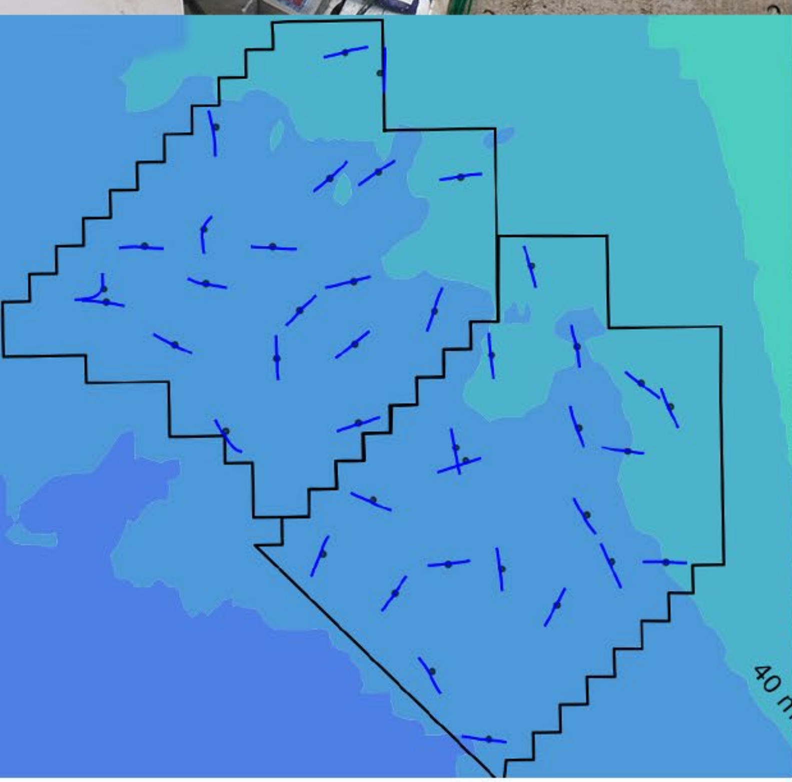
Vineyard Wind 1 Demersal Trawl Survey



Quarterly Report

Vineyard Wind 1 Study Area   Summer 2022 (July - September)

VINEYARD WIND 1 DEMERSAL TRAWL SURVEY

Summer 2022 Seasonal Report

Vineyard Wind 1 Study Area

September 2022

Prepared for Vineyard Wind 1 LLC

Prepared by:

Christopher Rillahan and Pingguo He

University of Massachusetts Dartmouth
School for Marine Science and Technology

Vineyard Wind 1 Demersal Trawl Survey
Summer 2022 Seasonal Report

Vineyard Wind 1 Study Area

Progress Report #11

July 1 – September 30, 2022

Project title:	Vineyard Wind 1 Demersal Trawl Survey Summer 2022 Seasonal Report – Vineyard Wind 1 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 1 LLC 700 Pleasant St, Suite 510 New Bedford, MA 02740
Report by:	Christopher Rillahan and Pingguo He
Date:	September 8, 2022

You may cite this report as:
Rillahan, C., He, P. (2022). Vineyard Wind 1 Demersal Trawl Survey Summer 2022 Seasonal Report – Vineyard Wind 1 Study Area. Progress report #11. University of Massachusetts Dartmouth - SMAST, New Bedford, MA. SMAST-CE-REP-2022-112. 43 pp.

SMAST-CE-REP-2022-112

Table of Contents

List of Tables

List of Figures

1. Introduction

In 2015, Vineyard Wind 1 LLC (Vineyard Wind) leased a 675 square kilometer (km^2; 197 square nautical miles [nmi^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 (89 nmi^2) area referred to as 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 United States 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 characteristics,

[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.

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 the VW1 Study Area and an adjacent area (Control 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 summer 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 (29 nmi^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, 2019). 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 project and segregation of the Lease Area OCS-A 0501. The VW1 Study Area was decreased from 306 in the 2020/2021 survey year to 265 km^2 (89 to 77 nmi^2) in the 2021/2022 survey year 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 [4 nmi^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 to 269.5 km^2 (94.5 to 78.6 nmi^2). The Control Area was sub-divided into 20 sub-areas (each ~13.5 km^2 [4 nmi^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 other 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 effort 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 (i.e., 100% change). The updated power analysis showed that increasing the 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 nmi^2) in the VW1 Study Area and one station per 13.5 km^2 (4 nmi^2) in the Control Area. As previously mentioned, the NEAMAP nearshore survey samples at a density of one station per ~100 km^2 (29 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 to 15.4 m). Door spread was targeted between 32.0 and 33.0 m (acceptable range: 28.8 to 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 between August 10 and 15, 2022. The F/V *Heather Lynn* is a commercial fishing vessel currently operating in the industry. One trip to the survey areas was made during which all planned tows were completed.

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 to provide desired 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).

A CTD sonde (RBR Concerto,[3] RBR LTD, Ottawa, Canada) was deployed off the side of the vessel at the conclusion of each tow. The CTD was lowered to the seafloor at a rate of ~30 cm per second. Upon hitting the seafloor, the sonde was immediately retrieved. The CTD recorded water column profiles of conductivity/salinity, temperature, and pressure/depth at a sampling rate of 8 Hertz.

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.

Straight sub-sampling by weight: 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 20.1 ± 0.4 minutes (mean ± one standard deviation) in the VW1 Study Area and 20.1 ± 0.2 minutes in the Control Area. Tow distances averaged 0.99 ± 0.04 nmi in the VW1 Study Area giving an average tow speed of 3.0 ± 0.1 knots. Similarly, tow distance averaged 0.98 ± 0.04 nmi in the Control Area giving an average tow speed of 2.9 ± 0.1 knots.

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 ± 0.8 m (range: 32.5 – 35.2 m) for tows in the VW1 Study Area and 34.0 ± 1.5 (range: 30.8 – 37.4 m) in the Control Area. Wing spread averaged 13.5 ± 0.3 m for tows in the VW1 Study Area (range: 12.8 – 14.0 m) and 13.4 ± 0.4 m for tows in the Control Area (range: 12.9 – 14.4 m). Headline height averaged 4.7 ± 0.1 m for tows in the VW1 Study Area (range: 4.5 – 4.9 m) and 4.8 ± 0.2 m for tows in the Control Area (range: 4.5 – 5.2 m). All tows were in the acceptable range for all trawl geometry parameters.

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 temperature followed the depth gradient with warmer temperatures observed in the shallow tows for the north (~16°C at 37 – 40 m). Bottom water temperature was 13 – 14°C during deeper tows in the southern half of the study areas (45 – 50 m). CTD data indicated that the deeper tows had warmer surface water with a strong thermocline around 10 – 11 m in both study areas (Figures 9 and 10).

3.2 Catch Data

3.2.1 VW1 Study Area

In the VW1 Study Area, a total of 25 species were caught over the duration of the survey (Table 3). Catch volume ranged from 45.3 to 730.4 kilograms per tow (kg/tow) with an average of 232.4 kg/tow. The majority of the catch was primarily comprised of a small subset of the observed species. The five most abundant species (butterfish, scup, little skate, red hake, and silver hake) accounted for 92.4% of the total catch weight. Data collected from this area included the catch of both adults and juveniles of most species observed.

Butterfish (*Peprilus triaconthus*) was the most abundant species, accounting for 47.5% of the total catch weight. Individuals ranged in length from 5 to 17 cm in length with a unimodal size distribution consisting of a peak at 12 cm (Figure 11). Butterfish were observed in all 20 tows at an average catch rate of 110.1 ± 30.5 kg/tow (mean ± Standard Error of the Mean [SEM], range: 2.2 – 459.2 kg/tow). Butterfish were caught throughout the VW1 Study Area with higher catches observed in the northern half of the VW1 Study Area (Figure 12).

Scup (*Stenotomus chrysops*) was the second most abundant species observed, accounting for 13.5% of the total catch weight. Individuals ranged in size from 20 to 28 cm with a unimodal size distribution consisting of a peak at 22 cm (Figure 13). Scup were observed in 10 of the 20 tows. Catch rates averaged 32.0 ± 12.8 kg/tow (range: 0 – 190.9 kg/tow). Scup were only observed in the northern half of the VW1 Study Area (Figure 14).

Little skate (*Leucoraja erinacea*) was the third most abundant species observed, accounting for 11.9% of the total catch weight. Individuals ranged in length from 10 to 31 cm (disk width) with a unimodal size distribution consisting of a peak at 26 cm (Figure 15). Little skate were observed in all 20 tows with an average catch rate of 27.8 ± 5.8 kg/tow (range: 5.2 – 108.7 kg/tow). Little skate were caught throughout the VW1 Study Area (Figure 16).

Red hake (*Urophycis chuss*) was the fourth most abundant species observed, accounting for 11.5% of the total catch weight. Individuals ranged in length from 18 to 40 cm with a bimodal size distribution consisting of peaks at 24 and 29 cm (Figure 17). Red hake were observed in all 20 tows. Catch rates averaged 26.8 ± 9.5 kg/tow (range: 0.4 – 167.0 kg/tow). Red hake were caught throughout the VW1 Study Area with the highest catches in the center of the VW1 Study Area (Figure 18).

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 17 to 44 cm with a unimodal peak at 22 cm (Figure 19). Silver hake were observed in all 20 tows at an average catch rate of 18.4 ± 2.5 kg/tow (range: 0.5 – 37.0 kg/tow). Silver hake were observed throughout the VW1 Study Area (Figure 20).

Atlantic longfin squid (*Dorytheuthis pealei*) is a commercially important species commonly referred to as loligo squid. Atlantic longfin squid ranged in length from 2 to 30 cm (mantle length) with a unimodal size distribution peaking at 14 cm (Figure 21). Atlantic longfin squid were observed in all 20 tows at an average catch rate of 12.3 ± 2.7 kg/tow (range: 1.0 – 46.4 kg/tow). Atlantic longfin squid were evenly caught throughout the VW1 Study Area (Figure 22). No squid “mops” were observed during this survey.

Fourspot flounder (*Paralichthys oblongus*) was the most abundant flatfish in the VW1 Study Area. Fourspot flounder ranged in length from 17 to 38 cm with a wide size distribution (Figure 23). Fourspot flounder were observed in all 20 tows at an average catch rate of 2.1 ± 0.3 kg/tow (range: 0.3 – 5.1 kg/tow). Fourspot flounder were caught throughout the VW1 Study Area (Figure 24).

Winter flounder (*Pleuronectes americanus*) was another commercially important flatfish species commonly caught in the VW1 Study Area. Winter flounder ranged in length from 14 to 36 cm with a wide size distribution (Figure 25). Winter flounder were observed in 13 of the 20 tows at an average catch rate of 0.2 ± 0.1 kg/tow (range: 0 – 0.9 kg/tow). Winter flounder were caught throughout the VW1 Study Area (Figure 26).

Less common recreational and commercial species observed included nine individuals of windowpane flounder (*Scophtalmus aquosus*, size range: 12 – 30 cm), two individuals of black sea bass (*Centropristis striata,* sizes: 28, 30 cm), two individuals of American lobster (*Homarus americanus*), one individual of monkfish (*Lophius americanus*, size: 39 cm), one individual of summer flounder (*Paralichthys dentatus*, size: 43 cm) and five individuals of Atlantic sea scallop (*Placopecten magellanicus*).

3.2.2 Control Area

In the Control Area, a total of 27 species were caught over the duration of the survey (Table 4). Catch volume ranged from 27.6 to 2,668.5 kg/tow with an average of 436.7 kg/tow. The majority of the catch was primarily comprised of a small subset of the observed species. The five most abundant species (butterfish, scup, little skate, Atlantic longfin squid, and silver hake) accounted for 97.4% of the total catch weight. Data collected from this area included the catch of both adults and juveniles of most species observed.

Butterfish was the most abundant species, accounting for 65.5% of the total catch weight. Individuals ranged in length from 5 to 18 cm in length with a unimodal size distribution consisting of a peak at 12 cm (Figure 11). Butterfish were observed in all 20 tows at an average catch rate of 285.4 ± 100.2 kg/tow (range: 0.5 – 1,803.2 kg/tow). Butterfish were caught throughout the Control Area (Figure 12).

Scup was the second most abundant species observed, accounting for 19.5% of the total catch weight. Individuals ranged in size from 18 to 34 cm with a unimodal size distribution consisting of a peak at 24 cm (Figure 13). Scup were observed in 16 of the 20 tows. Catch rates averaged 86.1 ± 39.4 kg/tow (range: 0 – 758.7 kg/tow). Scup were primarily observed in the northern half of the Control Area (Figure 14).

Little skate was the third most abundant species observed, accounting for 5.2% of the total catch weight. Individuals ranged in length from 14 to 29 cm (disk width) with a unimodal size distribution consisting of a peak at 26 cm (Figure 15). Little skate were observed in all 20 tows with an average catch rate of 22.6 ± 3.4 kg/tow (range: 3.0 – 52.9 kg/tow). Little skate were caught throughout the Control Area (Figure 16).

Atlantic longfin squid was the fourth most abundant species observed. Atlantic longfin squid ranged in length from 3 to 28 cm (mantle length) with a unimodal size distribution peaking at 14 cm (Figure 21). Atlantic longfin squid were observed in 19 of the 20 tows at an average catch rate of 16.0 ± 5.6 kg/tow (range: 0 – 116.6 kg/tow). Atlantic longfin squid were caught throughout the Control Area (Figure 22). No squid “mops” were observed during this survey.

Silver hake, a commercially important species also commonly referred to as whiting, was a frequently observed species in the Control Area. Individuals ranged in length from 14 to 40 cm with a unimodal peak at 20 cm (Figure 19). Silver hake were observed in all 20 tows at an average catch rate of 15.4 ± 4.1 kg/tow (range: 0.1 – 68.3 kg/tow). Silver hake were observed throughout the Control Area with highest catches observed in the northern half of the study area (Figure 20).

Red hake was the commonly observed in the Control Area. Individuals ranged in length from 18 to 39 cm with a bimodal size distribution consisting of peaks at 24 and 30 cm (Figure 17). Red hake were observed in 17 of the 20 tows. Catch rates averaged 6.1 ± 1.4 kg/tow (range: 0 – 17.4 kg/tow). Red hake were caught throughout the Control Area (Figure 18).

Fourspot flounder was the most abundant flatfish in the Control Area. Fourspot flounder ranged in length from 19 to 38 cm with a wide size distribution (Figure 23). Fourspot flounder were observed in all 20 tows at an average catch rate of 1.9 ± 0.4 kg/tow (range: 0.1 – 7.1 kg/tow). Fourspot flounder were caught throughout the Control Area (Figure 24).

Winter flounder was a commercially important flatfish species commonly caught in the Control Area. Winter flounder ranged in length from 17 to 39 cm with a wide size distribution (Figure 25). Winter flounder were observed in 10 of the 20 tows at an average catch rate of 0.4 ± 0.1 kg/tow (range: 0 – 2.1 kg/tow). Winter flounder were only caught in the northern half of the Control Area (Figure 26).

Less common recreational and commercial species observed included twenty-five individuals of windowpane flounder (size range: 11 – 30 cm), four individuals of American lobster, two individuals of monkfish (sizes: 26, 40 cm), one individual of summer flounder (size: 43 cm), one individual of bluefish (*Pomatomus saltatrix*, size: 66 cm), and five individuals of Atlantic sea scallop.

Two roughtail stingrays (*Dasyatis cantroura*) were caught. The animals were estimated to be ~1.5 m long (disk width). The stingrays were immediately returned to the sea and were observed to swim away.

4. Acknowledgments

We would like to thank the owner (Paul Farnham), captain (Mike Gallagher), and crew (Matt Manchester and Barry Klapp) of the F/V *Heather Lynn* for their help sorting, processing, and measuring the catch. Additionally, we would like to thank 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). 2019. 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	8/11/2022	Mostly Cloudy	3-6	S	0.5-1.25	6:59	N 41° 06.190	W 70° 13.280	22	7:19	N 41° 05.173	W 70° 13.015	23	14.28829	100
2	VW1	8/11/2022	Mostly Cloudy	7-10	s	0.5-1.25	8:29	N 41° 03.700	W 70° 31.165	24	8:49	N 41° 02.761	W 70° 31.302	24	13.79003	100
3	VW1	8/11/2022	Overcast	7-10	S	0.5-1.25	9:29	N 41° 03.010	W 70° 29.818	24	9:49	N 41° 02.962	W 70° 28.516	23	13.79624	100
4	VW1	8/11/2022	Overcast	7-10	S	0.5-1.25	10:41	N 41° 02.050	W 70° 30.586	25	11:01	N 41° 02.257	W 70° 31.838	24	13.9653	100
5	VW1	8/11/2022	Rain	3-6	S	0.5-1.25	12:29	N 41° 02.980	W 70° 32.666	25	12:44	N 41° 02.995	W 70° 33.964	23	13.5652	100
6	VW1	8/11/2022	Rain	7-10	S	0.5-1.25	13:24	N 41° 02.230	W 70° 34.506	23	13:44	N 40° 01.765	W 70° 35.325	24	13.49788	100
7	VW1	8/11/2022	Rain	7-10	S	0.5-1.25	14:30	N 41° 01.750	W 70° 35.109	24	14:50	N 40° 01.629	W 70° 33.871	24	13.26115	100
8	VW1	8/11/2022	Mostly Cloudy	7-10	S	0.5-1.25	15:29	N 41° 00.940	W 70° 32.899	26	15:49	N 41° 00.572	W 70° 31.750	26	13.68859	100
9	VW1	8/11/2022	Partly Cloudy	7-10	S	0.5-1.25	16:28	N 40° 58.900	W 70° 30.995	26	16:48	N 40° 58.185	W 70° 30.219	25	13.77936	100
10	VW1	8/11/2022	Mostly Cloudy	3-6	S	0.5-1.25	17:30	N 40° 58.680	W 70° 27.178	24	17:50	N 40° 58.977	W 70° 25.928	24	13.62097	100
11	Control	8/12/2022	Mostly Cloudy	1-2	E	0.1-0.5	6:27	N 40° 55.280	W 70° 28.997	26	6:47	N 40° 56.186	W 70° 27.275	25	13.2905	100
12	Control	8/12/2022	Mostly Cloudy	1-2	E	0.1-0.5	7:33	N 40° 57.190	W 70° 26.731	25	7:53	N 40° 56.799	W 70° 25.571	25	11.4815	100
13	Control	8/12/2022	Mostly Cloudy	1-2	E	0.1-0.5	8:35	N 40° 57.690	W 70° 23.437	24	8:55	N 40° 58.695	W 70° 23.683	23	13.61102	100
14	Control	8/12/2022	Mostly Cloudy	1-2	E	0.1-0.5	9:37	N 40° 59.950	W 70° 22.371	21	9:57	N 41° 00.951	W 70° 22.511	22	14.35027	100
15	Control	8/12/2022	Mostly Cloudy	1-2	E	0.1-0.5	10:33	N 41° 02.990	W 70° 21.395	21	10:53	N 41° 02.075	W 70° 21.046	21	14.97801	95
16	Control	8/12/2022	Mostly Cloudy	1-2	E	0.1-0.5	11:47	N 41° 01.130	W 70° 19.934	22	12:07	N 41° 00.176	W 70° 19.696	22	16.60534	100
17	Control	8/12/2022	Mostly Cloudy	1-2	E	0.1-0.5	14:06	N 40° 59.210	W 70° 19.968	23	14:26	N 40° 58.311	W 70° 19.573	23	14.8372	100
18	Control	8/12/2022	Mostly Cloudy	1-2	E	0.1-0.5	15:16	N 40° 58.270	W 70° 19.918	23	15:36	N 40° 58.129	W 70° 17.770	21	14.748	100
19	Control	8/12/2022	Mostly Cloudy	1-2	E	0.1-0.5	16:20	N 40° 59.440	W 70° 17.233	20	16:40	N 41° 00.035	W 70° 18.237	21	12.62548	95
20	Control	8/12/2022	Mostly Cloudy	1-2	E	0.1-0.5	17:36	N 40° 59.640	W 70° 17.142	20	17:56	N 40° 58.514	W 70° 16.631	20	15.86472	95
21	Control	8/13/2022	Mostly Cloudy	7-10	W	0.5-1.25	6:18	N 40° 55.550	W 70° 16.437	21	6:38	N 40° 55.577	W 70° 17.699	22	15.17653	100
22	Control	8/13/2022	Mostly Cloudy	7-10	W	0.5-1.25	7:28	N 40° 55.000	W 70° 18.440	23	7:48	N 40° 55.975	W 70° 19.031	23	14.29598	100
23	Control	8/13/2022	Mostly Cloudy	11-15	NW	0.5-1.25	8:37	N 40° 57.040	W 70° 19.858	23	8:57	N 40° 56.264	W 70° 19.218	23	14.26549	100
24	Control	8/13/2022	Mostly Cloudy	11-15	NW	0.5-1.25	9:41	N 40° 54.930	W 70° 20.174	23	10:01	N 40° 54.091	W 70° 20.780	24	13.40753	100
25	Control	8/13/2022	Partly Cloudy	11-15	NW	0.5-1.25	10:51	N 40° 51.330	W 70° 22.049	27	11:11	N 40° 51.461	W 70° 23.318	27	14.48152	120
26	Control	8/13/2022	Partly Cloudy	11-15	NW	0.5-1.25	11:52	N 40° 52.500	W 70° 24.043	27	12:12	N 40° 53.315	W 70° 24.685	26	13.68553	120
27	Control	8/13/2022	Clear	16-20	NW	0.5-1.25	12:59	N 40° 54.460	W 70° 25.795	26	13:19	N 40° 55.225	W 70° 25.091	25	13.44005	100
28	Control	8/13/2022	Clear	16-20	NW	0.5-1.25	13:56	N 40° 55.510	W 70° 24.374	24	14:16	N 40° 55.611	W 70° 23.129	24	13.71474	100
29	Control	8/13/2022	Clear	16-20	NW	0.5-1.25	14:55	N 40° 54.930	W 70° 22.106	23	15:15	N 40° 55.877	W 70° 22.258	24	13.5	100
30	Control	8/13/2022	Clear	11-15	NW	0.5-1.25	16:18	N 40° 58.010	W 70° 22.805	23	16:38	N 40° 57.708	W 70° 24.068	23	13.94582	100
31	VW1	8/13/2022	Clear	7-10	NW	0.5-1.25	17:31	N 41° 00.040	W 70° 27.231	23	17:51	N 41° 01.001	W 70° 26.255	23	13.53265	100
32	VW1	8/14/2022	Clear	1-2	E	0.1-0.5	6:24	N 40° 59.900	W 70° 29.068	24	6:44	N 41° 00.887	W 70° 29.131	24	13.43164	100
33	VW1	8/14/2022	Clear	1-2	E	0.1-0.5	7:24	N 41° 01.180	W 70° 28.761	24	7:44	N 41° 01.843	W 70° 27.888	23	13.55749	100
34	VW1	8/14/2022	Clear	1-2	E	0.1-0.5	8:22	N 41° 02.070	W 70° 27.530	22	8:42	N 41° 02.304	W 70° 26.213	22	13.81081	100
35	VW1	8/14/2022	Clear	1-2	E	0.1-0.5	9:22	N 41° 01.050	W 70° 24.415	23	9:42	N 41° 02.029	W 70° 23.956	23	14.11612	100
36	VW1	8/14/2022	Clear	1-2	E	0.1-0.5	10:25	N 41° 04720	W 70° 22.761	22	10:45	N 41° 04.591	W 70° 23.984	21	14.80079	100
37	VW1	8/14/2022	Partly Cloudy	1-2	E	0.1-0.5	11:25	N 41° 05.030	W 70° 25.458	22	11:45	N 41° 04.472	W 70° 26.538	22	14.0392	100
38	VW1	8/14/2022	Partly Cloudy	1-2	E	0.1-0.5	12:24	N 41° 04.340	W 70° 27.908	23	12:44	N 41° 05.013	W 70° 26.917	22	13.73968	100
39	VW1	8/14/2022	Partly Cloudy	1-2	E	0.1-0.5	13:25	N 41° 06.690	W 70° 25.751	21	13:45	N 41° 07.671	W 70° 25.715	20	14.52887	100
40	VW1	8/14/2022	Mostly Cloudy	1-2	E	0.1-0.5	14:20	N 41° 07.710	W 70° 26.305	20	14:40	N 41° 07.488	W 70° 27.584	21	15.34316	95

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. (^{0}C)	Trawl Warp (fm)	Headline Height (m)	Wing Spread (m)	Spread Door (m)
1	VW1	20.5	1.0	3.0	22	14.3	100		13.7	34.4
2	VW1	20.0	1.0	3.0	24	13.8	100	4.7	13.5	33.8
3	VW1	20.7	1.0	3.0	24	13.8	100	4.8	13.8	34.4
4	VW1	18.5	0.9	2.9	25	14.0	100	4.6	13.7	35.1
5	VW1	20.2	1.0	3.0	25	13.6	100	4.8	13.8	33.9
6	VW1	19.8	1.1	3.2	23	13.5	100	4.7	13.5	33.9
7	VW1	20.1	0.9	2.8	24	13.3	100	4.5	14.0	35.2
8	VW1	20.5	1.0	2.9	26	13.7	100	4.7	13.7	35.1
9	VW1	20.0	1.0	2.9	26	13.8	100	4.9	13.6	34.9
10	VW1	20.6	1.0	3.0	24	13.6	100	4.7	13.5	34.4
11	Control	20.2	1.0	3.0	26	13.3	100	5.0	13.5	33.8
12	Control	20.1	1.0	2.9	25	11.5	100	4.8	13.7	34.4
13	Control	20.2	1.0	3.1	24	13.6	100	4.6	13.8	34.9
14	Control	20.4	1.0	3.0	21	14.4	100	4.5	13.5	34.3
15	Control	19.5	1.0	3.0	21	15.0	95	4.9	13.1	32.6
16	Control	20.2	1.0	2.9	22	16.6	100	4.9	13.0	31.6
17	Control	20.2	1.0	2.9	23	14.8	100	4.8	13.5	34.2
18	Control	20.0	0.9	2.8	23	14.7	100	4.9	13.5	34.3
19	Control	19.5	1.0	3.0	20	15.5	95	5.1	12.9	30.8
20	Control	20.2	1.0	2.8	20	15.9	95	5.1	13.0	34.0
21	Control	20.0	1.0	3.0	21	15.2	100	4.8	13.5	34.3
22	Control	20.2	1.1	3.2	23	14.3	100	4.7	13.7	34.6
23	Control	20.0	0.9	2.8	23	14.3	100	4.8	12.9	32.7
24	Control	20.1	1.0	2.9	23	13.4	100	5.2	13.0	33.5
25	Control	20.0	1.0	3.0	27	14.5	120	4.5	14.4	37.4
26	Control	20.3	1.0	2.8	27	13.7	120	4.5	14.3	36.4
27	Control	20.0	0.9	2.8	26	13.4	100	4.8	13.4	34.6
28	Control	20.0	1.0	2.9	24	13.7	100	4.7	13.2	34.2
29	Control	20.0	1.0	2.9	23	13.5	100			
30	Control	20.1	1.0	3.0	23	13.9	100	4.9	13.4	33.7
31	VW1	20.0	1.0	2.9	23	13.5	100	4.6	13.4	34.5
32	VW1	20.1	1.0	3.0	24	13.4	100	4.7	13.5	33.9
33	VW1	20.1	0.9	2.8	24	13.6	100	4.9	13.1	32.7
34	VW1	20.3	1.0	3.0	22	13.8	100	4.7	13.3	33.4
35	VW1	20.2	1.0	3.1	23	14.1	100	4.6	13.6	34.4
36	VW1	20.2	0.9	2.8	22	14.8	100	4.7	13.0	33.1
37	VW1	20.1	1.0	2.9	22	14.0	100	4.6	13.2	33.2
38	VW1	20.2	1.0	3.0	23	13.7	100	4.6	13.2	33.5
39	VW1	20.0	1.0	3.0	21	14.5	100	4.6	13.2	33.8
40	VW1	20.0	1.0	3.0	20	15.3	95	4.9	12.8	32.5
Summary Statistics										
Control	Minimum	19.5	0.9	2.8	20.0	11.5	95.0	4.5	12.9	30.8
	Maximum	20.4	1.1	3.2	27.0	16.6	120.0	5.2	14.4	37.4
	Average	20.1	0.98	2.9	23.3	14.1	101.3	4.8	13.4	34.0
	St. Dev	0.2	0.04	0.1	2.1	1.1	6.7	0.2	0.4	1.5
VW1	Minimum	18.5	0.9	2.8	20.0	13.3	95.0	4.5	12.8	32.5
	Maximum	20.7	1.1	3.2	26.0	15.3	100.0	4.9	14.0	35.2
	Average	20.1	0.99	3.0	23.4	13.9	99.8	4.7	13.5	34.0
	St. Dev.	0.4	0.04	0.1	1.6	0.5	1.1	0.1	0.3	0.8

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) Mean	Catch/Tow (Kg) SEM*	% of Total Catch	Tows with Species Present
Butterfish	*Peprilus triacanthus*	2169.3	110.1	30.5	47.5	20
Scup	*Stenotomus chrysops*	617.4	32.0	12.8	13.5	10
Skate, Little	*Leucoraja erinacea*	541.5	27.8	5.8	11.9	20
Hake, Red	*Urophycis chuss*	526.5	26.8	9.5	11.5	20
Hake, Silver (Whiting)	*Merluccius bilinearis*	363.9	18.4	2.5	8.0	20
Squid, Atlantic Longfin	*Dorytheuthis pealei*	247.2	12.3	2.7	5.4	20
Flounder, Fourspot	*Paralichthys oblongus*	42.4	2.1	0.3	0.9	20
Crab, Rock	*Cancer irroratus*	26.9	1.4	0.3	0.6	19
Dogfish, Smooth	*Mustelus canis*	8.1	0.4	0.3	0.2	2
Skate, Barndoor	*Dipturus laevis*	6.3	0.3	0.12	0.14	9
Flounder, Winter	*Pleuronectes americanus*	4.6	0.2	0.06	0.10	13
Flounder, Gulfstream	*Citharichthys arctifrons*	2.1	0.11	0.05	0.05	7
Sea Robin, Northern	*Prionotus carolinus*	1.9	0.10	0.06	0.04	3
Skate, Winter	*Leucoraja ocellata*	1.6	0.08	0.08	0.04	1
Flounder, Windowpane	*Scophtalmus aquosus*	1.6	0.08	0.04	0.04	5
Flounder, Summer (Fluke)	*Paralichthys dentatus*	1.1	0.06	0.06	0.02	1
Sea Scallop	*Placopecten magellanicus*	1.0	0.05	0.04	0.02	3
Monkfish	*Lophius americanus*	0.8	0.04	0.04	0.02	1
Black Sea bass	*Centropristis striata*	0.8	0.04	0.04	0.02	1
Lobster, American	*Homarus americanus*	0.6	0.03	0.02	0.01	2
Herring, Blueback	*Alosa aestivalis*	0.3	0.01	0.01	0.01	2
Dogfish, Spiny	*Squalus acanthias*	0.2	0.01	0.01	0.00	1
Hake, Spotted	*Urophycis regia*	0.2	0.01	0.01	0.00	1
Alewife	*Alosa pseudoharengus*	0.1	0.01	0.01	0.00	1
Shad, American	*Alosa sapidissima*	0.1	0.01	0.01	0.00	1
Total		4566.51				

*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)		% of Total Catch	Tows with Species Present
			Mean	SEM*		
Butterfish	*Peprilus triacanthus*	5515.2	285.4	100.2	65.5	20
Scup	*Stenotomus chrysops*	1641.3	86.1	39.4	19.5	16
Skate, Little	*Leucoraja erinacea*	440.1	22.6	3.4	5.2	20
Squid, Atlantic Longfin	*Dorytheuthis pealei*	309.9	16.0	5.6	3.7	19
Hake, Silver (Whiting)	*Merluccius bilinearis*	298.7	15.4	4.1	3.5	20
Hake, Red	*Urophycis chuss*	119.2	6.1	1.4	1.4	17
Flounder, Fourspot	*Paralichthys oblongus*	37.7	1.9	0.4	0.4	20
Crab, Rock	*Cancer irroratus*	15.2	0.8	0.15	0.18	18
Sea Robin, Northern	*Prionotus carolinus*	13.5	0.7	0.25	0.16	8
Flounder, Winter	*Pleuronectes americanus*	7.7	0.4	0.14	0.09	10
Hake, Spotted	*Urophycis regia*	5.0	0.25	0.14	0.06	6
Flounder, Windowpane	*Scophtalmus aquosus*	3.4	0.18	0.11	0.04	5
Bluefish	*Pomatomus saltatrix*	3.3	0.18	0.18	0.04	1
Skate, Barndoor	*Dipturus laevis*	2.8	0.15	0.08	0.03	5
Dogfish, Smooth	*Mustelus canis*	2.8	0.15	0.15	0.03	1
Skate, Winter	*Leucoraja ocellata*	1.6	0.09	0.09	0.02	1
Monkfish	*Lophius americanus*	1.5	0.08	0.08	0.02	1
Dogfish, Spiny	*Squalus acanthias*	1.2	0.06	0.04	0.01	5
Lobster, American	*Homarus americanus*	1.1	0.05	0.03	0.01	4
Flounder, Summer (Fluke)	*Paralichthys dentatus*	0.9	0.05	0.05	0.01	1
Flounder, Gulfstream	*Citharichthys arctifrons*	0.6	0.03	0.01	0.01	6
Sea Scallop	*Placopecten magellanicus*	0.6	0.03	0.01	0.01	5
Alewife	*Alosa pseudoharengus*	0.3	0.01	0.01	0.004	3
Cusk-Eel, Fawn	*Lepophidium profundorum*	0.2	0.01	0.01	0.002	2
Sculpin, Longhorn	*Myoxocephalus octodecimspinosus*	0.1	0.01	0.01	0.001	1
Crab, Horseshoe	*Limulus polyphemus*	0.1	0.005	0.01	0.001	1
Stingray, Roughtail	*Dasyatis cantroura*	0.0	0.00	0.00	0.00	2
Total		8424.0				

*SEM - Standard Error of the Mean

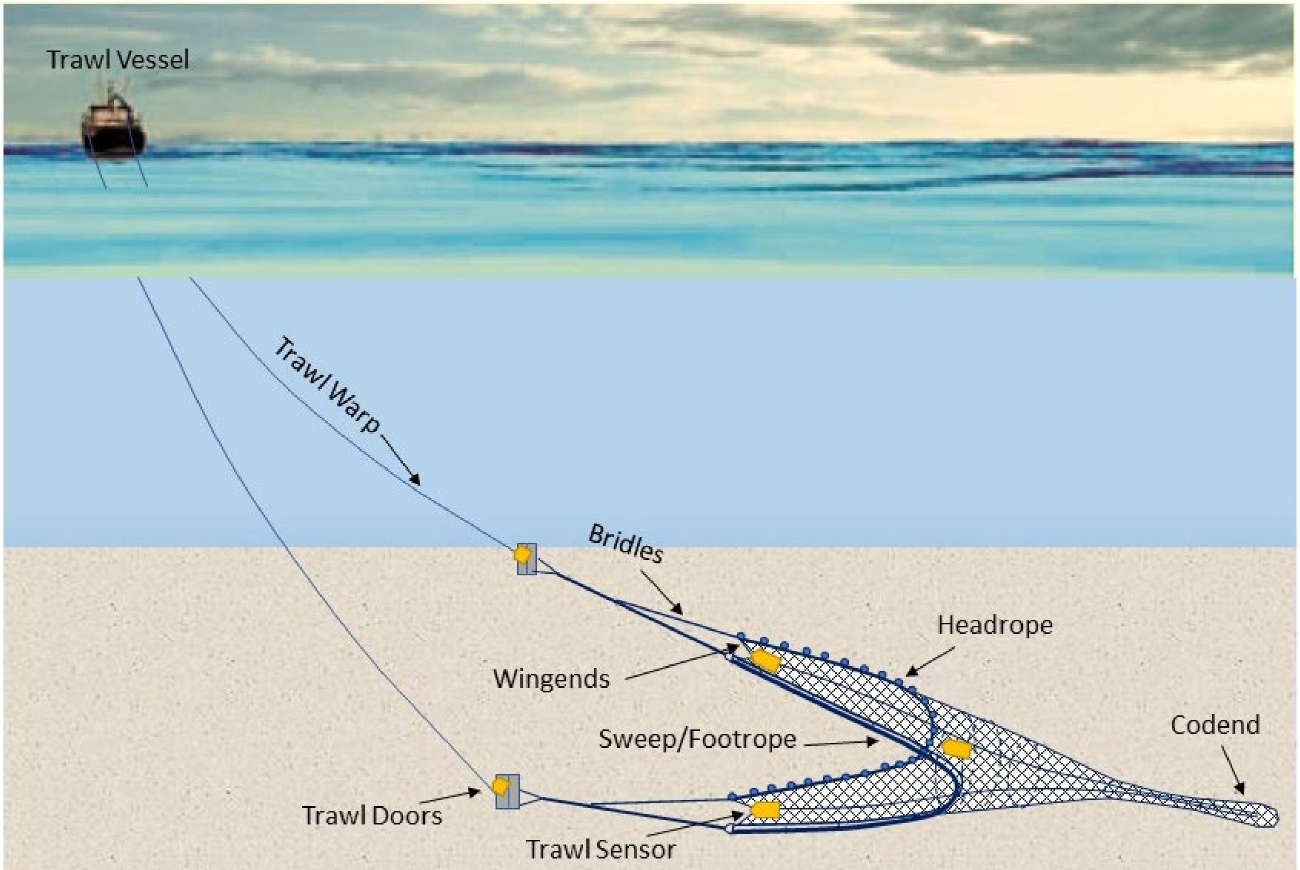


Figure 1: General schematic (not to scale) of a demersal otter trawl. Yellow rectangles indicate Simrad PX trawl geometry sensors.

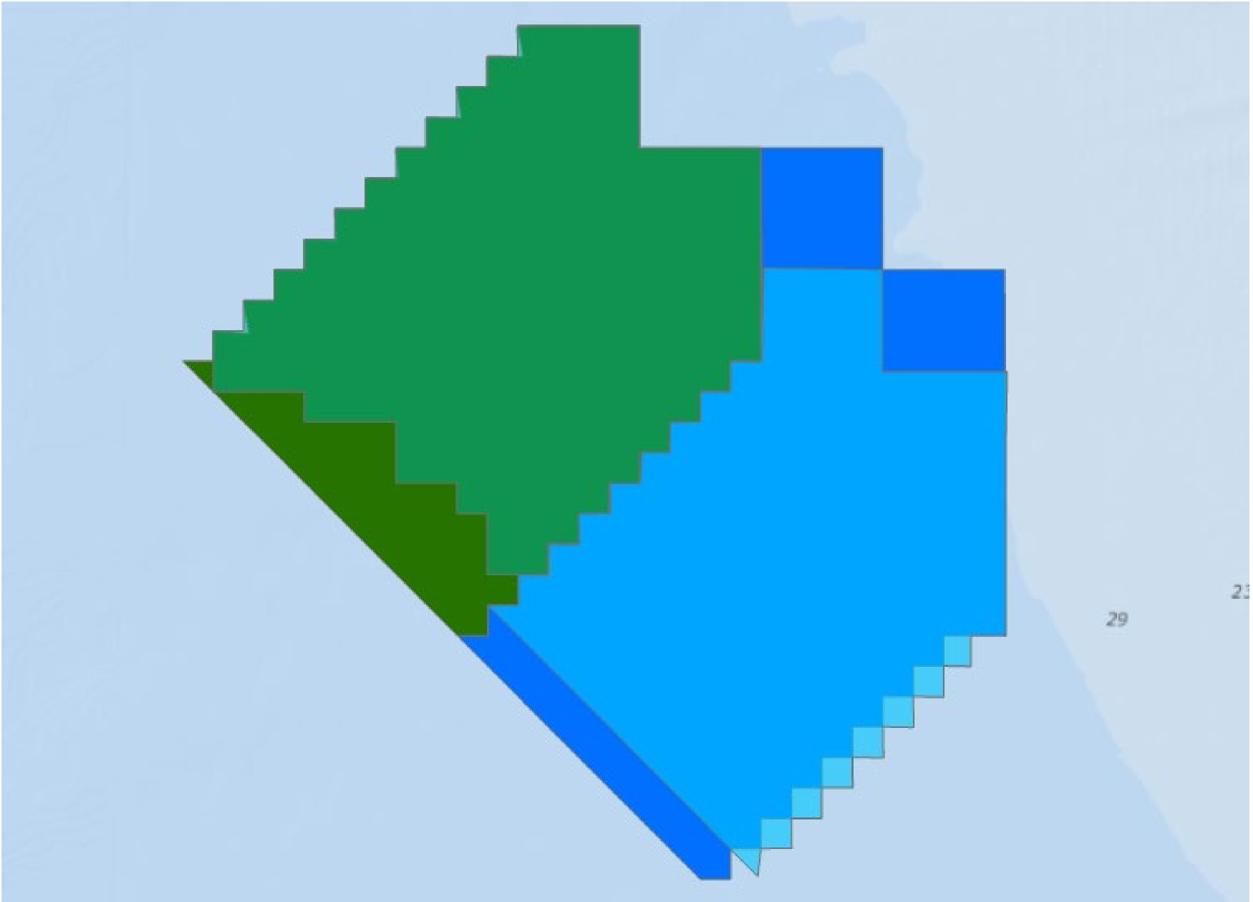


Figure 2: Boundary refinements of the VW1 Study Area and Control Area. The VW1 Study Area was reduced from 306 km^2 (89 nmi^2; dark green) in 2020/2021 to 265 km^2 (77nmi^2; light green) in 2021/2022. The Control Area was similarly reduced from 324 km^2 (94.5 nmi^2; dark blue) to 269.5 km^2 (78.6 nmi^2;light blue).

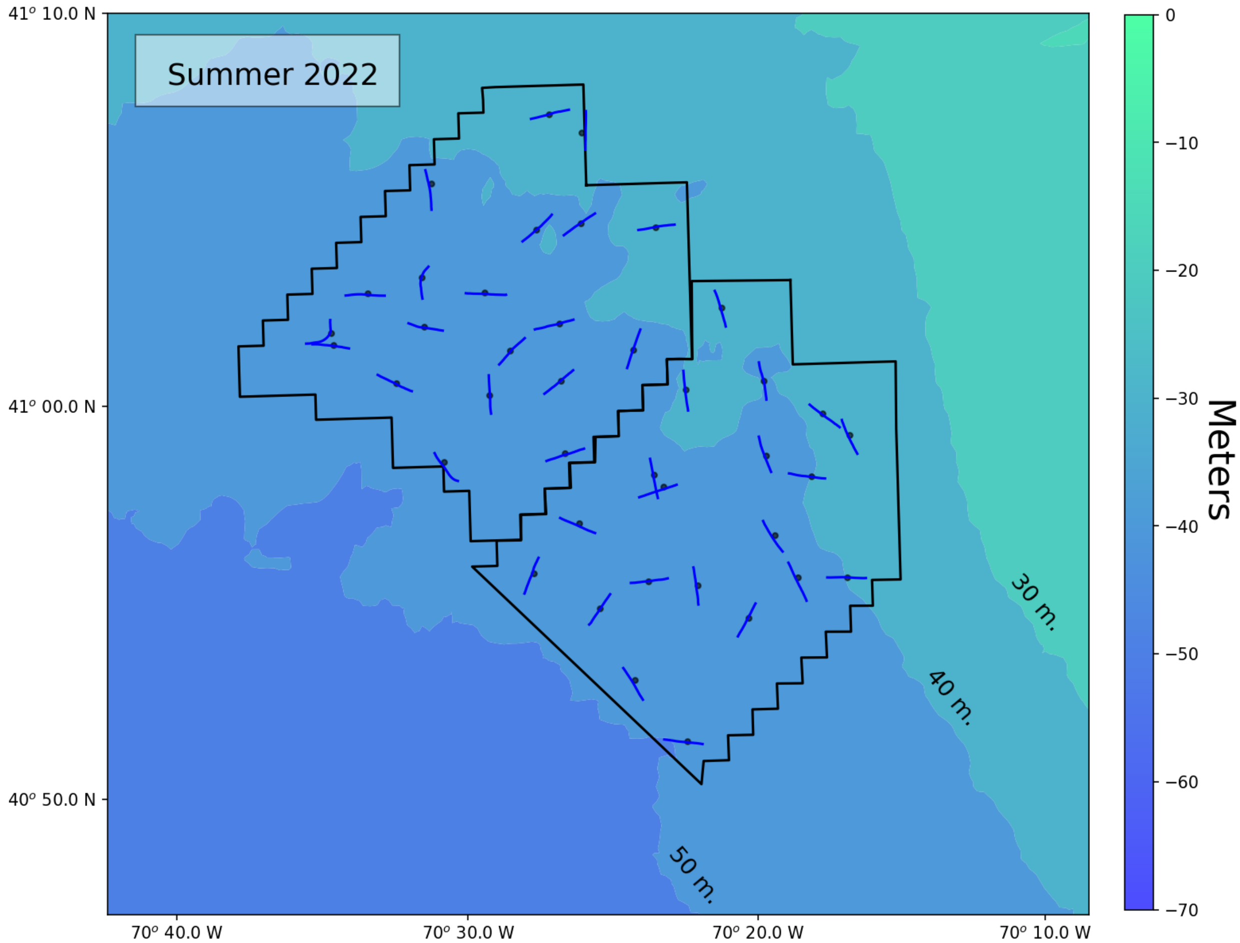


Figure 3: Tow locations (black dots) and trawl tracks (blue lines) from the VW1 Study Area (left) and the Control Area (right).

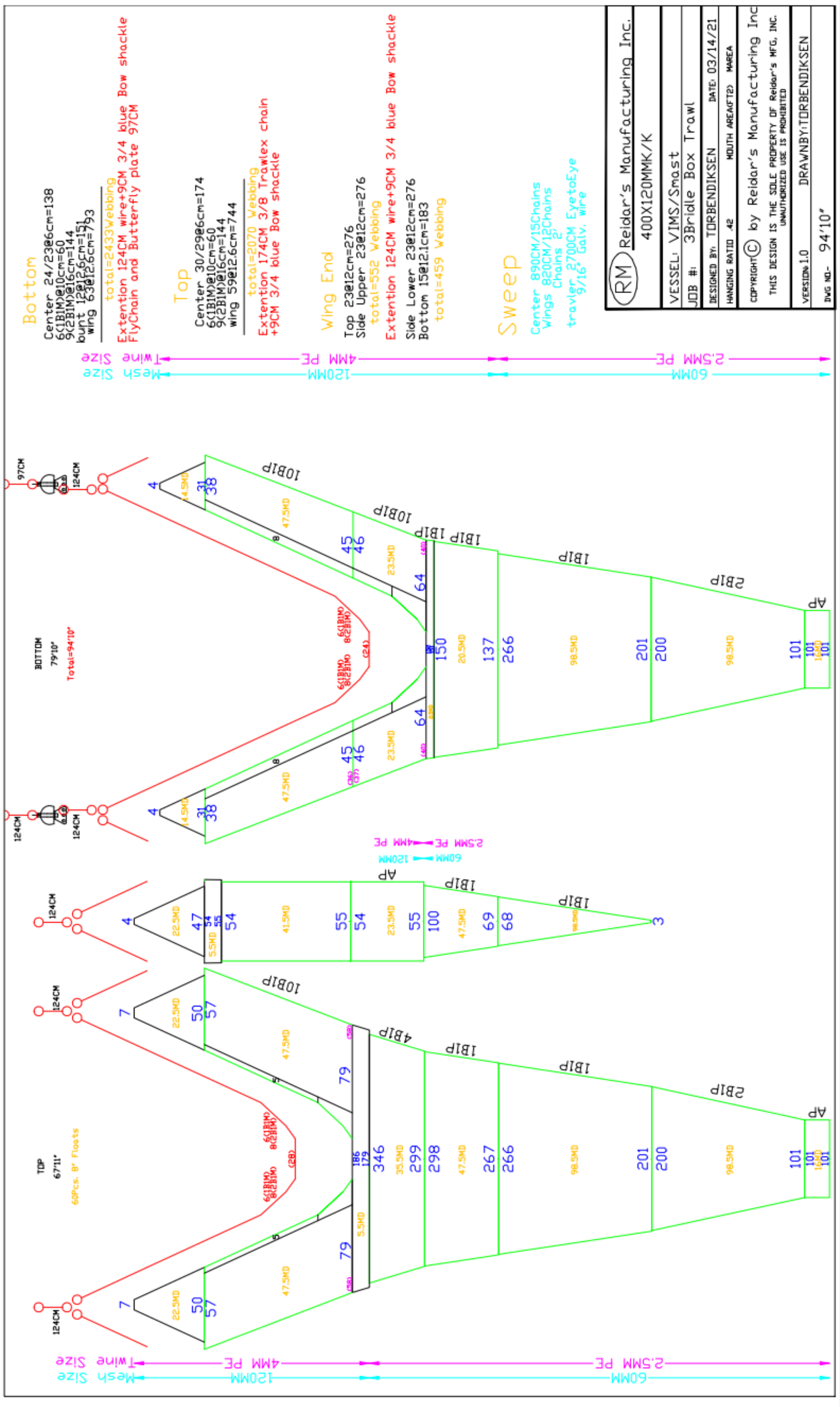


Figure 4: Schematic net plan for the NEAMAP trawl (Courtesy of Reidar's Manufacturing Inc.).

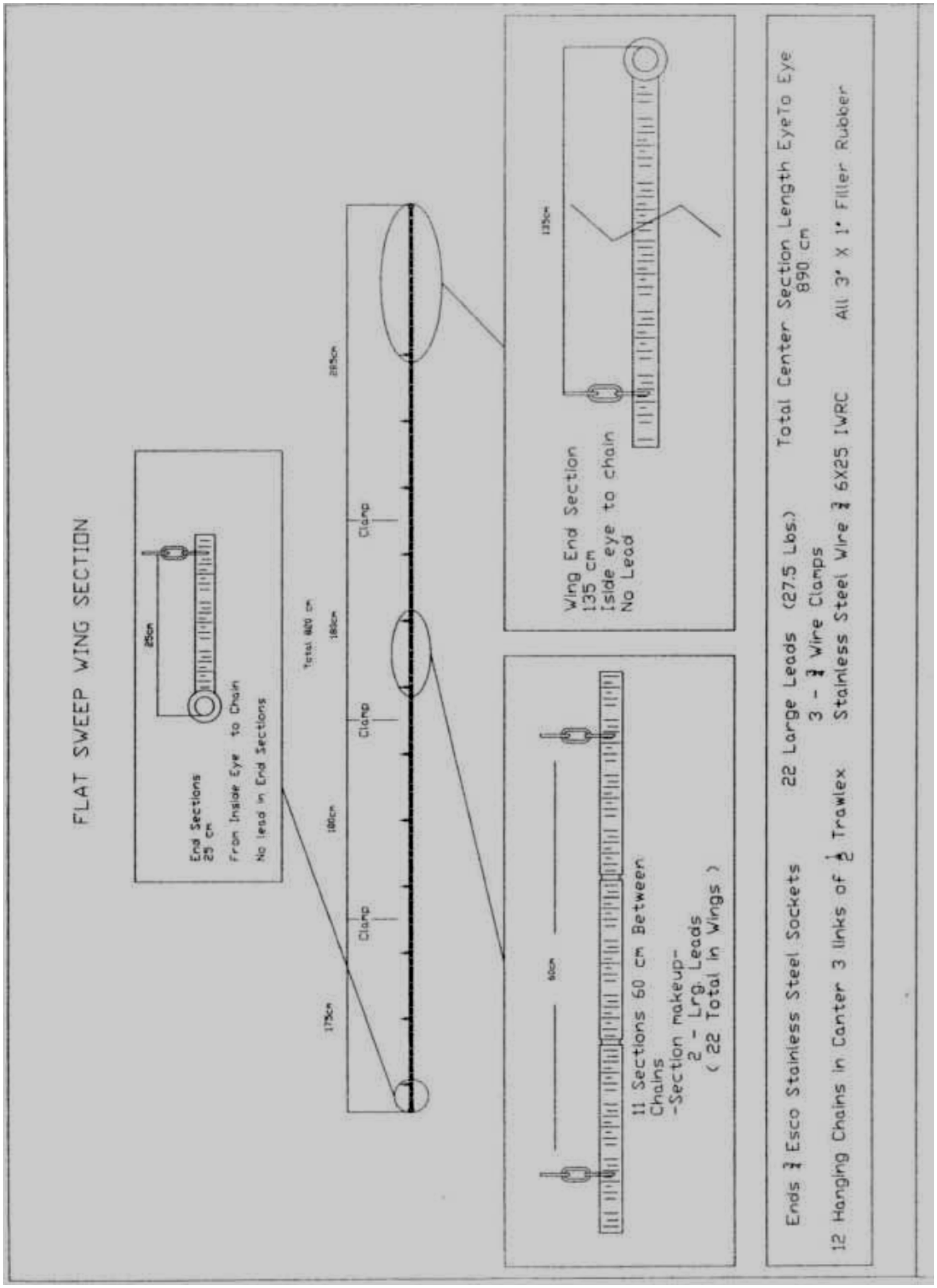


Figure 5: Sweep diagram for the survey trawl (Bonzek et al., 2008).

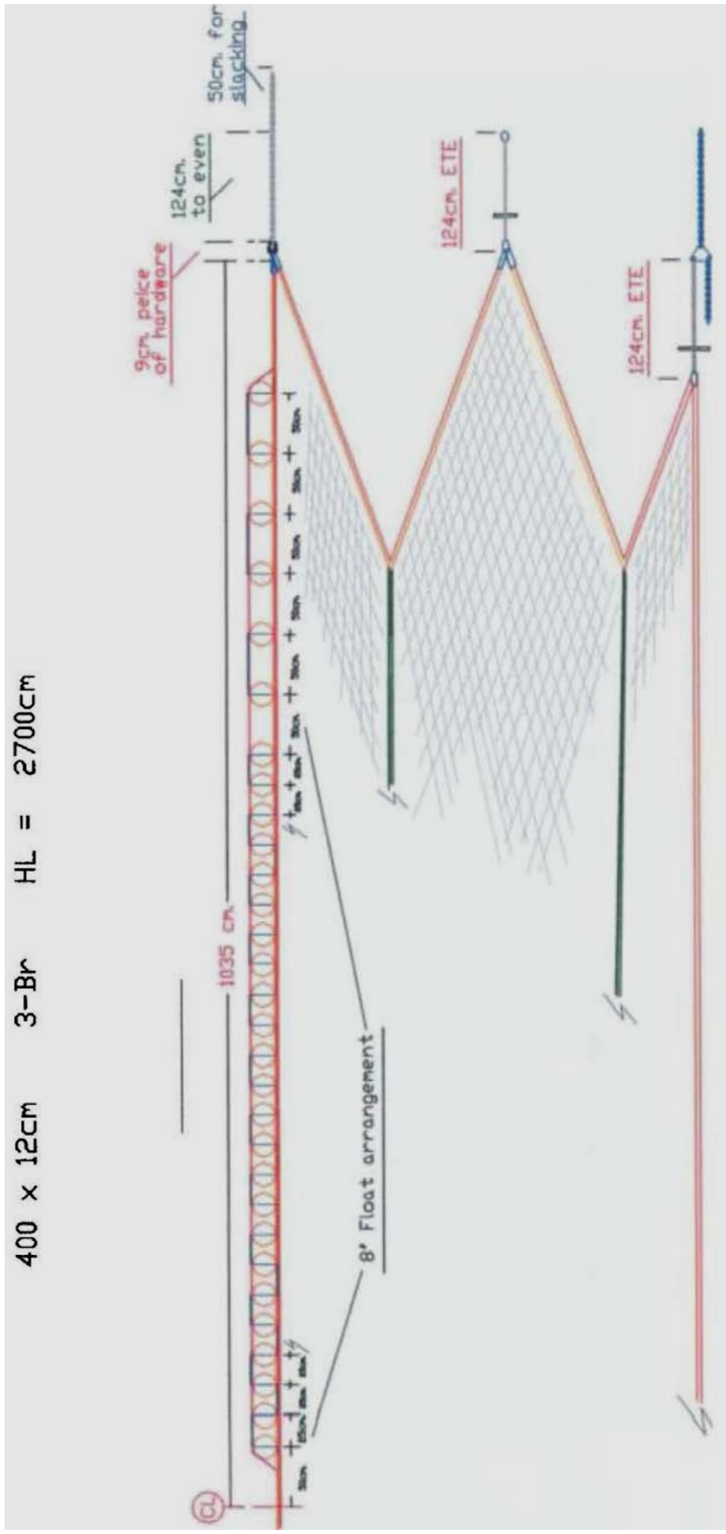


Figure 6: Headrope and rigging plan for the survey trawl (Bonzek et al., 2008).

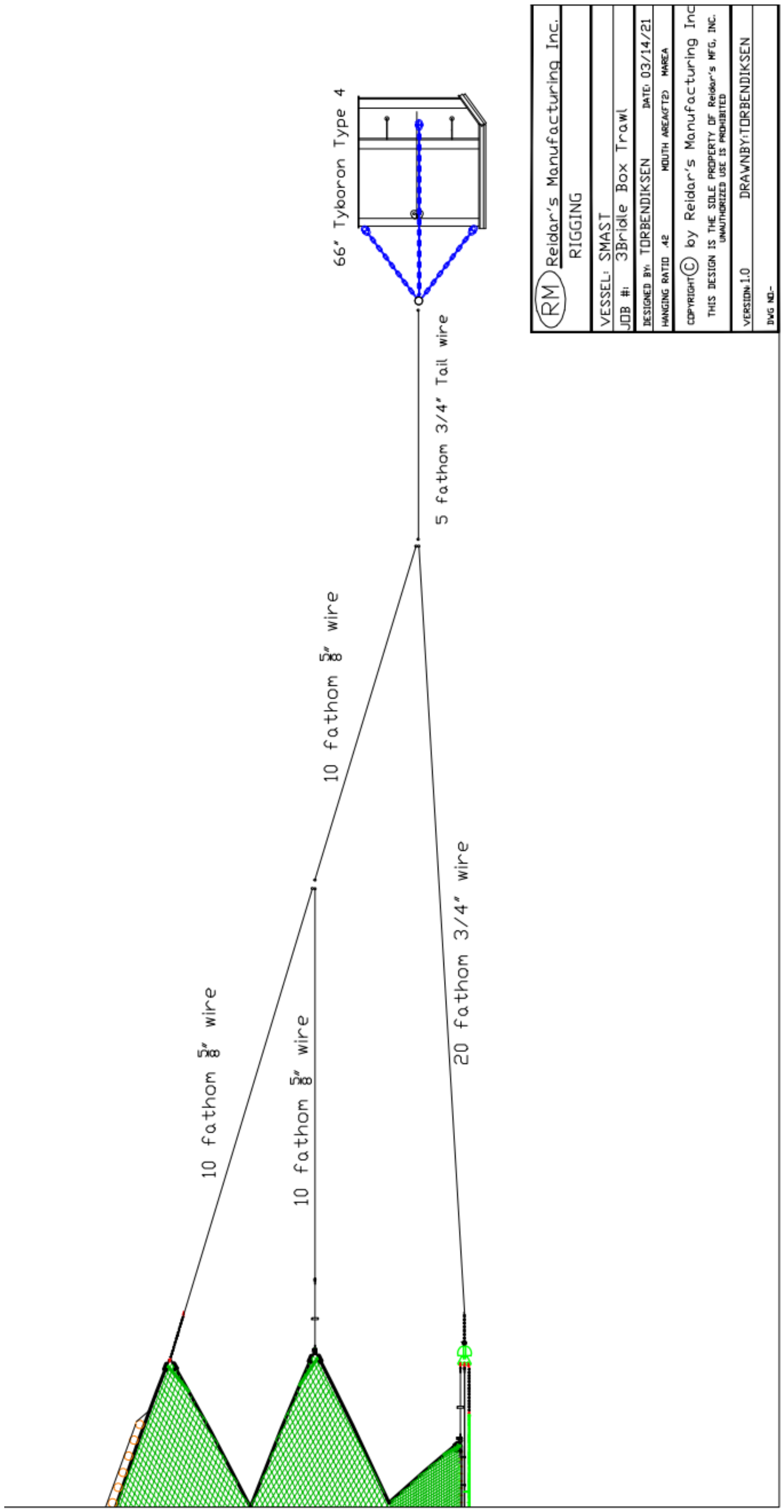


Figure 7: Bridle and door rigging schematic for the survey trawl (Courtesy of Reidar's Manufacturing Inc.).

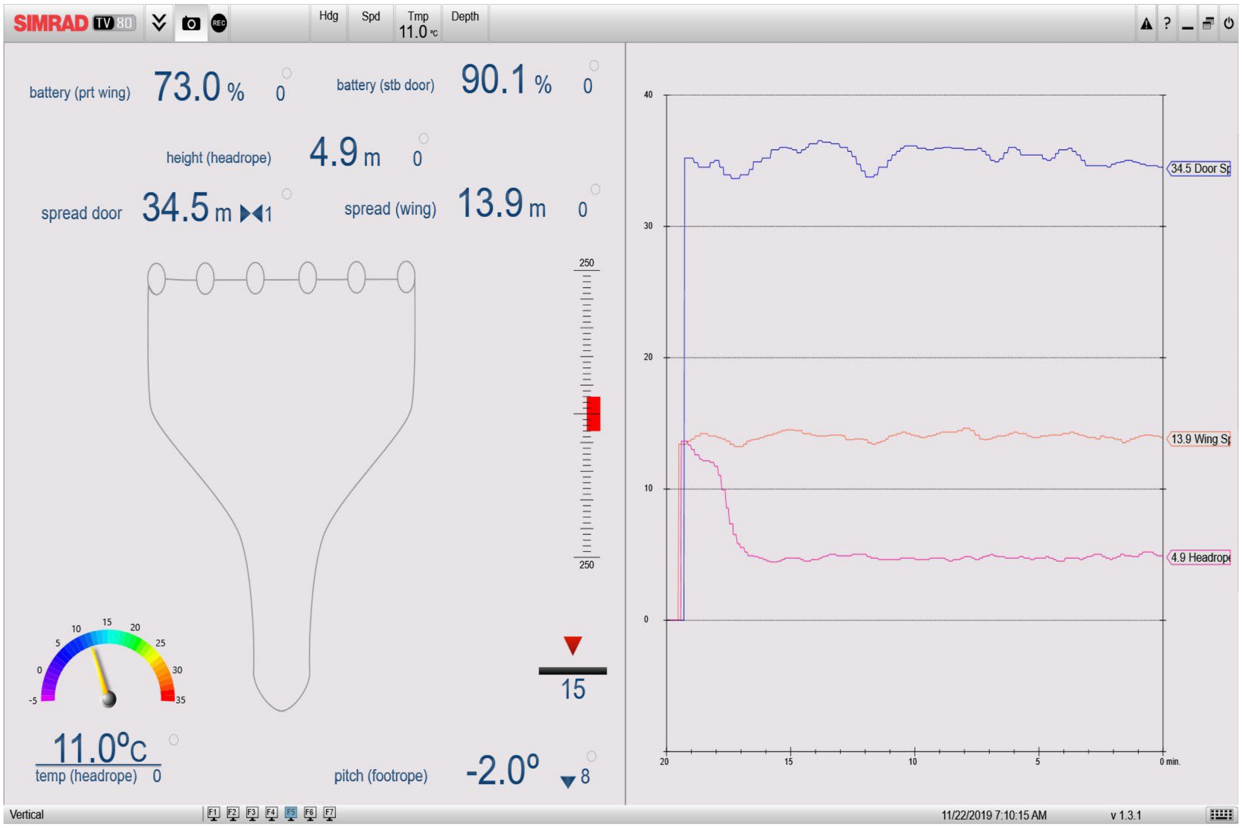


Figure 8: Screenshot of the SIMRAD TV80 software monitoring the trawl parameters.

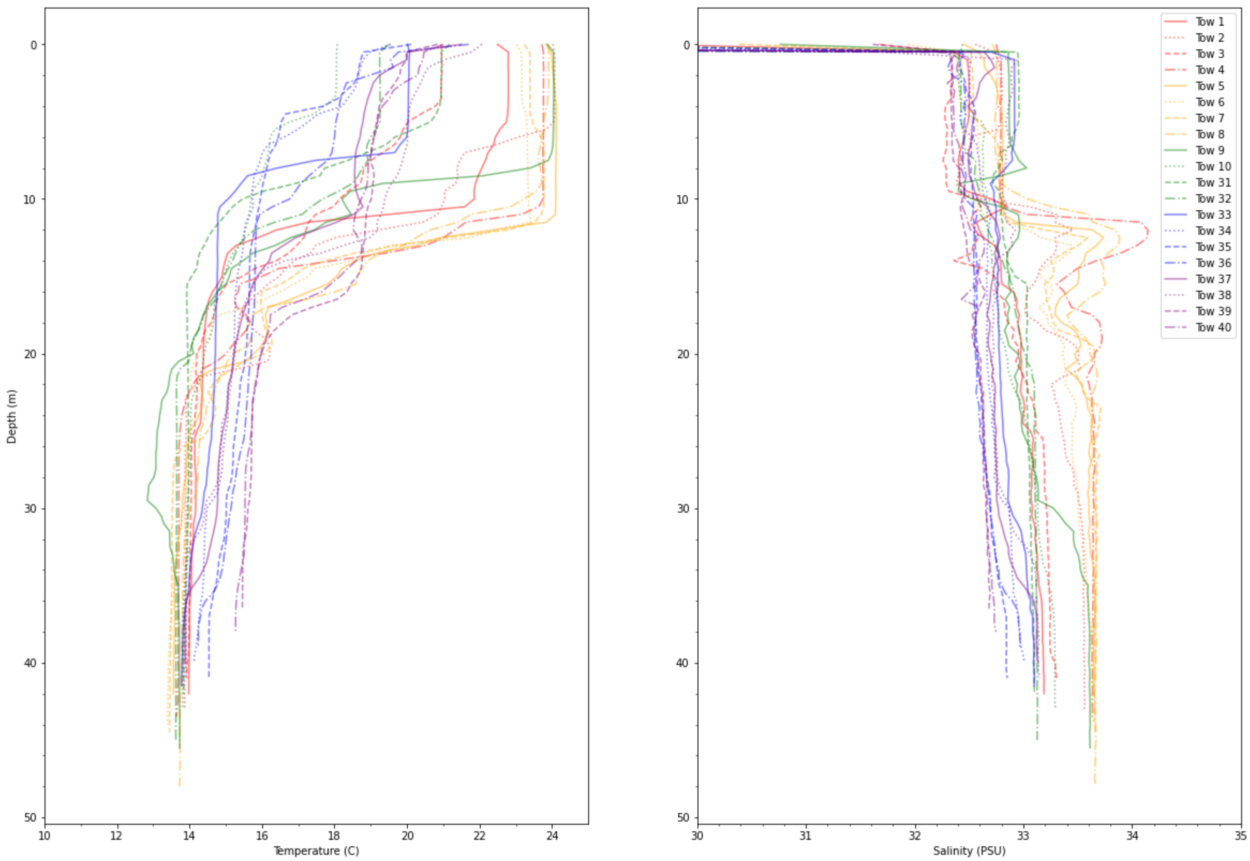


Figure 9: CTD downcast profiles from the VW1 Study Area.

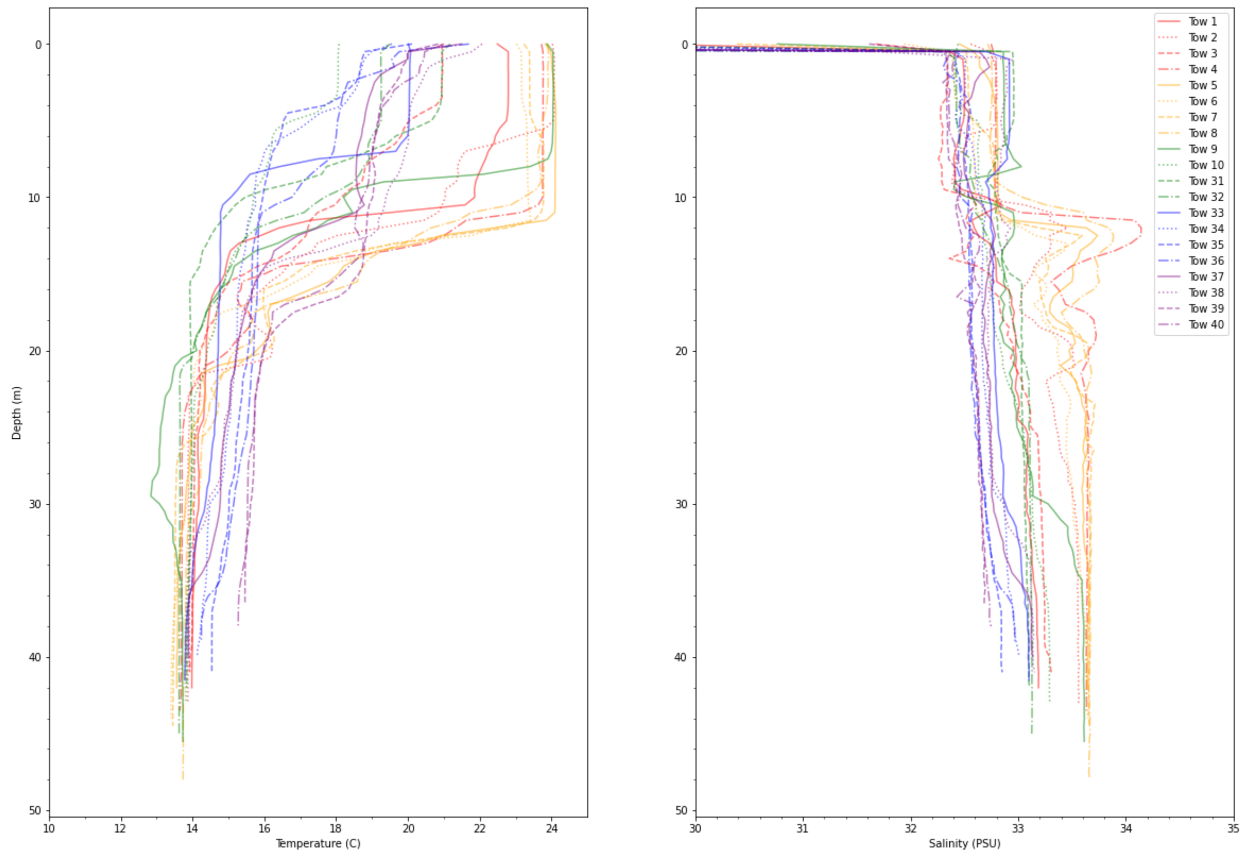
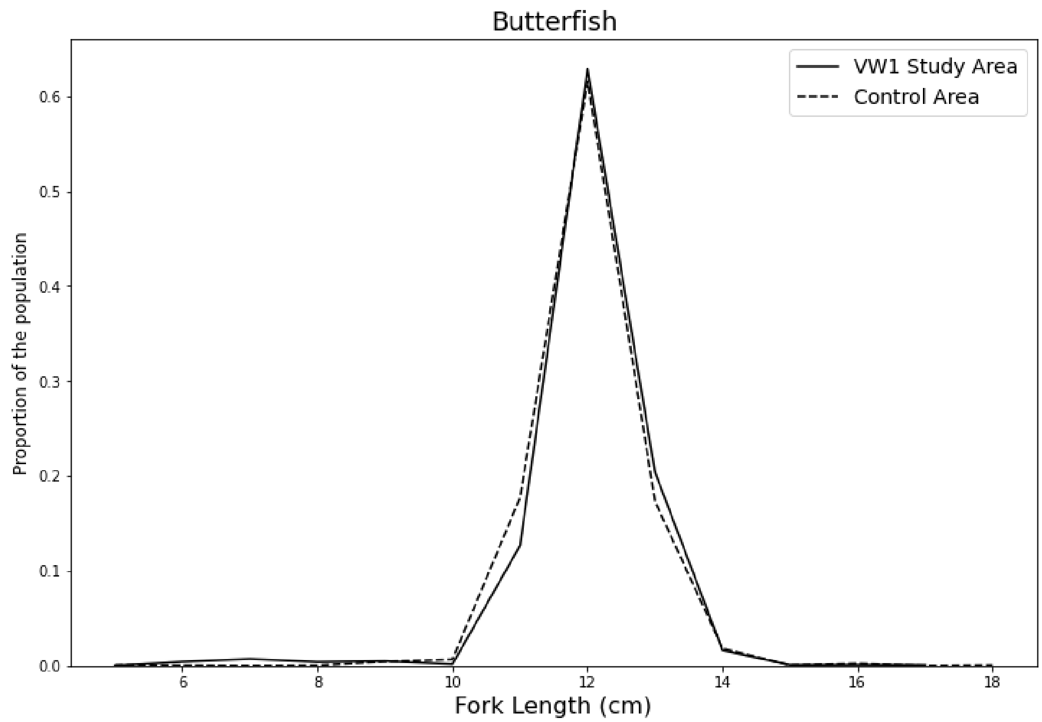


Figure 10: CTD downcast profiles from the Control Area



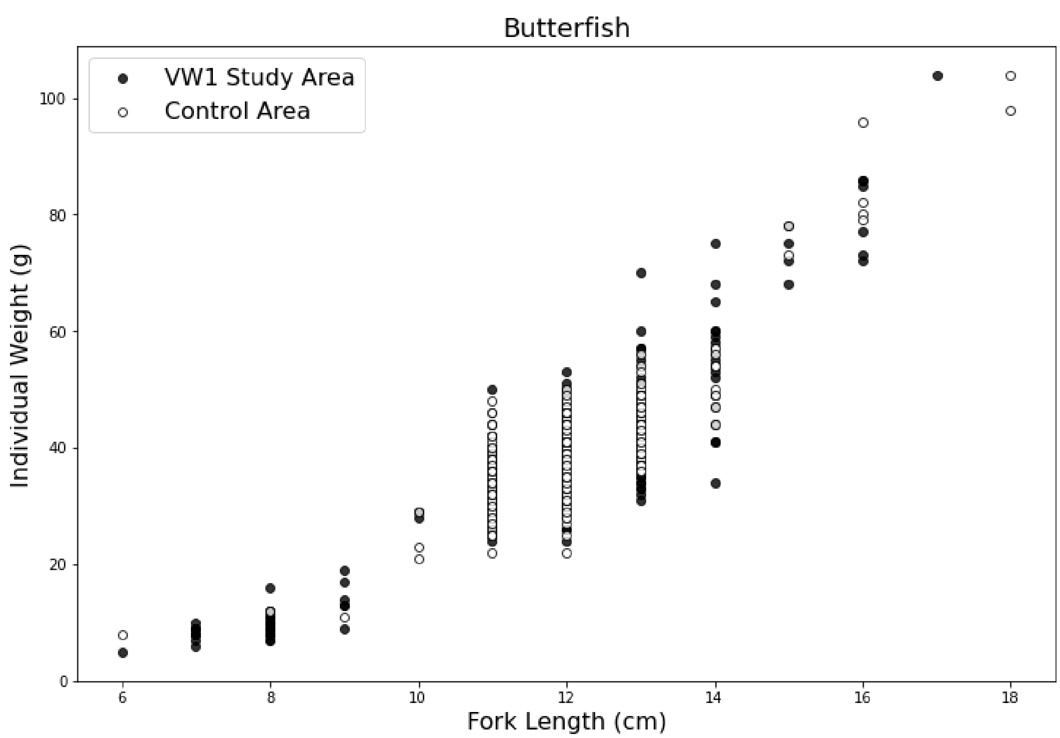


Figure 11: Population structure of butterfish in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

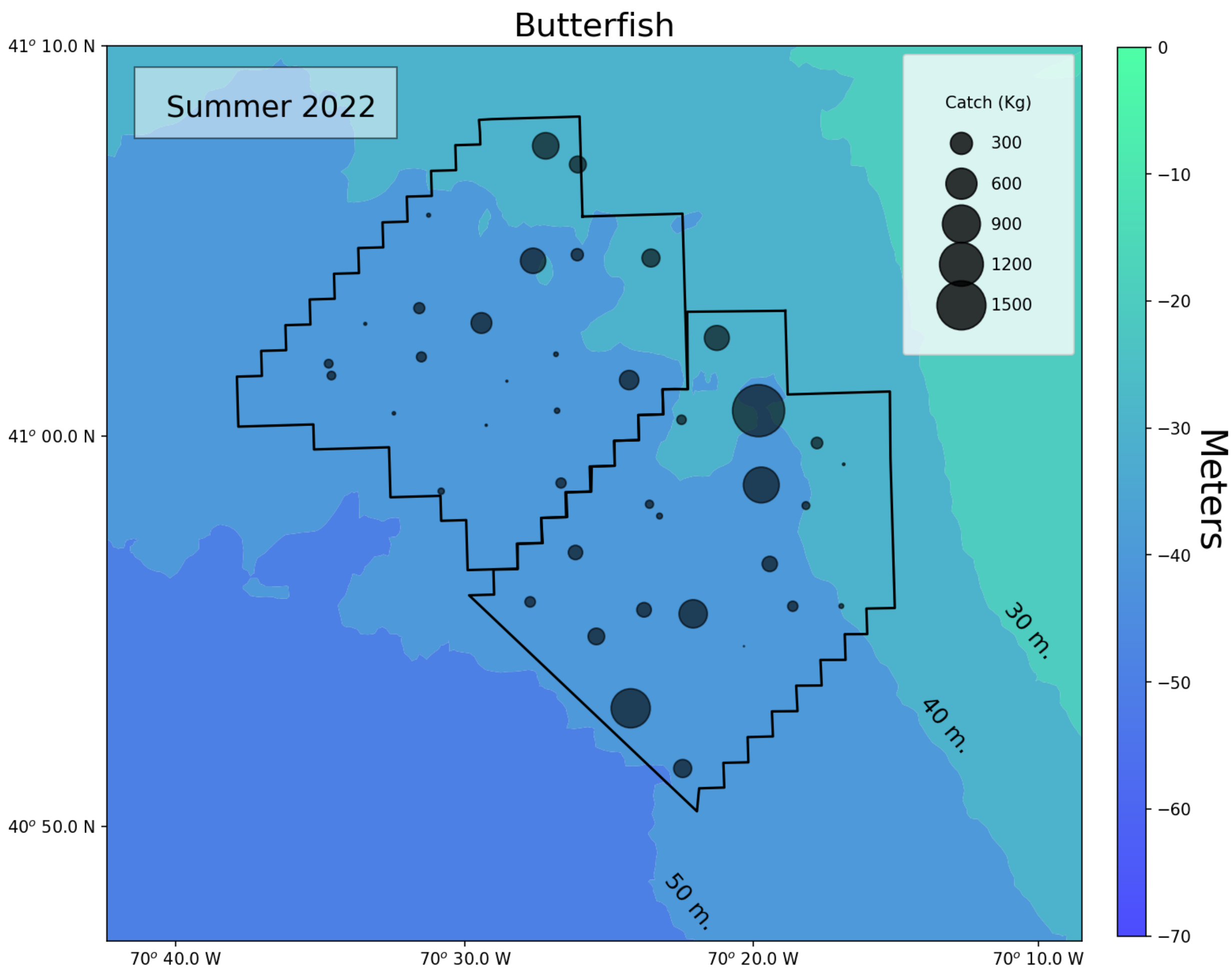


Figure 12: Distribution of the catch of butterfish in the VW1 Study Area (left) and Control Area (right).

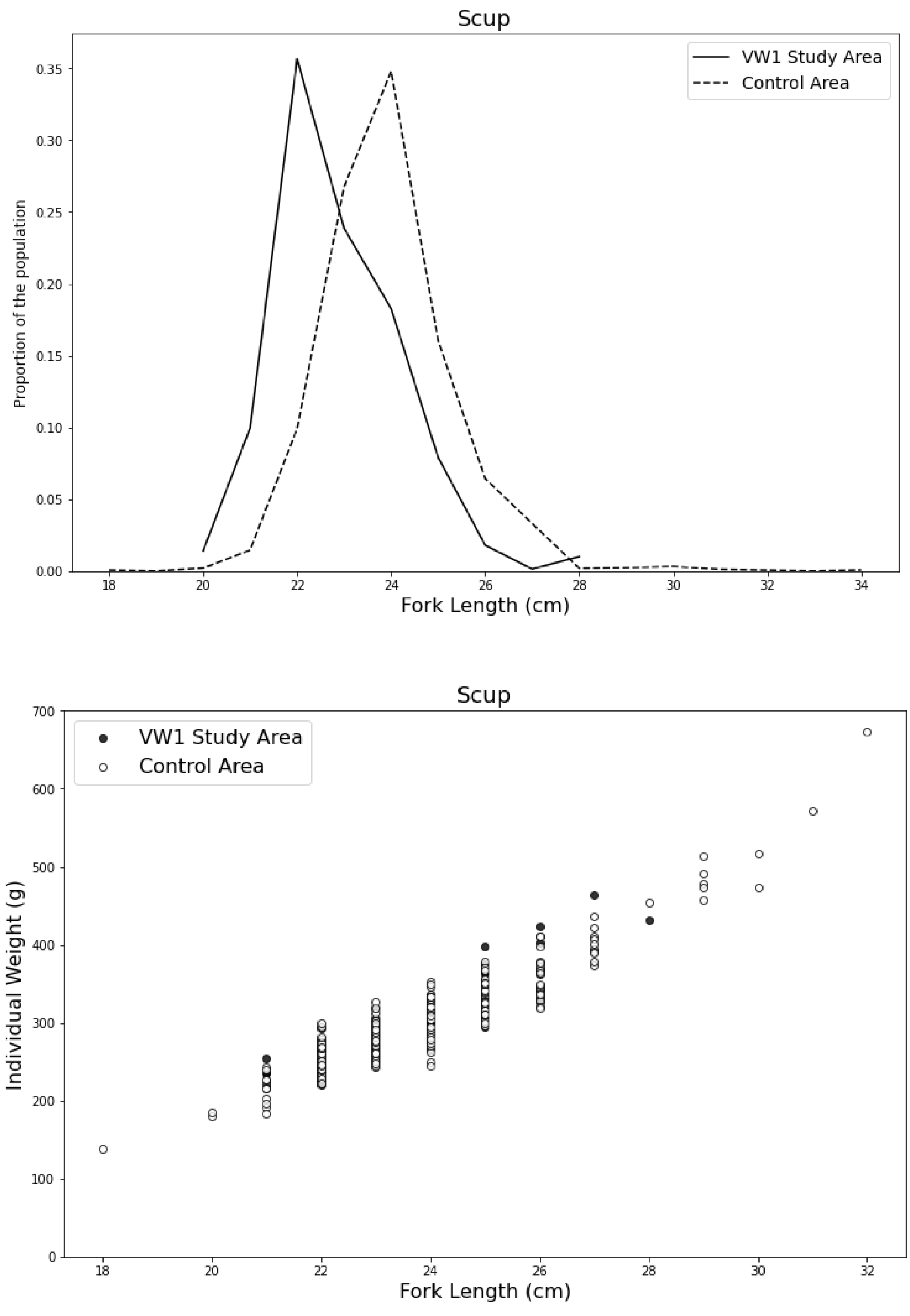


Figure 13: Population structure of scup in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

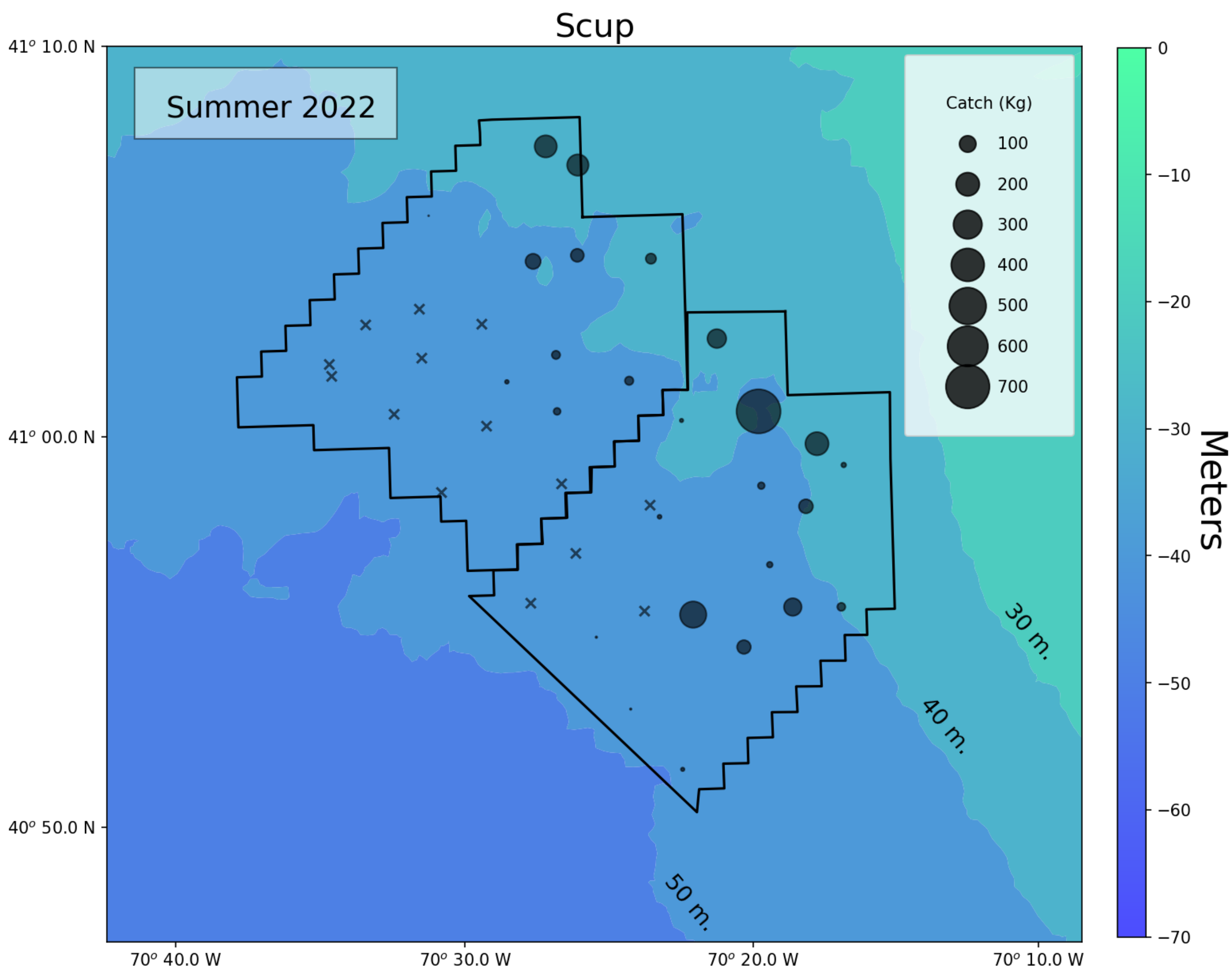
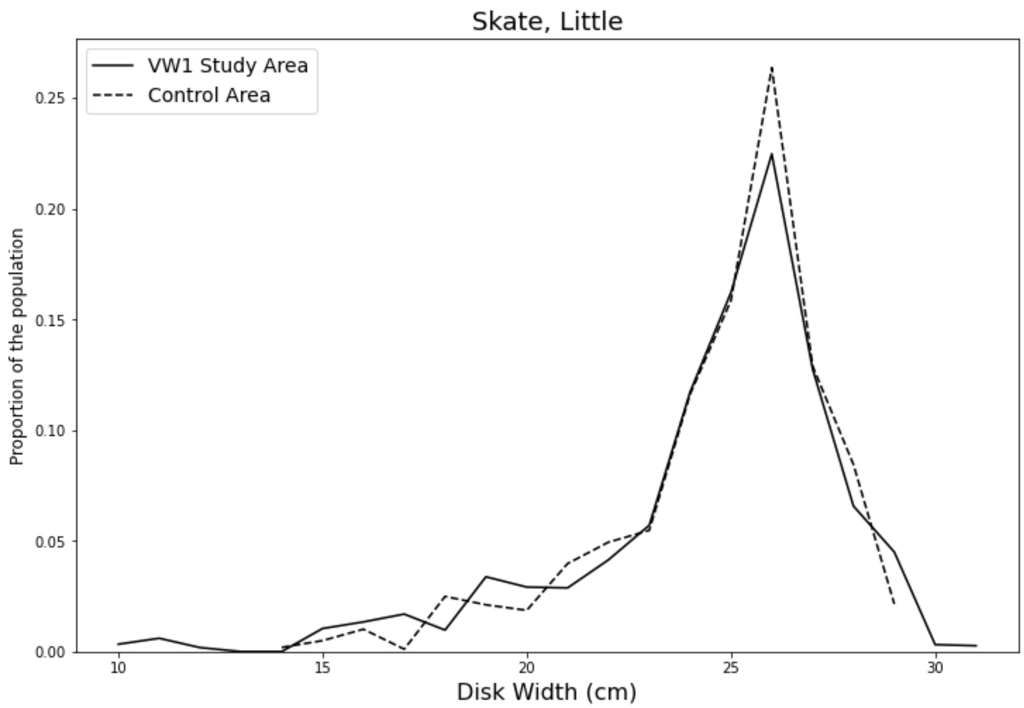


Figure 14: Distribution of the catch of scup in the VW1 Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



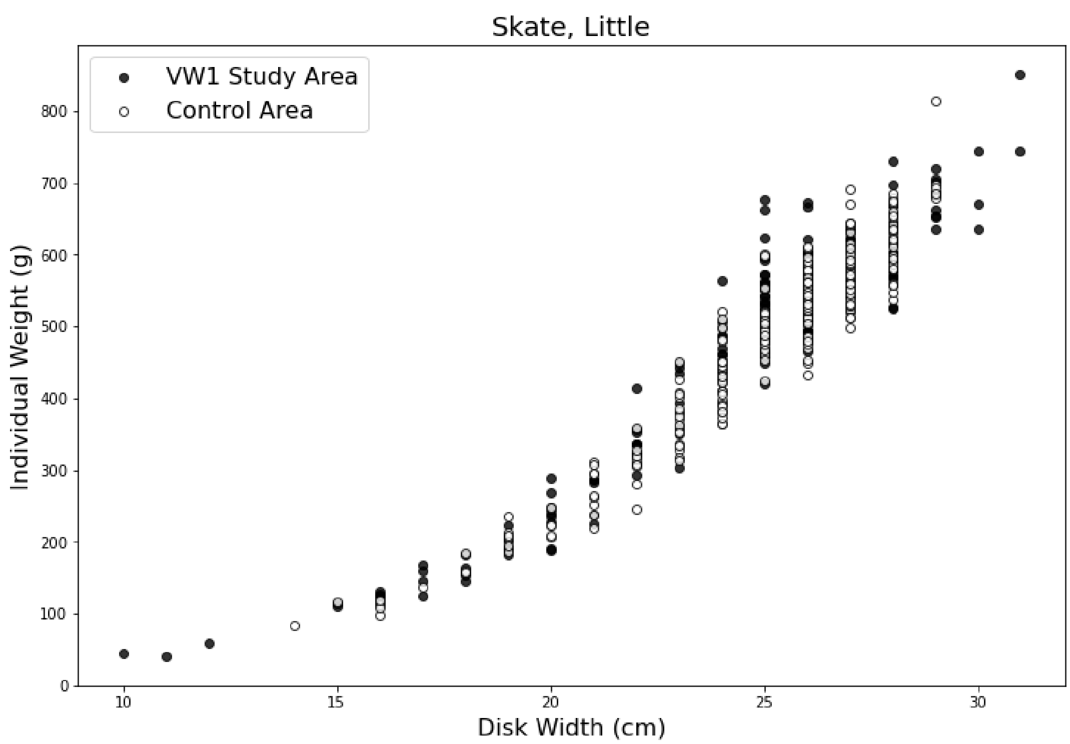


Figure 15: Population structure of little skate in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

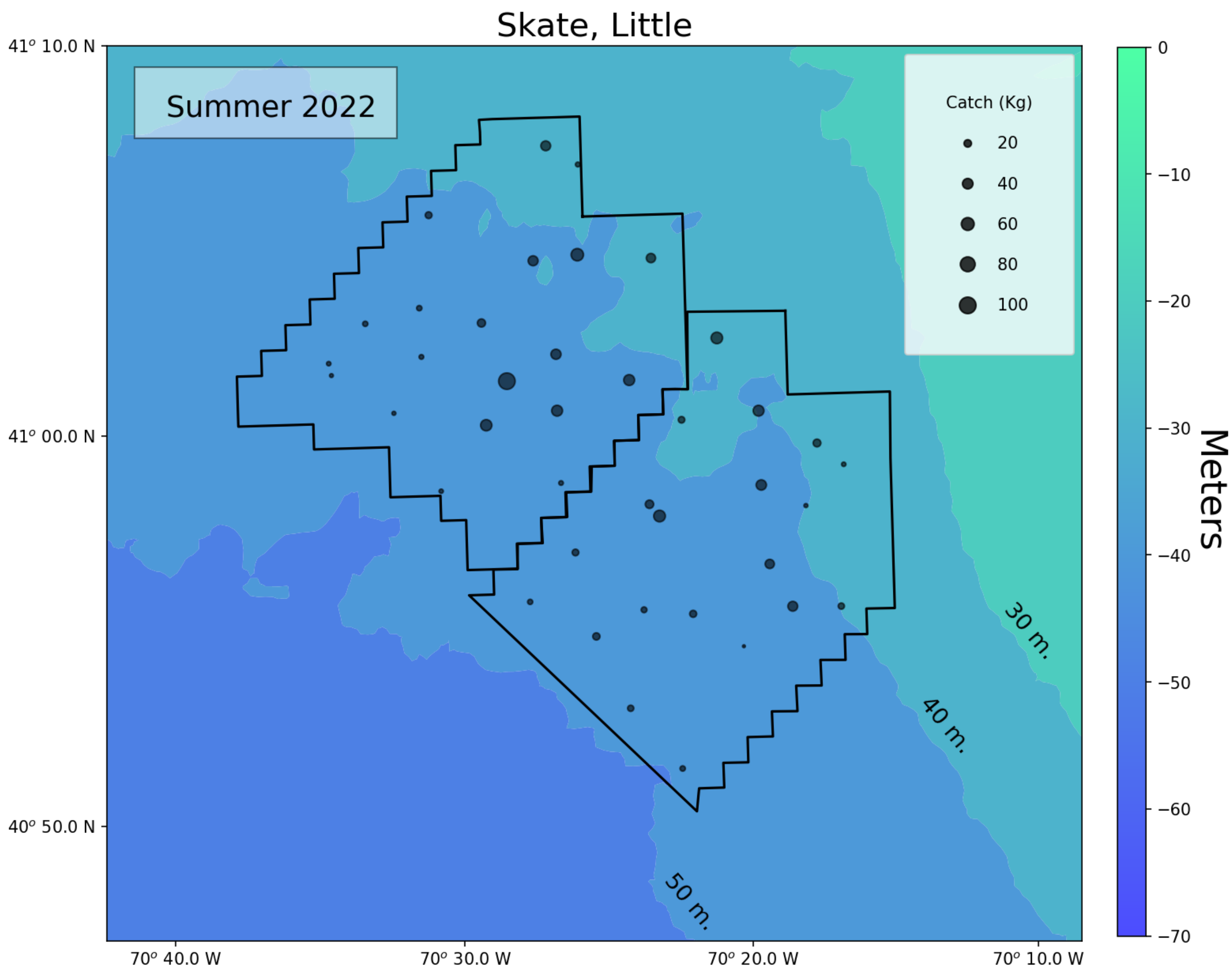
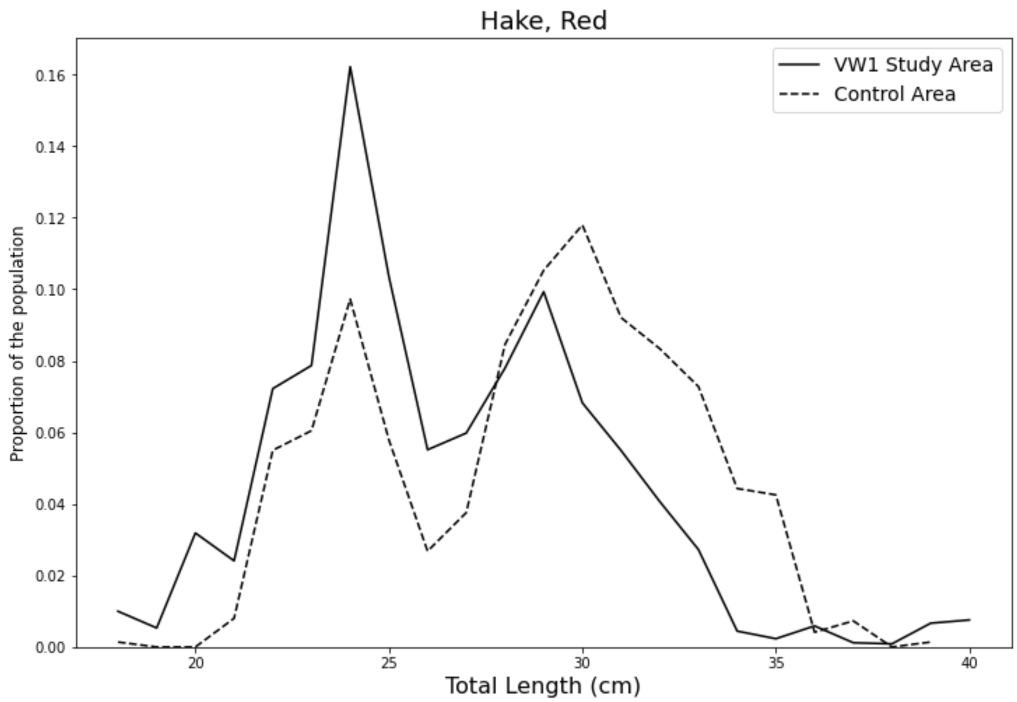


Figure 16: Distribution of the catch of little skate in the VW1 Study Area (left) and Control Area (right).



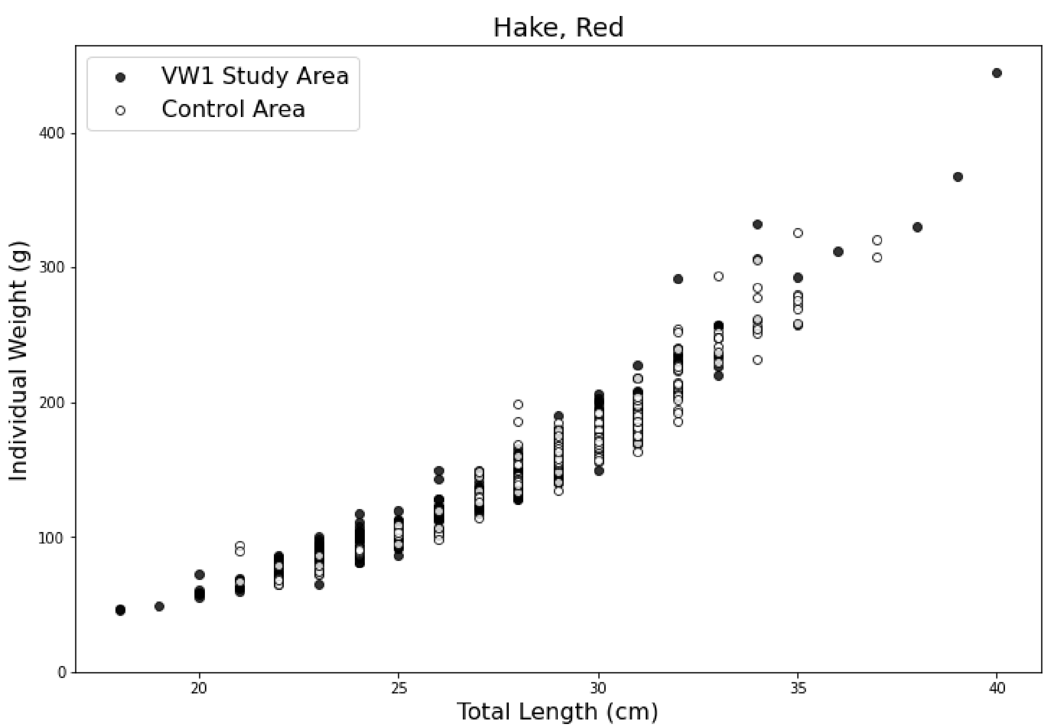


Figure 17: Population structure of red hake in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

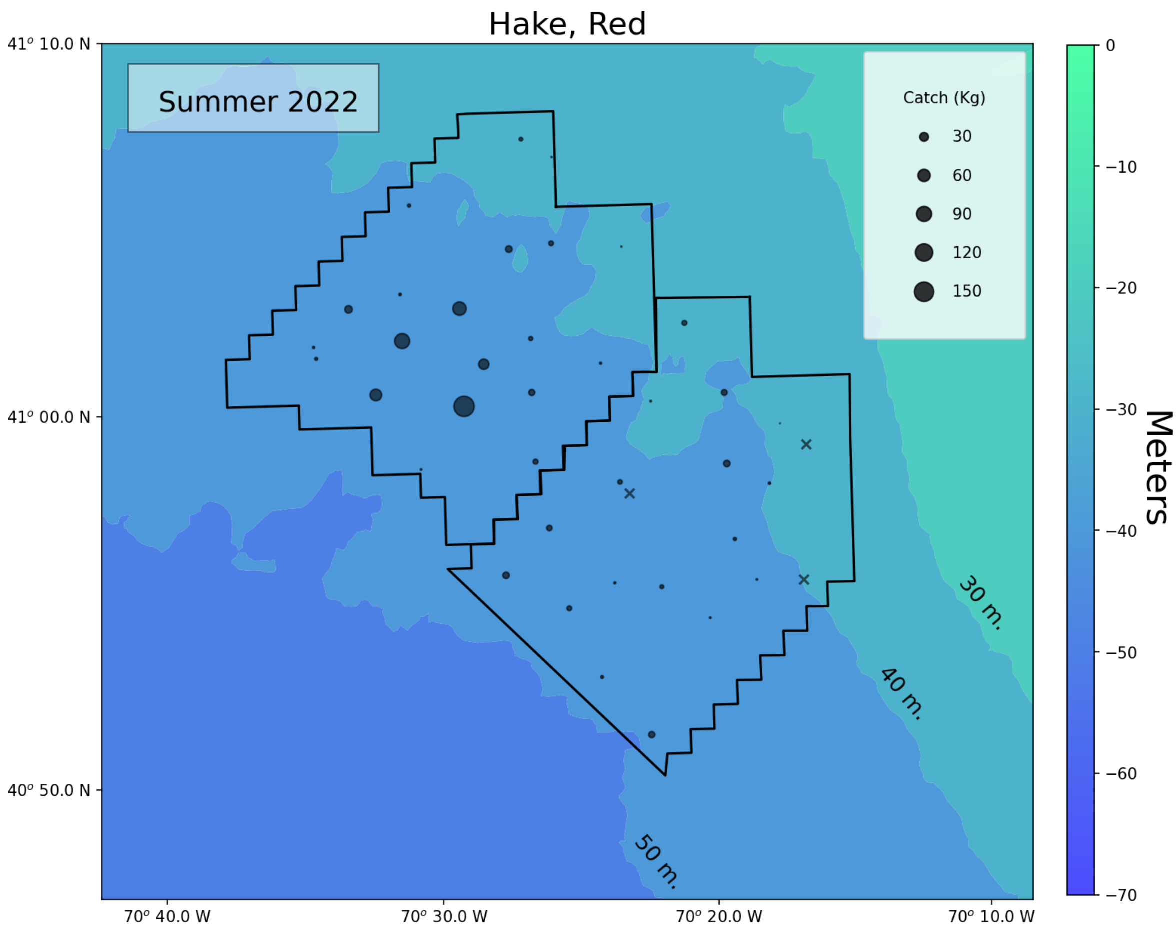
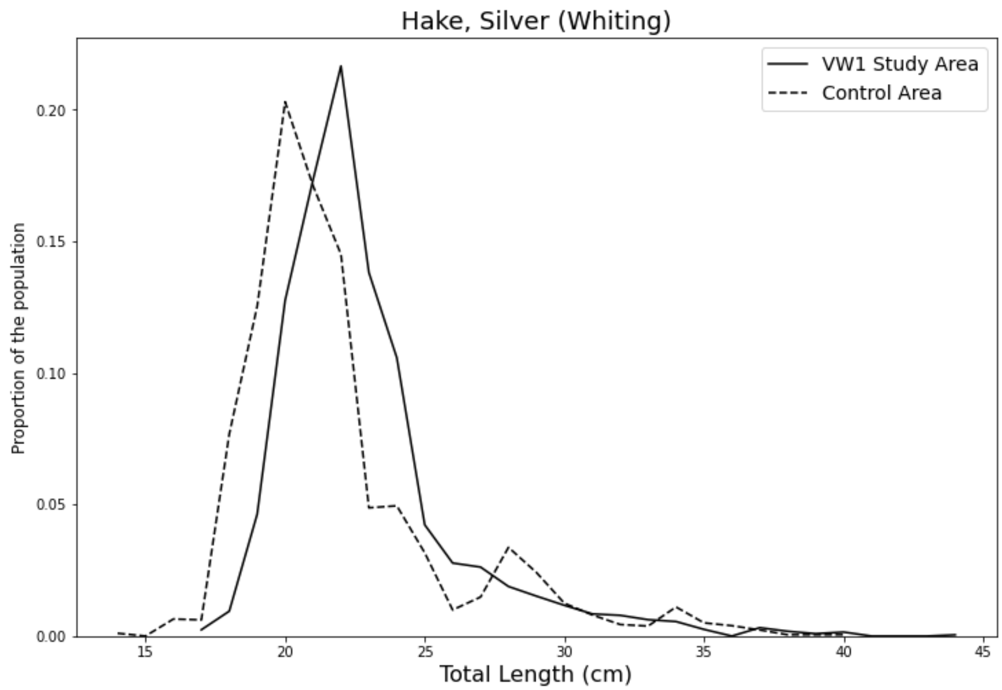


Figure 18: Distribution of the catch of red hake in the VW1 Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



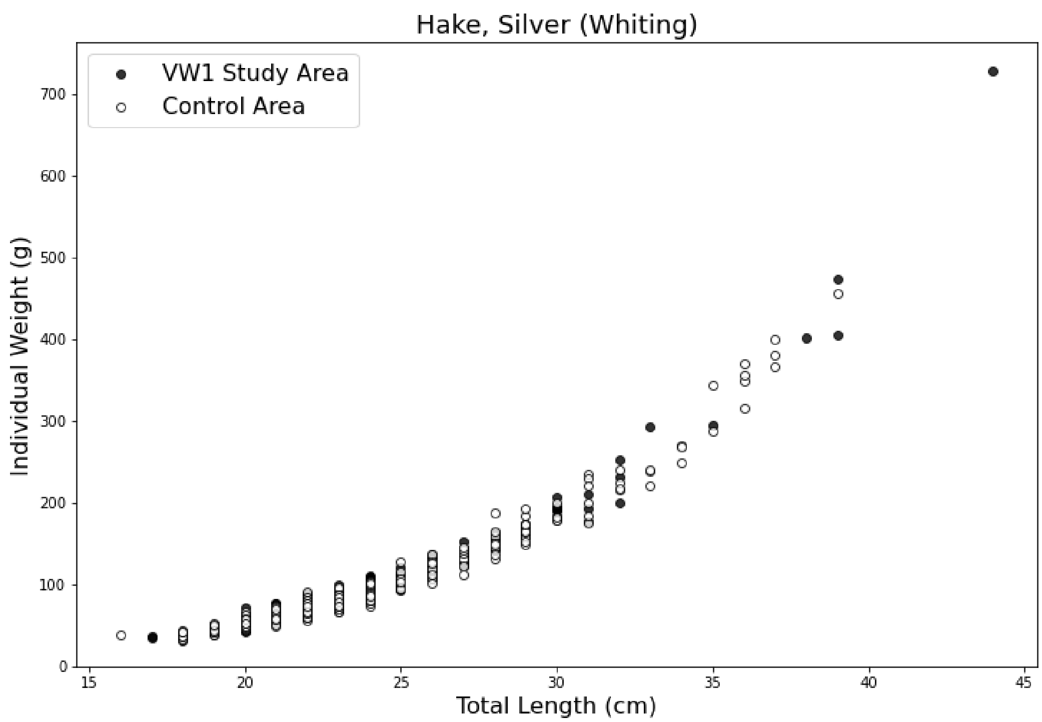


Figure 19: Population structure of silver hake in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

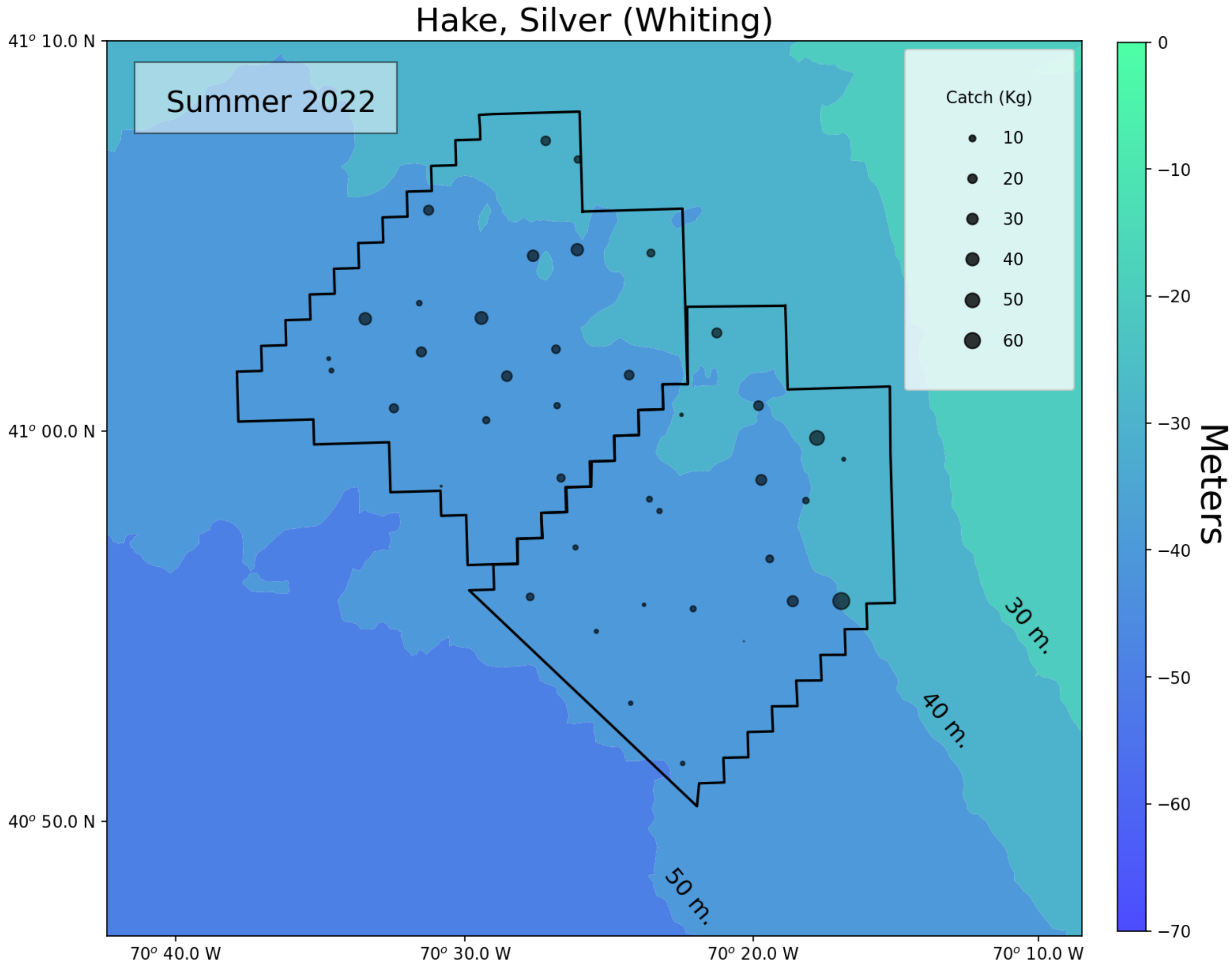


Figure 20: Distribution of the catch of silver hake in the VW1 Study Area (left) and Control Area (right).

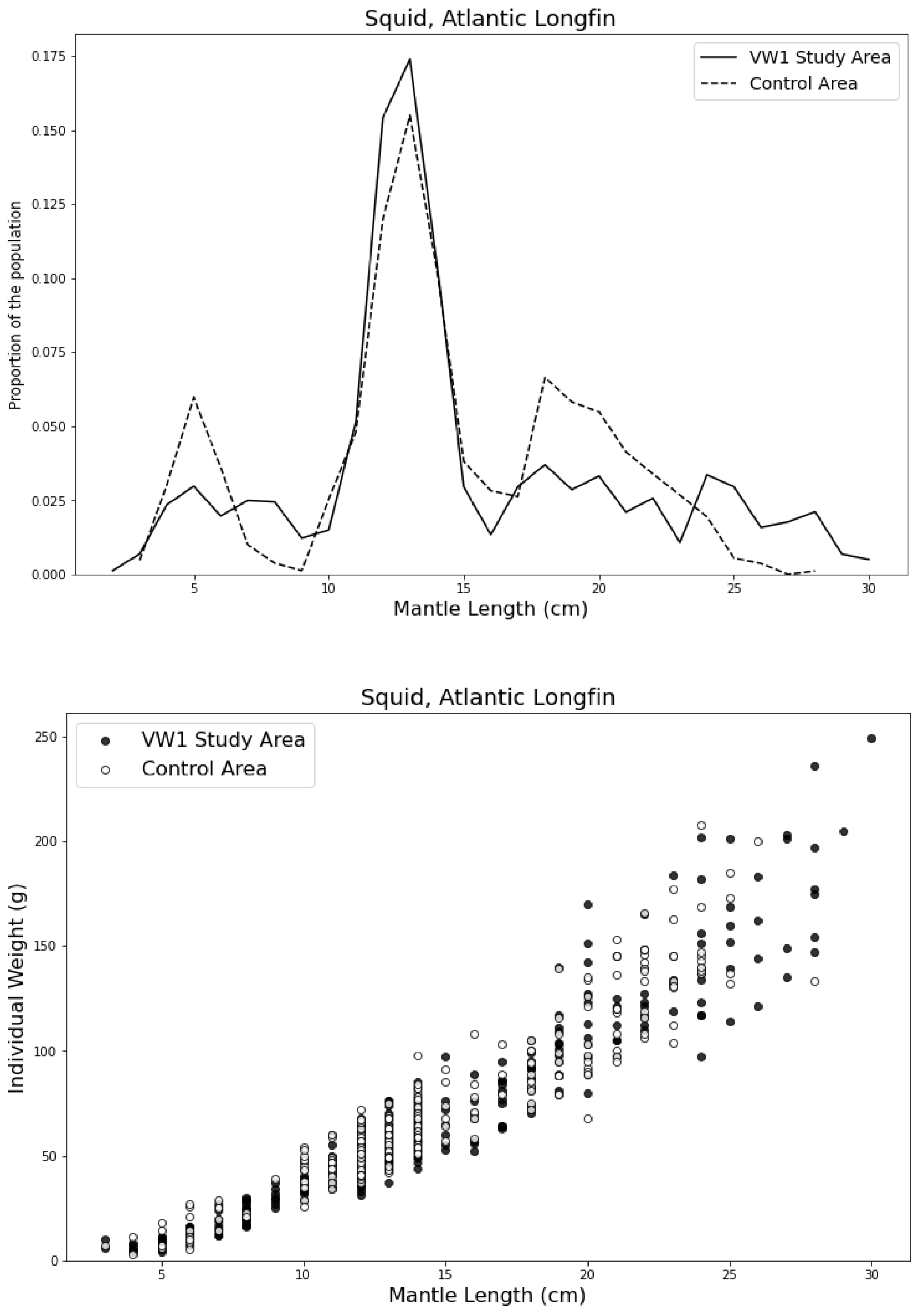


Figure 21: Population structure of Atlantic longfin squid in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

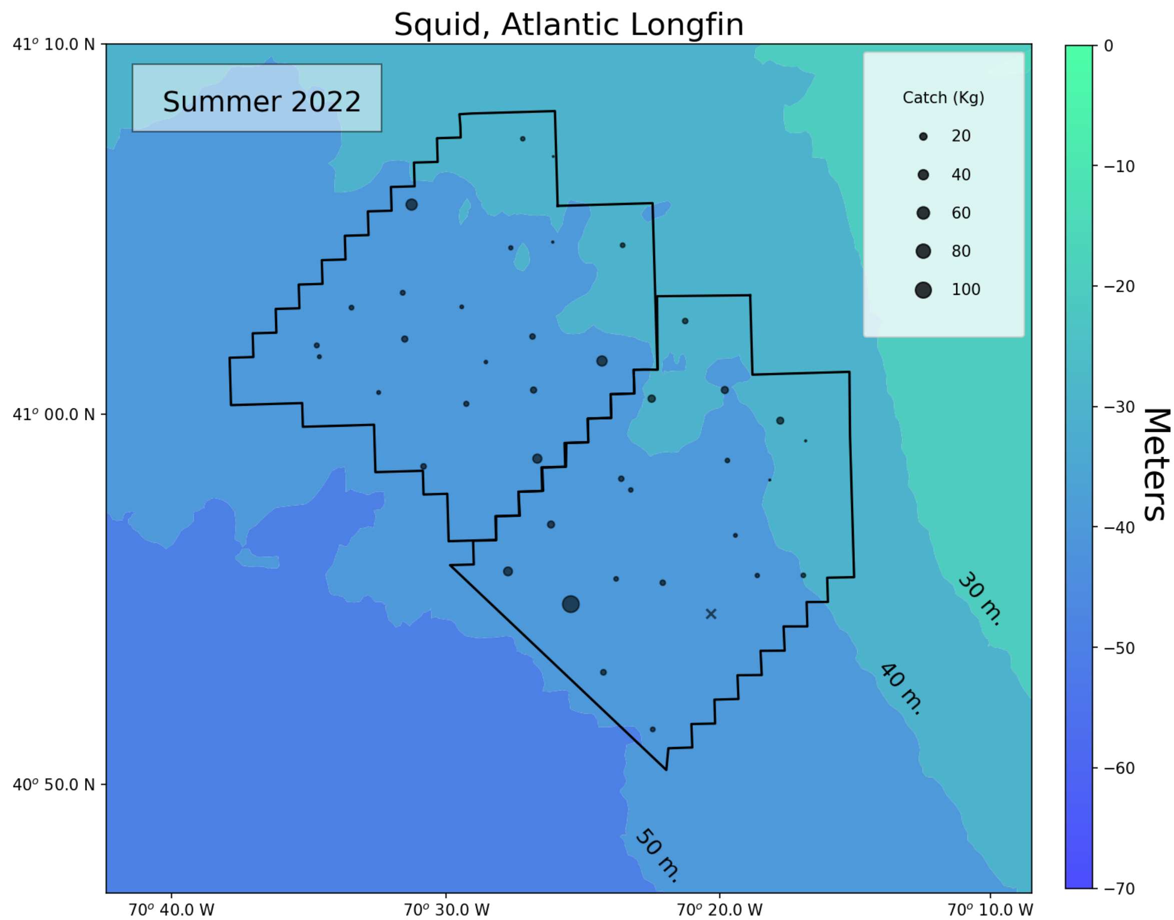
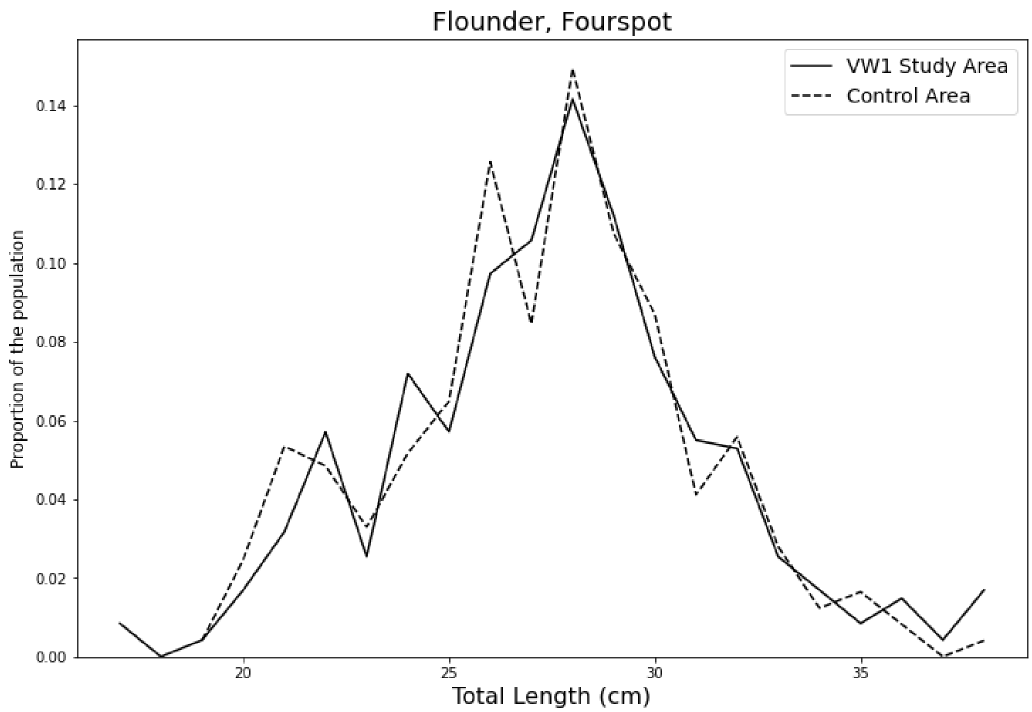


Figure 22: Distribution of the catch of Atlantic longfin squid in the VW1 Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.



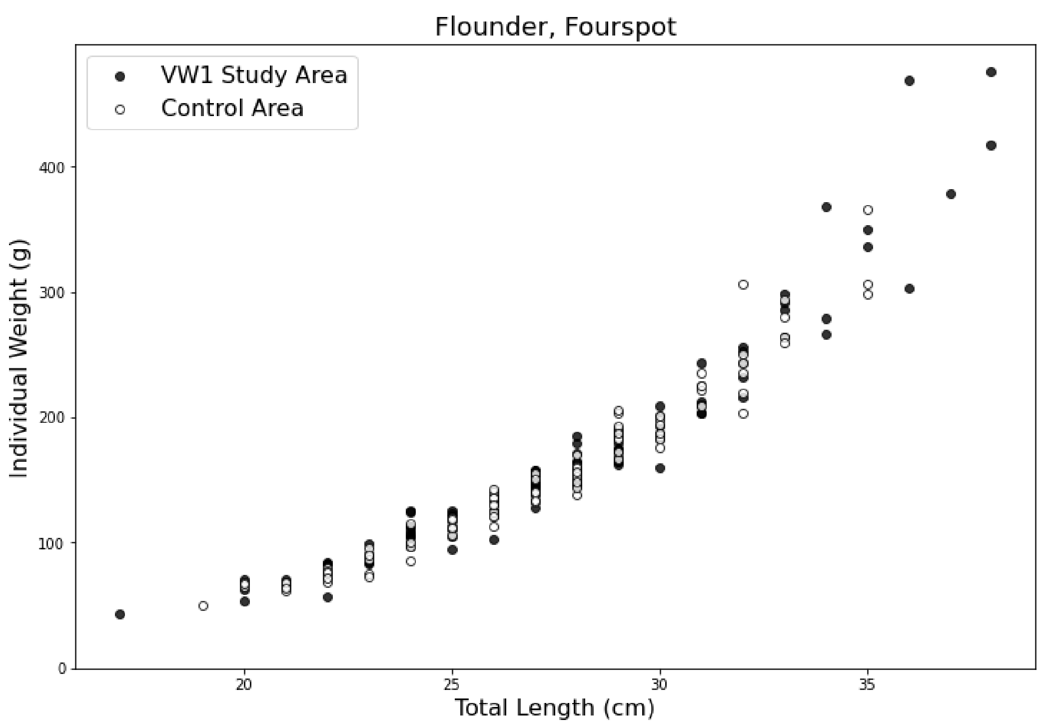


Figure 23: Population structure of fourspot flounder in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

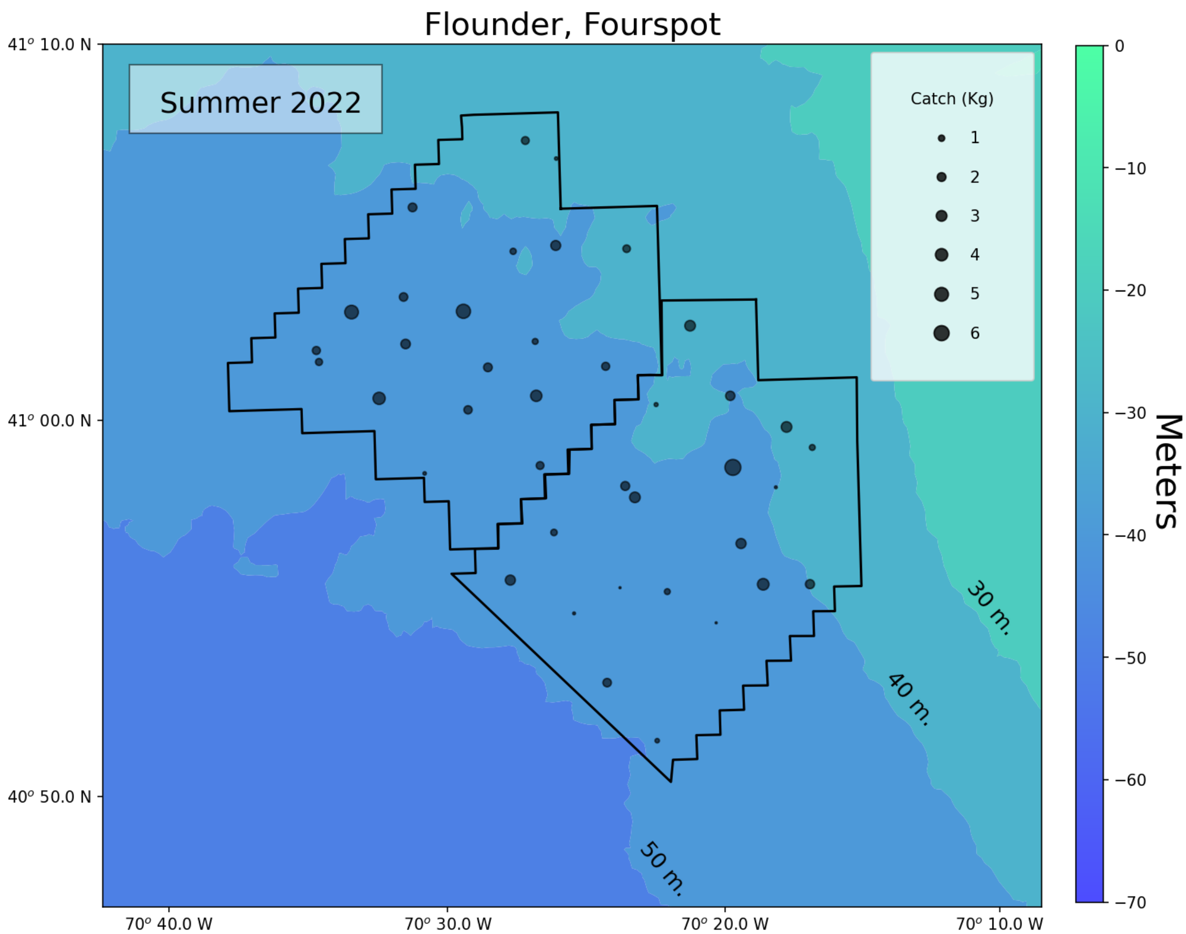
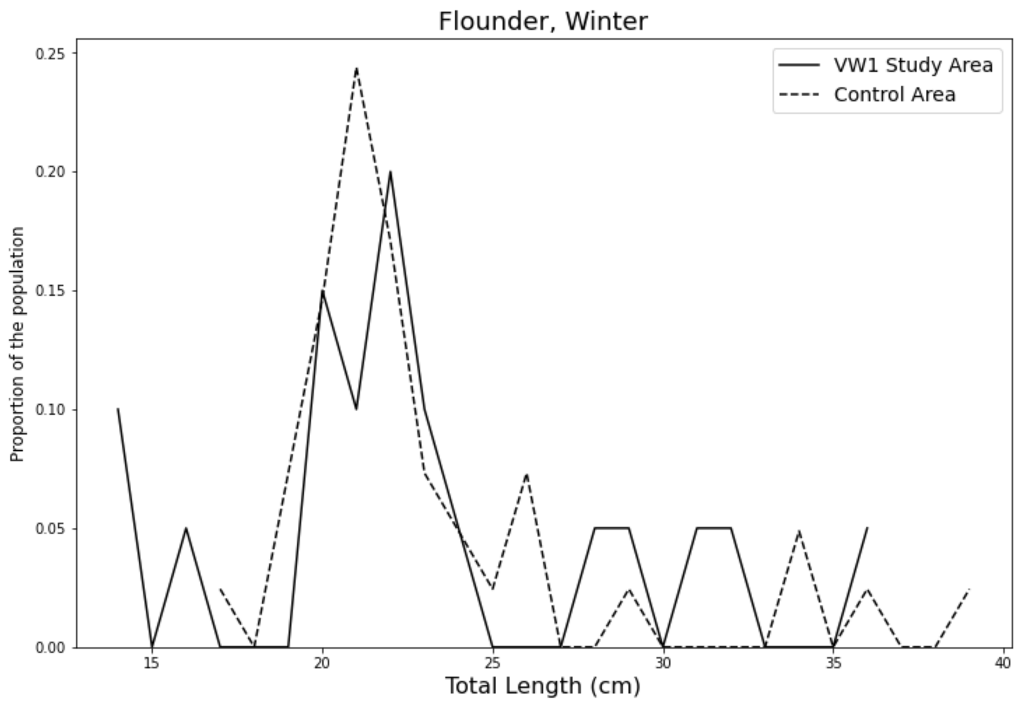


Figure 24: Distribution of the catch of fourspot flounder in the VW1 Study Area (left) and Control Area (right).



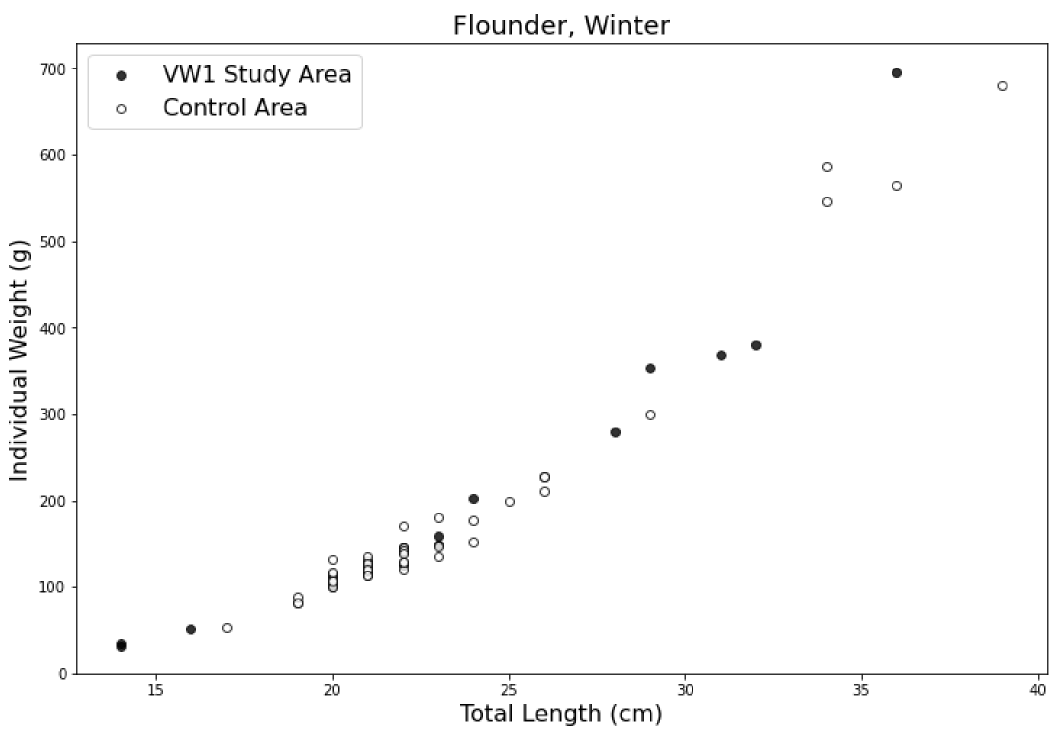


Figure 25: Population structure of winter flounder in the VW1 Study Area and Control Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

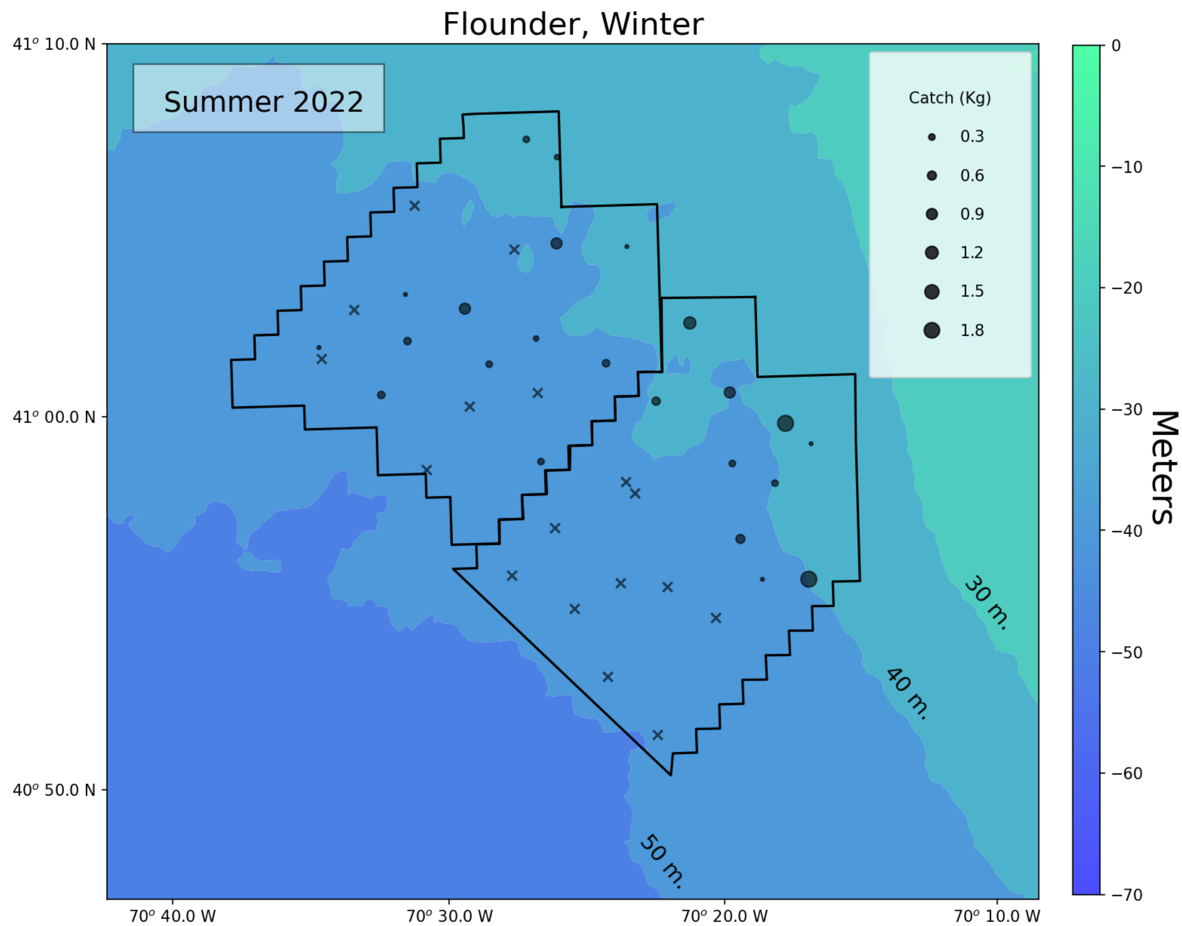


Figure 26: Distribution of the catch of winter flounder in the VW1 Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.