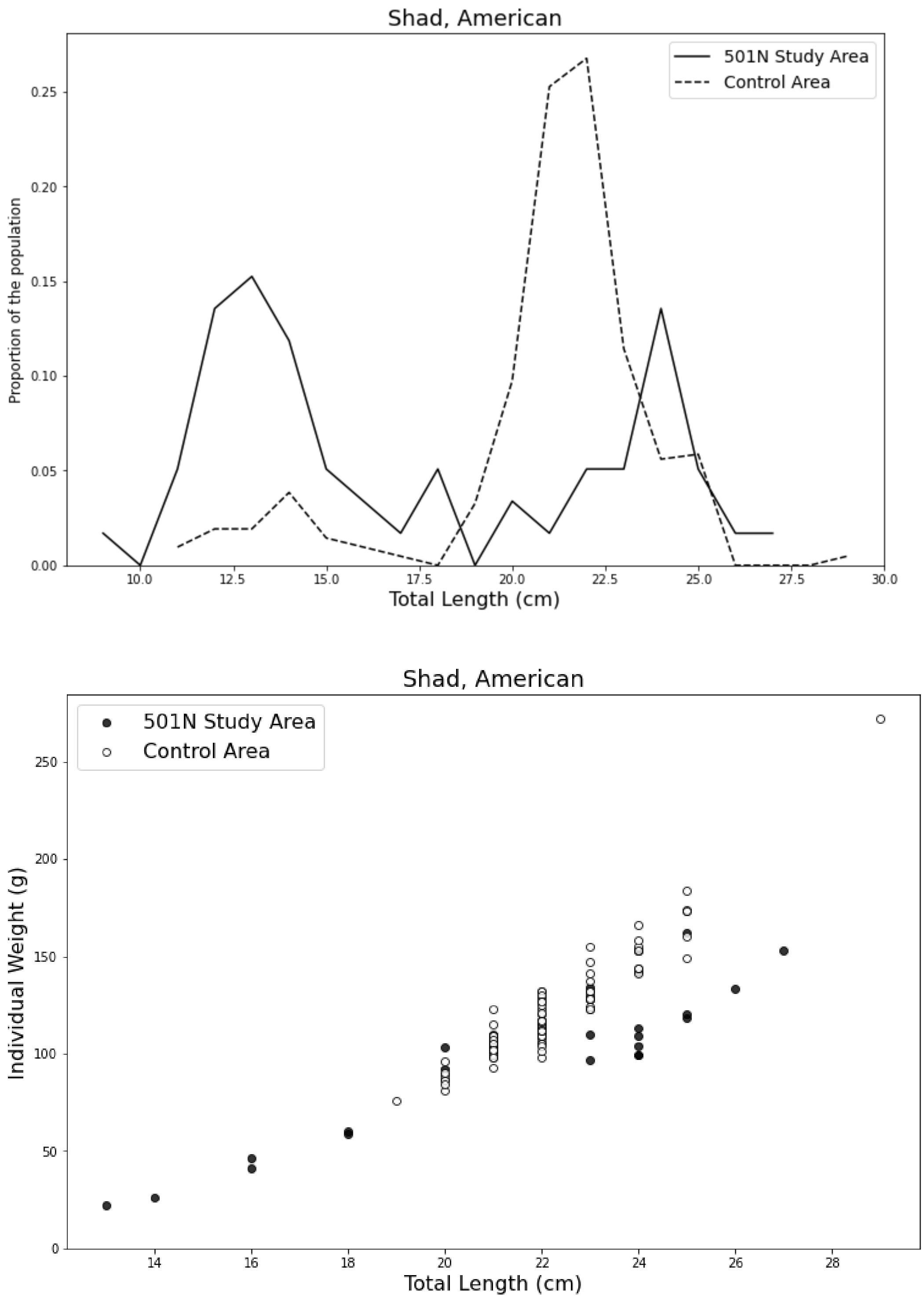


Figure 21: Population structure of American shad in the 501N Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

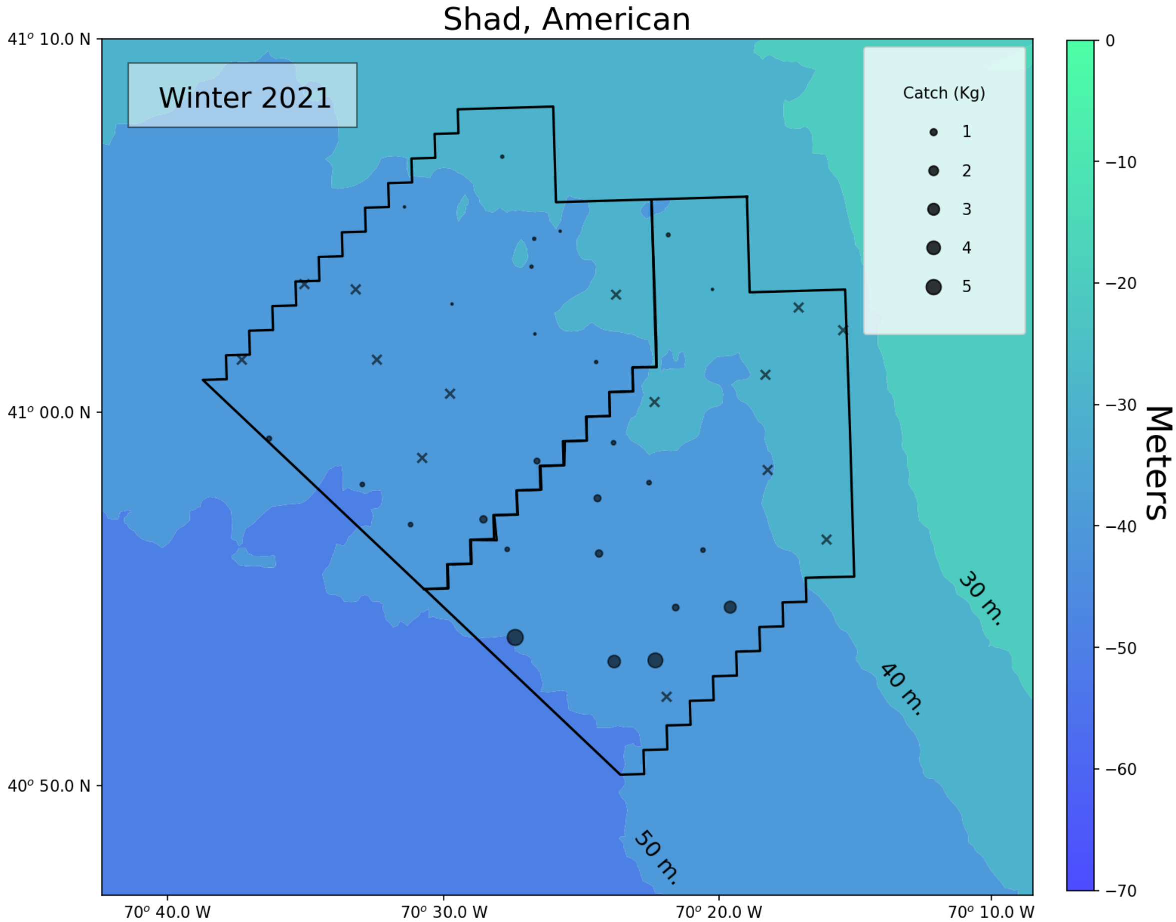


Figure 22: Distribution of the catch of American shad in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.