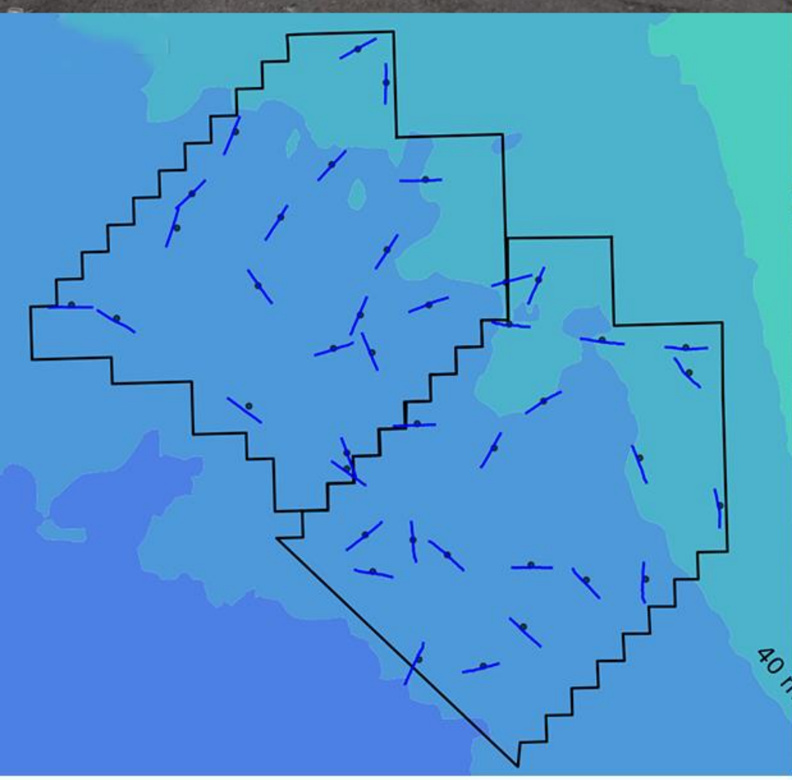
# Vineyard Wind Demersal Trawl Survey



## Quarterly Report

**Vineyard Wind 1 Study Area**

**Winter 2022 (January - March)**

# VINEYARD WIND DEMERSAL TRAWL SURVEY

## Winter 2022 Seasonal Report

## Vineyard Wind 1 Study Area

**March 2022**

**Prepared for Vineyard Wind LLC**

VINEYARD WIND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**School for Marine Science and Technology**


SMAST


**Vineyard Wind Demersal Trawl Survey**
**Winter 2022 Seasonal Report**

**Vineyard Wind 1 Study Area**


UMass Dartmouth

# Progress Report #10

January 1 – March 31, 2022

Project title: Vineyard Wind Demersal Trawl Survey Winter 2022 Seasonal Report – Vineyard Wind 1 Study Area

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**SMAST-CE-REP-2022-109**

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# 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 conducting fisheries studies in a 306 $km^2$ area referred to as "Vineyard Wind 1" or the "VW1 Study Area", which is the focus of this report. Fisheries studies are also being conducted in Vineyard Wind shareholder company lease areas. This includes Lease Area OCS-A 0534 (the "534 Study Area") and Lease Area OCS-A 0522 (the "522 Study Area"); these studies are reported separately.[1]

The Bureau of Ocean Energy Management (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) to assess if there is any impact due to the development of wind farms. The control site will be in the general vicinity with similar characteristics to the study areas (i.e., depth, habitat type, seabed

[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 VW1 Study Area, which is located in the area designated as Lease Area OCS-A 0501, is referred to as the "501N Study Area" in SMAST fisheries survey reports compiled prior to the lease area segregation. Similarly, the 534 Study Area, which is designated as Lease Area OCS-A 0534, is referred to as the 501S Study Area in SMAST fisheries survey reports compiled prior to the lease area segregation.

characteristics, etc.). The goal of the monitoring plan is to assess the impact that wind farm construction and operation may 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 marine ecosystem. 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 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 NEAMP survey protocol has also been adopted by trawl surveys conducted in other offshore wind development areas in the northeast US by other institutions. The bottom trawl survey is complemented by the drop camera survey and the lobster trap survey in the same area, also carried out by SMAST (reported separately).

The primary goal of this survey was to provide data related to fish abundance, distribution, and population structure in and around the VW1 Study Area. The data will serve as a baseline to be used in a future analysis under the BACI framework. The reports for the first two years of monitoring from spring 2019 to spring 2021 have been submitted to the sponsoring organization. This progress report documents the survey methodology, survey effort, and data collected during the winter of 2022.

# 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 Lease Area OCS-A 0501 using a commercial fishing vessel (Bonzek et al., 2008). The current NEAMAP 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., the 534 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 composition for a future environmental assessment using the BACI framework as recommended by BOEM (BOEM, 2013). Tow locations within the VW1 Study Area were selected using a spatially balanced sampling design. The VW1 Study Area was modified from the 2020/2021 survey year due to boundary refinements of projects within Lease Area OCS-A 0501. The VW1 Study Area was decreased from 306 $km^2$ to 265 $km^2$ by moving the southern boundary north (Figure 2). The current VW1 Study Area was sub-divided into 20 sub-areas (each ~13.25 $km^2$), and one trawl tow was made in each of the 20 sub-areas. This was designed to ensure adequate spatial coverage throughout the VW1 Study Area. The starting location within each sub-area was randomly selected (Figure 3).

An area located to the east of the VW1 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 VW1 Study Area. The Control Area was modified from the 2020/2021 survey year to align with the aforementioned changes to the VW1 Study Area. To align the northern and southern boundaries with the VW1 Study Area, areas to the north and south were removed from the Control Area. Additionally, the eastern boundary was slightly extended to match the width and area of the VW1 Study Area (Figure 2). These changes decreased the Control Area from 324 $km^2$ to 269.5 $km^2$. The Control Area was sub-divided into 20 sub-areas (each ~13.5$km^2$). An additional 20 tows, one per sub-area, were completed in the Control Area. The tow locations were selected in the same manner as the VW1 Study Area, using the spatially balanced 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, *Leucoraja erinacea*, Atlantic longfin squid, *Dorytheuthis pealei*, silver hake, *Merluccius bilinearis*, and fourspot flounder, *Paralichthys oblongus*, 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, *Leucoraja ocellata*, red hake, *Urophycis chuss*, windowpane flounder, *Scophtalmus aquosus*, monkfish, *Lophius americanus*, summer flounder, *Paralichthys dentatus*, scup, *Stenotomus chrysops*, yellowtail flounder, *Pleironectes ferrugineus*, winter flounder, *Pleuronectes americanus*, and butterfish, *Peprilus triacanthus*, had higher variability (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 VW1 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 VW1 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, assumes 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 13.25 $km^2$ (3.86 square nautical miles [$nmi^2$]) in the VW1 Study Area and one station per 13.5 $km^2$ (3.94 $nmi^2$) 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 4). 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 5). 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 6 and 7 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 (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 which 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 8).

## 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: January 31 – February 4, 2022
- Trip 2: February 5 – 9, 2022

Surveys were alternated daily between the VW1 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. Only one sub-sampling strategy was employed over the duration of the survey: straight sub-sampling by weight.

<u>Straight sub-sampling by weight:</u> When catch diversity was relatively low (five to 10 species), straight sub-sampling was used. In this method, the catch was sorted by species. An aggregated species weight was measured and then a sub-sample (50 – 100 individuals) was collected 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. This was the predominant sub-sampling strategy.

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 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 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 VW1 Study Area and the Control Area (Figure 3, Table 1). Operational parameters were similar between these two survey areas (Table 2). Tow durations averaged 20.0 ± 0.1 minutes (mean ± one standard deviation) in the VW1 Study Area and 20.1 ± 0.2 minutes in the Control Area. Tow distances averaged 1.0 ± 0.02 nautical miles (nmi) in the VW1 Study Area giving an average tow speed of 2.9 ± 0.1 knots. Similarly, tow distance averaged 1.0 ± 0.05 nmi 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 northeastern edge (~33 m). Depth increased to a maximum of 50 m along the southwestern boundary. Bottom water temperatures were relatively consistent across the VW1 Study Area (3.7 ± 0.6°C [38.7 ± 1.1°F]) and Control Area (4.3 ± 0.6°C [39.7 ± 1.1°F]) (Table 2). Bottom water temperatures were comparable to those observed in the winter 2020 (range: 4.5 – 6.3°C [40.1 – 43.3°F]) and 2021 (range: 3.5 – 4.6°C [38.3 – 40.3°F]) surveys.

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 35.8 ± 0.9 m (range: 34.0 – 37.6 m) for tows in the VW1 Study Area and 35.8 ± 1.3 (range: 33.8 – 37.8 m) in the Control Area. Wing spread averaged 14.1 ± 0.3 m for tows in the VW1 Study Area (range: 13.7 – 14.6 m) and 14.2 ± 0.4 m for tows in the Control Area (range: 13.4 – 14.9 m). Headline height averaged 4.9 ± 0.4 m for tows in the VW1 Study Area (range: 4.5 – 5.8

m) and 4.9 ± 0.4 m for tows in the Control Area (range: 4.5 – 6.1 m). All tows were in the acceptable range for all trawl geometry parameters.

## 3.2 Catch Data

### 3.2.1 VW1 Study Area

In the VW1 Study Area, a total of 19 species were caught over the duration of the survey (Table 3). Catch volume ranged from 7.6 to 192.7 kilograms per tow (kg/tow) with an average of 64.3 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, Atlantic cod, alewife, and longhorn sculpin) accounted for 97.8% 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 most abundant species, accounting for 89.6% of the total catch weight. Individuals ranged in length from 18 to 27 cm in length with a unimodal size distribution consisting of a peak at 20 cm (Figure 9). Atlantic herring were observed in all 20 tows at an average catch rate of 57.6 ± 12.8 kg/tow (mean ± Standard Error of the Mean [SEM], range: 0.4 – 186.6 kg/tow). Atlantic herring were caught throughout the VW1 Study Area with higher catches observed in the northeastern corner of the VW1 Study Area (Figure 10).

Little skate (*Leucoraja erinacea*) was the second most abundant species observed, accounting for 2.5% of the total catch weight. Individuals ranged in size from 6 to 34 cm (disk width) with a unimodal size distribution consisting of a peak at 27 cm (Figure 11). Little skate were observed in 18 of the 20 tows. Catch rates averaged 1.6 ± 0.4 kg/tow (range: 0 – 5.9 kg/tow). Little skate were observed throughout the VW1 Study Area (Figure 12).

Atlantic cod (*Gadus morhua*) was the third most abundant species observed, accounting for 2.0% of the total catch weight. Individuals ranged in length from 19 to 63 cm with a broad size distribution (Figure 13). Atlantic cod were observed in 13 of the 20 tows with an average catch rate of 1.3 ± 0.4 kg/tow (range: 0 – 6.8 kg/tow). Atlantic cod were primarily caught in the northern half of the VW1 Study Area (Figure 14).

Alewife (*Alosa pseudoharengus*) was the fourth most abundant species observed. Individuals ranged in length from 12 to 28 cm with a unimodal size distribution peaking at 20 cm (Figure 15).

Alewife were observed in 19 of the 20 tows. Catch rates averaged 1.3 ± 0.3 kg/tow (range: 0 – 4.4 kg/tow). Alewife were observed throughout the VW1 Study Area (Figure 16).

Longhorn sculpin (*Myoxocephalus octodecimspinosus*) was commonly caught in the VW1 Study Area. Individuals ranged in length from 23 to 37 cm with a unimodal peak at 29 cm (Figure 17). Longhorn sculpin were observed in 19 of the 20 tows at an average catch rate of 1.1 ± 0.1 kg/tow (range: 0 – 2.6 kg/tow). Longhorn sculpin were observed throughout the VW1 Study Area (Figure 18).

Blueback herring (*Alosa aestivalis*) was observed in all 20 tows in the VW1 Study Area. Individuals ranged in length from 8 to 22 cm with a unimodal peak at 14 cm (Figure 19). The average catch rate of blueback herring was 0.6 ± 0.1 kg/tow (range: 0.1 – 2.3 kg/tow). Blueback herring were caught throughout the VW1 Study Area (Figure 20).

Silver hake (*Merluccius bilinearis*), a commercially important species also commonly referred to as whiting, was a frequently observed species in the VW1 Study Area. Individuals ranged in length from 7 to 27 cm. Silver hake had a unimodal size distribution consisting of a peak at 12 cm (Figure 21). Silver hake were observed in 19 of the 20 tows at an average catch rate of 0.4 ± 0.2 kg/tow (range: 0 – 2.6 kg/tow). The catch of silver hake was distributed across the VW1 Study Area with the highest catches in the southwestern corner (Figure 22).

Windowpane flounder (*Scophtalmus aquosus*) is a federally regulated commercial flatfish species found in the VW1 Study Area. Individuals ranged in length from 11 to 27 cm with a wide size distribution (Figure 23). Windowpane flounder were observed in nine of the 20 tows at an average catch rate of 0.1 ± 0.02 kg/tow (range: 0 – 0.3 kg/tow). Windowpane flounder were sporadically caught throughout the VW1 Study Area (Figure 24).

Less common recreational and commercial species observed included two individuals of yellowtail flounder (*Pleuronectes ferrugineus*, sizes: 20, 27 cm), one individual of winter flounder (*Pleuronectes americanus,* size: 23 cm), one individual of summer flounder (*Paralichthys dentatus*, size: 36 cm) and one individual of Atlantic sea scallop (*Placopecten magellanicus*).

### 3.2.2 Control Area

In the Control Area, a total of 17 species were caught over the duration of the survey (Table 4). Catch volume ranged from 6.9 to 226.3 kg/tow with an average of 96.5 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, blueback herring, Atlantic cod, and alewife) accounted for 98.2% 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 most abundant species in the Control Area, accounting for 88.5% of the total catch weight. Individuals ranged in length from 18 to 26 cm in length with a unimodal size distribution consisting of a peak at 20 cm (Figure 9). Atlantic herring were observed in all 20 tows at an average catch rate of 85.4 ± 14.3 kg/tow (range: 1.3 – 214.3 kg/tow). Atlantic herring were caught throughout the Control Area with higher catches observed in the northern half of the Control area (Figure 10).

Little skate was the second most abundant species observed, accounting for 3.0% of the total catch weight. Individuals ranged in size from 9 to 29 cm (disk width) with a unimodal size distribution consisting of a peak at 26 cm (Figure 11). Little skate were observed in all 20 tows. Catch rates averaged 2.9 ± 0.6 kg/tow (range: 0.3 – 11.2 kg/tow). Little skate were observed throughout the Control Area (Figure 12).

Blueback herring was the third most abundant species observed in the Control Area. Individuals herring ranged in length from 10 to 27 cm with a bimodal distribution consisting of peaks at 14 and 20 cm (Figure 19). Blueback herring were observed in all 20 tows in the Control Area. The average catch rate of blueback herring was 2.5 ± 1.5 kg/tow (range: 0.1 – 29.2 kg/tow). Blueback herring were caught throughout the Control Area (Figure 20).

Atlantic cod was the fourth most abundant species observed in the Control Area. Individuals ranged in length from 23 to 61 cm with a broad size distribution (Figure 13). Atlantic cod were observed in 18 of the 20 tows with an average catch rate of 2.2 ± 0.5 kg/tow (range: 0 – 10.9 kg/tow). Atlantic cod were caught throughout the Control Area (Figure 14).

Alewife was the fifth most abundant species observed. Individuals ranged in length from 12 to 28 cm with a unimodal size distribution peaking at 20 cm (Figure 15). Alewife were observed in

18 of the 20 tows. Catch rates averaged 1.8 ± 0.5 kg/tow (range: 0 – 8.2 kg/tow). Alewife were observed throughout the Control Area (Figure 16).

Longhorn sculpin were commonly caught in the Control Area. Individuals ranged in length from 8 to 34 cm with a unimodal peak at 27 cm (Figure 17). Longhorn sculpin were observed in 16 of the 20 tows at an average catch rate of 0.7 ± 0.2 kg/tow (range: 0 – 2.1 kg/tow). Longhorn sculpin were observed throughout the Control Area (Figure 18).

Silver hake were a frequently observed species in the Control Area. Individuals ranged in length from 8 to 41 cm. Silver hake had a unimodal size distribution consisting of a peak at 11 cm (Figure 21). Silver hake were observed in 13 of the 20 tows at an average catch rate of 0.3 ± 0.1 kg/tow (range: 0 – 1.9 kg/tow). The catch of silver hake was distributed across the Control Area (Figure 22).

Windowpane flounder were found in the Control Area. Individuals ranged in length from 12 to 28 cm with a wide size distribution (Figure 23). Windowpane flounder were observed in 10 of the 20 tows at an average catch rate of 0.1 ± 0.02 kg/tow (range: 0 – 0.4 kg/tow). Windowpane flounder were sporadically caught throughout the Control Area (Figure 24).

Less common recreational and commercial species observed included one individual of winter flounder (size: 39 cm).

## 4. Acknowledgments

We would like to thank the owner (Paul Farnham), captain (Mike Gallagher), and crew (Matt Manchester, Scott Riley, and Barry Klapp) of the F/V *Heather Lynn* for their help sorting, processing, and measuring the catch. Additionally, we would like to thank Mike Coute, Keith Hankowsky, and David Gauld in our Fish Behavior and Conservation Engineering lab 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*.

Rillahan, C., He, P. (2020). Vineyard Wind Demersal Trawl Survey Annual Report – 501 North Stu dy Area. 2019/2020 Annual report. University of Massachusetts Dartmouth - SMAST, New Bedf ord, MA.  SMAST-CE-REP-2020-088.  216 pp.

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. (°C) | Trawl Warp (fm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | VW1 | 2/1/2022 | Mostly Cloudy | 16-20 | NE | 1.25-2.5 | 7:15 | N 41° 01.691 | W 70° 36.987 | 26 | 7:35 | N 41° 01.685 | W 70° 35.652 | 25 | 5.0 | 100 |
| 2 | VW1 | 2/1/2022 | Mostly Cloudy | 16-20 | NE | 1.25-2.5 | 8:23 | N 41° 01.598 | W 70° 35.436 | 26 | 8:43 | N 41° 01.066 | W 70° 34.288 | 25 | 4.9 | 100 |
| 3 | VW1 | 2/1/2022 | Mostly Cloudy | 16-20 | NE | 1.25-2.5 | 9:27 | N 40° 59.404 | W 70° 31.259 | 27 | 9:47 | N 40° 58.819 | W 70° 30.241 | 25 | 3.4 | 100 |
| 4 | VW1 | 2/1/2022 | Mostly Cloudy | 16-20 | NE | 1.25-2.5 | 10:21 | N 40° 57.826 | W 70° 28.931 | 25 | 10:41 | N 40° 57.262 | W 70° 26.896 | 24 | 3.5 | 100 |
| 5 | VW1 | 2/1/2022 | Mostly Cloudy | 16-20 | NE | 1.25-2.5 | 11:03 | N 40° 57.477 | W 70° 27.204 | 24 | 11:23 | N 40° 58.398 | W 70° 27.630 | 25 | 3.4 | 100 |
| 6 | Control | 2/1/2022 | Mostly Cloudy | 16-20 | NE | 1.25-2.5 | 12:01 | N 40° 56.322 | W 70° 26.404 | 25 | 12:21 | N 40° 55.679 | W 70° 27.487 | 26 | 3.5 | 100 |
| 7 | Control | 2/1/2022 | Mostly Cloudy | 16-20 | NE | 1.25-2.5 | 12:51 | N 40° 55.171 | W 70° 27.228 | 26 | 13:11 | N 40° 54.982 | W 70° 26.044 | 26 | 3.5 | 100 |
| 8 | Control | 2/1/2022 | Mostly Cloudy | 16-20 | NE | 1.25-2.5 | 13:44 | N 40° 55.376 | W 70° 25.281 | 25 | 14:04 | N 40° 56.337 | W 70° 25.416 | 25 | 3.6 | 100 |
| 9 | Control | 2/1/2022 | Partly Cloudy | 16-20 | NE | 1.25-2.5 | 14:36 | N 40° 55.765 | W 70° 24.667 | 25 | 14:56 | N 40° 55.156 | W 70° 23.776 | 25 | 3.8 | 100 |
| 10 | Control | 2/1/2022 | Partly Cloudy | 16-20 | NE | 1.25-2.5 | 15:26 | N 40° 53.365 | W 70° 25.077 | 26 | 15:46 | N 40° 52.362 | W 70° 25.715 | 27 | 3.9 | 100 |
| 11 | Control | 2/1/2022 | Mostly Cloudy | 16-20 | NE | 1.25-2.5 | 16:26 | N 40° 52.639 | W 70° 23.789 | 27 | 16:46 | N 40° 52.835 | W 70° 22.661 | 26 | 7.1 | 100 |
| 12 | Control | 2/2/2022 | Mostly Cloudy | 7-10 | E | 1.25-2.5 | 7:07 | N 40° 53.253 | W 70° 21.321 | 25 | 7:27 | N 40° 53.932 | W 70° 22.265 | 26 | 5.0 | 100 |
| 13 | Control | 2/2/2022 | Mostly Cloudy | 7-10 | E | 1.25-2.5 | 8:18 | N 40° 55.181 | W 70° 22.151 | 24 | 8:38 | N 40° 55.158 | W 70° 20.908 | 24 | 4.9 | 100 |
| 14 | Control | 2/2/2022 | Mostly Cloudy | 7-10 | E | 1.25-2.5 | 9:08 | N 40° 55.120 | W 70° 20.212 | 24 | 9:28 | N 40° 54.416 | W 70° 19.380 | 24 | 4.9 | 100 |
| 15 | Control | 2/2/2022 | Mostly Cloudy | 7-10 | E | 1.25-2.5 | 9:57 | N 40° 54.300 | W 70° 17.925 | 24 | 10:17 | N 40° 55.252 | W 70° 17.924 | 22 | 4.7 | 100 |
| 16 | Control | 2/2/2022 | Rain | 7-10 | E | 1.25-2.5 | 10:46 | N 40° 56.111 | W 70° 15.467 | 21 | 11:06 | N 40° 57.017 | W 70° 15.603 | 20 | 4.7 | 100 |
| 17 | Control | 2/2/2022 | Rain | 7-10 | E | 1.25-2.5 | 11:31 | N 40° 57.226 | W 70° 17.810 | 21 | 11:51 | N 40° 58.118 | W 70° 18.248 | 22 | 5.2 | 100 |
| 18 | Control | 2/2/2022 | Overcast | 7-10 | E | 1.25-2.5 | 12:31 | N 40° 59.552 | W 70° 16.036 | 19 | 12:51 | N 41° 00.244 | W 70° 16.834 | 19 | | 95 |
| 19 | Control | 2/2/2022 | Overcast | 7-10 | E | 1.25-2.5 | 13:26 | N 41° 00.495 | W 70° 15.818 | 18 | 13:46 | N 41° 00.531 | W 70° 17.122 | 20 | 4.0 | 95 |
| 20 | Control | 2/2/2022 | Mostly Cloudy | 7-10 | E | 1.25-2.5 | 14:13 | N 41° 00.619 | W 70° 18.478 | 21 | 14:33 | N 41° 00.766 | W 70° 19.853 | 22 | 4.0 | 100 |
| 21 | Control | 2/2/2022 | Mostly Cloudy | 7-10 | E | 1.25-2.5 | 15:05 | N 41° 01.205 | W 70° 22.693 | 22 | 15:25 | N 41° 01.075 | W 70° 21.518 | 22 | 3.8 | 100 |
| 22 | Control | 2/2/2022 | Overcast | 7-10 | E | 1.25-2.5 | 15:53 | N 41° 01.659 | W 70° 21.538 | 22 | 16:13 | N 41° 02.519 | W 70° 21.032 | 22 | 3.8 | 100 |
| 23 | VW1 | 2/6/2022 | Clear | 11-15 | N | 1.25-2.5 | 7:28 | N 41° 04.066 | W 70° 32.826 | 24 | 7:48 | N 41° 03.165 | W 70° 33.222 | 25 | | 100 |
| 24 | VW1 | 2/6/2022 | Clear | 11-15 | N | 1.25-2.5 | 8:23 | N 41° 04.109 | W 70° 12.855 | 24 | 8:43 | N 41° 04.746 | W 70° 31.966 | 24 | 2.9 | 100 |
| 25 | VW1 | 2/6/2022 | Clear | 11-15 | N | 1.25-2.5 | 9:17 | N 41° 05.419 | W 70° 31.306 | 23 | 9:37 | N 41° 06.294 | W 70° 30.815 | 23 | 2.7 | 100 |
| 26 | VW1 | 2/6/2022 | Partly Cloudy | 7-10 | N | 0.5-1.25 | 10:15 | N 41° 07.725 | W 70° 27.494 | 21 | 10:35 | N 41° 08.174 | W 70° 26.394 | 21 | 2.9 | 95 |
| 27 | VW1 | 2/6/2022 | Clear | 7-10 | N | 0.5-1.25 | 11:01 | N 41° 07.563 | W 70° 26.053 | 21 | 11:21 | N 41° 06.601 | W 70° 26.086 | 23 | 3.2 | 95 |
| 28 | VW1 | 2/6/2022 | Clear | 3-6 | N | 0.5-1.25 | 11:50 | N 41° 05.421 | W 70° 27.421 | 22 | 12:10 | N 41° 04.751 | W 70° 28.267 | 22 | 3.2 | 100 |
| 29 | VW1 | 2/6/2022 | Partly Cloudy | 3-6 | N | 0.5-1.25 | 12:37 | N 41° 04.694 | W 70° 25.607 | 23 | 12:57 | N 41° 04.709 | W 70° 24.331 | 22 | 3.7 | 100 |
| 30 | VW1 | 2/6/2022 | Partly Cloudy | 3-6 | N | 0.5-1.25 | 13:36 | N 41° 03.362 | W 70° 25.751 | 24 | 13:56 | N 41° 02.576 | W 70° 26.439 | 22 | 3.9 | 100 |
| 31 | VW1 | 2/6/2022 | Partly Cloudy | 3-6 | N | 0.5-1.25 | 14:24 | N 41° 01.836 | W 70° 26.776 | 22 | 14:44 | N 41° 00.950 | W 70° 27.293 | 23 | 3.7 | 100 |
| 32 | VW1 | 2/6/2022 | Partly Cloudy | 7-10 | N | 0.5-1.25 | 15:18 | N 41° 01.483 | W 70° 25.381 | 23 | 15:38 | N 41° 01.811 | W 70° 24.158 | 23 | 3.8 | 100 |
| 33 | VW1 | 2/6/2022 | Partly Cloudy | 7-10 | E | 0.5-1.25 | 16:09 | N 41° 02.090 | W 70° 22.683 | 22 | 16:29 | N 41° 02.339 | W 70° 21.438 | 22 | 4.0 | 100 |
| 34 | Control | 2/8/2022 | Rain | 7-10 | NE | 0.5-1.25 | 7:04 | N 40° 59.465 | W 70° 20.552 | 23 | 7:24 | N 40° 58.972 | W 70° 21.649 | 23 | 4.8 | 100 |
| 35 | Control | 2/8/2022 | Overcast | 7-10 | NE | 0.5-1.25 | 7:53 | N 41° 05.419 | W 70° 23.190 | 24 | 8:13 | N 40° 58.464 | W 70° 22.500 | 23 | 4.8 | 100 |
| 36 | Control | 2/8/2022 | Obscured | 11-15 | NE | 0.5-1.25 | 8:51 | N 40° 58.709 | W 70° 24.629 | 24 | 9:11 | N 40° 58.688 | W 70° 25.939 | 24 | 4.7 | 100 |
| 37 | VW1 | 2/8/2022 | Overcast | 11-15 | NE | 0.5-1.25 | 9:38 | N 41° 00.087 | W 70° 26.464 | 24 | 9:58 | N 41° 00.915 | W 70° 26.920 | 24 | 4.4 | 100 |
| 38 | VW1 | 2/8/2022 | Overcast | 11-15 | NE | 1.25-2.5 | 10:21 | N 41° 00.745 | W 70° 26.227 | 24 | 10:41 | N 41° 00.452 | W 70° 28.449 | 24 | 4.3 | 100 |
| 39 | VW1 | 2/8/2022 | Mostly Cloudy | 11-15 | E | 1.25-2.5 | 11:10 | N 41° 01.746 | W 70° 29.848 | 25 | 11:30 | N 41° 02.534 | W 70° 30.574 | 25 | 3.9 | 100 |
| 40 | VW1 | 2/8/2022 | Mostly Cloudy | 11-15 | E | 1.25-2.5 | 11:54 | N 41° 03.301 | W 70° 30.998 | 25 | 12:14 | N 41° 04.108 | W 70° 29.306 | 24 | 4.0 | 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) | Bottom Temp. (⁰C) | Trawl Warp (fm) | Headline Height (m) | Wing Spread (m) | Spread Door (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | VW1 | 20.2 | 1.0 | 3.1 | 26 | 5.0 | 100 | 4.7 | 14.4 | 36.7 |
| 2 | VW1 | 20.2 | 1.0 | 3.1 | 26 | 4.9 | 100 | 4.9 | 14.4 | 36.3 |
| 3 | VW1 | 20.1 | 1.0 | 2.9 | 27 | 3.4 | 100 | 4.9 | 14.5 | 36.4 |
| 4 | VW1 | 20.0 | 1.0 | 3.0 | 25 | 3.5 | 100 | 5.1 | 14.3 | 36.1 |
| 5 | VW1 | 20.0 | 1.0 | 3.0 | 24 | 3.4 | 100 | 4.5 | 14.1 | 37.6 |
| 6 | Control | 20.1 | 1.1 | 3.2 | 25 | 3.5 | 100 | 4.8 | 13.7 | 36.4 |
| 7 | Control | 20.0 | 1.0 | 2.9 | 26 | 3.5 | 100 | 6.1 | | |
| 8 | Control | 20.1 | 1.0 | 3.0 | 25 | 3.6 | 100 | 4.7 | 14.5 | 37.6 |
| 9 | Control | 20.0 | 1.0 | 2.9 | 25 | 3.8 | 100 | 4.9 | 14.6 | 37.8 |
| 10 | Control | 20.7 | 1.1 | 3.3 | 26 | 3.9 | 100 | 4.7 | 14.7 | 36.8 |
| 11 | Control | 20.2 | 0.9 | 2.7 | 27 | | 100 | 5.4 | 13.8 | 36.9 |
| 12 | Control | 20.1 | 1.0 | 3.0 | 25 | 5.0 | 100 | 4.8 | 14.5 | 36.3 |
| 13 | Control | 19.8 | 1.0 | 3.0 | 24 | 4.9 | 100 | 5.3 | 13.8 | 35.3 |
| 14 | Control | 20.0 | 1.0 | 2.9 | 24 | 4.9 | 100 | 5.1 | 13.8 | 34.3 |
| 15 | Control | 20.0 | 1.0 | 3.0 | 24 | 4.7 | 100 | 4.8 | 14.2 | 35.5 |
| 16 | Control | 20.0 | 0.9 | 2.8 | 21 | 4.7 | 100 | 4.8 | 13.9 | 34.9 |
| 17 | Control | 20.1 | 1.0 | 2.9 | 21 | 5.2 | 100 | 4.5 | 14.6 | 37.1 |
| 18 | Control | 20.0 | 0.9 | 2.8 | 19 | | 95 | 4.6 | 13.8 | 34.5 |
| 19 | Control | 20.0 | 1.0 | 3.1 | 18 | 4.0 | 95 | 5.1 | 13.4 | 34.7 |
| 20 | Control | 20.1 | 1.1 | 3.2 | 21 | 4.0 | 100 | 5.0 | 13.9 | 35.0 |
| 21 | Control | 20.1 | 1.0 | 2.9 | 22 | 3.8 | 100 | 4.5 | 14.9 | |
| 22 | Control | 20.1 | 1.0 | 2.8 | 22 | 3.8 | 100 | 4.5 | 14.6 | 37.2 |
| 23 | VW1 | 20.0 | 1.0 | 2.9 | 24 | | 100 | 5.8 | 14.1 | 36.0 |
| 24 | VW1 | 19.9 | 1.0 | 2.9 | 24 | 2.9 | 100 | 4.6 | 14.6 | 37.2 |
| 25 | VW1 | 20.0 | 1.0 | 2.9 | 23 | 2.7 | 100 | 4.8 | 14.2 | 35.6 |
| 26 | VW1 | 20.0 | 1.0 | 2.9 | 21 | 2.9 | 95 | 5.0 | 14.0 | 35.2 |
| 27 | VW1 | 20.0 | 0.9 | 2.8 | 21 | 3.2 | 95 | 4.8 | 14.0 | 34.9 |
| 28 | VW1 | 20.0 | 0.9 | 2.8 | 22 | 3.2 | 100 | 4.8 | 14.3 | 34.8 |
| 29 | VW1 | 20.0 | 1.0 | 3.0 | 23 | 3.7 | 100 | 5.2 | 13.7 | 34.0 |
| 30 | VW1 | 20.0 | 0.9 | 2.8 | 24 | 3.9 | 100 | 4.8 | 14.1 | 35.9 |
| 31 | VW1 | 20.2 | 1.0 | 2.9 | 22 | 3.7 | 100 | 4.9 | 13.9 | 35.1 |
| 32 | VW1 | 20.1 | 1.0 | 2.9 | 23 | 3.8 | 100 | 4.7 | 14.3 | |
| 33 | VW1 | 20.1 | 1.0 | 2.9 | 22 | 4.0 | 100 | 4.5 | 14.4 | 36.5 |
| 34 | Control | 20.0 | 1.0 | 2.9 | 23 | 4.8 | 100 | 5.2 | 13.7 | 33.8 |
| 35 | Control | 20.0 | 0.9 | 2.8 | 24 | 4.8 | 100 | 4.6 | 14.4 | |
| 36 | Control | 20.0 | 1.0 | 3.0 | 24 | 4.7 | 100 | 5.0 | 14.0 | 34.7 |
| 37 | VW1 | 20.0 | 1.0 | 2.9 | 24 | 4.4 | 100 | 5.1 | 13.8 | |
| 38 | VW1 | 20.0 | 1.0 | 2.9 | 24 | 4.3 | 100 | 4.9 | 14.2 | 35.3 |
| 39 | VW1 | 20.0 | 1.0 | 2.9 | 25 | 3.9 | 100 | 5.0 | 14.0 | 35.4 |
| 40 | VW1 | 20.1 | 1.0 | 2.9 | 25 | 4 | 100 | 5.1 | 13.8 | 34.7 |
| Summary Statistics | | | | | | | | | | |
| Control | Minimum | 19.8 | 0.9 | 2.7 | 18.0 | 3.5 | 95.0 | 4.5 | 13.4 | 33.8 |
| | Maximum | 20.7 | 1.1 | 3.3 | 27.0 | 5.2 | 100.0 | 6.1 | 14.9 | 37.8 |
| | Average | 20.1 | 1.0 | 3.0 | 23.3 | 4.3 | 99.5 | 4.9 | 14.2 | 35.8 |
| | St. Dev | 0.2 | 0.05 | 0.1 | 2.4 | 0.6 | 1.5 | 0.4 | 0.4 | 1.3 |
| VW1 | Minimum | 19.9 | 0.9 | 2.8 | 21.0 | 2.7 | 95.0 | 4.5 | 13.7 | 34.0 |
| | Maximum | 20.2 | 1.0 | 3.1 | 27.0 | 5.0 | 100.0 | 5.8 | 14.6 | 37.6 |
| | Average | 20.0 | 1.0 | 2.9 | 23.8 | 3.7 | 99.5 | 4.9 | 14.1 | 35.8 |
| | St. Dev. | 0.1 | 0.02 | 0.1 | 1.7 | 0.6 | 1.5 | 0.3 | 0.3 | 0.9 |

**Table 3: Total and average catch weights from 20 tows within the VW1 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* | 1155.3 | 57.6 | 12.8 | 89.6 | 20 |
| **Skate, Little** | *Leucoraja erinacea* | 32.4 | 1.6 | 0.4 | 2.5 | 18 |
| **Atlantic Cod** | *Gadus morhua* | 26.3 | 1.3 | 0.4 | 2.0 | 13 |
| **Alewife** | *Alosa pseudoharengus* | 25.6 | 1.3 | 0.3 | 2.0 | 19 |
| **Sculpin, Longhorn** | *Myoxocephalus octodecimspinosus* | 22.1 | 1.1 | 0.1 | 1.7 | 19 |
| **Herring, Blueback** | *Alosa aestivalis* | 11.1 | 0.6 | 0.1 | 0.9 | 20 |
| **Hake, Silver (Whiting)** | *Merluccius bilinearis* | 8.2 | 0.4 | 0.2 | 0.6 | 19 |
| **Sea Raven** | *Hemitripterus americanus* | 2.6 | 0.1 | 0.1 | 0.2 | 3 |
| **Shad, American** | *Alosa sapidissima* | 1.8 | 0.1 | 0.02 | 0.1 | 11 |
| **Flounder, Windowpane** | *Scophtalmus aquosus* | 1.4 | 0.1 | 0.02 | 0.1 | 9 |
| **Hake, Red** | *Urophycis chuss* | 1.0 | 0.05 | 0.03 | 0.1 | 5 |
| **Mackerel, Atlantic** | *Scomber scombrus* | 0.5 | 0.02 | 0.02 | 0.04 | 2 |
| **Flounder, Summer (Fluke)** | *Paralichthys dentatus* | 0.4 | 0.02 | 0.02 | 0.03 | 1 |
| **Flounder, Gulfstream** | *Citharichthys arctifrons* | 0.3 | 0.01 | 0.01 | 0.02 | 2 |
| **Scup** | *Stenotomus chrysops* | 0.2 | 0.01 | 0.01 | 0.02 | 2 |
| **Flounder, Yellowtail** | *Pleuronectes ferrugineus* | 0.2 | 0.01 | 0.01 | 0.02 | 1 |
| **Flounder, Winter** | *Pleuronectes americanus* | 0.2 | 0.01 | 0.01 | 0.02 | 2 |
| **Squid, Atlantic Longfin** | *Dorytheuthis pealei* | 0.2 | 0.01 | 0.01 | 0.02 | 1 |
| **Sea Scallop** | *Placopecten magellanicus* | 0.1 | 0.01 | 0.01 | 0.01 | 1 |
| **Total** | | 1289.91 | | | | |

*SEM - Standard Error of the Mean

**Table 4: Total and average catch weights from 20 tows 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* | 1713.0 | 85.4 | 14.3 | 88.5 | 20 |
| **Skate, Little** | *Leucoraja erinacea* | 57.3 | 2.9 | 0.6 | 3.0 | 20 |
| **Herring, Blueback** | *Alosa aestivalis* | 51.0 | 2.5 | 1.5 | 2.6 | 20 |
| **Atlantic Cod** | *Gadus morhua* | 43.8 | 2.2 | 0.5 | 2.3 | 18 |
| **Alewife** | *Alosa pseudoharengus* | 36.4 | 1.8 | 0.5 | 1.9 | 18 |
| **Sculpin, Longhorn** | *Myoxocephalus octodecimspinosus* | 13.3 | 0.7 | 0.2 | 0.7 | 16 |
| **Hake, Silver (Whiting)** | *Merluccius bilinearis* | 5.4 | 0.3 | 0.1 | 0.3 | 13 |
| **Mackerel, Atlantic** | *Scomber scombrus* | 5.1 | 0.3 | 0.2 | 0.3 | 7 |
| **Shad, American** | *Alosa sapidissima* | 3.8 | 0.2 | 0.0 | 0.2 | 17 |
| **Sea Raven** | *Hemitripterus americanus* | 2.6 | 0.1 | 0.1 | 0.1 | 4 |
| **Flounder, Windowpane** | *Scophtalmus aquosus* | 1.7 | 0.1 | 0.0 | 0.1 | 10 |
| **Dogfish, Smooth** | *Mustelus canis* | 1.5 | 0.1 | 0.1 | 0.1 | 1 |
| **Flounder, Winter** | *Pleuronectes americanus* | 0.8 | 0.04 | 0.04 | 0.04 | 1 |
| **Hake, Spotted** | *Urophycis regia* | 0.2 | 0.01 | 0.01 | 0.01 | 1 |
| **Squid, Atlantic Longfin** | *Dorytheuthis pealei* | 0.1 | 0.01 | 0.01 | 0.01 | 1 |
| **Flounder, Gulfstream** | *Citharichthys arctifrons* | 0.1 | 0.00 | 0.01 | 0.01 | 1 |
| **Hake, Red** | *Urophycis chuss* | 0.1 | 0.01 | 0.01 | 0.01 | 1 |
| **Total** | | 1936.2 | | | | |

*SEM - Standard Error of the Mean

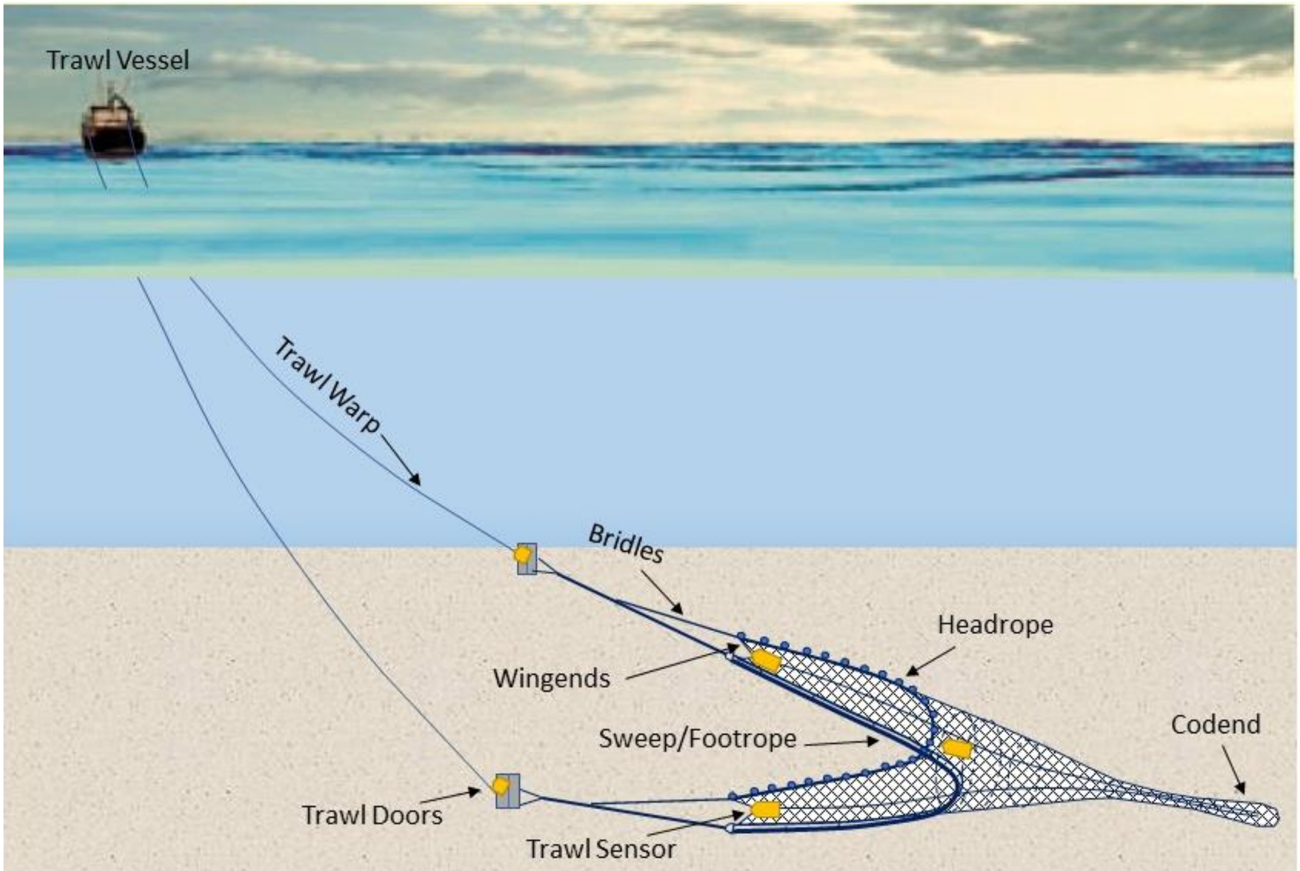



**Figure 1: General schematic (not to scale) of a demersal otter trawl. Yellow rectangles indicate Simrad PX trawl geometry sensors.**

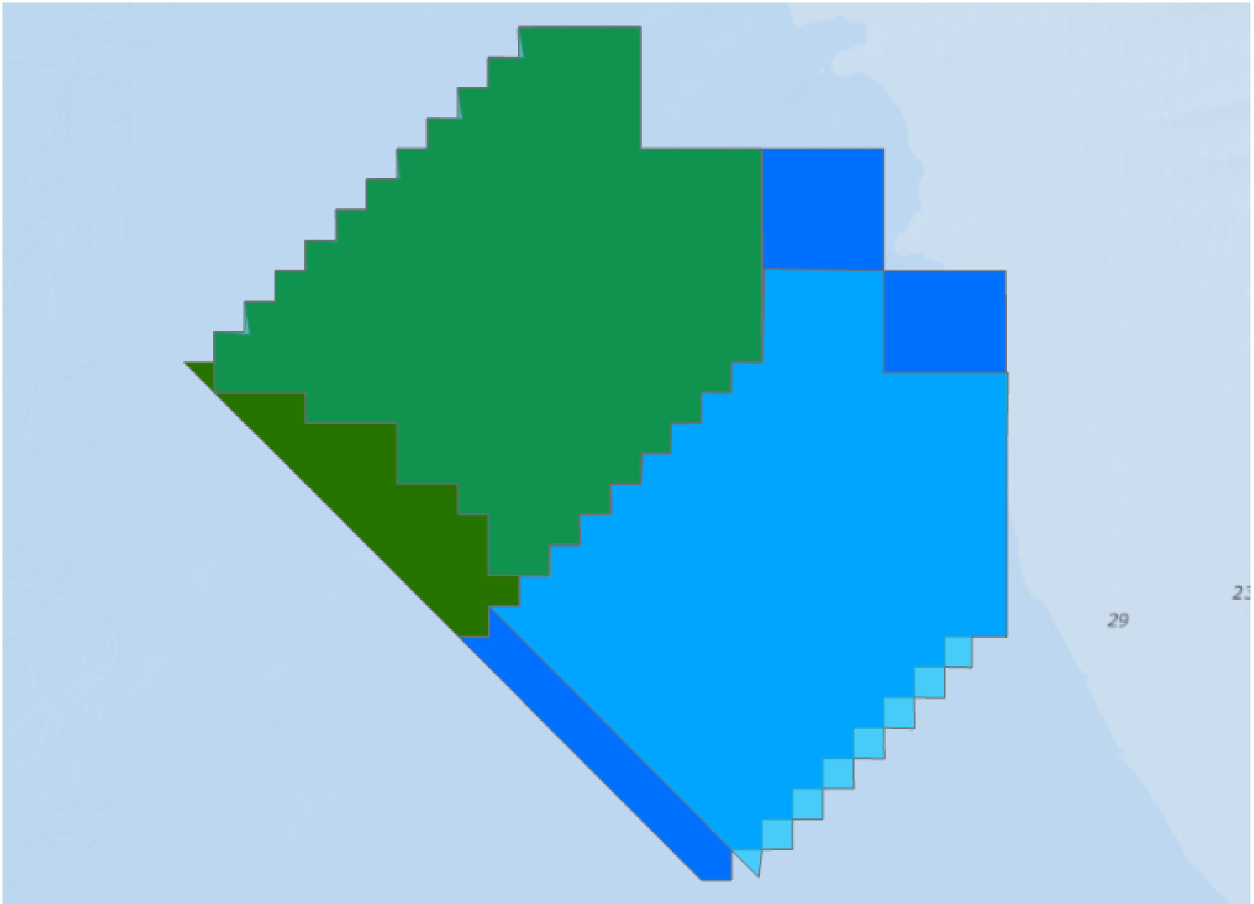



**Figure 2: Boundary refinements of the VW1 Study Area and Control Area. The VW1 Study Area was reduced from 306 km$^2$ (dark green) in 2020/2021 to 265 km$^2$ (light green) in 2021/2022. The Control Area was similarly reduced from 324 km$^2$ (dark blue) to 269.5 km$^2$ (light blue).**

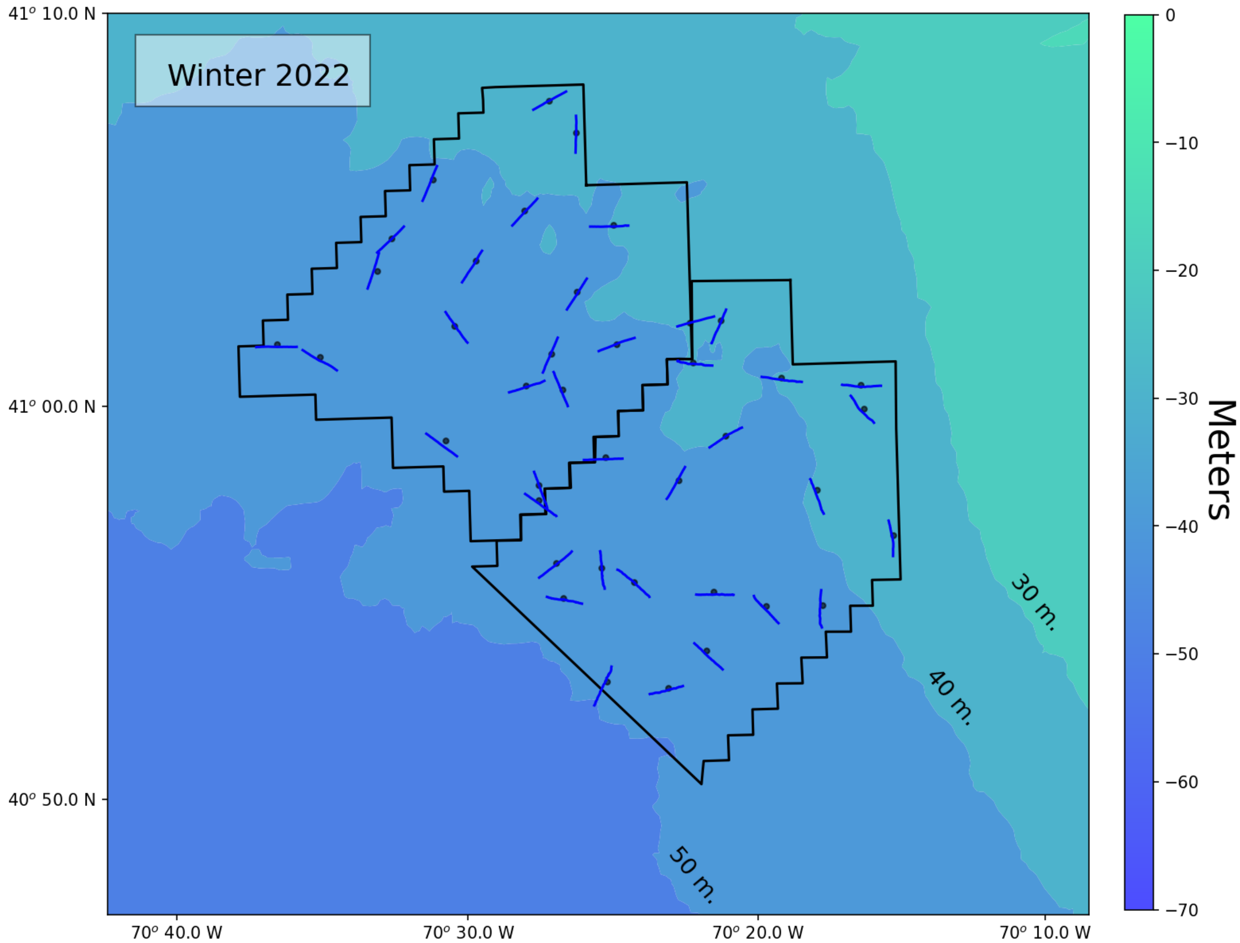



**Figure 3: Tow locations (black dots) and trawl tracks (blue lines) from the VW1 Study Area (left) and the Control Area (right).**

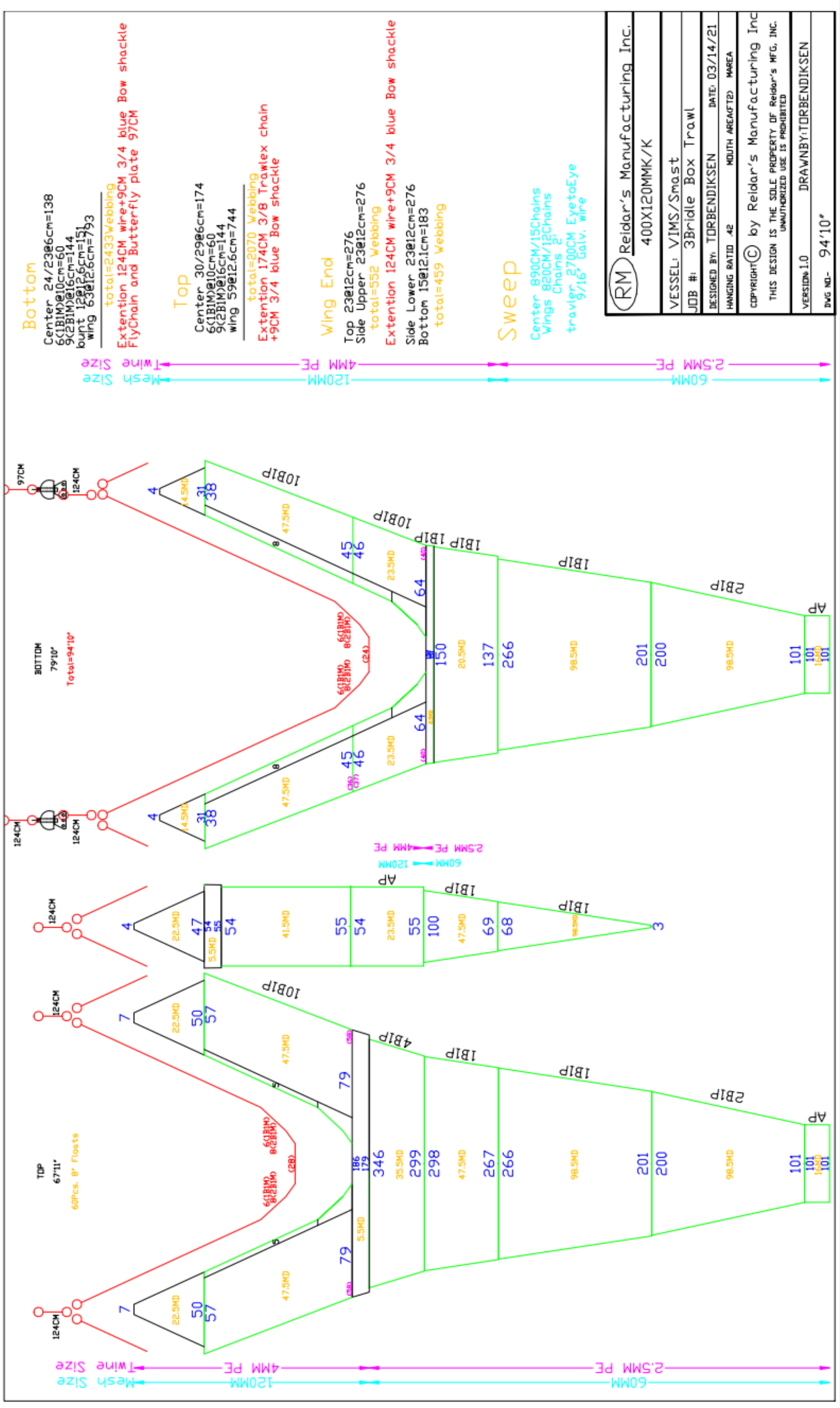



**Figure 4: Schematic net plan for the NEAMAP trawl (Courtesy of Reidar's Manufacturing Inc.).**

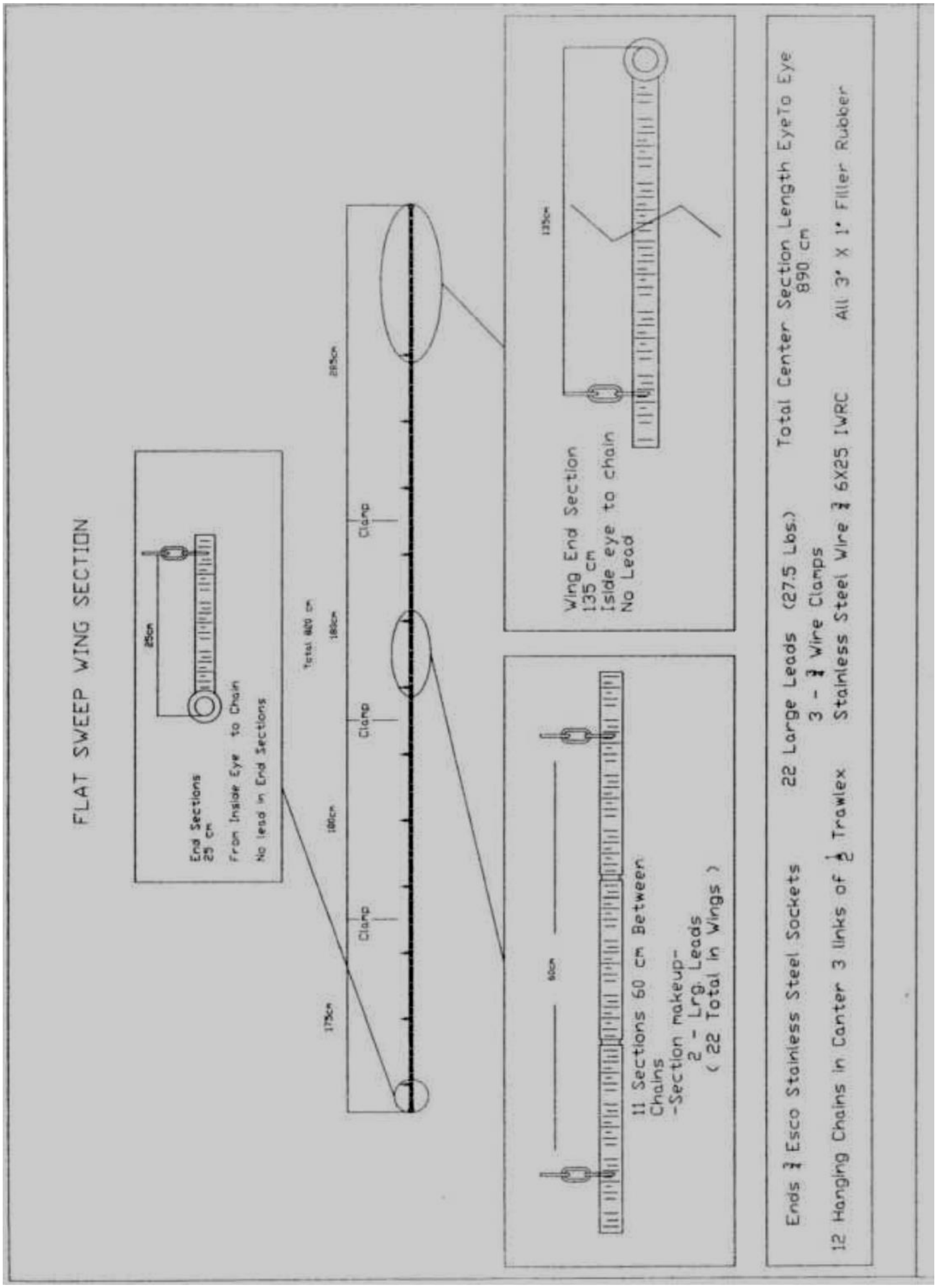



**Figure 5: Sweep diagram for the survey trawl (Bonzek et al., 2008).**

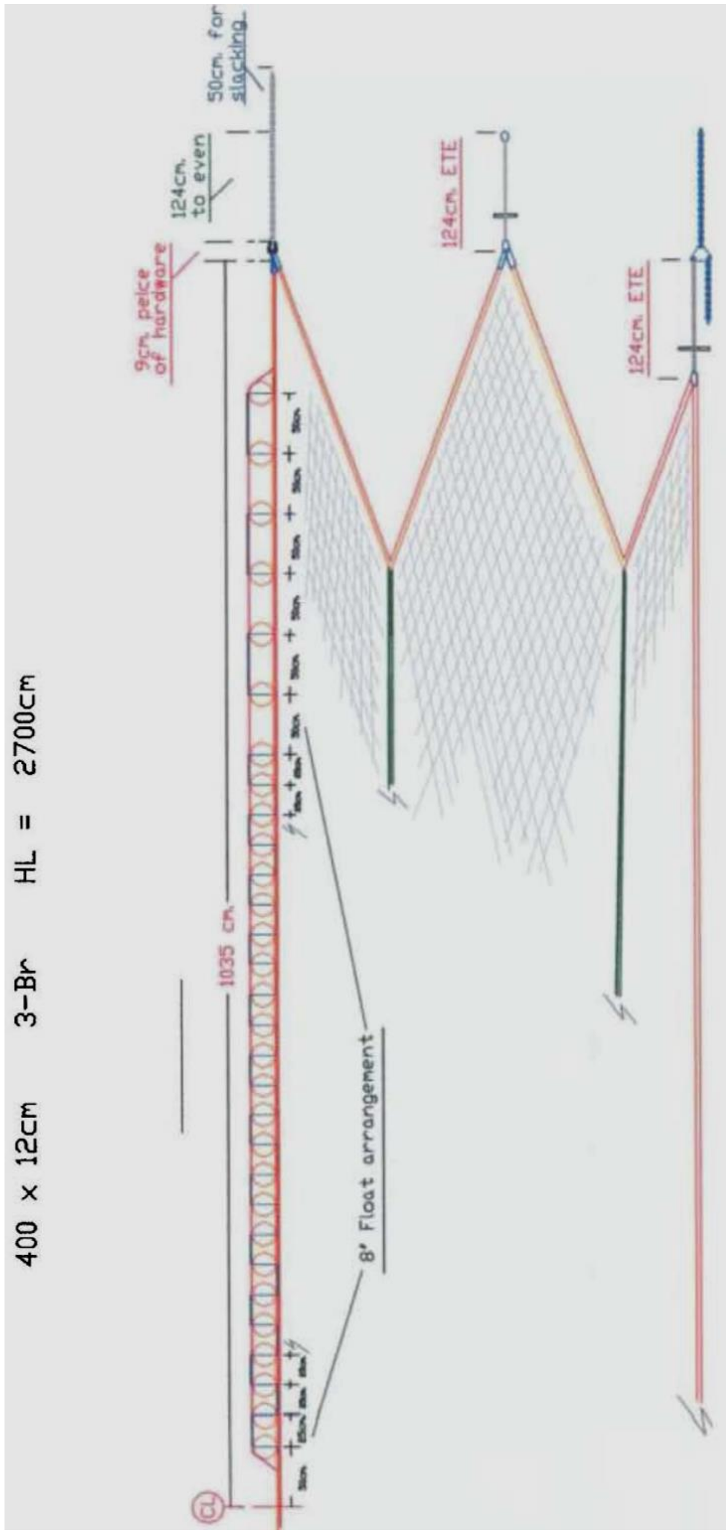



**Figure 6: Headrope and rigging plan for the survey trawl (Bonzek et al., 2008).**

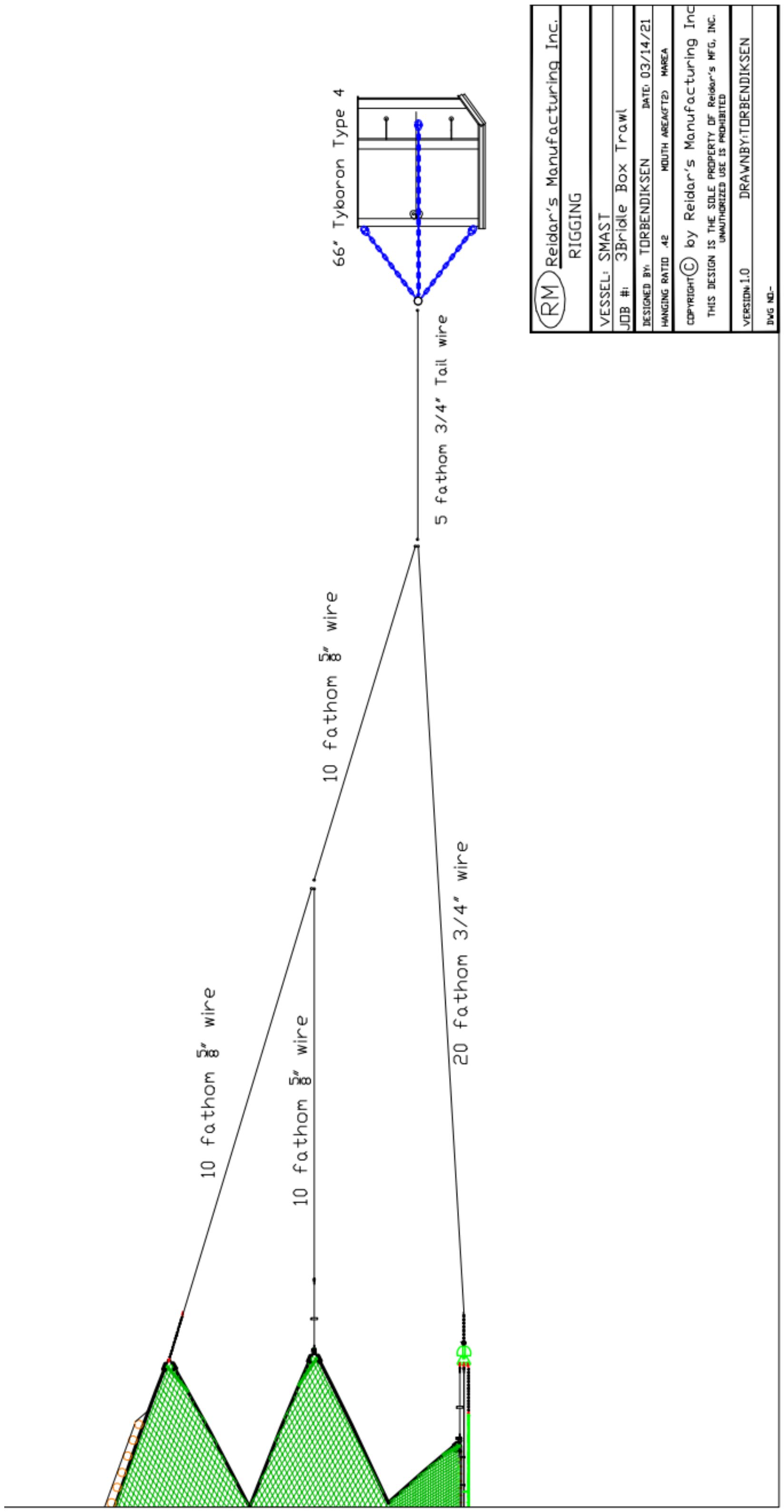



**Figure 7: Bridle and door rigging schematic for the survey trawl (Courtesy of Reidar's Manufacturing Inc.).**

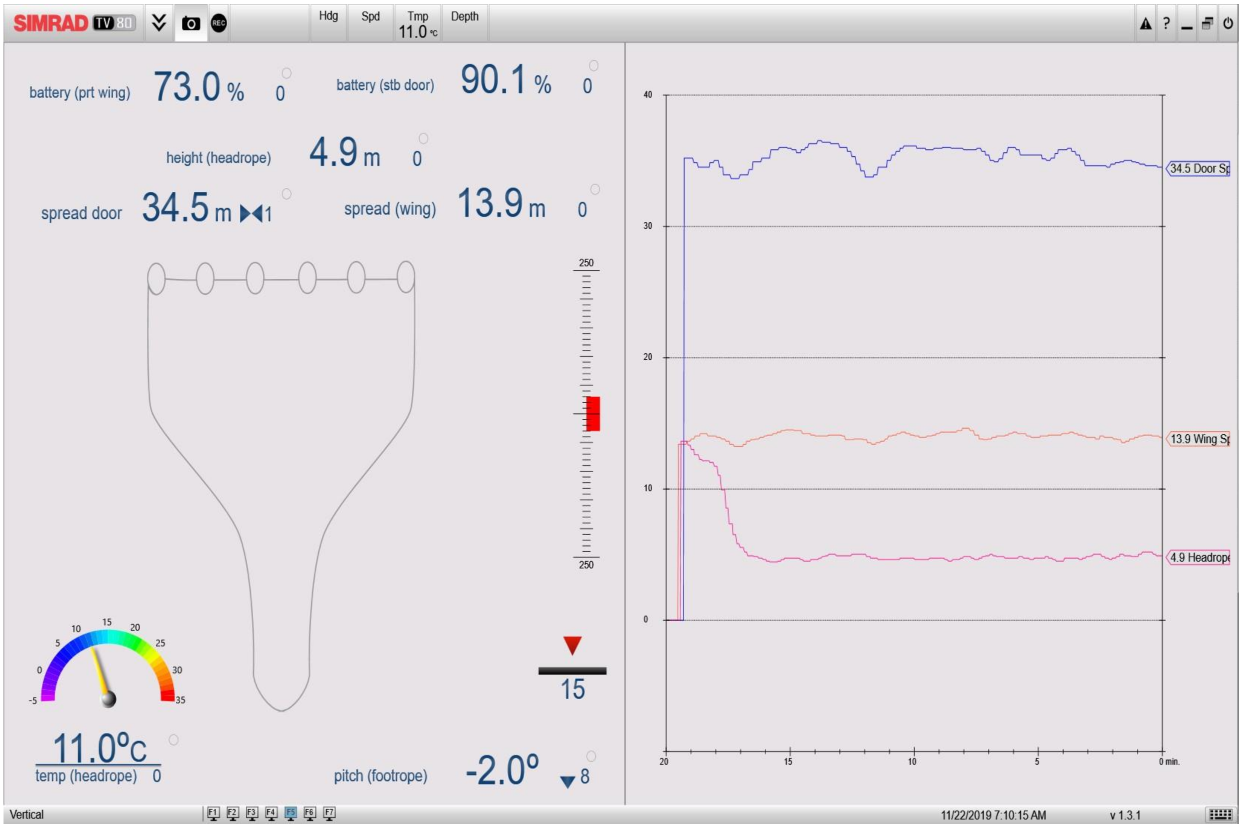
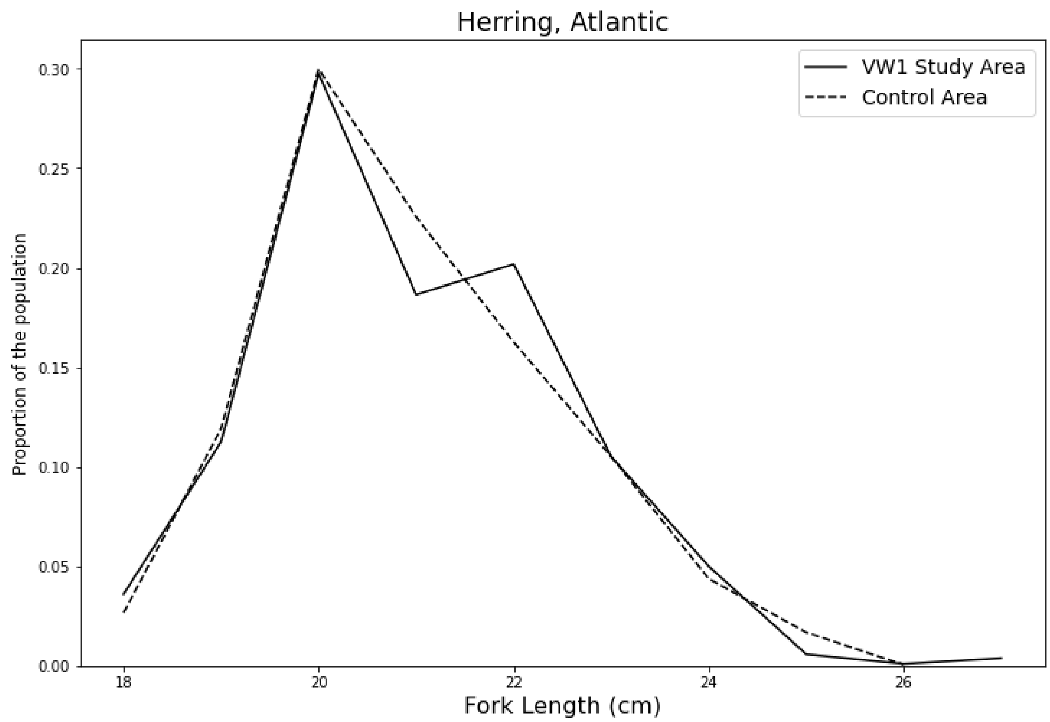



**Figure 8: Screenshot of the SIMRAD TV80 software monitoring the trawl parameters.**



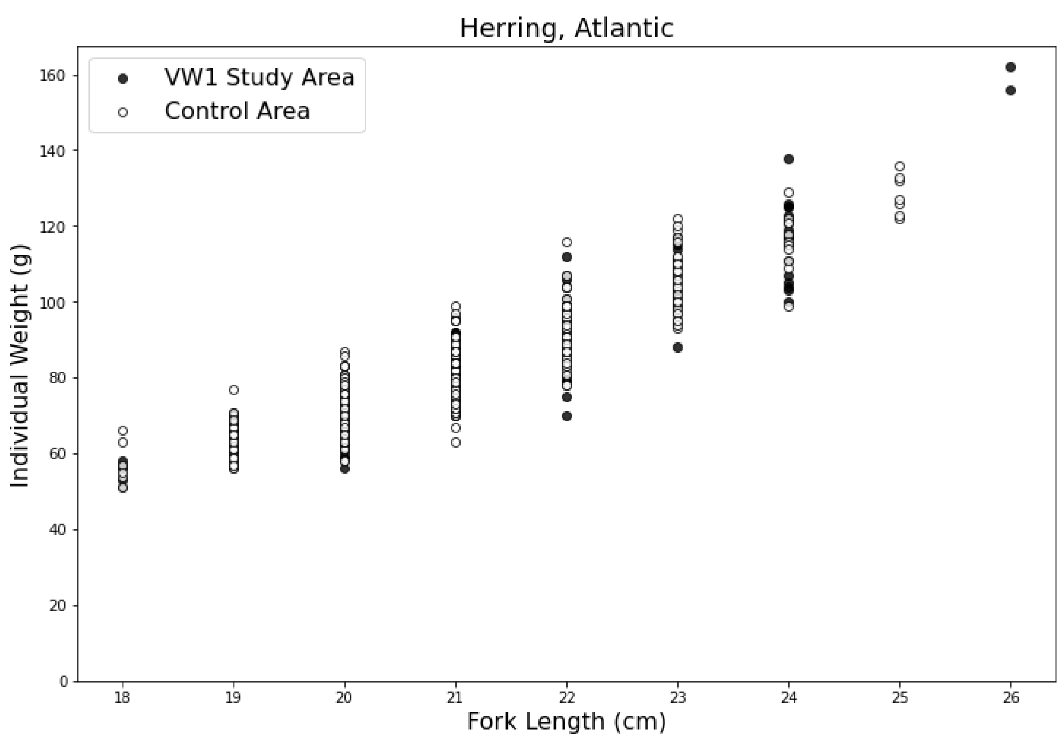




**Figure 9: Population structure of Atlantic herring in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).**

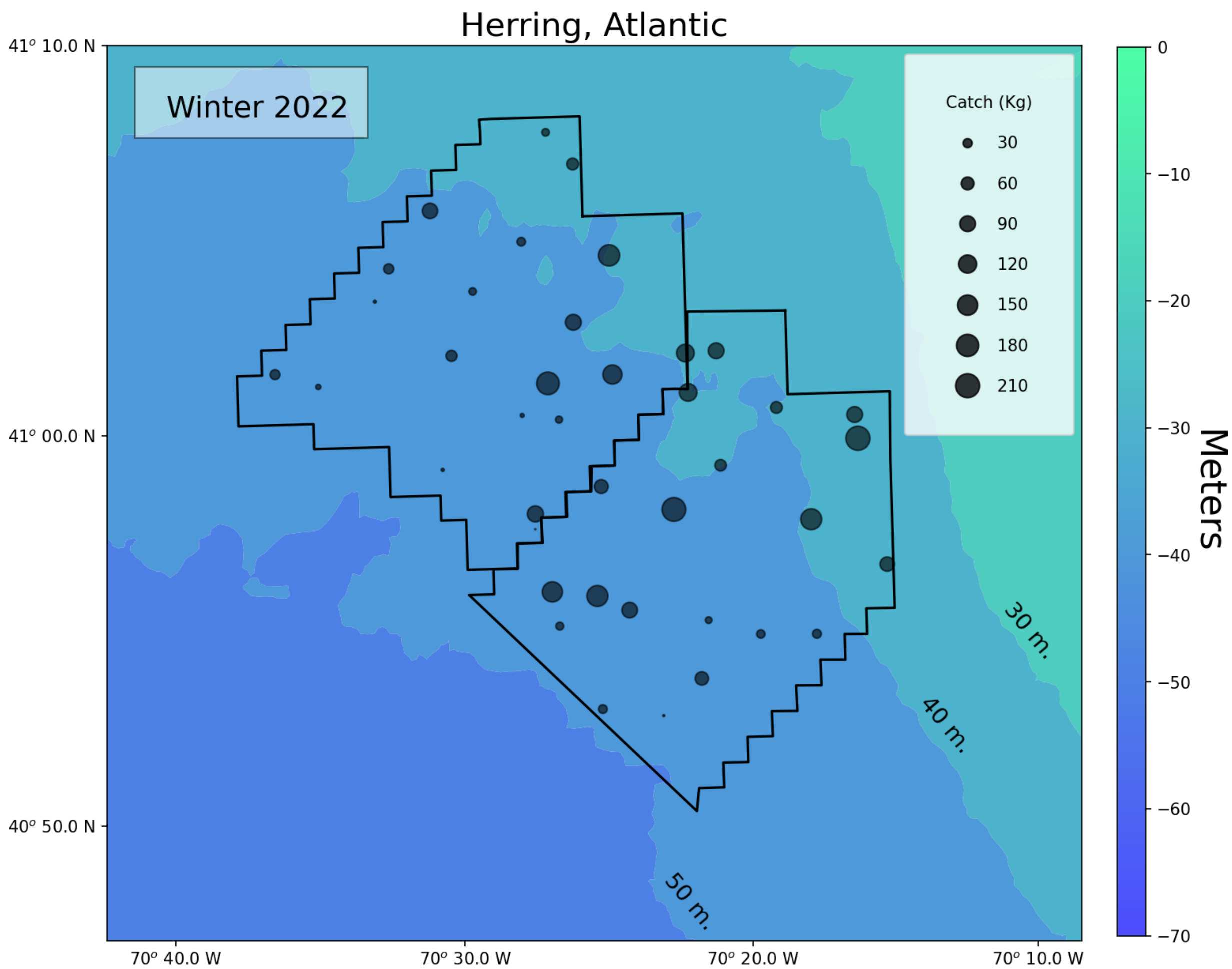
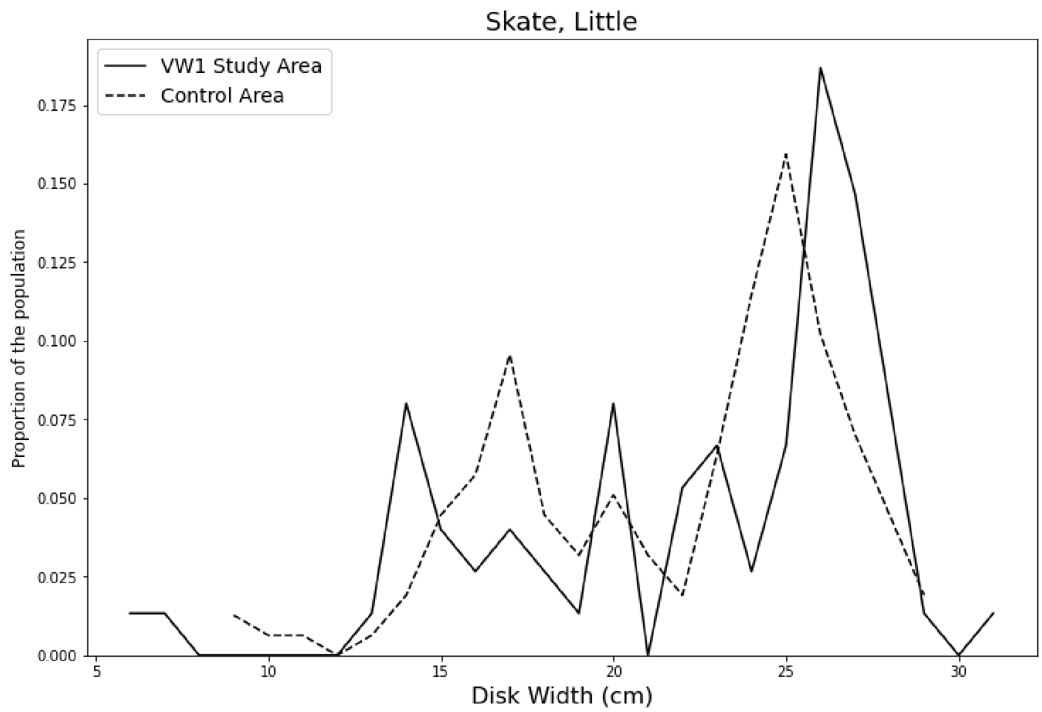



**Figure 10: Distribution of the catch of Atlantic herring in the VW1 Study Area (left) and Control Area (right).**



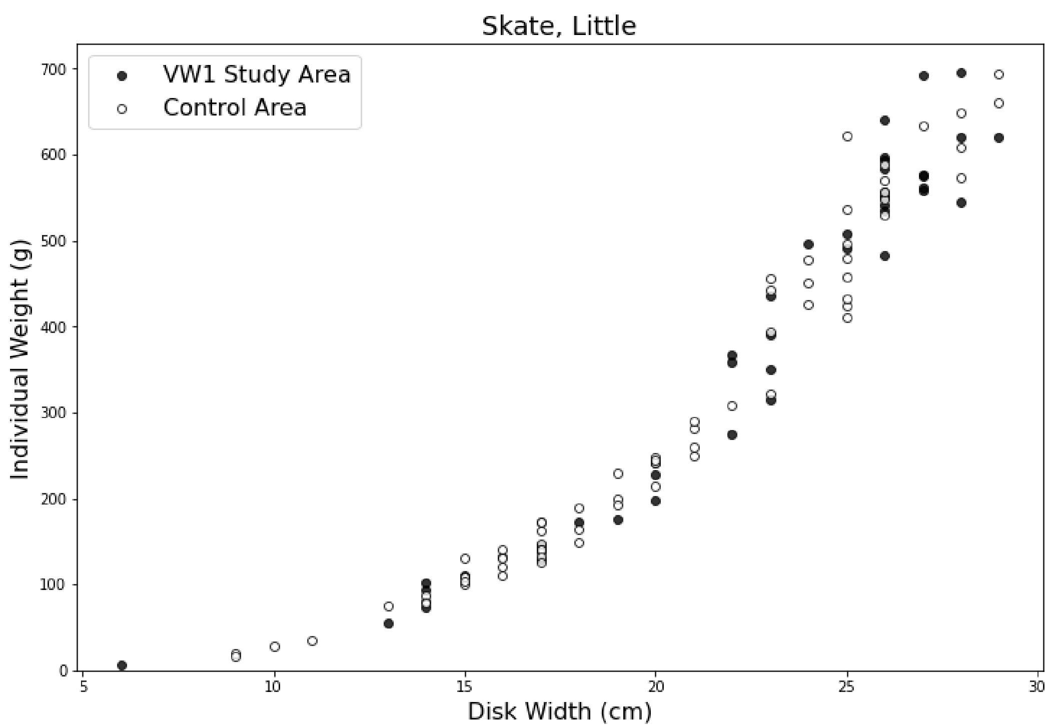




**Figure 11: Population structure of little skate in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).**

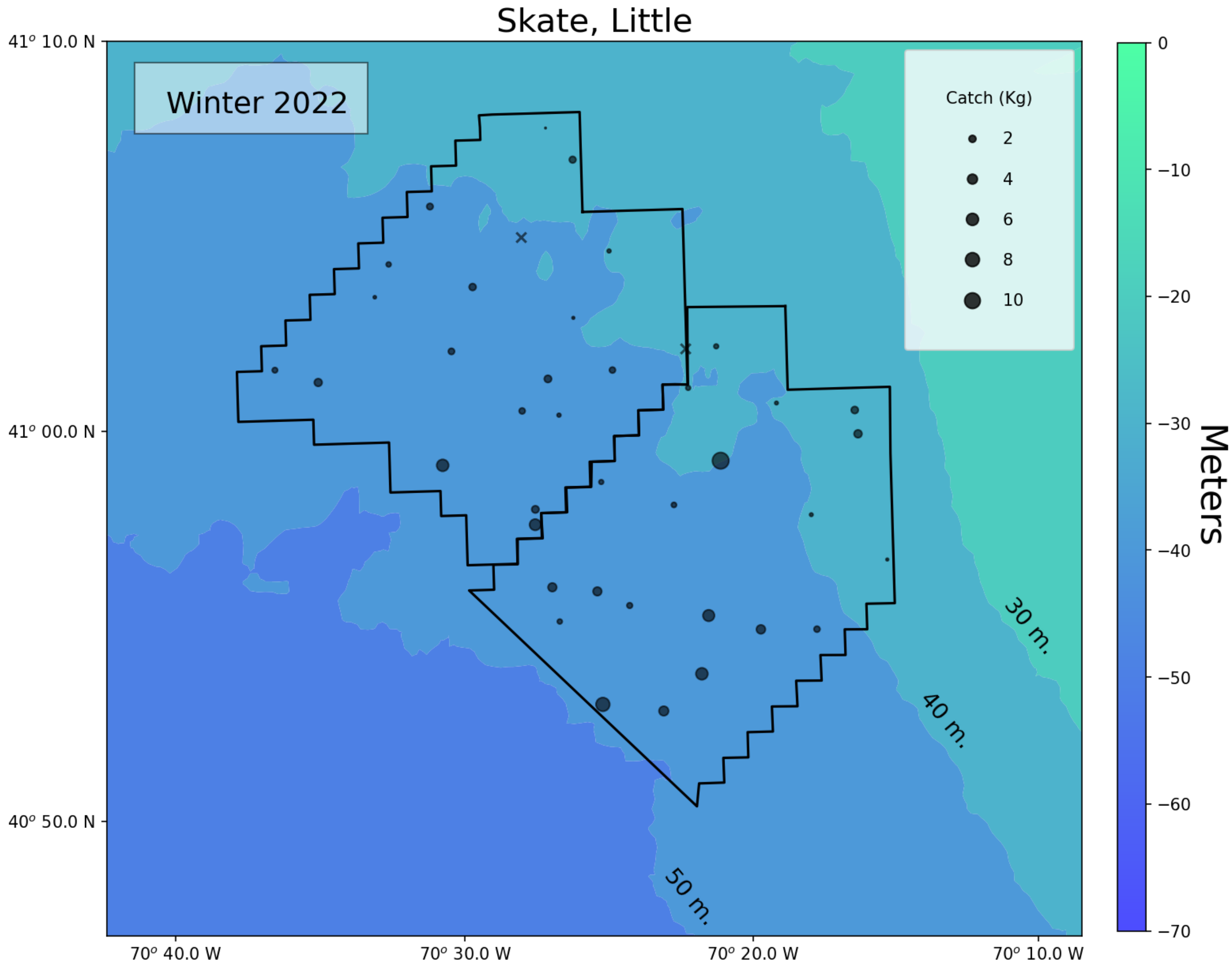



**Figure 12: Distribution of the catch of little skate in the VW1 Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.**

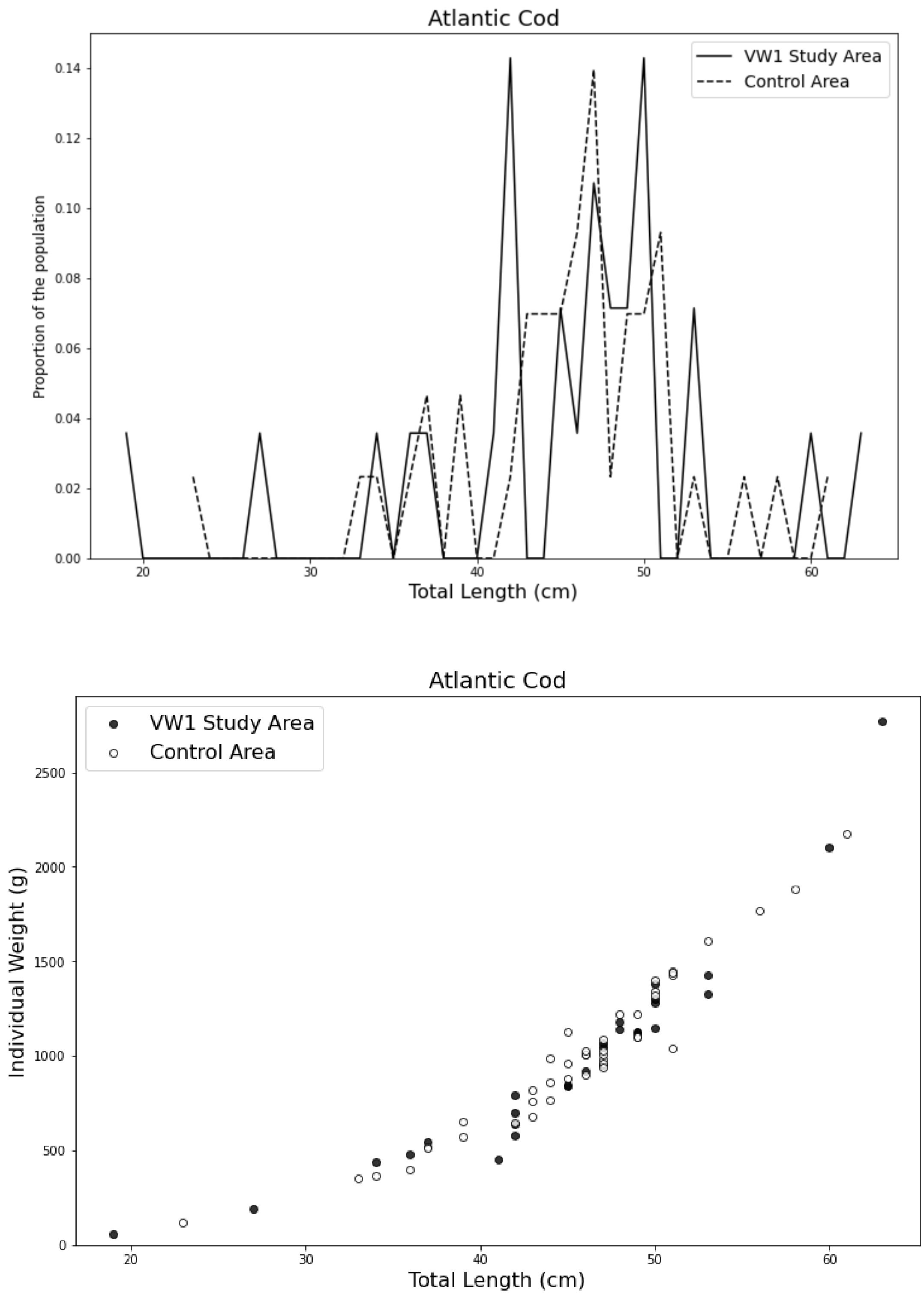



**Figure 13: Population structure of Atlantic cod in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).**

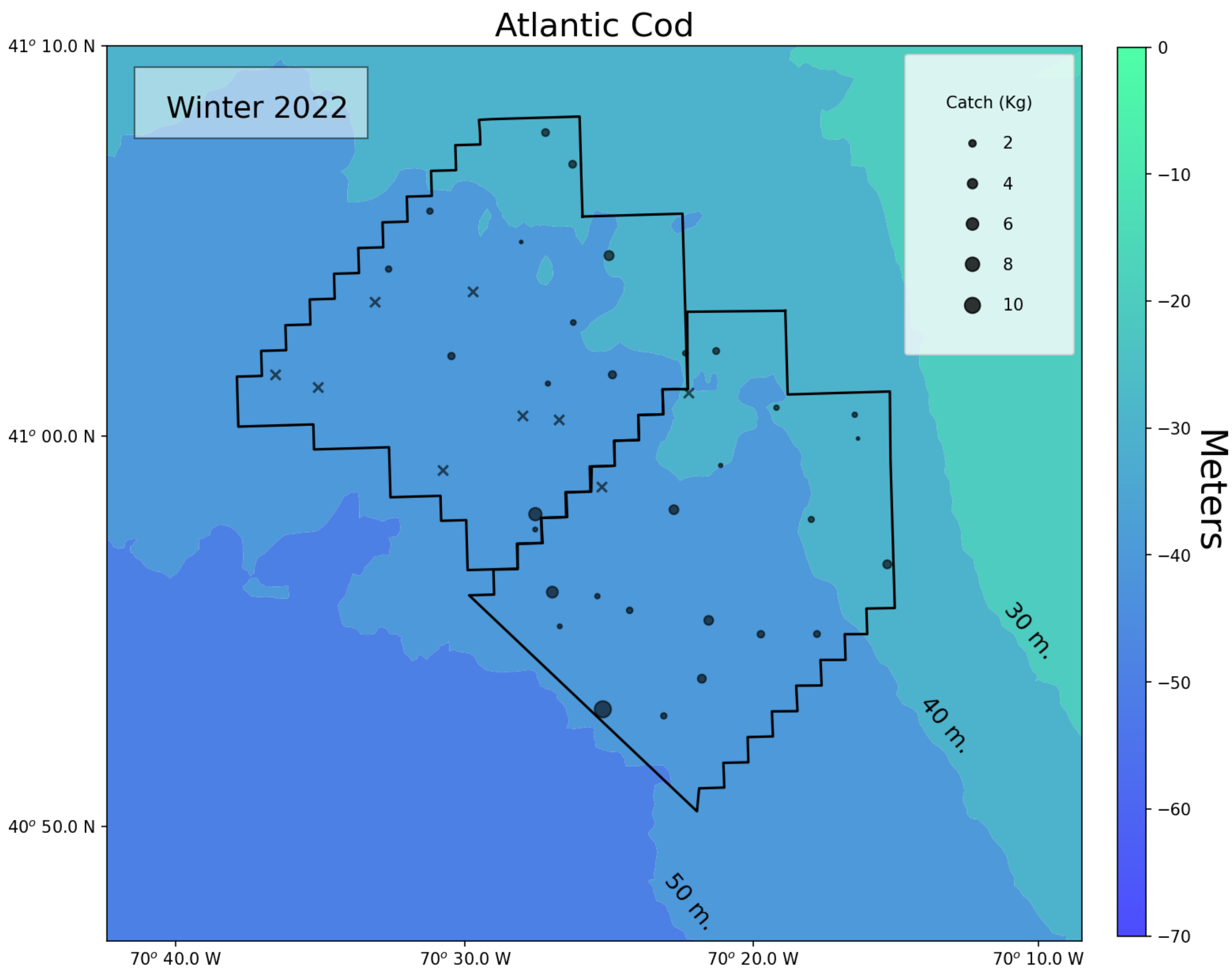
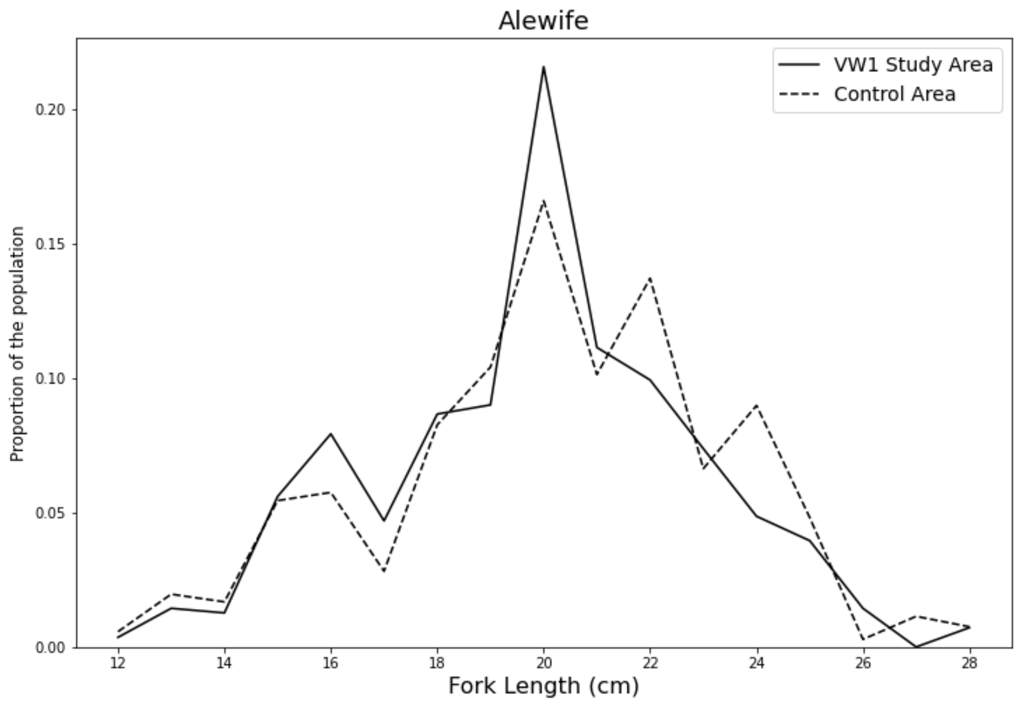



**Figure 14: Distribution of the catch of Atlantic cod in the VW1 Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.**



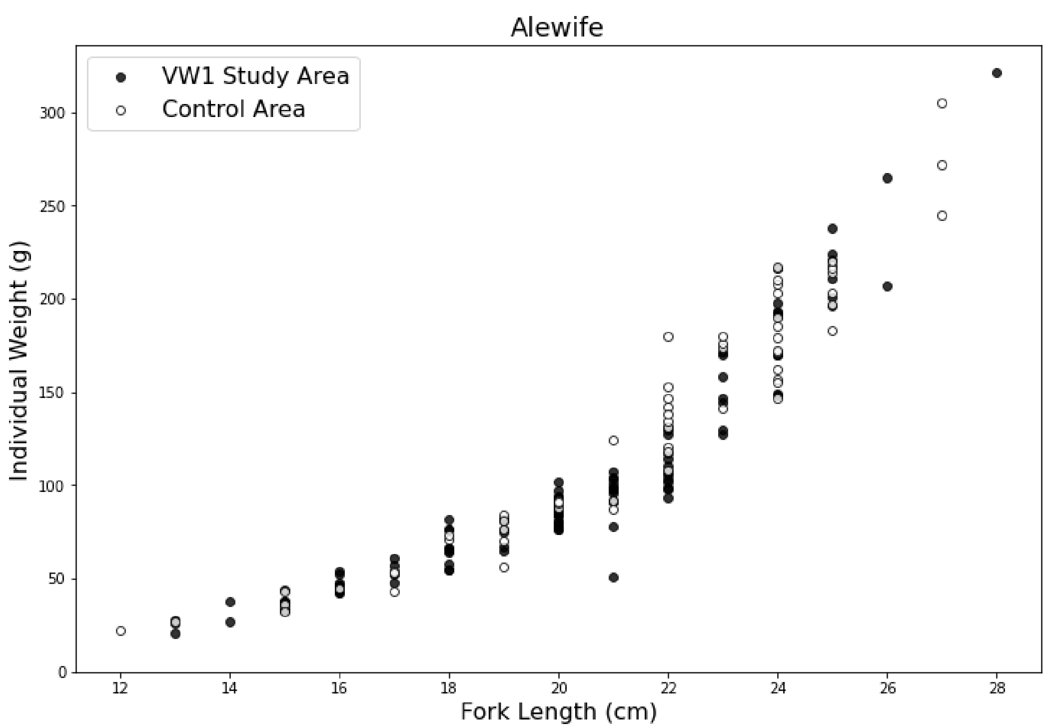




**Figure 15: Population structure of alewife in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).**

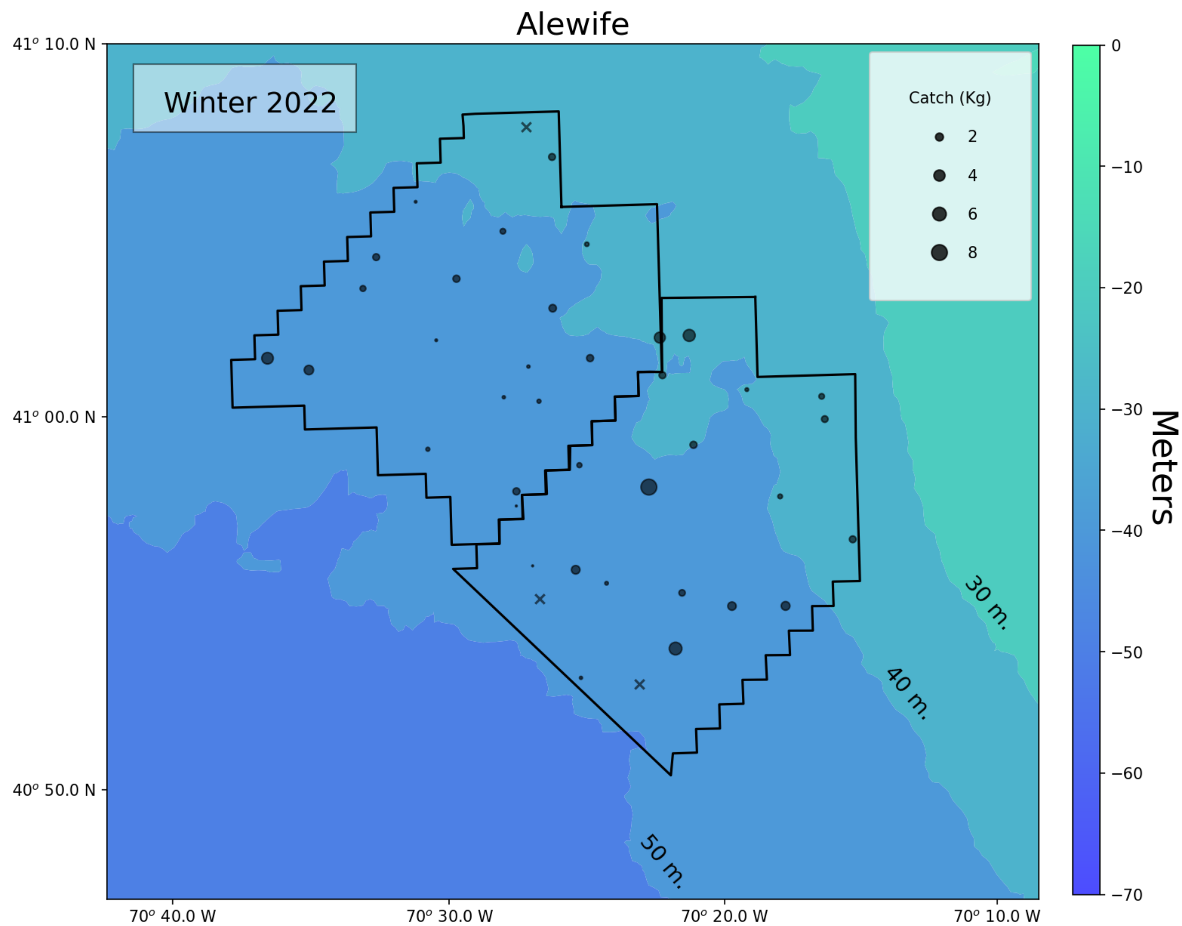
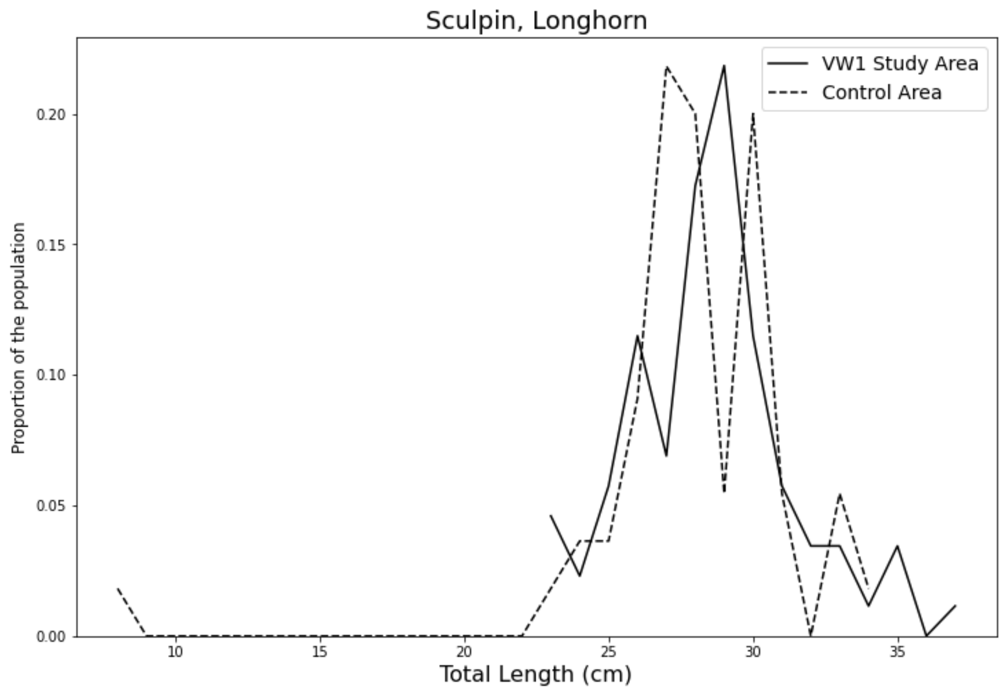



**Figure 16: Distribution of the catch of alewife in the VW1 Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.**



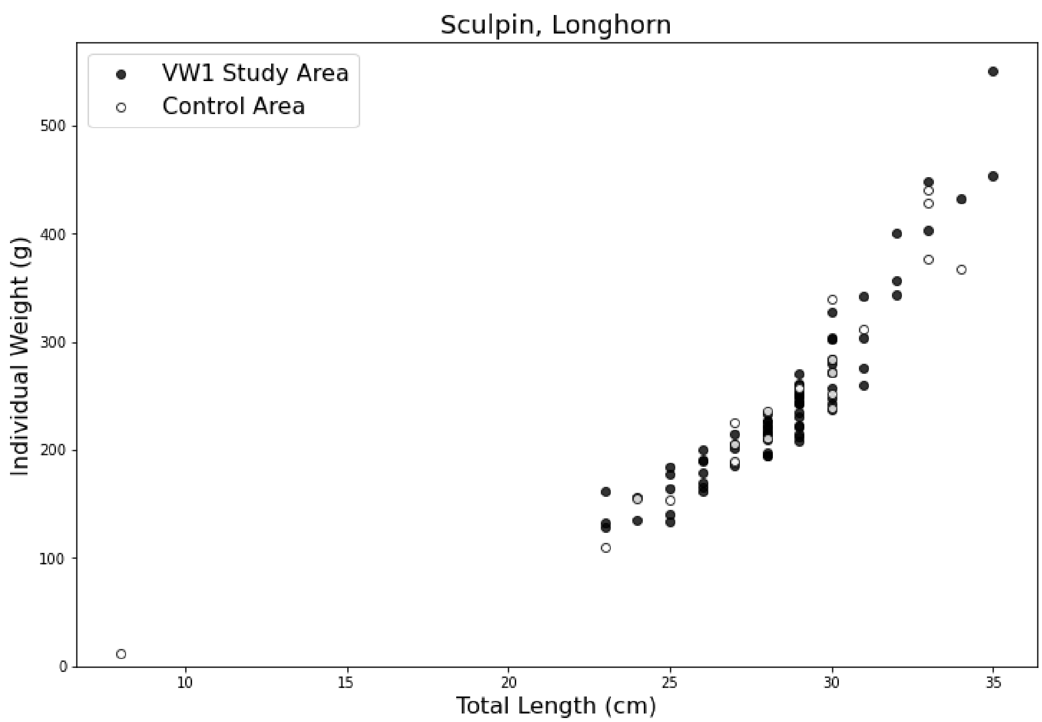




**Figure 17: Population structure of longhorn sculpin in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).**

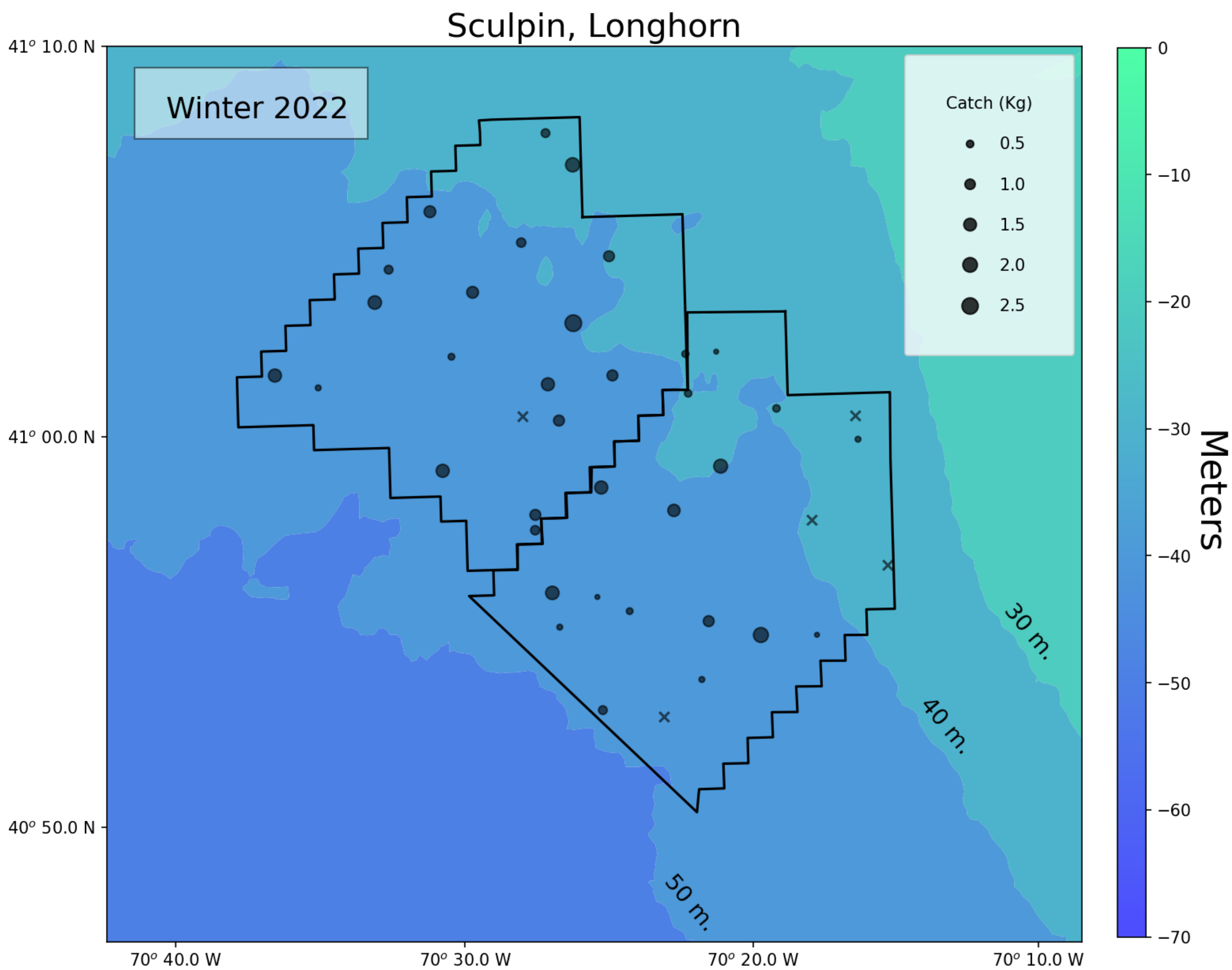
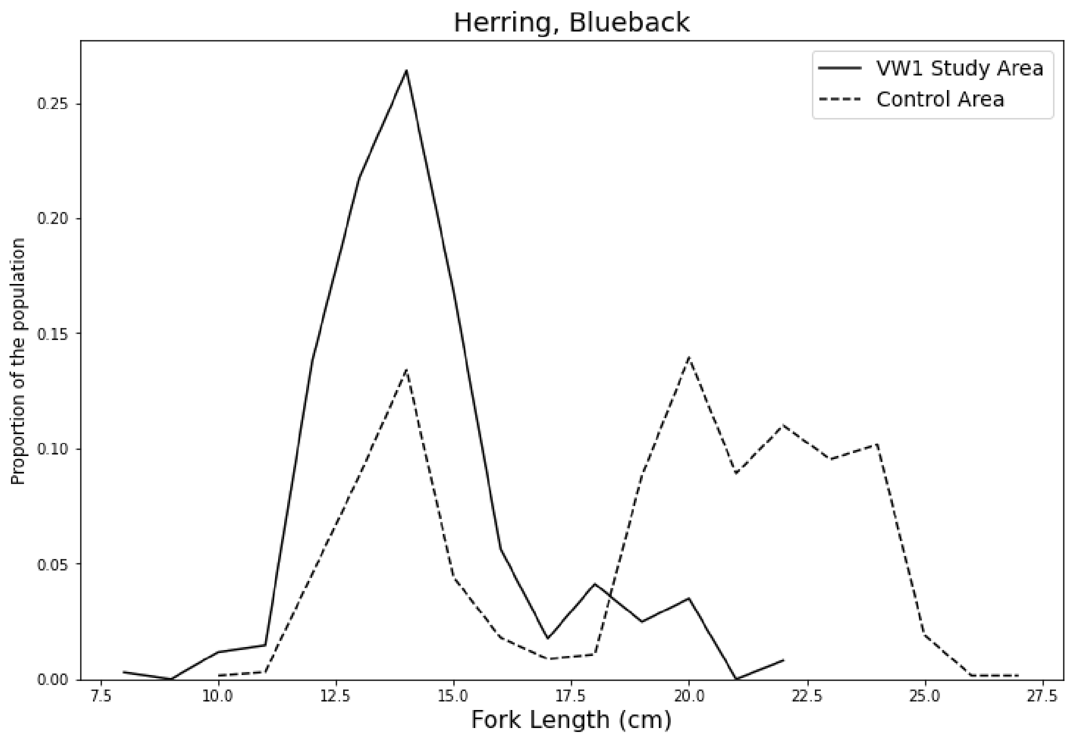



**Figure 18: Distribution of the catch of longhorn sculpin in the VW1 Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.**



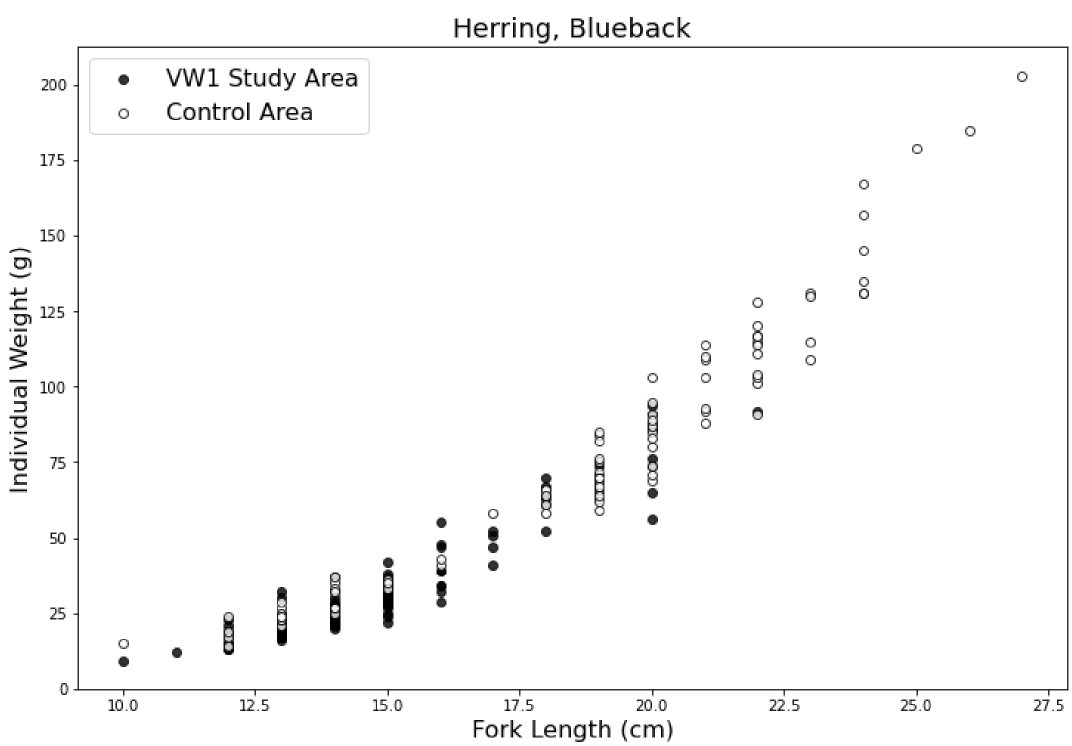




**Figure 19: Population structure of blueback herring in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).**

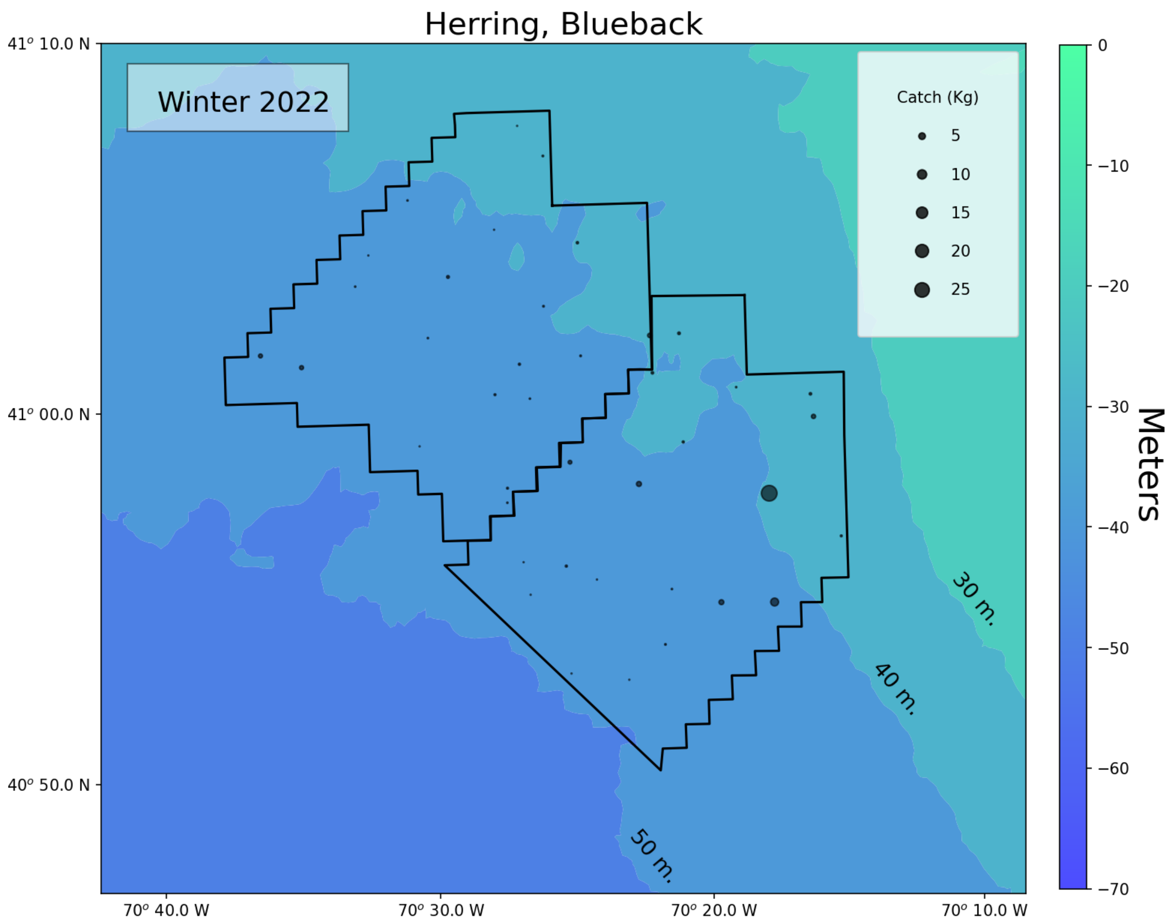
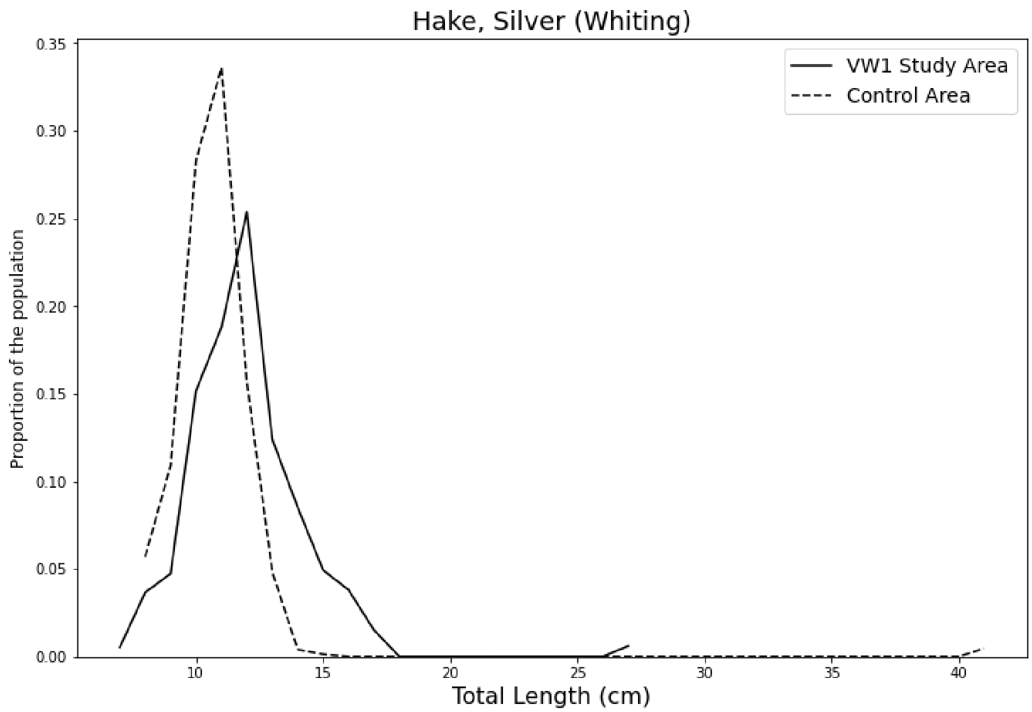



**Figure 20: Distribution of the catch of blueback herring in the VW1 Study Area (left) and Control Area (right).**



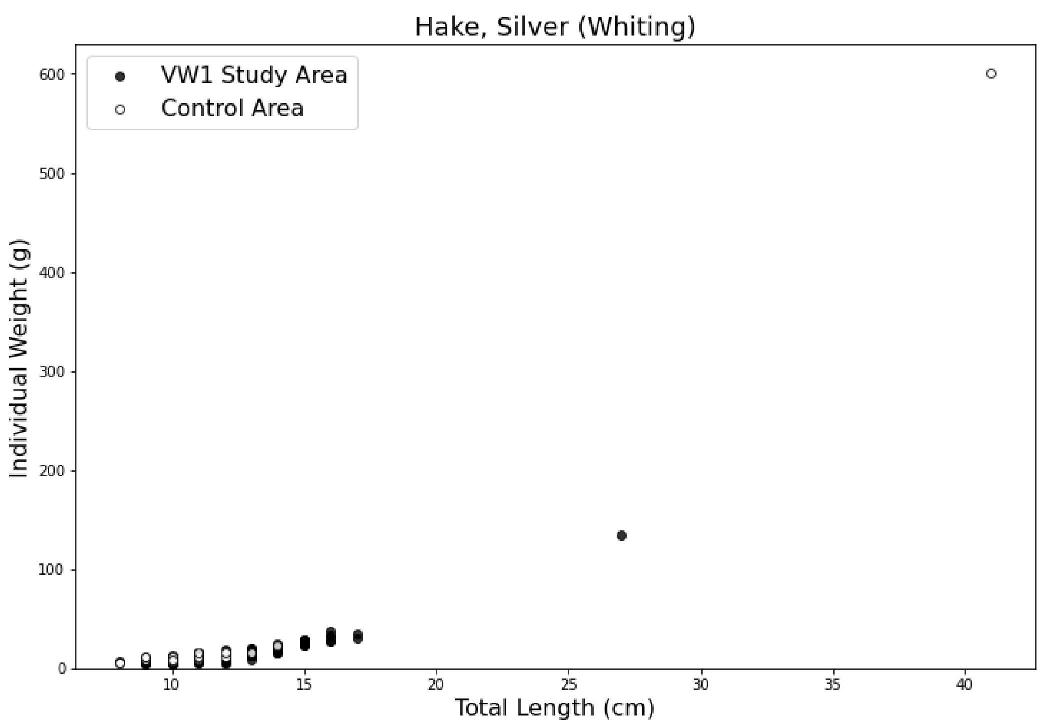




**Figure 21: Population structure of silver hake in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).**

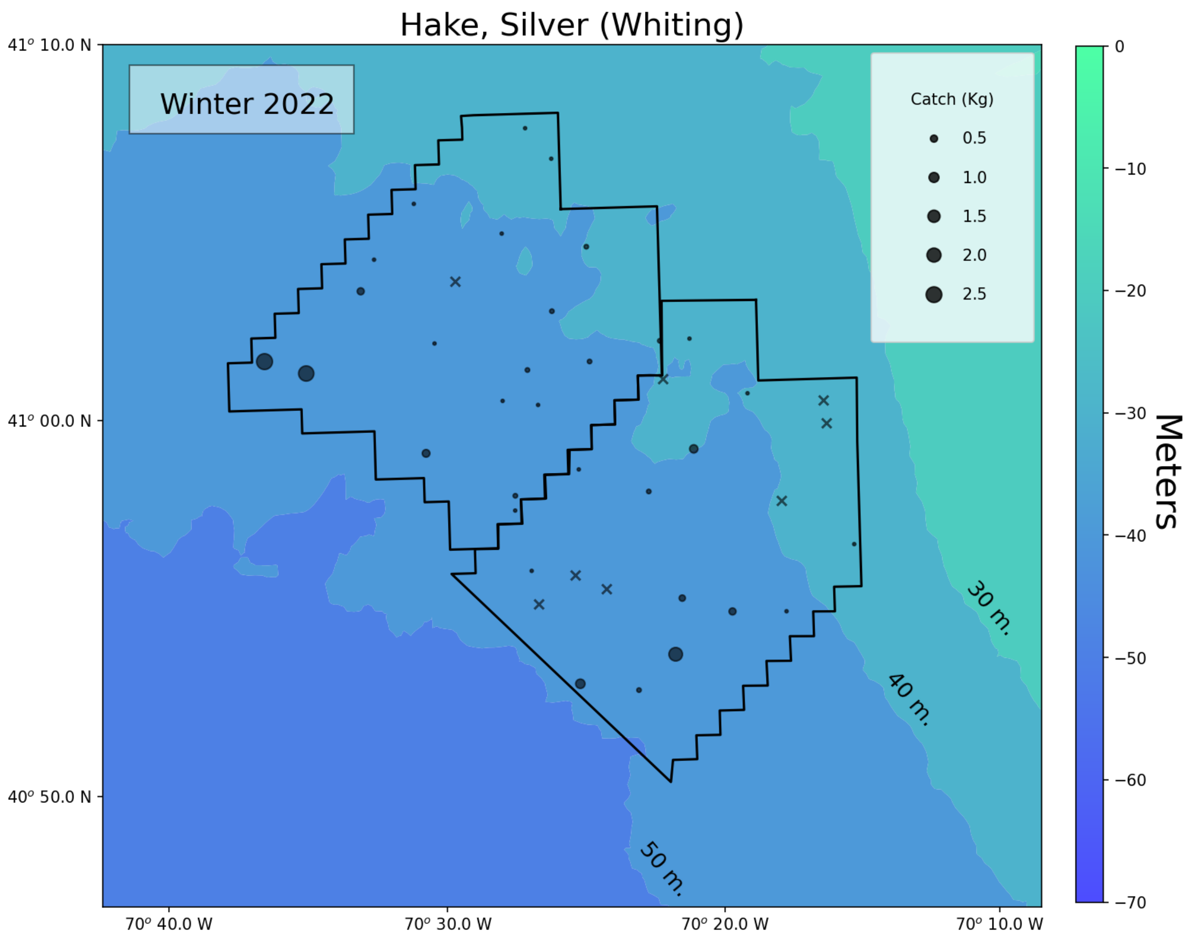
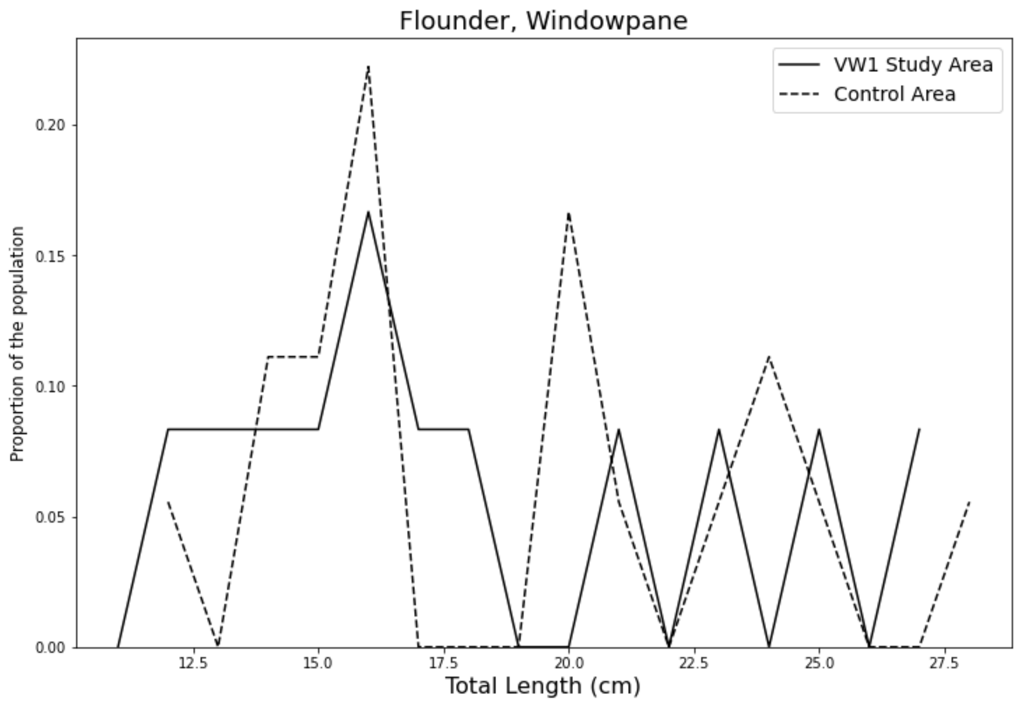



**Figure 22: Distribution of the catch of silver hake in the VW1 Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.**



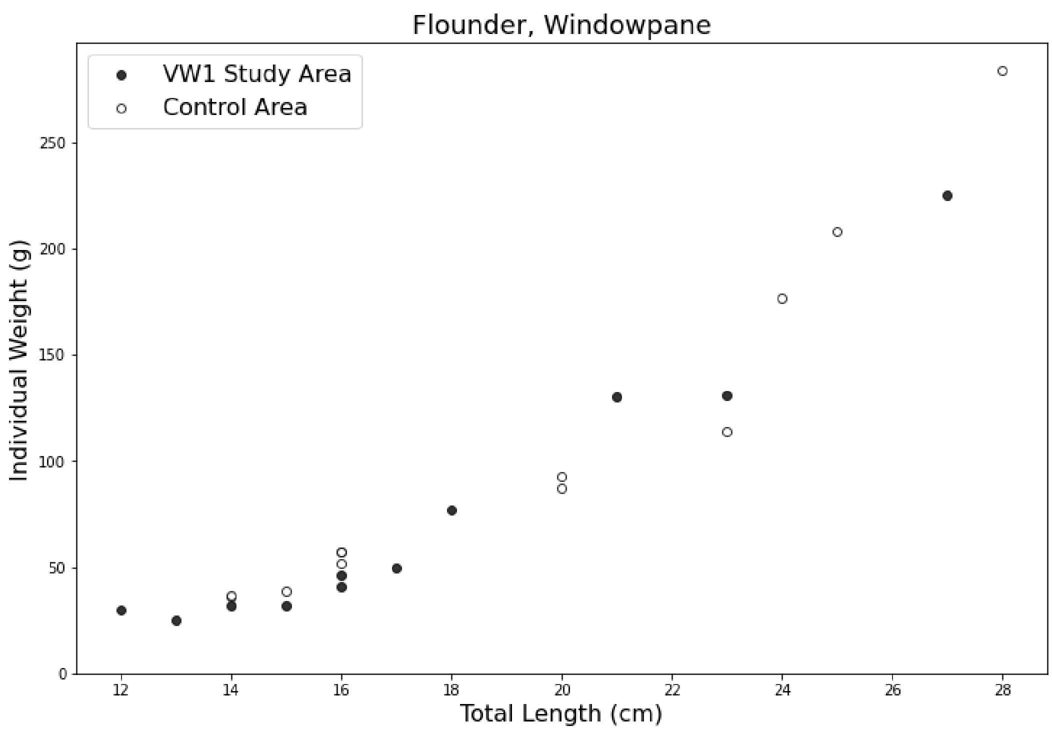




**Figure 23: Population structure of windowpane flounder in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).**

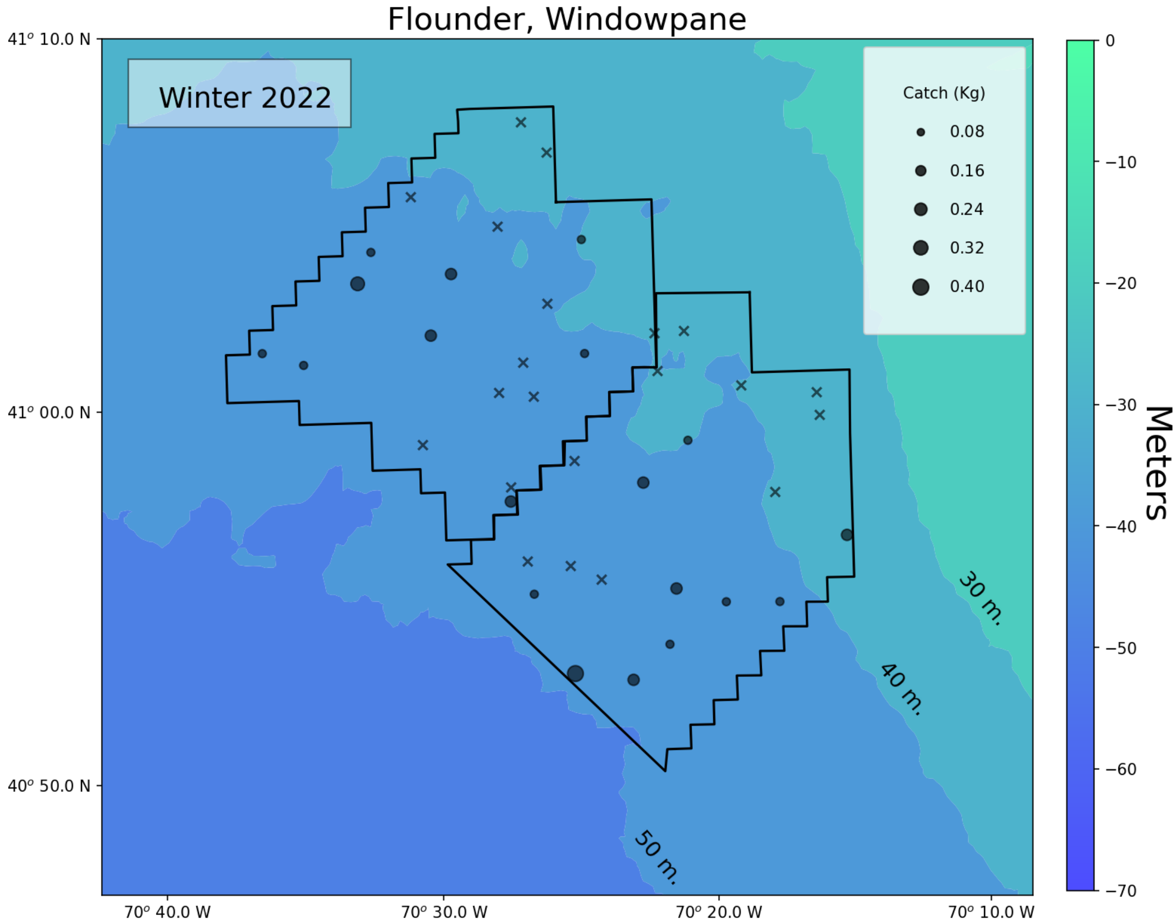



**Figure 24: Distribution of the catch of windowpane flounder in the VW1 Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.**