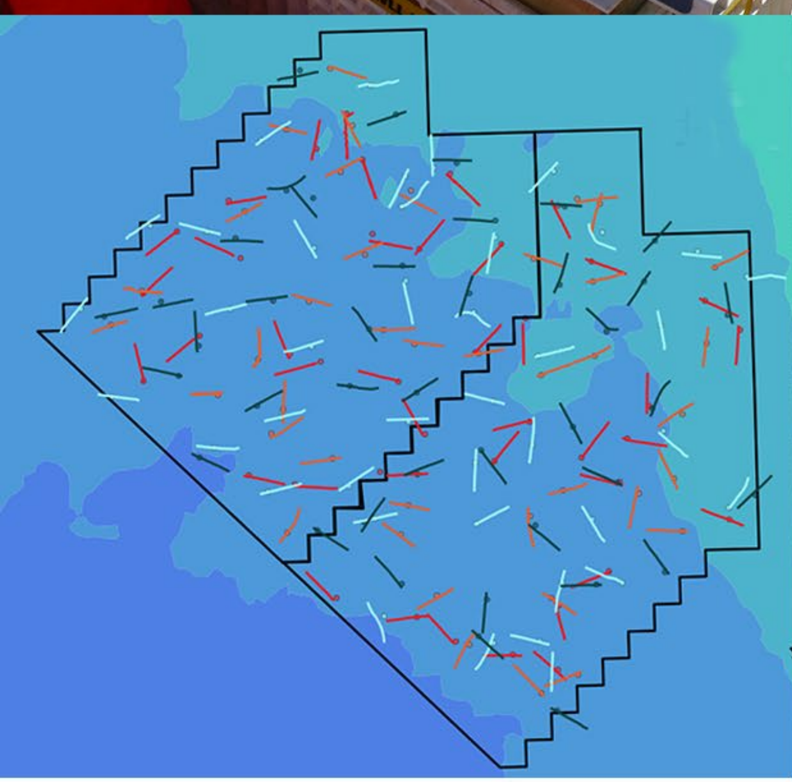
Vineyard Wind Demersal Trawl Survey



Annual Report
2020-2021

501 North Study Area

VINEYARD WIND DEMERSAL TRAWL SURVEY

2020/2021 Annual Report

501N Study Area

November 2021

Prepared for Vineyard Wind LLC

VINEYARD WIND

Prepared by:

Chris Rillahan and Pingguo He

University of Massachusetts Dartmouth
School for Marine Science and Technology

SMAST

Vineyard Wind Demersal Trawl Survey Annual Report

501N Study Area

UMass Dartmouth

2020/2021 Annual Report
June 1, 2020 – September 31, 2021

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Project leaders: Pingguo He and Christopher Rillahan
University of Massachusetts Dartmouth
School for Marine Science and Technology
836 S. Rodney French Blvd., New Bedford, MA 02744
Tel. (508) 910-6323, Fax. (508) 999-8197
Email: phe@umassd.edu

Submitted to: Vineyard Wind LLC
700 Pleasant St, Suite 510
New Bedford, MA 02740

Report by: Christopher Rillahan and Pingguo He

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1. Summary

Vineyard Wind LLC (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 impact of the proposed offshore renewable energy development on marine fish and invertebrate communities in the northern portion of Lease Area OCS-A 0501 (the "501N Study Area). One component of the monitoring plan is a demersal trawl survey. The trawl survey is modeled after the Northeast Area Monitoring and Assessment Program (NEAMAP), a regional survey used to assess nearshore fish communities. The data collected from this survey is intended to provide baseline information on species abundance, distribution, population structure, and community composition to be used in a future impact analysis. Pre-construction monitoring started in 2019. Data provided in this report is the second year of pre-construction monitoring, including four seasonal surveys. Vineyard Wind is also conducting fisheries studies within the southern portion of Lease Area OCS-A 0501 (the "501S Study Area") and within Lease Area OCS-A 0522 (the "522 Study Area"); these studies are reported separately.[1]

Four seasonal trawl surveys were conducted using commercial fishing vessels. Twenty tows were conducted each season in the 501N Study Area. An additional 20 tows were collected in a neighboring region, which will serve as a control (Control Area). Tow locations were randomly selected using a systematic unaligned sampling design. A standardized bottom trawl with a 1" knotless liner was towed behind the vessel for 20 minutes at 3 knots. Acoustic sensors were used to ensure the net's performance by monitoring the trawl geometry. The catch was sorted by species. Aggregated weights, as well as individual fish lengths and weights, were collected.

A total of 160 tows were completed throughout the year split equally between the 501N Study Area and the Control Area, and among the four seasons. In general, the data were similar to that observed during the 2019/2020 survey year. The catch data obtained shows a dynamic area with a diversity of marine species. A total of 42 species were collected; however, the majority of the catch was comprised of a small subset of the observed species. The five most abundant species (little skate, scup, spiny dogfish, winter skate, and silver hake) accounted for 77% in the Control Area and 78% in the 501N Study Area, respectively. Interannual changes in abundance varied amongst species. All species caught displayed seasonal variations in distribution and abundance. The data indicated a unique assemblage of species and abundance in each of the four seasons. The winter and fall surveys exhibited strong similarity to those in 2019/2020. The spring and summer surveys displayed significant differences from the previous year. In general, catch rates were lower in 2020/2021, compared to 2019/2020, presumably due to differences in survey timing (2019: mid- to late June; 2021: early May) and the resulting cooler bottom water temperatures (~3°C cooler in 2021). Conversely, bottom water temperatures were ~5°C warmer during the 2020 summer survey compared to the 2019 summer survey. As a result, the catch was dominated by heat-tolerant species such as scup, butterfish, and summer flounder. No differences in species assemblages were observed between the 501N Study Area and Control Area.

An updated power analysis was conducted using data aggregated from two survey years. The results indicate that the current bottom trawl survey effort would provide reasonable "power" to detect small to medium scales of change in abundance for the most common species if changes in abundance do occur. Additional data only caused small changes to the Coefficients of Variation (CVs) for most species. Common species, i.e., species frequently observed regardless of abundance, including little skate and Atlantic longfin squid, exhibited low variability resulting in the projected ability to detect a 25% change in abundance or greater. Most commercial species, including summer flounder, black sea bass, and silver hake, exhibited modest variability. The current sampling effort should be able to detect 30 – 40% changes in abundance.

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

2. Introduction

In 2015, Vineyard Wind leased a 675 square kilometer (km^2) area for renewable energy development on the Outer Continental Shelf, Lease Area OCS-A 0501, which is located approximately 14 miles south of Martha's Vineyard off the south coast of Massachusetts. Vineyard Wind is developing the northern portion of Lease Area OCS-A 0501 and fisheries studies are being conducted in a 306 km^2 area referred to as "501 North" or the "501N Study Area", which is the focus of this report. Vineyard Wind is also conducting fisheries studies within the southern portion of Lease Area OCS-A 0501 (the "501S Study Area")[1] and within Lease Area OCS-A 0522 (the "522 Lease Area"); these studies are reported separately.

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 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) and the fishing industry, has developed a monitoring plan to assess the potential environmental impacts of the proposed development on marine fish and invertebrate communities. The impact of the development will be evaluated using the Before-After-Control-Impact (BACI) framework. This framework is commonly used to assess the environmental impact of an activity (i.e., wind farm development and operation). Under this framework, monitoring will occur prior to development (Before), and then during construction and operation (After). During these periods, changes in the ecosystem will be compared between the development site (Impact) and a control site (Control). The control site will be in the general vicinity with similar characteristics to the impact areas (i.e., depth, habitat type, seabed characteristics, etc.). The goal of the monitoring plan is to assess the impact that wind farm construction and operation have on the ecosystem within an ever-changing ocean.

The current monitoring plan incorporates multiple surveys utilizing a range of survey methods to assess different facets of the regional ecology. The trawl survey is one component of the overall 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, trawls are a general tool for assessing the biological communities along the seafloor and are widely used by institutions worldwide for ecological monitoring. Since they are actively towed behind a vessel, they are less biased by fish activity and behavior than passive fishing gear (e.g., 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 fishery resources. The current trawl survey closely emulates the Northeast Area Monitoring and Assessment Program (NEAMAP) survey protocol. In doing so, the goal was to ensure compatibility with other regional surveys, including the National Marine Fisheries Service annual spring and fall trawl surveys, the annual NEAMAP spring and fall trawl surveys, and state trawl surveys including the Massachusetts Division of Marine Fisheries trawl survey. The bottom trawl survey is complemented by an optical benthic survey and a lobster trap survey, both are also carried out by SMAST.

The primary goal of this survey was to provide data related to seasonal fish abundance, distribution, population structure, and community composition in and around the 501N Study Area. The data will serve as a baseline to be used in a future analysis under the BACI framework. This report documents the survey methodology, survey effort, and data collected during four seasonal surveys between the summer of 2020 and the spring of 2021. Surveys planned for spring 2020 were not conducted due to the COVID-19 pandemic. The 2019/2020 annual report, as well as eight seasonal reports between 2019 to 2021, have been submitted to the sponsoring organization.

3. 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 survey protocol samples at a resolution of ~100 km^2, which is inadequate to provide scientific information related to potential changes on a smaller scale. Adapting existing methods with increased resolution (see Section 3.1) 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 501S Study Area and 522 Study Area).

3.1 Survey Design

The current survey is designed to provide baseline data on species abundance, population structure, and community composition for a future environmental assessment using the BACI framework as recommended by BOEM (BOEM, 2019). Four surveys were conducted to assess the seasonal variability in the resident populations. The seasonal surveys consisted of spring (April – June), summer (July – September), fall (October – December), and winter (January – March) surveys. In temperate oceans, the distribution of mobile marine species can fluctuate seasonally, typically coinciding with seasonal changes in water temperature. The timing of the seasonal surveys was intended to capture these generalized trends in the population dynamics. The timing of the spring survey coincides with the inshore movement of many species and is associated with increasing water temperatures. The summer survey is intended to characterize the resident summer species that occur during seasonally warm water temperatures. The fall survey occurs during decreasing water temperatures, which typically triggers the offshore movement of many coastal species. Finally, the winter survey occurs during stable cold temperatures in the region. Additionally, the spring and fall surveys are intended to coincide with ongoing state and federal fisheries surveys.

Tow locations for each survey within the 501N Study Area were selected using a spatially balanced systematic unaligned sampling design. The 501N Study Area was modified from the 2019/2020 survey year due to boundary refinements of projects within the Lease Area OCS-A 0501. The current 501N Study Area was increased from 249.3 km^2 to 306 km^2 by adding additional area to the southeastern corner. The current 501N Study Area was sub-divided into 20 sub-areas (each ~15.3 km^2), and one trawl tow was made in each of the 20 sub-areas. This was designed to ensure adequate spatial coverage throughout the 501N Study Area. The starting location within each area were randomly selected (Figure 2).

An area located to the east of the 501N Study Area was established as a control region, further referred to as the Control Area. The selected region has similar depth contours, bottom types, and benthic habitats to the 501N Study Area. The Control Area was modified from the 2019/2020 survey year. The change was due to differences in depths and catch rates observed in the

2019/2020 survey data. The goal was to increase the similarity between the 501N Study Area and Control Area. The Control Area was shifted ~1 nautical mile (nmi) to the northeast to be in line with the southern boundary of the 501N Study Area (Figure 2). Shifting effort to the northeast reduces the area located in the easterly adjacent Lease Area OCS-A 0520 as well as increases the overlap with the SMAST lobster and drop camera surveys. A small additional area was added to the north of the 501N Study Area to increase overlap with other environmental surveys. These changes increased the Control Area from 306 km^2 to 324 km^2. An additional 20 tows were completed in the Control Area (each ~16.2 km^2). Tow locations were selected in the same manner as the 501N Study Area, using the systematic unaligned 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 501N Study Area or Control Area (100% change). The updated power analysis showed that increasing survey effort would only result in small improvements in detectability.

When distributing the survey effort, randomly selecting multiple tow locations across the 501N Study Area and Control Area accounts for spatial variations in fish populations. Alternatively, multiple tows could be sampled from a single tow track, which would assume that the tow track is representative of the larger ecosystem. The distributed approach, applied here, assumed that the catch characteristics across each 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 seasonal surveys had a sampling density of one station per 15.3 km^2 (4.5 square nautical miles [nmi^2]) in the 501N Study Area and one station per 16.2 km^2 (4.7 nmi^2) in the Control Area. As previously mentioned, the NEAMAP nearshore survey samples at a density of one station per ~100 km^2 (30 nmi^2).

3.2 Trawl Net

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

The survey trawl is a three-bridle four-seam bottom trawl (Figure 3). This net style allows for a high vertical opening (~5 meters [m]) relative to the size of the net and consistent trawl geometry. These features make it a suitable net to sample a wide diversity of species with varying life history characteristics (i.e., demersal, pelagic, benthic, etc.). To effectively capture benthic organisms, a "flat sweep" was used (Figure 4). A "flat sweep" contains tightly packed rubber disks and lead weights, which ensures close contact with the substrate and minimizes the escape of fish under the net. This is permissible due to the soft bottom (i.e., sand/mud) in the 501N Study Area. To ensure the retention of small individuals, a 1" mesh size knotless liner was used within a 12-centimeter (cm) diamond mesh codend. Thyboron Type IV 66" trawl doors were used to horizontally open the net. The trawl doors were connected to the trawl by a series of steel wire bridles (see Figures 5 and 6 for a diagram of the trawl's rigging during the surveys). For a detailed description of the trawl design, see Bonzek et al. (2008).

3.3 Trawl Geometry and Acoustic Monitoring Equipment

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

The Simrad PX net mensuration system (Kongsberg Group, Kongsberg, Norway) was used to monitor the net geometry (Figure 1). Two sensors were placed in the doors, one in each, to measure the distance between the doors, referred to as door spread. Two sensors placed on the center wingends measured the horizontal spread of the net, commonly referred to as the wing spread. A sensor with a sonar transducer was placed on the top of the net (headrope) to measure the vertical net opening, referred to as headline height. The headline sensor also measured bottom water temperature. To ensure the net was on the bottom a sensor was placed behind the footrope in the belly of the net. That sensor was equipped with a tilt sensor 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 7).

3.4 Survey Operations

The summer survey was conducted on F/V *Endurance*, a 120' stern trawler operating out of New Bedford, Massachusetts. The larger vessel was due to the implementation of required safety precautions due to COVID-19. The fall, winter, and spring surveys were conducted on the F/V *Heather Lynn*, an 84' stern trawler operating out of Point Judith, Rhode Island. Both boats are commercial trawling vessels currently operating in the industry. The spring 2020 survey was canceled due to the COVID-19 pandemic; instead, the spring 2021 survey serves to complete the four seasonal surveys in the 2020/2021 survey year. The seasonal surveys were completed between the following dates, during which all planned tows were completed:

- Summer Survey: August 24 – September 2, 2020

- Fall Survey: November 6 – 23, 2020
- Winter Survey: February 3 – 16, 2021
- Spring Survey: May 3 – 8, 2021

Surveys were alternated daily between the 501N Study Area and Control Area. Tows were only conducted during daylight hours. All tows started at least 30 minutes after sunrise and ended 30 minutes before sunset. This was intended to reduce the variability commonly observed during crepuscular periods. Tow duration was 20 minutes at a target tow speed of 3.0 knots. 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 a 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 provided the required geometry by constraining the horizontal spreading of the net and increasing the headline height.

In addition to monitoring the net geometry to ensure acceptable performance (as described in Section 3.3 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).

3.5 Catch Processing

The catch from each tow was sorted by species. Aggregated weight for 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. Two sub-sampling strategies were employed over the duration of the four seasonal surveys: straight sub-sampling by weight and discard by count.

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.

Discard by count: The discard by count method was used when a large catch of large-bodied fish was caught. For this method, a sub-sample of the species (30 – 50 individuals) was collected to calculate a mean individual weight. The remaining individuals were counted and discarded. The aggregated weight for the species is the total number of individuals multiplied by the average individual weight. This method was primarily used during the fall survey when large volumes of spiny dogfish were caught.

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

3.6 Data Analysis

3.6.1 Catch Per Unit Effort Analysis

To assess the influence of season and area (i.e., 501N Study Area versus Control Area) on the observed catch, a catch per unit effort (CPUE) analysis was conducted. The catch was standardized to account for small variations in the tow path. The area fished by the trawl, commonly referred to as the swept area, was calculated for each tow by multiplying the tow distance by the average wing spread. The data was then standardized to an ideal swept area (25,000 square meters [$m^{2]}$) for each species, i, and tow, j, (Equation [Eq.] 1). The ideal swept area assumes a tow distance of one nautical mile at a wing spread of 13.5 m. The ideal wing spread was very close to the annual average swept area observed in the surveys (24,935 m^2). This standardization method is used by NEAMAP to create indices of abundance (Bonzek et al., 2017). If the swept area was higher or lower on a given tow, the associated catch was respectively, and proportionately, scaled down or up. For example, if a tow had a swept area of 12,500 m^2, half of an ideal tow, then the respective catch would be doubled. Conversely, if a tow had double the swept area (50,000 m^2), then the catch would be halved. In this dataset, most tows only required small adjustments (<±5%).

$$Standardized\ Catch_{ij} = \left(\frac{Catch_{ij}}{Swept\ Area_j/25{,}000\ m^2}\right) \qquad Eq. 1$$

The generalized linear modeling (GLM) framework was used to model the observed catch as a function of season and area. Models were produced for each species. The full model had two explanatory variables, season and area. Season was a categorical variable with four levels to account for the four seasonal surveys (spring, summer, fall, and winter). Area was a categorical variable with two levels (501N Study Area and Control Area) to examine catch differences between the two survey areas.

The response (standardized catch) was therefore modeled as:

$$\log(standardized\ catch)_i = \beta_0 + \beta_{survey} + \beta_{area} + \varepsilon_i \qquad Eq. 2$$

β_0 is an intercept term, β_{survey} and β_{area} are the two explanatory variables, and ε_i is the error term. A Gaussian error distribution was used with a log link function. To evaluate the importance of each explanatory variable on the model fit, two nested models were subsequently created with only one of the two explanatory variables. A likelihood ratio test was used to compare each nested model to the full model (Zuur et al., 2009). P-values less than 0.05 indicated that removing the explanatory variable significantly reduced the model's fit, while p-values greater than 0.05 indicated that removing the explanatory variable did not significantly impact the model.

Additionally, Akaike Information Criterion values were used to examine the relative goodness of fit between the candidate models. Residual analysis was used to validate each model and ensure the residuals were normally distributed with no heteroscedasticity.

The models were fit using the 'glm' function in the Stats package in the R programming language (version 3.6.2, R Core Team, 2018). Only data from the 2020 – 2021 surveys were used in this analysis. The previous annual report had shown a significant area-effect for many species (i.e., the 501N Study Area and Control Area had significantly different catch rates). As a result, we did not aggregate all the survey data (2019 – 2021) so as not to confound this effect. The goal of this analysis was to reassess these impacts given the modifications of the two areas.

3.6.2 Fish Size Structure Analysis

To assess potential differences in the size structures of fish populations between the 501N Study Area and the Control Area, kernel density estimation (KDEs) was used. This process uses the length-frequency data collected from the surveys to estimate a probability density function for each survey area using a kernel function. Each probability density function is effectively a smooth curve representing the observed size-frequency of each species in each survey area. The two curves are then compared to a null model, of no difference, and a permutation test to assess statistically significant differences between the two areas. During the permutation test, the survey area is randomly reassigned for each data point. Numerous permutations of the data serve to create a robust, "random" dataset. The observed data is then compared to the randomized dataset. Statistically, significant differences would indicate that the differences observed in the data were highly unlikely to be collected randomly thereby indicating a different size structure between the two survey areas. This method is outlined by Langlois et al. (2012) and used by Bond et al. (2018) to look at the size structure of fish populations around, and away from, a subsea pipeline.

KDEs were created for each species and season. Bandwidths were selected using the 'dpik' function in the 'KernSmooth' package in the R programming language (Wand, 2015). This method uses the 'plug-in' style, which does not make assumptions about the distribution of the data. The statistical test compared the area between the two KDEs to the results of 100,000 permutations of the data. The permutation test randomly reassigned the survey area and compared the random pairs using the 'sm.density.compare' function in R's 'sm' package

(Bowman and Azzalini, 2018). The result is a null model assuming no difference between areas. Data outside of one standard error, above or below the null model, indicates significant differences between the two survey areas. As with the CPUE analysis, only data from 2020 – 2021 was evaluated to reassess the impacts of the survey area on the catch.

3.6.3 Condition Index Analysis

The condition of fish was compared between seasons and the two survey areas. Fish condition is a general metric comparing the weight of a fish at a given length and is typically an indication of fish well-being (Blackwell et al., 2000). Fish with a high condition (i.e., plump fish) may indicate favorable environmental conditions, including adequate prey availability, which may lead to increased survival or fecundity. Fish with low condition (i.e., lean fish) may indicate the opposite (Blackwell et al., 2000). Fish condition was evaluated using a relative condition factor (Eq. 3, LeCren, 1951). The relative condition factor (Kn) is derived from the weight of the fish (W) compared to the predicted length-specific mean weight for the population (W').

$$K_n = \frac{W}{W'} \qquad Eq. 3$$

A value of 1 indicates that the fish is of average condition. K_n values greater than 1 indicate that the fish is heavier given its length, or of better condition than average, while values less than 1 indicate a fish with a below-average condition.

To calculate the predicted length-specific mean weight, weight-length curves for each species were fit for the population of animals in and around the development area. Individual length and weight data were aggregated between surveys and areas, including additional data collected in the 501S Study Area and 522 Study Area. The weight-length curves were fit using the exponential relationship defined in Eq. 4 converted to logarithmic form (Eq. 5).

$$W = aL^b \qquad Eq. 4$$

$$\log W = \log a + b \log L \qquad Eq. 5$$

A regression model was used to estimate the model parameters (a and b) using the ordinary least squares method in the statsmodels package (version 0.11.1) in the Python programming language. Relative condition factors for each fish were calculated using Eq. 3 where W is the measured weight and W' is the length-specific model estimated weight, derived from Equation 5. A generalized linear model, the same as used in the CPUE analysis, was used to assess the influence of season and survey area on fish condition.

3.6.4 Community Structure Analysis

To assess the community dynamics in the 501N Study Area and Control Area a multivariate analysis was conducted using the Primer-E statistical software package (Primer 7, Quest Research Limited, Auckland, New Zealand). The goal of this analysis was to investigate changes in the community composition between seasons and survey areas.

A resemblance matrix was created using Bray-Curtis dissimilarity coefficients of the square root transformed catch data. This resulted in a measurement of similarity between tows based on the species composition of the catch. The catch data were transformed to reduce the influence of numerically dominant species, ensuring a community-based assessment (Clarke and Gorley, 2015). A one-way Analysis of Similarities (ANOSIM) was conducted using both tow area and season, individually, as factors. The ANOSIM is a non-parametric, ANOVA-like, statistical test that compares the similarity between groups to the similarity within groups. The result is a statistic, R. A value of 0 indicates no difference between treatment groups and the maximum of 1 indicates a large separation between treatment groups. A permutation test (9,999 permutations) was used to test against the null hypothesis where similarities within treatments were smaller or equal to the similarities between treatments. The permutation test randomly reassigns the treatment and calculates the test statistic. The result is a distribution of possible random outcomes, which is compared against the measured statistic.

To visualize the data, non-metric multidimensional scaling plots (nMDS) were created. These figures plot the similarity data in a low-dimensional space so that distances between points represent the relative similarity/dissimilarity between them. This analysis was conducted on the 2020 – 2021 dataset as well as the aggregated dataset (2019 – 2021). Pairwise comparisons between surveys were used to investigate seasonal changes in species composition as well as annual variations within a season (e.g., spring 2019 versus spring 2021).

3.6.5 Power Analysis

To ensure the survey's ability to detect changes in fish populations, a power analysis was conducted using the data collected during the seasonal surveys. In statistics, the term "power" refers to the probability of rejecting a false null hypothesis, otherwise known as a type 2 error or a false negative (Murphy, Myors, and Wolach, 2014). In other words, it is a measure of the probability of detecting a change occurring in the environment. Studies with high statistical power have a high probability of detecting a change in the environment, given the environment is in fact changing.

The goal of a power analysis is to understand the balance between several variables including sample size, magnitude of change (expressed as a percent of change, PC), type 1 error rate (α, the probability of a false positive), and type 2 error rate (β, the probability of a false negative). The power analysis conducted in this report is based on the equations in Van Belle (2011) as expressed in Eq. 6.

$$n = \frac{2(z_{1-\frac{\alpha}{2}} + z_{1-\beta})^2 (CV)^2}{[\ln(1 - PC)]^2} \qquad Eq. 6$$

Where N is the total sample size (number of tows) required per treatment, z is the z-score given α (type-1 error rate) or β (type-2 error rate), CV is the coefficient of variation observed in the population, and PC is the percent change in the population means. PC = $(\mu_0 - \mu_1)/\mu_0$, with μ_0 and μ_1 being mean CPUEs of pre-development and post-development respectively. CVs were derived from the standardized catch rates observed throughout the four seasonal surveys. In many ecological analyses, α is usually set at 0.05, and β at 0.2 (Van Belle, 2011). β is the probability of not detecting the change when there is a change (false negative). The value (1- β) is called "power" – the power to detect a change when in fact there is a change. Fixing α, β, and the CV demonstrates that the ability to detect a change is inversely related to the sample size. More samples are required to detect smaller changes. The equation can be reformulated to estimate any one of the parameters assuming the rest of the parameters are set.

The power analysis presented in this report is an updated analysis incorporating all seasonal survey data collected between 2019 and 2021.

4. Results

4.1 Operational Data

Twenty tows were completed during each survey period in both the 501N Study Area and the Control Area for a total of 160 tows (Figure 2, Tables 1 through 4). Tow duration, tow speed, and tow distance were similar between survey areas and seasons (Table 5). Tow durations were close to the targeted 20 minutes averaging 20.1 ± 0.7 minutes (mean ± one standard deviation) in the 501N Study Area and 20.2 ± 0.4 minutes in the Control Area ($p = 0.1760$, unpaired t-test). The targeted tow duration was maintained between seasons; the only exception was during the fall survey (Figure 8). Due to large volumes of spiny dogfish, one tow was shortened to prevent damage to the survey trawl. Tow speed averaged 2.9 ± 0.1 knots in the 501N Study Area and 2.9 ± 0.1 knots in the Control Area ($p = 0.1930$). The average tow speed showed little variation between surveys or survey areas (Figure 8). Tow distances averaged 1.0 ± 0.04 nmi in the 501N Study Area and 1.0 ± 0.05 nmi in Control Area. No statistical differences were observed between them ($p = 0.7779$). Similarly, the average tow distance showed little variation between surveys or survey areas (Figure 8).

The seafloor in both areas follows a northeast to southwest depth gradient with the shallowest tow along the northeast edge (20 fathoms [35 m]). Depth increases to a maximum of 27 fathoms (50 m) along the southwest boundary. Tow depths ranged from 20 to 27 fathoms (36.6 – 49.4 m) in the 501N Study Area and 17 to 27 fathoms (31.1 – 51.2 m) in the Control Area. The distribution of starting depths was shallower in the Control Area compared to the 501N Study Area (Figure 9). This contrasts with the 2019/2020 survey data. During that year, it was observed that the distribution of tows was significantly deeper in the Control Area. These results were part of the reason for adjusting the survey areas. The updated data shows improved similarity in the depth distributions between the two survey areas. The average starting depth in the 501N Study Area was 23.3 ± 1.9 fathoms and 22.5 ± 2.5 fathoms in the Control Area (p-value: 0.0227).

4.2 Environmental Data

Bottom water temperature followed seasonal trends in both survey areas (Figure 10). The bottom water temperature was highest during the summer survey and coldest during the winter survey. During the summer survey, water temperatures averaged 15.9 ± 1.1°C in the 501N Study Area and 16.5 ± 1.2°C in the Control Area. The bottom temperature was significantly warmer than observed in 2019 where the temperature averaged 11.4 ± 0.8°C in the 501N Study Area and 12.0 ± 0.6°C in the Control Area (Figure 10). Bottom temperatures began to cool during the fall survey with the 501N Study Area averaging 14.5 ± 0.2°C and the Control Aera averaging 14.3 ± 0.4°C. Winter bottom temperatures averaged 3.9 ± 0.2°C in the 501N Study Area and 4.2 ± 0.3°C in the Control Area. Fall and winter temperatures were relatively consistent with those observed in 2019 – 2020; however, the 2021 spring survey was noticeably cooler than spring 2019. Bottom water temperature during the 2021 spring survey averaged 6.7 ± 0.3°C in the 501N Study Area and 7.6 ± 1.2°C in the Control Area. In comparison, during the 2019 spring survey, bottom water temperatures averaged 10.0 ± 0.7°C in the 501N Study Area and 9.6 ± 0.6°C in the Control Area. The differences between these two surveys are presumably due to the timing of the surveys. Due to contracting and permitting issues, the 2019 spring survey occurred in mid-June while the 2021 spring survey occurred in early May.

Within each seasonal survey, bottom temperatures tended to follow the depth gradient. Shallow tows were warmer than deep tows in the spring and summer surveys and cooler than deeper tows in the winter survey. During the fall survey, bottom temperatures were relatively uniform throughout the survey areas.

4.3 Trawl Performance

The trawl geometry data indicated that the trawl typically took about two to three minutes to open and stabilize. Once open, readings tended to be stable through the duration of the tow. Wing spread measurements were largely within the ideal range of 13.0 to 14.0 m, averaging 13.8 ± 0.5 m for tows in the 501N Study Area (range: 11.9 – 15.1 m) and 13.7 ± 0.5 m for tows in the Control Area (range: 12.5 – 14.6 m, $p = 0.025$). Wing spread is the most important trawl performance metric as it is used to measure the swept area. Wing spread readings were consistent across the surveys with all tows within the acceptable tolerance limits (Figure 11). Wing spread readings increased slightly with trawl warp and depth; however, this effect was small, and readings were relatively stable across the range of depths encountered within the surveys (Figures 12, 13). Wing spread measurements were slightly higher in the 501N Study Area, compared to the Control Area, presumably due to the distribution of tows in deeper water.

Door spread averaged 33.8 ± 1.2 m (range: 31.5 – 38.3 m) for tows in the 501N Study Area and 33.1 ± 1.5 (range: 29.3 – 37.0 m, $p = 0.0032$) in the Control Area. Door spread was relatively consistent across surveys (Figure 11). Similar to wing spread, door spread readings tended to increase with depth due to increased trawl warp (Figure 13). All tows were within the acceptable tolerance limit except for one tow. This tow occurred during the summer survey and was considered a valid tow because the wing spread was well within the acceptable limits.

The headline height of the trawl averaged 4.8 ± 0.3 m for tows in the 501N Study Area (range: 4.1 – 5.6 m) and 4.9 ± 0.3 m for tows in the Control Area (range: 4.2 – 5.5 m, $p = 0.6720$). Obtaining the desired headline height had been a persistent problem in the 2019 2020 surveys with the headline height frequently lower than the acceptable tolerance limit. Previous improvements to trawl operations have shown significant improvements; however, during the summer survey, seven of the 40 tows were still slightly below the acceptable tolerance limit. During the fall survey, eight additional floats were added to the headline to increase buoyancy. All subsequent tows were within the acceptable tolerance limits. The additional buoyancy on this net may be required to compensate for the deeper depths encountered in this survey compared to the NEAMAP inshore survey.

4.4 Catch Data

4.4.1 Overview

The data obtained from the four seasonal surveys conducted show that the two survey areas are dynamic in their species composition and abundance. A total of 42 species were caught in at least one seasonal survey during the year; their common and scientific names, total catch (by weight), and mean catch per tow are provided in Table 6 for the 501N Study Area and Table 7 for the Control Area. Forty species were caught in the 501N Study Area, and 39 species were caught in the Control Area, with 37 species shared between the two regions. Catch volume ranged from 0.4 kilograms per tow (kg/tow) to 1,713.6 kg/tow. The majority of the catch was primarily comprised of a small subset of the observed species. The five most abundant species (little skate, scup, spiny dogfish, silver hake, and winter skate) were shared between the two regions and accounted for 77.3% and 77.8% of the total catch weight in the 501N Study Area and Control Area, respectively. The next four most abundant species (butterfish, Atlantic longfin squid, Atlantic herring, and red hake) were similarly shared between regions and comprised 13.7% and 13.9% of the catch in the 501N Study Area and Control Area, respectively. These nine species represented around 92% of catch weight. Data collected from both areas included the catch of both adults and juveniles of most species observed.

4.4.2 Little Skate

Little skate (*Leucoraja erinacea*) was the most abundant species by weight in both the 501N Study Area (27.4% of the catch) and the Control Area (32.8% of the catch). Little skates were common throughout the year, being observed in 75 of the 80 tows in the 501N Study Area and 78 of the 80 tows in the Control Area. Annually, catch rates averaged 64.9 ± 8.4 kg/tow (mean ± Standard Error of the Mean [SEM], range: 0 – 358.3 kg/tow) in the 501N Study Area and 88.5 ± 11.1 kg/tow (range: 0 – 385.8 kg/tow) in the Control Area ($p < 0.0001$). In general, the catch was highest in the summer and fall surveys, moderate in the spring survey, and low in the winter survey ($p = 0.3607$, Figure 14). Catch rates and trends appeared very similar to those observed in 2019/2020 (Figure 14).

The catch rate of little skate in the summer survey averaged 118.5 ± 23.4 kg/tow in the 501N Study Area and 120.3 ± 22.4 kg/tow in the Control Area (Figure 14). Little skates were observed in all 20 tows in both survey areas. During the summer survey, the catch was distributed throughout the survey areas with higher catches observed in deeper tows located in the southern half of each area (Figure 15). Individuals ranged in size from 13 to 30 cm (disk width, Figure 16). The KDE analysis indicated that the distribution of skates was shifted slightly towards larger individuals in the 501N Study Area with a peak at 25 cm compared to the Control Area with a peak at 24 cm ($p = 0.0001$, Figure 17).

The catch rate of little skate was the highest during the fall survey with catch rates averaging 110.6 ± 13.0 kg/tow in the 501N Study Area and 177.1 ± 28.7 kg/tow in the Control Area (Figure 14). Little skates were observed in all 20 tows in both survey areas. The catch was observed to be distributed throughout both survey areas in the fall survey with higher catch still observed in the southern areas (Figure 15). Individuals ranged in size from 14 to 35 cm (disk width) in the fall survey (Figure 16). The KDE analysis indicated that the distribution of little skates was slightly larger in the 501N Study Area with a peak at 26 cm compared to the Control Area with a peak at 25 cm ($p = 0.0001$, Figure 17).

Little skate abundance was low during the winter survey (501N Study Area: 2.0 ± 0.6, Control Area: 9.9 ± 3.0); however, they were still observed in 15 of the 20 tows in the 501N Study Area and 18 of the 20 tows in the Control Area. Similar to other seasons, the catch was distributed throughout both survey areas with the highest catches observed in the southeastern corner of the Control Area (Figure 15). Individuals ranged in size from 5 to 31 cm (disk width) in the winter survey with a broad size distribution (Figure 16). The 501N Study Area had a broader size distribution, including smaller individuals. The size distribution of the Control Area primarily included individuals between 20 – 30 cm ($p < 0.0001$, Figure 17)

During the spring survey, the little skate catch was modest. The seasonal catch rates averaged 34.0 ± 4.2 kg/tow in the 501N Study Area and 56.4 ± 8.2 kg/tow in the Control Area (Figure 14). Little skates were observed in all 20 tows in both survey areas with the catch evenly distributed throughout both survey areas (Figure 15). Individuals ranged in size from 10 to 34 cm (disk width) in the spring survey with no significant difference between the survey areas ($p = 0.247$, Figures 16, 17).

The condition of little skates was the highest during the winter survey (501N Study Area: 1.04 ± 0.16, Control Area: 1.07 ± 0.16). The condition of little skates was ~1.0 (i.e., average) during the remaining seasons. No significant difference was observed between survey areas ($p = 0.4861$, Figure 18).

4.4.3 Scup

Scup (*Stenotomus chrysops*) was the second most abundant species in both survey areas despite the catch being limited to the summer and fall surveys. In general, the catch was high and consistent during the summer and fall surveys. Low catches were observed in the spring survey and no catch was observed in the winter survey. The annual catch rate averaged 47.0 ± 11.1 kg/tow (range: 0 – 514.2 kg/tow) in the 501N Study Area and 60.2 ± 17.4 kg/tow (range: 0 – 1094.8 kg/tow) in the Control Area. The GLM analysis indicated that the survey area and season were significant predictors of the catch (area: $p < 0.0001$, season: $p < 0.0001$). The annual average catch rate was approximately double that observed in 2019/2020 (Figure 19). This is primarily due to significantly higher catches in the summer of 2020 compared to 2019. These higher catch rates may be correlated with the warmer bottom temperature in 2020.

The summer catch of scup averaged 100.4 ± 36.2 kg/tow in the 501N Study Area and 145.3 ± 63.4 kg/tow in the Control Area (Figure 19). The summer catches were varied, ranging from 0 to 674.2 kg. Several large tows (>500 kg) served to boost the seasonal average. Scup were caught in 18 of the 20 tows in the 501N Study Area and 17 of the 20 tows in the Control Area. The catch of scup appeared to be spread across the survey areas with a sporadic distribution of large tows (Figure 20). In general, the population structure of scup was similar between the two survey areas and seasons. In the summer survey, scup ranged in size from 5 to 32 cm with a unimodal peak around 22 cm (Figure 21). The shape of the distributions was similar between survey areas with the Control Area shifted toward larger fish ($p = 0.0001$, Figure 22).

The scup catch remained high in the fall survey with similar catches between the survey areas. Fall survey catch rates of scup averaged 86.9 ± 16.4 kg/tow in the 501N Study Area and 94.9 ± 13.9 kg/tow in the Control Area (Figure 19). Scup were caught in every tow in both survey areas. The catch of scup was distributed throughout both survey areas (Figure 20). Individuals ranged in size from 7 to 29 cm with a unimodal peak at 23 cm (Figure 21). The shape of the distributions was similar between survey areas with the Control Area shifted toward larger fish ($p = 0.0001$, Figure 22).

Catch rates of scup were low during the spring survey (501N Study Area: 0.8 ± 0.3 kg/tow, Control Area: 0.4 ± 0.1 kg/tow, Figure 19). Scup were caught in 13 of the 20 tows in the 501N Study Area and 14 of the 20 tows in the Control Area. The catch of scup was distributed throughout both survey areas (Figure 20). During the spring survey, scup had a wide size distribution ranging from 9 to 32 cm in length. (Figure 21). The shape of the distributions was similar between survey areas with the 501N Study Area shifted toward larger fish ($p = 0.039$, Figure 22).

No scup were collected in the winter survey.

The condition of scup was not significantly different between survey areas ($p = 0.2533$, Figure 23). Generally, the condition was higher in the fall survey (501N Study Area: 1.02 ± 0.07, Control Area: 1.04 ± 0.09) and lower in the summer survey (501N Study Area: 0.97 ± 0.08, Control Area: 0.94 ± 0.13).

4.4.4 Spiny Dogfish

Spiny dogfish (*Squalus acanthias*) was the third most abundant species observed in both the 501N Study Area and Control Area accounting for 19.3% and 12.1% of the catch weight, respectively. Annually, catch rates averaged 42.8 ± 19.7 kg/tow (range: 0 – 1,188.0 kg/tow) in the 501N Study Area and 33.2 ± 13.9 kg/tow (range: 0 – 957.0 kg/tow) in the Control Area ($p = 0.0001$). While spiny dogfish were the most abundant species by weight, there was a distinct seasonality to the catch ($p < 0.0001$). Spiny dogfish were present in both survey areas in the spring and fall surveys with the highest catches observed during the fall survey. Annual catch rates were significantly lower in 2020/2021, which was primarily due to relatively low catches in the fall 2020 survey compared to the fall 2019 survey (Figure 24).

The spiny dogfish catch rates were the highest during the fall survey, which included many of the largest aggregated tows of the year. The catch rate of spiny dogfish averaged 165.9 ± 73.3 kg/tow in the 501N Study Area and 76.7 ± 47.4 kg/tow in the Control Area (Figure 24). Spiny dogfish were observed in 19 of the 20 tows in both the 501N Study Area and the Control Area. The highest catches in the fall survey were observed in deeper waters along the southern boundary in both survey areas (Figure 25). Individuals ranged in length from 45 to 85 cm with a unimodal distribution consisting of a peak at 68 cm (Figure 26). The KDE analysis indicated that the size distribution in the Control Area was wider consisting of more large individuals ($p < 0.0001$, Figure 27).

During the spring survey, seasonal catch rates averaged 4.9 ± 4.6 kg/tow in the 501N Study Area and 56.2 ± 26.6 kg/tow in the Control Area (Figure 24). The catch of spiny dogfish was noticeably different between the two survey areas. In the 501N Study Area, catch rates were low and infrequent (eight of the 20 tows). In the Control Area, high catches (>100 kilograms [kg]) were observed in the southeastern corner (Figure 25). Individuals were primarily small during the spring survey, ranging in size from 20 – 75 cm, with the majority of the catch between 20 to 40 cm (Figures 27, 28).

Only six spiny dogfish were caught during the summer survey in the 501N Study Area. No dogfish were caught in the Control Area. No spiny dogfish were collected during the winter survey in either survey area.

The condition of spiny dogfish was highest in the spring survey (501N Study Area: 1.02 ± 0.13, Control Area: 1.11 ± 0.14), average in the fall survey (501N Study Area: 0.99 ± 0.13, Control Area: 1.00 ± 0.13), and lowest in the summer survey (501N Study Area: 0.83 ± 0.15, Control Area: 1.02 ± 0.07, $p < 0.0001$, Figure 28). It should be repeated that only six individuals were caught in the summer survey. Spiny dogfish tended to be in better condition in the Control Area compared to the 501N Study Area ($p < 0.0095$).

4.4.5 Winter Skate

Winter skate (*Leucoraja ocellata*) was the fourth most abundant species in the 501N Study Area and the fifth most abundant species in the Control Area. Winter skates were consistently caught during the spring and fall surveys with lower catches observed in the summer survey. Annually, catch rates averaged 12.8 ± 2.0 kg/tow (range: 0 – 70.7 kg/tow) in the 501N Study Area and 13.8 ± 2.2 kg/tow (range: 0 – 79.7 kg/tow) in the Control Area. GLM analysis indicated that there was a significant seasonal trend ($p = 0.0001$) but no difference between survey areas ($p = 0.1239$). Catch rates were about half of those observed during the 2019/2020 survey season (Figure 29).

The catch rate was highest in the spring survey, averaging 33.6 ± 4.6 kg/tow in the 501N Study Area and 40.0 ± 3.9 kg/tow in the Control Area (Figure 29). Winter skates were caught in every tow in the Control Area and 19 of the 20 tows in the 501N Study Area. The catch of winter skate was evenly distributed throughout both survey areas (Figure 30). Winter skates had a wide size distribution ranging from 26 to 55 cm in length (disk width, Figure 31). The size distributions were not significantly different between the two survey areas ($p = 0.667$, Figure 32).

The catch of winter skate was lower but consistent during the fall survey. Seasonal catch rates averaged 14.3 ± 3.2 kg/tow in the 501N Study Area and 14.4 ± 3.4 kg/tow in the Control Area (Figure 29). Winter skates were caught in 17 of the 20 tows in both survey areas. The catch was highest in the deeper tows to the south in both survey areas (Figure 30). Individuals had a wide size distribution similar to the spring survey, ranging from 20 to 69 cm in length (disk width, Figure 31). The distribution of the catch was shifted towards smaller individuals in the Control Area as compared to the 501N Study Area ($p = 0.002$, Figure 32).

Winter skates were sporadically caught at low abundances during the summer survey. Catch rates averaged 3.2 ± 1.2 kg/tow in the 501N Study Area and 0.8 ± 0.3 kg/tow in the Control Area

(Figure 29). Winter skates were caught in nine of the 20 tows in the 501N Study Area and six of the 20 tows in the Control Area. The catch of winter skate was distributed throughout both survey areas (Figure 30). Individuals ranged in size from 24 to 51 cm (disk width) with no significant difference between the two survey areas (Figures 32, 33).

Only three winter skates were caught in the winter survey.

Winter skates exhibited seasonal variations in condition with the highest condition observed in the summer survey (501N Study Area: 1.06 ± 0.11, Control Area: 1.13 ± 0.11) and the lowest condition observed in the fall survey (501N Study Area: 0.98 ± 0.09, Control Area: 0.97 ± 0.12). There was no significant difference in the condition of winter skates between the two survey areas ($p = 0.4486$, Figure 33).

4.4.6 Silver Hake

Silver hake (*Merluccius bilinearis*), commonly referred to as whiting, is a commercially important species in the region. By weight, silver hake was the fifth most abundant species in the 501N Study Area and the fourth most abundant species in the Control Area, accounting for about 5% of the annual catch. Annual catch rates averaged 12.7 ± 2.8 kg/tow (range: 0 – 136.4 kg/tow) in the 501N Study Area and 17.3 ± 3.6 kg/tow (range: 0 – 169.8 kg/tow) in the Control Area. The GLM analysis indicated that the survey area and season were significant predictors of the catch (area: $p = 0.0263$, season: $p < 0.0001$). During the 2019/2020 survey season, silver hake was the most consistent species caught in the survey with individuals present in 159 of the 160 tows conducted. The 2020/2021 survey season exhibited significantly lower catches with the average annual catch rate reduced 80% compared to the previous year (Figure 34). The most notable change was between the 2019 and 2021 spring surveys where catch rates were reduced by 87% and 78% in the 501N Study Area and Control Area, respectively. Similar decreases were observed in the summer survey.

The catch of silver hake was highest in the fall survey with a significant disparity between the two survey areas. The catch of silver hake averaged 31.9 ± 6.9 kg/tow in the 501N Study Area and 49.8 ± 10.5 kg/tow in the Control Area (Figure 34). Silver hake were observed in all 20 tows in both survey areas. The catch of silver hake was evenly distributed across both survey areas (Figure 35). Individuals ranged in length from 10 to 32 cm with unimodal peaks at 23 cm in both survey areas (Figure 36). The distribution of the catch was shifted towards larger individuals in the 501N Study Area compared to the Control Area (p = 0.005, Figure 37).

The catch decreased in subsequent seasons with similar catch rates observed in the spring and summer surveys. During the spring survey, the catch of silver hake averaged 5.2 ± 0.7 kg/tow in the 501N Study Area and 9.4 ± 1.4 kg/tow in the Control Area (Figure 34). Silver hake were observed in all 20 tows in both survey areas. The catch of silver hake was evenly distributed across both survey areas (Figure 35). Individuals ranged in length from 10 to 36 cm with a unimodal peak at 24 cm (Figure 36). The size characteristics of the catch were similar between survey areas with the Control Area capturing more small individuals (p = 0.002, Figure 37).

Catches of silver hake were more sporadic in the summer survey compared to the spring and fall surveys. Catch rates averaged 13.4 ± 6.9 kg/tow in the 501N Study Area and 9.7 ± 4.6 kg/tow in the Control Area (Figure 34). Silver hake were observed in 16 of the 20 tows in the 501N Study Area and 10 of the 20 tows in the Control Area. The catch of silver hake was primarily distributed across the southern half of the survey areas (Figure 35). This is presumably due to the warm temperatures observed during the survey. Individuals ranged in length from 16 to 40 cm with a unimodal peak at 20 cm (Figure 36). The size characteristics of the catch were similar between survey areas with small variations in the length composition (p = 0.003, Figure 37).

Low catches were observed in the winter survey, averaging 0.2 ± 0.8 kg/tow in the 501N Study Area and 0.2 ± 0.1 kg/tow in the Control Area (Figure 34). Silver hake were observed in 13 of the 20 tows in the 501N Study Area and nine of the 20 tows in the Control Area. The catch of silver hake was primarily observed in the southern half of the survey areas (Figure 35). Silver hake caught in the winter survey were primarily small (Figure 36). Individuals ranged in length from 7 to 32 cm with peaks at 10 and 23 cm. The population in the 501N Study Area was primarily comprised of individuals in the 10-cm cohort. The population of the Control Area was more evenly spaced between the small (10 cm) and larger cohort (23 cm, Figure 37).

Silver hake displayed significant seasonal differences in condition (p = 0.001, Figure 38). Condition was highest in the spring (501N Study Area: 1.06 ± 0.1, Control Area: 1.05 ± 0.1) and lowest in the fall survey (501N Study Area: 0.95 ± 0.07, Control Area: 0.96 ± 0.09). Survey area was not a significant predictor of fish condition (p = 0.2975).

4.4.7 Butterfish

Butterfish (*Peprilus triacanthus*) was consistently caught in both survey areas. Butterfish were observed in almost every tow during the summer, fall, and spring surveys. By weight, butterfish was the sixth most abundant species in both survey areas. Annually, catch rates averaged 11.1 ± 2.1 kg/tow (range: 0 – 101.4 kg/tow) in the 501N Study Area and 13.8 ± 2.8 kg/tow (range: 0 – 115.8 kg/tow) in the Control Area. The GLM analysis indicated that there was a significant seasonal effect, but the two survey areas were not significantly different (area: $p = 0.2854$, season: $p < 0.0001$). In general, the annual catch rate was half of that observed in the 2019/2020 survey year (Figure 39). Catch rates between the two years were significantly lower during the spring 2021 and summer 2020 surveys, compared to spring 2019 and summer 2019 surveys, but higher in fall 2020 survey compared to the fall 2019 survey, respectively. The large difference between catches in the spring survey could be due to the timing of the two surveys (May versus June).

The catch rate of butterfish was highest in the summer survey with catch rates averaging 16.9 ± 5.2 kg/tow in the 501N Study Area and 28.6 ± 8.5 kg/tow in the Control Area (Figure 39). Butterfish were observed in 19 of the 20 tows in the 501N Study Area and all 20 tows in the Control Area. The catch of butterfish was evenly distributed across both survey areas (Figure 40). Individuals ranged from 6 to 17 cm in length with a unimodal size distribution peaking at 8 cm (Figure 41). Fish in the 501N Study Area had a wide size distribution while the Control Area exhibited a narrow distribution ($p < 0.0001$, Figure 42).

Catch rates in the fall survey were similar to the summer survey. Seasonal catch rates averaged 26.7 ± 4.1 kg/tow in the 501N Study Area and 24.6 ± 4.8 kg/tow in the Control Area (Figure 39). Butterfish were observed in all 20 tows in both survey areas. The butterfish catch was evenly distributed across both survey areas (Figure 40). Individuals ranged in length from 6 to 21 cm with a wide unimodal size distribution peaking at 8 cm (Figure 41). The size characteristics of the catch were similar between survey areas with small variations in the length composition ($p = 0.002$, Figure 42).

The catch of butterfish was consistent but low during the spring survey. Catch rates averaged 1.0 ± 0.2 kg/tow in the 501N Study Area and 2.0 ± 0.3 kg/tow in the Control Area (Figure 39). Butterfish were observed in 19 of the 20 tows in the 501N Study Area and 18 of the 20 tows in the Control Area. The catch of butterfish was evenly distributed across both survey areas (Figure

40). Individuals ranged from 9 to 20 cm in length with a wide size distribution (Figure 41). Fish in the 501N Study Area had a narrower size distribution compared to the Control Area ($p < 0.0001$, Figure 42).

No butterfish were collected during the winter survey.

Butterfish displayed seasonal differences in condition ($p = 0.001$, Figure 43). The condition was highest in the fall survey (501N Study Area: 1.01 ± 0.22, Control 1.14 ± 0.29) and lowest in the summer survey (501N Study Area: 0.95 ± 0.12, Control Area: 0.98 ± 0.17). In general, the condition was higher in the Control Area compared to the 501N Study Area ($p < 0.0001$).

4.4.8 Atlantic Longfin Squid

Atlantic longfin squid (*Doryteuthis pealei*), a commercially important species commonly called Loligo squid, was consistently caught in both survey areas during the spring, summer, and fall surveys. Annually, catch rates averaged 8.8 ± 1.2 kg/tow (range: 0 – 41.4 kg/tow) in the 501N Study Area and 7.5 ± 1.1 kg/tow (range: 0 – 45.2 kg/tow) in the Control Area. The GLM analysis indicated that season was a significant predictor of catch rate ($p = 0.0001$) but not survey area ($p = 0.1462$). In general, the catch of Atlantic longfin squid was higher during the 2020/2021 survey year, compared to the 2019/2020 survey year. This is due to higher catches in the summer and fall surveys. Lower catches were observed during the spring 2021 survey compared to the spring 2019 survey. As with butterfish, this could be due to the different timing of the surveys. No squid eggs (i.e., "squid mops") were observed during any of the surveys.

The catch of Atlantic longfin squid was highest during the summer survey. The seasonal catch averaged 21.2 ± 2.3 kg/tow in the 501N Study Area and 20.4 ± 2.3 kg/tow in the Control Area (Figure 44). Atlantic longfin squid were caught in all 20 tows in both survey areas. The catch was evenly distributed across both survey areas (Figure 45). Individuals ranged in length from 3 to 23 cm (mantle length) with a unimodal distribution peaking at 4 cm (Figure 46). The size structure was similar between areas with the 501N Study Area catching a greater proportion of small squid in the catch ($p = 0.017$, Figure 47).

Atlantic longfin squid were present in the fall survey but at lower abundances (501N Study Area: 13.5 ± 1.5 kg/tow, Control Area: 9.2 ± 1.2 kg/tow, Figure 44). Atlantic longfin squid were caught in all 20 tows in the 501N Study Area and 19 of the 20 tows in the Control Area. The catch was distributed throughout both survey areas (Figure 45). Individuals ranged in length from 3 to 23 cm with a wide unimodal size distribution peak between 5 and 8 cm (Figure 46). The size distribution in the 501N Study Area was shifted slightly toward larger individuals compared to the Control Area ($p < 0.0001$, Figure 47)

The catch of Atlantic longfin squid in the spring survey was low with an average catch of 0.4 ± 0.1 kg/tow in the 501N Study Area and 0.2 ± 0.4 kg/tow in the Control Area (Figure 44). Atlantic ongfin squid were caught in 16 of the 20 tows in the 501N Study Area and 17 of the 20 tows in the Control Area. Similar to previous seasons, the catch was dispersed throughout both survey areas (Figure 45). Individuals ranged in length from 4 to 23 cm with a wide unimodal peak around 12 cm (Figure 46). The size distribution of Atlantic longfin squid was similar between the two survey areas ($p = 0.135$, Figure 61).

Only two Atlantic longfin squid were caught during the winter survey.

Atlantic longfin squid displayed seasonal variations in condition ($p = 0.0001$, Figure 48). The condition was highest in the fall survey (501N Study Area: 1.16 ± 0.29, Control Area: 1.25 ± 0.3) and lowest in the summer survey (501N Study Area: 0.89 ± 0.21, Control Area: 0.83 ± 0.19). No differences in condition were observed between the two survey areas ($p = 0.9753$).

4.4.9 Atlantic Herring

Atlantic herring (*Clupea harengus*) were frequently caught during the winter and spring surveys. Annually, catch rates averaged 7.2 ± 2.4 kg/tow (range: 0 – 151.4 kg/tow) in the 501N Study Area and 8.4 ± 4.1 kg/tow (range: 0 – 302.2 kg/tow) in the Control Area. The GLM analysis indicated that there was a strong seasonal variation in the catch rate ($p = 0.0001$), but no difference between survey areas ($p = 0.5494$). Much of the catch was collected during the winter survey. In the winter 2020 survey, there was a significant disparity between the 501N Study Area and the Control Area. The winter 2021 survey did not show the same disparity. Both survey areas had catch rates similar to that observed in the Control Area in 2020. Atlantic herring were frequently caught in the spring 2021 survey, which contrasts with the spring 2019 survey in which no Atlantic herring were caught.

Catch rates during the winter survey averaged 25.9 ± 8.0 kg/tow in the 501N Study Area and 31.2 ± 15.4 kg/tow in the Control Area (Figure 49). Atlantic herring were caught in all 20 tows in the 501N Study Area and 17 of the 20 tows in the Control Area. The catch was distributed throughout the survey areas with a higher catch observed in the northern half of both survey areas (Figure 50). Individuals ranged in length from 16 to 24 cm with a unimodal peak at 19 – 20 cm (Figure 51). The population of fish caught in the Control Area was slightly larger than the population in the 501N Study Area ($p = 0.0001$, Figure 52).

The catch of Atlantic herring was low but consistent in the spring survey. Catch rates averaged 3.0 ± 2.0 kg/tow in the 501N Study Area and 2.4 ± 1.5 kg/tow in the Control Area (Figure 49). Atlantic herring were caught in 14 of the 20 tows in the 501N Study Area and 18 of the 20 tows in the Control Area. The catch was dispersed throughout both survey areas (Figure 50). Individuals ranged in length from 18 to 24 cm with a narrow unimodal peak at 21 cm (Figure 51). The size distribution was similar between the survey areas ($p = 0.0001$, Figure 52).

Only six Atlantic herring were caught in the 501N Study Area in six tows during the summer and fall surveys (three in each survey). A single individual was caught in the Control Area during the fall survey.

The condition of Atlantic herring was not significantly different between survey areas ($p = 0.392$). The condition appeared to be higher during the spring survey (501N Study Area: 1.07 ± 0.07, Control Area: 1.08 ± 0.07) and lower during the winter survey (501N Study Area: 0.97 ± 0.11, Control Area: 0.97 ± 0.07, Figure 53).

4.4.10 Red Hake

Red hake (*Urophycis chuss*) was one of the most abundant and consistently caught species in the 2019/2020 survey year. Catch rates in the 2020/2021 survey year were dramatically lower with the red hake catch limited primarily to the fall and spring surveys (Figure 54). Annually, catch rates averaged 5.9 ± 1.1 kg/tow (range: 0 – 58.5 kg/tow) in the 501N Study Area and 9.2 ± 1.7 kg/tow (range: 0 – 83.1 kg/tow) in the Control Area. The GLM analysis indicated that survey area and season were significant predictors of the catch (area: $p < 0.0001$, season: $p = 0.0011$).

The catch of red hake exhibited significant disparity between the two survey areas in the fall survey (501N Study Area: 10.5 ± 2.9 kg/tow, Control Area: 18.8 ± 4.8 kg/tow, Figure 54). Red hake were observed in 19 of the 20 tows in both survey areas. The catch of red hake was distributed throughout both survey areas (Figure 55). Individuals ranged in length from 17 to 44 cm with a wide unimodal size distribution peaking between 24 and 27 cm (Figure 56). The population structure within the 501N Study Area was shifted slightly toward smaller individuals compared to the Control Area ($p < 0.0001$, Figure 57).

The catch characteristics of red hake was similar during the spring survey. The seasonal catch averaged 9.2 ± 1.5 kg/tow in the 501N Study Area and 17.7 ± 3.0 kg/tow in the Control Area (Figure 54). Red hake were observed in 19 of the 20 tows in the 501N Study Areas and all 20 tows in the Control Area. Similar to the fall survey, the catch of red hake was distributed throughout both survey areas (Figure 55). Individuals ranged in length from 10 to 39 cm with a wide unimodal size distribution peaking at 28 cm (Figure 56). The population structure was not significantly different between the two survey areas ($p = 0.101$, Figure 57).

Low catches were observed in the summer survey averaging 3.9 ± 2.6 kg/tow in the 501N Study Area and 0.4 ± 0.4 kg/tow in the Control Area (Figure 54). Red hake were observed in eight of the 20 tows in the 501N Study Area and two of the 20 tows in the Control Area. The catch of red hake was primarily located in deeper water in the southern half of the survey areas (Figure 55). Due to the low numbers observed, red hake had a broad size distribution ranging from 18 to 36 cm in length (Figure 56). The population in the 501N Study Area had a narrower size distribution primarily associated with individuals around 23 cm. The Control Area had a broader size distribution ($p < 0.0001$, Figure 57).

During the winter survey, only five individuals were caught between four tows in the 501N Study Area. Three individuals were caught between two tows in the Control Area.

Red hake displayed significant seasonal differences in condition (Figure 58, $p = 0.0001$). The condition was highest in the winter survey; however, only eight individuals were collected. The condition was also high in the summer survey (501N Study Area: 1.03 ± 0.1, Control Area: 1.05 ± 0.09). The condition of fish was around 1 (i.e., "normal") in the fall and spring surveys. Throughout the surveys, the condition of fish was slightly higher in the Control Area compared to the 501N Study Area ($p = 0.003$).

4.4.11 Smooth Dogfish

Smooth dogfish (*Mustelus canis*) were frequently caught during the summer survey. Annually, catch rates average 3.5 ± 1.1 kg/tow (range: 0 – 62.4 kg/tow) in the 501N Study Area and 2.5 ± 0.8 kg/tow (range: 0 – 50.6 kg/tow) in the Control Area. The GLM analysis indicated that there was a strong seasonal effect but only a weak area effect when predicting catch rates (Season: p = 0.0001, Survey Area: p = 0.0355).

Smooth dogfish were most common during the summer survey. The seasonal catch rates averaged 14.0 ± 3.4 kg/tow in the 501N Study Area and 9.6 ± 2.4 kg/tow in the Control Area (Figure 59). Smooth dogfish were observed in 19 of the 20 tows in the 501N Study Area and 16 of the 20 tows in the Control Area. The catch of smooth dogfish was distributed across both survey areas (Figure 60). Individuals ranged in length from 52 to 101 cm with a wide size distribution (Figure 61). The size distributions of dogfish in the two survey areas were not statistically different (p = 0.137, Figure 62). Similarly, the condition of individuals was not different between the two survey areas (p = 0.2955, Figure 63).

One additional dogfish was caught in the 501N Study Area during the spring survey. Five individuals were caught in the Control Area: two in the fall survey and three in the spring survey.

4.4.12 Summer Flounder

Summer flounder (*Paralichthys dentatus*), also known as fluke, is a commercially important flatfish that was commonly observed during the surveys. Summer flounder were frequently observed during the spring, summer, and fall surveys. Annually, catch rates averaged 2.9 ± 0.6 kg/tow (range: 0 – 24.2 kg/tow) in the 501N Study Area and 3.2 ± 0.6 kg/tow (range: 0 – 30.6 kg/tow) in the Control Area. Data from the 2019/2020 survey year exhibited seasonal changes in the catch rate with a strong disparity between the two survey areas. The current survey year showed similar seasonal trends (p = 0.0001) with similar catch rates between the two survey areas (p = 0.861). Comparing the two survey years, in 2020/2021, catches were higher in the summer survey, similar in the fall survey, and lower in the spring survey. These differences are probably due to warmer summer temperatures increasing the catch and the earlier spring survey reducing the catch.

The highest catch rates of summer flounder were observed during the summer survey (501N Study Area: 9.4 ± 1.6 kg/tow, Control Area: 9.4 ± 1.8 kg/tow, Figure 64). Summer flounder were observed in all 20 tows in the 501N Study Area and 19 of the 20 tows in the Control Area. The catch of summer flounder appeared to be distributed across both survey areas (Figure 65). Individuals ranged in size from 36 to 72 cm with a broad size distribution (Figure 66). While the distributions were similar between the survey areas, the population in the 501N Study Area was slightly smaller ($p = 0.027$, Figure 67).

During the fall survey, catch rates averaged 1.7 ± 0.4 kg/tow in the 501N Study Area and 2.4 ± 0.5 kg/tow in the Control Area (Figure 64). Summer flounder were observed in 15 of the 20 tows in the 501N Study Area and 18 of the 20 tows in the Control Area. The catch of summer flounder appeared evenly distributed throughout the survey areas (Figure 65). In general, the population was smaller during the fall survey with individuals ranging in length from 25 to 63 cm (Figure 66). Similar to the summer survey, the size distribution of the population in the 501N Study Area was shifted to be slightly smaller ($p = 0.022$, Figure 67).

The catch of summer flounder during the spring survey was relatively low, averaging 0.6 ± 02 kg/tow in the 501N Study Area and 0.9 ± 0.4 kg/tow in the Control Area (Figure 64). Summer flounder were observed in 11 of the 20 tows in both survey areas. The catch was distributed across both survey areas (Figure 65). Thirty-nine individuals were caught in both survey areas with a wide length distribution ranging from 29 to 67 cm in length (Figure 66). The distribution of lengths was similar between both survey areas ($p = 0.344$, Figure 67).

No summer flounder were collected during the winter survey.

Summer flounder exhibited seasonal variations in condition ($p = 0.0001$, Figure 68). The condition of summer flounder was highest during the summer survey (501N Study Area: 1.04 ± 0.08, Control Area: 1.05 ± 0.08). The condition was close to 1 during the fall survey (501N Study Area: 1.0 ± 0.11, Control Area: 0.98 ± 0.08). Fish condition was lowest during the spring survey (501N Study Area: 0.93 ± 0.05, Control Area: 0.96 ± 0.06). The survey area was not a significant predictor of condition in summer flounder ($p = 0.6069$).

4.4.13 Black Sea Bass

Black sea bass (*Centropristis striata*) is another commercially important species in the region. During the 2019/2020 survey season, only 23 individuals were collected, primarily during the fall survey. Conversely, black sea bass were routinely caught in the summer, fall, and spring surveys in the current survey year. Annually, catch rates averaged 2.2 ± 0.3 kg/tow (range: 0 – 11.0 kg/tow) in the 501N Study Area and 1.3 ± 0.2 kg/tow (range: 0 – 8.5 kg/tow) in the Control Area. The catch of black sea bass exhibited seasonal trends ($p < 0.0001$) and an area effect, with higher catches observed in the 501N Study Area ($p < 0.0001$).

During the summer survey, catch rates of black sea bass averaged 0.7 ± 0.4 kg/tow in the 501N Study Area and 1.5 ± 0.5 kg/tow in the Control Area (Figure 69). Black sea bass were observed in six of the 20 tows in the 501N Study Area and 14 of the 20 tows in the Control Area. The catch was primarily located in the northern half of the survey areas (Figure 70). Individuals ranged in length from 22 to 55 cm with a broad size distribution (Figure 71). While the size distributions were similar between the survey areas, the population structure in the 501N Study Area was shifted toward slightly smaller individuals ($p = 0.011$, Figure 72).

The catch of black sea bass showed a significant disparity between the two survey areas in the fall survey. The seasonal catch rates averaged 3.3 ± 0.3 kg/tow in the 501N Study Area and 0.9 ± 0.2 kg/tow in the Control Area (Figure 69). Black sea bass were observed in all 20 tows in the 501N Study Area and 18 of the 20 tows in the Control Area. The catch of black sea bass appeared evenly distributed throughout the survey areas (Figure 70). In general, the population was smaller during the fall survey with individuals ranging from 8 to 45 cm in length (Figure 71). The peak of the distribution in both survey areas occurred around 28 cm. The 501N Study Area had a narrow size distribution while the population structure in the Control Area was wider and included more small fish ($p = 0.0001$, Figure 72)

Black sea bass were most abundant during the spring survey. This is presumably due to the timing of the survey correlating with their annual inshore migration. Seasonal catch rates averaged 5.0 ± 0.7 kg/tow in the 501N Study Area and 2.9 ± 0.4 kg/tow in the Control Area (Figure 69). Black sea bass were observed in 19 of the 20 tows in both survey areas with the catch distributed across both survey areas (Figure 70). Black sea bass had a wide size distribution ranging from 11 to 55 cm in length (Figure 71). The population structure was similar between both survey areas ($p = 0.59$, Figure 72).

No black sea bass were collected during the winter survey.

Black sea bass exhibited seasonal variations in condition ($p = 0.0001$, Figure 73). The condition of black sea bass was highest during the fall survey (501N Study Area: 1.03 ± 0.12, Control Area: 1.06 ± 0.11) and lowest during the spring survey (501N Study Area: 0.96 ± 0.08, Control Area: 0.96 ± 0.09). No significant differences were observed between the survey areas ($p = 0.1166$).

4.4.14 Northern Sea Robin

Northern Sea Robin (*Prionotus carolinus*) were commonly caught during the summer, fall, and spring surveys. Annually, catch rates averaged 1.9 ± 0.4 kg/tow (range: 0 – 21.3 kg/tow) in the 501N Study Area and 5.3 ± 1.9 kg/tow (range: 0 – 128.0 kg/tow) in the Control Area. Annual average catch rates were similar between the two survey years; however, the majority of the catch in the 2019/2020 survey year occurred during the fall survey while the catch was more distributed throughout the survey year in 2020/2021. The GLM analysis of the current survey year indicated that season was a strong predictor of catch rates ($p < 0.0001$) while survey area was a weak predictor of the catch ($p = 0.0827$).

The catch of northern sea robin was highest in the Control Area during the summer survey (12.7 ± 7.2 kg/tow). This contrasts with a relatively low catch in the 501N Study Area (1.1 ± 0.3 kg/tow, Figure 74). Northern sea robins were observed in 13 of the 20 tows in the 501N Study Area and 10 of the 20 tows in the Control Area. The high seasonal catch rate observed in the Control Area was primarily due to a couple of large tows in the southeastern corner. In general, the rest of the catch was scattered across both survey areas (Figure 75). Individuals ranged in length from 18 to 40 cm with a unimodal peak around 27 cm (Figure 76). The population of northern sea robin in the 501N Study Area was shifted toward larger individuals compared to the Control Area ($p < 0.0001$, Figure 77).

During the fall survey, the catch of northern sea robins was moderate with similar catches observed in the two survey areas (Figure 74). Seasonally, catch rates averaged 5.6 ± 1.3 kg/tow in the 501N Study Area and 7.3 ± 1.9 kg/tow in the Control Area. Northern sea robins were observed in all 20 tows in the 501N Study Area and 18 of the 20 tows in the Control Area. The catch of northern sea robins appeared to correlate with depth as the catch increased toward the southern boundary (Figure 75). Individuals ranged in length from 9 to 34 cm with the majority of individuals between 19 to 30 cm (Figure 76). The length distribution was similar between the two survey areas (p = 0.048, Figure 77).

The catch of northern sea robins was low but consistent during the spring survey. Seasonal catch rates averaged 0.9 ± 0.2 kg/tow in the 501N Study Area and 1.2 ± 0.2 kg/tow in the Control Area. Northern sea robins were observed in 17 of the 20 tows in the 501N Study Area and 19 of the 20 tows in the Control Area. The catch of northern sea robins was distributed across both survey areas (Figure 75). Individuals ranged in length from 10 to 33 cm. The population structure had a bimodal distribution with peaks at 11 and 25 cm (Figure 76). The length distribution was similar between the two survey areas (p = 0.212, Figure 77).

No northern sea robins were collected during the winter survey.

Northern sea robins exhibited seasonal variations in condition (p = 0.0001, Figure 73). The condition of northern sea robins was around 1 during the summer and fall surveys with a low condition observed during the spring survey (501N Study Area: 0.98 ± 0.13, Control Area: 0.93 ± 0.1). Fish in the Control Area appeared to be in slightly higher condition than those in the 501N Study Area (p = 0.0044).

4.4.15 Winter Flounder

Winter flounder (*Pseudopleuronectes americanus*), also known as blackback flounder, is a federally regulated groundfish commonly caught at low levels during the summer and fall surveys. Annually, variations in the catch were observed between seasons with a strong disparity between the two survey areas (Season: p = 0.0001, Survey Area: p = 0.0033). Catch rates average 1.9 ± 0.4 kg/tow (range: 0 – 22.1 kg/tow) in the 501N Study Area and 0.4 ± 0.1 kg/tow (range: 0 – 4.1 kg/tow) in the Control Area. The same disparity was observed in 2019/2020 survey year with significantly higher catches observed in the 501N Study Area.

Catch rates were highest during the summer survey, averaging 4.6 ± 1.2 kg/tow in the 501N Study Area and 0.8 ± 0.1 kg/tow in the Control Area (Figure 79). Winter flounder were caught in 19 of the 20 tows in the 501N Study Area and 16 of the 20 tows in the Control Area. The catch was distributed throughout the two survey areas with the highest catches located in the southern half of the 501N Study Area (Figure 80). Winter flounder ranged in length from 20 to 44 cm (Figure 81). The population in the 501N Study Area had a unimodal distribution peaking around 32 cm. The Control Area had a similarly shaped distribution, but the peak was around 23 cm ($p < 0.0001$, Figure 82).

Catch rates during the fall survey averaged 2.7 ± 0.5 kg/tow in the 501N Study Area and 0.7 ± 0.3 kg/tow in the Control Area (Figure 79). Winter flounder were observed in 19 of the 20 tows in the 501N Study Area and 11 of the 20 tows in the Control Area. The catch was distributed throughout both survey areas (Figure 80). The size range of winter flounder was similar to that of the summer survey, ranging from 21 to 47 cm in length (Figure 81). The population in the 501N Study Area had a greater proportion of large fish compared to the population of the Control Area ($p = 0.048$, Figure 82).

During the spring survey, only five winter flounder were caught in four tows in the 501N Study Area. Similarly, 10 individuals were caught in four tows in the Control Area. Only two individuals were caught in the winter survey. Both were caught in the 501N Study Area.

Winter flounder exhibited seasonal variations in condition ($p = 0.0001$, Figure 83). The condition of winter flounder was highest during the summer survey (501N Study Area: 1.05 ± 0.08, Control Area: 1.05 ± 0.07) and lowest during the spring survey (501N Study Area: 0.91 ± 0.09, Control Area: 0.90 ± 0.1). No significant differences were observed between the survey areas ($p = 0.8189$).

4.4.16 Fourspot flounder

Fourspot flounder (*Paralichthys oblongus*) was the most common flatfish species observed during the survey. Fourspot flounder were observed in almost every tow in the spring, summer, and fall surveys. Annually, catch rates averaged 1.3 ± 0.2 kg/tow (range: 0 – 8.5 kg/tow) in the 501N Study Area and 1.7 ± 0.3 kg/tow (range: 0 – 11.5 kg/tow) in the Control Area. The GLM analysis indicated that season was a significant predictor of catch rate ($p = 0.0001$) but not survey area ($p = 0.077$, Figure 84). The seasonal trends were consistent between the 2019/2020 and 2020/2021 survey years with similar catch rates observed between the spring, summer, and fall surveys. While the seasonal trends were similar, the catch rates were ~30% lower in the 2020/2021 survey year compared to the 2019/2020 survey year (Figure 84).

The catch rate of fourspot flounder during the summer survey was 2.3 ± 0.5 kg/tow in the 501N Study Area and 2.0 ± 0.5 kg/tow in the Control Area (Figure 84). Fourspot flounder were caught in every tow in the 501N Study Area and 16 of the 20 tows in the Control Area. The catch was distributed throughout both survey areas with the highest catches observed in the southern half of each survey area (Figure 85). Individuals ranged in length from 17 to 37 cm with bimodal peaks at 20 and 30 cm (Figure 86). The size structure of the population was similar between survey areas with the population in the 501N Study Area containing a greater proportion of large fish ($p = 0.007$, Figure 87).

Catch rates were similar during the fall survey, averaging 1.6 ± 0.3 kg/tow in the 501N Study Area and 2.6 ± 0.7 kg/tow in the Control Area (Figure 84). Fourspot flounder were caught in 19 of the 20 tows in both survey areas with the catch distributed throughout both survey areas (Figure 85). Individuals ranged in length from 13 to 41 cm. The smaller cohort observed in the summer survey was absent during the fall survey, leaving a single unimodal distribution peaking around 31 cm (Figure 86). This population structure was similar between the two survey areas ($p = 0.03$, Figure 87).

During the spring survey, catch rates averaged 1.2 ± 0.2 kg/tow in the 501N Study Area and 2.3 ± 0.3 kg/tow in the Control Area (Figure 84). Fourspot flounder were caught in 19 of the 20 tows in the 501N Study Area and all 20 tows in the Control Area with the catch distributed throughout both survey areas (Figure 85). The size distribution was similar to the fall survey with individuals ranging in length from 14 to 43 cm (Figure 86). Both survey areas had a unimodal distribution peaking at around 30 cm ($p = 0.3$, Figure 87).

No fourspot flounder were collected during the winter survey.

Fourspot flounder exhibited seasonal variations in condition ($p = 0.0001$, Figure 88). The condition of fourspot flounder was highest in Control Area during the spring survey (501N Study Area: 1.0 ± 0.08, Control Area: 1.02 ± 0.1) and lowest in the 501N Study Area during the fall survey (501N Study Area: 0.96 ± 0.1, Control Area: 1.0 ± 0.09). In general, fish condition was higher in the Control Area compared to the 501N Study Area ($p = 0.0263$).

4.4.17 Windowpane Flounder

Windowpane flounder (*Scophtalmus aquosus*), also known as sand dab, is a federally regulated groundfish. Windowpane flounder were observed in all surveys and both survey areas. Annually, catch rates averaged 1.0 ± 0.2 kg/tow (range: 0 – 8.2 kg/tow) in the 501N Study Area and 2.0 ± 0.5 kg/tow (range: 0 – 28.2 kg/tow) in the Control Area. The GLM analysis indicated that season and survey area were significant predictors of catch rate (Season: $p = 0.0001$, Area: 0.0005). Seasonal trends were similar between the two survey years with the highest catches observed in the fall survey, followed by the summer survey. Catch rates were low in the spring and winter surveys. In general, catch rates were higher in the 2020/2021 survey year compared to the 2019/2020 survey year. In the 2019/2020 survey year, the catch rates were similar between the two survey areas; however, the 2020/2021 survey year displayed significant disparity between the two survey areas with higher catches observed in the Control Area.

During the summer survey, catch rates averaged 0.8 ± 0.3 kg/tow in the 501N Study Area and 1.3 ± 0.4 kg/tow in the Control Area (Figure 89). Windowpane flounder were caught in 15 of the 20 tows in the 501N Study Area and 18 of the 20 tows in the Control Area. The catch of windowpane flounder was distributed across the two survey areas (Figure 90). Windowpane flounder ranged in length from 15 to 32 cm with bimodal peaks at 18 and 28 cm (Figure 91). The population in the 501N Study Area was primarily associated with the larger cohort while the Control Area had a significant number of individuals in the smaller cohort ($p = 0.048$, Figure 92).

The highest catch rates of windowpane flounder were observed during the fall survey (501N Study Area: 3.1 ± 0.6 kg/tow, Control Area: 6.5 ± 1.8 kg/tow, Figure 89). Windowpane flounder were observed in 19 of the 20 tows in both survey areas with higher catches collected in the northern half of the survey areas (Figure 90). Windowpane flounder ranged in length from 16 to 31 cm with a unimodal peak at around 21 cm (Figure 91). The 501N Study Area had a smaller secondary peak at around 26 cm ($p < 0.0001$, Figure 92).

Catch rates were relatively low during the spring survey, averaging 0.2 ± 0.06 kg/tow in the 501N Study Area and 0.3 ± 0.09 kg/tow in the Control Area (Figure 89). Windowpane flounder were observed in 11 of the 20 tows in the 501N Study Area and 13 of the 20 tows in the Control Area. The catch of windowpane was scattered across both survey areas (Figure 90). Windowpane flounder ranged in length from 18 to 32 cm with a broad size distribution (Figure 91). The size structure within the two survey areas was similar (p = 0.303, Figure 92).

Only eight individuals were collected during the winter survey. A total of three individuals were caught in three tows in the 501N Study Area. Similarly, a total of five individuals were caught in five tows in the Control Area.

Windowpane flounder exhibited seasonal and survey area variations in condition (p = 0.0007 and 0.0381, respectively, Figure 93). The condition of windowpane flounder was highest in the summer survey (501N Study Area: 1.03 ± 0.1, Control Area: 1.02 ± 0.1) and lowest in the spring survey (501N Study Area: 1.0 ± 0.07, Control Area: 0.97 ± 0.1). In general, the condition of windowpane flounder was higher in the Control Area compared to the 501N Study Area (p = 0.0381).

4.4.18 Cancer Crab

Cancer crab (*Cancer sp.*), an aggregation of Jonah crab (*Cancer borealis*) and Atlantic rock crab (*Cancer irroratus*), were frequently observed throughout all four of the seasonal surveys. Annually, catch rates average 0.8 ± 0.2 kg/tow (range: 0 – 9.1 kg/tow) in the 501N Study Area and 0.5 ± 0.1 kg/tow (range: 0 – 9.5 kg/tow) in the Control Area. The GLM analysis indicated that season was a significant predictor of catch rate but not survey area (Season: p = 0.0199, Survey Area: p = 0.1314).

Cancer crabs were most abundant during the summer and fall surveys. The average catch rate in the summer survey was 1.2 ± 0.6 kg/tow in the 501N Study Area and 0.1 ± 0.04 kg/tow in the Control Area (Figure 94). Cancer crabs were caught in six of the 20 tows in the 501N Study Area and two of the 20 tows in the Control Area. During the fall survey, the catch rate averaged 1.4 ± 0.5 kg/tow in the 501N Study Area and 1.2 ± 0.5 kg/tow in the Control Area (Figure 94). Cancer crabs were caught in 13 of the 20 tows in the 501N Study Area and 12 of the 20 tows in the Control Area. Cancer crabs were primarily found in the deep tows in the summer survey and shallower tows in the fall survey (Figure 95).

The Cancer crab catch was modest in the winter survey. The average catch rate was 0.5 ± 0.3 kg/tow in the 501N Study Area and 0.4 ± 0.1 kg/tow in the Control Area (Figure 94). Cancer crabs were caught in 10 of the 20 tows in the 501N Study Area and 15 of the 20 tows in the Control Area with the catch distributed around both survey areas (Figure 95).

The catch of Cancer crabs was lowest in the spring survey. The average catch rate was 0.5 ± 0.2 kg/tow in the 501N Study Area and 0.3 ± 0.1 kg/tow in the Control Area (Figure 94). Cancer crabs were caught in 14 of the 20 tows in the 501N Study Area and nine of the 20 tows in the Control Area.

4.4.19 Monkfish

Monkfish (*Lophius americanus*), a commercially important species, was regularly caught during the 2019/2020 survey year. Catch rates during the 2020/2021 survey year were low and intermittent. Annually, catch rates averaged 0.8 ± 0.2 kg/tow (range: 0 – 11.8 kg/tow) in the 501N Study Area and 0.2 ± 0.1 kg/tow (range: 0 – 10.8 kg/tow) in the Control Area. The current season exhibited a 79% and 97% reduction in the annual catch rate, compared to the 2019/2020 survey year, in the 501N Study Area and Control Area, respectively. The GLM analysis indicated that neither season nor survey area were significant predictors of catch rate (Season: $p = 0.502$, Area: $p = 0.2177$).

The catch rate of monkfish was highest in the 501N Study Area during the summer survey with a large disparity between survey areas (501N Study Area: 1.6 ± 0.7 kg/tow, Control Area: 0.2 ± 1 kg/tow, Figure 96). Monkfish were caught in eight of the 20 tows in the 501N Study Area and only three of the 20 tows in the Control Area, with the catch primarily occurring in deeper tows along the southern boundary in both survey areas (Figure 97). A total of 19 individuals were caught through the summer: 15 individuals in the 501N Study Area and four in the Control Area. Sizes ranged from 29 to 70 cm (Figure 98). The population structure was similar between survey areas ($p = 0.747$, Figure 99).

Catch rates were similar in the fall survey between the two survey areas. Seasonally, catch rates averaged 1.3 ± 0.5 kg/tow in the 501N Study Area and 0.9 ± 0.5 kg/tow in the Control Area. A total of 12 individuals were caught throughout the whole season. Seven individuals caught in the 501N Study Area and five in the Control Area. Monkfish lengths ranged from 35 to 80 cm (Figure 98). The population structure was similar between survey areas ($p = 0.846$, Figure 99).

In the fall survey, the catch of monkfish was higher in the Control Area (1.2 ± 0.6 kg/tow) compared to the 501N Study Area (0.2 ± 0.1 kg/tow, Figure 96). Monkfish were caught in eight of the 20 tows in the Control Area and three of the 20 tows in the 501N Study Area. Similar to the other seasons, monkfish were observed throughout both survey areas (Figure 97). Twelve individuals were caught ranging from 29 to 83 cm in length (Figure 98). The size distribution of monkfish was not significantly different between the two survey areas (p = 0.537).

Only one monkfish was caught in the winter survey. The individual was caught in the 501N Study Area.

The condition of monkfish was not significantly different between seasons or survey areas (Season: p = 0.5062, Survey Area: p = 0.2933, Figure 100).

4.4.20 Alewife

Alewife (*Alosa pseudoharengus*) were consistently caught in both survey areas in the spring and winter surveys with sporadic captures in the summer and fall surveys. Annually, catch rates averaged 0.5 ± 0.1 kg/tow (range: 0 – 5.3 kg/tow) in the 501N Study Area and 1.7 ± 0.8 kg/tow (range: 0 – 59.3 kg/tow) in the Control Area. Catch rates in the 501N Study Area and Control Area were 97% and 83% lower in the 2020/2021 survey season, respectively, compared to the 2019/2020 survey season. The lower catch rates were observed in every season. Data from the 2019/2020 survey season showed that alewife were frequently caught at low levels during the spring and winter survey with a few large catches (100 – 500 kg/tow). Alewife were still frequently encountered in 2020/2021; however, no large catches were observed. Alewife are a schooling species whose distribution is spatially patchy. Changes in catch patterns could be due to changes in abundance or a lack of encounters due to the random sampling design and spatial distribution. The GLM analysis indicated that both season and area were significant predictors of catch rate (Season: p = 0.0008, Area: p = 0.004).

The catch rate of alewife was highest in the spring survey with a large disparity between survey areas (501N Study Area: 1.0 ± 0.3 kg/tow, Control Area: 5.4 ± 3.0 kg/tow, Figure 101). This was primarily due to one large tow in the Control Area with a catch of 59.3 kg. Alewife were caught in 12 of the 20 tows in the 501N Study Area and only 16 of the 20 tows in the Control Area. Higher catch rates were primarily associated with shallow water to the north (Figure 102). Individuals ranged in size from 18 to 28 cm (Figure 103). The population in the 501N Study Area had a wide size distribution, peaking at 20 cm, with a greater proportion of larger fish. The Control Area had a narrow size distribution peaking at 19 cm ($p < 0.0001$, Figure 104).

During the winter survey, catch rates were low but consistent. Seasonal catches averaged 0.6 ± 0.1 kg/tow in the 501N Study Area and 1.0 ± 0.4 kg/tow in the Control Area (Figure 101). Alewife were caught in every tow in the 501N Study Area and 18 of the 20 tows in the Control Area. The catch was distributed throughout both survey areas (Figure 102). Individuals ranged in size from 10 to 26 cm with bimodal peaks at 14 and 19 cm (Figure 103). While both peaks were present in the two survey areas, the population in the Control Area was strongly skewed toward the larger fish ($p = 0.0001$, Figure 104). The 501N Study Area was only moderately skewed toward the larger fish.

Alewife were only caught in the Control Area during the fall survey (0.4 ± 0.2 kg/tow, Figure 101). Alewife were caught in seven of the 20 tows in the Control Area. Alewife ranged in size from 18 to 25 cm with a unimodal peak at 20 cm (Figure 103).

Only four individuals were caught during the summer survey between the two survey areas.

Alewife displayed seasonal and survey area differences in condition (Season: $p = 0.0001$, Area: $p = 0.0001$, Figure 104). The condition was highest in fish caught in the spring survey (501N Study Area: 1.04 ± 0.1, Control Area: 1.02 ± 0.1). The condition in the 501N Study Area was below average during the winter survey (501N Study Area: 0.87 ± 0.16, Control Area: 1.02 ± 0.12).

4.4.21 Longhorn Sculpin

Longhorn sculpin (*Myoxocephalus octodecimspinosus*) were frequently observed during the spring and winter surveys. Annually, catch rates averaged 0.7 ± 0.4 kg/tow (range: 0 – 31.0 kg/tow) in the 501N Study Area and 0.8 ± 0.2 kg/tow (range: 0 – 5.7 kg/tow) in the Control Area. The GLM analysis indicated that neither season nor survey area was significant predictors of catch rate (Season: $p = 0.4485$, Area: $p = 0.1118$). The longhorn sculpin catch was higher in the 2020/2021 survey year compared to the 2019/2020 survey year. Catch rates were similar between the winter surveys, however, catch rates during the spring 2021 survey were significantly higher than the spring 2019 survey.

Longhorn sculpin were most abundant during the winter survey with catch rates averaging 0.8 ± 0.1 kg/tow in the 501N Study Area and 2.0 ± 0.4 kg/tow in the Control Area (Figure 106). Longhorn sculpin were caught in 19 of the 20 tows in the 501N Study Area and 15 of the 20 tows in the Control Area. The catch of longhorn sculpin was distributed throughout both survey areas with higher catches observed in deeper tows in the southern portion of both survey areas (Figure 107). Individuals ranged in length from 20 to 35 cm (Figure 108). No significant differences were observed in the population structure in the two survey areas (p = 0.694, Figure 109).

Longhorn sculpin were also frequently caught during the spring survey but at lower abundances. Catch rates averaged 0.5 ± 0.2 kg/tow in the 501N Study Area and 1.1 ± 0.3 kg/tow in the Control Area (Figure 106). Sculpin were caught in 12 of the 20 tows in both survey areas with most of the catch observed in the northern half of the survey areas (Figure 107). Individuals ranged in length from 21 to 36 cm with a wide size distribution (Figure 108). No significant differences were observed in the population structure in the two survey areas (p = 0.652, Figure 109).

During the summer survey, there was one tow with 31.0 kg of longhorn sculpin in the 501N Study Area. Otherwise, only two longhorn sculpin were caught in the 501N Study Area in two tows and one longhorn sculpin was caught in the Control Area.

No longhorn sculpin were collected during the fall survey.

Longhorn sculpin displayed seasonal and survey area differences in condition (Season: p = 0.0001, Area: p = 0.0104, Figure 110). The condition was highest in the spring survey (501N Study Area: 1.04 ± 0.07, Control Area: 1.04 ± 0.1) and lowest in the winter survey (501N Study Area: 0.95 ± 0.09, Control Area: 1.00 ± 0.1).

4.4.22 Blueback Herring

Blueback herring (*Alosa aestivalis*) were frequently observed during the spring and winter surveys. Catch rates during the spring survey averaged 2.2 ± 1.2 kg/tow in the 501N Study Area and 0.5 ± 0.2 kg/tow in the Control Area (Figure 111). Blueback herring were caught in 11 of the 20 tows in the 501N Study Area and six of the 20 tows in the Control Area. The catch of blueback herring was distributed throughout both survey areas (Figure 112). Individuals ranged in length from 18 to 25 cm with a unimodal peak at 22 cm (Figure 113). The population in the 501N Study

Area consisted of a narrow distribution around the peak while the Control Area had a wider distribution with a greater proportion of small fish (p = 0.0001, Figure 114).

Blueback herring were also observed during the winter survey. Seasonally, catch rates averaged 0.1 ± 0.07 kg/tow in the 501N Study Area and 0.1 ± 0.03 kg/tow in the Control Area (Figure 111). Blueback herring were caught in five of the 20 tows in both survey areas with most observations in the northern half of the survey areas (Figure 112). Individuals ranged in length from 9 to 19 cm with a unimodal peak at 11 cm (Figure 113). The population in the 501N Study Area consisted of a narrow distribution around the peak while the Control Area had a wider distribution with a greater proportion of large fish (p = 0.0001, Figure 114)

Only one individual was caught in the fall survey. No blueback herring were collected in the summer survey.

Blueback herring displayed no seasonal or survey area differences in condition (Season: p = 0.3693, Area: p = 0.4687, Figure 115). The condition was around 1 during the winter and spring surveys in both survey areas.

4.4.23 Barndoor Skate

Barndoor skates (*Dipturus laevis*) were frequently caught during the summer, fall, and spring surveys. Annually, catch rates averaged 0.5 ± 0.1 kg/tow (range: 0 – 5.1 kg/tow) in the 501N Study Area and 0.2 ± 0.05 kg/tow (range: 0 – 2.3 kg/tow) in the Control Area. The GLM analysis indicated that season and survey area were significant predictors of catch rate (Season: p = 0.0001, Survey Area: p = 0.0001). The annual catch rate of barndoor skate was significantly lower in the 2020/2021 survey year compared to the 2019/2020 survey year. This is solely due to dramatically lower catches in the spring 2021 survey compared to the spring 2019 survey. Otherwise, catch rates between the survey years were similar during the summer, fall, and winter surveys (Figure 116).

The catch of barndoor skate was highest during the summer survey. The seasonal catch rates averaged 1.5 ± 0.4 kg/tow in the 501N Study Area and 0.4 ± 0.1 kg/tow in the Control Area (Figure 116). Barndoor skates were observed in 15 of the 20 tows in the 501N Study Area and nine of the 20 tows in the Control Area. The catch of barndoor skate was primarily distributed in the deeper tows in the south around both survey areas (Figure 117). Barndoor skates ranged in size from 5 to 69 cm (disk width, Figure 118). The population in the 501N Study Area was primarily composed of small individuals with a unimodal peak at around 5 cm. The Control Area was comprised of larger individuals with the population centered around 30 cm (p = 0.0001, Figure 119).

The catch rates were moderate during the spring survey. The seasonal catch rates averaged 0.3 ± 0.1 kg/tow in the 501N Study Area and 0.4 ± 0.1 kg/tow in the Control Area (Figure 116). Barndoor skates were caught in 11 of the 20 tows in the 501N Study Area and 12 of the 20 tows in the Control Area. The catch appeared to be distributed throughout both survey areas (Figure 117). Barndoor skates ranged in size from 14 to 40 cm (disk width, Figure 118). No significant differences were observed between the populations in the two survey areas (p = 0.28, Figure 119).

The catch of barndoor skate was low and infrequent during the fall survey. The seasonal catch rates averaged 0.1 ± 0.04 kg/tow in the 501N Study Area and 0.2 ± 0.1 kg/tow in the Control Area (Figure 116). Barndoor skates were only observed in 10 of the 20 tows in the 501N Study Area and five of the 20 tows in the Control Area. The catch of barndoor skate was distributed around both survey areas (Figure 117). Barndoor skates ranged in size from 19 to 37 cm (disk width, Figure 118). No significant differences were observed between the populations in the two survey areas (p = 0.691, Figure 119).

No individuals were observed in the winter survey.

Barndoor skates displayed seasonal and survey area differences in condition (Season: p = 0.0001, Area: p = 0.0483, Figure 120). The condition was highest in the summer survey (501N Study Area: 1.14 ± 0.24, Control Area: 1.02 ± 0.1) and lowest in the fall survey (501N Study Area: 0.89 ± 0.16, Control Area: 0.79 ± 0.13). Barndoor skates in the 501N Study Area appeared to be in better condition than those observed in the Control Area.

4.4.24 Atlantic Cod

Atlantic cod (*Gadus morhua*) were sporadically caught in low numbers throughout the year with the majority of the catch occurring during the winter survey (Figure 121). The seasonal catch rate in the winter survey averaged 0.3 ± 0.1 kg/tow (range: 0 – 2.3 kg/tow) in the 501N Study Area and 0.7 ± 0.1 kg/tow (range: 0 – 1.7 kg/tow) in the Control Area. A total of 11 fish were caught in the 501N Study Area. One fish was caught during the summer survey while the remaining 10 fish were caught during the winter survey. A total of 23 fish were caught in the Control Area. Three fish were caught in the spring survey while the remaining 20 fish were caught during the winter survey (Figure 122). Individuals ranged in length from 21 to 54 cm.

4.4.25 Atlantic Sea Scallop

Atlantic sea scallop (*Placopecten magellanicus*) is a commercially important shellfish species that was caught in both survey areas. Due to their sedentary life history, the catch is perceived to reflect the abundance on the seafloor as it should not change with the season. Annually, the total catch of scallops was 19.2 kg in the 501N Study Area, which consisted of 235 individuals in 33 tows (Figure 123). The total catch of scallops in the Control Area was 14.1 kg, which consisted of 180 individuals in 27 tows (Figure 124).

4.4.26 American Lobster

American lobster (*Homarus americanus*) is a commercially important crustacean that was occasionally caught in both survey areas. Annually, the total catch of lobster was 7.9 kg in the 501N Study Area, which consisted of 17 individuals in 11 tows. The total catch of lobster in the Control Area was 5.0 kg, which consisted of nine individuals in five tows. All lobsters were caught during the summer and fall surveys.

4.4.27 Other Commercial Species or Species of Interest

Eighteen yellowtail flounder (*Pleuronectes ferrugineus*) were caught over the duration of the survey year. Yellowtail flounder is a federally regulated groundfish. Ten individuals were caught in the 501N Study Area. Eight were caught during the summer survey, the remaining two were caught during the spring survey. Eight yellowtail flounder were caught in the Control Area. Six were caught during the summer survey, one during the winter survey, and one during the spring survey. Individuals ranged in length from 22 to 43 cm.

Thirteen bluefish (*Pomatomus saltatrix*) were caught during the summer and fall surveys. Six individuals were caught in the 501N Study Area. Five individuals were caught during the summer survey, and one was caught during the fall survey. Seven bluefish were caught in the Control Area. Six were caught during the summer survey and one was caught during the fall survey. Individuals ranged in length from 22 to 57 cm.

Ten weakfish (*Cynoscion regalis*) were caught during the fall survey. Five individuals were caught in the 501N Study Area and the Control Area. Individuals ranged in length from 24 to 42 cm.

Six haddock (*Melanogrammus aeglefinus*) were caught in the 501N Study Area. Two were caught in each of the summer, fall, and winter surveys. Individuals ranged in length from 14 to 57 cm.

Two conger eels (*Conger oceanicus*) were caught, one in the 501N Study Area during the spring survey and one in the Control Area during the fall survey.

One thresher shark (*Alopias vulpinus*) was caught in the 501N Study Area during the summer survey. The shark was estimated to be ~2.0 m long (fork length). The shark was immediately returned to the sea and was observed to swim away.

One cownose ray (*Rhinoptera bonasus)* was caught in the Control Area during the fall survey. The animal was immediately returned to the sea and was observed to swim away.

4.5 Community Structure

The community structure within the 501N Study Area and Control Area displayed seasonal changes in species composition throughout the 2020/2021 survey year. The analysis of similarities test (ANOSIM) yielded an R statistic of 0.801 when assessing the similarities between seasons. The R statistic can range from 0, indicating no difference in species composition, to 1, which would indicate a clear separation between seasons. The separation in seasons was very similar to that observed in the 2019/2020 survey year (Figure 125).

Pairwise tests indicate that the winter survey had a clear difference in species composition compared to the spring, summer, and fall surveys (R = 0.90, 0.95, and 0.947, respectively). Winter tows were primarily associated with Atlantic herring, little skate, and longhorn sculpin. The winter 2021 survey showed a strong similarity to the winter 2020 survey (R = 0.233, Figure 126).

In general, the spring, summer, and fall surveys exhibited more similarities between each other (R range: 0.569 – 0.918, Figure 125). The spring survey exhibited the highest similarity between tows and was associated with little skate, winter skate, red hake, silver hake, and black sea bass. The spring survey was most similar to the fall survey (R = 0.774) and distinct from the summer and winter surveys (R = 0.918 and 0.9, respectively). The spring 2021 survey was also moderately distinct from the spring 2019 survey (R = 0.791). This is probably due to the difference in timing between the two surveys.

Summer survey tows were associated with little skate, Atlantic longfin squid, scup, butterfish, and summer flounder. The summer survey showed a strong similarity to the fall survey (R = 0.569) and significant differences from the spring and winter surveys (R = 0.918 and 0.95, respectively). Like the spring survey, the summer 2020 survey was moderately distinct from the summer 2019 survey (R = 0.768). While the timing of the survey was similar between years, the bottom water temperatures were significantly warmer in 2020, which may change species distribution.

Finally, fall survey tows were associated with little skate, scup, silver hake, butterfish, spiny dogfish, and Atlantic longfin squid. The fall survey showed a strong similarity to the summer survey (R = 0.569), moderate similarity to the fall survey (R = 0.774), and low similarity to the winter survey (R = 0.947). The fall 2020 survey showed a strong similarity to the fall 2019 survey (R = 0.273).

There were no significant differences in community structure between the two survey areas (Figure 127). The two areas yielded an R statistic of 0.004, which indicated no difference in species composition. The species with the highest similarities between survey areas were little skate, silver hake, Atlantic herring, scup, winter skate, butterfish, and Atlantic longfin squid. The nMDS plot shows no distinct clustering of points related to the survey areas (Figure 127).

In summary, each season exhibits a distinct species assemblage. The winter survey is the most distinct but exhibited strong similarity between survey years. The fall survey, while distinct, showed some similarities to the spring and summer surveys. The fall survey also exhibited strong consistency between survey years. The spring and summer surveys were unique and exhibited significant inter-annual differences.

4.6 Power Analysis

Catch data collected from the 2020/2021 survey year exhibited a high level of variability resulting in CVs ranging from 1.17 (little skate) to 12.61 (cunner, Table 8). The variability of the data is inversely related to the ability to detect a change in catch rates. This leads to decreased power or a need to increase the sample size (number of tows). The data from the 2020/2021 survey year was used to update the power analysis presented in the previous annual report (Rillahan and He, 2020).

The results of the power analysis indicated that several species, including little skate, Atlantic longfin squid, and fourspot flounder had relatively low variability (CV: ~1) and therefore a high probability of detecting a small to moderate change. Detecting a 25% change in the two areas, with 80% confidence, would require 218 – 367 tows per area, which under the current sampling intensity (80 tows/area/year) would require two to three years of sampling before and after impact. Detecting larger changes would require a smaller number of tows. To increase the ability to detect a smaller change (i.e., a 10% change), the sample size would have to be increased eight-fold (1,630 – 2,737 tows per area, Figure 128). Incorporating the 2020/2021 survey year data into the power analysis resulted in moderate increases in the variability, and therefore effort required, in all these species.

Many of the common species observed, including winter skate, silver hake, red hake, windowpane flounder, monkfish, summer flounder, scup, yellowtail flounder, winter flounder, and butterfish had CVs between 1.5 and 2.5. These species would have a high probability of detecting a moderate change (i.e., 30 – 50% change). Detecting a 50% change in the two survey areas, with 80% confidence, would require 83 – 207 tows per area, which under the current sampling intensity (80 tows/area/year) would require one to two years of sampling before and after impact. To detect a 25% change, sampling would have to be increased to 485 – 1,205 tows. Incorporating an additional year of data had mixed effects on this group. Summer flounder, black sea bass, and butterfish were more abundant during the 2020/2021 survey year. As a result, the CVs, and the ability to detect changes decreased. For example, the black sea bass CV decreased from 4.01 in the 2019/2020 survey year to 2.07 with both survey years combined. Winter flounder, scup, red hake, and windowpane flounder had modest increases in their CVs.

Spiny dogfish, Atlantic cod, alewife, blueback herring, and Atlantic herring exhibited strong seasonality, which led to high variability (CVs:2.5 – 5). These species would have a high probability of detecting moderate to large changes (i.e., 50 – 75% change). Detecting a 75% change in the two areas, with 80% confidence, would require 89 – 217 tows per area, which under the current sampling intensity (80 tows/area/year) would require one to two years of sampling before and after impact. To detect a 50% change, sampling would have to be increased to 357 – 870 tows. To detect a 25% change, sampling would have to be increased to 2,074 – 5,056 tows.

The current sampling effort has the statistical power to detect a complete disappearance of every species observed from either survey area (100% change). The relationship between power and the sample size for the 10 most abundant species, by weight, can be found in Figures 129 – 138.

5. Discussion

Four successful seasonal surveys were conducted during the 2020/2021 survey year. This work is a continuation of the effort started in 2019 and expands the existing data set. This collection of surveys will serve as two of the three years of pre-construction baseline data that will be used in the BACI analysis. The current survey methodology has proven to be effective in collecting high-quality data relevant to fish abundance, population structure, and community assemblages. Modification to this year's survey methodology included the expansion of the 501N Study Area from 249.3 to 306 km^2, due to boundary refinements of the project within Lease Area OCS-A 0501. Additionally, the 2019/2020 survey year data showed a disparity in tow depths and catch rates between the two survey areas. To improve compatibility between the two survey areas, the Control Area was also slightly modified. The result was increased similarity in the depth profiles between the two survey areas (Figure 9). The number of species exhibiting significant differences in catch rates between survey areas was reduced from 71% of species in the 2019/2020 survey year to 47% of species in the 2020/2021 survey year.

The NEAMAP survey trawl has provided consistent trawl geometry; however, improvements were made during the current survey year. During the 2019/2020 survey year, issues were encountered with the trawl headline height being lower than the acceptable tolerance limit. To correct this issue, eight additional trawl floats were added to the headline during the fall survey to provide extra floatation. This provided the desired increased headline height without significant effects on the door spread or wing spread. The addition of the floats improved the trawl geometry with all trawl parameters within the acceptable tolerance limits for the remainder of the survey year.

In general, the data collected during the 2020/2021 survey year were similar to that in the 2019/2020 survey year. While the surveys revealed high species diversity in both survey areas, documenting a total of 42 species, the majority of the catch was comprised of a small number of dominant species. Little skate, scup, spiny dogfish, winter skate, and silver hake were the five most abundant species in the 501N Study Area and Control Area accounting for 77 – 78% of the total catch weight, respectively. Interannual changes in abundance varied amongst species. For example, scup, Atlantic longfin squid, and black sea bass exhibited increases in annual average catch rates. Conversely, spiny dogfish, winter skate, silver hake, butterfish, and red hake exhibited decreased annual catch rates. Little skate, Atlantic herring, and summer flounder remained similar between years.

These survey areas are dynamic with seasonal changes in species assemblages, abundances, and population structures. The seasonal changes were largely in line with those observed in the 2019/2020 survey year. Species composition during the fall and winter surveys showed strong similarity to that observed in the same surveys in 2019/2020. The spring and summer surveys exhibited significant differences in the community composition compared to the same seasons in 2019/2020. In general, catch rates were lower in the spring 2021 survey compared to the spring 2019 survey. This may be due to changes in the timing of the surveys. Due to contracting delays, the spring 2019 survey occurred in mid-late June while permitting issues resulted in the spring 2021 survey occurring in early May. Changes in timing can change local abundances due to the seasonal movement of fish. Additionally, the bottom water temperature was about 3^{o}C cooler in 2021 compared to 2019. The summer 2020 survey also showed significant differences compared to the summer 2019 survey. While the time of the survey was similar, both occurring in mid-August, the bottom water temperature was 5^{o}C warmer in 2020 compared to 2019. The species assemblage during 2020 was shifted toward heat-tolerant species (i.e., scup, butterfish, summer flounder) while species that prefer cooler water (i.e., silver hake, winter skate) appeared to move to deeper water.

The updated power analysis, using the collected data for two years of survey effort, indicated that the current bottom trawl survey effort would provide reasonable “power” to detect small to medium scales of change in abundance for most common species if changes in abundance do occur. Additional data only caused small changes to the CVs for most species. Common species, including little skate and Atlantic longfin squid, exhibited low variability resulting in the projected ability to detect a 25% change in abundance or greater. Most commercial species, including summer flounder, black sea bass, and silver hake, exhibited modest variability. The current sampling effort should be able to detect 30 – 40% changes in abundance.

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

Tow Number	Survey	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	Summer 2020	501N	8/25/2020	Clear	7-10	SW	0.5-1.25	7:06	N 41° 04.134	W 70° 32.288	23	7:26	N 41° 04.292	W 70° 31.051	21	16.0	100
2	Summer 2020	501N	8/25/2020	Clear	7-10	SW	0.5-1.25	9:54	N 41° 04.921	W 70° 29.603	21	10:14	N 41° 06.139	W 70° 29.263	21	16.1	100
3	Summer 2020	501N	8/25/2020	Clear	7-10	SW	0.5-1.25	11:09	N 41° 06.270	W 70° 28.352	21	11:29	N 41° 05.217	W 70° 28.381	21	16.3	90
4	Summer 2020	501N	8/25/2020	Partly Cloudy	7-10	SW	0.5-1.25	12:28	N 41° 05.237	W 70° 27.934	21	12:48	N 41° 04.236	W 70° 27.483	21	16.6	90
5	Summer 2020	501N	8/25/2020	Partly Cloudy	7-10	SW	0.5-1.25	14:07	N 41° 03.175	W 70° 27.660	22	14:27	N 41° 02.986	W 70° 26.351	21	15.9	90
6	Summer 2020	501N	8/25/2020	Partly Cloudy	11-15	SW	0.5-1.25	15:34	N 41° 02.848	W 70° 26.208	21	15:54	N 41° 03.681	W 70° 25.258	22	16.1	90
7	Summer 2020	501N	8/25/2020	Partly Cloudy	11-15	SW	0.5-1.25	16:41	N 41° 04.860	W 70° 25.175	20	17:01	N 41° 04.025	W 70° 24.124	21	16.9	90
8	Summer 2020	501N	8/25/2020	Partly Cloudy	16-20	SW	0.5-1.25	18:09	N 41° 03.044	W 70° 23.419	20	18:29	N 41° 02.318	W 70° 24.339	21	16.4	80
9	Summer 2020	Control	8/26/2020	Clear	16-20	NW	0.5-1.25	6:44	N 41° 04.155	W 70° 21.817	20	7:04	N 41° 03.213	W 70° 21.215	20	16.3	90
10	Summer 2020	Control	8/26/2020	Clear	16-20	NW	0.5-1.25	8:57	N 41° 02.601	W 70° 20.767	20	9:17	N 41° 02.294	W 70° 19.414	19	17.1	90
11	Summer 2020	Control	8/26/2020	Clear	16-20	NW	0.5-1.25	10:17	N 41° 01.681	W 70° 17.076	18	10:37	N 41° 01.215	W 70° 15.810	17	17.1	80
12	Summer 2020	Control	8/26/2020	Partly Cloudy	16-20	NW	0.5-1.25	11:33	N 41° 01.029	W 70° 15.777	17	11:53	N 41° 00.073	W 70° 15.886	18	17.2	80
13	Summer 2020	Control	8/26/2020	Partly Cloudy	11-15	NW	0.5-1.25	13:01	N 40° 56.079	W 70° 15.756	19	13:22	N 40° 56.474	W 70° 17.049	20	17.8	80
14	Summer 2020	Control	8/26/2020	Partly Cloudy	11-15	NW	0.5-1.25	14:21	N 40° 57.111	W 70° 19.644	22	14:42	N 40° 57.377	W 70° 20.957	22	17.4	90
15	Summer 2020	Control	8/26/2020	Clear	7-10	NW	0.5-1.25	15:17	N 40° 57.824	W 70° 20.877	22	15:37	N 40° 58.646	W 70° 20.038	23	17.2	100
16	Summer 2020	Control	8/26/2020	Clear	7-10	NW	0.5-1.25	16:39	N 40° 58.255	W 70° 19.541	23	16:59	N 40° 58.053	W 70° 18.162	21	17.1	100
17	Summer 2020	Control	8/27/2020	Mostly Cloudy	7-10	NW	0.5-1.25	6:33	N 40° 58.855	W 70° 18.787	21	6:53	N 40° 59.853	W 70° 18.747	21	17.5	90
18	Summer 2020	Control	8/27/2020	Mostly Cloudy	7-10	NW	0.5-1.25	8:26	N 40° 55.001	W 70° 19.963	22	8:46	N 40° 54.629	W 70° 21.245	22	16.6	90
19	Summer 2020	Control	8/27/2020	Mostly Cloudy	7-10	NW	0.5-1.25	10:24	N 40° 54.382	W 70° 21.900	22	10:44	N 40° 53.366	W 70° 21.552	24	16.0	90
20	Summer 2020	Control	8/27/2020	Partly Cloudy	3-6	NW	0.5-1.25	11:44	N 40° 52.333	W 70° 21.508	24	12:04	N 40° 53.043	W 70° 22.539	24	15.7	100
21	Summer 2020	Control	8/27/2020	Partly Cloudy	3-6	NW	0.1-0.5	13:45	N 40° 52.953	W 70° 22.961	24	14:05	40° N 40.52.96	W 70° 24.161	25	15.4	90
22	Summer 2020	Control	8/27/2020	Partly Cloudy	3-6	NW	0.1-0.5	15:41	N 40° 53.290	W 70° 25.145	26	16:01	N 40° .53.971	W 70° 25.949	25	14.7	100
23	Summer 2020	Control	8/28/2020	Overcast	3-6	SW	0.5-1.25	6:18	N 40° 53.957	W 70° 25.987	25	6:38	N 40° 53.855	W 70° 27.276	26	13.8	100
24	Summer 2020	Control	8/28/2020	Obscured	3-6	SW	0.5-1.25	7:39	N 40° 54.423	W 70° 29.064	26	7:59	N 40° 55.052	W 70° 29.851	26	13.9	100
25	Summer 2020	501N	8/28/2020	Overcast	3-6	SW	0.5-1.25	9:40	N 40° 37.445	W 70° 31.809	26	10:00	N 40° 57.236	W 70° 30.569	24	13.6	100
26	Summer 2020	501N	8/28/2020	Partly Cloudy	3-6	SW	0.5-1.25	11:54	N 40° 57.122	W 70° 28.891	24	12:14	N 40° 57.174	W 70° 30.201	24	14.2	90
27	Summer 2020	501N	8/28/2020	Mostly Cloudy	3-6	SW	0.5-1.25	13:43	N 40° 57.421	W 70° 27.201	24	14:03	N 40° 57.448	W 70° 25.937	23	15.9	90
28	Summer 2020	Control	8/28/2020	Partly Cloudy	3-6	SW	0.5-1.25	14:45	N 40° 57.682	W 70° 23.784	23	15:05	N 40° 58.444	W 70° 22.959	22	17.3	90
29	Summer 2020	Control	8/28/2020	Partly Cloudy	3-6	SW	0.5-1.25	16:24	N 41° 00.108	W 70° 22.754	21	16:44	N 41° 01.093	W 70° 22.769	21	17.3	80
30	Summer 2020	501N	8/28/2020	Partly Cloudy	3-6	SW	0.5-1.25	17:20	N 41° 01.075	W 70° 23.488	21	17:40	N 41° 00.422	W 70° 24.305	22	16.4	80
31	Summer 2020	Control	8/29/2020	Obscured	3-6	SW	0.5-1.25	6:30	N 40° 58.723	W 70° 22.534	21	6:50	N 40° 58.499	W 70° 23.767	22	17.7	90
32	Summer 2020	Control	8/29/2020	Overcast	7-10	SW	0.5-1.25	7:54	N 40° 58.432	W 70° 26.079	22	8:14	N 40° 59.283	W 70° 26.690	23	17.3	90
33	Summer 2020	501N	8/29/2020	Overcast	7-10	SW	0.5-1.25	9:05	N 40° 59.747	W 70° 26.934	22	9:25	N 40° 54.988	W 70° 28.079	23	17.0	85
34	Summer 2020	501N	8/29/2020	Overcast	7-10	SW	0.5-1.25	10:30	N 41° 00.186	W 70° 24.505	23	10:50	N 40° 59.927	W 70° 30.784	25	15.8	90
35	Summer 2020	501N	8/29/2020	Mostly Cloudy	11-15	SW	0.5-1.25	11:55	N 41° 00.340	W 70° 30.352	24	12:15	N 41° 01.235	W 70° 30.811	24	15.8	90
36	Summer 2020	501N	8/29/2020	Overcast	11-15	SW	0.5-1.25	13:49	N 41° 00.928	W 70° 33.223	24	14:09	N 41° 00.285	W 70° 34.302	25	14.8	100
37	Summer 2020	501N	8/29/2020	Rain	11-15	SW	0.5-1.25	15:01	N 40° 59.765	W 70° 35.074	26	15:21	N 41° 00.707	W 70° 35.340	25	14.2	100
38	Summer 2020	501N	8/29/2020	Rain	11-15	SW	0.5-1.25	16:46	N 41° 01.906	W 70° 35.068	24	17:06	N 41° 02.570	W 70° 34.122	23	14.5	90
39	Summer 2020	501N	9/2/2020	Overcast	11-15	ESE	0.5-1.25	7:12	N 41° 02.887	W 70° 32.135	23	7:32	N 41° 03.307	W 70° 33.331	24	17.5	90
40	Summer 2020	501N	9/2/2020	Overcast	11-15	ESE	0.5-1.25	8:22	N 41° 03.528	W 70° 33.838	23	8:42	N 41° 02.897	W 70° 34.926	23	17.6	90

Note: fm = fathom

Table 2: Operational and environmental conditions for each tow during the fall survey.

Tow Number	Survey	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	Fall 2020	501N	11/7/20	Partly Cloudy	7-10	SW	0.5-1.25	6:57	N 41° 01.973	W 70° 34.736	24	7:17	N 41° 02.081	W 70° 35.661	24		95
2	Fall 2020	501N	11/7/20	Clear	7-10	SW	0.5-1.25	8:16	N 41° 01.332	W 70° 35.363	25	8:38	N 41° 01.012	W 70° 36.691	25		100
3	Fall 2020	501N	11/7/20	Clear	7-10	SW	0.5-1.25	9:30	N 40° 59.466	W 70° 33.521	27	9:45	N 41° 59.495	W 70° 32.530	26	14.6	100
4	Fall 2020	501N	11/7/20	Clear	7-10	SW	0.5-1.25	10:59	N 41° 00.116	W 70° 31.509	26	11:19	N 41° 01.014	W 70° 31.329	25	14.6	100
5	Fall 2020	501N	11/7/20	Clear	7-10	SW	0.5-1.25	12:37	N 40° 59.778	W 70° 30.502	25	12:57	N 40° 58.750	W 70° 30.549	25	14.7	95
6	Fall 2020	501N	11/7/20	Clear	7-10	SW	0.5-1.25	13:42	N 40° 58.854	W 70° 29.955	24	14:02	N 40° 53.390	W 70° 30.867	25	14.5	100
7	Fall 2020	501N	11/7/20	Clear	7-10	SW	0.5-1.25	14:46	N 40° 56.625	W 70° 30.071	25	15:06	N 40° 55.828	W 70° 30.701	26	14.8	100
8	Fall 2020	501N	11/7/20	Clear	7-10	SW	0.5-1.25	16:07	N 40° 57.743	W 70° 29.978	25	16:27	N 40° 57.869	W 70° 28.746	24	14.8	95
9	Fall 2020	Control	11/8/20	Clear	7-10	SW	0.5-1.25	6:25	N 40° 56.567	W 70° 25.912	24	6:45	N 40° 56.752	W 70° 27.115	25	14.6	95
10	Fall 2020	Control	11/8/20	Clear	7-10	SW	0.5-1.25	7:49	N 40° 55.674	W 70° 26.377	25	8:09	N 40° 56.244	W 70° 27.375	25		95
11	Fall 2020	Control	11/8/20	Clear	7-10	SW	0.5-1.25	9:18	N 40° 54.611	W 70° 25.176	25	9:38	N 40° 54.147	W 70° 26.274	26	14.7	100
12	Fall 2020	Control	11/8/20	Clear	7-10	SW	0.5-1.25	10:53	N 40° 52.703	W 70° 25.098	27	11:13	N 40° 53.526	W 70° 24.434	25		100
13	Fall 2020	Control	11/8/20	Clear	7-10	SW	0.5-1.25	12:22	N 40° 52.711	W 70° 23.177	25	12:42	N 40° 51.988	W 70° 22.284	26	14.7	100
14	Fall 2020	Control	11/8/20	Clear	7-10	SW	0.5-1.25	13:37	N 40° 52.201	W 70° 22.196	26	13:57	N 40° 52.530	W 70° 21.060	25	14.7	100
15	Fall 2020	Control	11/8/20	Clear	3-6	SW	0.5-1.25	14:55	N 40° 53.969	W 70° 21.214	24	15:15	N 40° 54.460	W 70° 22.199	24	14.7	95
16	Fall 2020	Control	11/8/20	Clear	3-6	SW	0.5-1.25	15:51	N 40° 55.645	W 70° 22.528	23	16:11	N 40° 56.560	W 70° 22.679	24	14.7	95
17	Fall 2020	Control	11/9/20	Clear	7-10	SW	0.5-1.25	6:30	N 40° 57.143	W 70° 20.799	23	6:50	N 40° 56.923	W 70° 21.961	23	14.2	95
18	Fall 2020	Control	11/9/20	Clear	3-6	SW	0.33-0.5	7:53	N 40° 51.026	W 70° 19.128	22	8:13	N 40° 56.093	W 70° 19.412	22	13.8	95
19	Fall 2020	Control	11/9/20	Clear	3-6	SW	0.33-0.5	9:20	N 40° 55.991	W 70° 18.791	22	9:40	N 40° 55.947	W 70° 17.546	22	13.5	95
20	Fall 2020	Control	11/9/20	Clear	3-6	SW	0.33-0.5	10:28	N 40° 51.030	W 70° 17.856	21	10:49	N 40° 51.934	W 70° 18.418	22	13.4	95
21	Fall 2020	Control	11/9/20	Clear	3-6	SW	0.33-0.5	11:47	N 40° 58.551	W 70° 18.390	22	12:07	N 40° 59.081	W 70° 17.309	21	13.9	95
22	Fall 2020	Control	11/9/20	Clear	3-6	SW	0.33-0.5	13:07	N 41° 00.028	W 70° 16.945	20	13:27	N 41° 00.915	W 70° 16.774	19	14.3	75
23	Fall 2020	Control	11/9/20	Clear	3-6	SW	0.33-0.5	14:24	N 41° 00.506	W 70° 19.977	21	14:44	N 41° 00.131	W 70° 21.123	21		95
24	Fall 2020	Control	11/9/20	Clear	3-6	SW	0.33-0.5	15:21	N 41° 00.095	W 70° 21.224	21	15:41	N 40° 59.817	W 70° 22.293	21	14.3	95
25	Fall 2020	501N	11/10/20	Mostly Cloudy	7-10	SW	0.5-1.25	6:31	N 41° 00.476	W 70° 23.434	22	6:51	N 41° 00.325	W 70° 24.654	22	14.4	95
26	Fall 2020	501N	11/10/20	Partly Cloudy	7-10	SW	0.5-1.25	7:44	N 41° 00.583	W 70° 25.397	22	8:04	N 41° 00.730	W 70° 26.604	23	14.4	95
27	Fall 2020	501N	11/10/20	Clear	7-10	SW	0.5-1.25	9:11	N 41° 01.016	W 70° 26.289	23	9:31	N 41° 01.006	W 70° 27.599	25	14.5	100
28	Fall 2020	501N	11/10/20	Clear	7-10	SW	0.5-1.25	10:22	N 41° 01.619	W 70° 29.021	23	10:42	N 41° 01.570	W 70° 30.178	25	14.2	100
29	Fall 2020	501N	11/10/20	Clear	11-15	SW	0.5-1.25	11:37	N 41° 02.755	W 70° 28.500	24	11:58	N 40° 03.121	W 70° 27.295	23	14.5	95
30	Fall 2020	501N	11/10/20	Clear	11-15	SW	0.5-1.25	12:50	N 41° 04.794	W 70° 29.066	22	13:10	N 41° 05.192	W 70° 27.983	22	14.5	95
31	Fall 2020	501N	11/10/20	Clear	11-15	SW	0.5-1.25	14:03	N 41° 05.841	W 70° 29.656	22	14:23	N 41° 06.063	W 70° 30.898	22		95
32	Fall 2020	501N	11/10/20	Clear	11-15	SW	0.5-1.25	15:24	N 41° 04.794	W 70° 31.215	23	15:44	N 41° 03.707	W 70° 32.301	25	14.5	95
33	Fall 2020	Control	11/11/20	Partly Cloudy	11-15	SW	0.5-1.25	6:36	N 41° 02.818	W 70° 15.461	17	6:56	N 41° 02.415	W 70° 16.614	18	14.5	75
34	Fall 2020	Control	11/11/20	Clear	11-15	SW	0.5-1.25	7:30	N 41° 02.301	W 70° 14.487	20	7:50	N 41° 00.103	W 70° 20.663	21		95
35	Fall 2020	Control	11/11/20	Clear	11-15	SW	0.5-1.25	8:38	N 41° 03.362	W 70° 20.481	21	8:58	N 41° 04.261	W 70° 20.159	21	14.5	95
36	Fall 2020	Control	11/11/20	Clear	11-15	SW	0.5-1.25	9:44	N 41° 04.173	W 70° 19.689	19	10:04	N 41° 04.064	W 70° 20.941	20	14.4	75
37	Fall 2020	501N	11/11/20	Mostly Cloudy	11-15	SW	0.5-1.25	10:47	N 41° 02.493	W 70° 21.469	21	11:07	N 41° 02.805	W 70° 22.676	21	14.5	95
38	Fall 2020	501N	11/11/20	Mostly Cloudy	11-15	SW	0.5-1.25	11:56	N 41° 03.856	W 70° 25.546	23	12:16	N 41° 04.296	W 70° 26.637	22	14.5	95
39	Fall 2020	501N	11/11/20	Overcast	11-15	SW	0.5-1.25	13:13	N 41° 05.521	W 70° 27.981	22	13:33	N 41° 06.355	W 70° 28.521	22	14.2	95
40	Fall 2020	501N	11/11/20	Overcast	11-15	SW	0.5-1.25	14:18	N 41° 07.185	W 70° 27.781	21	14:38	N 41° 07.971	W 70° 28.894	21		95

Note: fm = fathom

Table 3: Operational and environmental conditions for each tow during the winter survey.

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

Note: fm = fathom

Table 4: Operational and environmental conditions for each tow during the spring survey.

Tow Number	Survey	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	Spring 2021	501N	5/4/2021	Fog	7-10	SE	0.5-1.25	7:03	N 41° 07.137	W 70° 30.570	20	7:23	N 41° 07.341	W 70° 29.319	20	6.6	95
2	Spring 2021	501N	5/4/2021	Fog	7-10	SE	0.5-1.25	8:03	N 41° 04.767	W 70° 29.799	21	8:23	N 41° 04.491	W 70° 30.947	21	6.4	95
3	Spring 2021	501N	5/4/2021	Fog	7-10	SE	0.5-1.25	9:01	N 41° 04.549	W 70° 30.214	22	9:21	N 41° 03.788	W 70° 29.404	23	6.4	100
4	Spring 2021	501N	5/4/2021	Fog	7-10	SE	0.5-1.25	10:04	N 41° 06.037	W 70° 27.674	20	10:24	N 41° 06.338	W 70° 26.490	20	7.0	95
5	Spring 2021	501N	5/4/2021	Fog	7-10	SE	0.5-1.25	10:56	N 41° 05.144	W 70° 25.572	20	11:16	N 41° 05.121	W 70° 24.373	20	7.2	95
6	Spring 2021	501N	5/4/2021	Fog	7-10	SE	0.5-1.25	12:01	N 41° 03.692	W 70° 24.925	22	12:21	N 41° 03.621	W 70° 23.732	21	7.3	100
7	Spring 2021	501N	5/4/2021	Overcast	7-10	SE	0.5-1.25	13:01	N 41° 02.266	W 70° 24.388	22	13:21	N 41° 01.347	W 70° 24.789	22	7.2	100
8	Spring 2021	501N	5/4/2021	Overcast	7-10	SE	0.5-1.25	13:55	N 41° 02.544	W 70° 26.272	22	14:15	N 41° 02.559	W 70° 27.546	23	6.9	100
9	Spring 2021	501N	5/4/2021	Overcast	11-15	SE	0.5-1.25	14:48	N 41° 01.531	W 70° 28.249	24	15:08	N 41° 00.740	W 70° 27.525	23	6.6	100
10	Spring 2021	501N	5/4/2021	Overcast	11-15	SE	0.5-1.25	15:49	N 40° 59.257	W 70° 26.667	24	16:09	N 40° 59.771	W 70° 25.574	23	6.5	100
11	Spring 2021	501N	5/4/2021	Overcast	16-20	SE	0.5-1.25	16:51	N 40° 59.569	W 70° 27.483	24	17:11	N 40° 59.662	W 70° 28.789	25	6.5	100
12	Spring 2021	Control	5/5/2021	Overcast	7-10	SE	0.5-1.25	6:30	N 41° 04.043	W 70° 22.095	22	6:50	N 41° 03.972	W 70° 20.836	21	7.8	100
13	Spring 2021	Control	5/5/2021	Overcast	7-10	SE	0.5-1.25	7:41	N 41° 02.790	W 70° 21.298	21	8:01	N 41° 01.862	W 70° 21.731	22	7.5	100
14	Spring 2021	Control	5/5/2021	Overcast	7-10	SE	0.5-1.25	8:48	N 41° 01.444	W 70° 20.679	22	9:08	N 41° 00.926	W 70° 19.711	22	7.6	100
15	Spring 2021	Control	5/5/2021	Overcast	7-10	SE	0.5-1.25	9:43	N 41° 01.539	W 70° 19.339	22	10:03	N 41° 02.317	W 70° 18.642	20	8.3	100
16	Spring 2021	Control	5/5/2021	Fog	7-10	SE	0.5-1.25	10:48	N 41° 02.855	W 70° 18.792	20	11:08	N 41° 03.528	W 70° 17.948	19	8.7	95
17	Spring 2021	Control	5/5/2021	Fog	7-10	SE	0.5-1.25	11:57	N 41° 02.036	W 70° 16.199	18	12:17	N 41° 01.057	W 70° 15.991	19	9.1	95
18	Spring 2021	Control	5/5/2021	Fog	7-10	SE	0.5-1.25	13:00	N 40° 59.626	W 70° 18.064	21	13:20	N 40° 58.813	W 70° 18.602	22	8.7	95
19	Spring 2021	Control	5/5/2021	Fog	7-10	SE	0.5-1.25	14:05	N 40° 58.164	W 70° 20.937	24	14:25	N 40° 59.124	W 70° 21.589	22	7.8	100
20	Spring 2021	Control	5/5/2021	Fog	7-10	SE	0.5-1.25	15:16	N 40° 57.541	W 70° 20.857	23	15:36	N 40° 57.116	W 70° 19.666	23	7.2	100
21	Spring 2021	Control	5/5/2021	Fog	7-10	SE	0.5-1.25	16:11	N 40° 55.738	W 70° 18.922	23	16:31	N 40° 54.927	W 70° 18.170	23	7.5	100
22	Spring 2021	Control	5/5/2021	Fog	7-10	SE	0.5-1.25	17:09	N 40° 56.508	W 70° 15.886	21	17:29	N 40° 57.277	W 70° 14.802	19	8.6	95
23	Spring 2021	Control	5/6/2021	Mostly Cloudy	7-10	NW	0.5-1.25	6:26	N 40° 51.154	W 70° 20.881	26	6:46	N 40° 51.648	W 70° 21.005	26	7.3	100
24	Spring 2021	Control	5/6/2021	Mostly Cloudy	7-10	NW	0.5-1.25	7:23	N 40° 52.908	W 70° 23.569	26	7:43	N 40° 53.573	W 70° 24.513	26	7.0	120
25	Spring 2021	Control	5/6/2021	Clear	11-15	NW	0.5-1.25	8:40	N 40° 53.561	W 70° 24.191	26	9:00	N 40° 54.491	W 70° 24.060	25	6.9	120
26	Spring 2021	Control	5/6/2021	Clear	11-15	NW	0.5-1.25	9:49	N 40° 54.655	W 70° 21.615	24	10:09	N 40° 54.667	W 70° 20.366	24	7.1	100
27	Spring 2021	Control	5/6/2021	Clear	11-15	NW	0.5-1.25	10:45	N 40° 55.545	W 70° 21.698	23	11:05	N 40° 56.158	W 70° 22.645	24	7.1	100
28	Spring 2021	Control	5/6/2021	Clear	11-15	NW	0.5-1.25	11:38	N 40° 57.204	W 70° 23.404	23	11:58	N 40° 57.987	W 70° 24.156	23	7.0	100
29	Spring 2021	Control	5/6/2021	Clear	11-15	NW	0.5-1.25	12:34	N 40° 57.773	W 70° 25.432	24	12:54	N 40° 57.431	W 70° 26.635	24	6.8	100
30	Spring 2021	Control	5/6/2021	Clear	11-15	NW	0.5-1.25	13:24	N 40° 56.842	W 70° 27.336	25	13:44	N 40° 56.066	W 70° 28.055	25	6.6	100
31	Spring 2021	Control	5/6/2021	Clear	11-15	NW	0.5-1.25	14:18	N 40° 55.409	W 70° 27.606	26	14:38	N 40° 54.681	W 70° 26.808	26	6.7	120
32	Spring 2021	501N	5/6/2021	Clear	11-15	NW	0.5-1.25	15:13	N 40° 55.621	W 70° 28.551	26	15:33	N 40° 56.141	W 70° 29.592	26	6.6	120
33	Spring 2021	501N	5/6/2021	Clear	11-15	NW	0.5-1.25	16:17	N 40° 57.582	W 70° 32.378	27	16:37	N 40° 58.002	W 70° 33.509	28	6.5	120
34	Spring 2021	501N	5/6/2021	Clear	7-10	NW	0.5-1.25	17:17	N 40° 59.059	W 70° 31.738	26	17:37	N 40° 59.513	W 70° 30.601	26	6.7	120
35	Spring 2021	501N	5/7/2021	Partly Cloudy	3-6	E	0.1-0.5	6:26	N 41° 00.130	W 70° 35.055	27	6:46	N 40° 59.920	W 70° 33.847	26	6.4	120
36	Spring 2021	501N	5/7/2021	Clear	3-6	E	0.1-0.5	7:26	N 41° 00.529	W 70° 33.319	26	7:46	N 41° 01.490	W 70° 33.385	27	6.4	120
37	Spring 2021	501N	5/7/2021	Clear	3-6	E	0.1-0.5	8:24	N 41° 01.728	W 70° 31.691	25	8:44	N 41° 01.843	W 70° 30.413	25	6.6	100
38	Spring 2021	501N	5/7/2021	Clear	3-6	E	0.1-0.5	9:18	N 41° 03.190	W 70° 31.187	23	9:38	N 41° 03.223	W 70° 32.496	25	6.6	100
39	Spring 2021	501N	5/7/2021	Clear	3-6	E	0.1-0.5	10:17	N 41° 01.584	W 70° 35.275	24	10:37	N 41° 01.382	W 70° 36.591	24	6.4	100
40	Spring 2021	501N	5/7/2021	Clear	3-6	E	0.1-0.5	11:06	N 41° 01.616	W 70° 37.682	25	11:26	N 41° 01.788	W 70° 33.468	26	6.6	100

Note: fm = fathom

Table 5: Details of tows with operational, environmental, and gear performance parameters for each survey tow.

Tow #	Survey	Tow Area	Tow Duration (min.)	Tow Distance (nmi.)	Tow Speed (knots)	Start Depth (fm)	Trawl Warp (fm)	Bottom Temp. (^oC)	Headline Height (m.)	Wing Spread (m.)	Spread Door (m.)
1	Summer	501N	19.6	1.0	2.9	23	100	16.0	4.1	13.2	
2	Summer	501N	18.6	1.0	3.1	21	100	16.1	4.1	13.9	
3	Summer	501N	21.1	1.1	3.0	21	90	16.3	4.3	13.4	38.3
4	Summer	501N	20.0	1.0	3.0	21	90	16.6	4.5	13.3	36.9
5	Summer	501N	20.6	1.0	3.0	22	90	15.9	4.5	13.6	
6	Summer	501N	20.8	1.1	3.1	21	90	16.1	4.5	13.2	
7	Summer	501N	20.4	1.1	3.1	20	90	16.9	4.2	13.9	
8	Summer	501N	19.9	1.0	3.0	20	80	16.4	4.4	13.3	
9	Summer	Control	20.2	1.0	2.9	20	90	16.3	4.7	12.5	29.4
10	Summer	Control	20.9	1.0	3.0	20	90	17.1	4.3	14.2	34.1
11	Summer	Control	20.0	1.0	3.0	18	80	17.1	4.6	12.8	32.6
12	Summer	Control	19.8	0.9	2.8	17	80	17.2	4.5	12.6	31.7
13	Summer	Control	21.3	1.1	3.0	19	80	17.8	4.5	13.1	33.0
14	Summer	Control	21.1	1.0	2.9	22	90	17.4	5.5	13.3	32.8
15	Summer	Control	20.2	1.1	3.1	22	100	17.2	4.8	12.5	30.4
16	Summer	Control	20.1	1.1	3.2	23	100	17.1	4.7	13.3	32.5
17	Summer	Control	20.5	1.0	2.8	21	90	17.5	4.9	12.9	30.0
18	Summer	Control	20.0	1.0	3.0	22	90	16.6	4.9	12.9	32.1
19	Summer	Control	20.4	1.0	2.9	22	90	16.0	4.5	13.4	33.1
20	Summer	Control	20.2	1.0	3.0	24	100	15.7	4.2	13.3	32.9
21	Summer	Control	19.3	0.9	2.8	24	90	15.4	4.5	13.3	32.3
22	Summer	Control	19.5	0.9	2.9	26	100	14.7	4.7	13.9	33.2
23	Summer	Control	20.1	1.0	2.9	25	100	13.8	4.5	13.8	34.0
24	Summer	Control	20.2	0.9	2.8	26	100	13.9	4.7	13.3	33.8
25	Summer	501N	20.3	1.0	2.9	26	100	13.6	4.5	13.8	34.0
26	Summer	501N	20.1	1.0	3.0	24	90	14.2	4.9	13.1	31.6
27	Summer	501N	20.2	1.0	2.9	24	90	15.9	4.6	13.3	32.5
28	Summer	Control	20.3	1.0	2.9	23	90	17.3	4.6	13.1	31.7
29	Summer	Control	19.6	1.0	2.9	21	80	17.3	4.9	12.6	30.4
30	Summer	501N	19.8	0.9	2.7	21	80	16.4	5.6	12.9	31.8
31	Summer	Control	20.4	1.0	2.8	21	90	17.7	4.6	13.2	32.1
32	Summer	Control	20.0	1.0	2.9	22	90	17.3	4.8	13.0	31.2
33	Summer	501N	20.1	1.0	3.0	22	85	17.0	4.7	13.1	32.2
34	Summer	501N	20.1	1.0	3.1	23	90	15.8	4.6	13.5	33.2
35	Summer	501N	20.6	1.0	2.8	24	90	15.8	4.5	13.3	33.2
36	Summer	501N	20.2	1.0	2.9	24	100	14.8	4.6	13.4	32.8
37	Summer	501N	20.0	1.0	2.9	26	100	14.2	4.6	13.1	31.5
38	Summer	501N	20.2	1.0	3.0	24	90	14.5	4.7	13.3	32.4
39	Summer	501N	20.2	1.0	3.0	23	90	17.5	4.5	13.6	33.8
40	Summer	501N	20.0	1.0	2.9	23	90	17.6	4.5	13.4	33.0

Table 5 (Cont.): Details of tows with operational, environmental, and gear performance parameters for each survey tow.

Tow #	Survey	Tow Area	Tow Duration (min.)	Tow Distance (nmi.)	Tow Speed (knots)	Start Depth (fm)	Trawl Warp (fm)	Bottom Temp. (^oC)	Headline Height (m.)	Wing Spread (m.)	Spread Door (m.)
1	Fall	501N	20.0	1.00	3.2	24	95				
2	Fall	501N	17.8	0.86	2.9	25	100				
3	Fall	501N	15.3	0.77	3.0	27	100	14.6	4.8		33.4
4	Fall	501N	20.1	1.00	3.0	26	100	14.6	4.8	13.6	32.1
5	Fall	501N	20.9	1.00	2.9	25	95	14.7	5.5		33.2
6	Fall	501N	19.6	0.91	2.8	24	100	14.5	4.8	15.1	34.6
7	Fall	501N	20.4	0.95	2.8	25	100	14.8	4.5	14.3	34.3
8	Fall	501N	20.1	0.96	2.9	25	95	14.8	4.7	13.8	32.8
9	Fall	Control	20.1	0.94	2.8	24	95	14.6	4.9	13.5	31.8
10	Fall	Control	20.2	0.95	2.8	25	95		4.7	13.3	32.6
11	Fall	Control	19.7	0.98	3.0	25	100	14.7	4.4	14.2	34.0
12	Fall	Control	20.7	0.99	2.9	27	100		4.7	13.2	32.4
13	Fall	Control	20.2	1.01	3.0	25	100	14.7	4.6		33.9
14	Fall	Control	19.9	0.92	2.8	26	100	14.7	4.9	13.8	31.9
15	Fall	Control	19.5	0.95	2.9	24	95	14.7	5.0		33.3
16	Fall	Control	19.7	0.94	2.9	23	95	14.7	4.5	14.0	33.4
17	Fall	Control	19.9	0.93	2.8	23	95	14.2	4.9	13.1	31.5
18	Fall	Control	20.8	1.01	2.9	22	95	13.8	4.7	14.4	32.7
19	Fall	Control	20.0	0.96	2.9	22	95	13.5	4.4	14.4	33.8
20	Fall	Control	21.2	1.03	2.9	21	95	13.4	4.9	14.1	32.0
21	Fall	Control	20.5	0.99	2.9	22	95	13.9	4.7	14.2	32.6
22	Fall	Control	20.1	0.92	2.8	20	75	14.3	5.1	12.5	29.3
23	Fall	Control	20.0	0.95	2.9	21	95		4.7	14.1	33.5
24	Fall	Control	19.8	0.87	2.6	21	95	14.3	4.5	14.6	33.3
25	Fall	501N	20.3	0.95	2.8	22	95	14.4	4.5	15.0	33.7
26	Fall	501N	20.0	0.93	2.8	22	95	14.4	4.8	13.9	32.8
27	Fall	501N	20.5	1.00	2.9	23	100	14.5	4.7	14.1	33.7
28	Fall	501N	19.7	0.93	2.8	23	100	14.2	4.8	14.4	32.6
29	Fall	501N	21.1	1.00	2.8	24	95	14.5	4.5	14.1	34.3
30	Fall	501N	19.8	0.94	2.8	22	95	14.5	4.9	13.8	32.5
31	Fall	501N	20.2	0.92	2.7	22	95				
32	Fall	501N	20.4	0.93	2.7	23	95	14.5	4.6	14.9	34.5
33	Fall	Control	20.5	0.96	2.8	17	75	14.5	5.3	14.6	31.7
34	Fall	Control	20.3	0.93	2.8	20	95		4.7	14.0	32.0
35	Fall	Control	20.6	0.94	2.7	21	95	14.5	4.6	13.9	33.1
36	Fall	Control	20.0	0.96	2.9	19	75	14.4	5.1		30.5
37	Fall	501N	19.9	0.99	3.0	21	95	14.5	4.7	14.8	32.1
38	Fall	501N	20.1	0.95	2.8	23	95	14.5	4.7		32.3
39	Fall	501N	19.8	0.95	2.9	22	95	14.2	4.9		32.6
40	Fall	501N	19.9	0.91	2.7	21	95				33.1

Table 5 (Cont.): Details of tows with operational, environmental, and gear performance parameters for each survey tow.

Tow #	Survey	Tow Area	Tow Duration (min.)	Tow Distance (nm.)	Tow Speed (knots)	Start Depth (fm)	Trawl Warp (fm)	Bottom Temp. (^{o}C)	Headline Height (m.)	Wing Spread (m.)	Spread Door (m.)
1	Winter	501N	20.2	1.0	2.9	24	100	3.5		14.2	33.9
2	Winter	501N	20.7	1.0	2.9	23	95	3.6	5.0	14.1	34.8
3	Winter	501N	20.1	1.0	3.0	25	100	3.8	5.4	13.8	33.3
4	Winter	501N	20.0	1.0	2.9	26	100	3.8	5.2	13.9	34.0
5	Winter	501N	21.0	1.0	2.8	25	100	4.2	5.2	13.9	33.7
6	Winter	501N	20.1	1.0	2.9	25	100	4.0	5.3	13.4	32.2
7	Winter	501N	20.2	1.0	2.9	25	100	4.2	5.2		34.9
8	Winter	501N	20.6	1.0	2.9	25	100	4.2	5.0	14.2	34.4
9	Winter	501N	20.6	1.0	2.9	26	100	4.1	5.6	13.9	34.8
10	Winter	501N	20.4	1.0	2.9	27	120	4.1	4.9	14.5	35.4
11	Winter	501N	20.5	1.0	3.0	26	120		4.8	14.1	33.6
12	Winter	Control	21.3	1.0	2.9	25	100	4.3	5.3	13.9	33.3
13	Winter	Control	20.6	1.0	3.0	27	120	4.4	5.1	14.0	34.0
14	Winter	Control	20.1	1.0	2.8	27	120	4.6	4.8	14.2	35.0
15	Winter	Control	20.0	0.9	2.8	26	120	4.4	5.0	13.9	35.6
16	Winter	Control	20.5	0.9	2.7	26	120	4.5	5.2	13.5	32.4
17	Winter	Control	20.2	1.0	3.0	25	100	4.6	5.0	13.6	34.1
18	Winter	Control	20.4	0.9	2.8	24	100	4.5	4.9	14.0	34.5
19	Winter	Control	20.0	1.0	2.9	23	100	4.5	5.3	13.6	32.9
20	Winter	Control	19.2	0.9	2.8	24	100	4.4	4.9	14.1	35.2
21	Winter	Control	20.0	1.0	3.0	24	100	4.3	5.2	14.0	33.6
22	Winter	Control	20.2	1.0	2.9	22	95	4.2	5.0	14.1	33.7
23	Winter	501N	20.5	1.0	2.9	21	95		4.8	14.1	34.0
24	Winter	501N	20.2	1.0	2.9	23	100	3.6	4.8	14.2	35.2
25	Winter	501N	20.5	1.0	3.0	23	100	3.9	5.1	14.0	33.8
26	Winter	501N	19.5	0.9	2.9	22	95	3.7	5.2	13.8	32.7
27	Winter	501N	20.4	1.0	3.0	21	95	3.6	5.4	13.4	32.3
28	Winter	501N	20.5	1.0	2.9	22	95	3.5	5.0	14.1	34.0
29	Winter	501N	19.8	1.0	3.0	21	95	3.8	5.1	13.6	33.4
30	Winter	501N	20.0	1.0	2.9	22	95	4.0	5.3	13.9	34.5
31	Winter	501N	20.2	1.0	2.9	22	95	3.8	4.8	14.1	34.1
32	Winter	Control	20.0	1.0	2.9	21	95	3.7	4.9	14.1	33.8
33	Winter	Control	20.3	1.0	2.8	20	95	3.6	5.2	13.5	32.2
34	Winter	Control	20.1	0.9	2.8	19	95		4.7	13.9	34.2
35	Winter	Control	19.8	0.9	2.8	17	75	3.7	5.5	13.6	33.6
36	Winter	Control	20.0	0.9	2.7	19	95	3.9	5.4	13.3	30.1
37	Winter	Control	20.2	0.9	2.7	21	95	4.2	5.0	13.7	34.5
38	Winter	Control	20.2	0.9	2.7	21	95	4.0	5.1	13.4	32.6
39	Winter	Control	20.0	0.9	2.8	22	95		4.7	14.1	34.2
40	Winter	Control	20.3	1.1	3.2	22	100	4.3	5.0	13.9	34.1

Table 5 (Cont.): Details of tows with operational, environmental, and gear performance parameters for each survey tow.

Tow #	Survey	Tow Area	Tow Duration (min.)	Tow Distance (nmi.)	Tow Speed (knots)	Start Depth (fm)	Trawl Warp (fm)	Bottom Temp. (°C)	Headline Height (m.)	Wing Spread (m.)	Spread Door (m.)
1	Spring	501N	20.3	1.0	2.9	20	95	6.6	4.8	14.0	34.9
2	Spring	501N	19.8	1.0	2.9	21	95	6.4	5.2	13.6	32.6
3	Spring	501N	20.2	1.0	2.9	22	100	6.4	4.7	11.9	35.0
4	Spring	501N	20.0	1.0	2.9	20	95	7.0	5.0	14.7	34.6
5	Spring	501N	20.2	0.9	2.7	20	95	7.2	4.9	13.7	33.8
6	Spring	501N	20.0	0.9	2.7	22	100	7.3	4.7	14.5	34.3
7	Spring	501N	19.8	1.0	3.0	22	100	7.2	4.8	14.6	34.9
8	Spring	501N	20.2	1.0	2.9	22	100	6.9	4.8	14.0	34.3
9	Spring	501N	20.1	1.0	2.9	24	100	6.6	4.9	14.1	34.6
10	Spring	501N	20.3	1.0	3.0	24	100	6.5	5.2	13.7	32.5
11	Spring	501N	20.2	1.0	2.9	24	100	6.5	4.7	14.2	35.5
12	Spring	Control	20.0	1.0	2.9	22	100	7.8	4.8	14.0	34.2
13	Spring	Control	20.1	1.0	3.0	21	100	7.5	5.1	13.6	33.5
14	Spring	Control	20.2	0.9	2.8	22	100	7.6	4.7	14.0	34.7
15	Spring	Control	20.2	0.9	2.8	22	100	8.3	4.6	13.9	35.3
16	Spring	Control	20.4	0.9	2.8	20	95	8.7	4.7	14.0	34.6
17	Spring	Control	20.2	1.0	2.9	18	95	9.1	4.8	13.8	33.7
18	Spring	Control	20.1	1.0	2.9	21	95	8.7	4.9	13.4	33.1
19	Spring	Control	20.1	1.1	3.2	24	100	7.8	4.9	13.8	33.6
20	Spring	Control	20.3	1.0	3.0	23	100	7.2	4.9	13.7	34.4
21	Spring	Control	20.2	1.0	3.0	23	100	7.5	4.8		34.3
22	Spring	Control	20.3	1.1	3.3	21	95	8.6	5.2	13.9	32.3
23	Spring	Control	20.4	1.0	2.9	26	100	7.3	5.3	13.6	33.9
24	Spring	Control	20.1	1.0	2.9	26	120	7.0	4.6	14.2	36.7
25	Spring	Control	20.1	1.0	2.9	26	120	6.9	4.9	14.2	35.7
26	Spring	Control	20.0	1.0	2.9	24	100	7.1	4.9	14.1	34.7
27	Spring	Control	20.1	0.9	2.8	23	100	7.1	5.3	13.7	33.3
28	Spring	Control	20.2	1.0	2.9	23	100	7.0	5.3	13.6	33.4
29	Spring	Control	20.0	1.0	3.0	24	100	6.8	5.4	13.5	32.9
30	Spring	Control	20.0	1.0	2.9	25	100	6.6	5.1	14.0	34.2
31	Spring	Control	19.9	1.0	2.9	26	120	6.7	4.5	14.5	37.0
32	Spring	501N	20.0	1.0	2.9	26	120	6.6	5.2	13.9	34.2
33	Spring	501N	20.0	1.0	2.9	27	120	6.5	5.1	14.0	35.3
34	Spring	501N	20.0	1.0	3.0	26	120	6.7	5.0	14.2	35.5
35	Spring	501N	20.1	0.9	2.8	27	120	6.4	5.2	13.7	34.0
36	Spring	501N	19.9	1.0	2.9	26	120	6.4	4.8	14.2	35.7
37	Spring	501N	20.2	1.0	2.9	25	100	6.6	5.1	13.9	34.1
38	Spring	501N	20.0	1.0	3.0	23	100	6.6	4.9	14.0	34.8
39	Spring	501N	20.1	1.0	3.0	24	100	6.4	4.9	13.9	34.5
40	Spring	501N	19.5	1.0	2.9	25	100	6.6	5.0	13.8	34.3
Summary Statistics											
	Control	**Minimum**	19.2	0.9	2.6	17.0	75.0	3.6	4.2	12.5	29.3
		Maximum	21.3	1.1	3.3	27.0	120.0	17.8	5.5	14.6	37.0
		Average	20.2	1.0	2.9	22.5	96.7	10.6	4.9	13.7	33.1
		St. Dev	0.4	0.05	0.1	2.5	9.8	5.1	0.3	0.5	1.5
	501N	**Minimum**	15.3	0.8	2.7	20.0	80.0	3.5	4.1	11.9	31.5
		Maximum	21.1	1.1	3.2	27.0	120.0	17.6	5.6	15.1	38.3
		Average	20.1	1.0	2.9	23.3	98.0	10.2	4.8	13.8	33.8
		St. Dev.	0.7	0.04	0.1	1.9	8.2	5.2	0.3	0.5	1.2
		T-Test	0.1760	0.7779	0.1930	0.0227	0.3611	0.5880	0.6720	0.0250	0.0032

Table 6: Total and mean catch weight of species observed in the 501N Study Area.

Species Name	Scientific Name	Total Weight (Kg)	Catch/Tow (Kg)		% of Total Catch	Tows with Species Present
			Mean	SEM*		
Skate, Little	*Leucoraja erinacea*	5215.1	64.9	8.4	27.4	75
Scup	*Stenotomus chrysops*	3754.2	46.6	10.9	19.7	50
Dogfish, Spiny	*Squalus acanthias*	3677.2	44.6	20.7	19.3	31
Skate, Winter	*Leucoraja ocellata*	1030.1	12.7	2.0	5.4	46
Hake, Silver	*Merluccius bilinearis*	1015.8	12.6	2.7	5.3	69
Butterfish	*Peprilus triacanthus*	878.2	11.0	2.0	4.6	58
Squid, Atlantic Longfin	*Dorytheuthis pealei*	686.3	8.6	1.2	3.6	56
Herring, Atlantic	*Clupea harengus*	575.7	7.2	2.3	3.0	40
Hake, Red	*Urophycis chuss*	472.8	5.9	1.1	2.5	50
Dogfish, Smooth	*Mustelus canis*	275.2	3.4	1.1	1.4	20
Flounder, Summer (Fluke)	*Paralichthys dentatus*	223.8	2.8	0.6	1.2	46
Black Sea bass	*Centropristis striata*	177.5	2.2	0.3	0.9	45
Northern Sea Robin	*Prionotus carolinus*	152.6	1.9	0.4	0.8	50
Flounder, Winter	*Pleuronectes americanus*	148.0	1.9	0.4	0.8	43
Flounder, Fourspot	*Paralichthys oblongus*	99.3	1.2	0.2	0.5	57
Flounder, Windowpane	*Scophtalmus aquosus*	82.3	1.0	0.2	0.4	48
Crab, Rock	*Cancer irroratus*	66.6	0.8	0.2	0.4	42
Monkfish	*Lophius americanus*	59.3	0.7	0.2	0.3	19
Sculpin, Longhorn	*Myoxocephalus octodecimspinosus*	56.7	0.7	0.4	0.3	34
Hake, Spotted	*Urophycis regia*	54.4	0.7	0.2	0.3	20
Herring, Blueback	*Alosa aestivalis*	47.6	0.6	0.3	0.3	17
Skate, Barndoor	*Dipturus laevis*	37.5	0.5	0.1	0.2	36
Alewife	*Alosa pseudoharengus*	32.3	0.4	0.1	0.2	35
Sea Scallop	*Placopecten magellanicus*	19.2	0.2	0.0	0.1	33
Ocean Pout	*Zoarces americanus*	19.0	0.2	0.1	0.1	11
Bluefish	*Pomatomus saltatrix*	9.4	0.1	0.1	0.05	5
Menhaden, Atlantic	*Brevoortia tyrannus*	8.5	0.1	0.1	0.04	4
Lobster, American	*Homarus americanus*	7.9	0.1	0.03	0.04	11
Atlantic Cod	*Gadus morhua*	6.7	0.1	0.04	0.04	6
Sea Robin, Striped	*Prionotus evolans*	5.9	0.1	0.04	0.03	5
Flounder, Gulfstream	*Citharichthys arctifrons*	4.5	0.1	0.01	0.02	24
Shad, American	*Alosa sapidissima*	4.4	0.1	0.02	0.02	14
Flounder, Yellowtail	*Pleuronectes ferrugineus*	2.5	0.03	0.01	0.01	8
Mackerel, Atlantic	*Scomber scombrus*	2.3	0.03	0.01	0.01	8
Weakfish	*Cynoscion regalis*	2.3	0.03	0.01	0.01	4
Haddock	*Melanogrammus aeglefinus*	2.2	0.03	0.02	0.01	6
Sea Raven	*Hemitripterus americanus*	1.6	0.02	0.01	0.01	3
Cunner	*Tautogolabrus undulatus*	1.0	0.01	0.01	0.01	1
Eel, Conger	*Conger oceanicus*	0.7	0.01	0.01	0.00	1
Shark, Thresher	*Alopias vulpinus*	0.0	0.0	0.0	0.0	1
Total		**18916.6**				

*SEM - Standard Error of the Mean

Table 7: Total and mean catch weight of species observed in the Control Area.

Species Name	Scientific Name	Total Weight (Kg)	Catch/Tow (Kg)		% of Total Catch	Tows with Species Present
			Mean	SEM*		
Skate, Little	*Leucoraja erinacea*	7159.3	88.5	11.1	32.8	78
Scup	*Stenotomus chrysops*	4705.3	58.2	16.5	21.6	51
Dogfish, Spiny	*Squalus acanthias*	2637.5	32.7	13.1	12.1	31
Hake, Silver (Whiting)	*Merluccius bilinearis*	1379.6	17.1	3.5	6.3	59
Skate, Winter	*Leucoraja ocellata*	1109.8	13.7	2.2	5.1	45
Butterfish	*Peprilus triacanthus*	1078.0	13.4	2.7	4.9	58
Hake, Red	*Urophycis chuss*	737.1	9.1	1.7	3.4	43
Herring, Atlantic	*Clupea harengus*	645.5	8.1	3.9	3.0	36
Squid, Atlantic Longfin	*Dorytheuthis pealei*	583.9	7.2	1.1	2.7	58
Northern Sea Robin	*Prionotus carolinus*	416.7	5.1	1.9	1.9	47
Flounder, Summer (Fluke)	*Paralichthys dentatus*	243.7	3.0	0.6	1.1	48
Dogfish, Smooth	*Mustelus canis*	188.8	2.3	0.7	0.9	21
Flounder, Windowpane	*Scophtalmus aquosus*	165.5	2.1	0.6	0.8	55
Flounder, Fourspot	*Paralichthys oblongus*	137.9	1.7	0.3	0.6	55
Alewife	*Alosa pseudoharengus*	136.5	1.7	0.8	0.6	41
Black Sea bass	*Centropristis striata*	104.2	1.3	0.2	0.5	51
Hake, Spotted	*Urophycis regia*	72.4	0.9	0.5	0.3	17
Sculpin, Longhorn	*Myoxocephalus octodecimspinosus*	61.8	0.8	0.2	0.3	28
Monkfish	*Lophius americanus*	45.8	0.6	0.2	0.2	16
Crab, Rock	*Cancer irroratus*	36.3	0.5	0.1	0.2	37
Flounder, Winter	*Pleuronectes americanus*	34.4	0.4	0.1	0.2	32
Shad, American	*Alosa sapidissima*	23.5	0.3	0.1	0.1	20
Mackerel, Atlantic	*Scomber scombrus*	21.4	0.3	0.1	0.1	19
Skate, Barndoor	*Dipturus laevis*	18.4	0.2	0.0	0.1	26
Ocean Pout	*Zoarces americanus*	17.1	0.2	0.1	0.1	13
Atlantic Cod	*Gadus morhua*	16.6	0.2	0.1	0.1	17
Sea Scallop	*Placopecten magellanicus*	14.1	0.2	0.0	0.1	27
Herring, Blueback	*Alosa aestivalis*	10.7	0.1	0.1	0.05	11
Bluefish	*Pomatomus saltatrix*	8.7	0.1	0.05	0.04	6
Lobster, American	*Homarus americanus*	5.0	0.1	0.03	0.02	5
Flounder, Gulfstream	*Citharichthys arctifrons*	4.5	0.1	0.01	0.02	26
Sea Raven	*Hemitripterus americanus*	3.5	0.04	0.02	0.02	6
Crab, Horseshoe	*Limulus polyphemus*	2.3	0.03	0.03	0.01	2
Weakfish	*Cynoscion regalis*	2.1	0.03	0.02	0.01	3
Flounder, Yellowtail	*Pleuronectes ferrugineus*	1.5	0.02	0.01	0.01	7
Sea Robin, Striped	*Prionotus evolans*	1.5	0.02	0.02	0.01	1
Ray, Cownose	*Rhinotera bonasus*	1.1	0.01	0.01	0.01	1
Menhaden, Atlantic	*Brevoortia tyrannus*	1.0	0.01	0.01	0.00	3
Eel, Conger	*Conger oceanicus*	1.0	0.01	0.01	0.00	1
Total		**21833.9**				

*SEM - Standard Error of the Mean

Table 8: Coefficient of variance (CV) and the total number of tows required to detect a certain percentage of change for each species in two survey areas as calculated from power analysis, assuming type-1 error α=0.05 and type-2 error β=0.80.

	2019-2020 CV	2020-2021 CV	2019-2021					
			CV	**10%**	**25%**	**50%**	**75%**	**100%**
Skate, Little	0.97	1.17	1.07	1630	218	37	9	0
Flounder, Fourspot	1.10	1.34	1.23	2154	288	49	12	0
Squid, Atlantic Longfin	1.15	1.30	1.39	2737	367	63	15	0
Skate, Winter	1.47	1.42	1.60	3616	485	83	20	0
Hake, Silver	1.19	1.90	1.61	3676	493	84	21	0
Crab, Cancer	1.63	2.28	1.90	5085	682	117	29	1
Flounder, Summer (Fluke)	2.05	1.77	1.93	5246	703	121	30	1
Black Sea Bass	4.01	1.30	2.07	6052	811	139	34	1
Flounder, Winter	2.15	2.21	2.21	6922	928	159	39	1
Sea Scallop	2.64	2.05	2.31	7528	1009	173	43	1
Hake, Red	1.66	1.72	2.30	7480	1003	172	43	1
Butterfish	2.32	1.76	2.37	7940	1065	183	45	1
Flounder, Windowpane	1.84	2.40	2.42	8252	1106	190	47	1
Scup	2.08	2.42	2.51	8884	1191	205	51	2
Monkfish	1.85	2.79	2.52	8988	1205	207	51	2
Flounder, Yellowtail	2.11	3.91	2.79	11021	1478	254	63	2
Flounder, Gulfstream	2.38	1.81	2.85	11492	1541	265	66	2
Atlantic Cod	3.93	2.84	3.31	15463	2074	357	89	3
Ocean Pout	3.84	2.77	3.34	15789	2117	364	91	3
Skate, Barndoor	2.50	2.33	3.47	17024	2283	393	98	3
Bluefish	3.06	3.94	3.48	17163	2302	396	99	3
Lobster, American	3.77	3.40	3.59	18252	2448	421	105	4
Sculpin, Longhorn	2.03	3.56	3.53	17660	2368	408	102	4
Dogfish, Smooth	4.56	2.77	3.56	17901	2401	413	103	4
Herring, Atlantic	4.04	3.78	3.99	22485	3016	519	129	5
Dogfish, Spiny	3.48	3.99	4.29	26029	3491	601	150	6
Weakfish	4.05	5.17	4.56	29448	3950	680	170	6
Hake, Spotted	4.42	4.14	4.69	31057	4165	717	179	7
Herring, Blueback	3.93	5.48	4.97	34951	4688	807	201	8
Alewife	3.92	4.73	5.16	37695	5056	870	217	8
Squid, Shortfin	3.85		5.53	43255	5801	999	249	10
Northern Sea Robin	7.07	3.47	5.79	47424	6361	1095	273	11
Sea Raven	8.30	4.59	6.08	52210	7003	1206	301	12
Sea Robin, Striped		5.78	8.24	95937	12868	2216	554	22
Shad, American	6.44	3.95	7.81	86218	11564	1992	498	20
Menhaden, Atlantic	7.88	5.98	9.10	117145	15712	2706	676	27
Cunner	8.89	12.61	13.14	244015	32730	5637	1409	56
Haddock	8.34	9.87	11.83	197923	26547	4573	1143	46
Mackerel, Atlantic	9.61	4.97	12.26	212588	28514	4911	1227	49
Shark, Thresher	7.23		17.52	433887	58197	10024	2506	100
Eel, Conger	9.24	9.09	12.89	235070	31530	5431	1357	54
Flounder, American Plaice	8.89		17.86	451099	60506	10422	2605	104
Kingfish, Northern	8.89		17.86	451099	60506	10422	2605	104

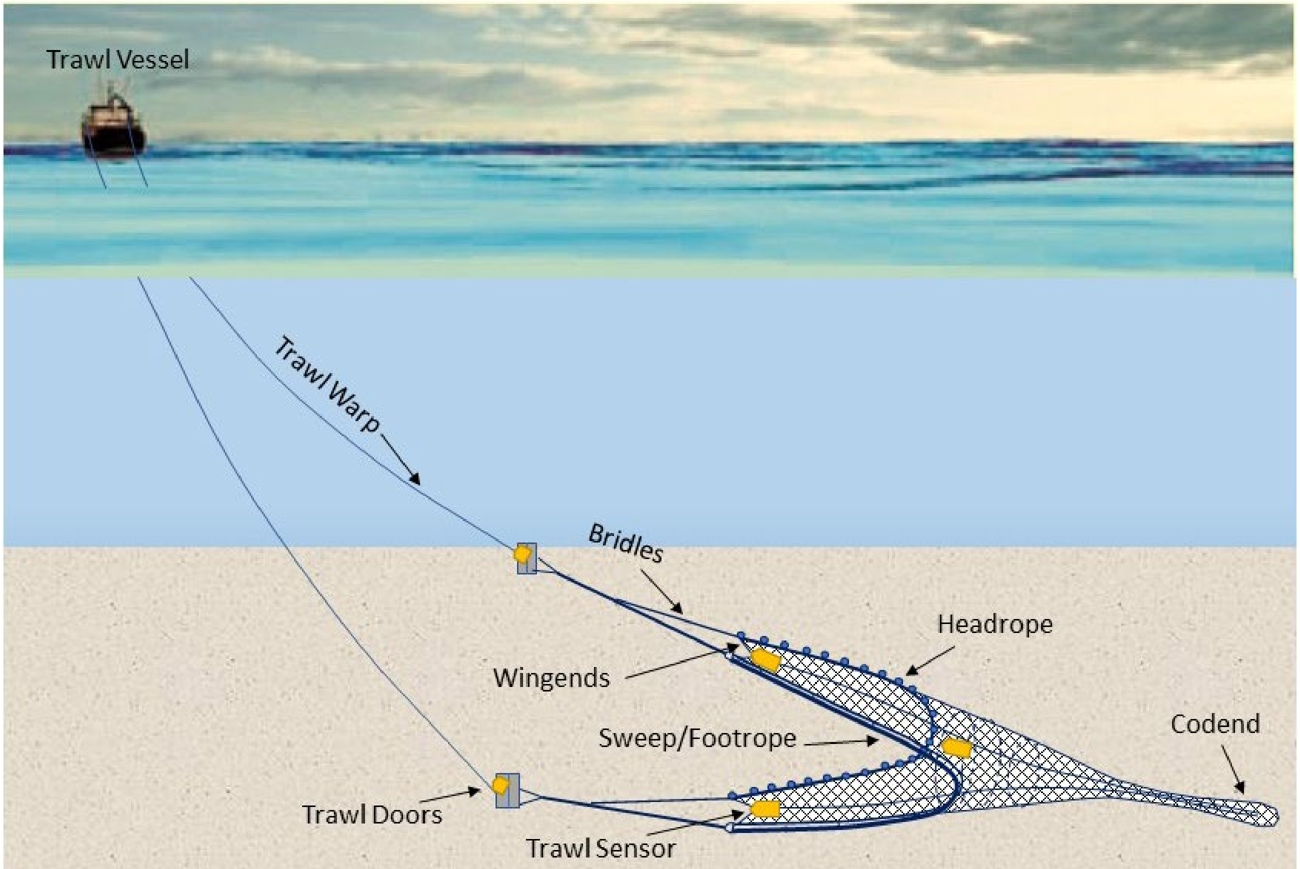


Figure 1: General schematic (not to scale) of a demersal otter trawl. Yellow rectangles indicate geometry sensors.

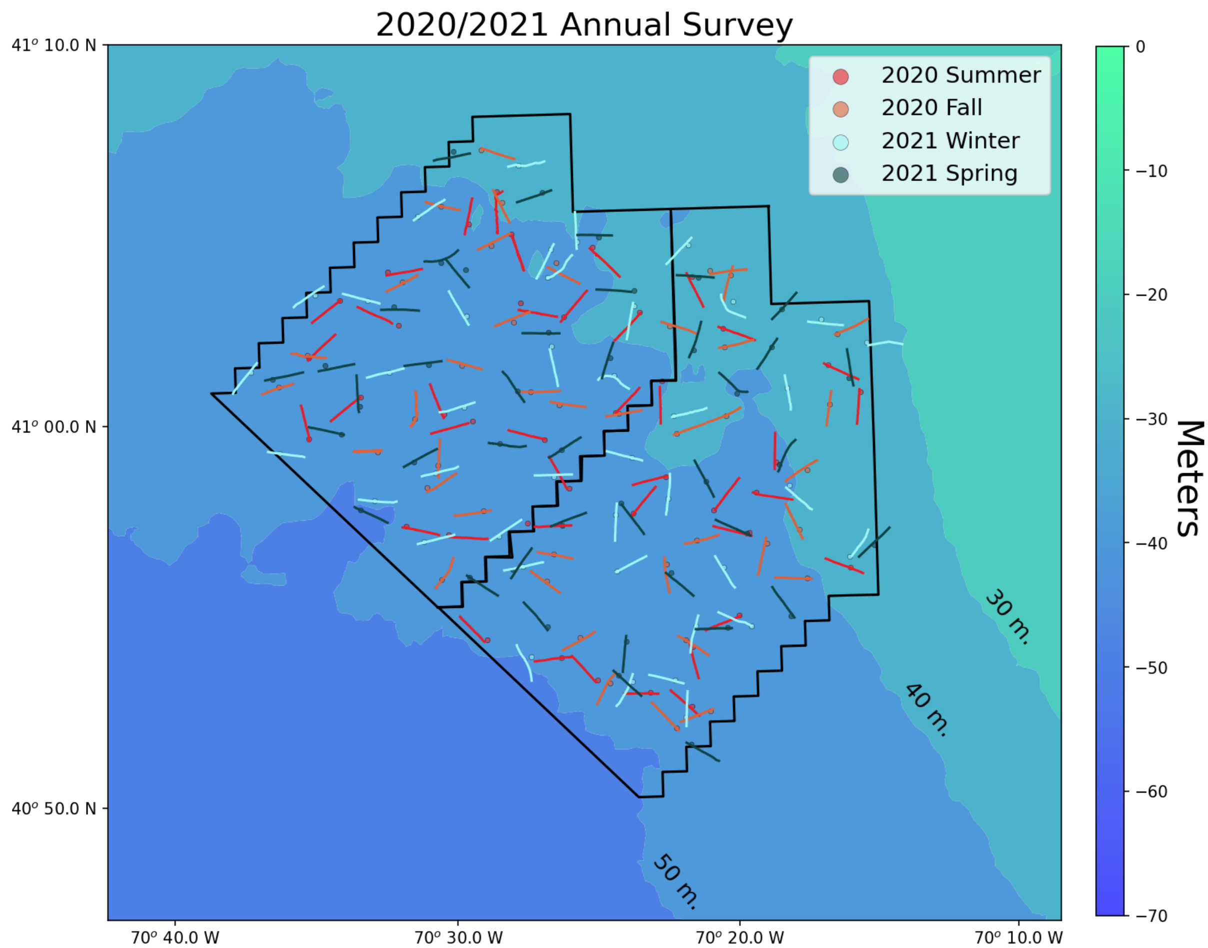


Figure 2: Tow locations (dots) and trawl tracks (lines) from the 501N Study Area (left) and the Control Area (right).

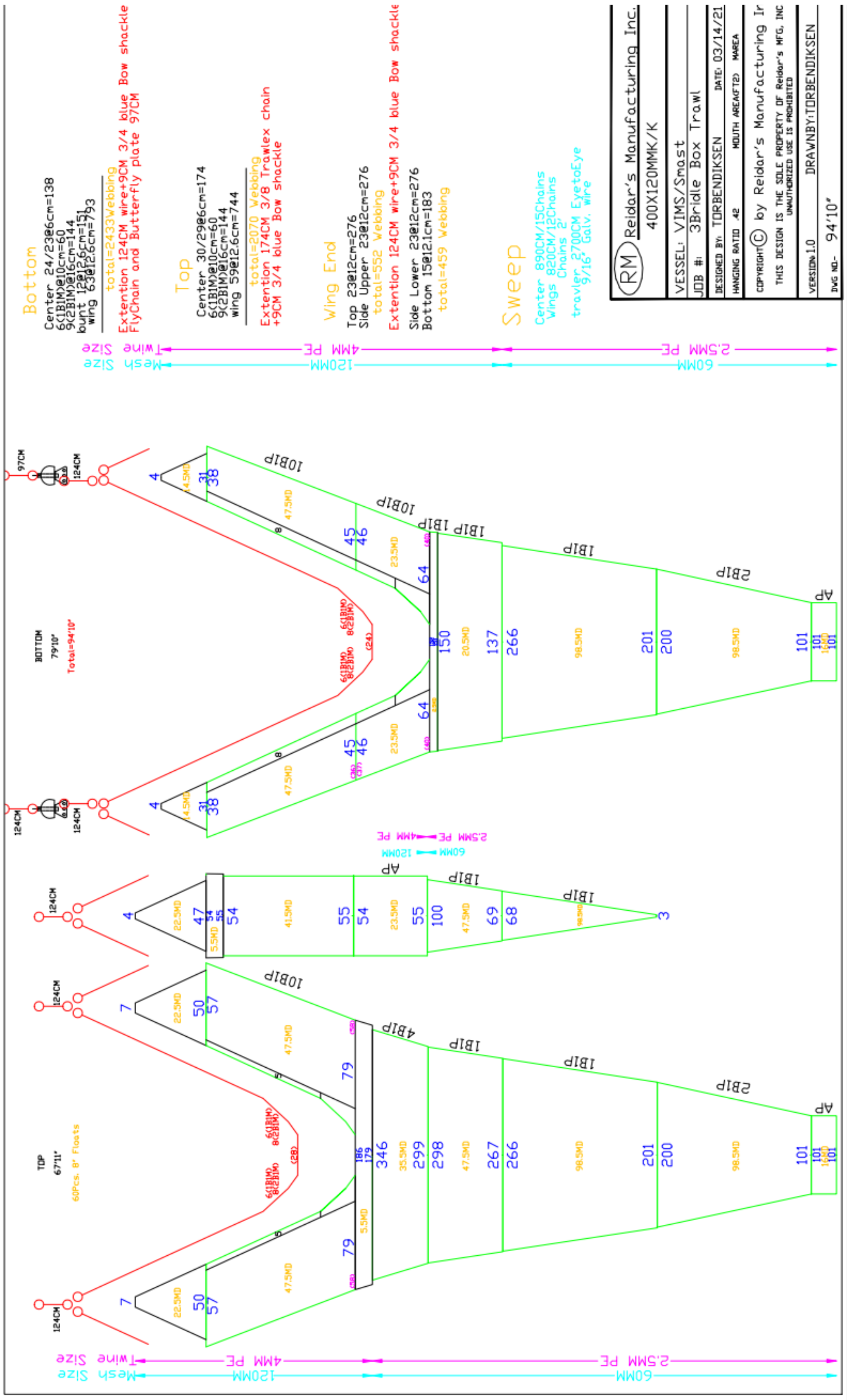


Figure 3: Schematic net plan for the NEAMAP trawl (Courtesy of Reidar's Manufacturing Inc.).

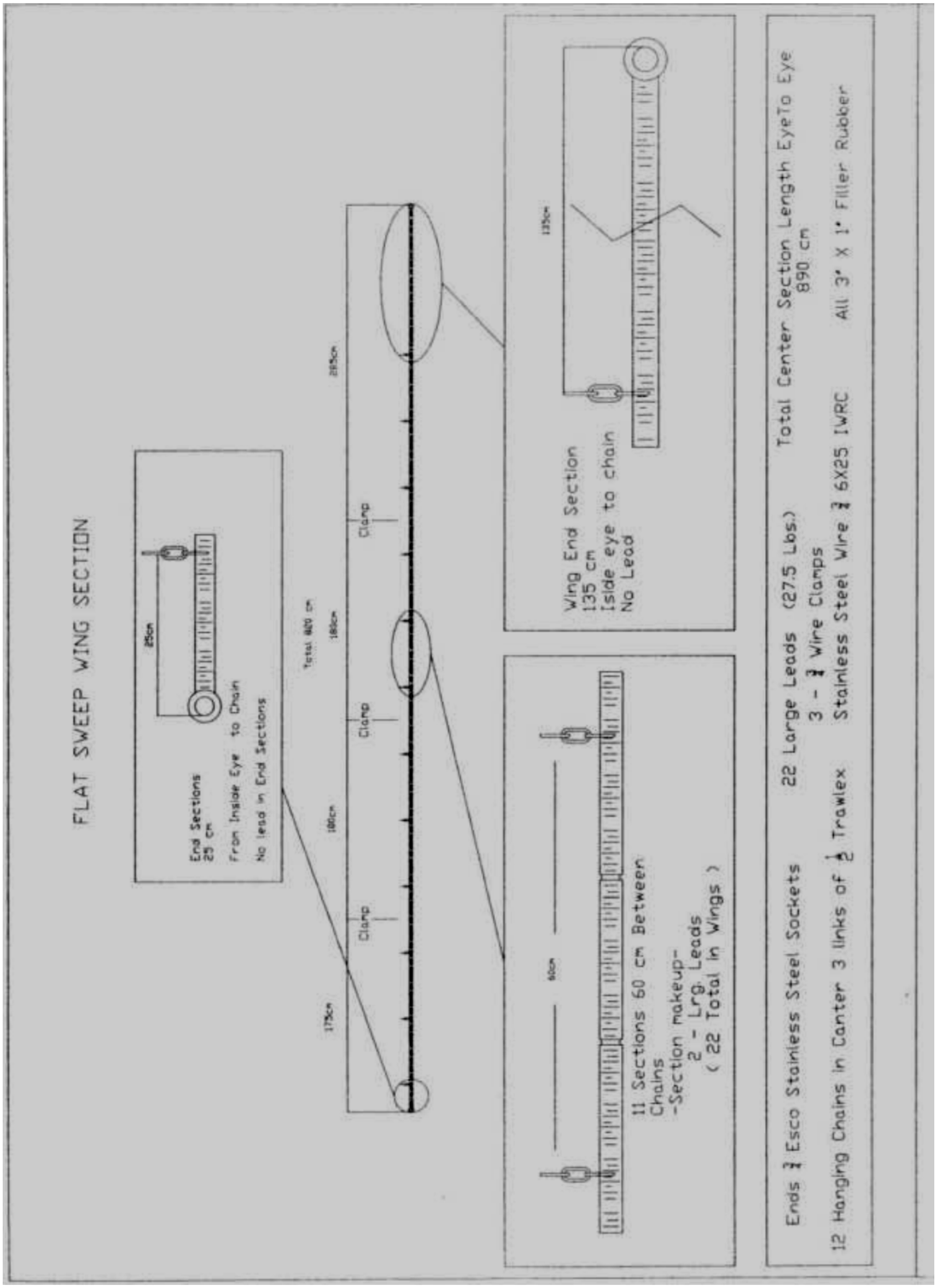


Figure 4: Sweep diagram for the survey trawl (Bonzek et al., 2008).

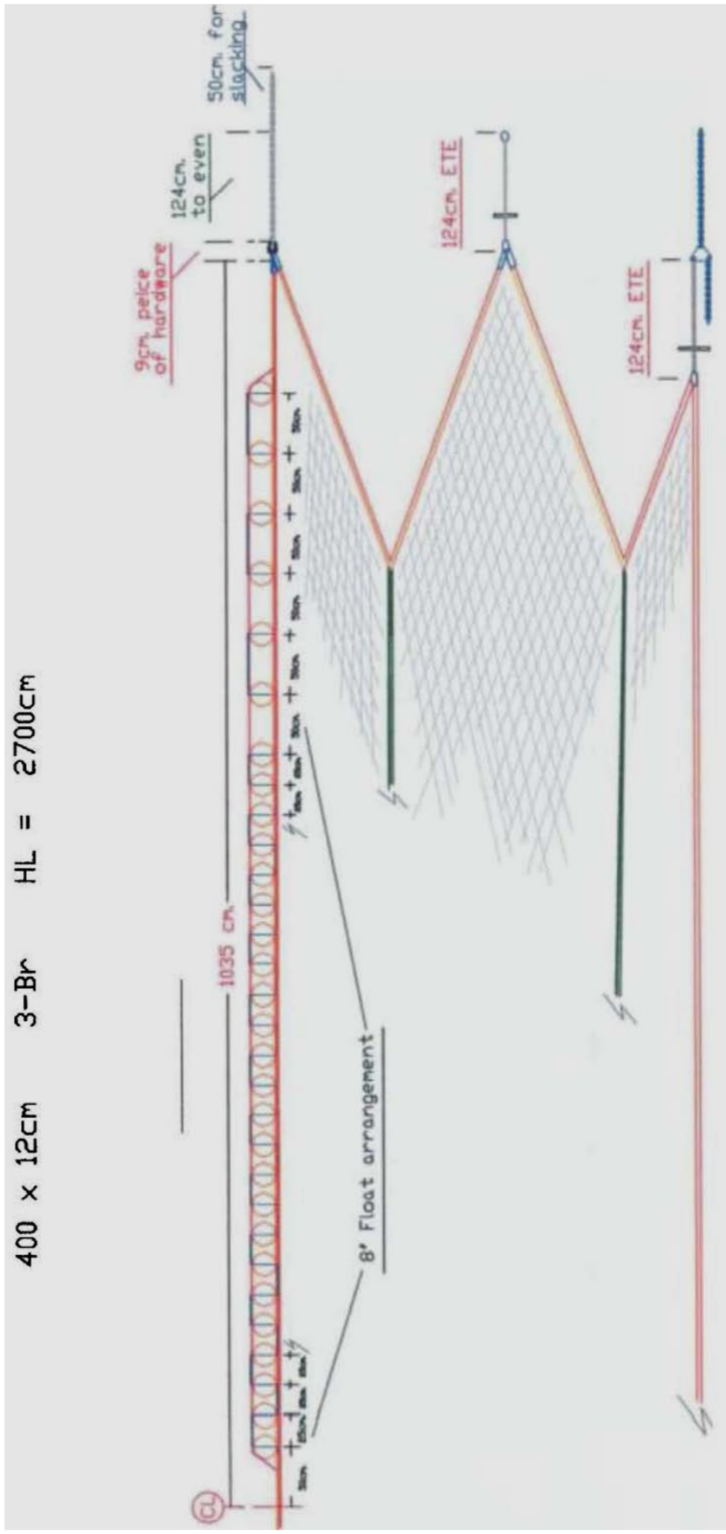


Figure 5: Headrope and rigging plan for the survey trawl (Bonzek et al., 2008).

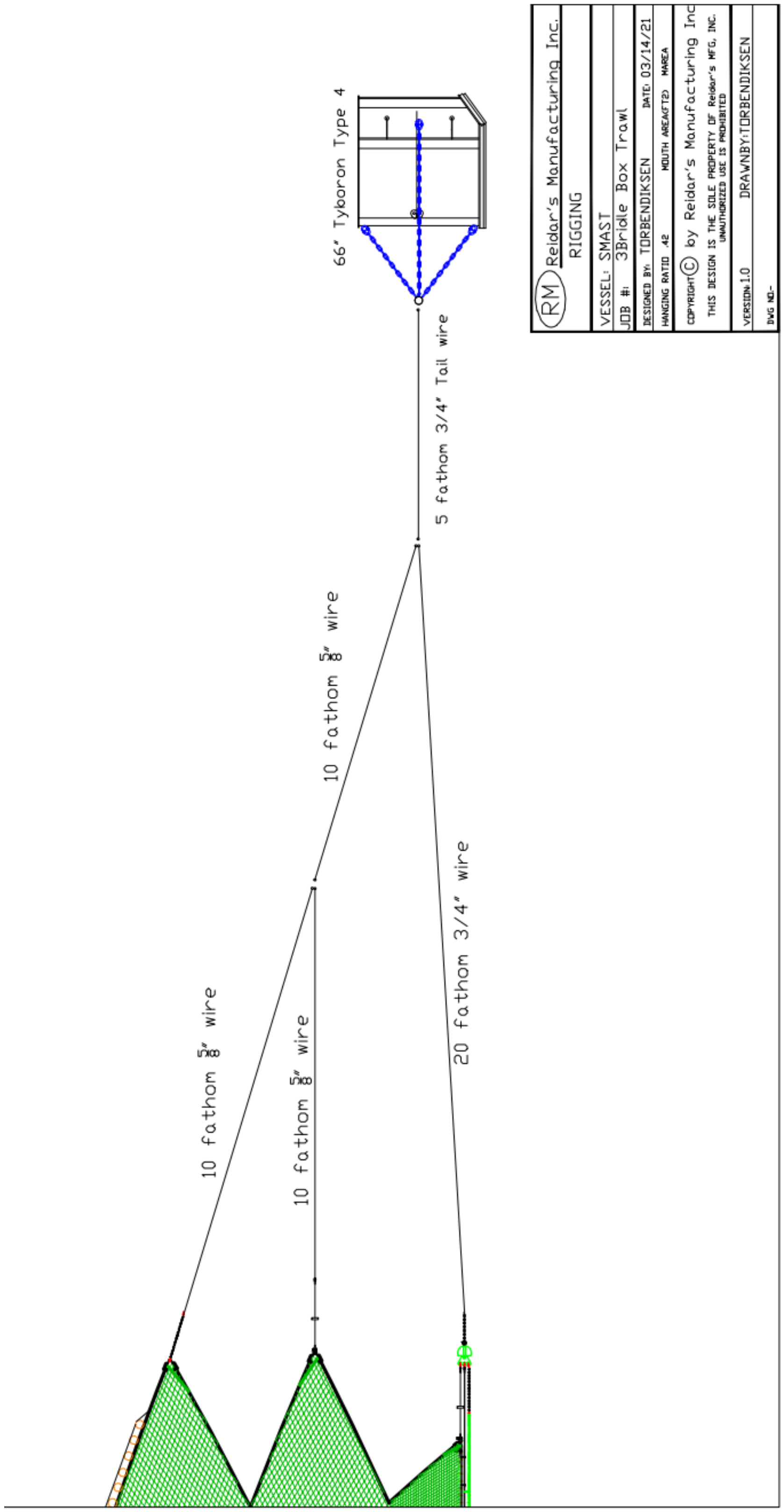


Figure 6: Bridle and door rigging schematic for the survey trawl (Courtesy of Reidar's Manufacturing Inc.).

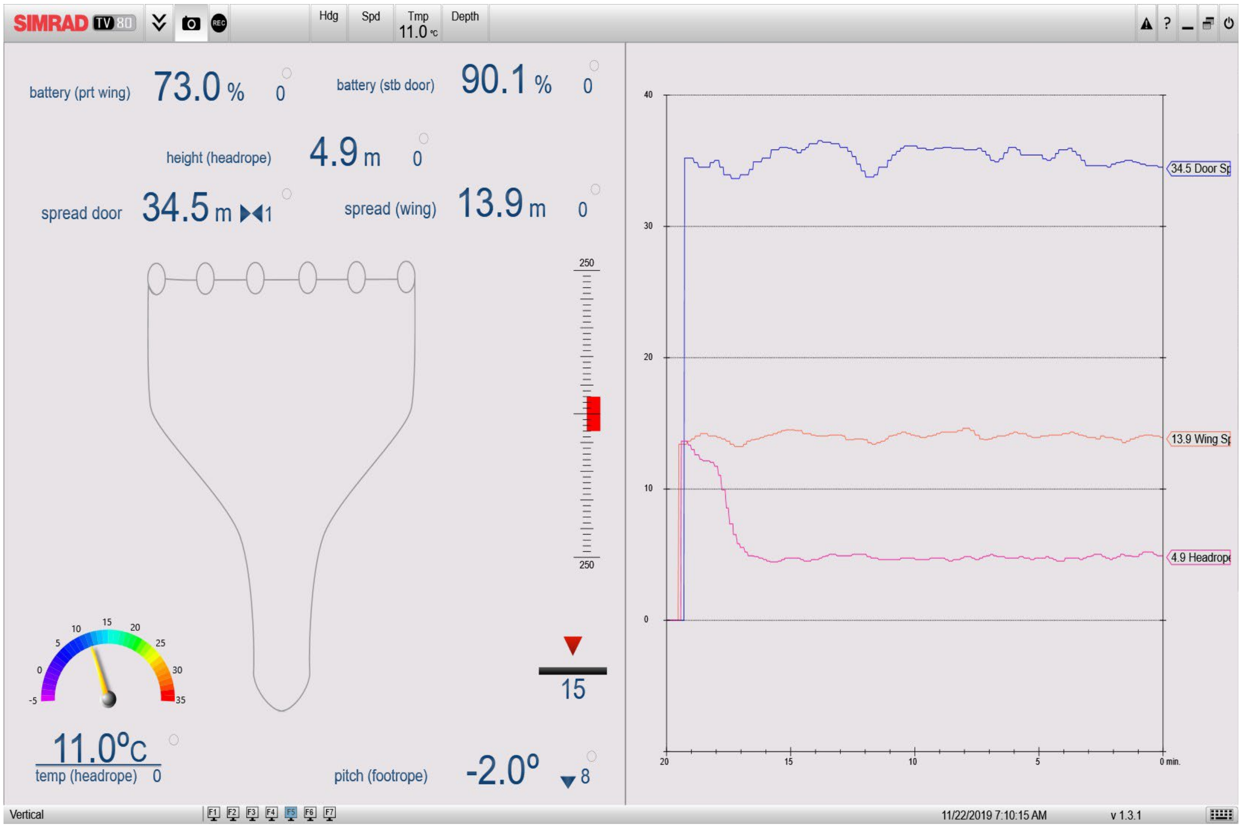


Figure 7: Screenshot of the SIMRAD TV80 software monitoring the trawl parameters.

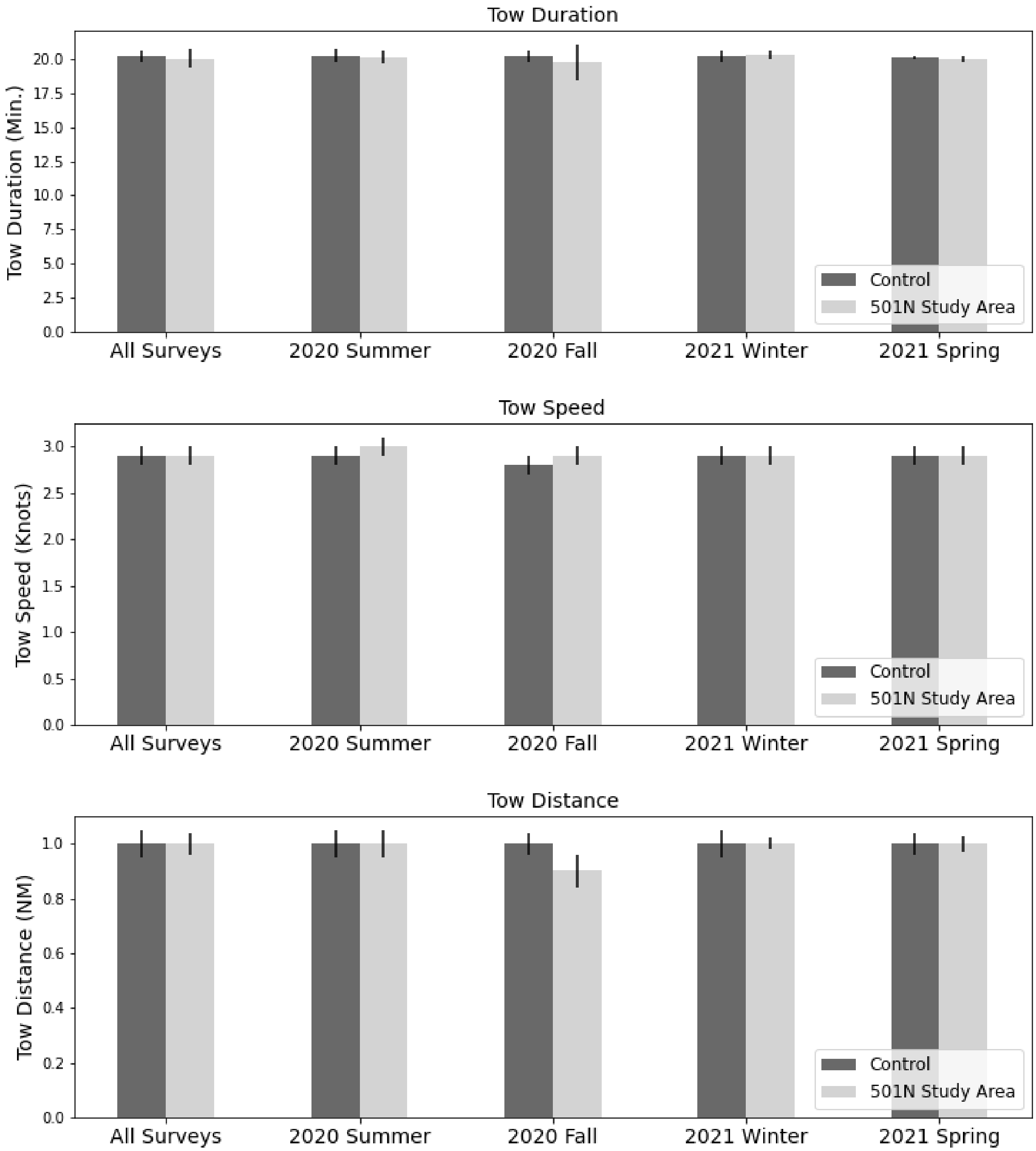


Figure 8: Operational data from the seasonal surveys including tow duration, tow speed, and tow distance.

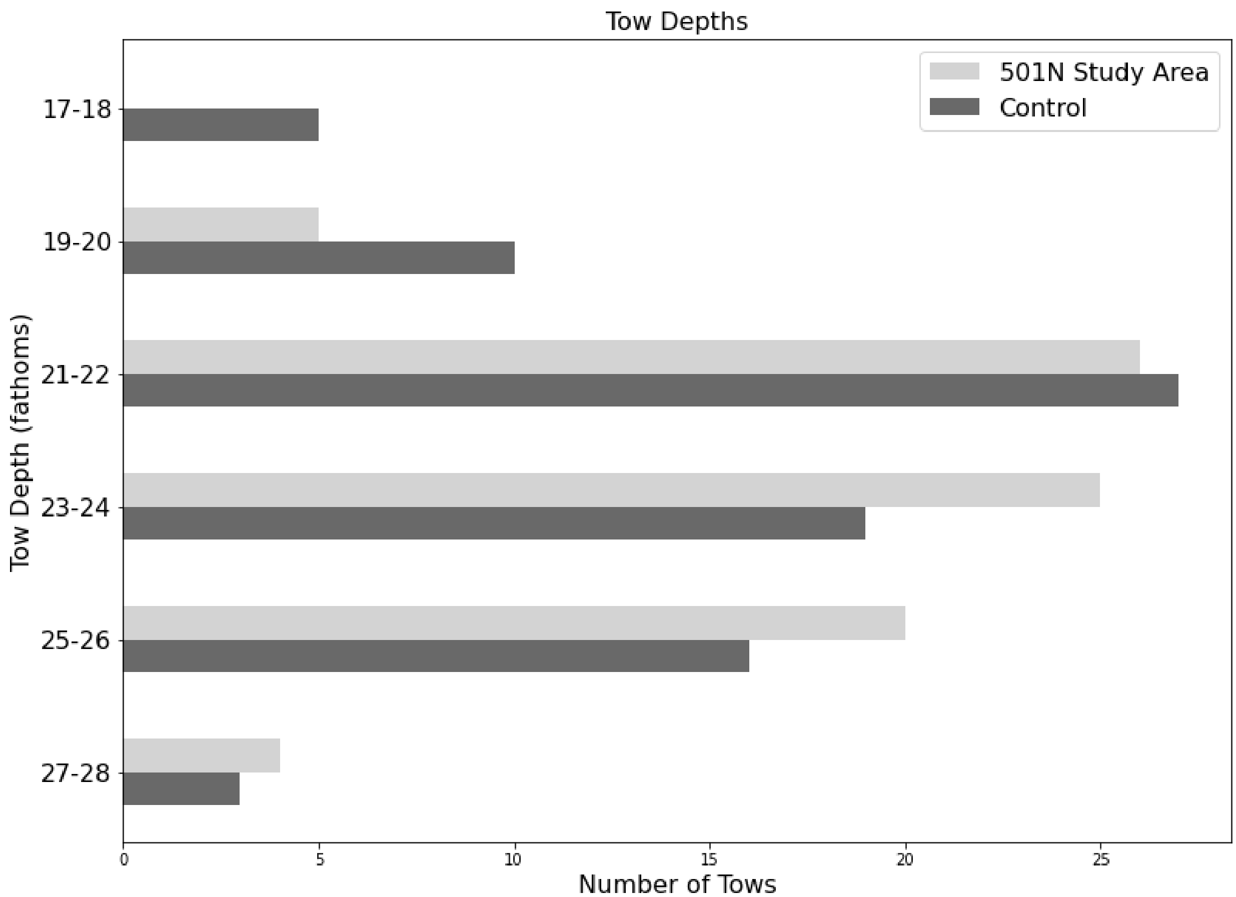


Figure 9: Distribution of tow depths at the start of each tow.

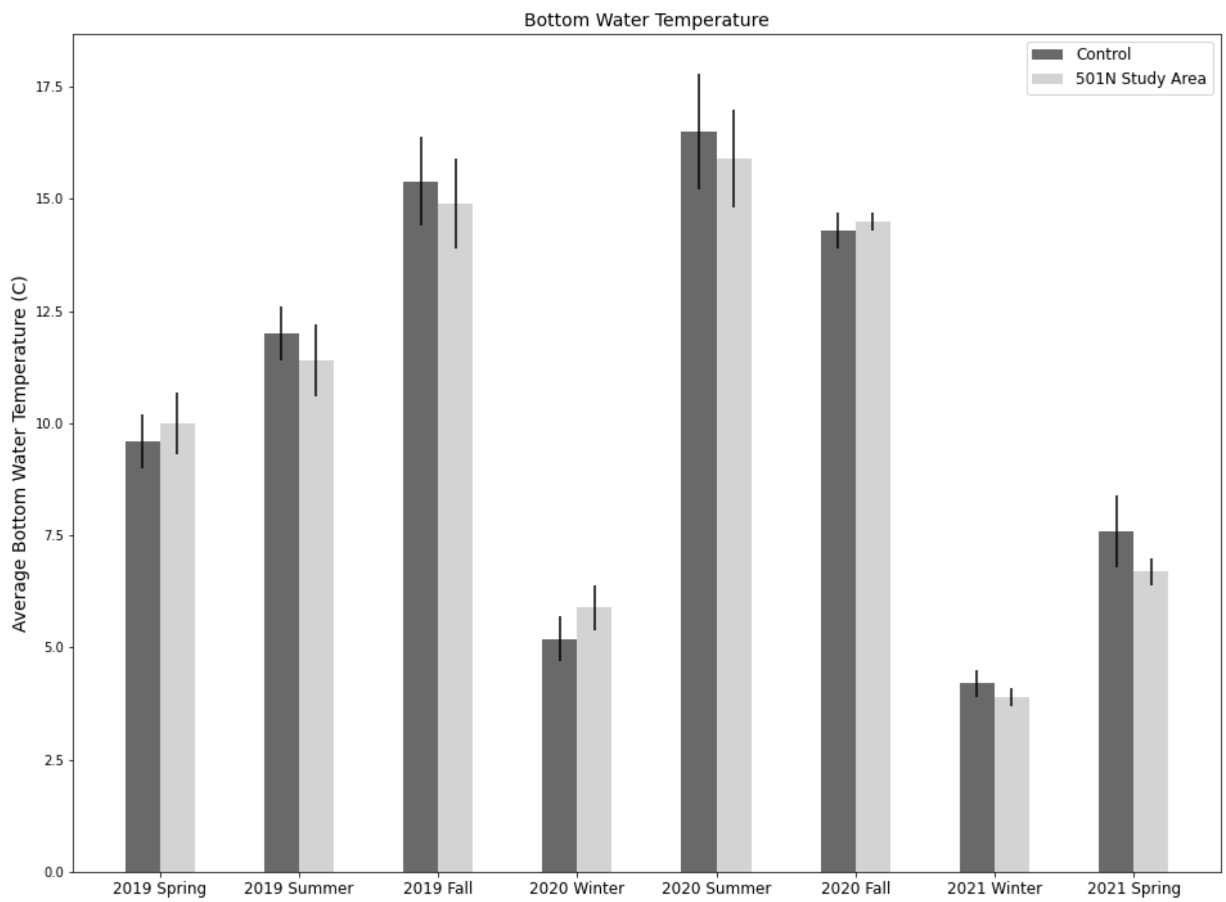


Figure 10: Average seasonal bottom water temperature within the 501N Study Area and Control Area between 2019 – 2021.

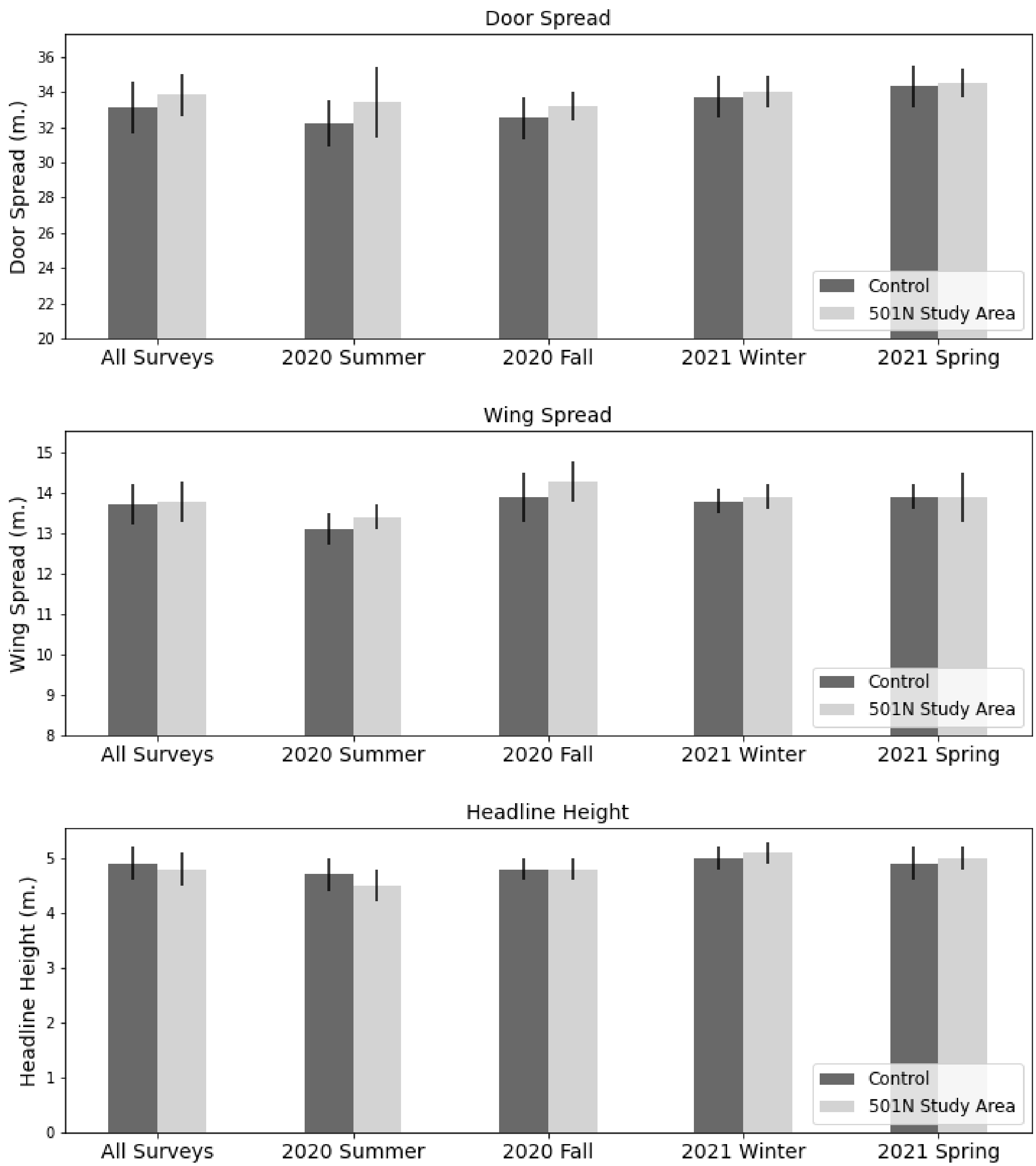


Figure 11: Seasonal averages of the trawl parameters including door spread, wing spread, and headline height.

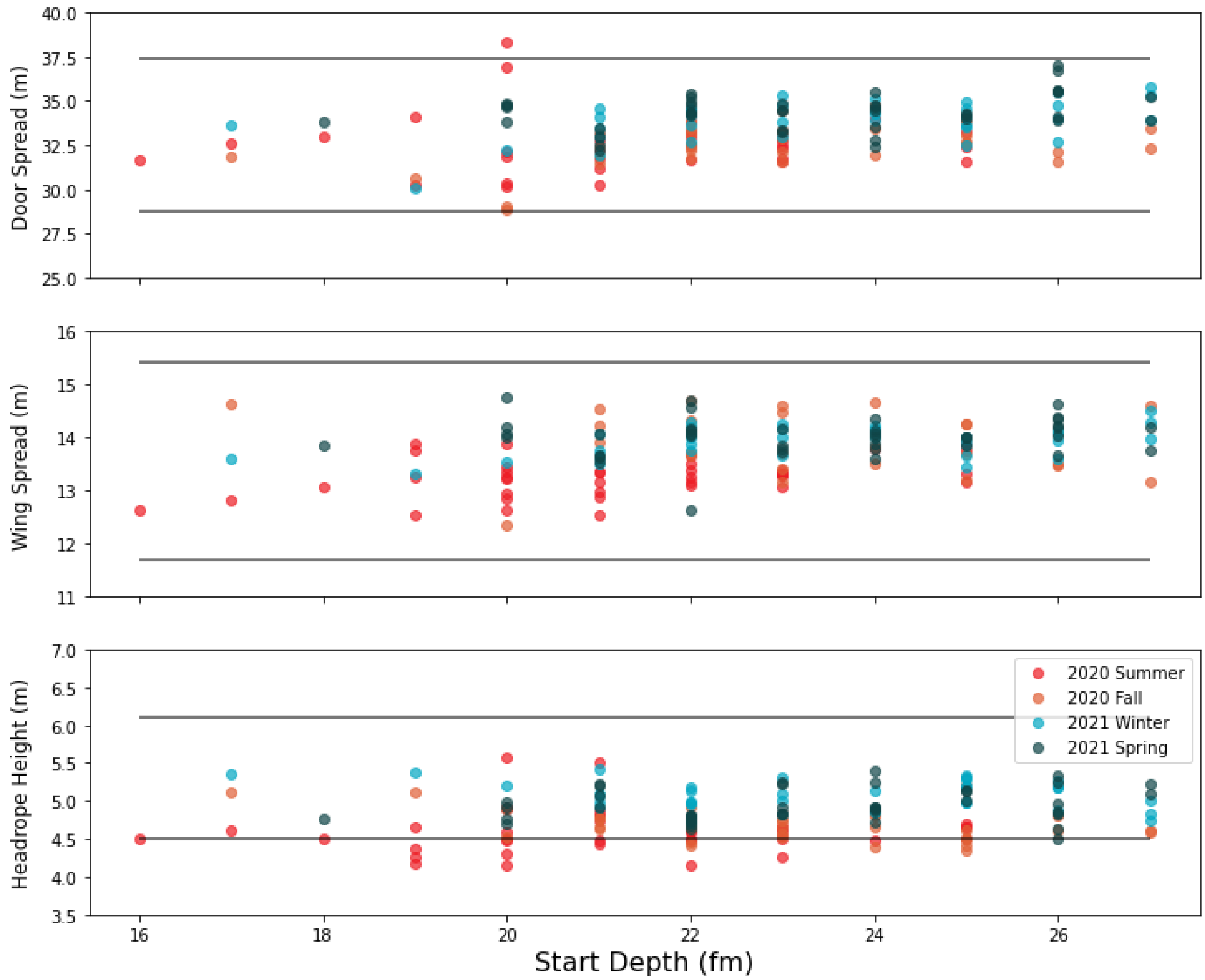


Figure 12: Trawl parameters with respect to the starting depth.

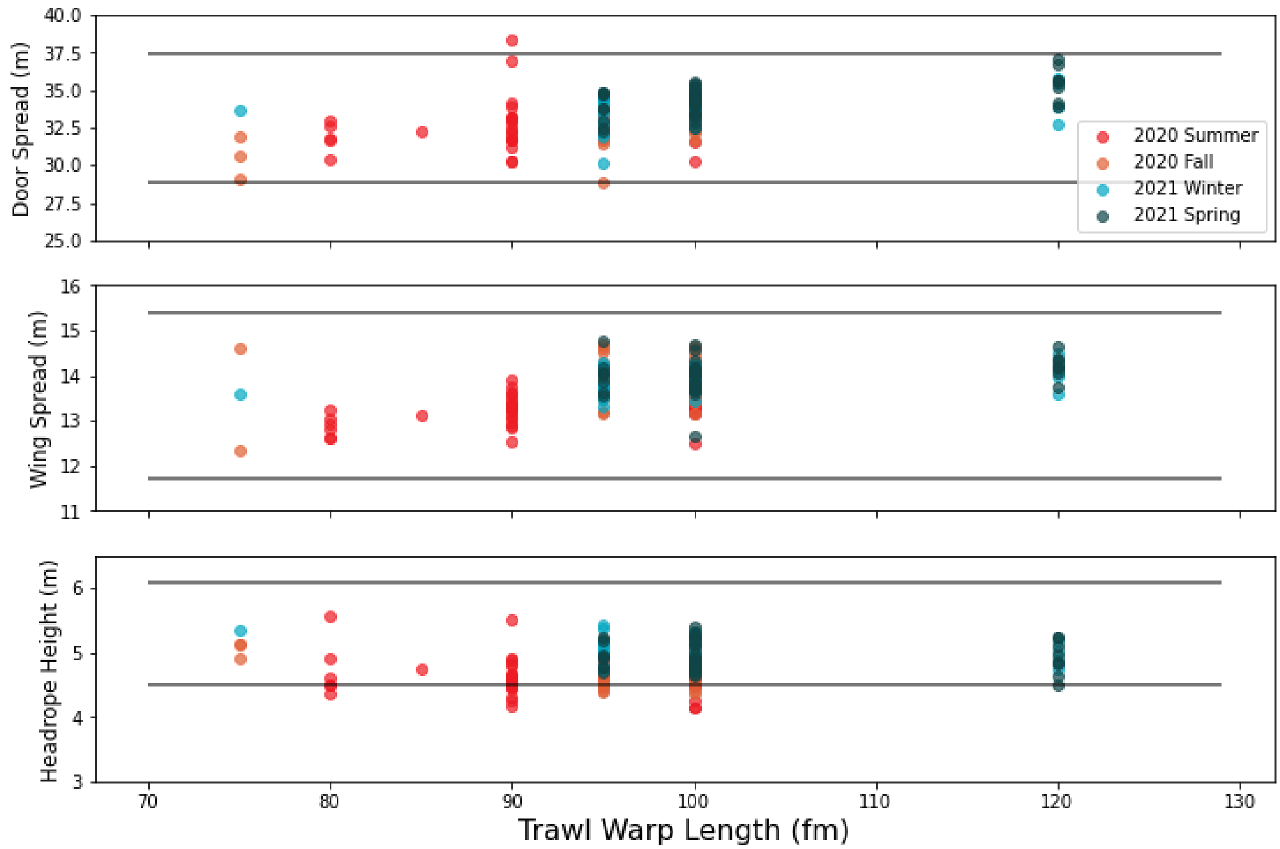


Figure 13: Trawl parameters with respect to the trawl warp.

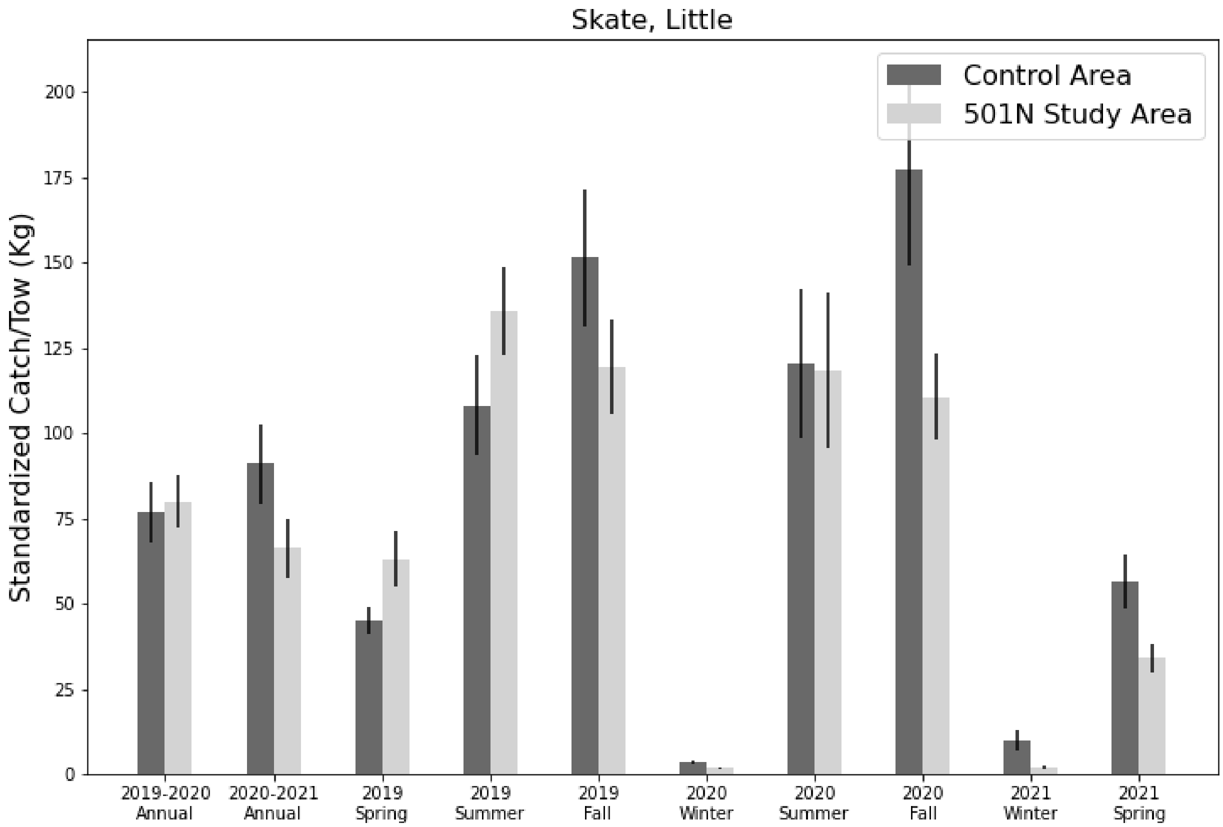


Figure 14: Seasonal catch rates of little skate in the 501N Study Area and Control Area.

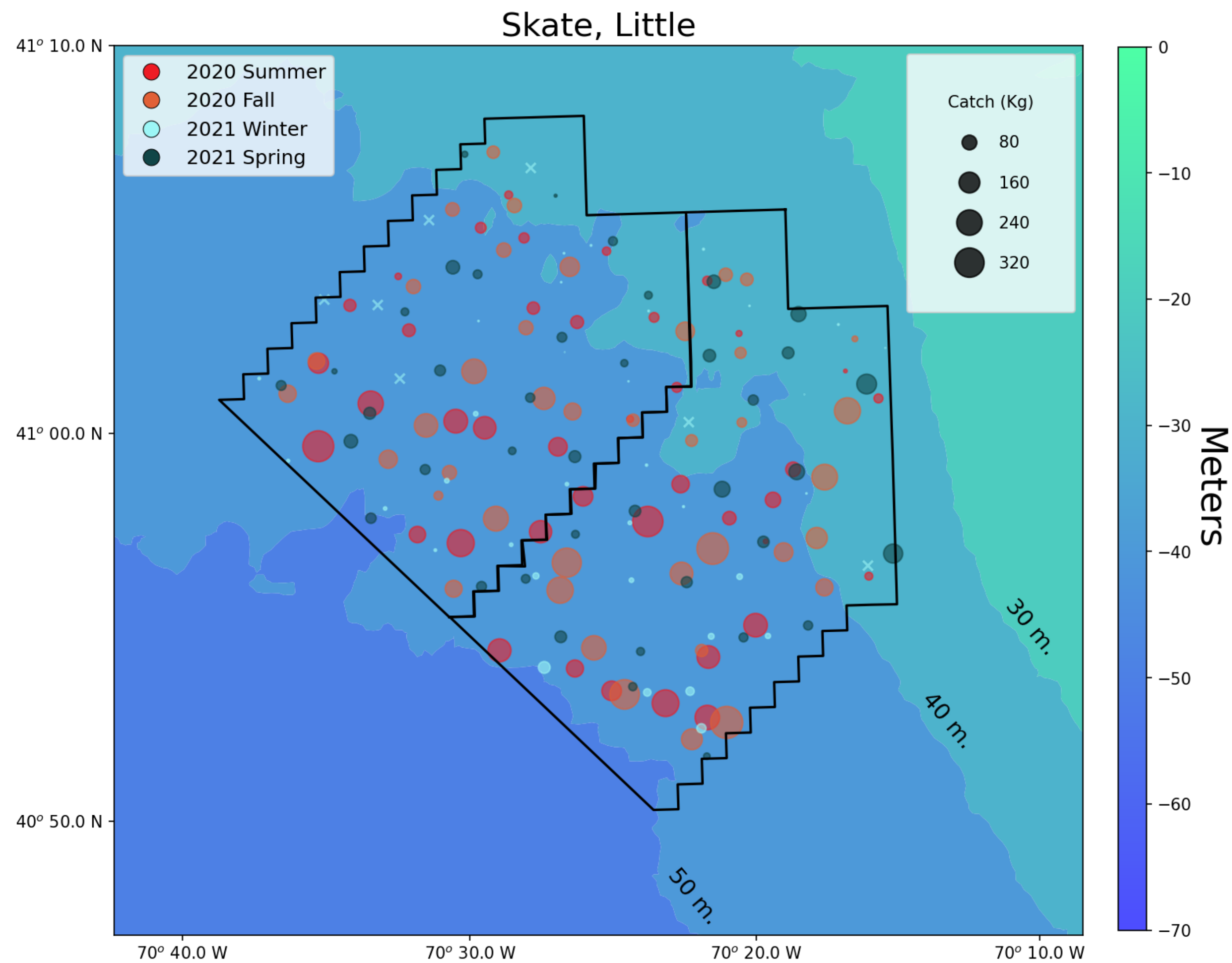


Figure 15: Seasonal distribution of the little skate catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.

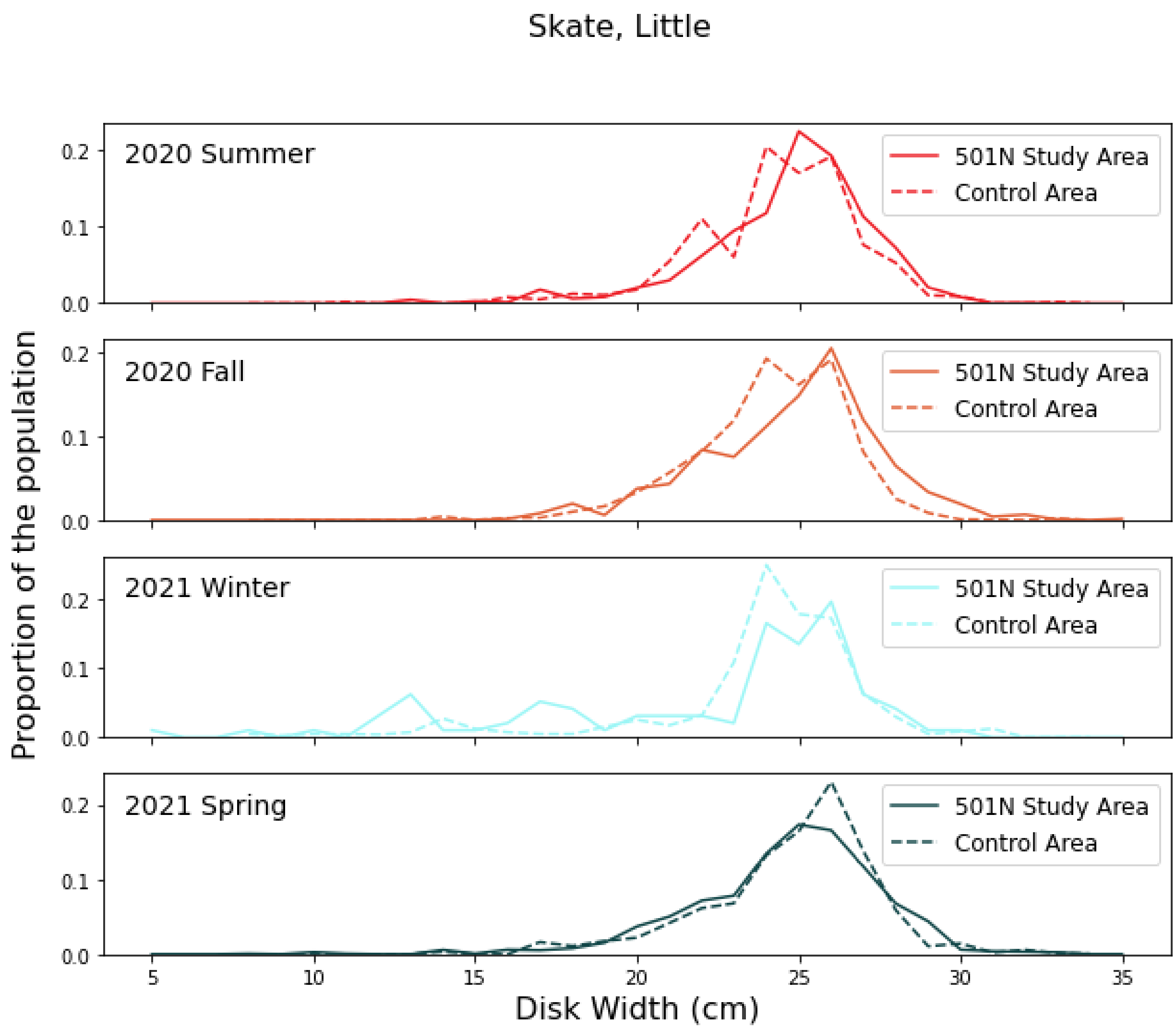


Figure 16: The seasonal length distributions of little skate in the 501N Study Area and Control Area.

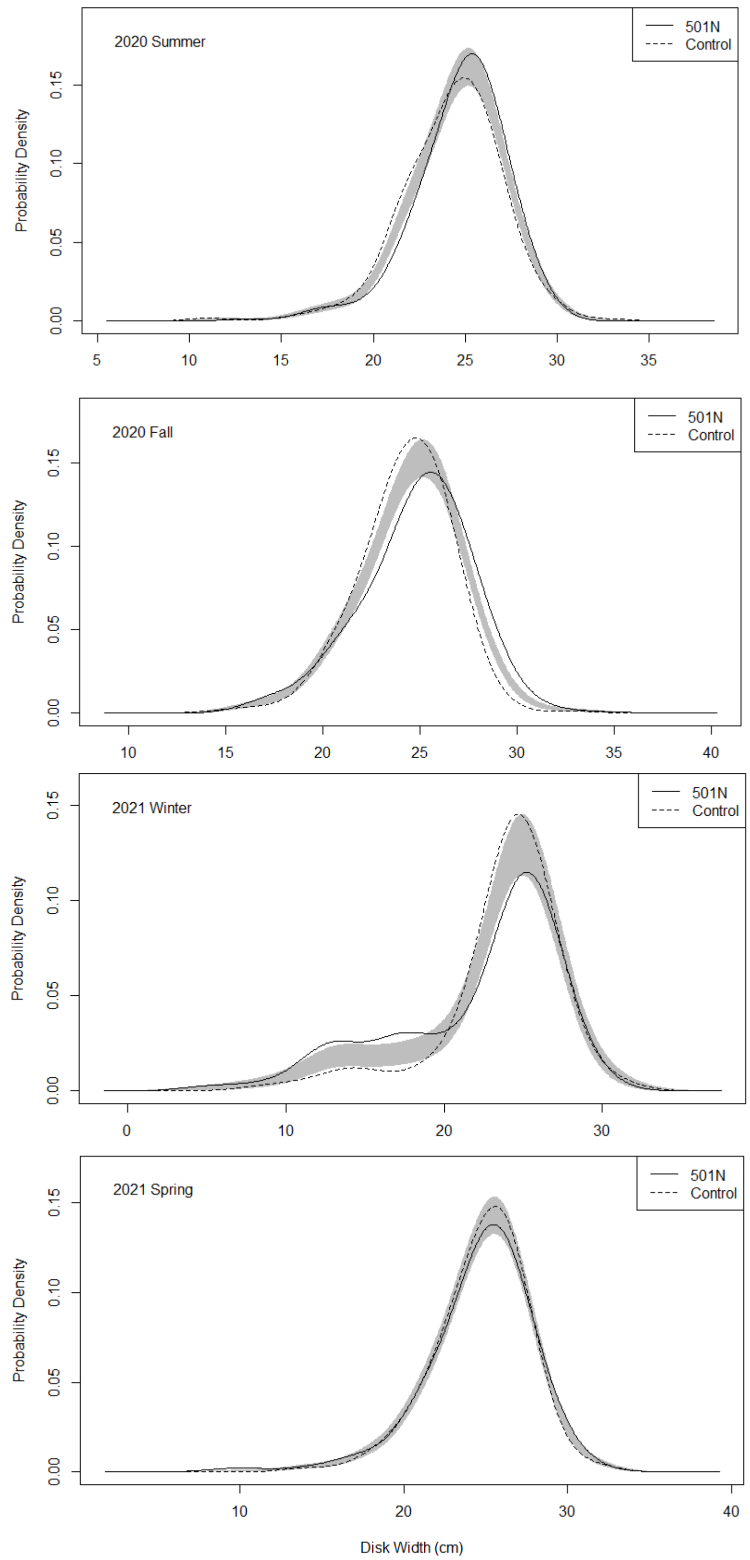


Figure 17: The population structure of little skate in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.

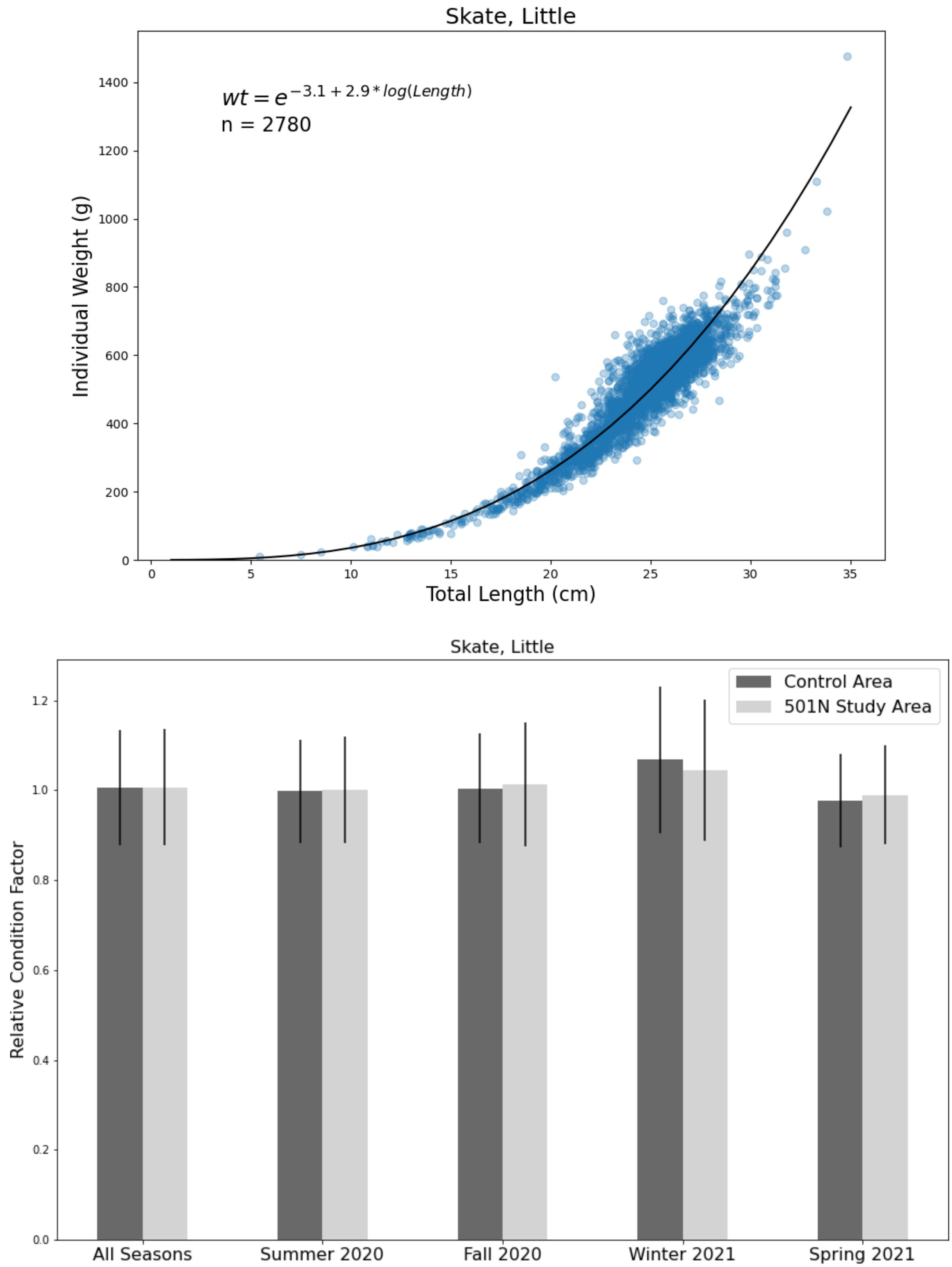


Figure 18: The seasonal condition of little skate (bottom) as derived from the length-weight relationship (top).

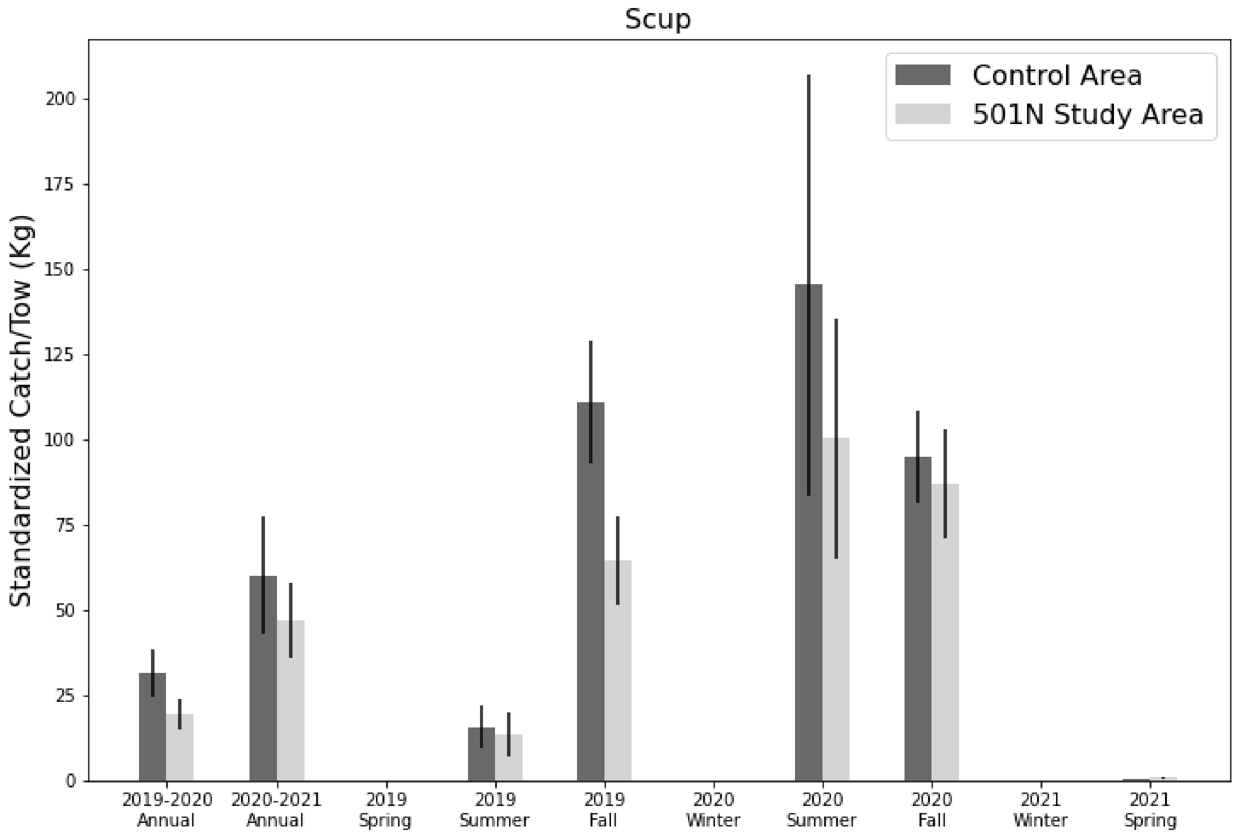


Figure 19: Seasonal catch rates of scup in the 501N Study Area and Control Area.

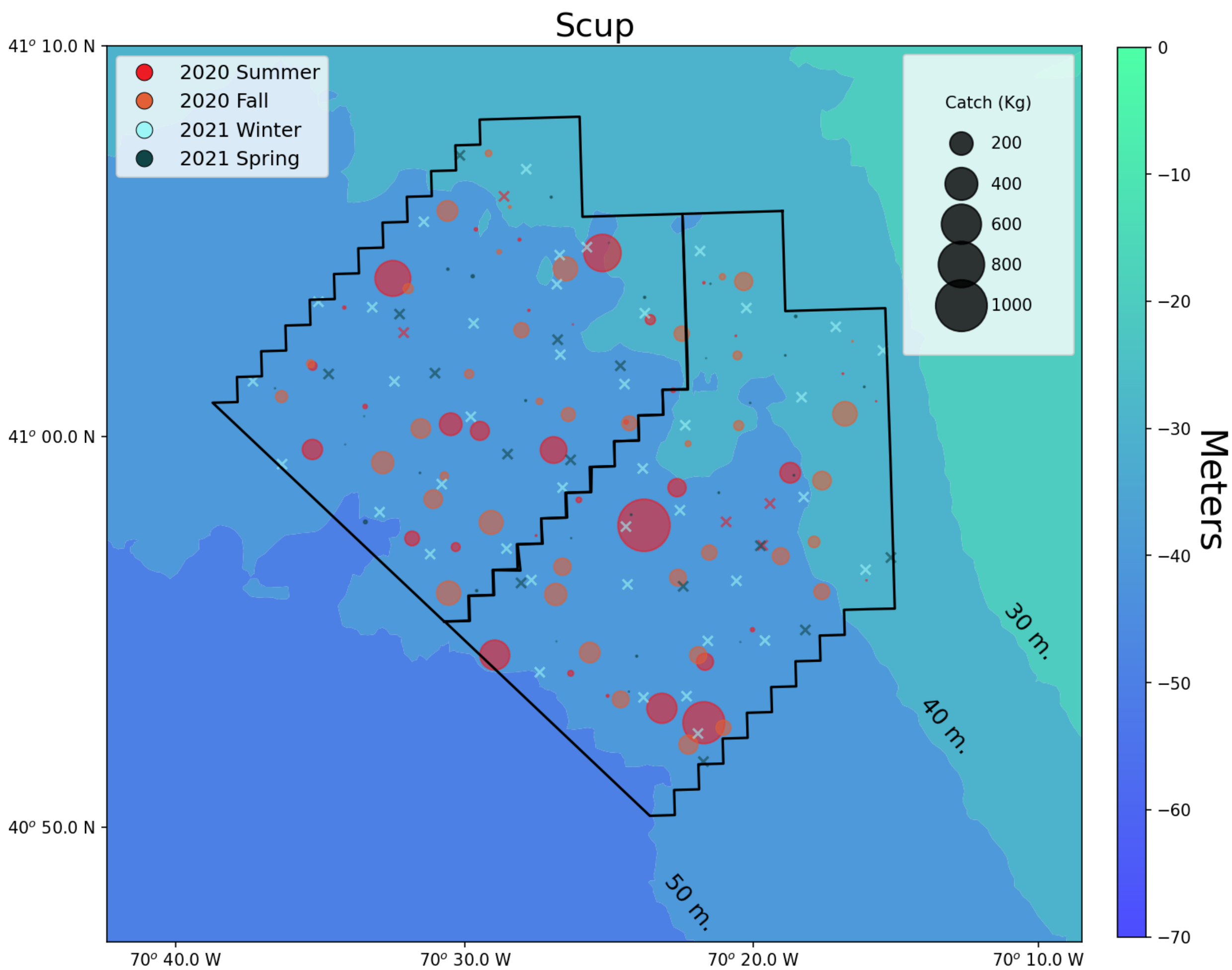


Figure 20: Seasonal distribution of the scup catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

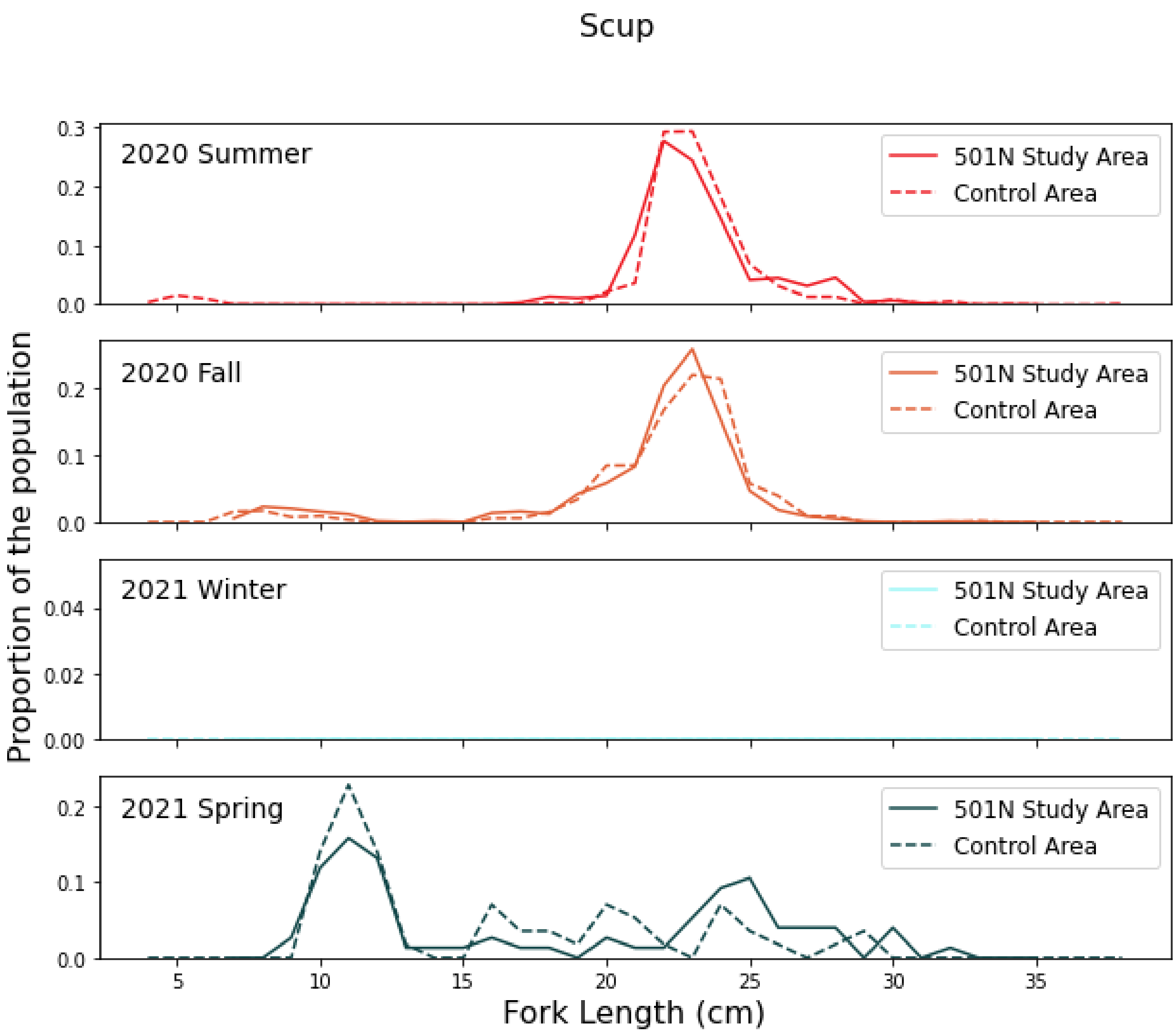


Figure 21: The seasonal length distributions of scup in the 501N Study Area and Control Area.

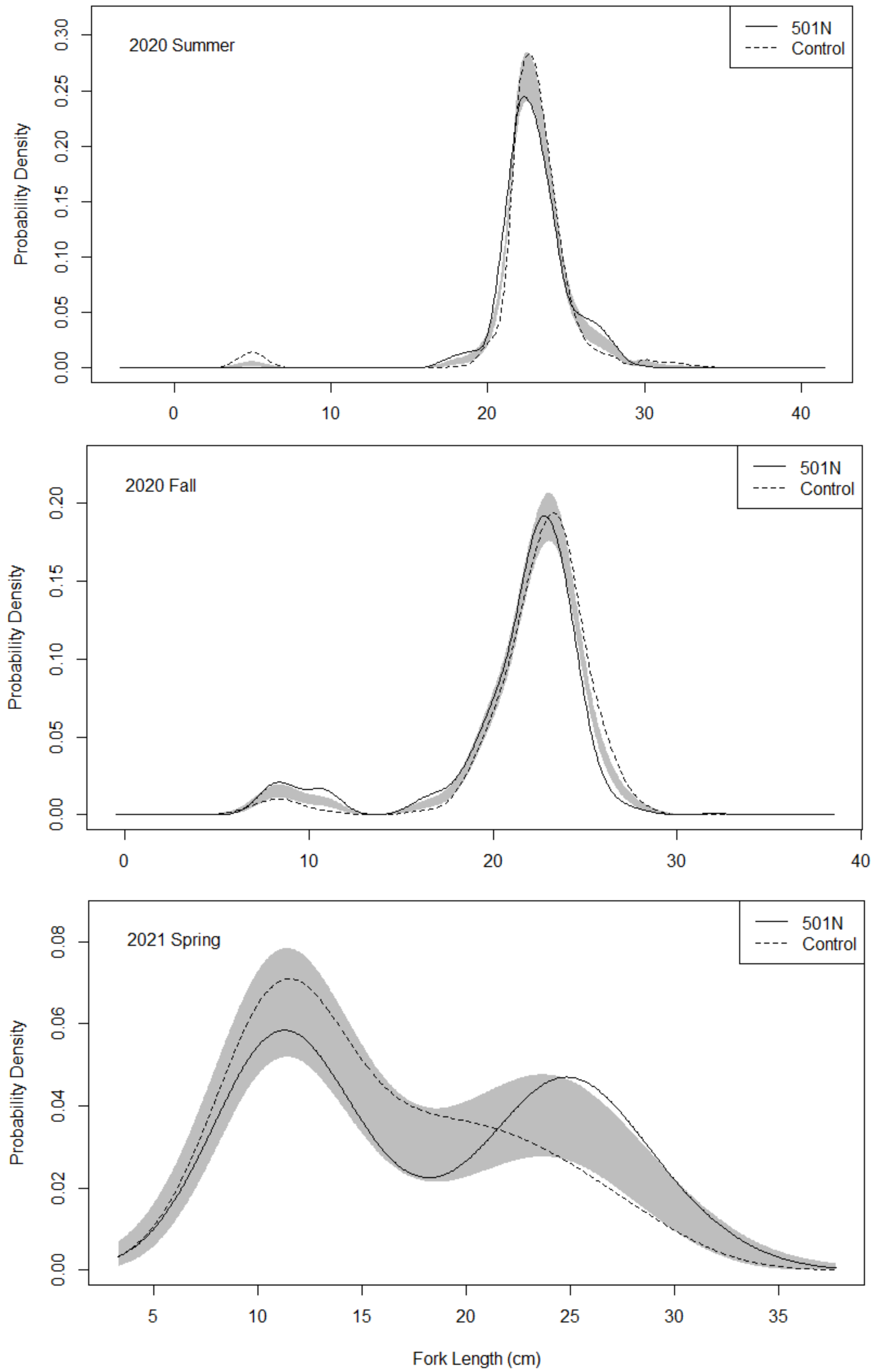
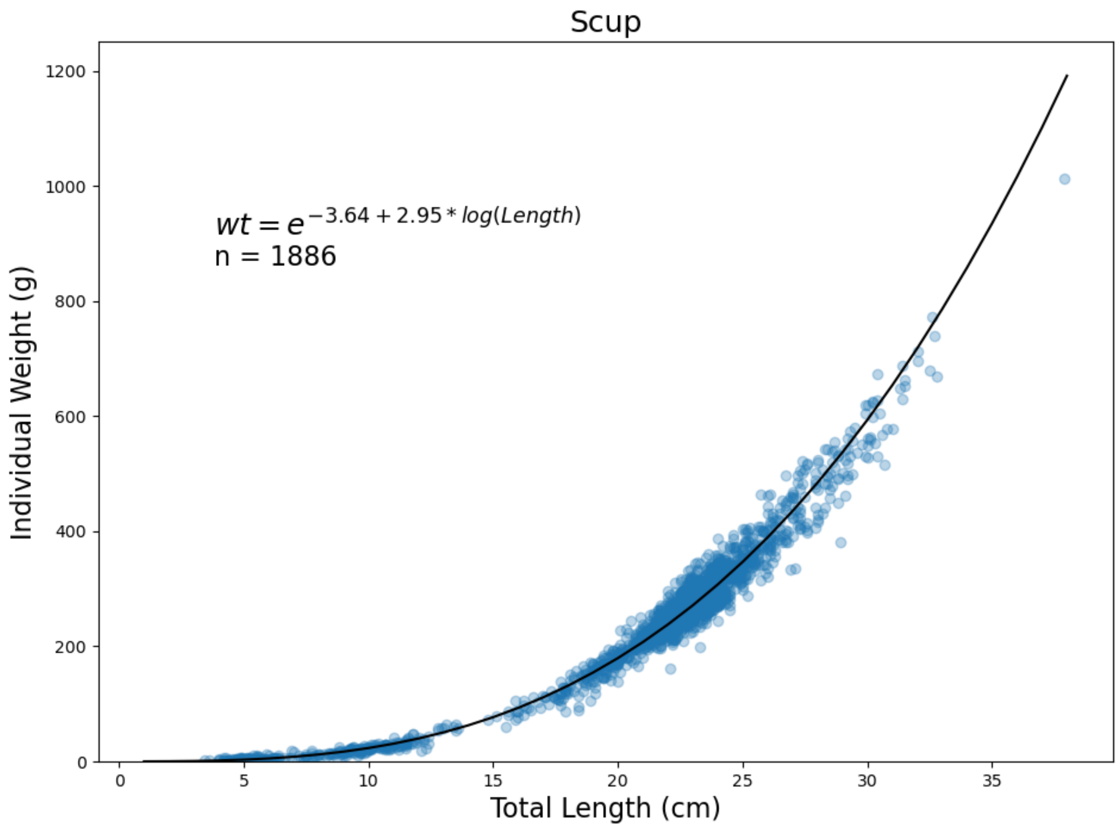


Figure 22: The population structure of scup in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



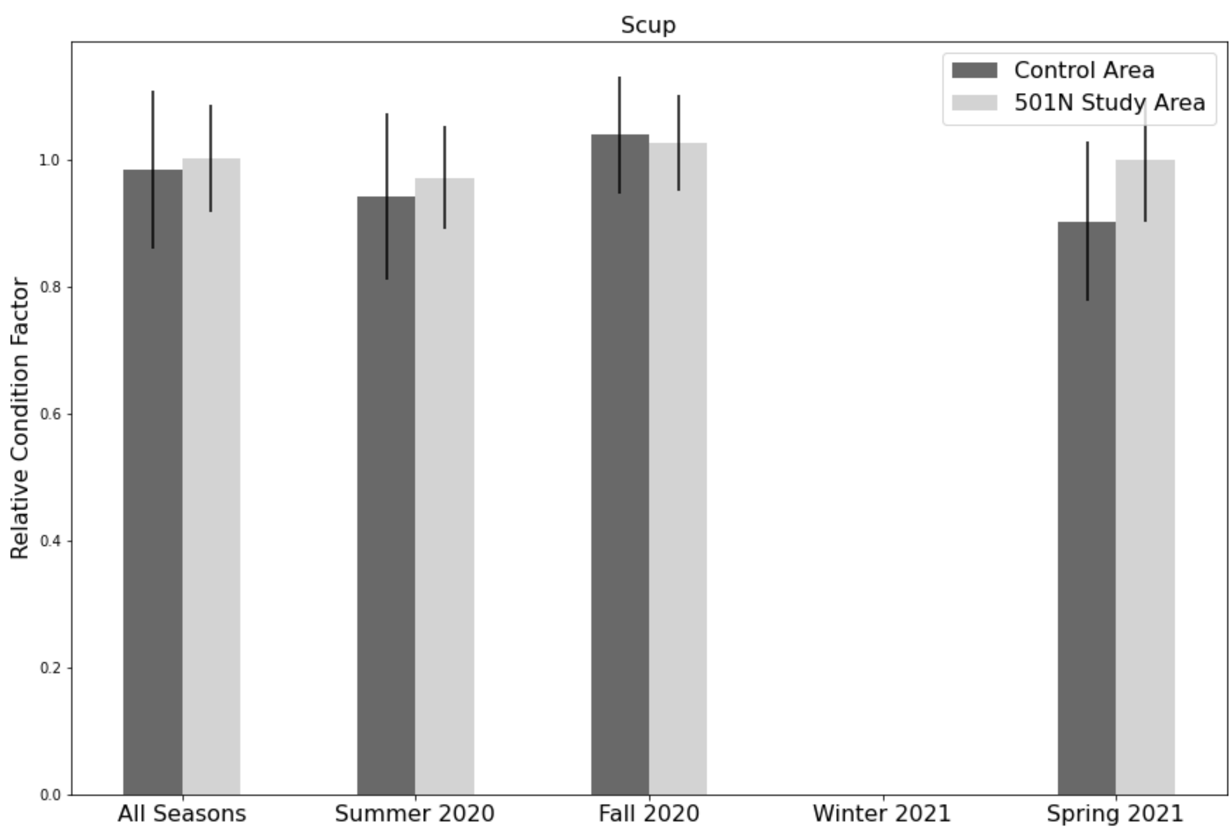


Figure 23: The seasonal condition of scup (bottom) as derived from the length-weight relationship (top).

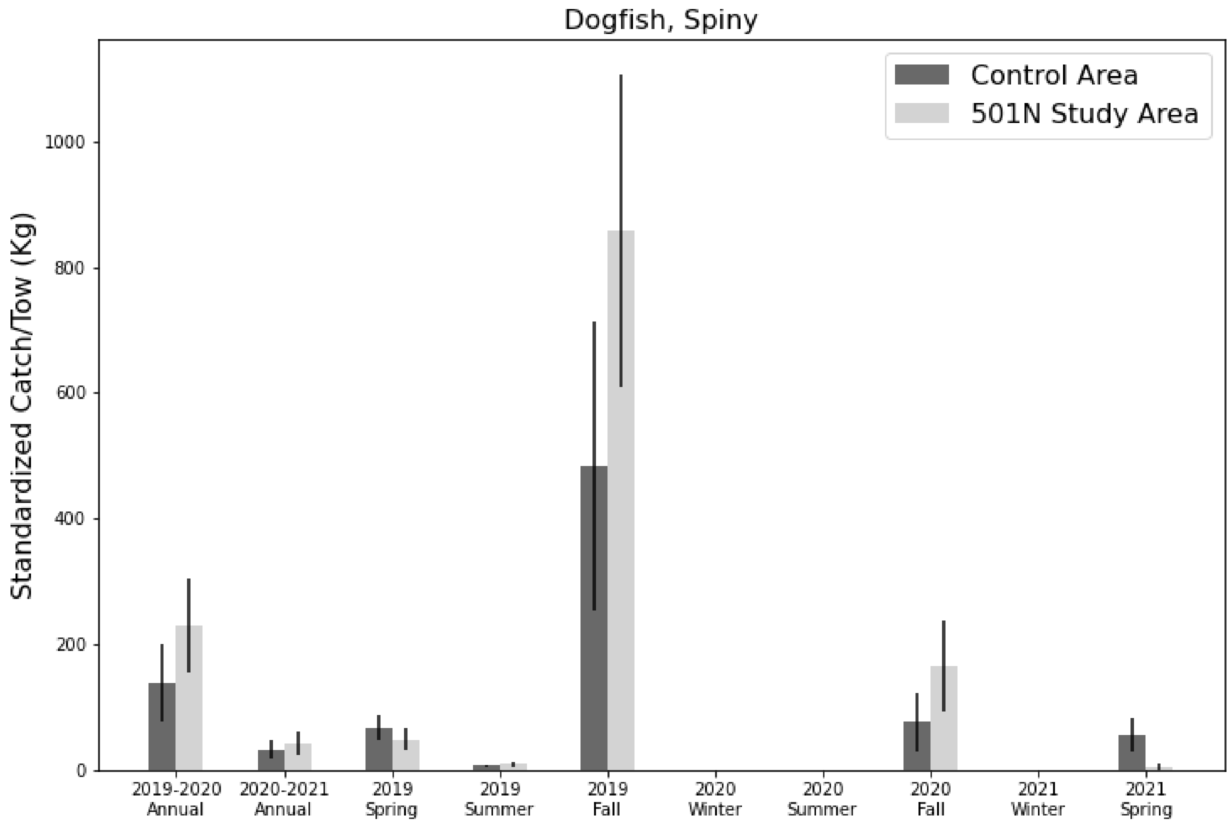


Figure 24: Seasonal catch rates of spiny dogfish in the 501N Study Area and Control Area.

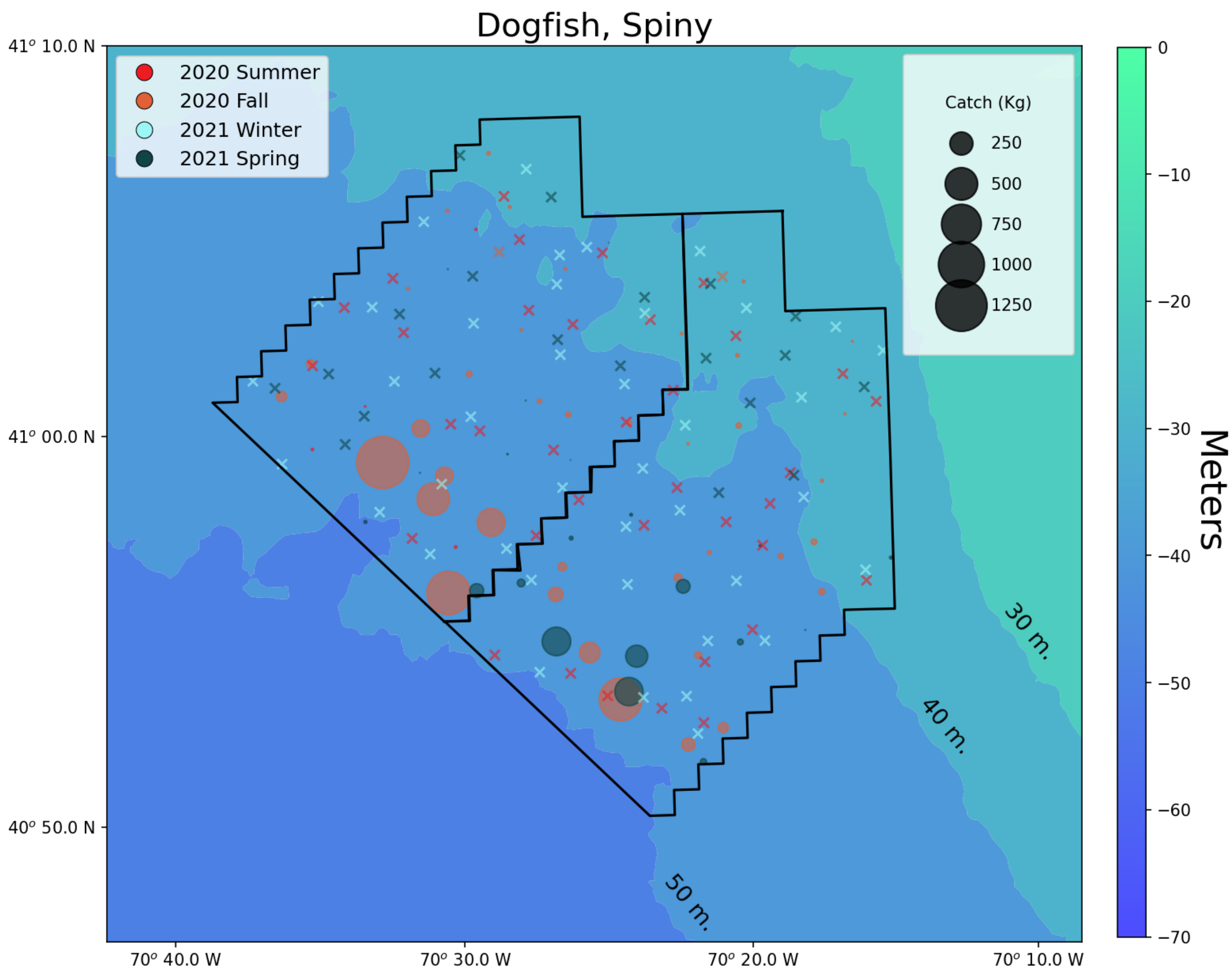


Figure 25: Seasonal distribution of the spiny dogfish catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

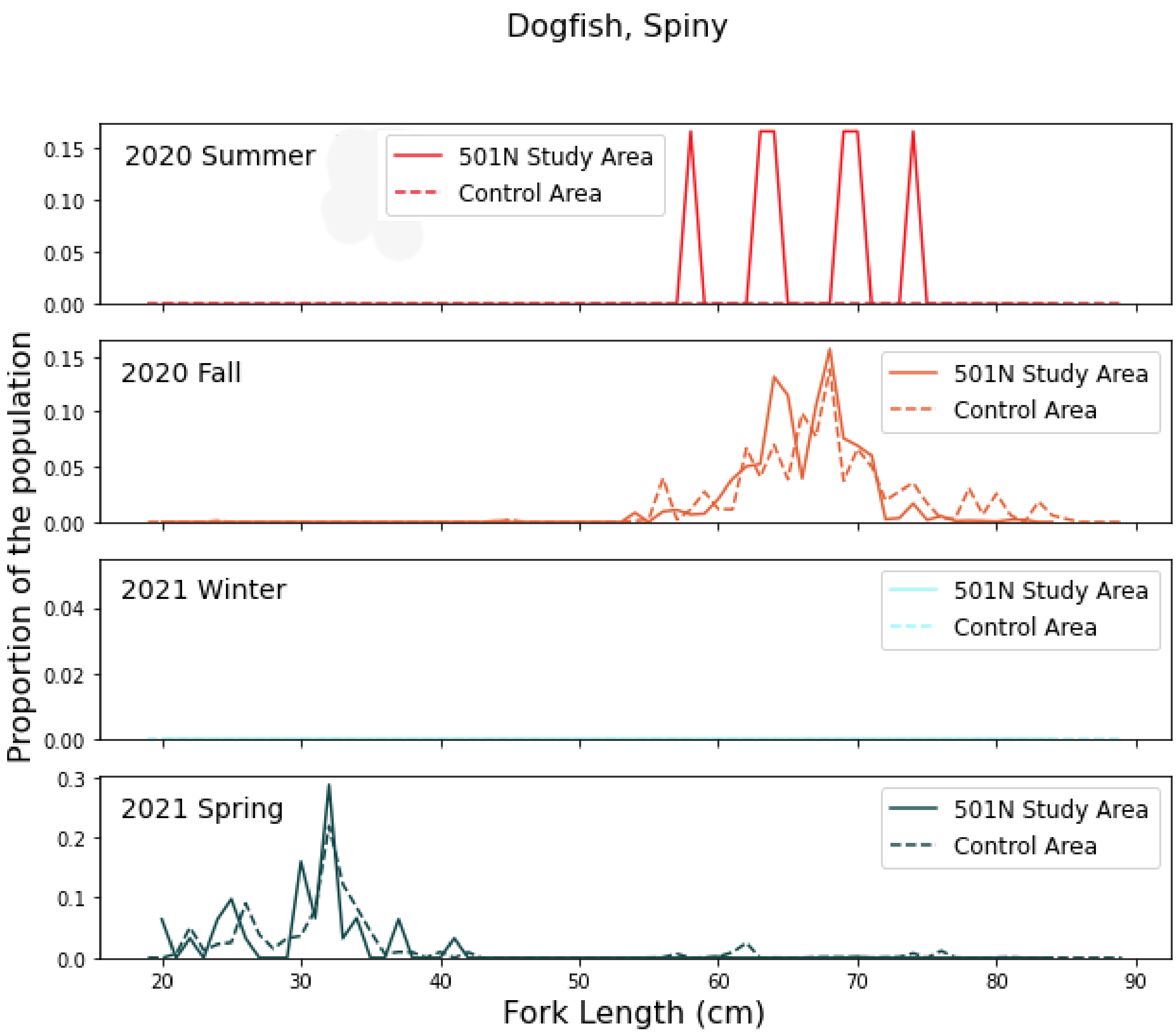


Figure 26: The seasonal length distributions of spiny dogfish in the 501N Study Area and Control Area.

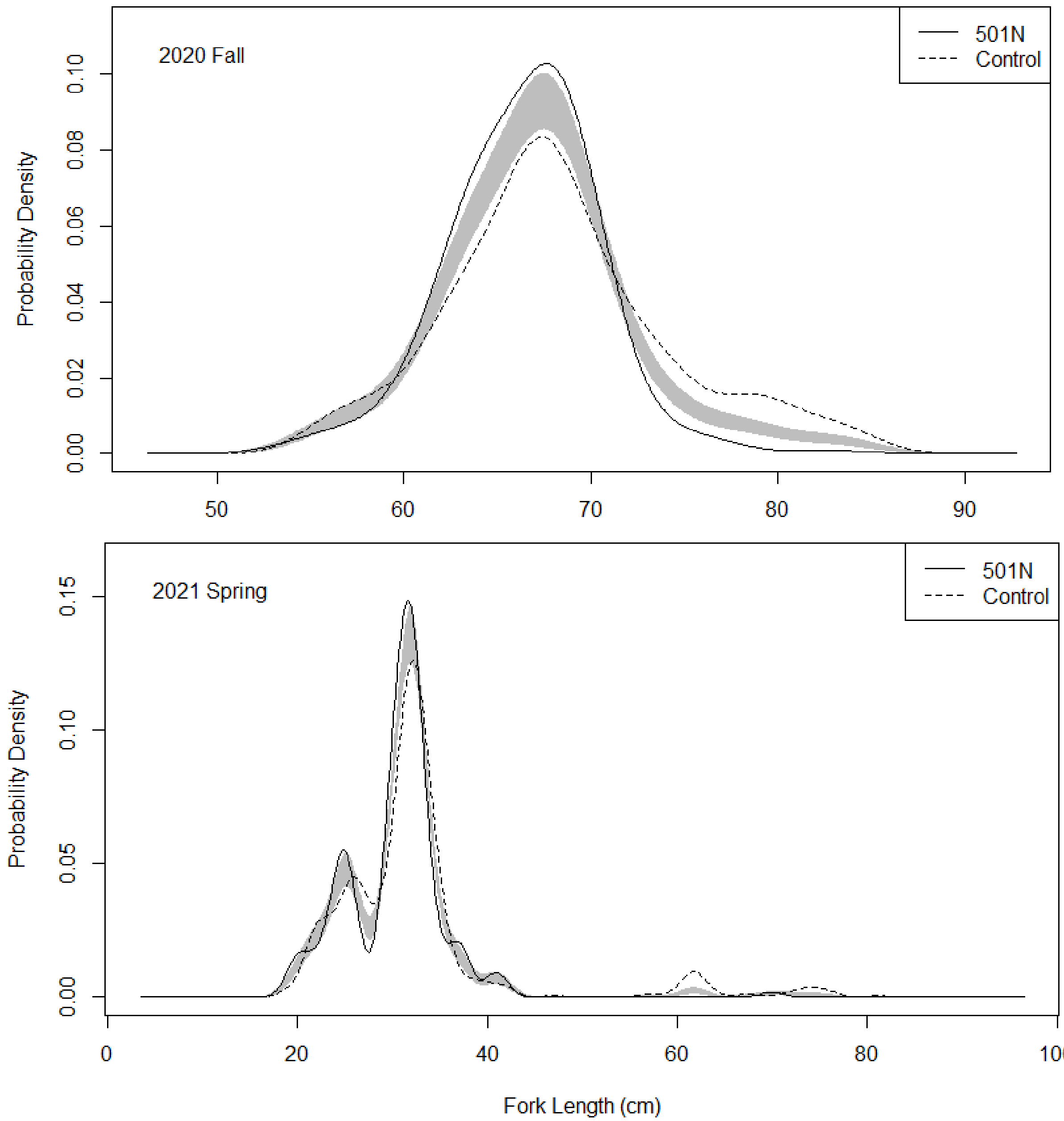
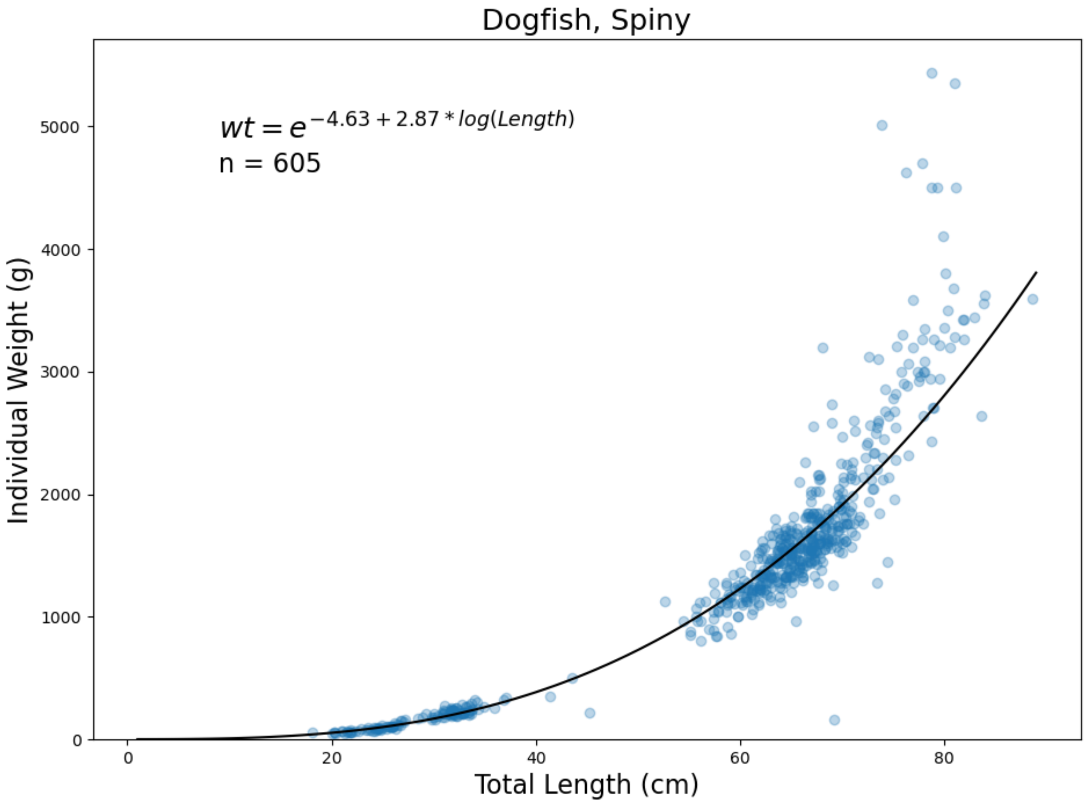


Figure 27: The population structure of spiny dogfish in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



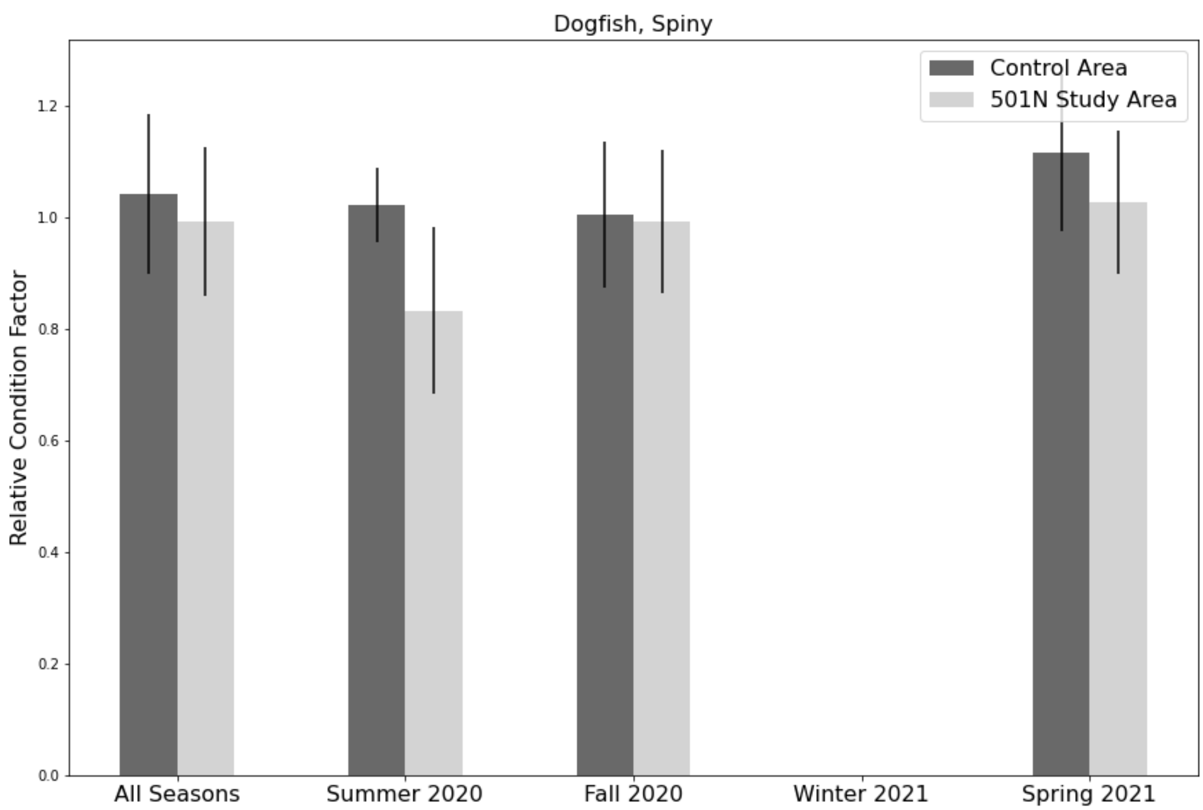


Figure 28: The seasonal condition of spiny dogfish (bottom) as derived from the length-weight relationship (top).

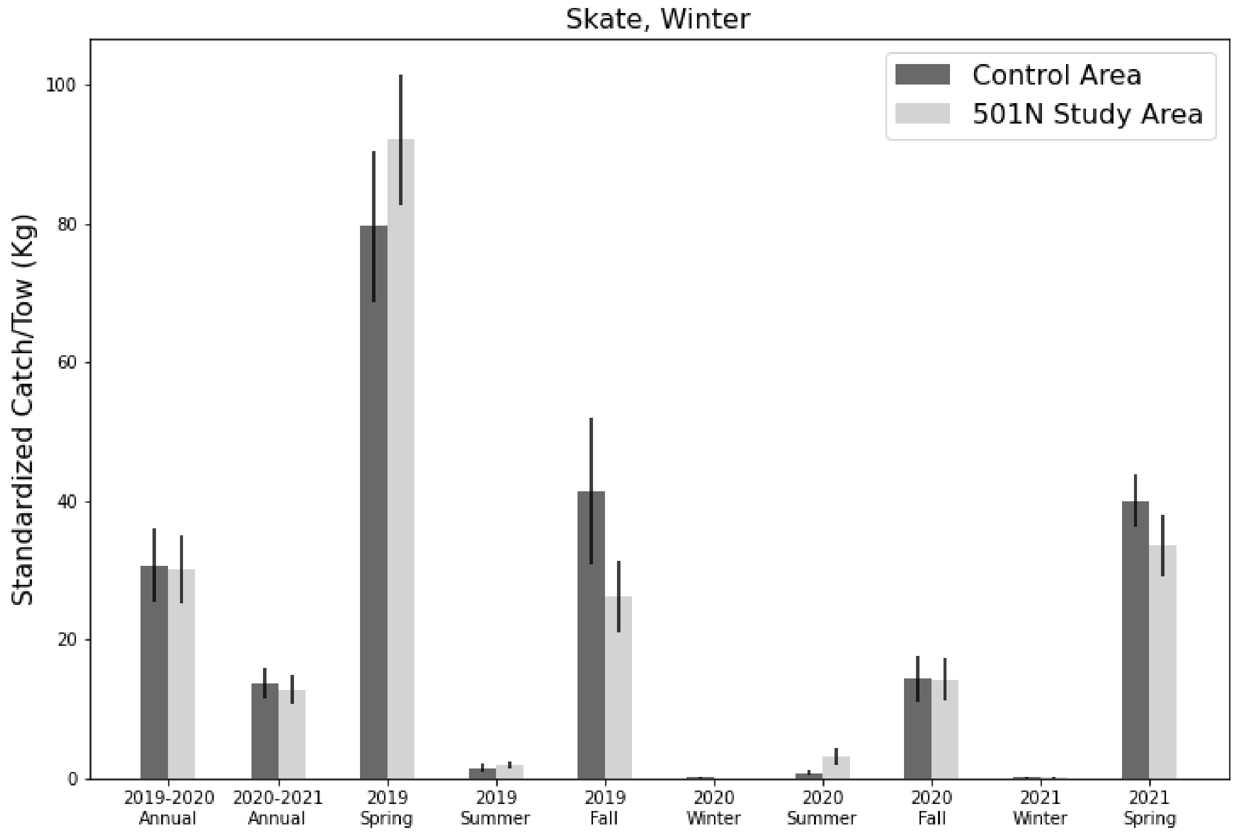


Figure 29: Seasonal catch rates of winter skate in the 501N Study Area and Control Area.

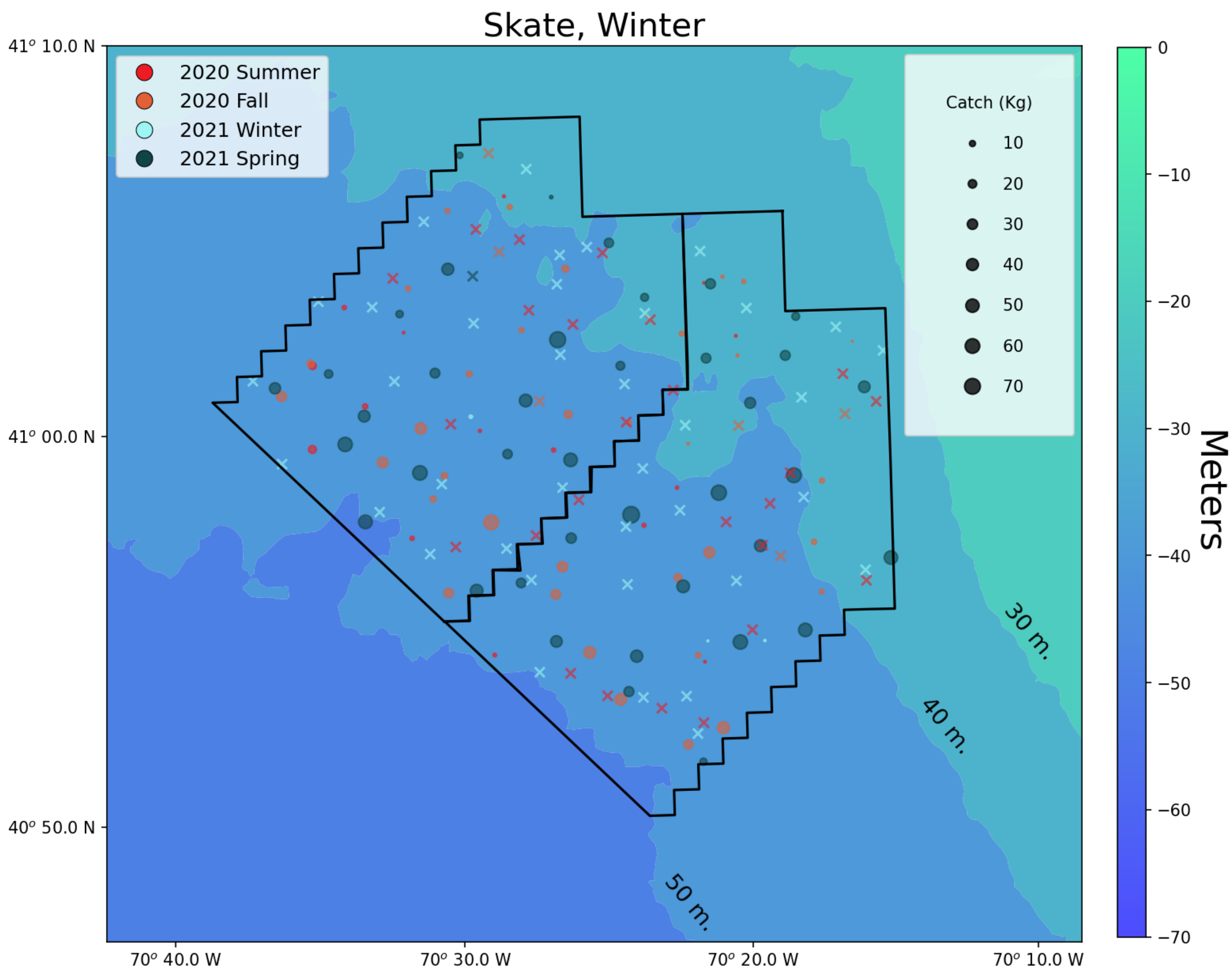


Figure 30: Seasonal distribution of the winter skate catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

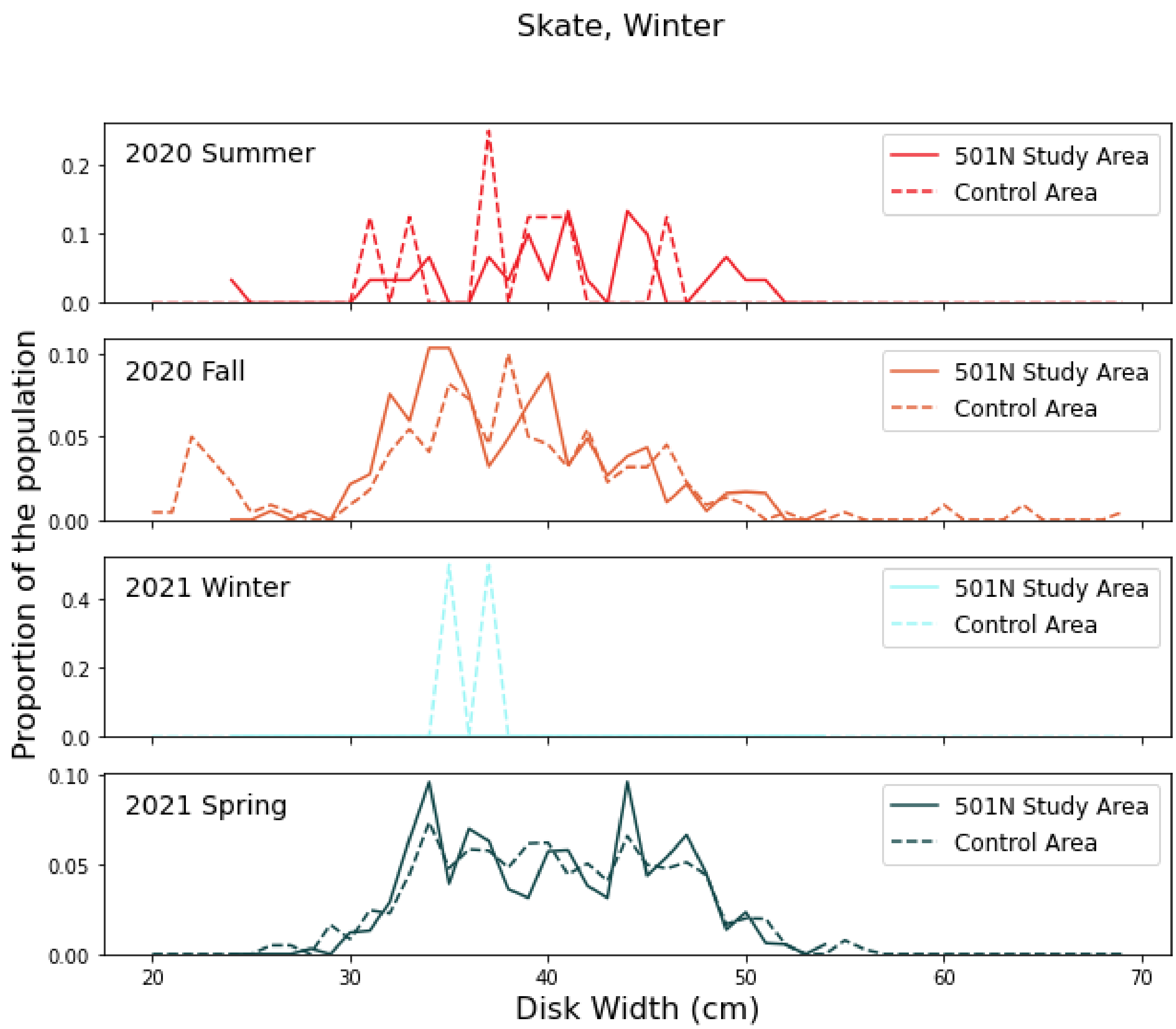


Figure 31: The seasonal length distributions of winter skate in the 501N Study Area and Control Area.

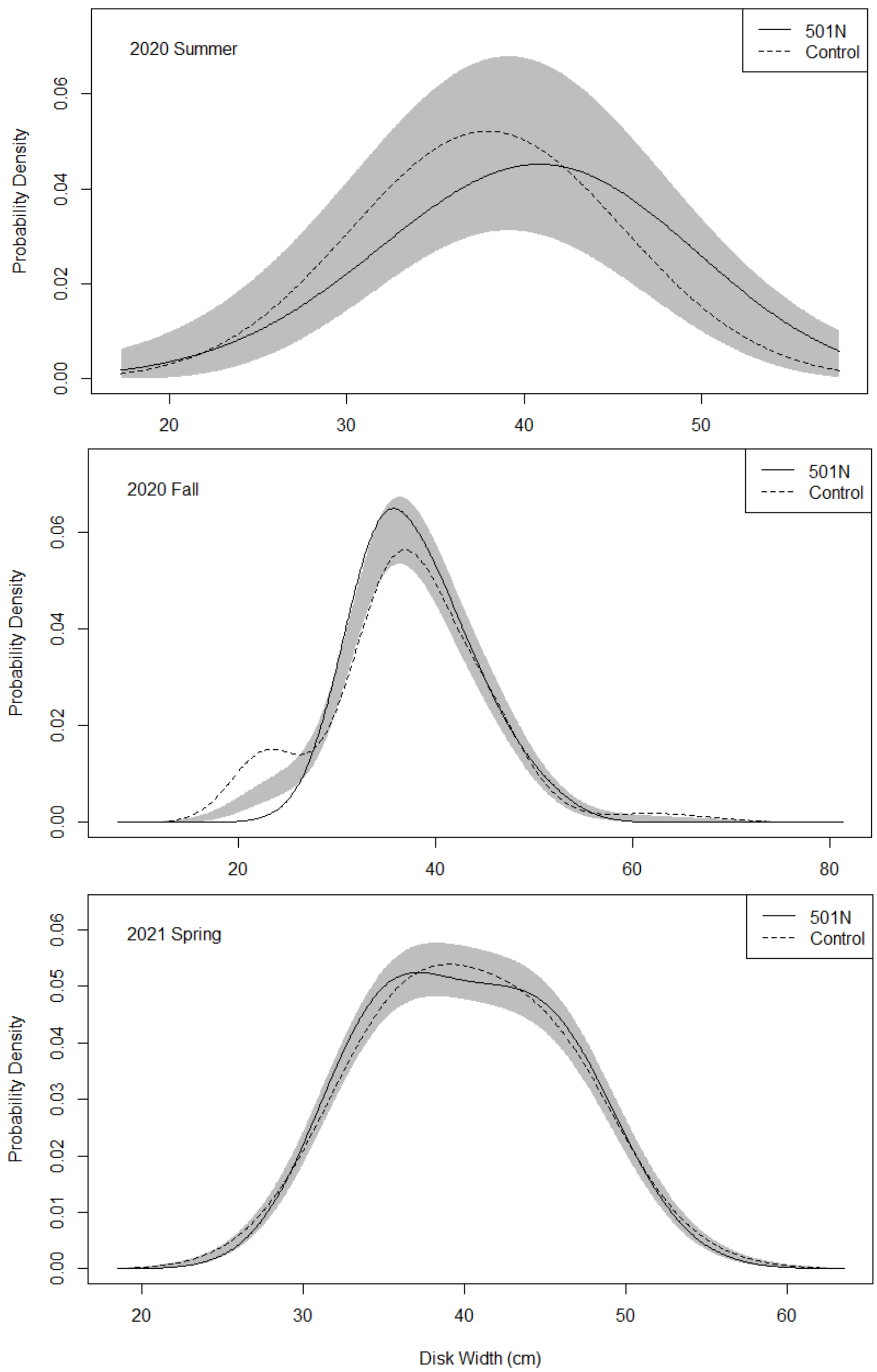
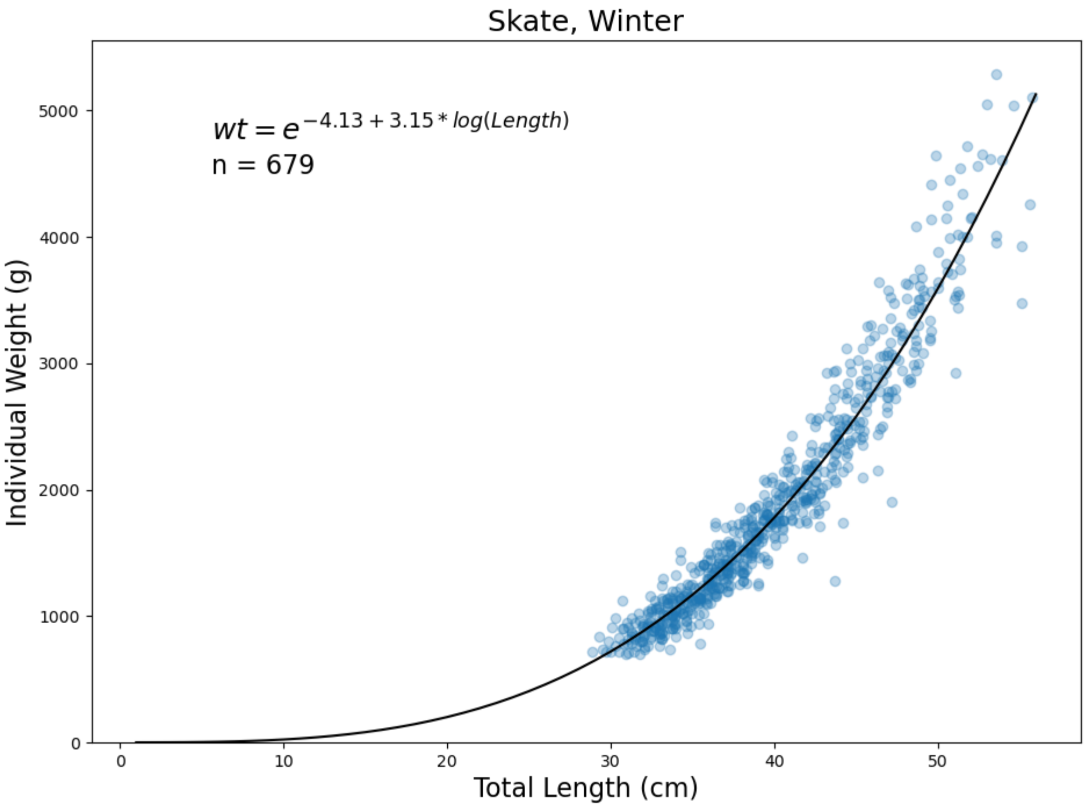


Figure 32: The population structure of winter skate in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



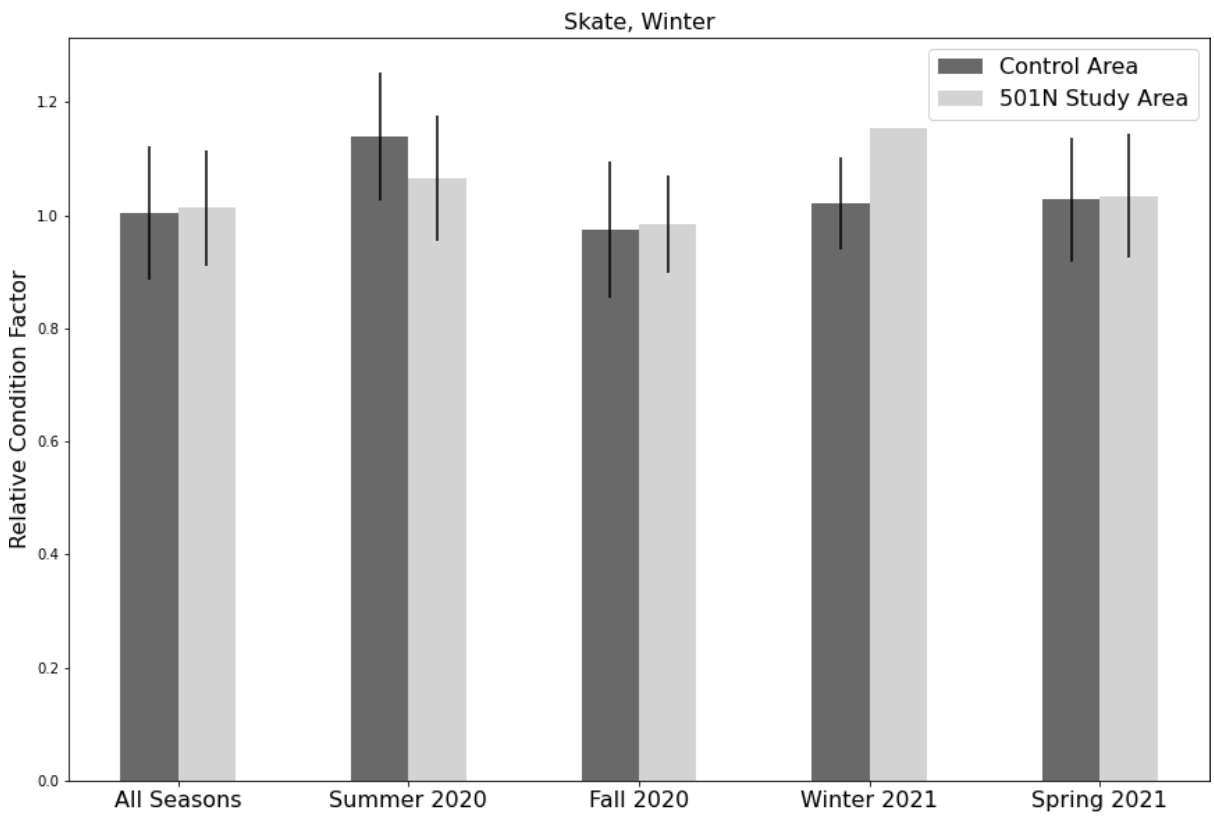


Figure 33: The seasonal condition of winter skate (bottom) as derived from the length-weight relationship (top).

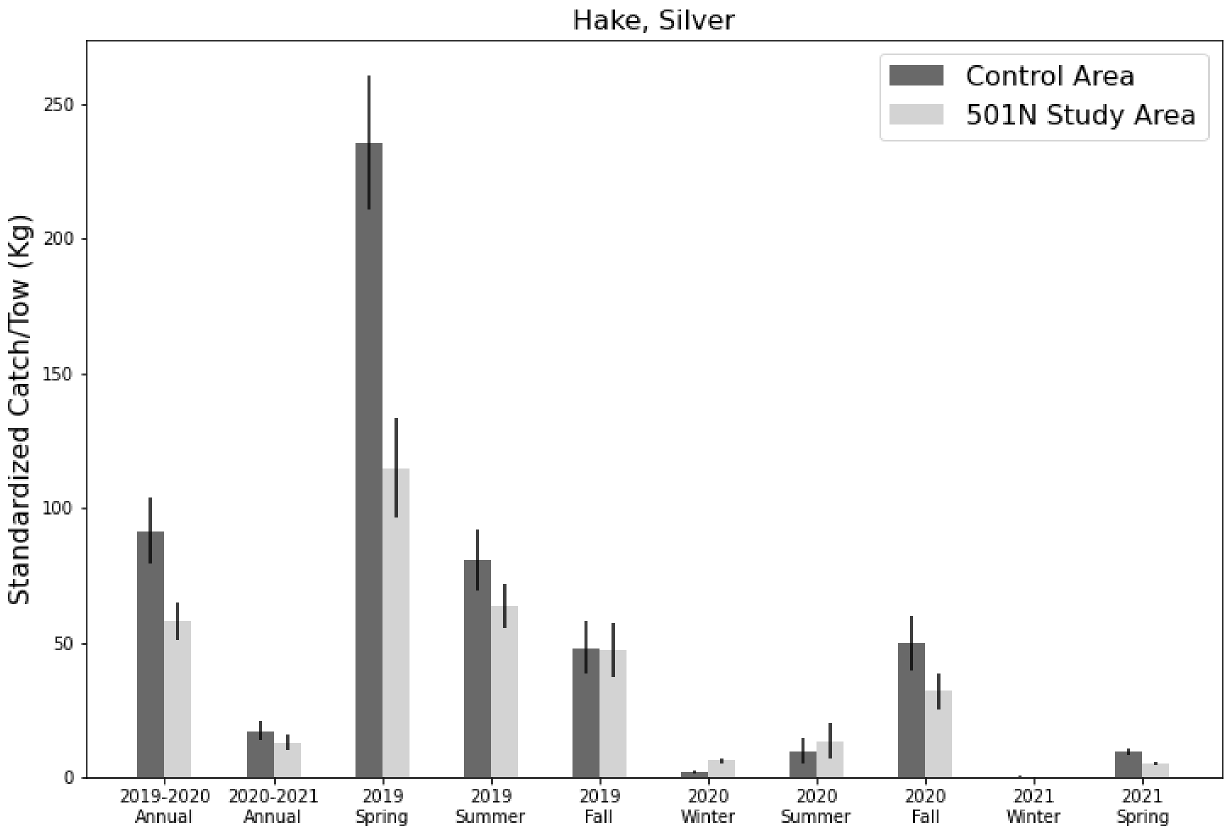


Figure 34: Seasonal catch rates of silver hake in the 501N Study Area and Control Area.

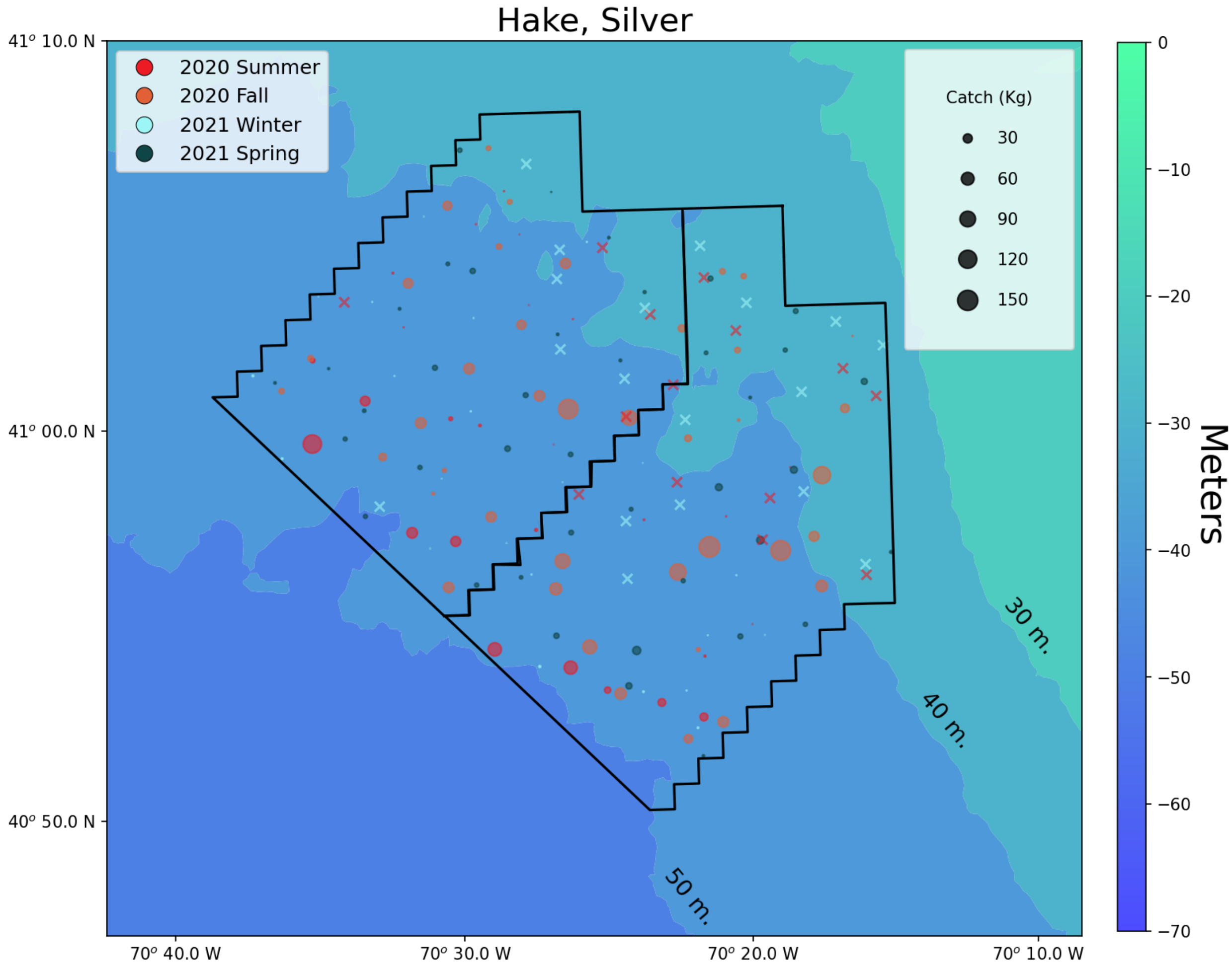


Figure 35: Seasonal distribution of the silver hake catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

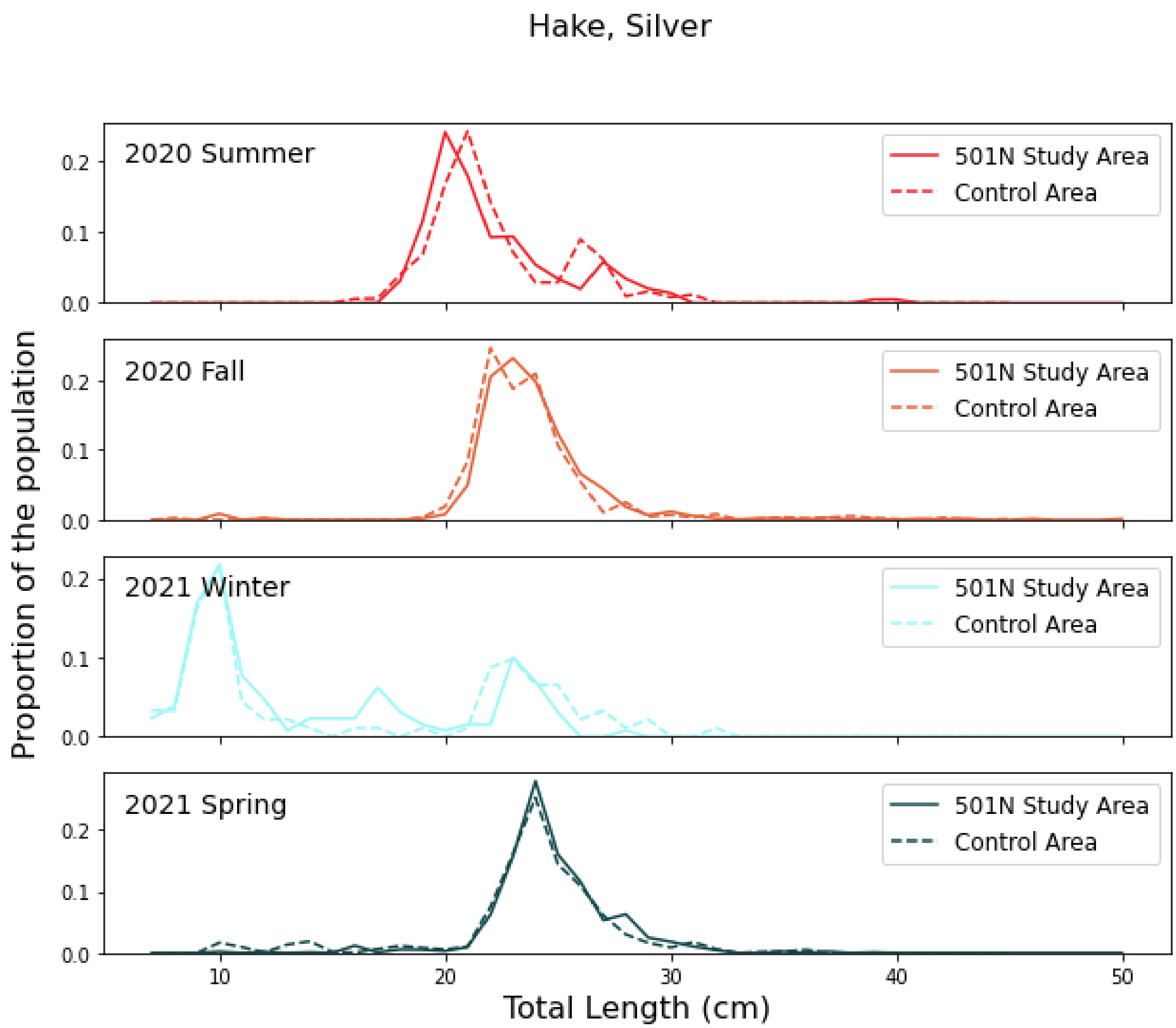


Figure 36: The seasonal length distributions of silver hake in the 501N Study Area and Control Area.

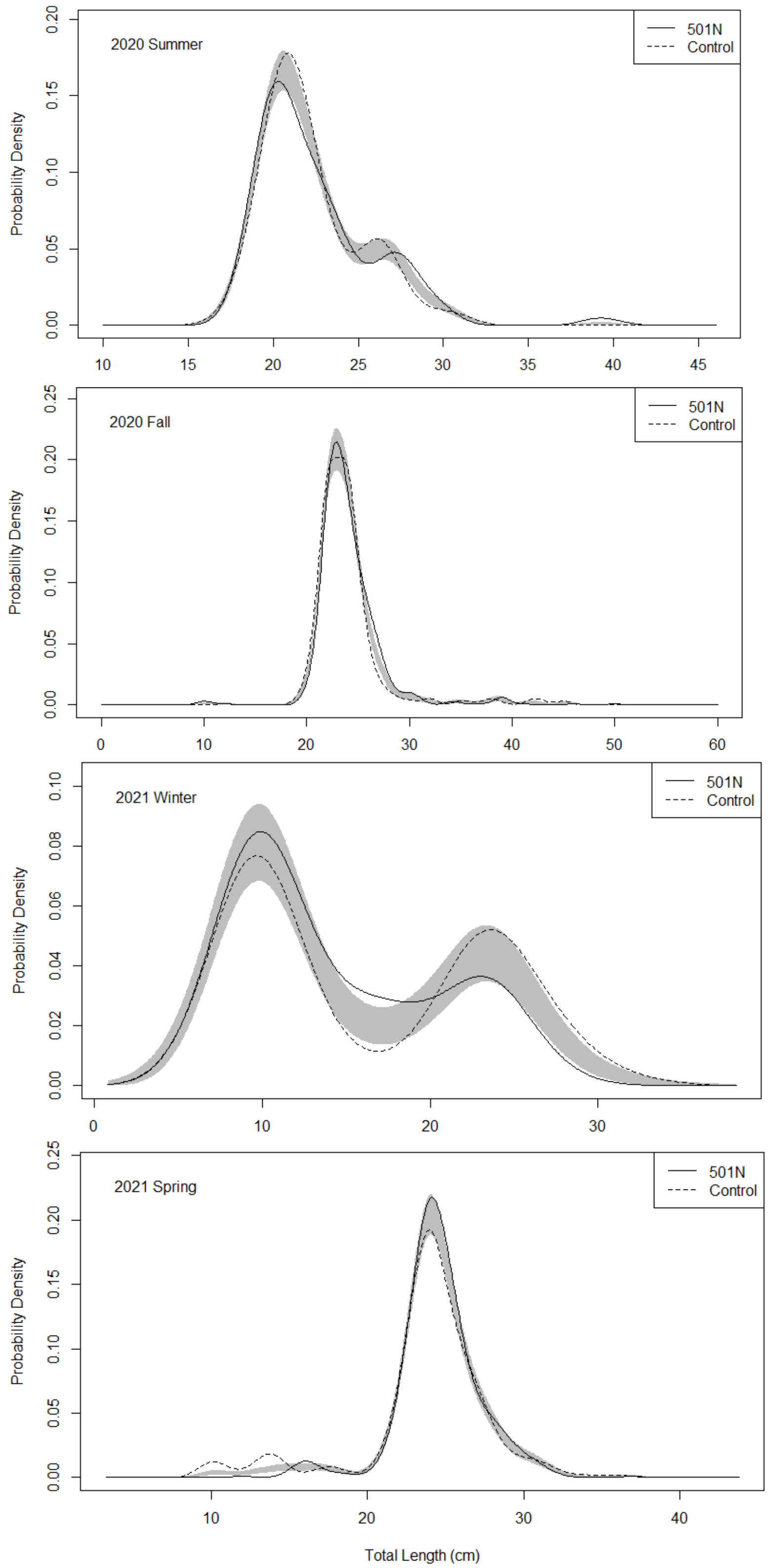
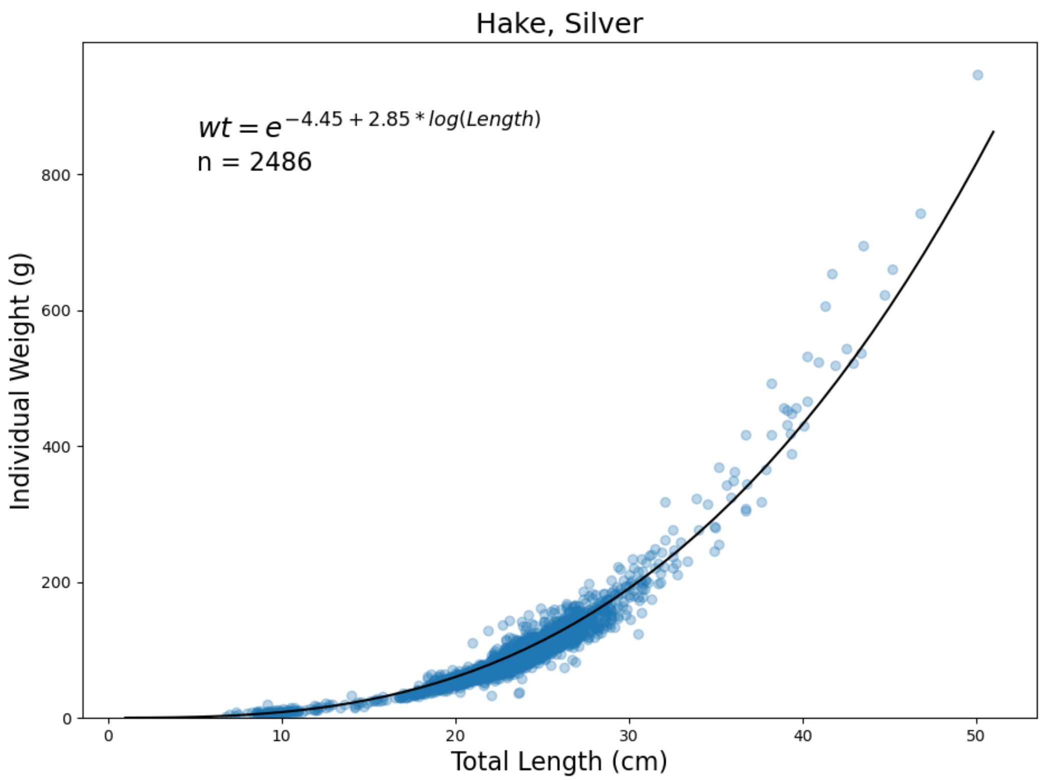


Figure 37: The population structure of silver hake in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



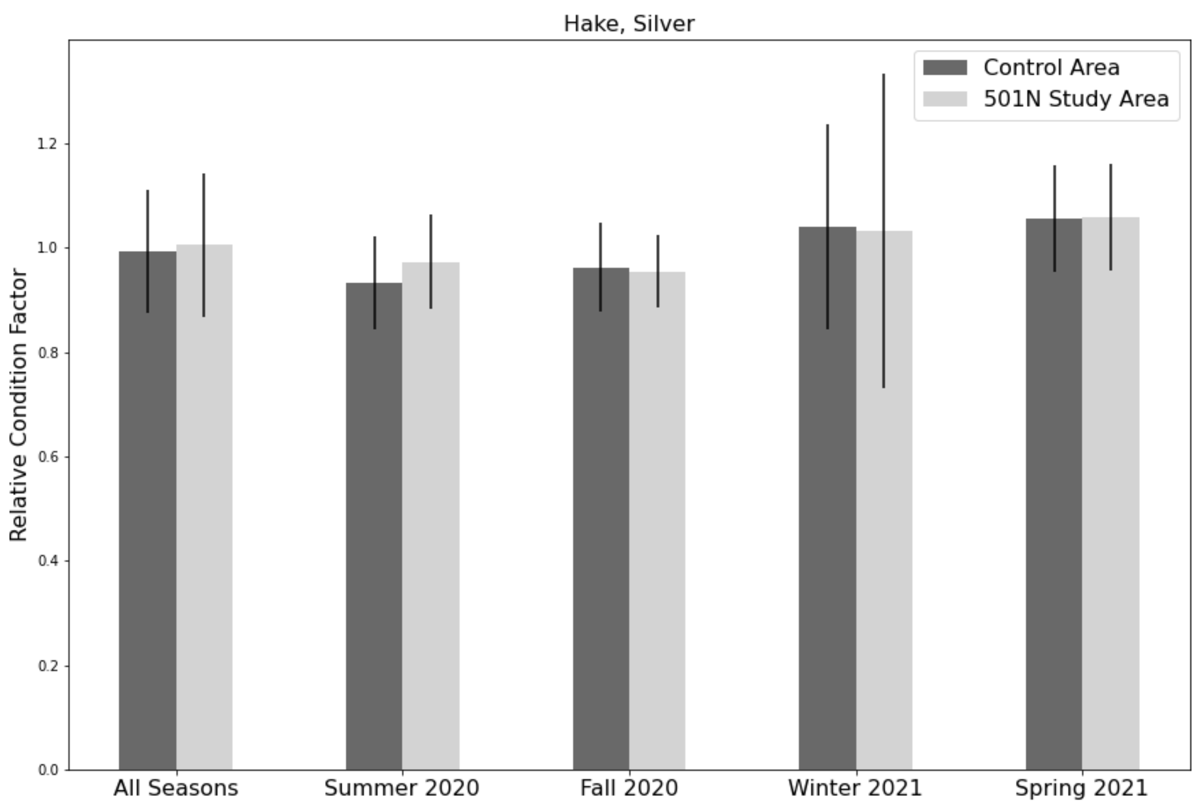


Figure 38: The seasonal condition of silver hake (bottom) as derived from the length-weight relationship (top).

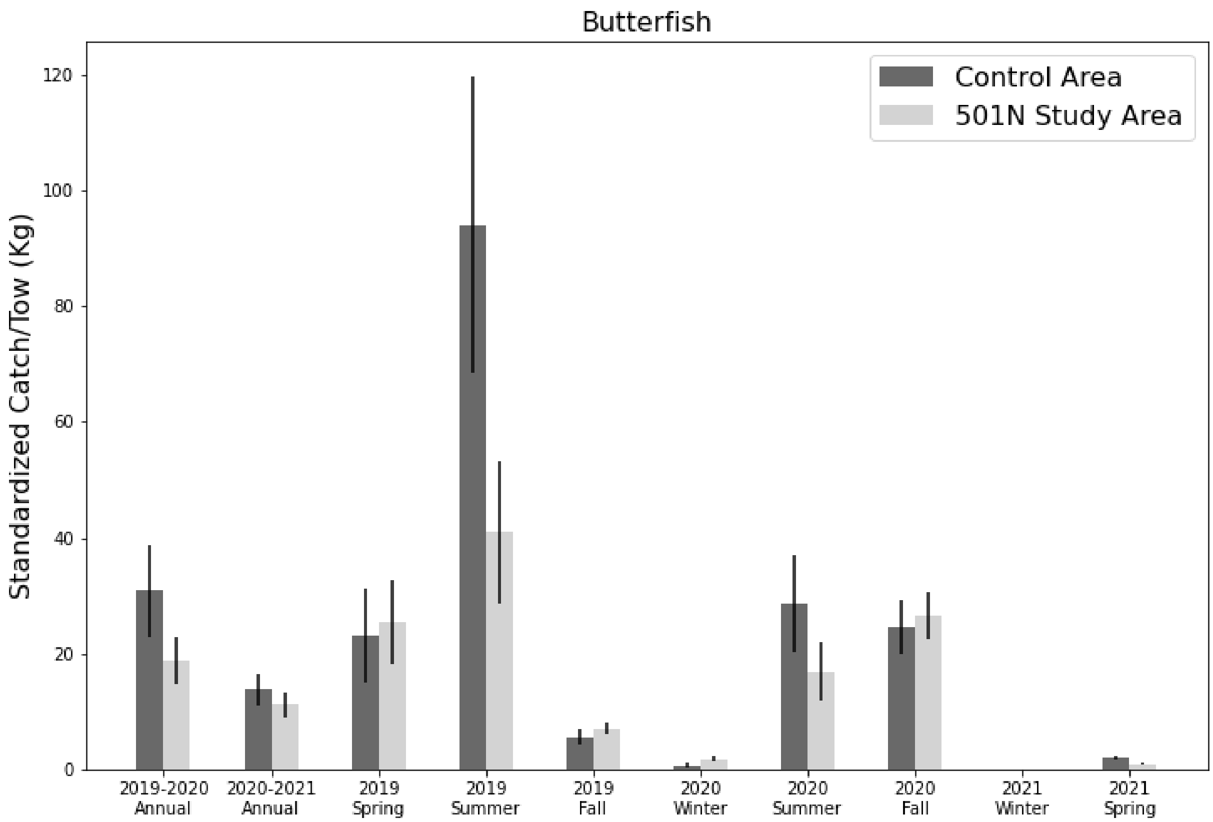


Figure 39: Seasonal catch rates of butterfish in the 501N Study Area and Control Area.

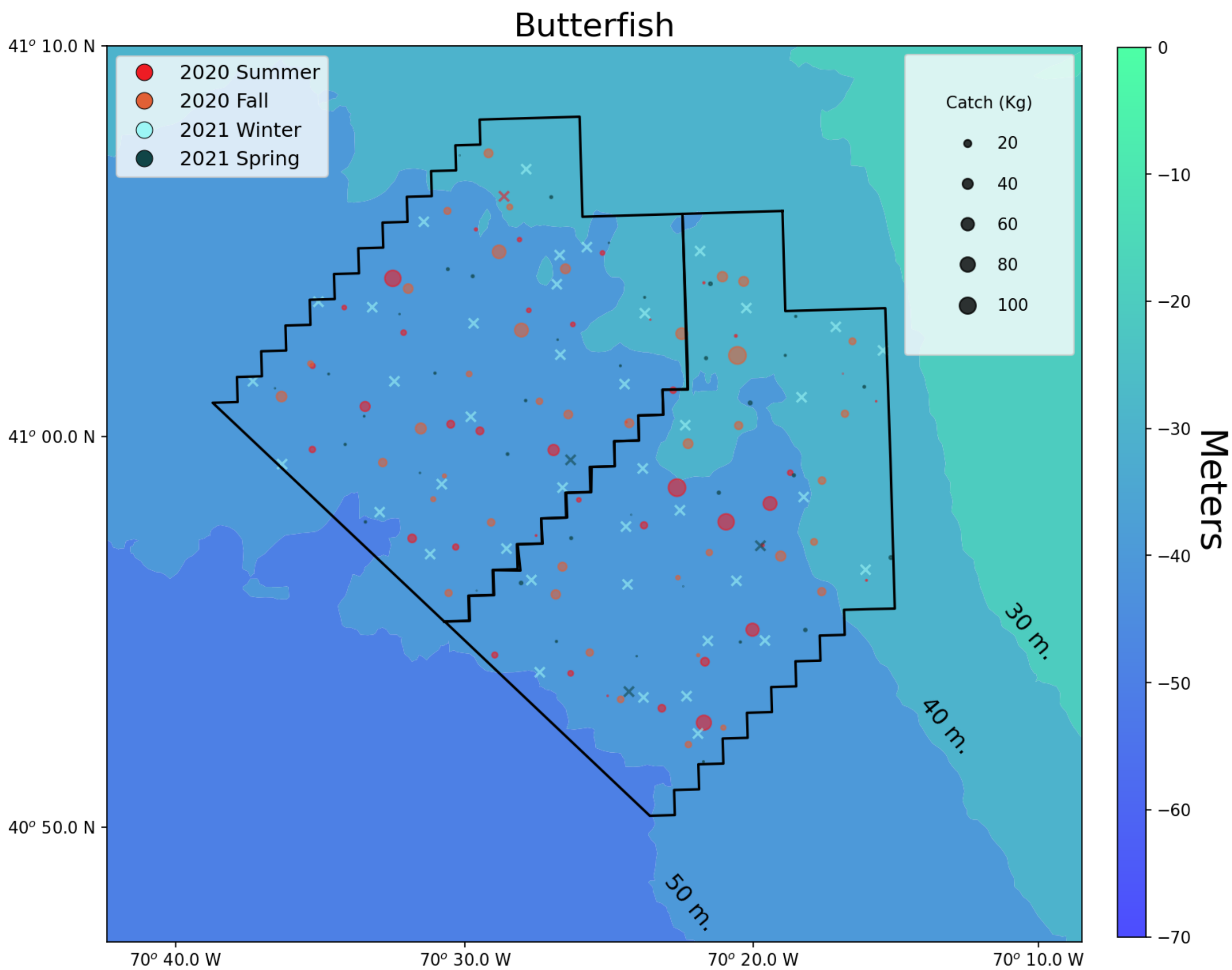


Figure 40: Seasonal distribution of the butterfish catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

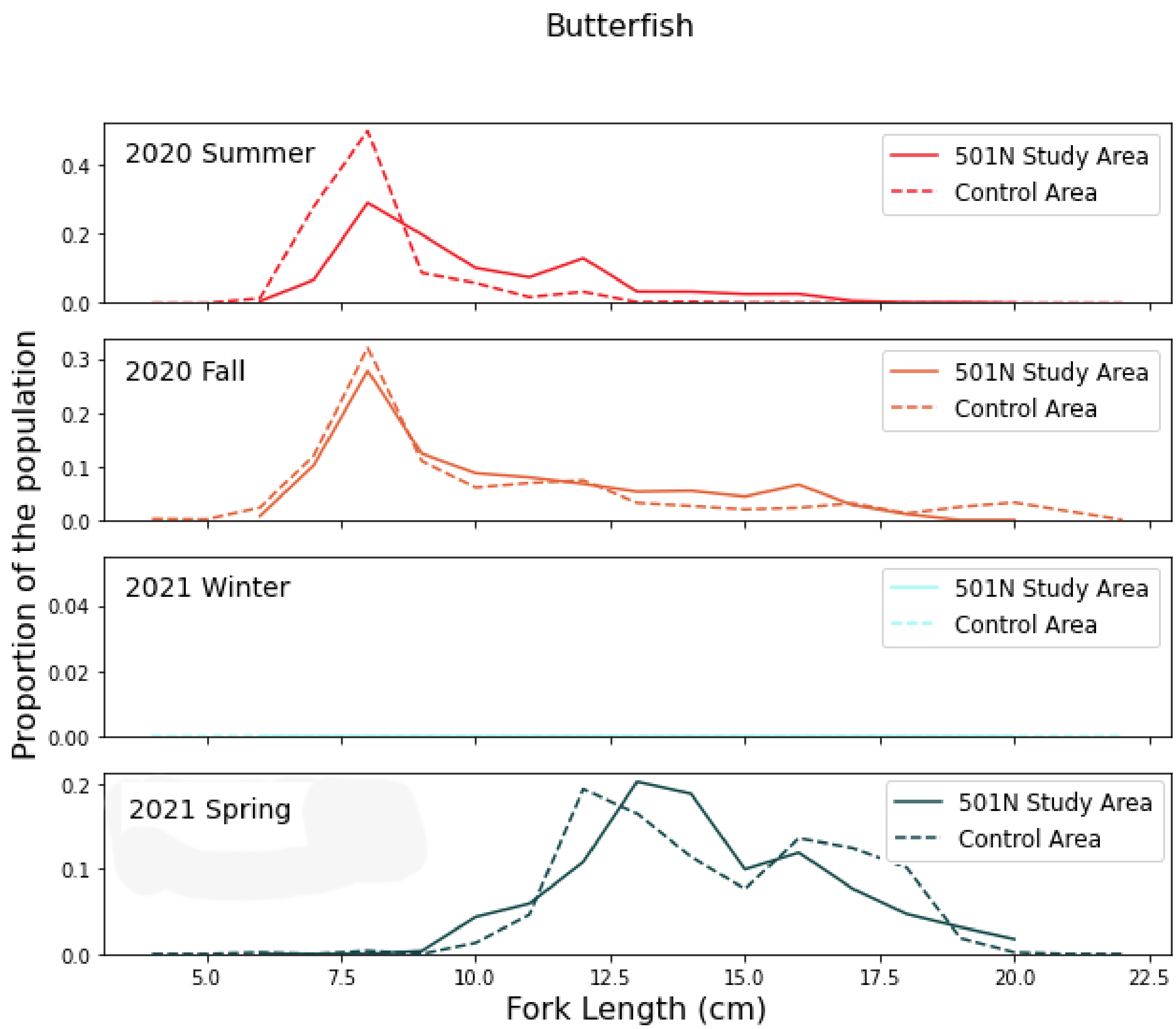


Figure 41: The seasonal length distributions of butterfish in the 501N Study Area and Control Area.

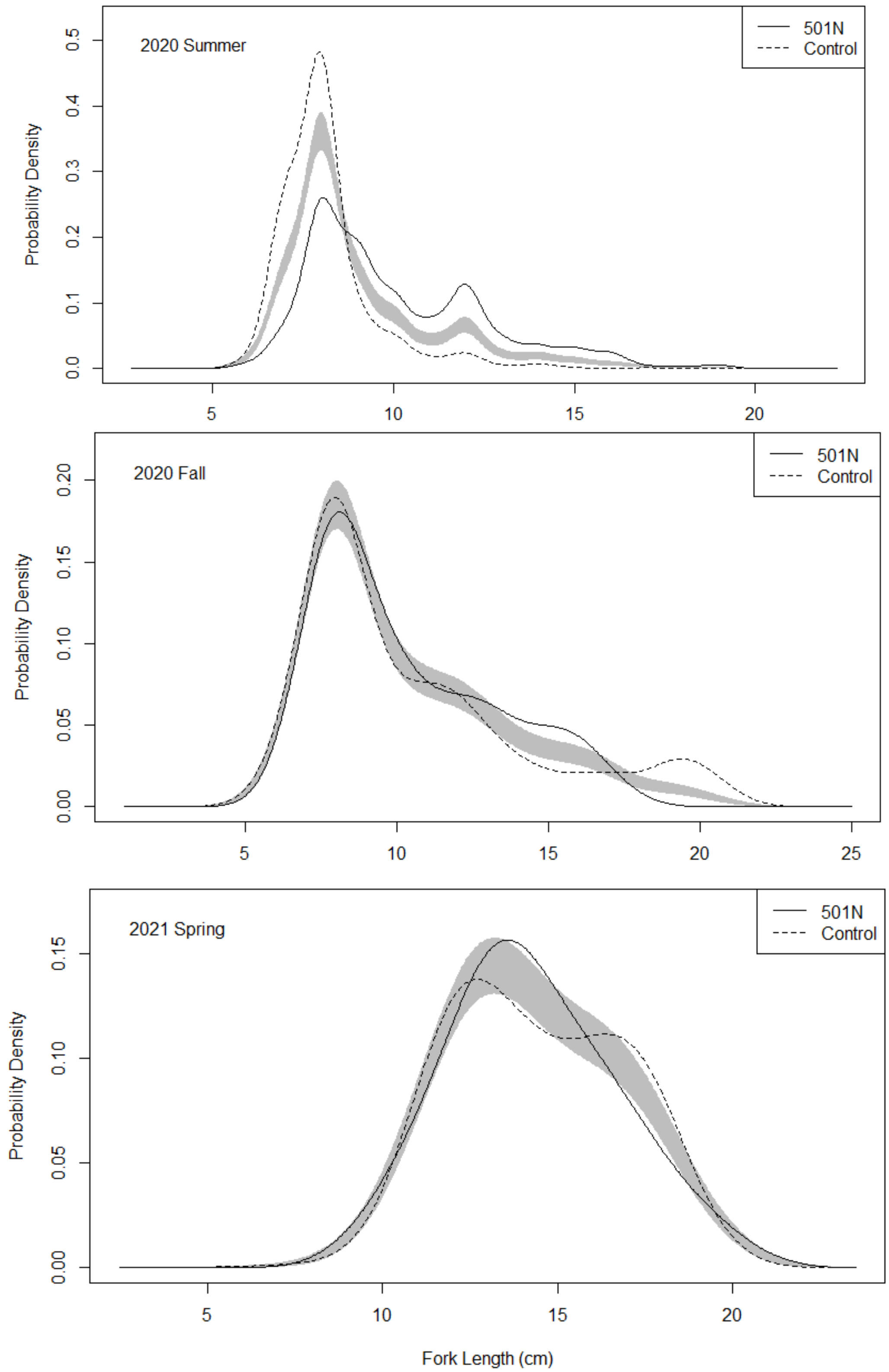


Figure 42: The population structure of butterfish in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.

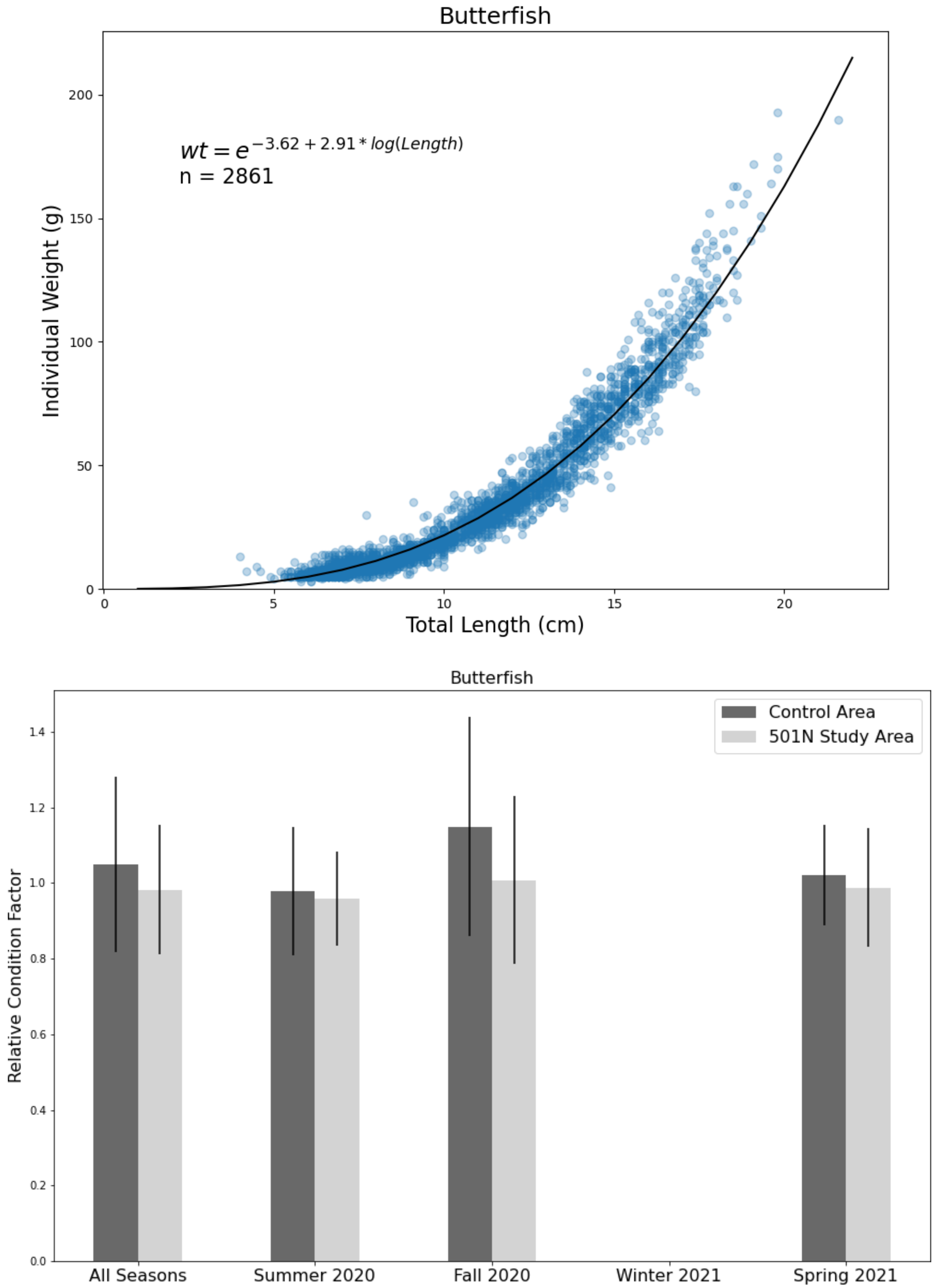


Figure 43: The seasonal condition of butterfish (bottom) as derived from the length-weight relationship (top).

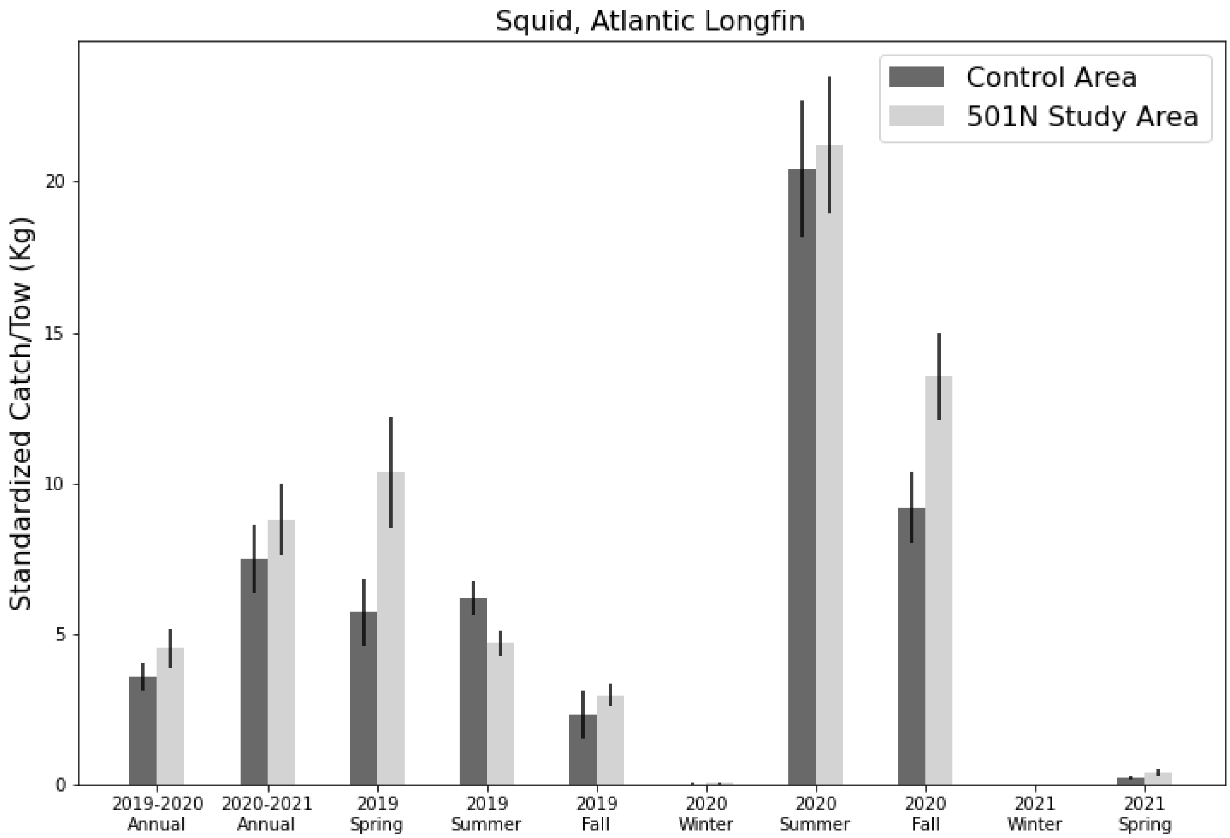


Figure 44: Seasonal catch rates of Atlantic longfin squid in the 501N Study Area and Control Area.

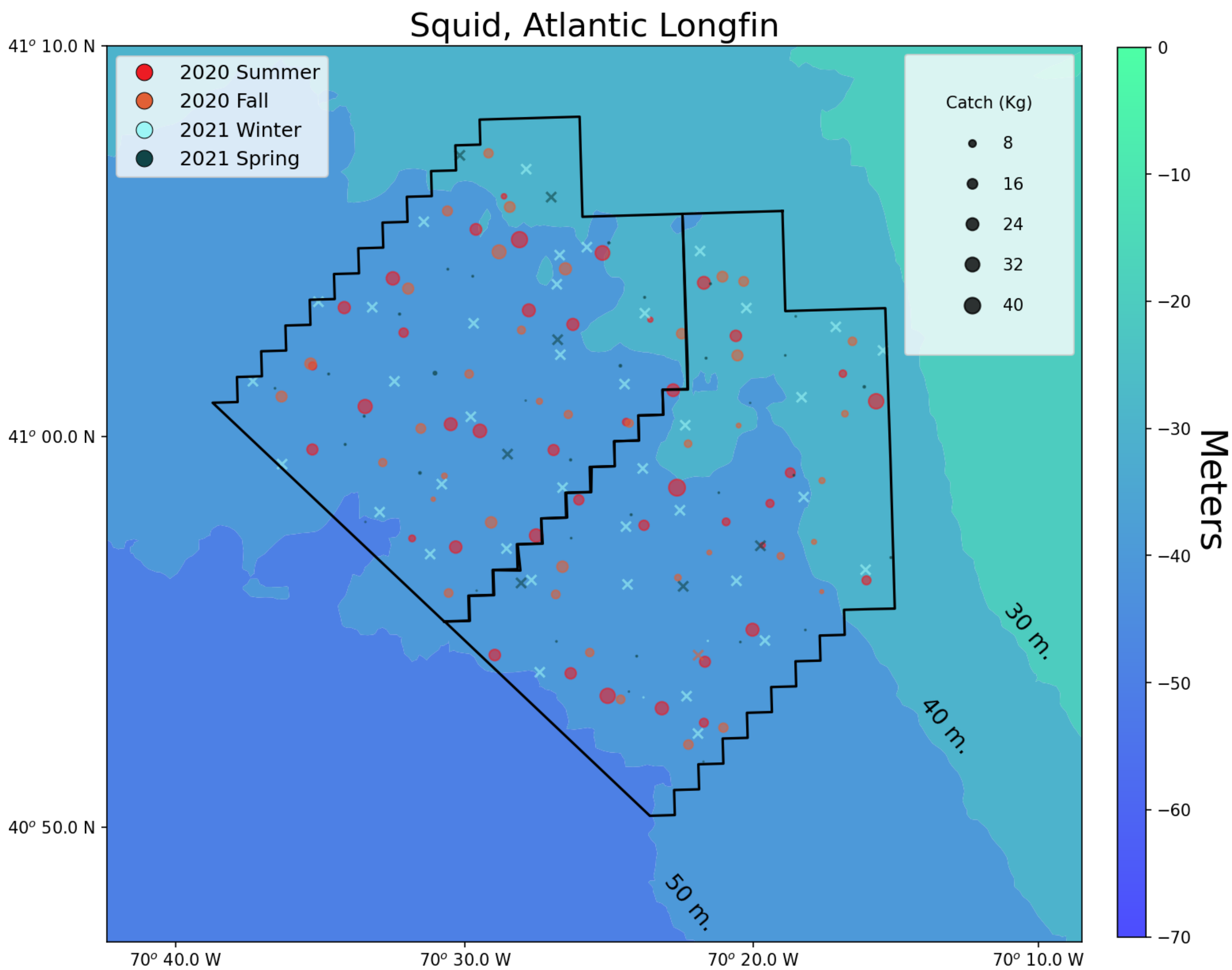


Figure 45: Seasonal distribution of the Atlantic longfin squid catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

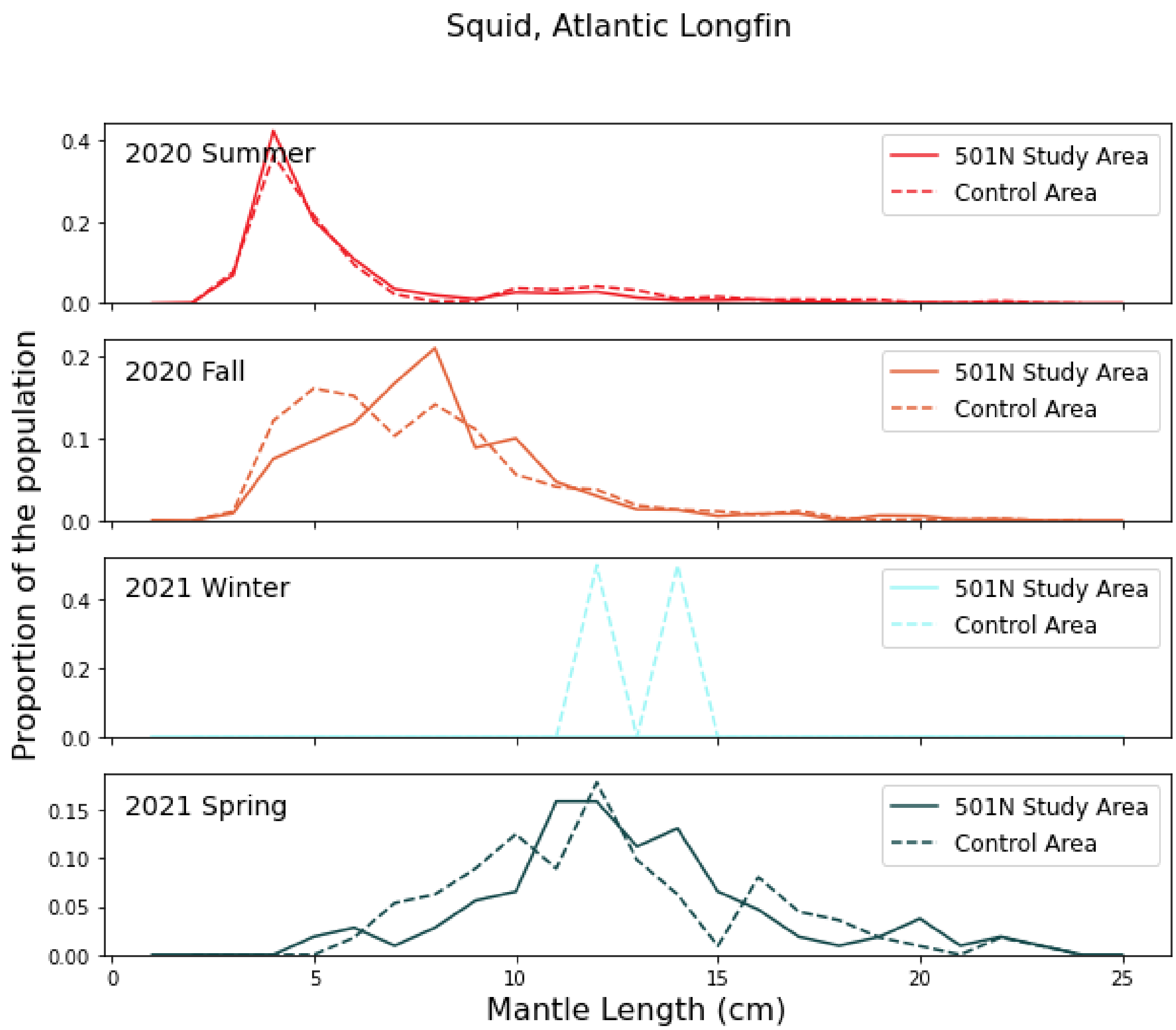


Figure 46: The seasonal length distributions of Atlantic longfin squid in the 501N Study Area and Control Area.

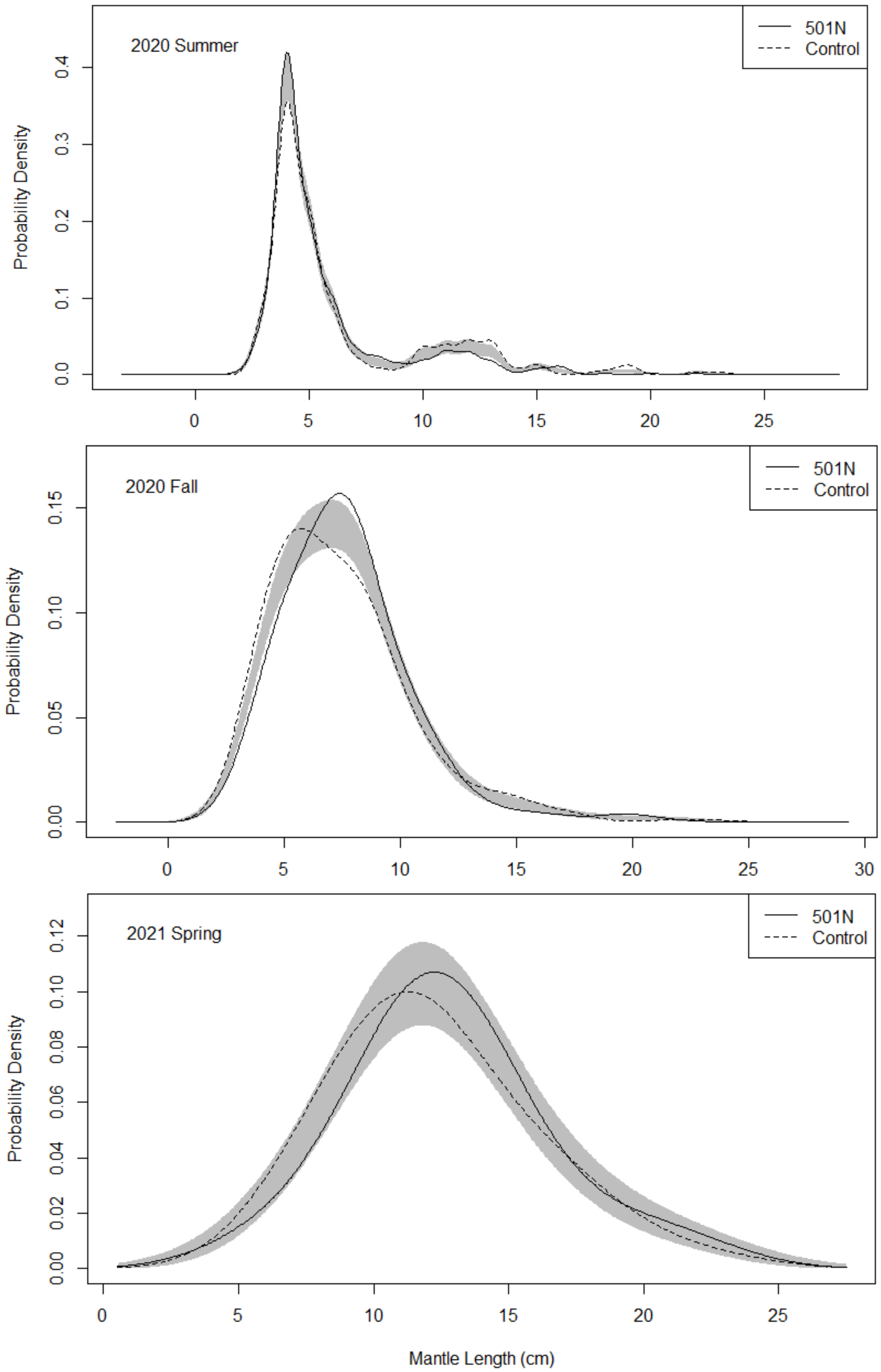
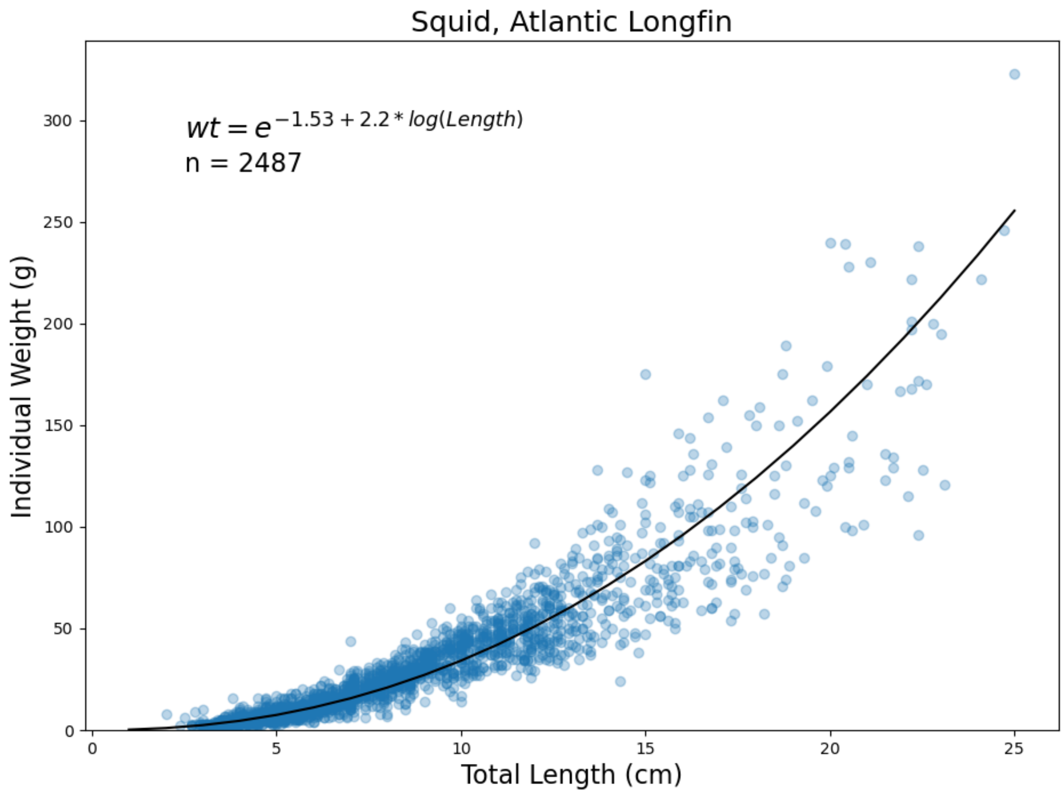


Figure 47: The population structure of Atlantic longfin squid in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



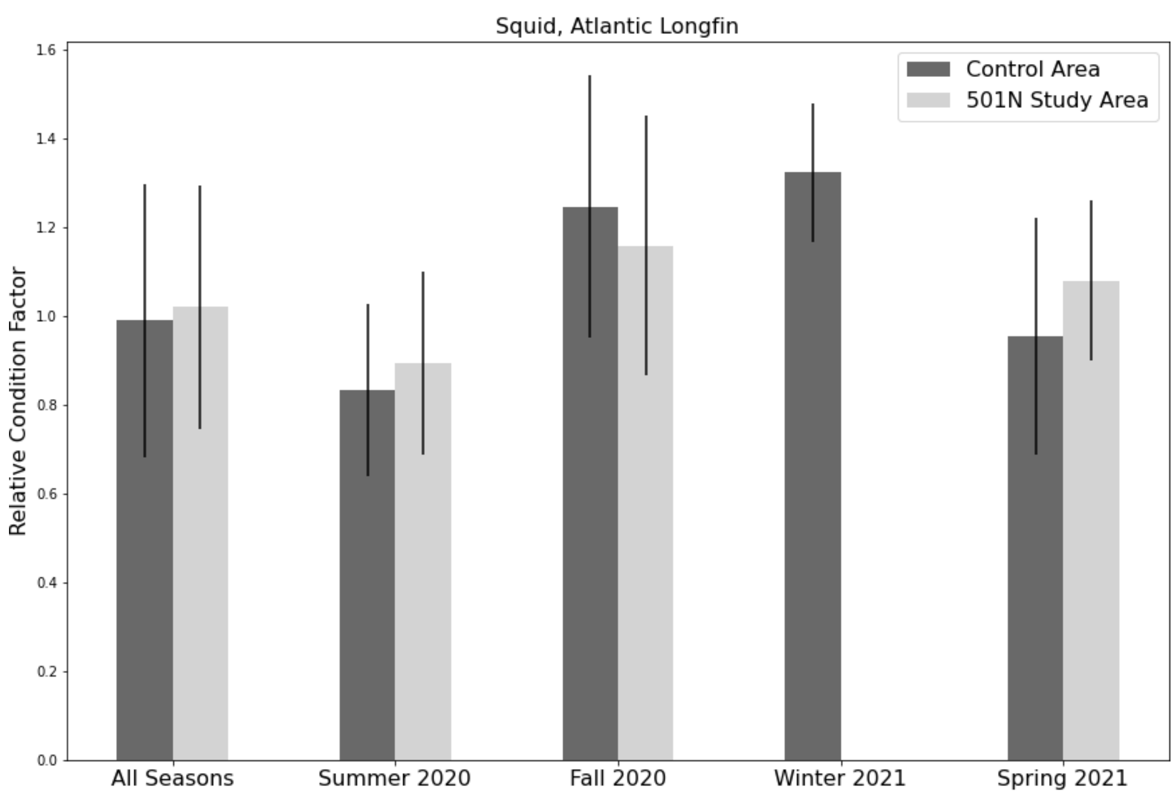


Figure 48: The seasonal condition of Atlantic longfin squid (bottom) as derived from the length-weight relationship (top).

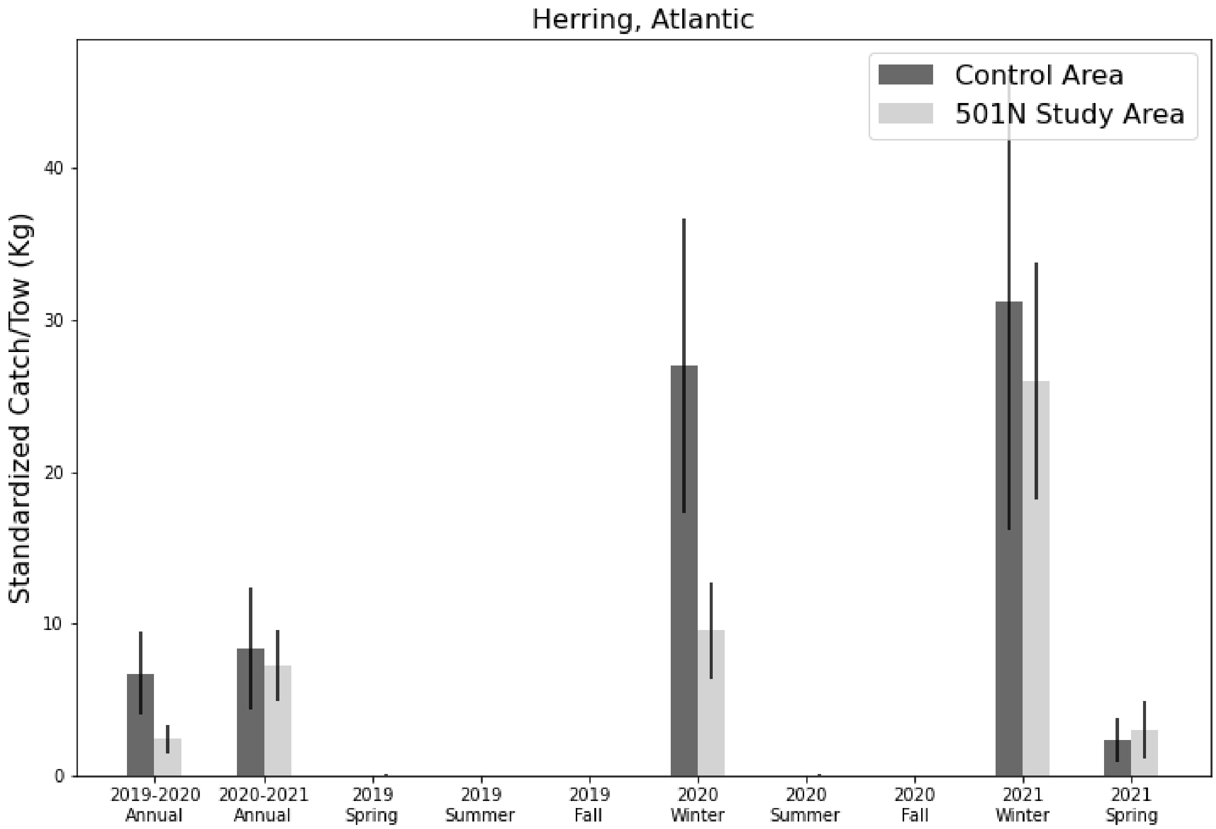


Figure 49: Seasonal catch rates of Atlantic herring in the 501N Study Area and Control Area.

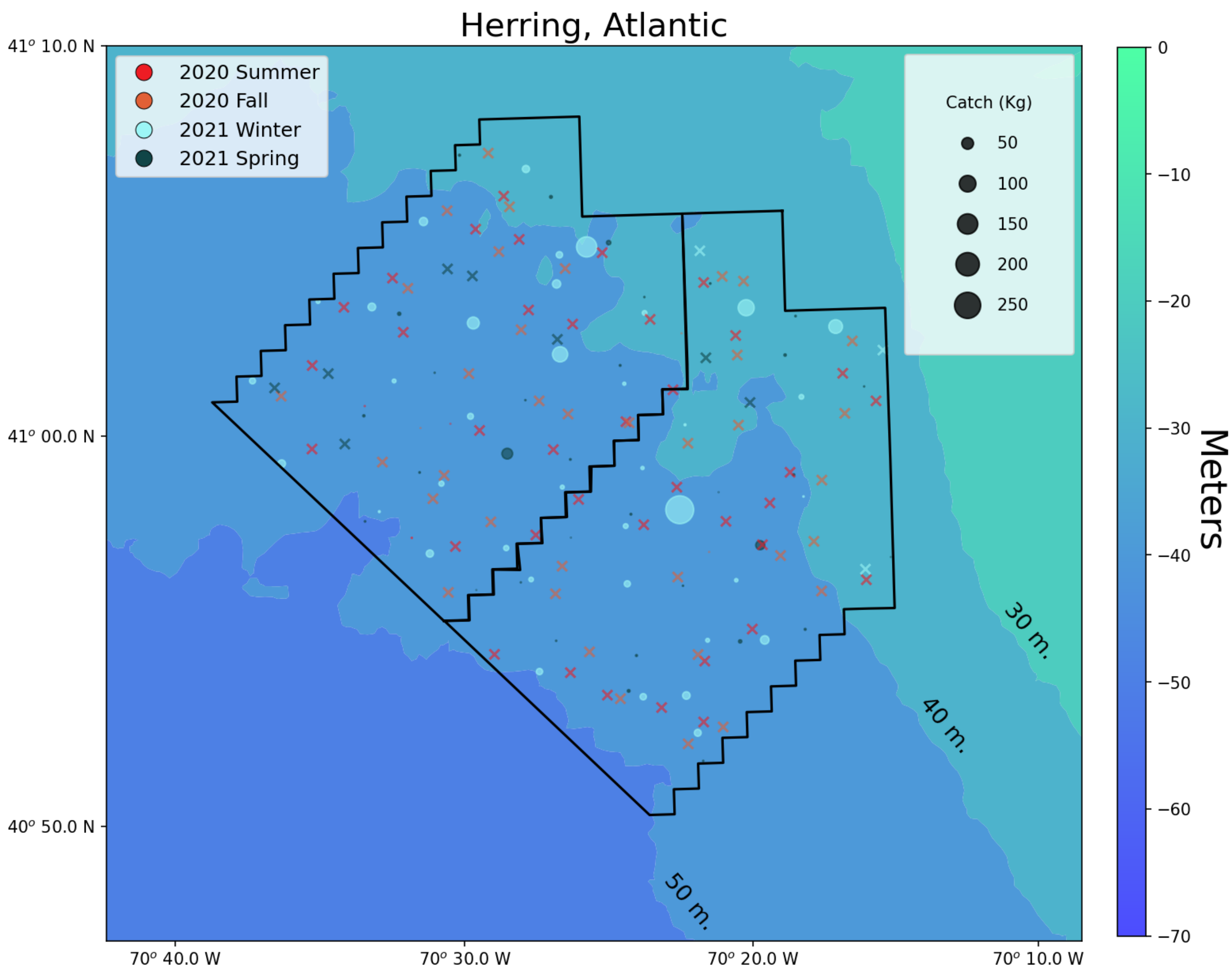


Figure 50: Seasonal distribution of the Atlantic herring catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

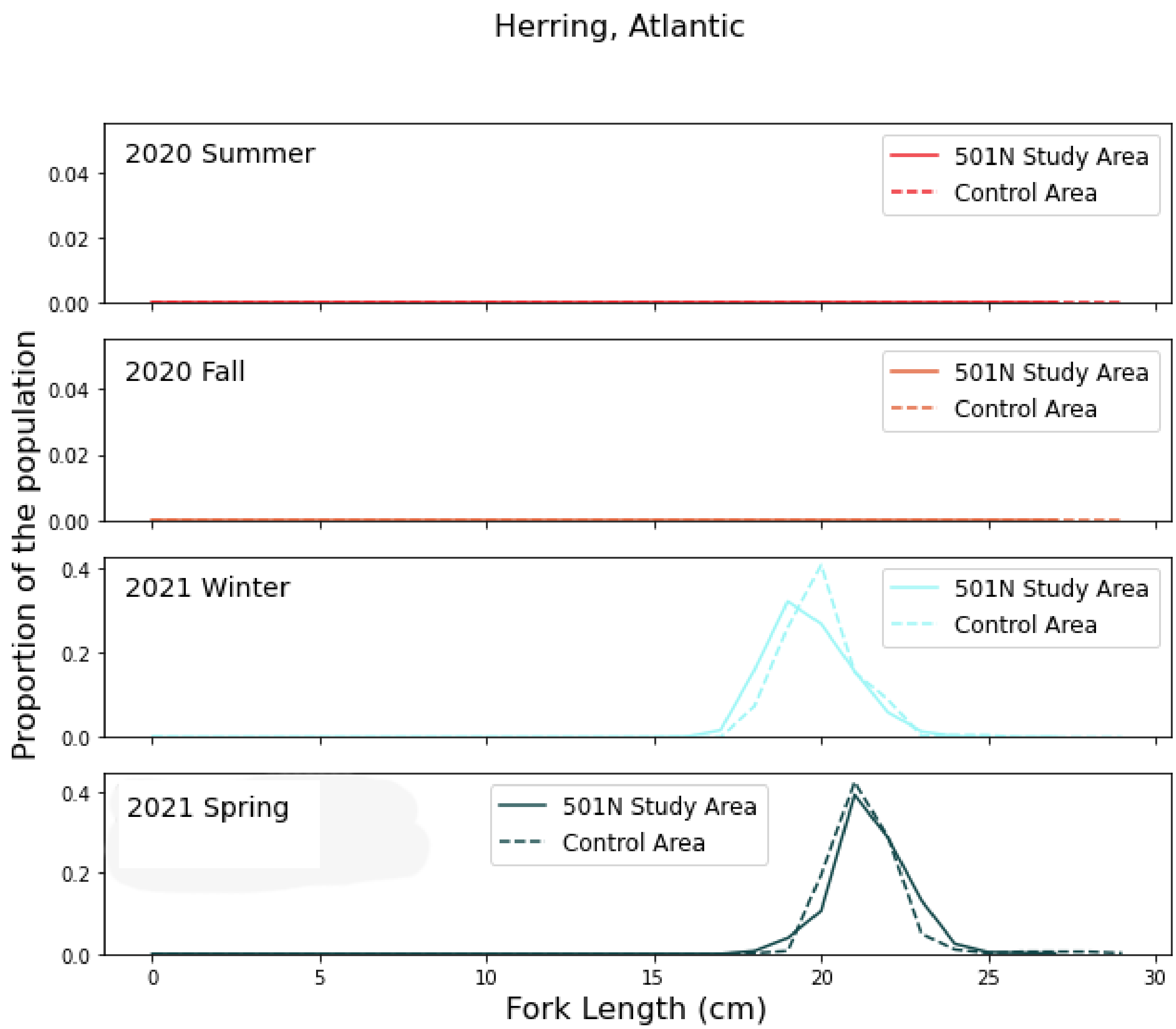


Figure 51: The seasonal length distributions of Atlantic herring in the 501N Study Area and Control Area.

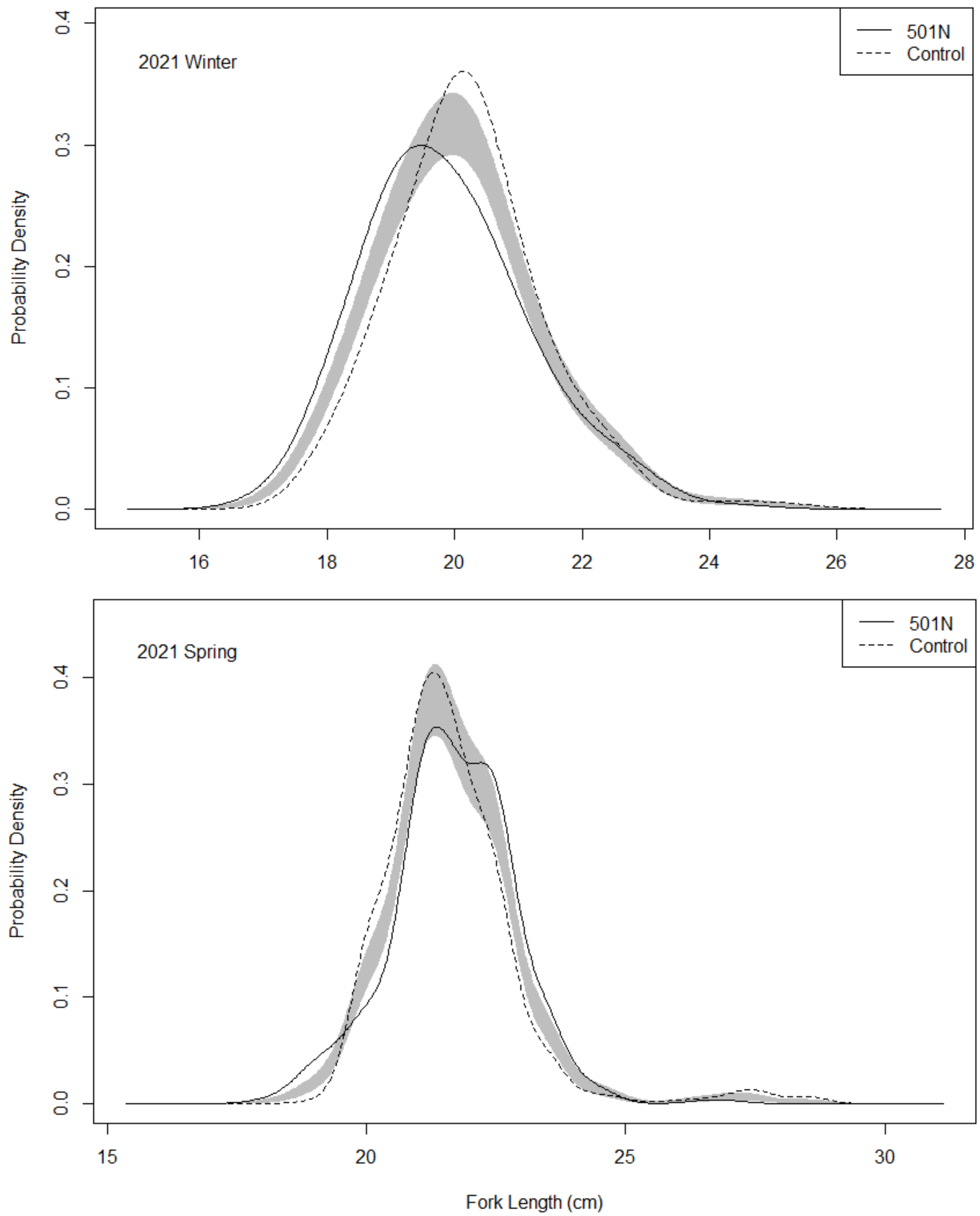
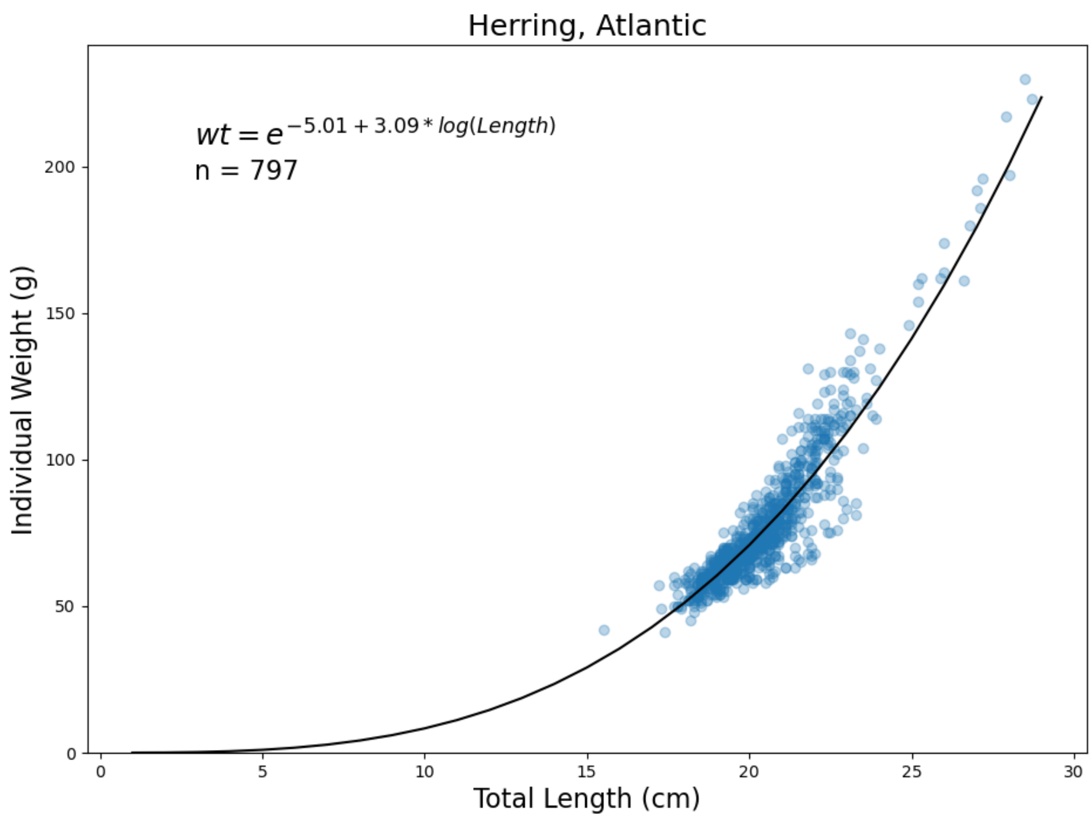


Figure 52: The population structure of Atlantic herring in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



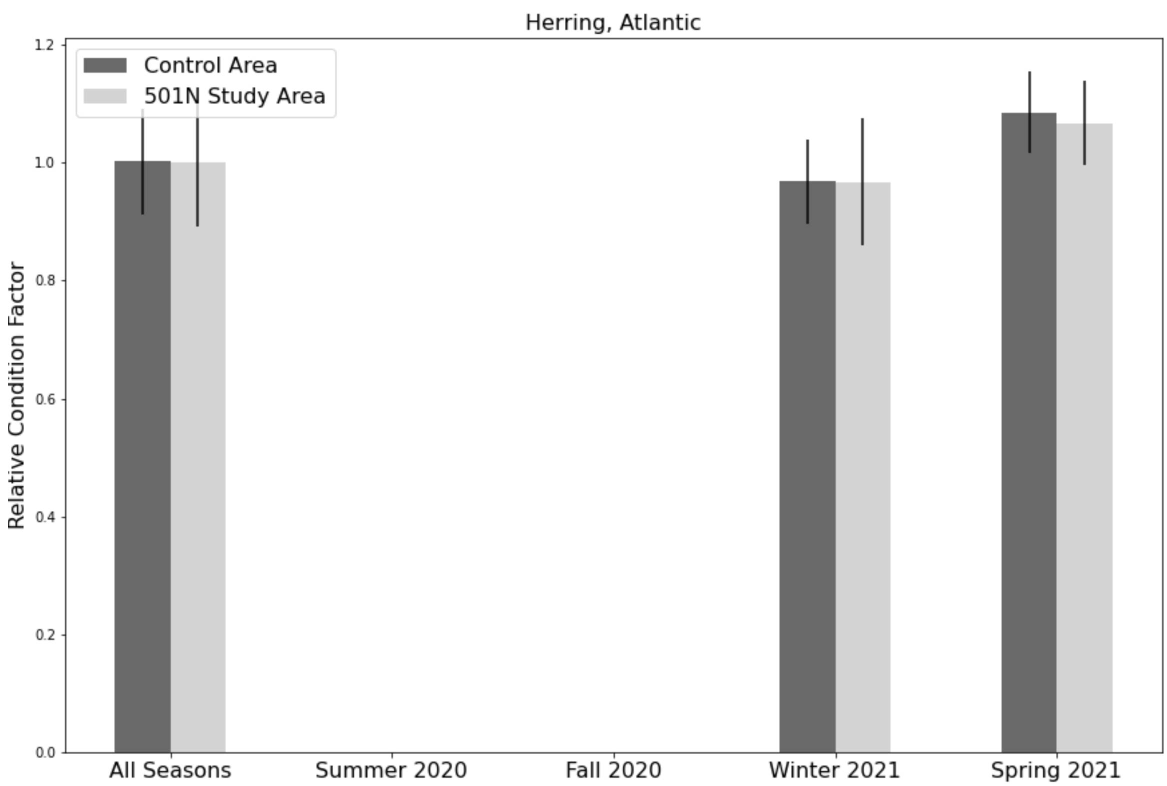


Figure 53: The seasonal condition of Atlantic herring (bottom) as derived from the length-weight relationship (top).

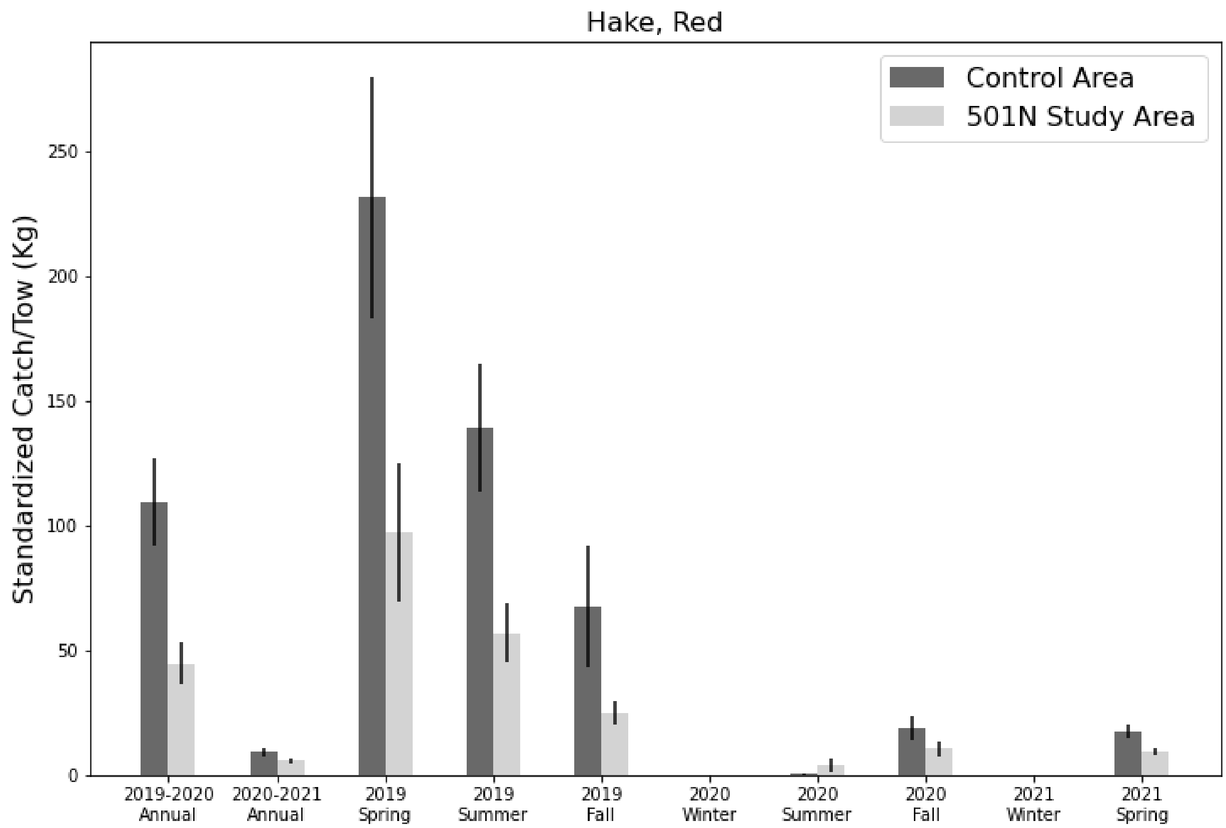


Figure 54: Seasonal catch rates of red hake in the 501N Study Area and Control Area.

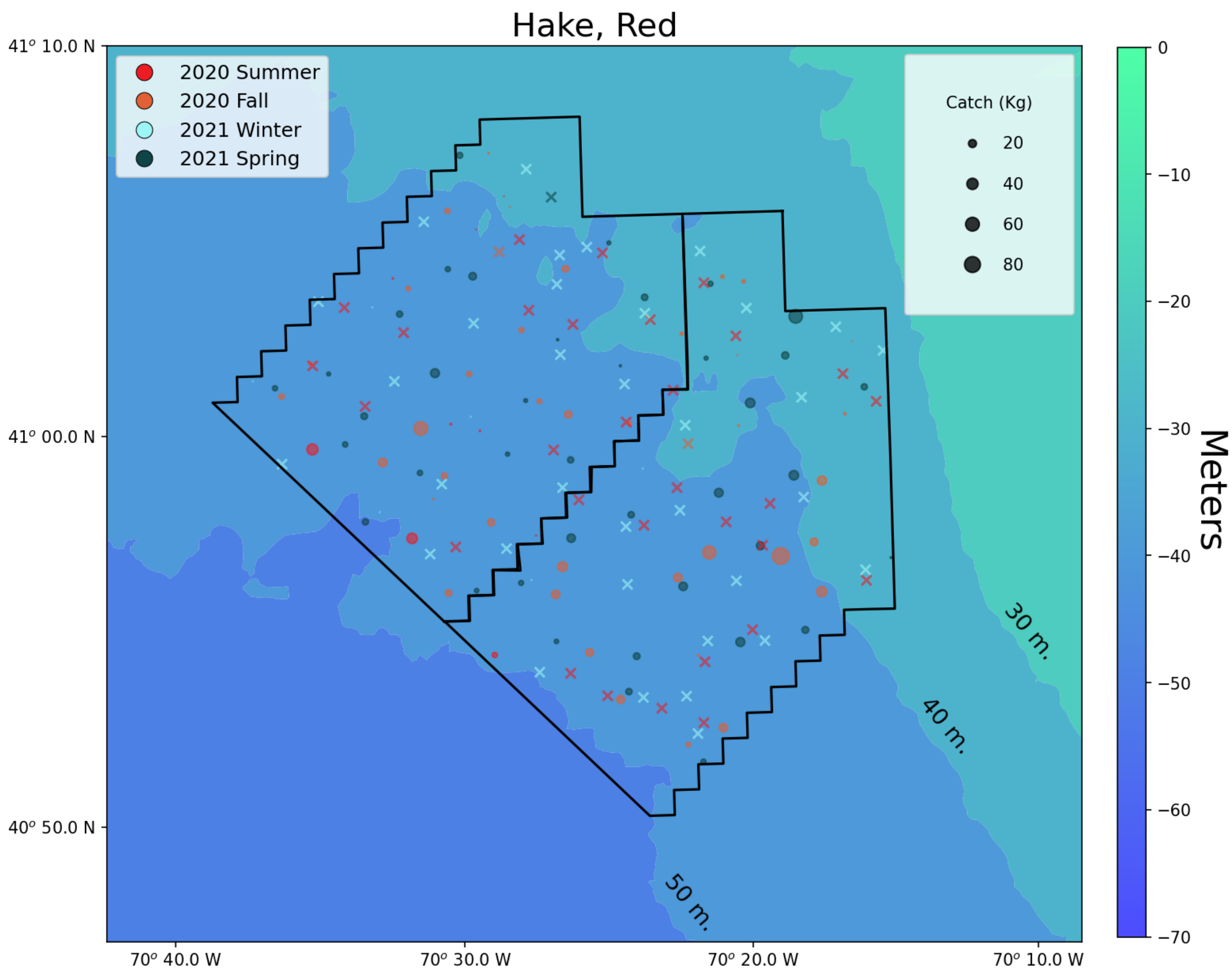


Figure 55: Seasonal distribution of the red hake catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

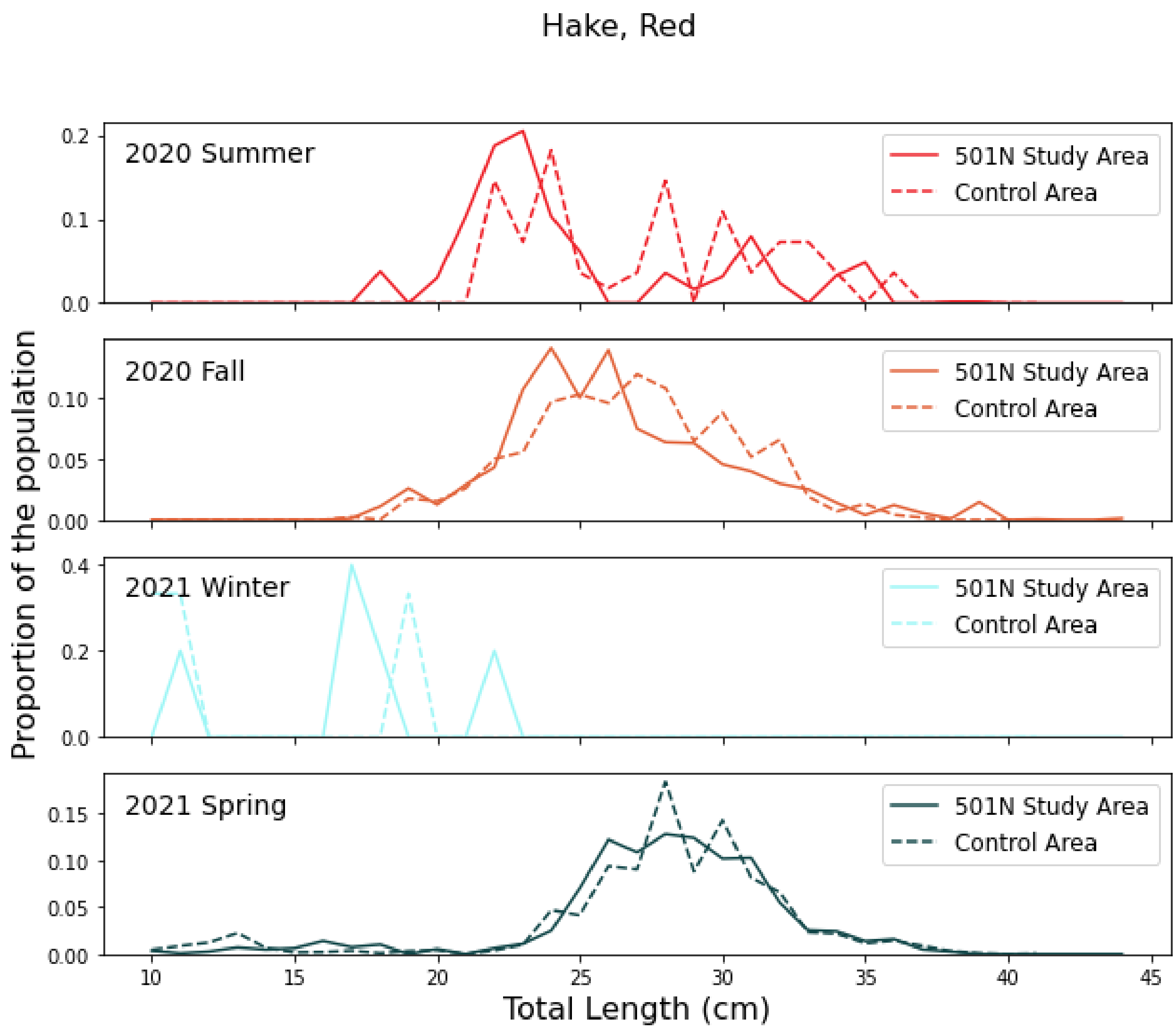


Figure 56: The seasonal length distributions of red hake in the 501N Study Area and Control Area.

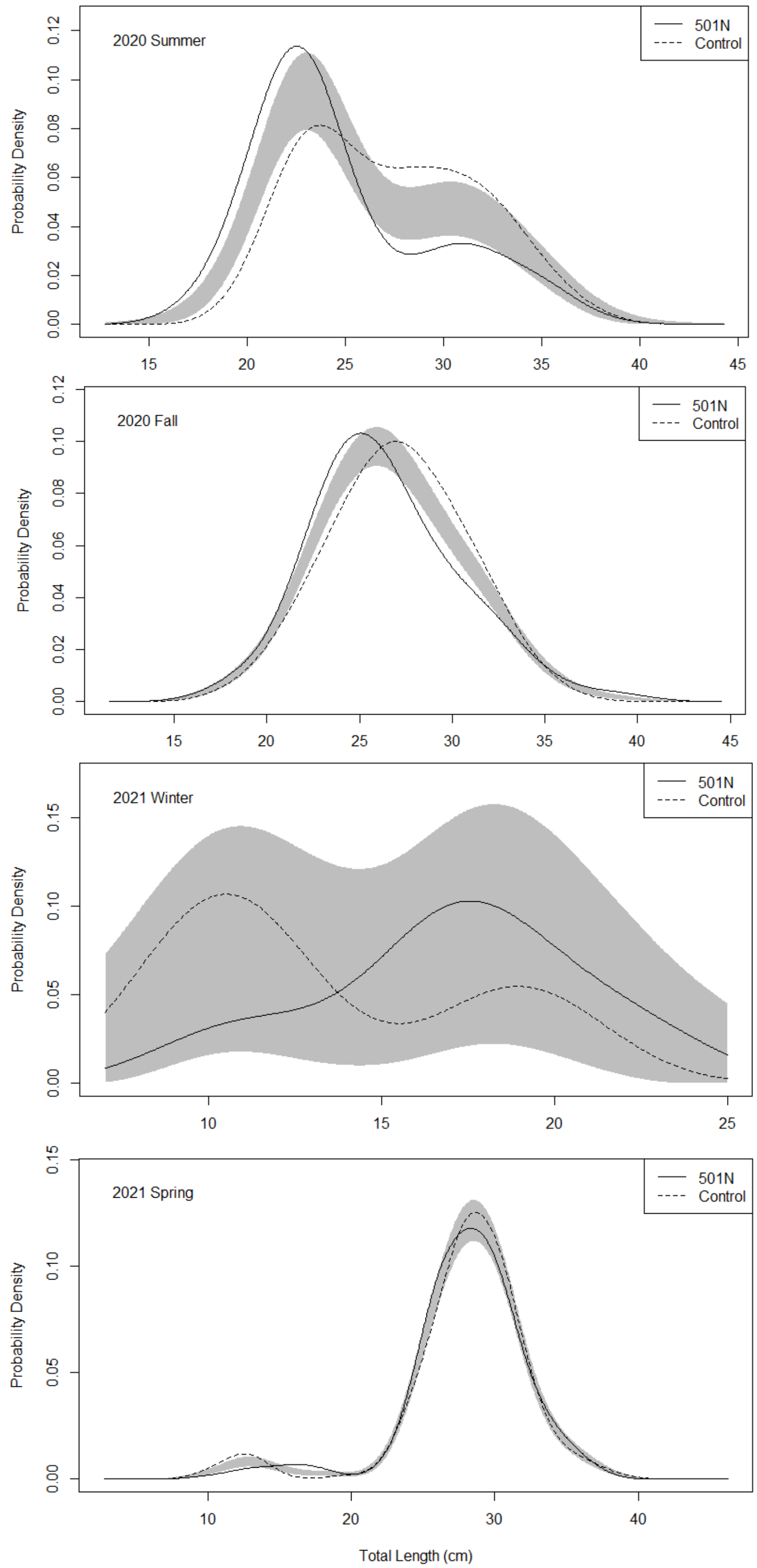
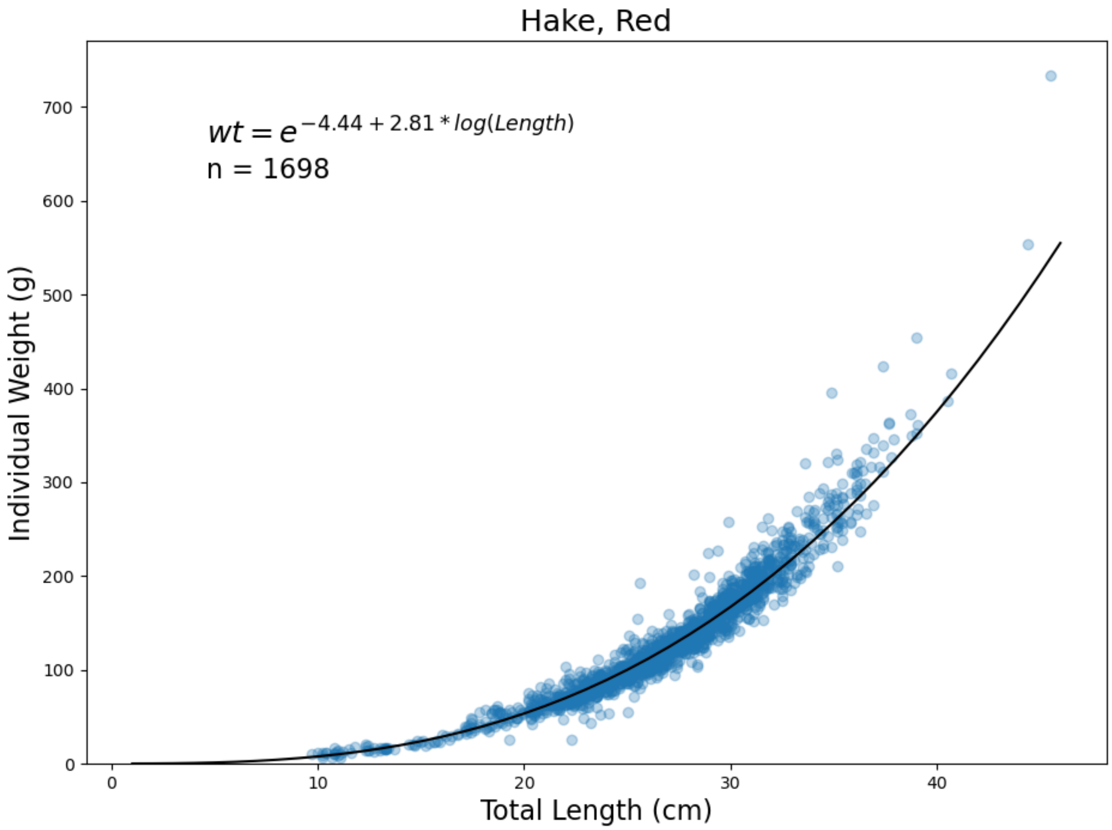


Figure 57: The population structure of red hake in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



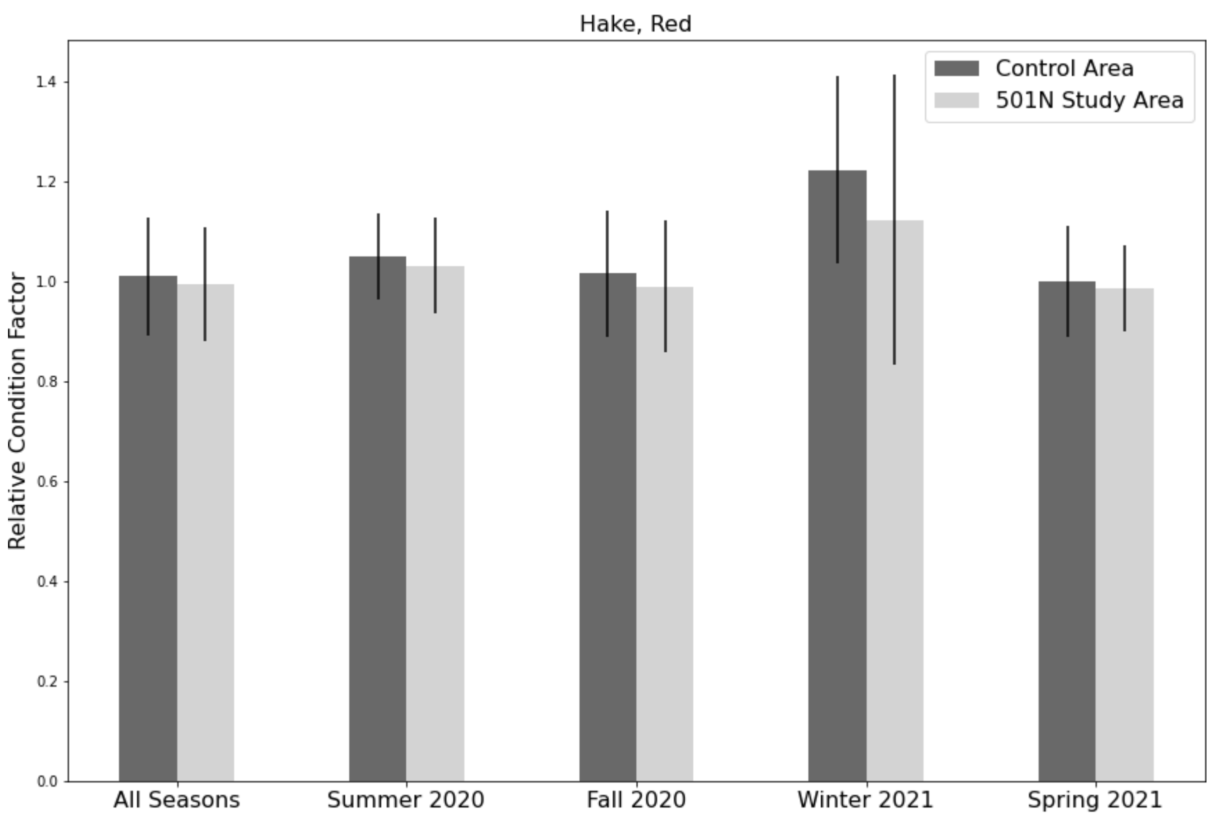


Figure 58: The seasonal condition of red hake (bottom) as derived from the length-weight relationship (top).

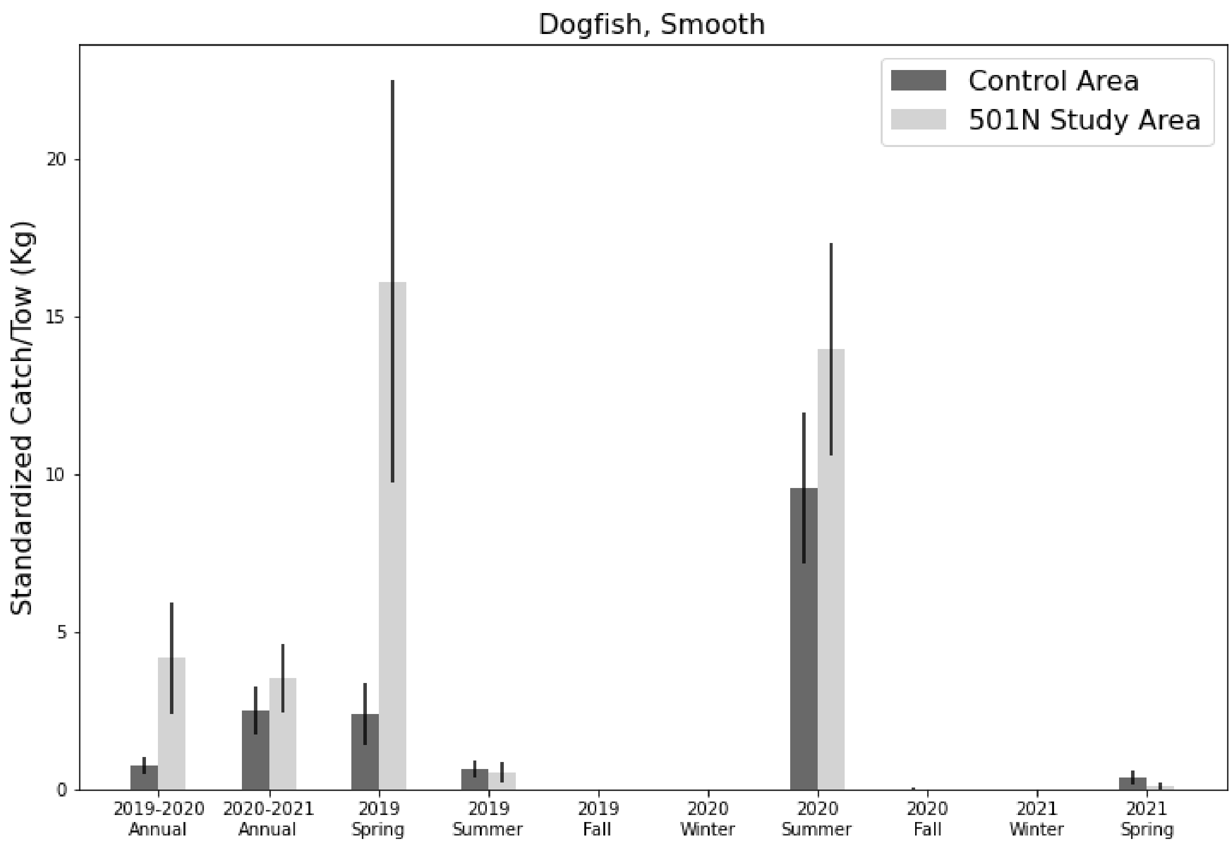


Figure 59: Seasonal catch rates of smooth dogfish in the 501N Study Area and Control Area.

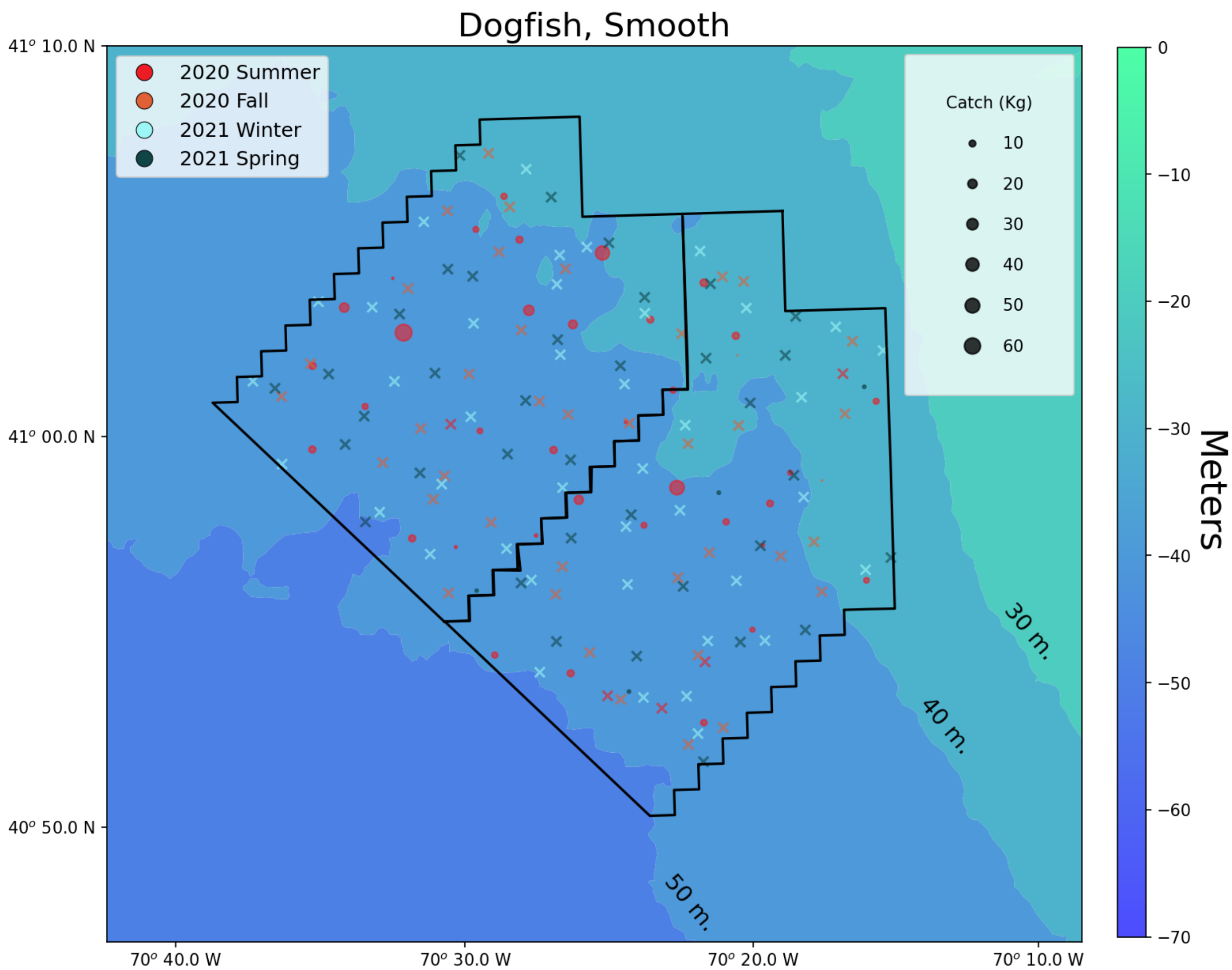


Figure 60: Seasonal distribution of the smooth dogfish catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

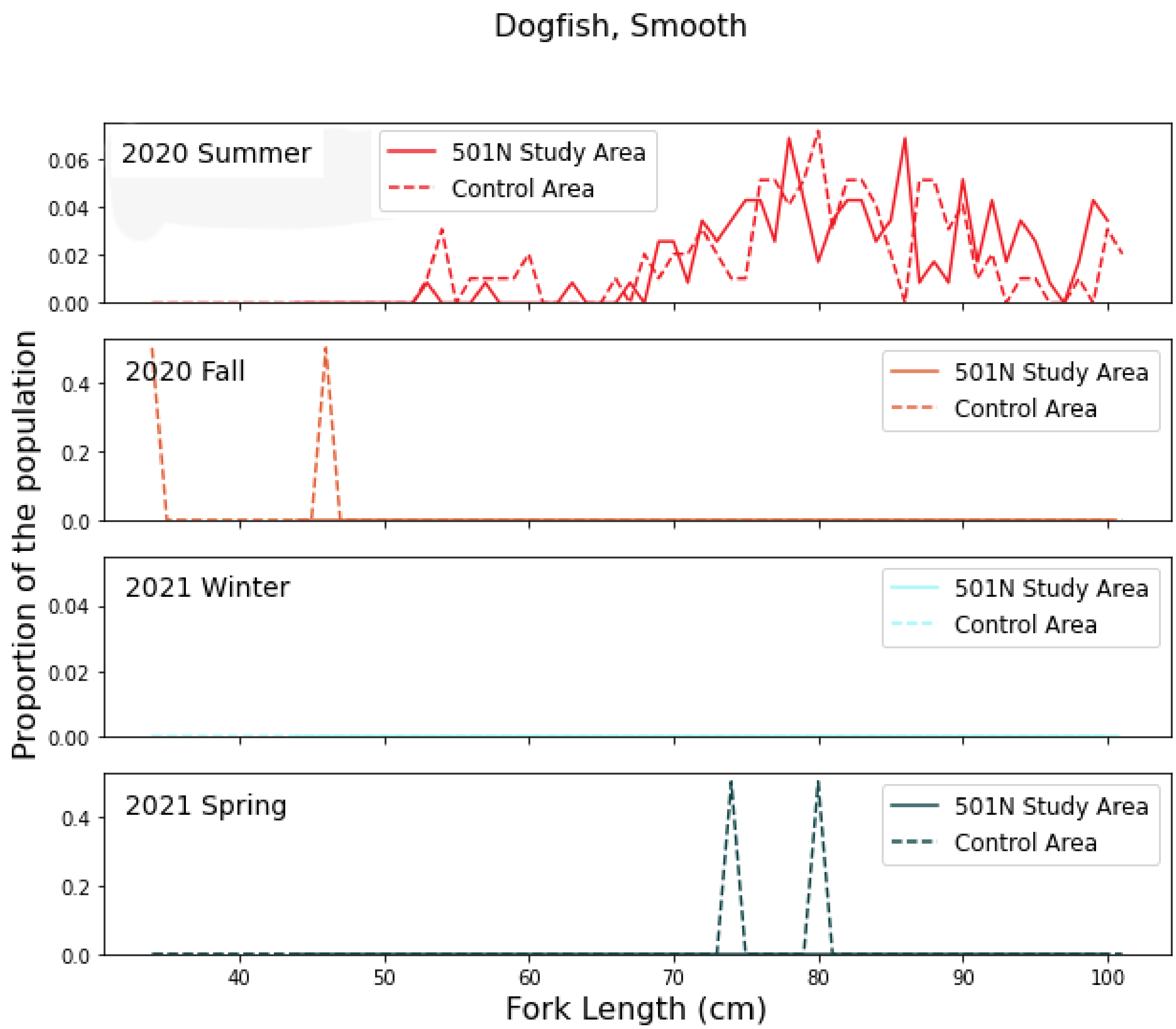


Figure 61: The seasonal length distributions of smooth dogfish in the 501N Study Area and Control Area.

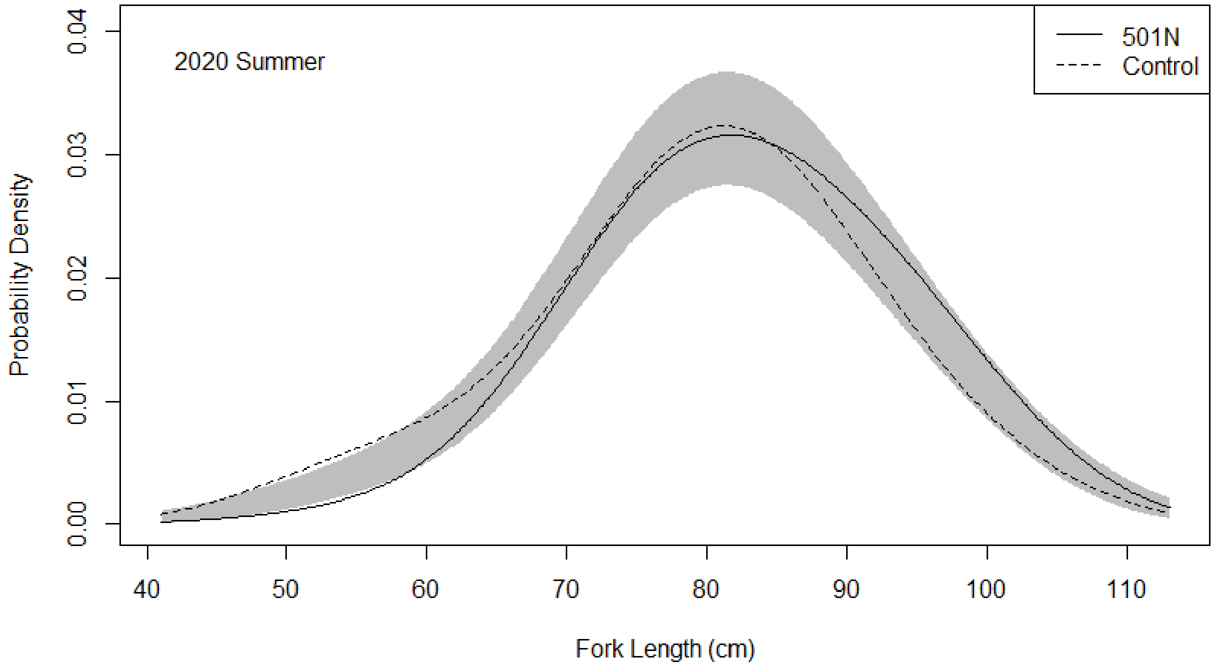


Figure 62: The population structure of smooth dogfish in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.

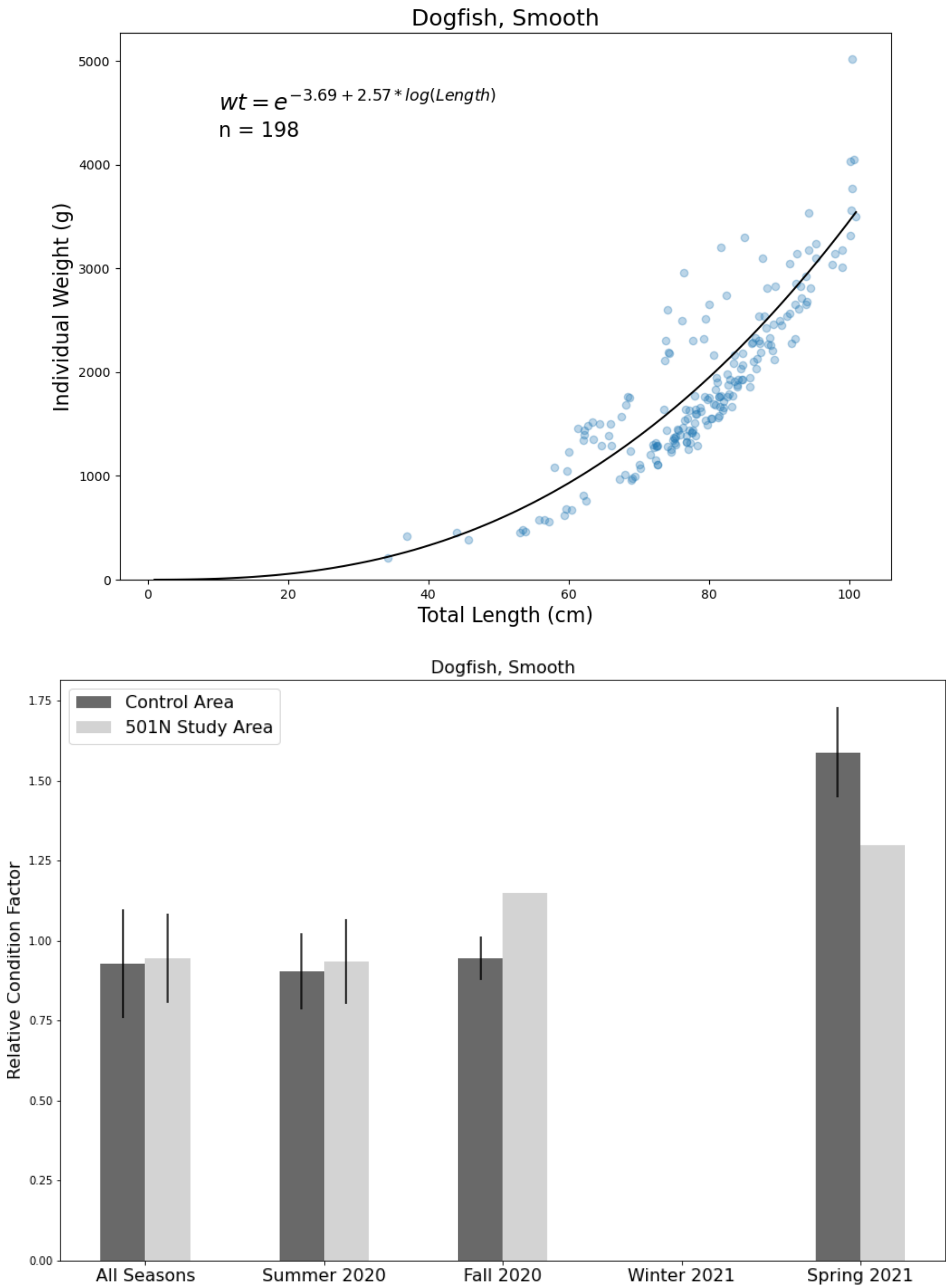


Figure 63: The seasonal condition of smooth dogfish (bottom) as derived from the length-weight relationship (top).

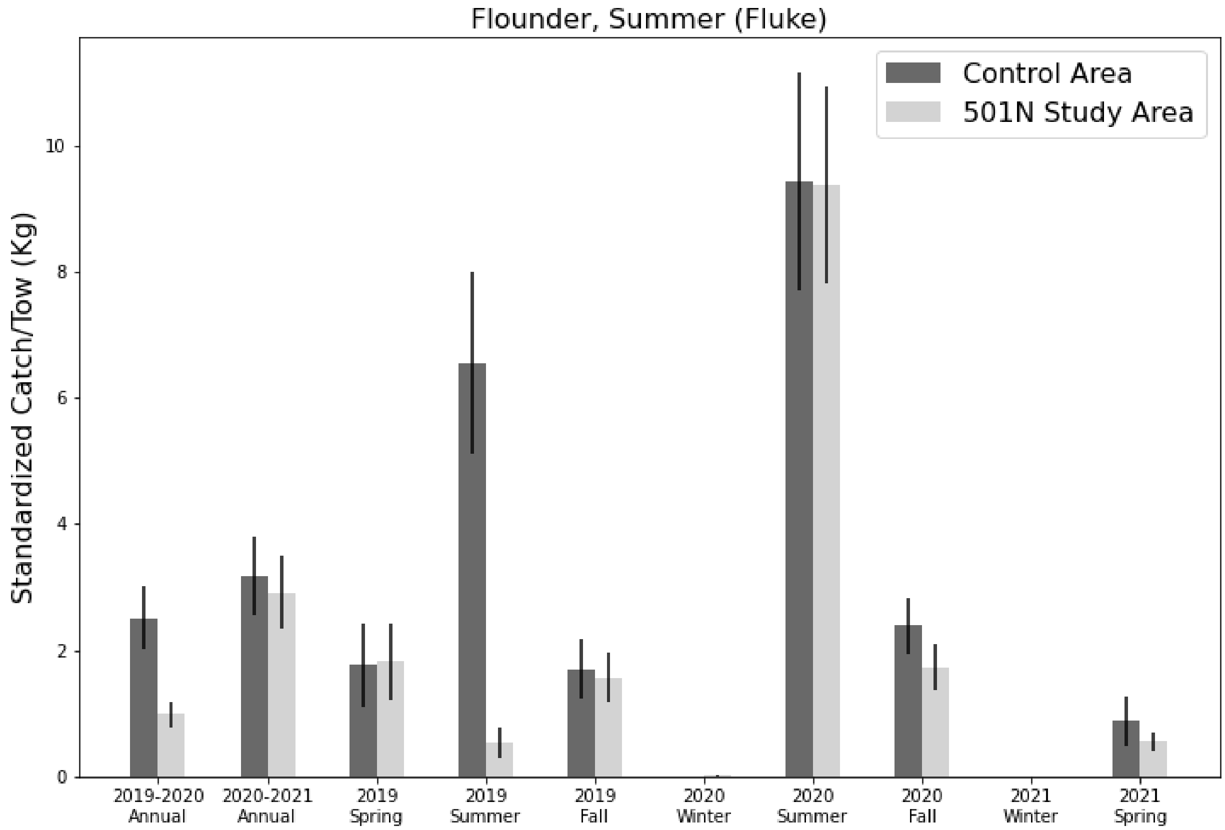


Figure 64: Seasonal catch rates of summer flounder in the 501N Study Area and Control Area.

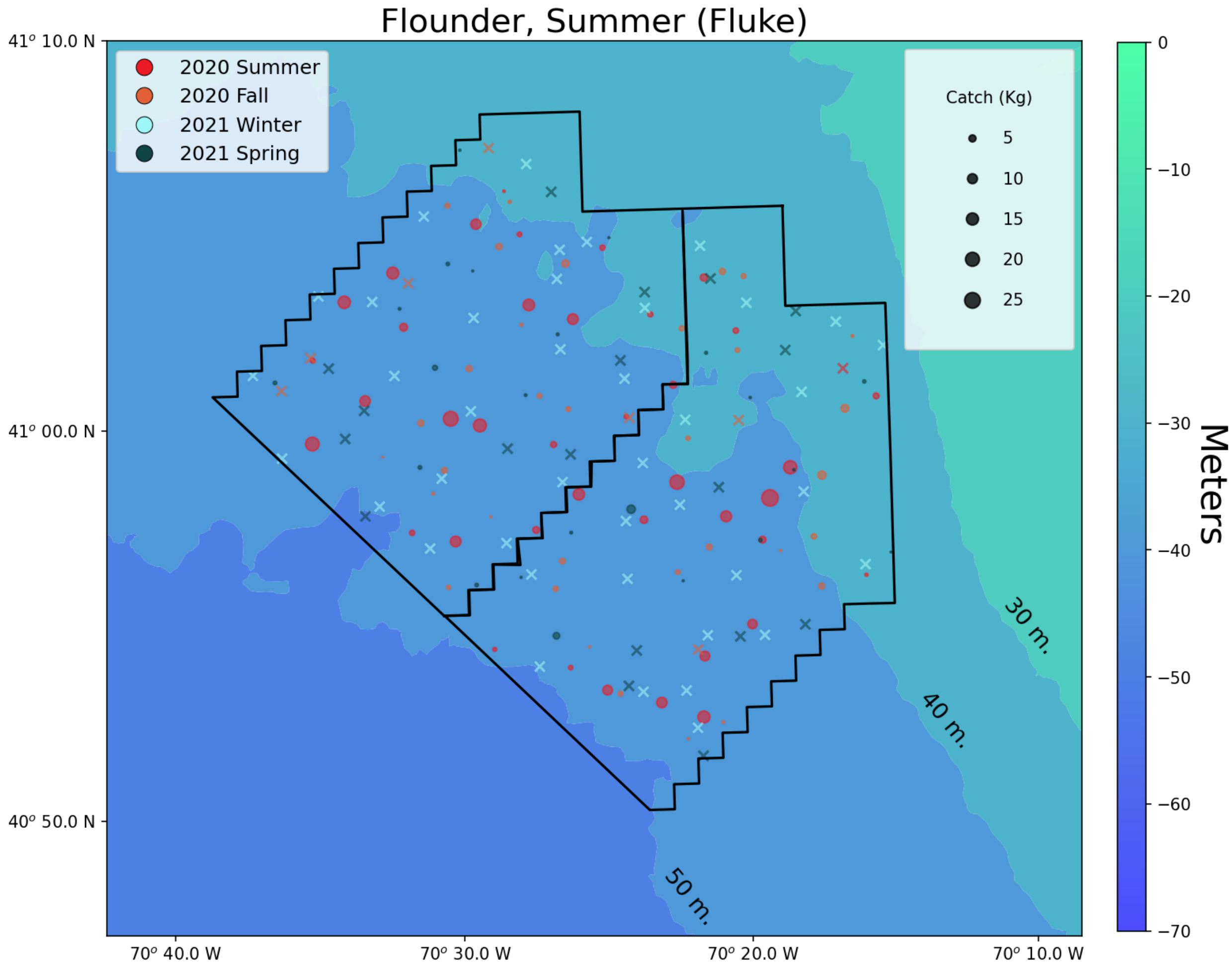


Figure 65: Seasonal distribution of the summer flounder catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

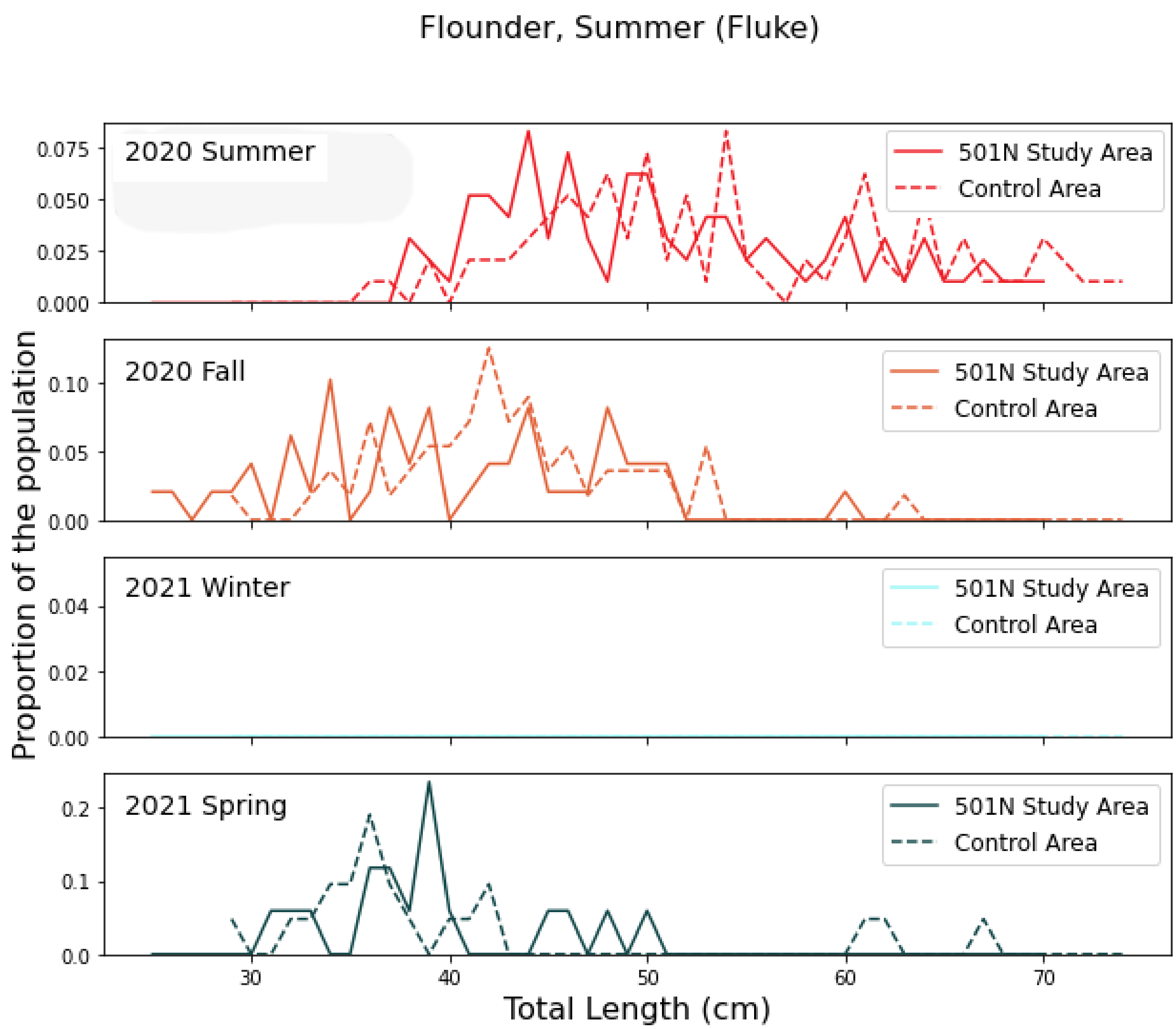


Figure 66: The seasonal length distributions of summer flounder in the 501N Study Area and Control Area.

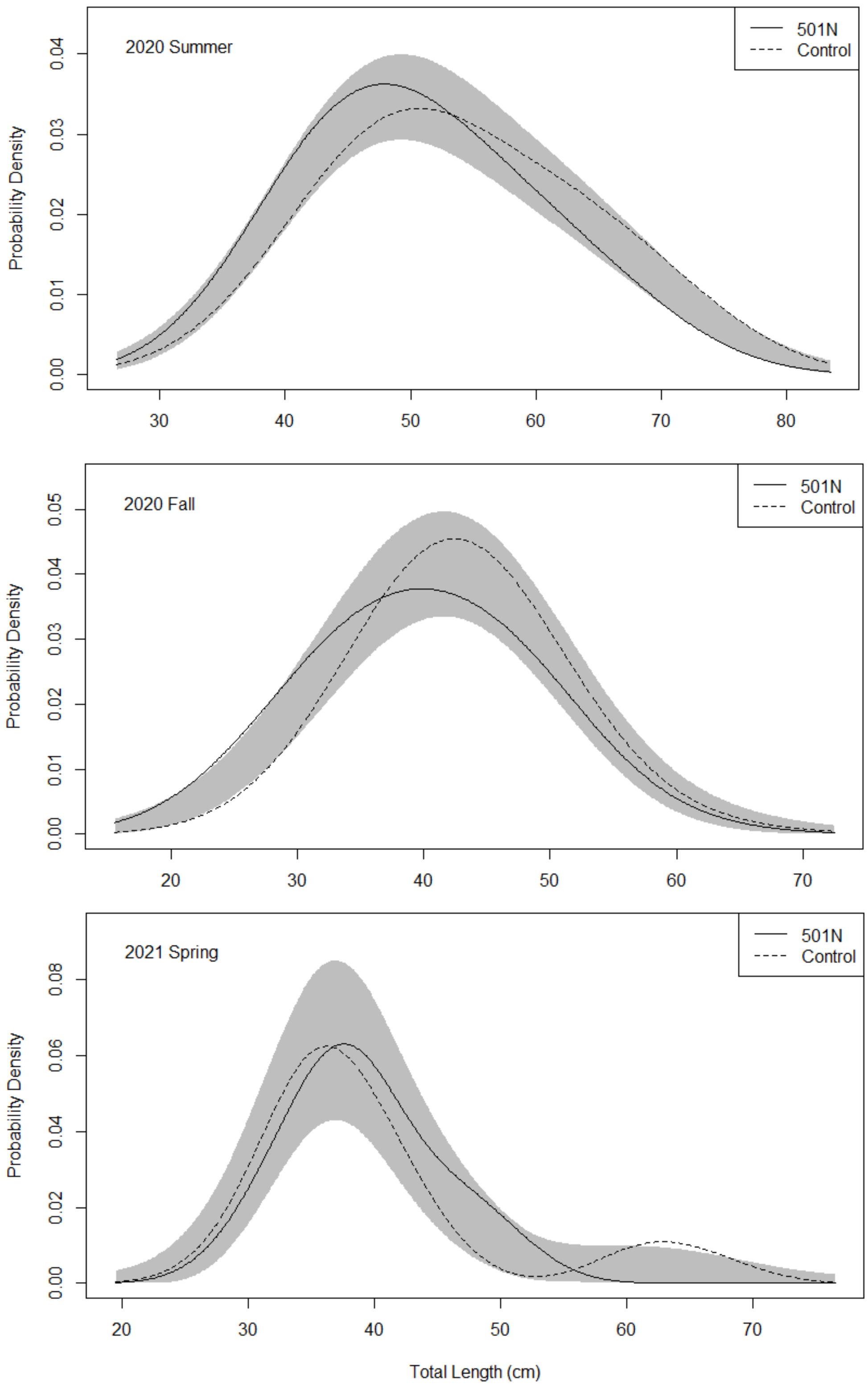


Figure 67: The population structure of summer flounder in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.

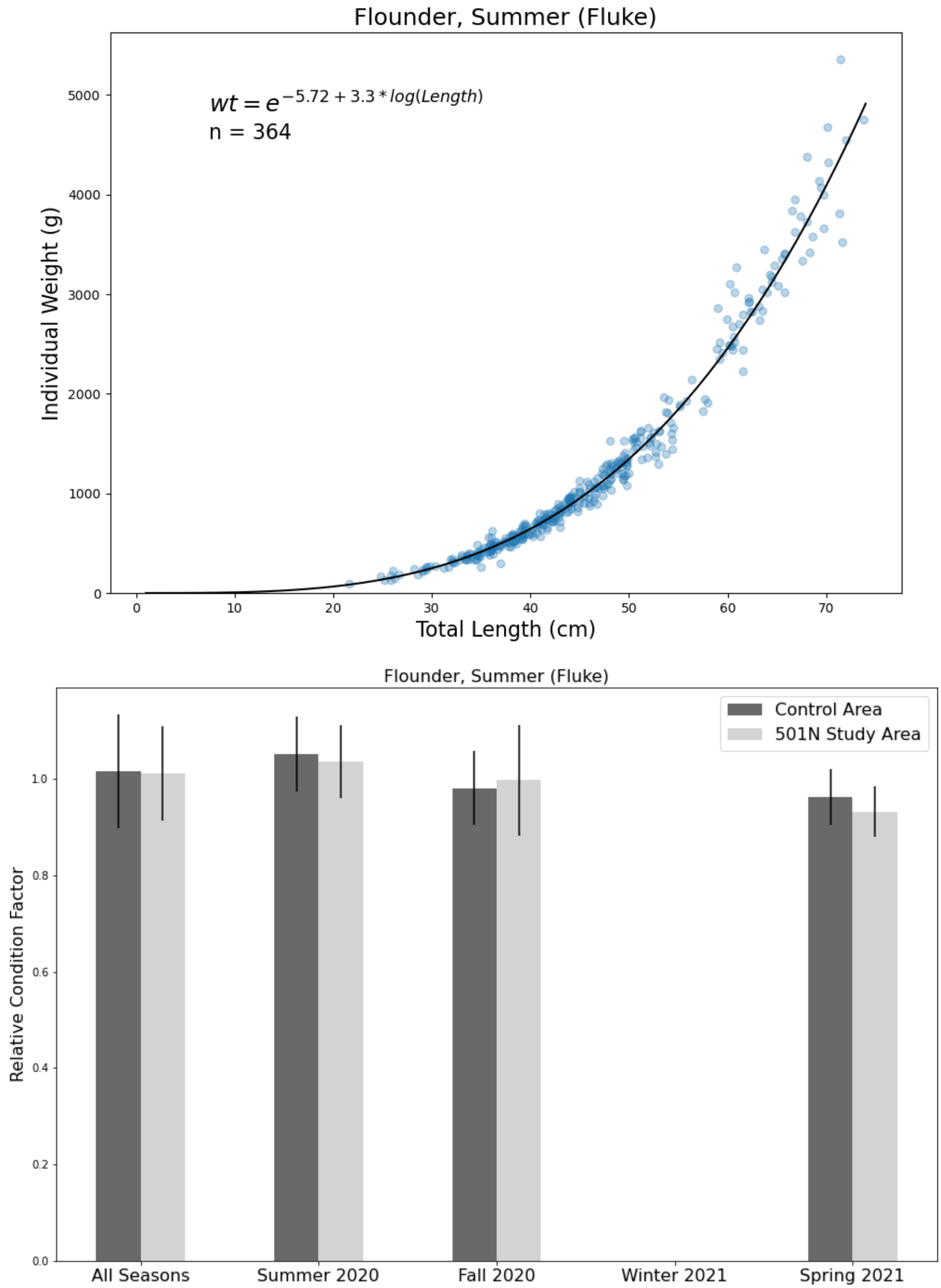


Figure 68: The seasonal condition of summer flounder (bottom) as derived from the length-weight relationship (top).

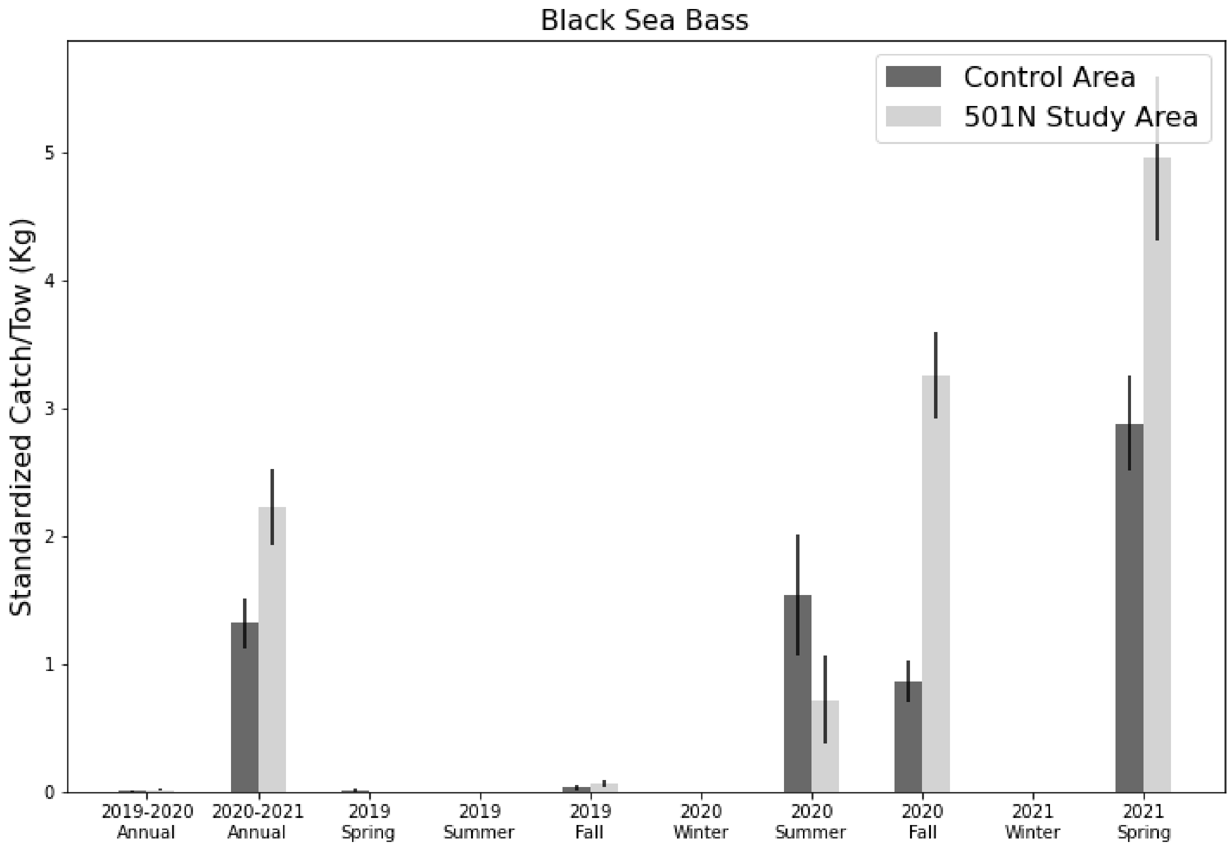


Figure 69: Seasonal catch rates of black sea bass in the 501N Study Area and Control Area.

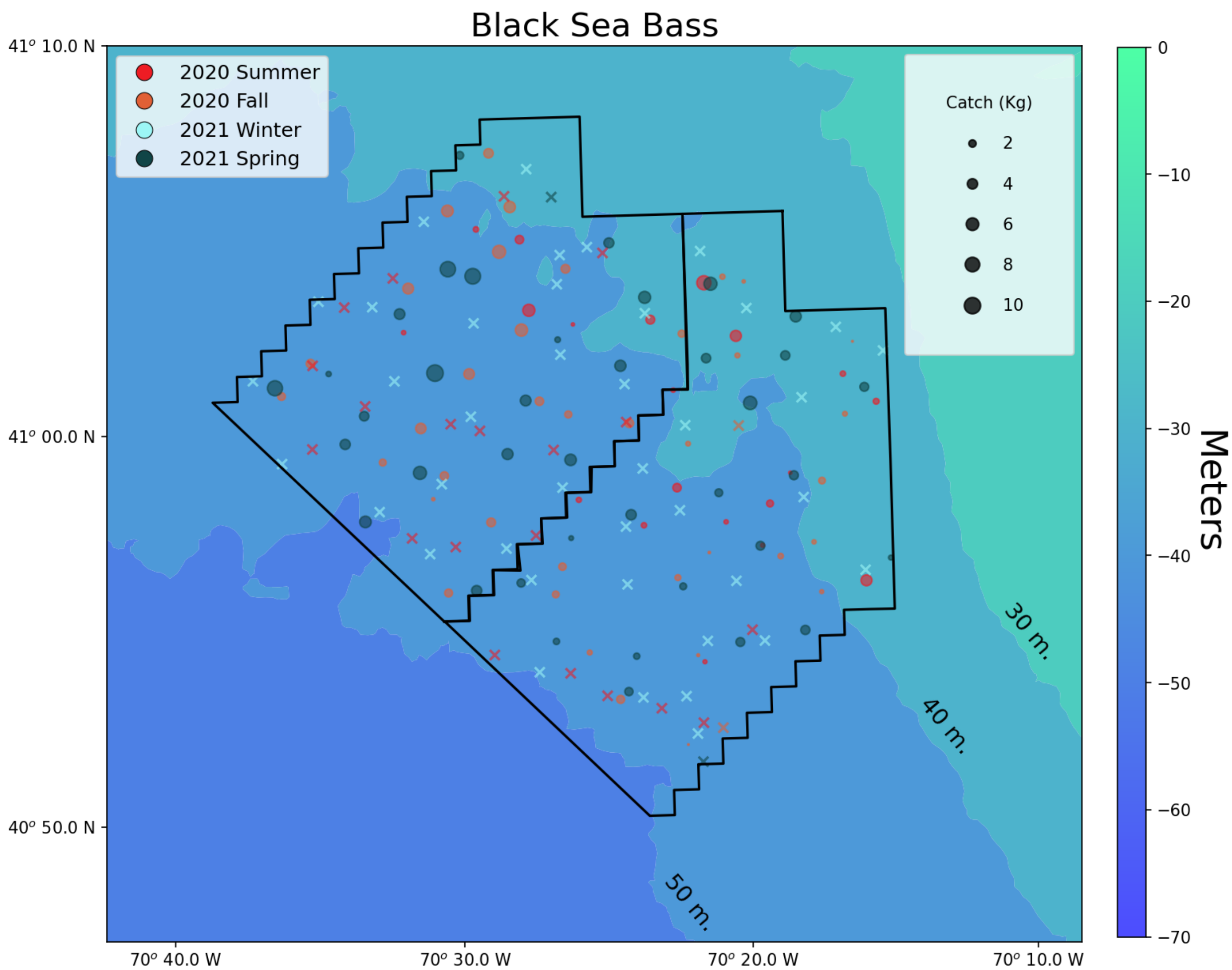


Figure 70: Seasonal distribution of the black sea bass catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

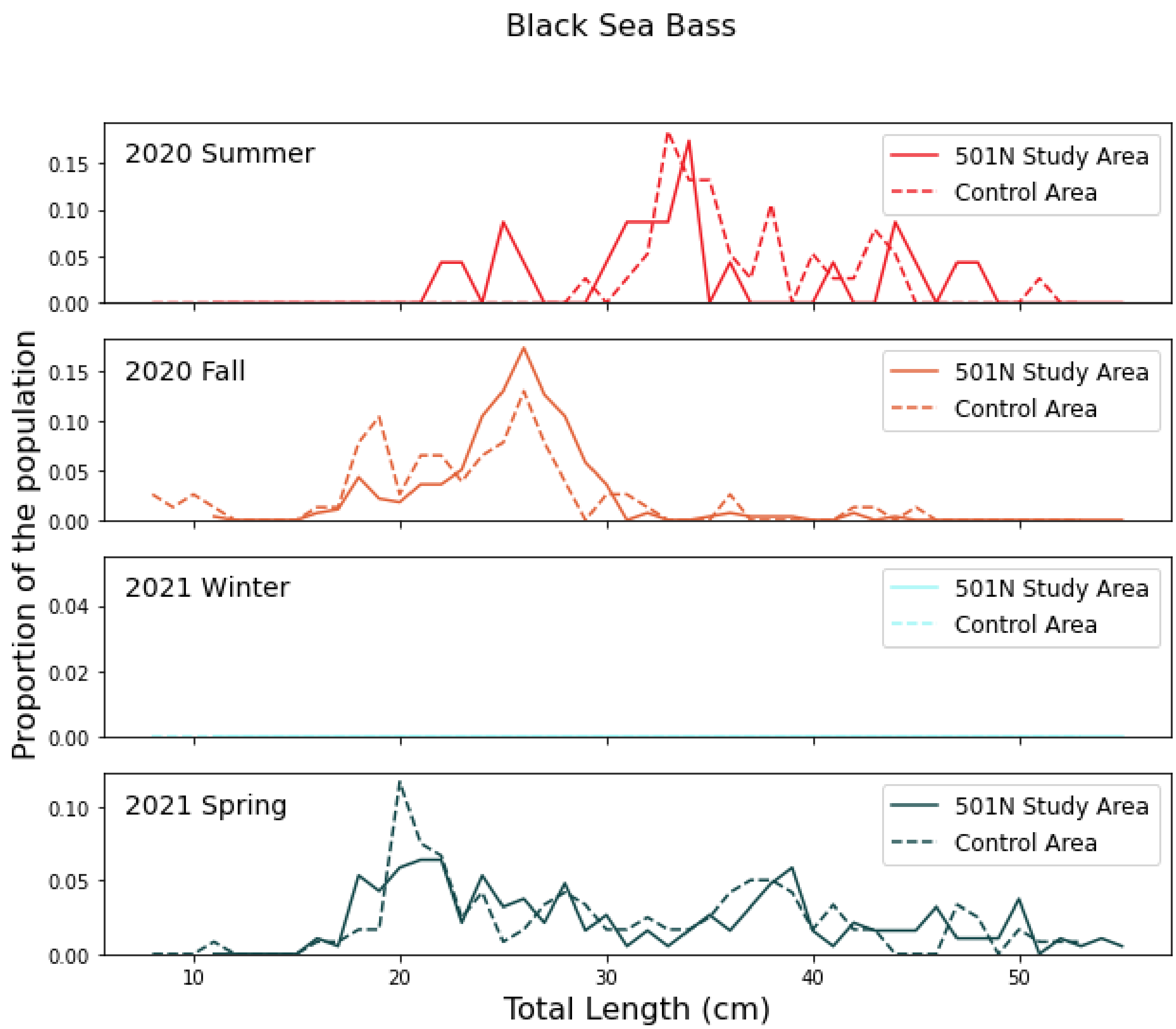


Figure 71: The seasonal length distributions of black sea bass in the 501N Study Area and Control Area.

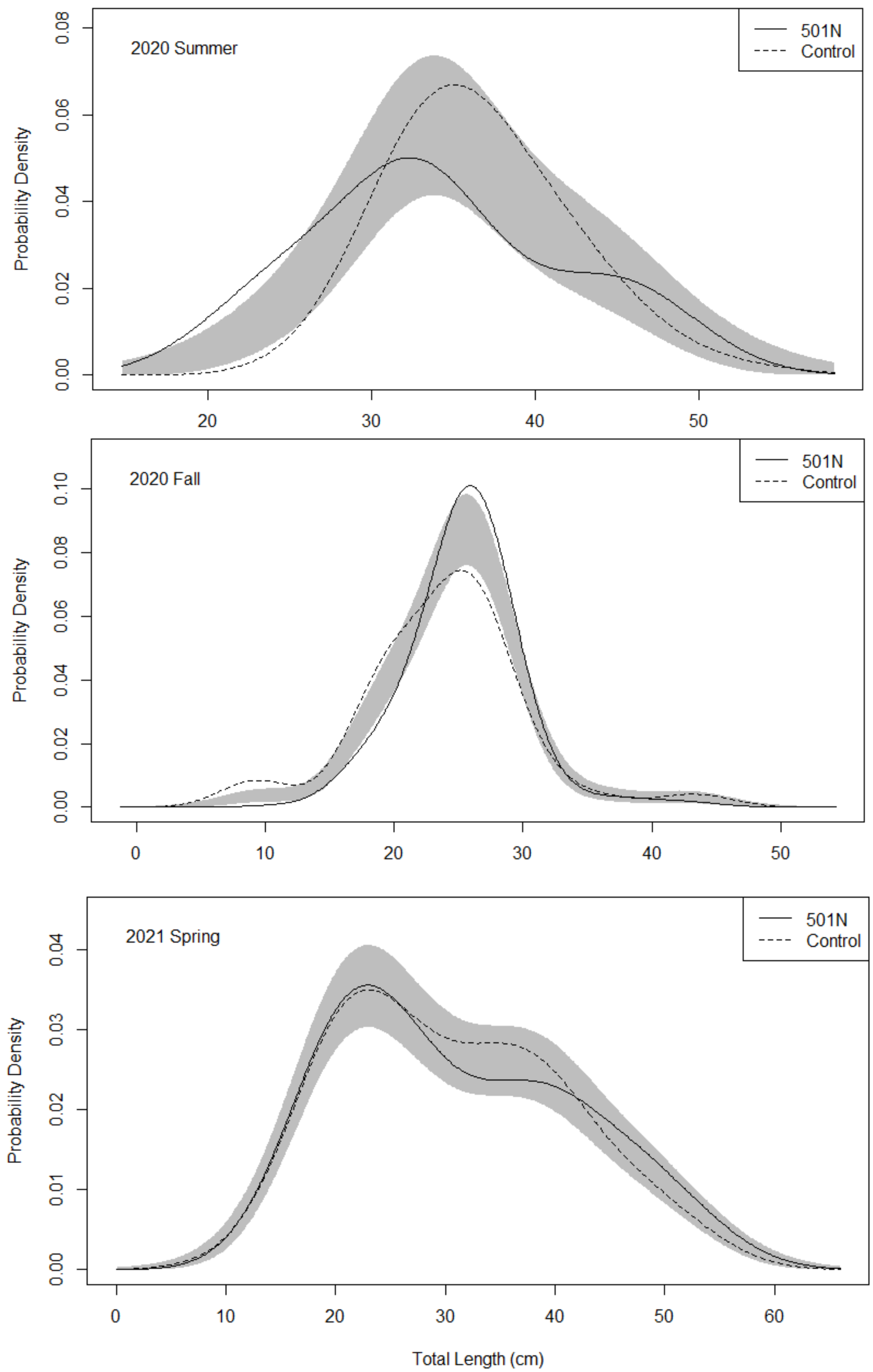


Figure 72: The population structure of black sea bass in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.

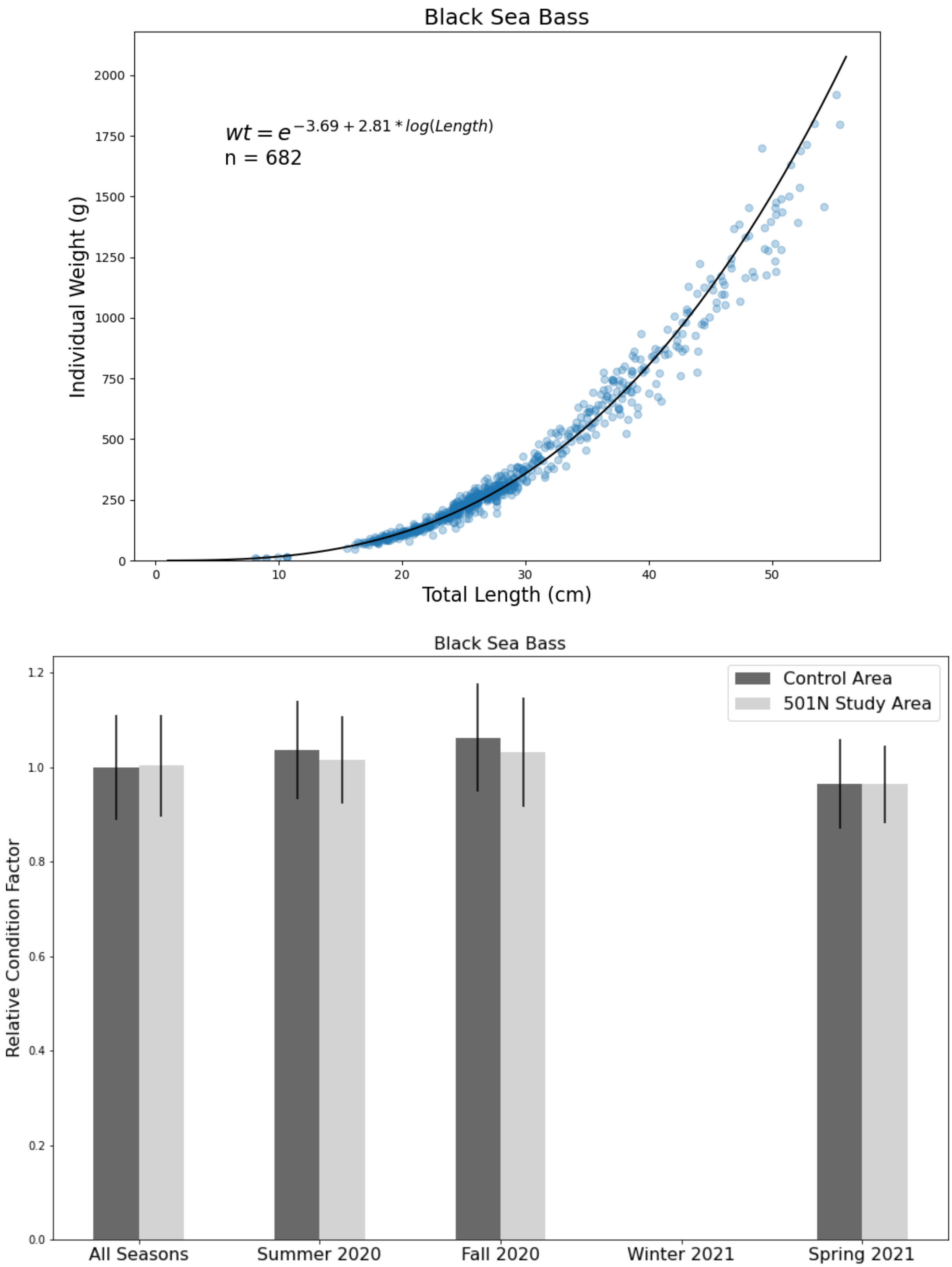


Figure 73: The seasonal condition of black sea bass (bottom) as derived from the length-weight relationship (top).

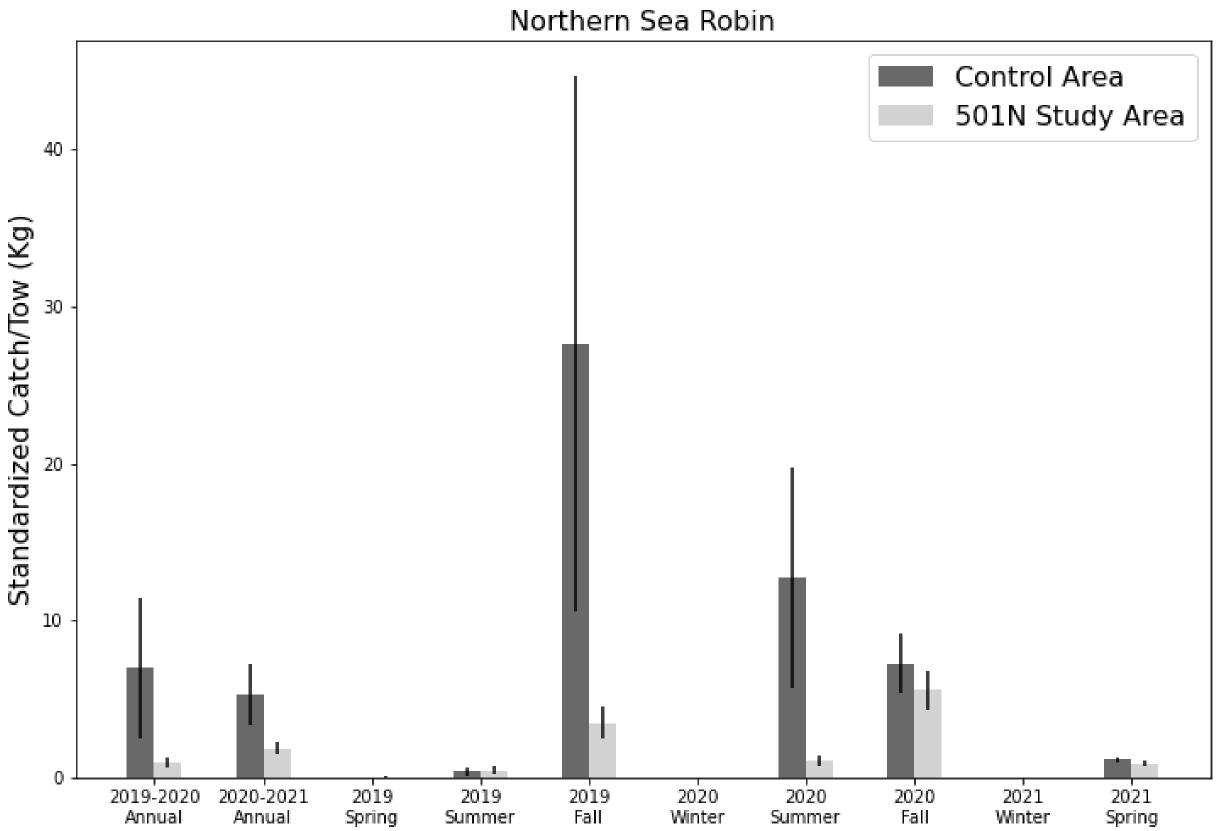


Figure 74: Seasonal catch rates of northern sea robin in the 501N Study Area and Control Area.

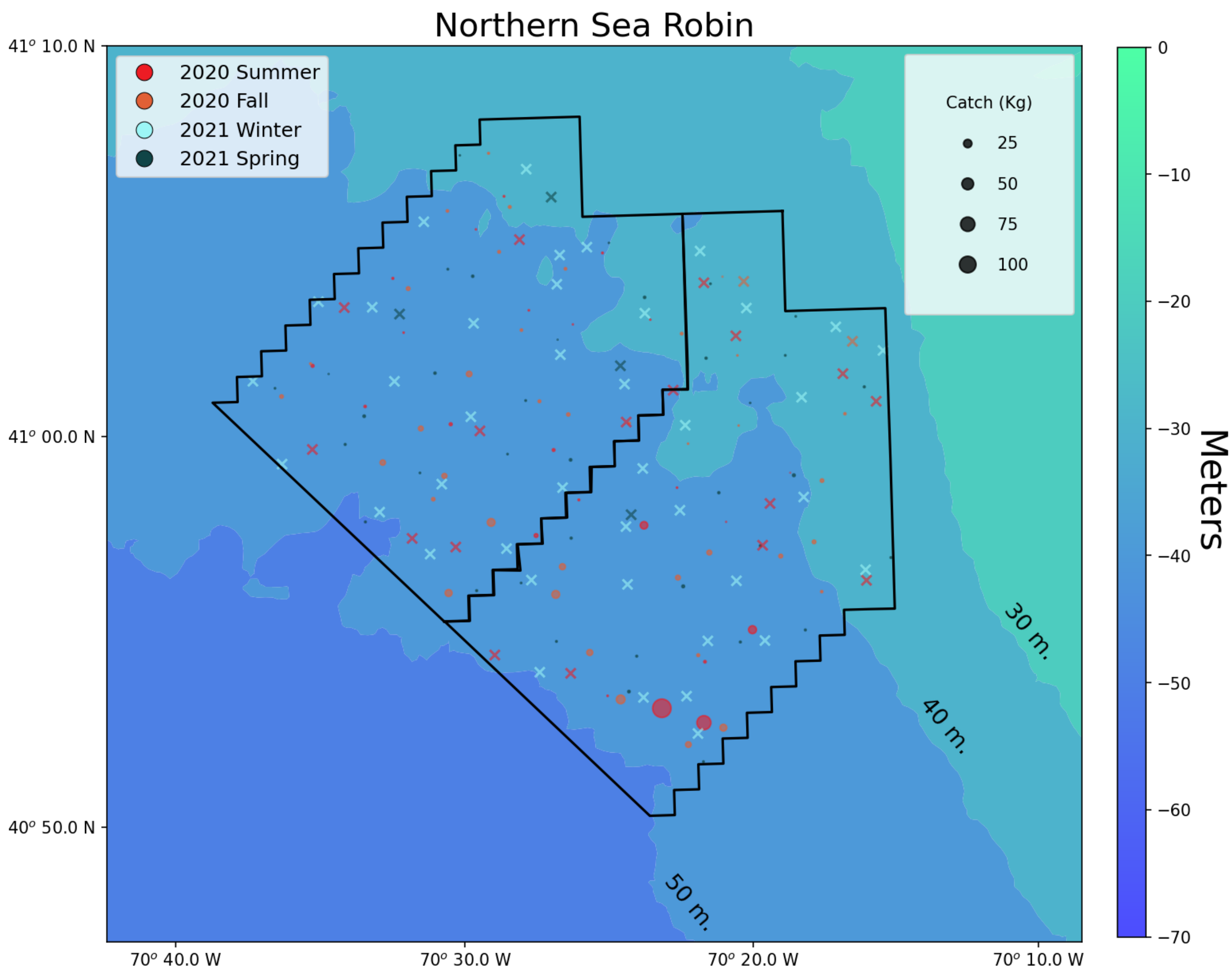


Figure 75: Seasonal distribution of the northern sea robin catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

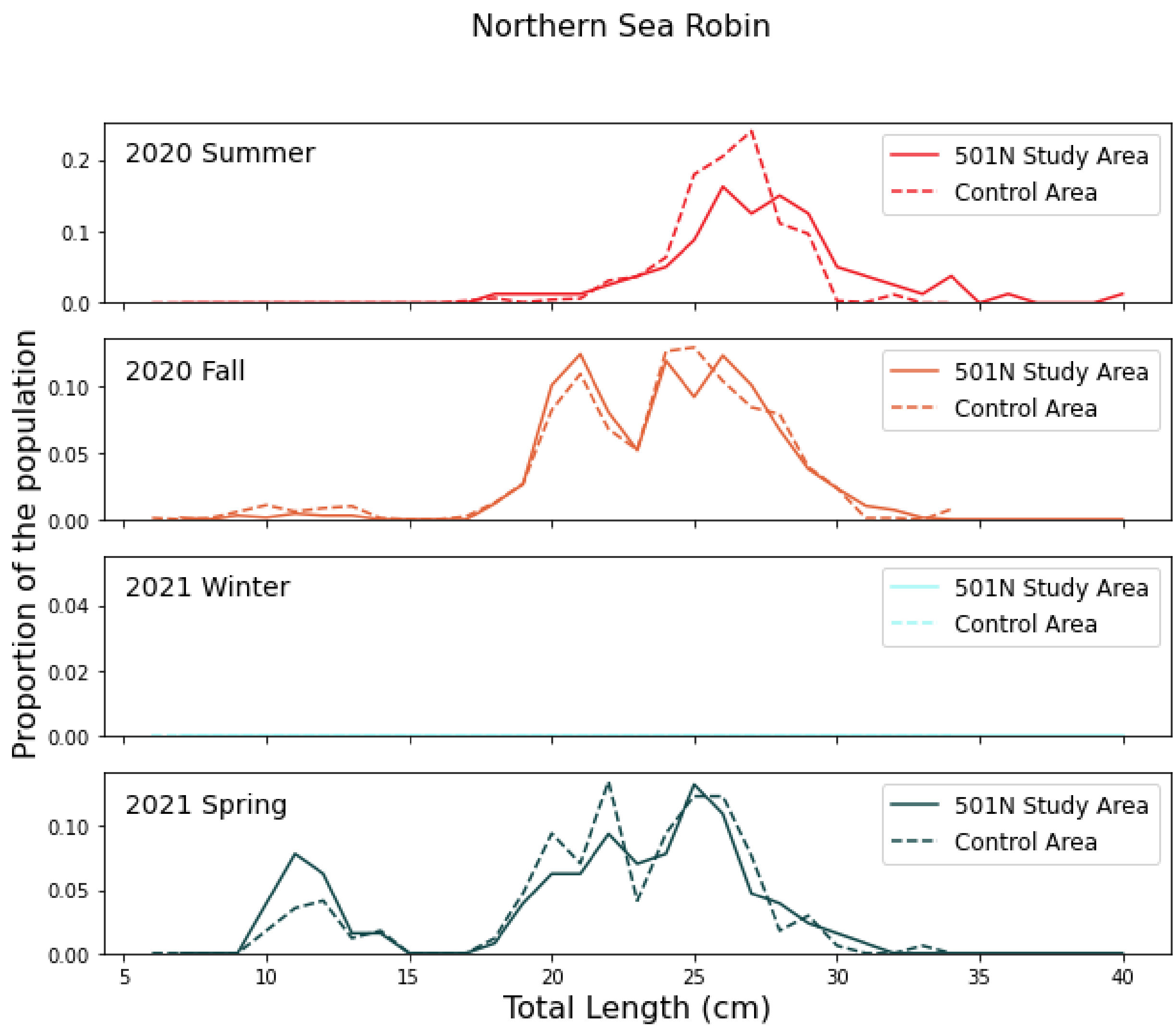


Figure 76: The seasonal length distributions of northern sea robin in the 501N Study Area and Control Area.

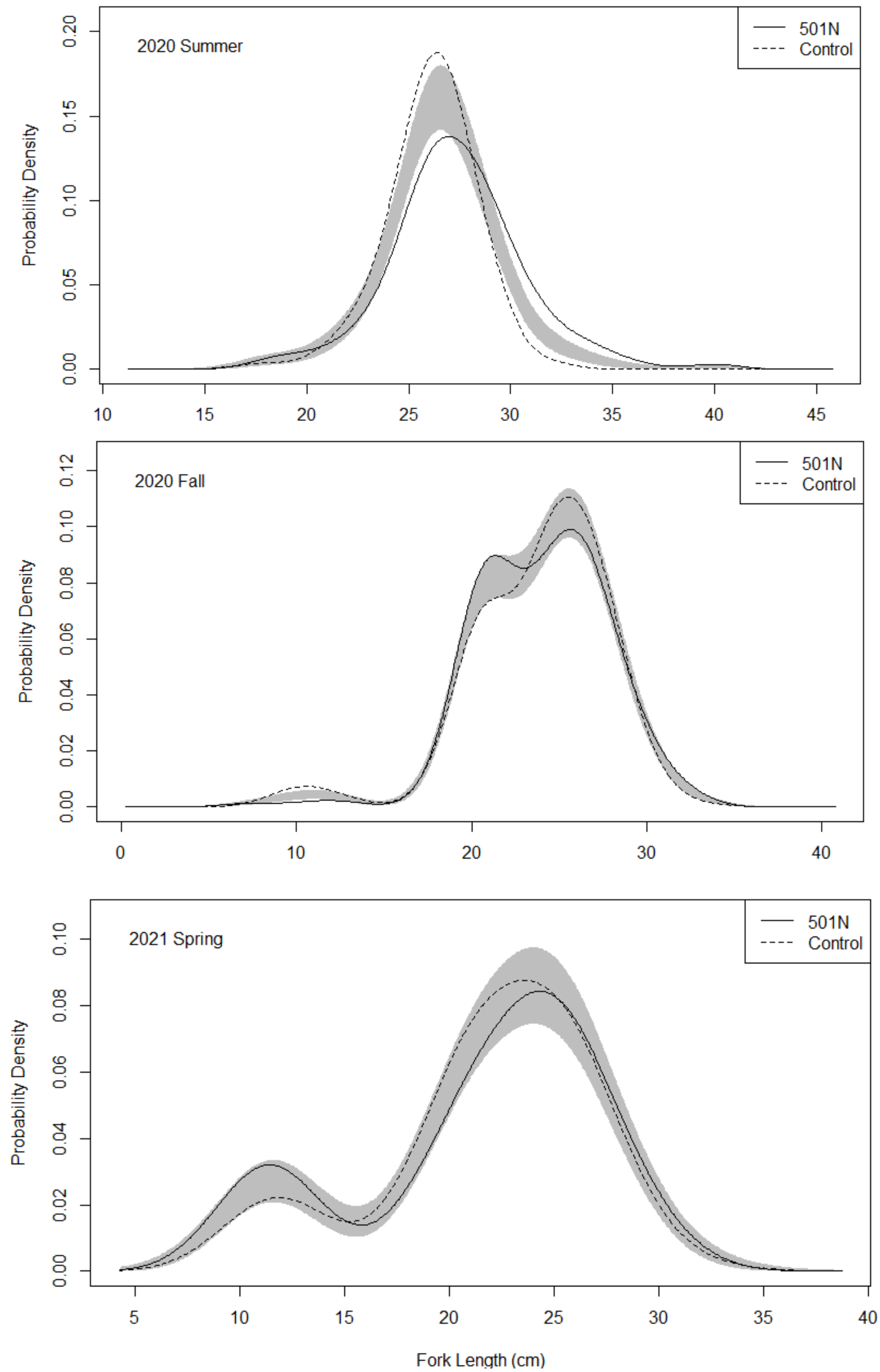


Figure 77: The population structure of northern sea robin in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.

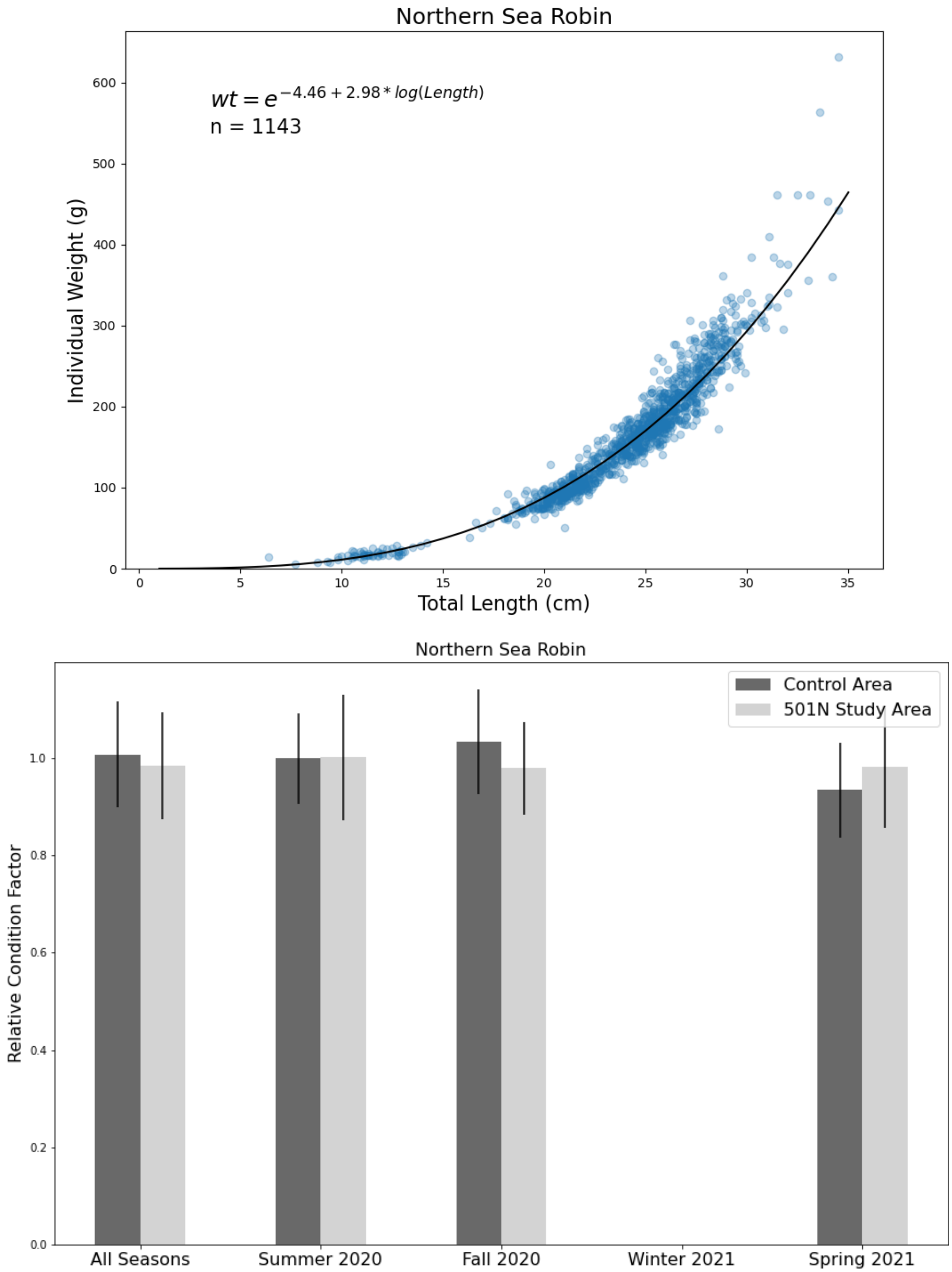


Figure 78: The seasonal condition of northern sea robin (bottom) as derived from the length-weight relationship (top).

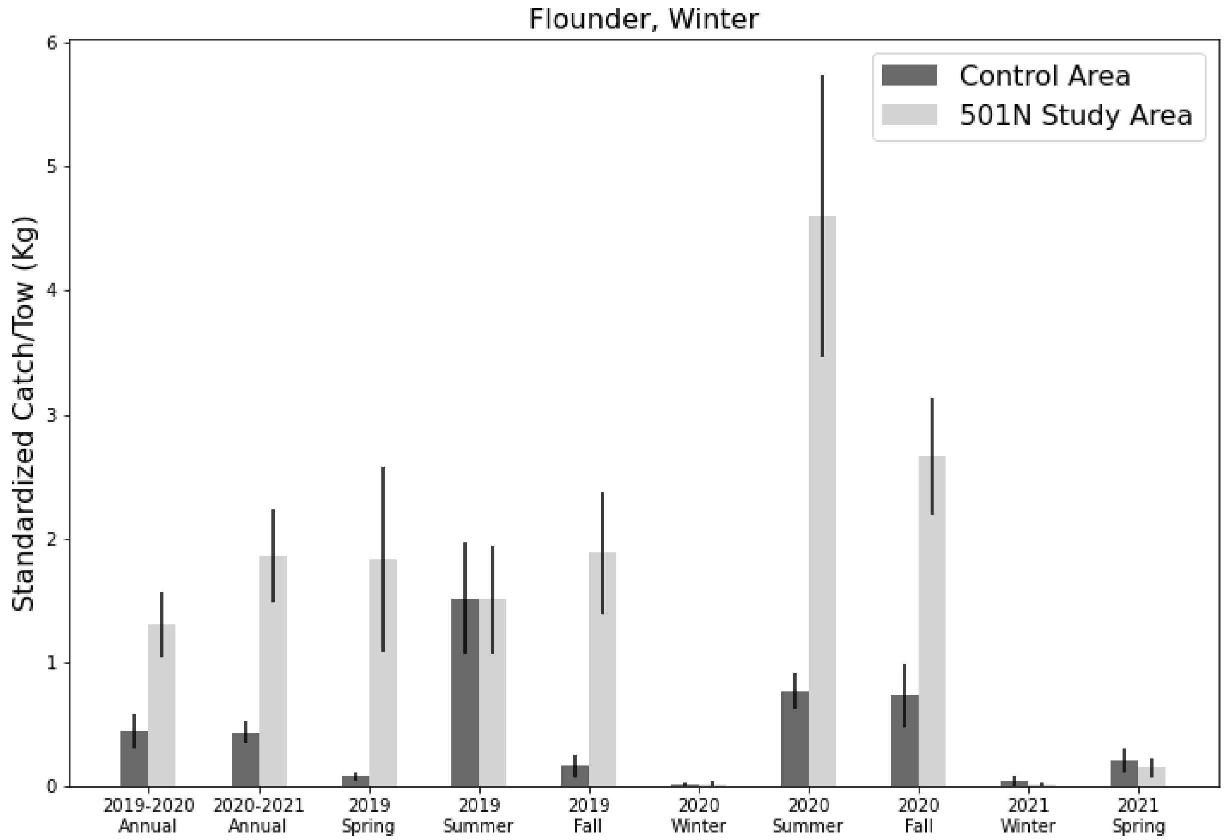


Figure 79: Seasonal catch rates of winter flounder in the 501N Study Area and Control Area.

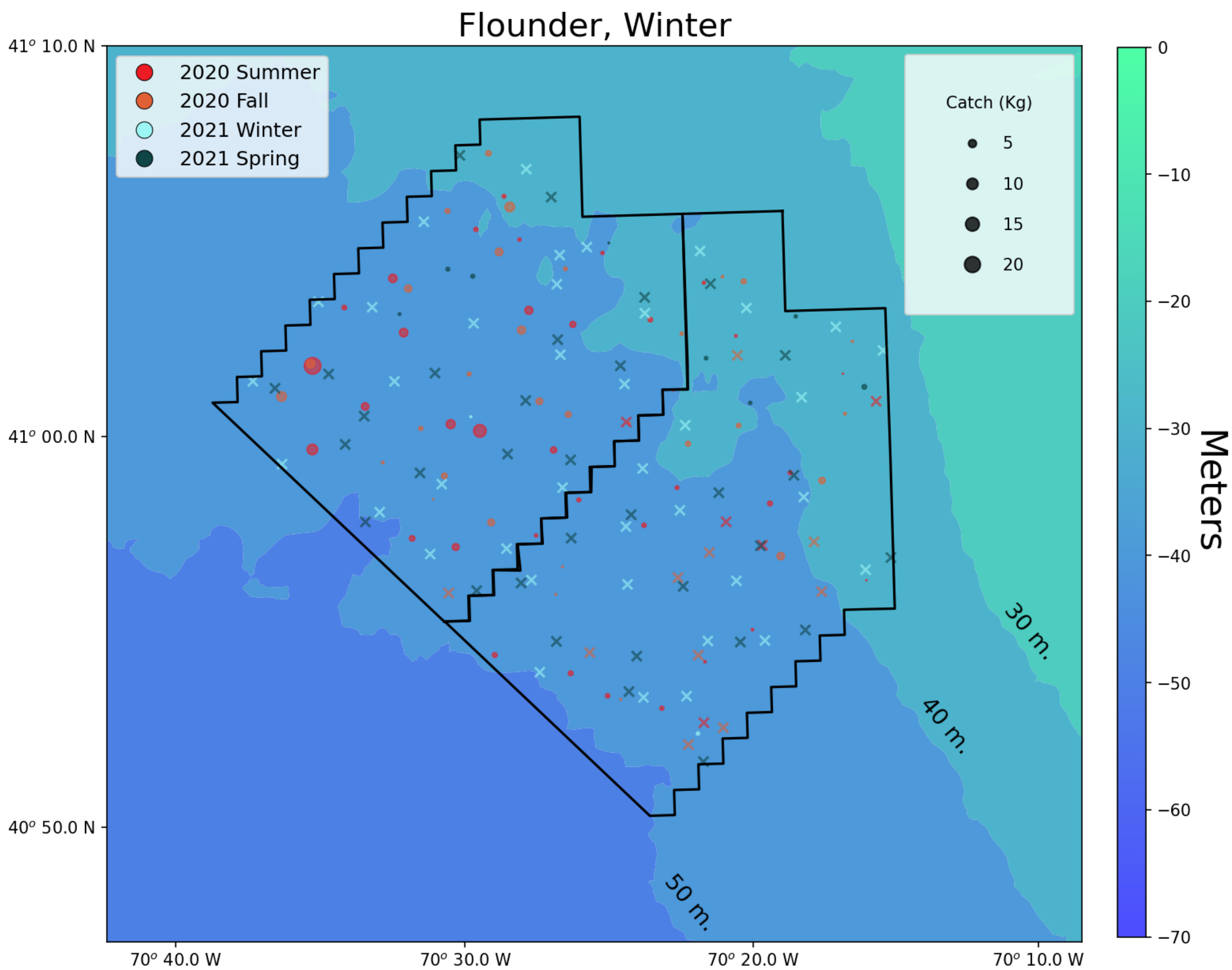


Figure 80: Seasonal distribution of the winter flounder catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

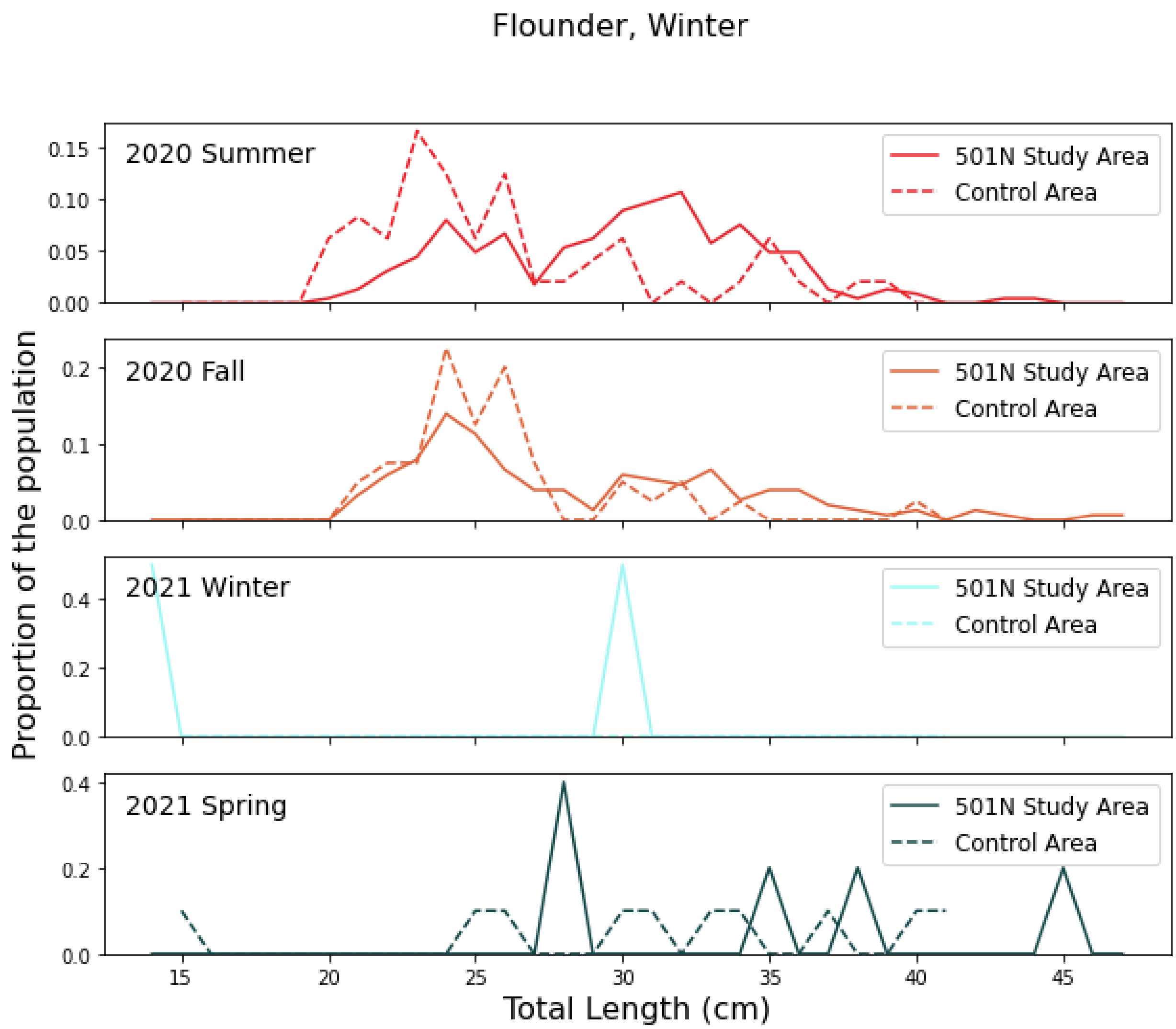


Figure 81: The seasonal length distributions of winter flounder in the 501N Study Area and Control Area.

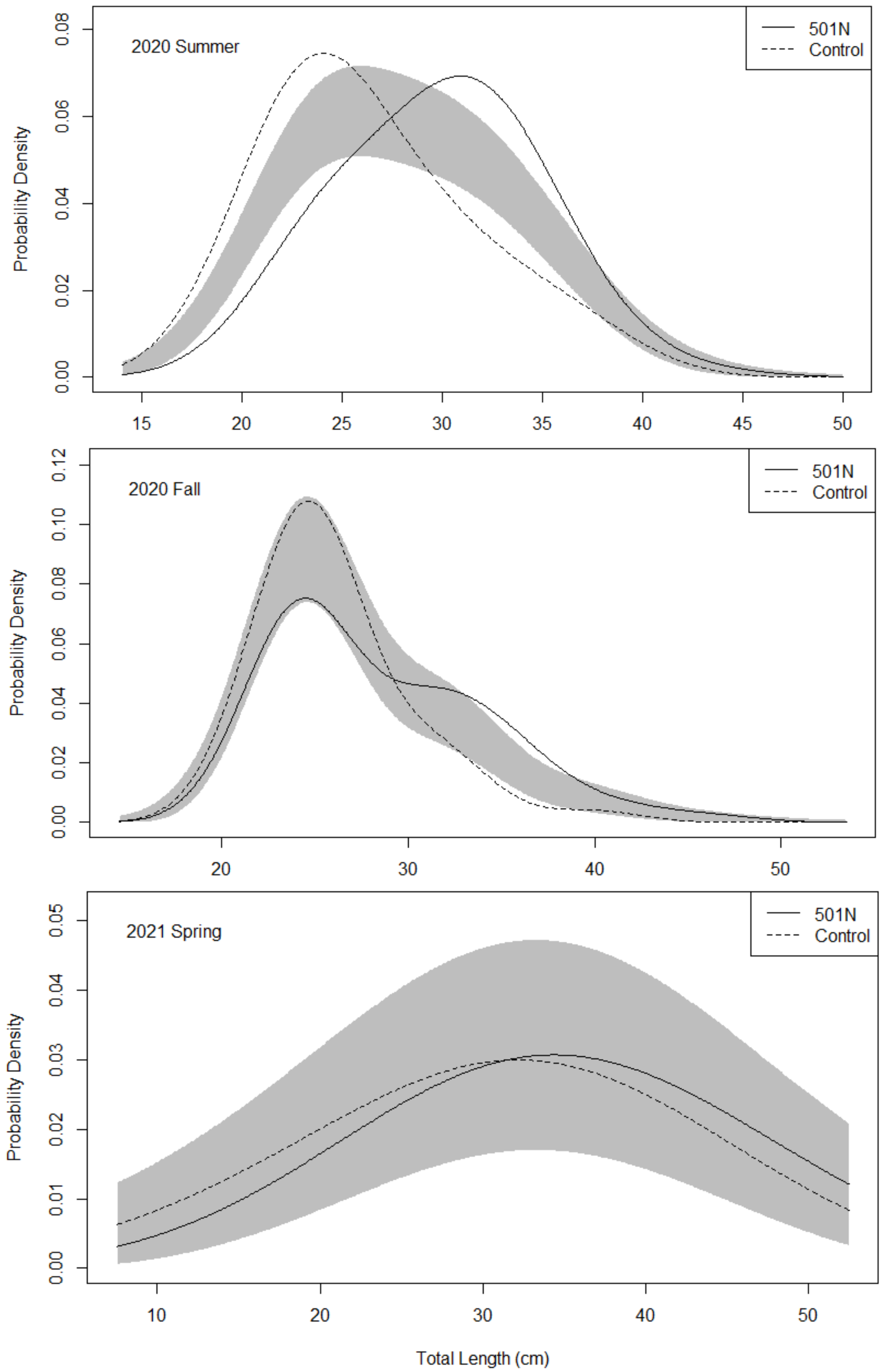
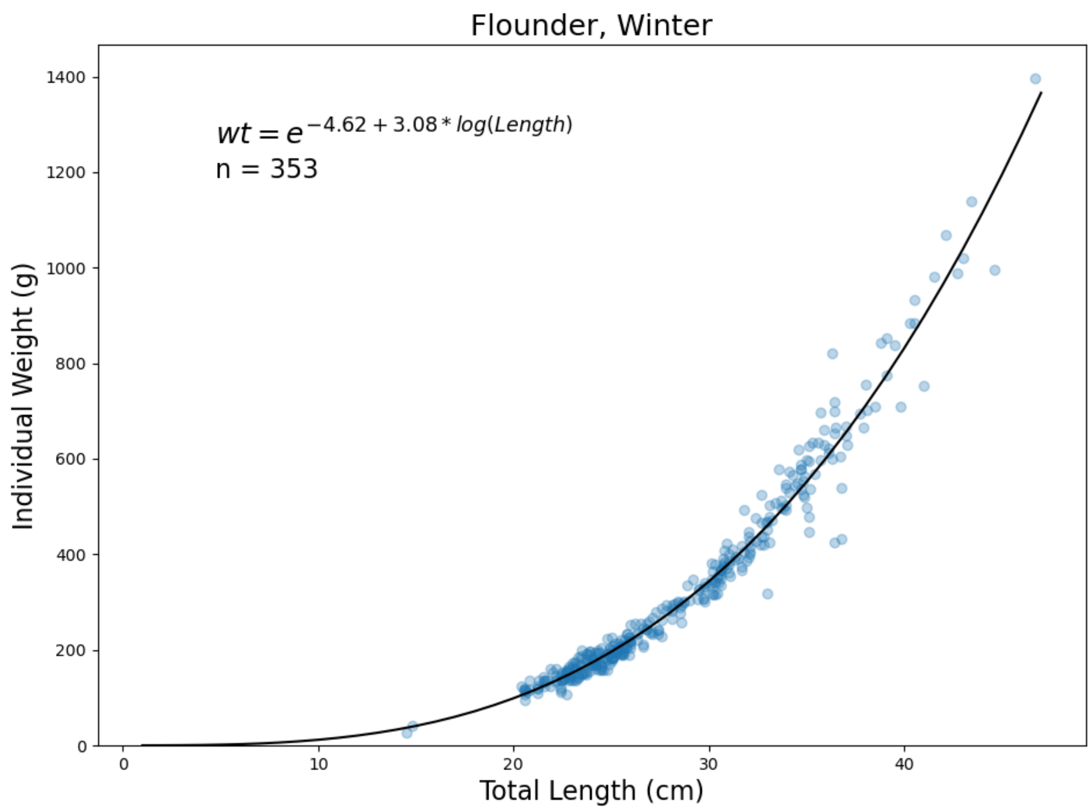


Figure 82: The population structure of winter flounder in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



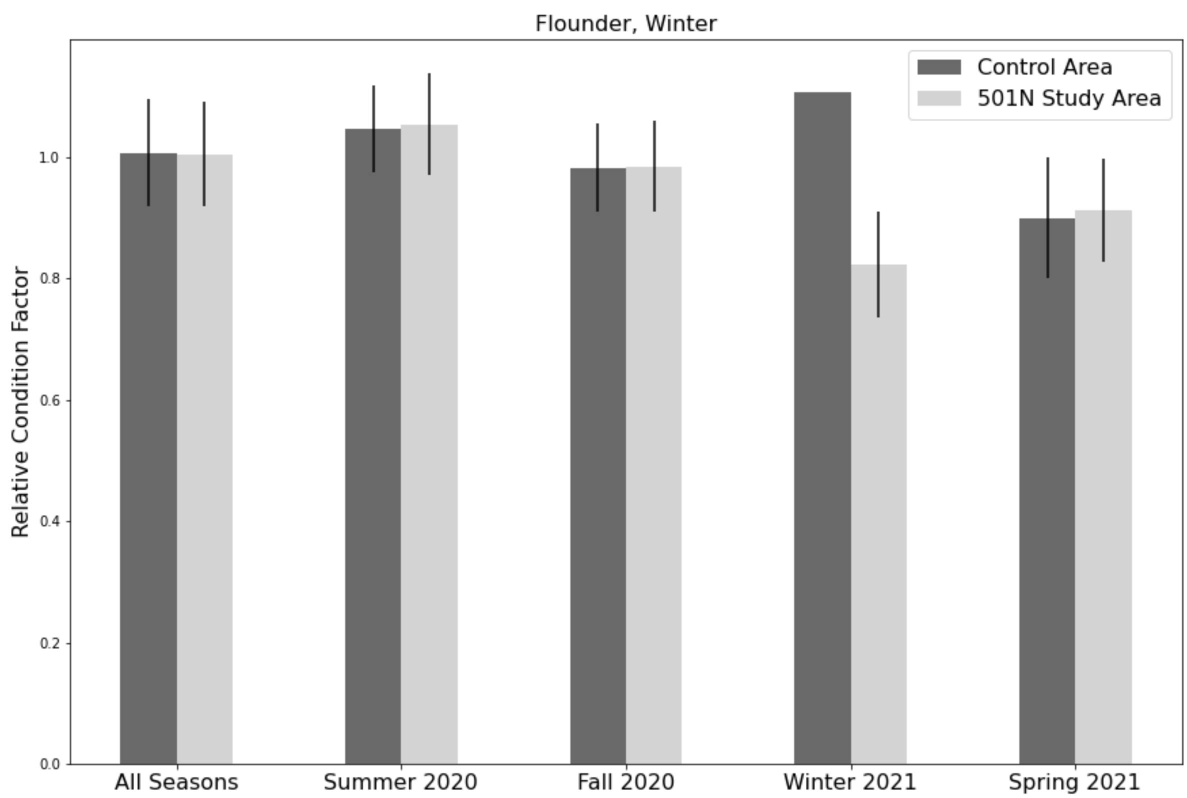


Figure 83: The seasonal condition of winter flounder (bottom) as derived from the length-weight relationship (top).

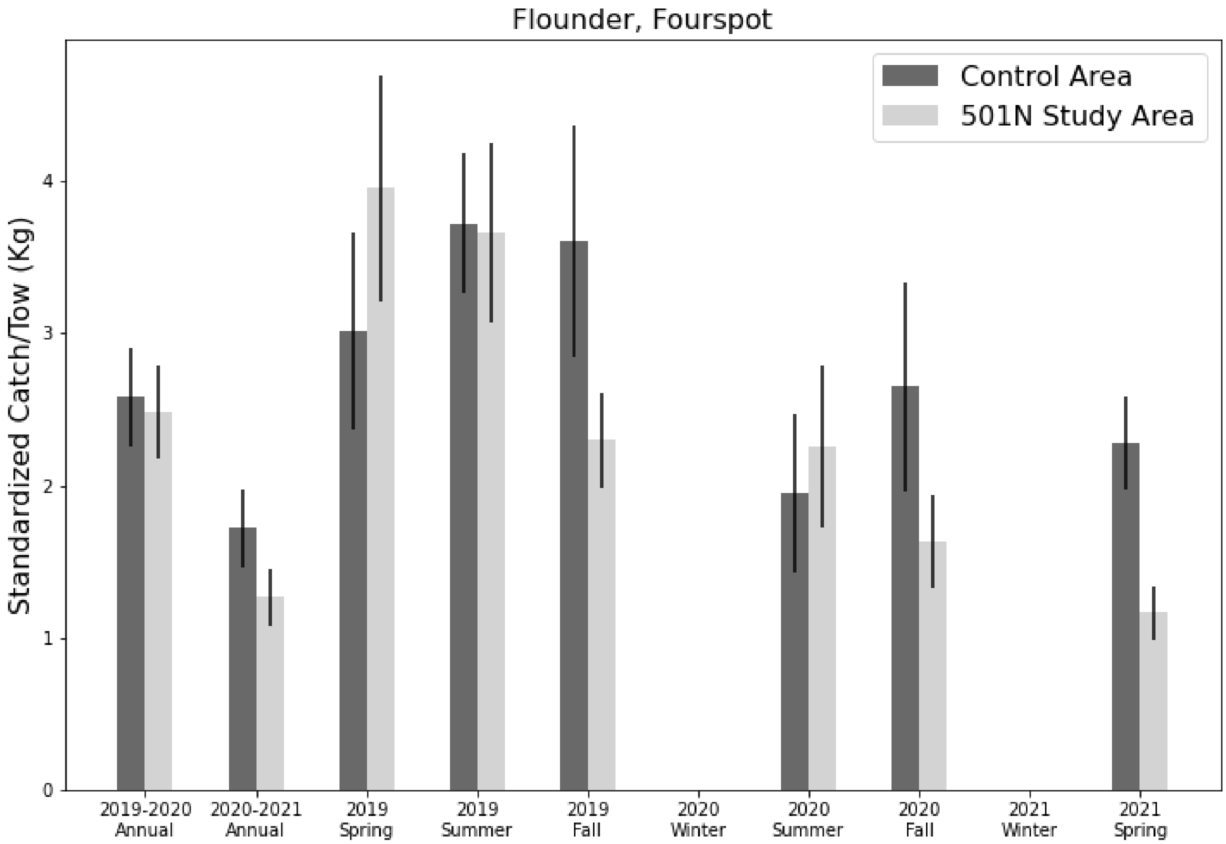


Figure 84: Seasonal catch rates of fourspot flounder in the 501N Study Area and Control Area.

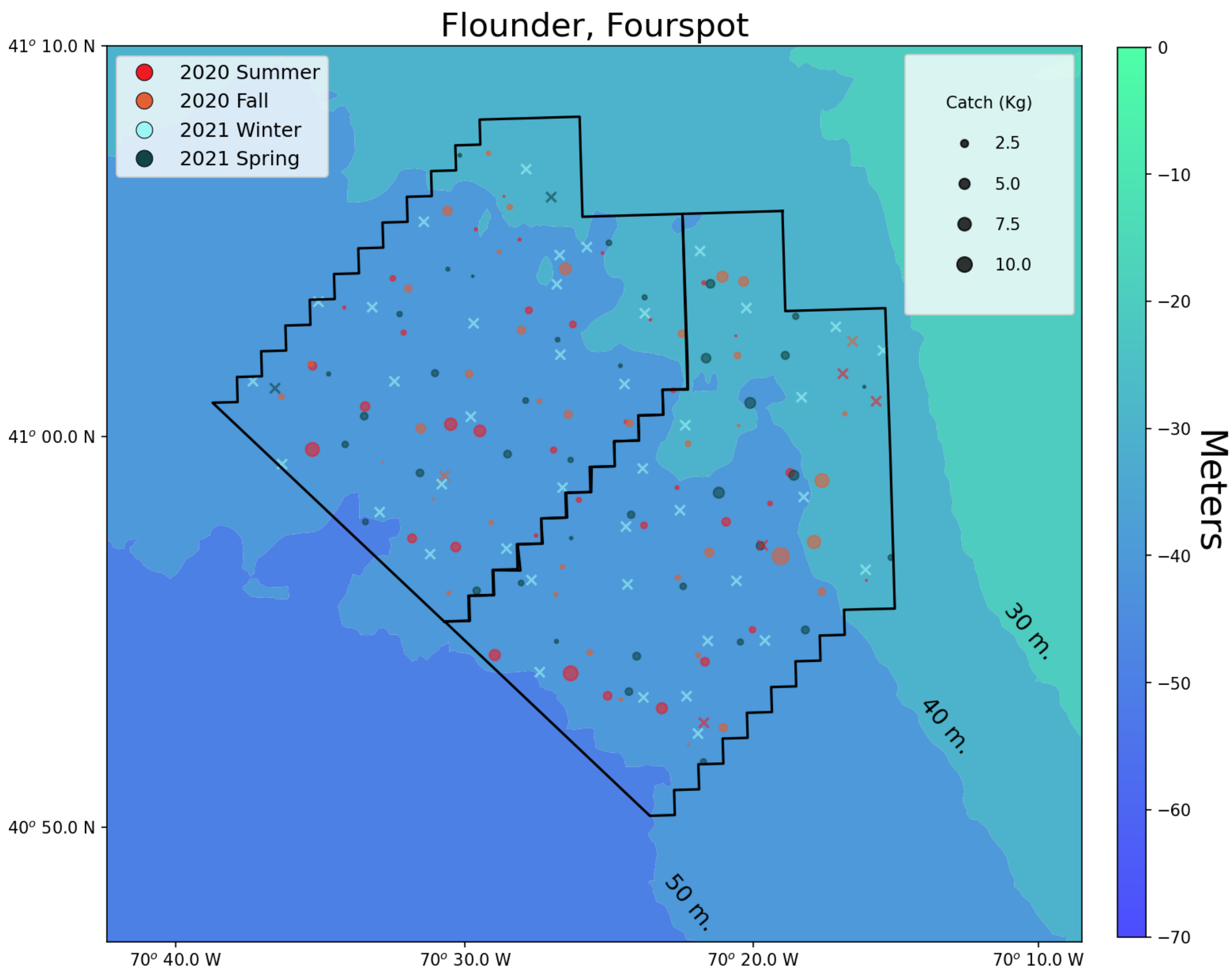


Figure 85: Seasonal distribution of the fourspot flounder catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

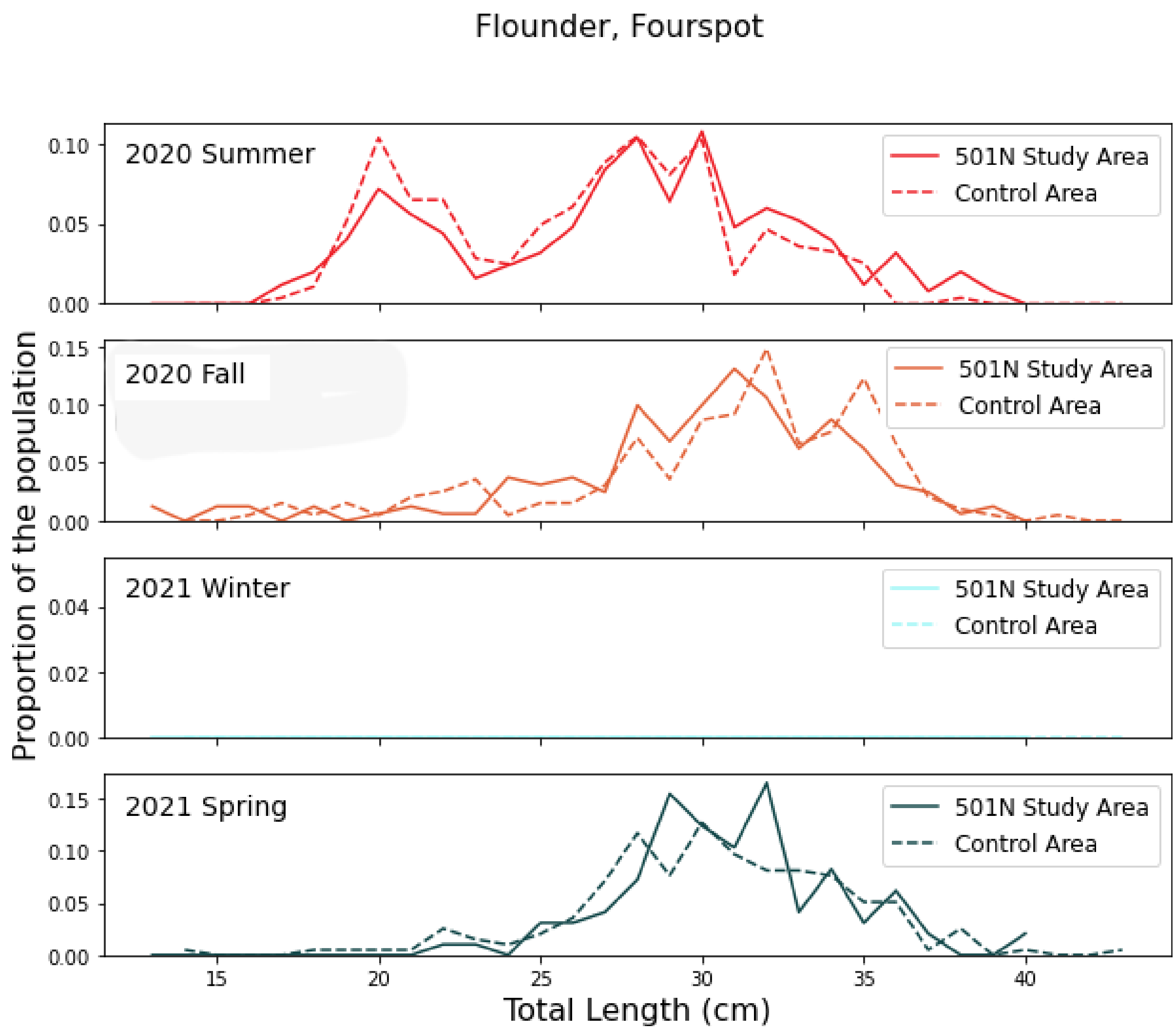


Figure 86: The seasonal length distributions of fourspot flounder in the 501N Study Area and Control Area.

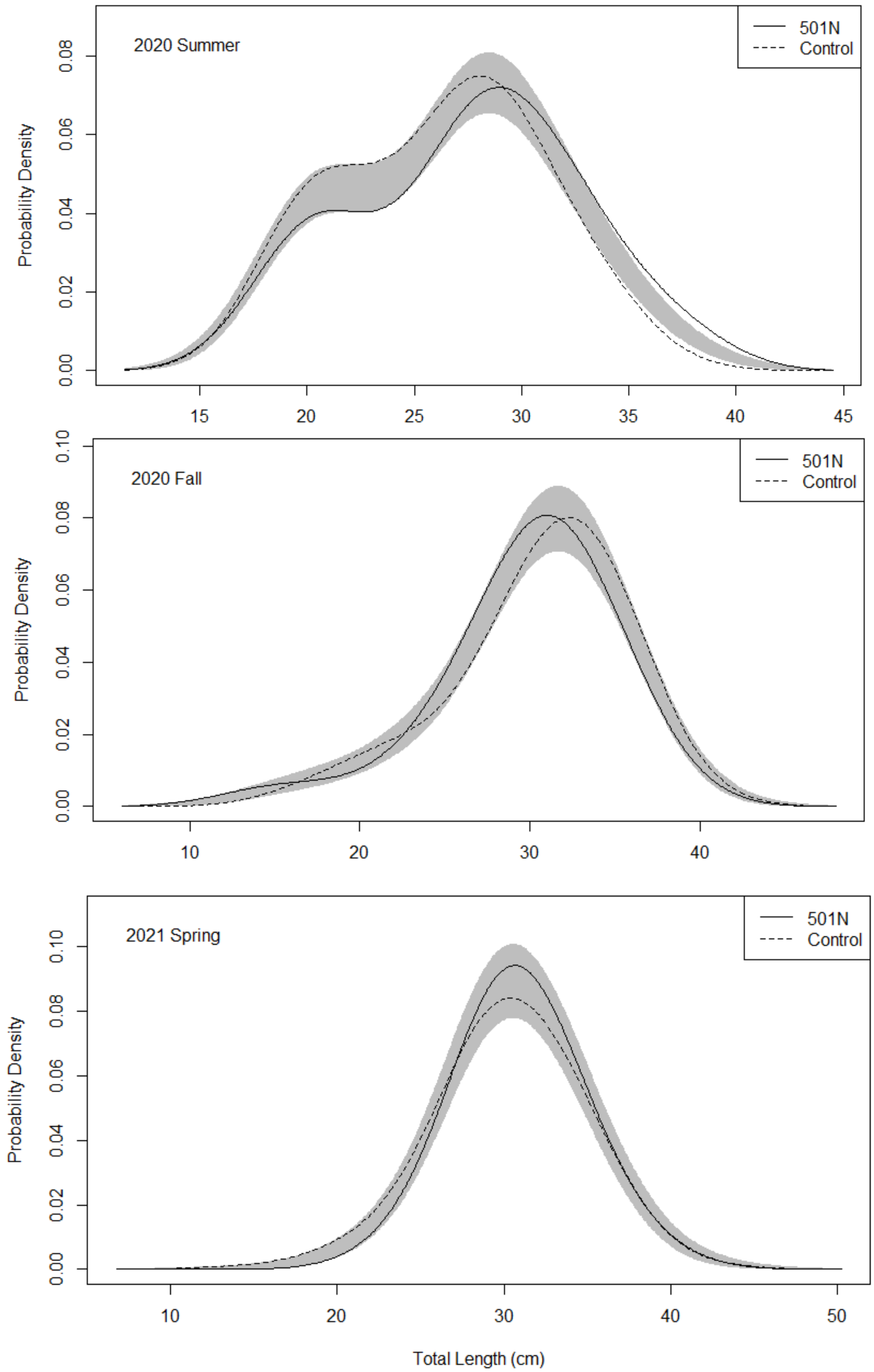
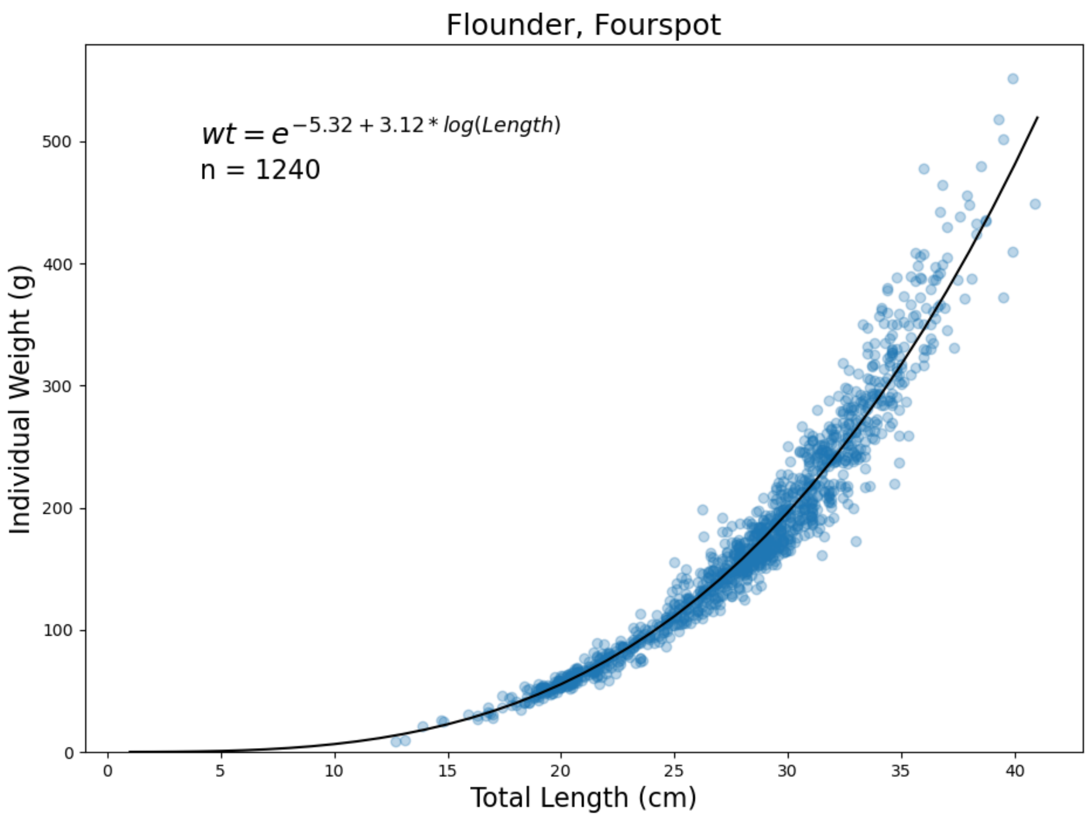


Figure 87: The population structure of fourspot flounder in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



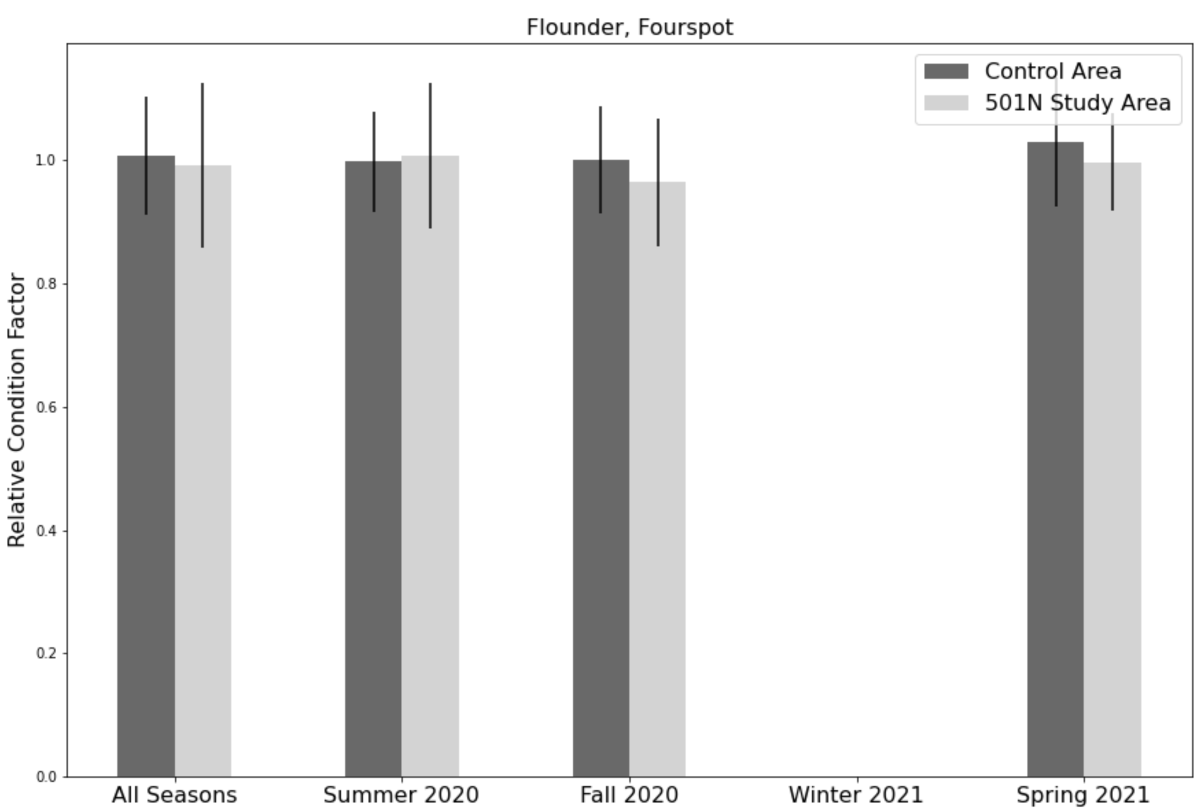


Figure 88: The seasonal condition of fourspot flounder (bottom) as derived from the length-weight relationship (top).

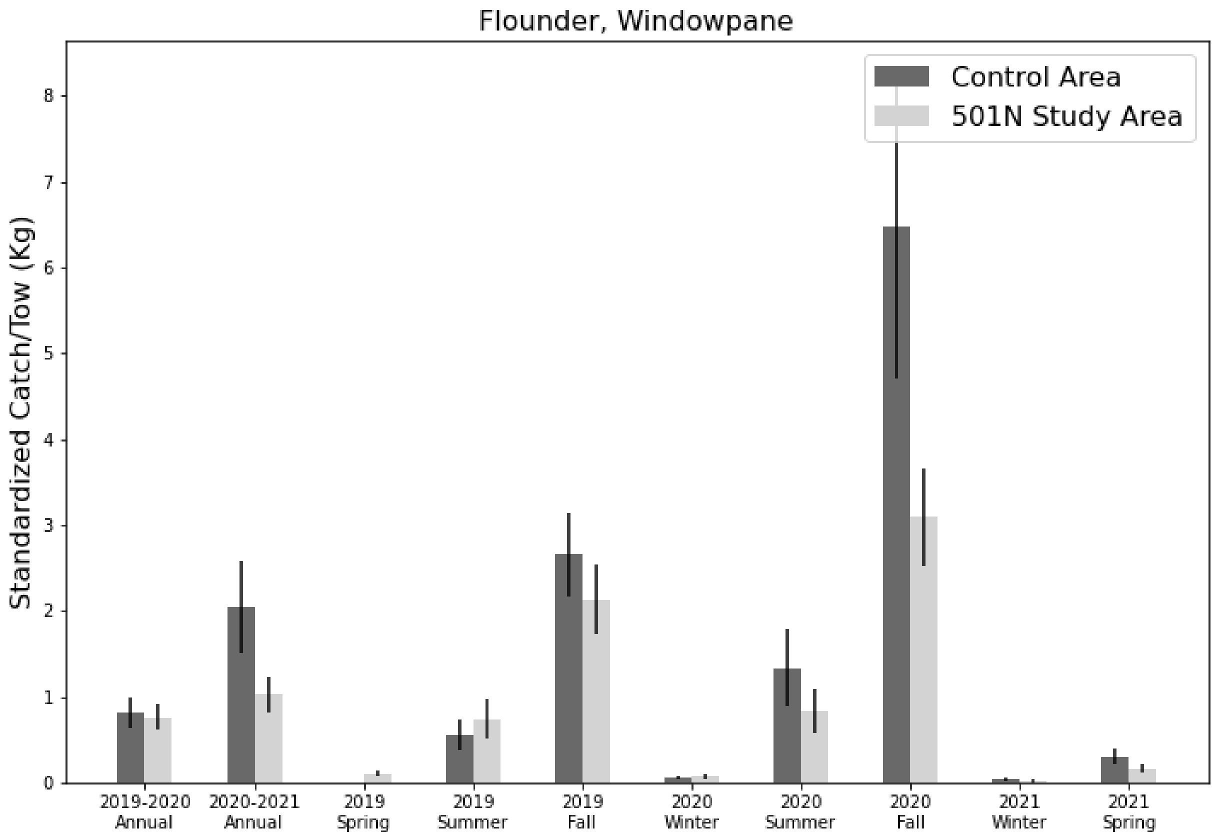


Figure 89: Seasonal catch rates of windowpane flounder in the 501N Study Area and Control Area.

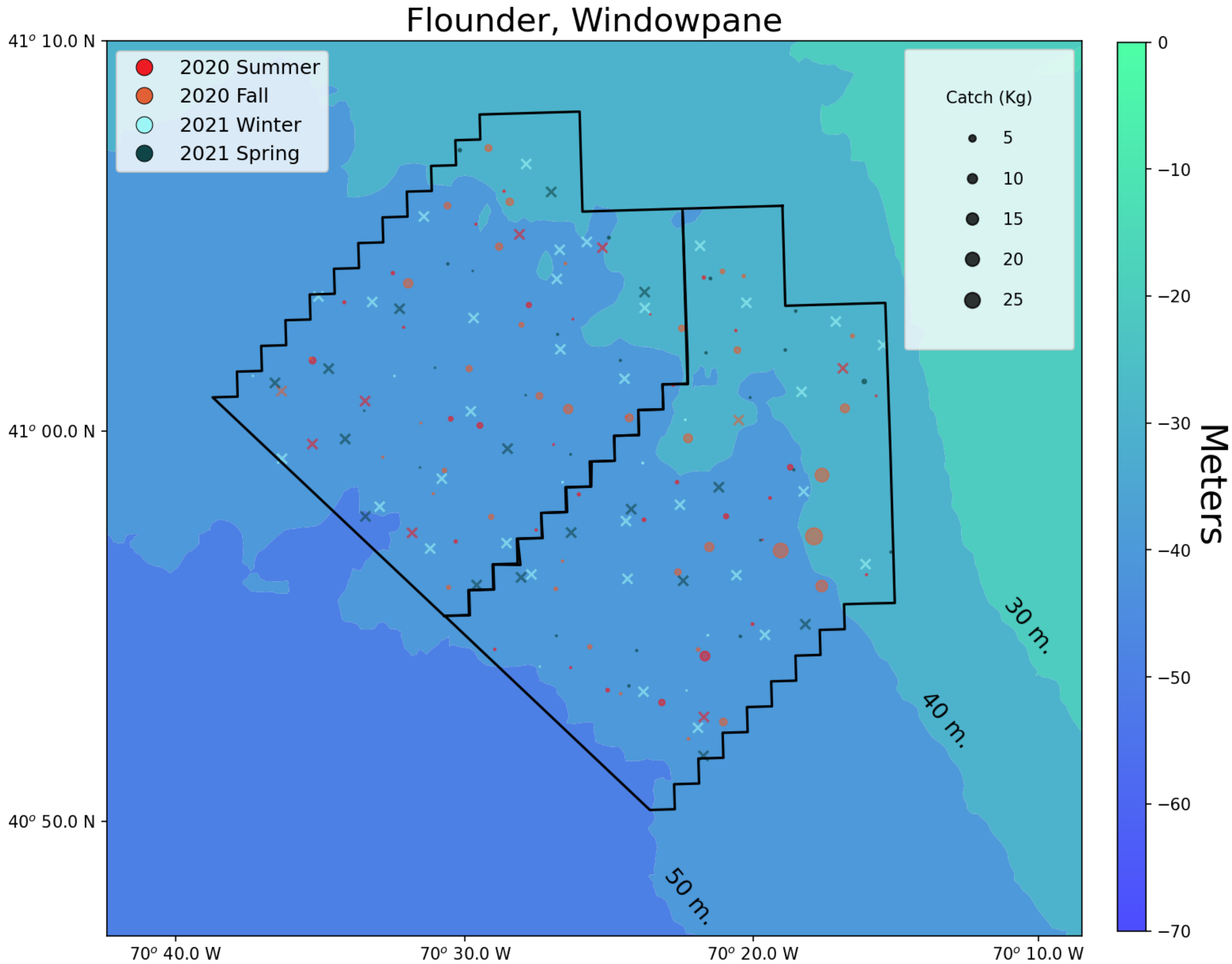


Figure 90: Seasonal distribution of the windowpane flounder catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

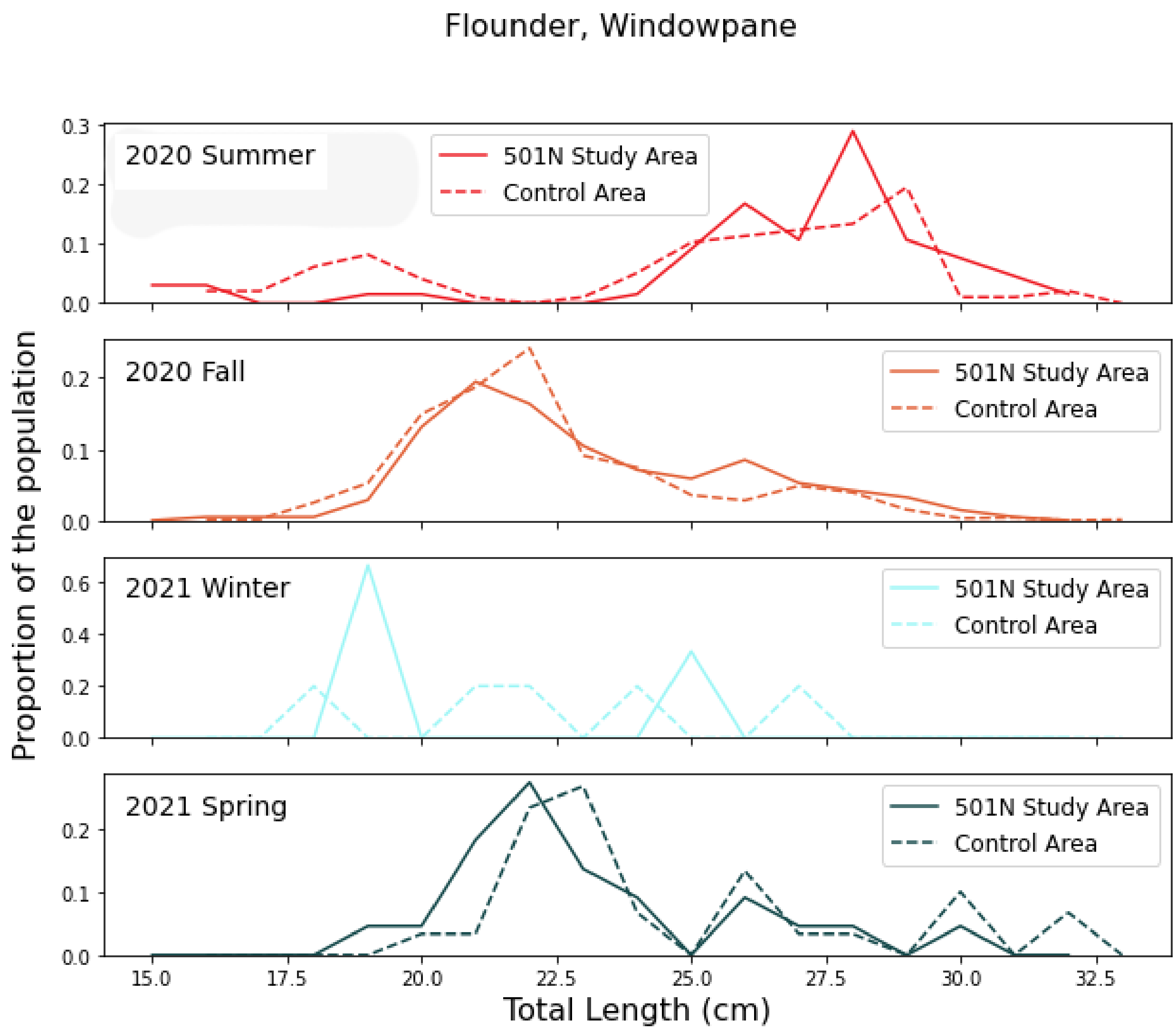


Figure 91: The seasonal length distributions of windowpane flounder in the 501N Study Area and Control Area.

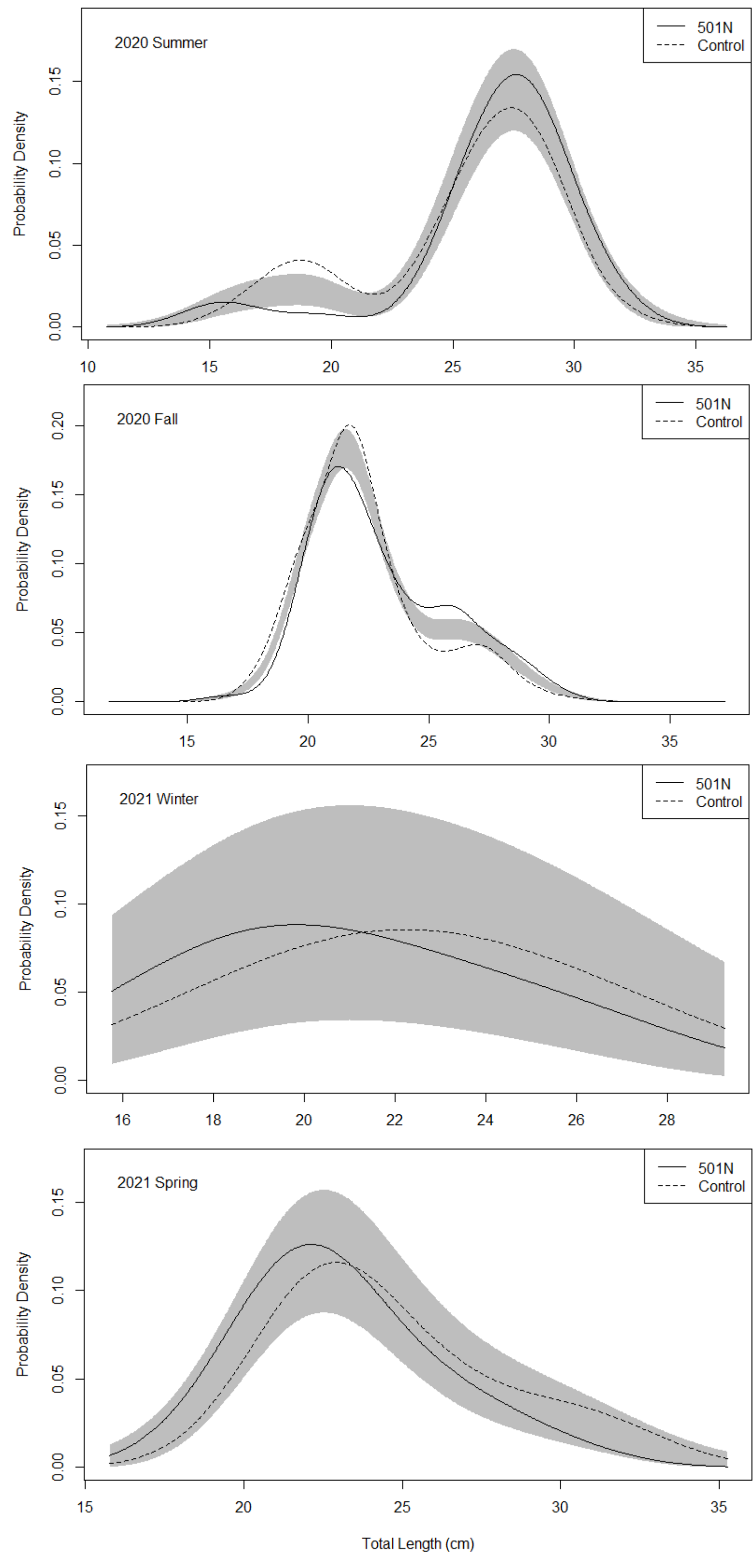
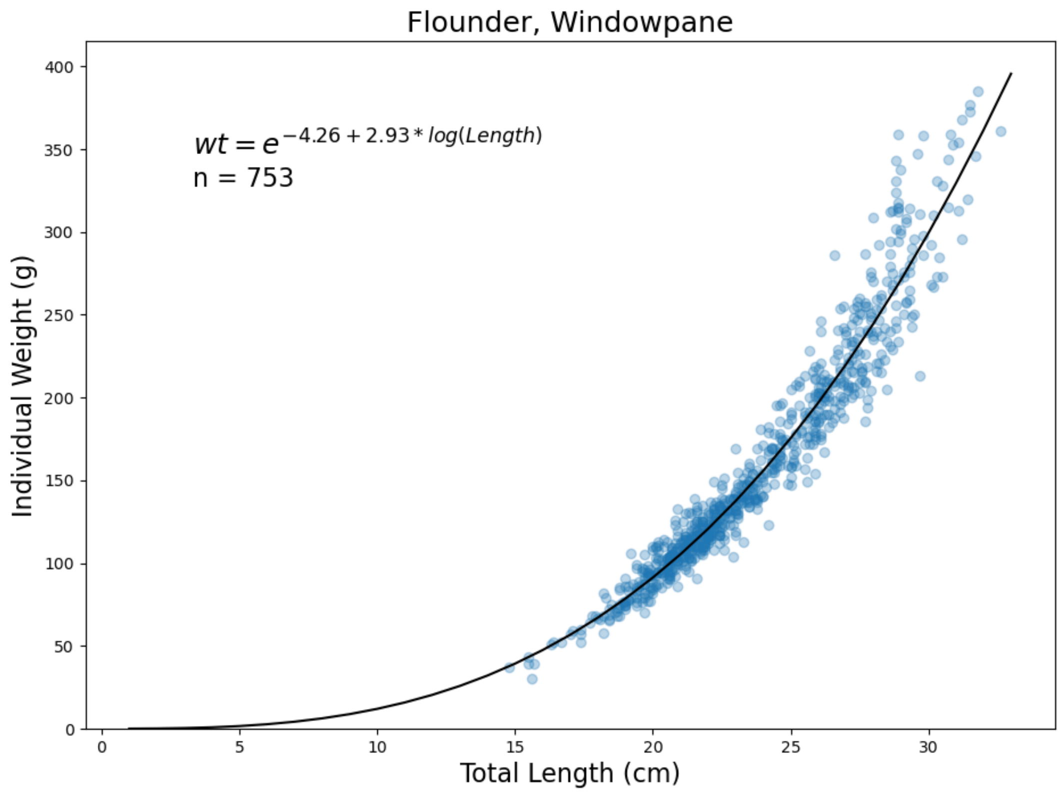


Figure 92: The population structure of windowpane flounder in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



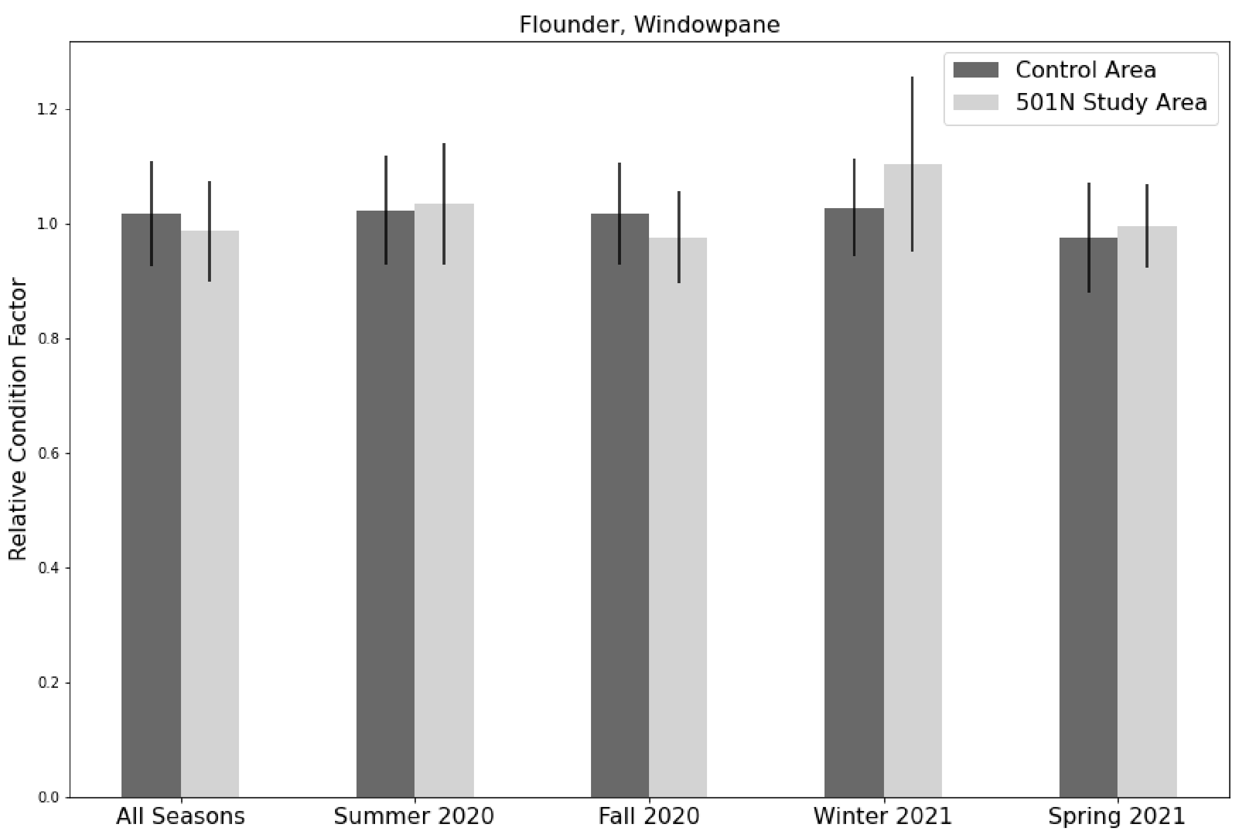


Figure 93: The seasonal condition of windowpane flounder (bottom) as derived from the length-weight relationship (top).

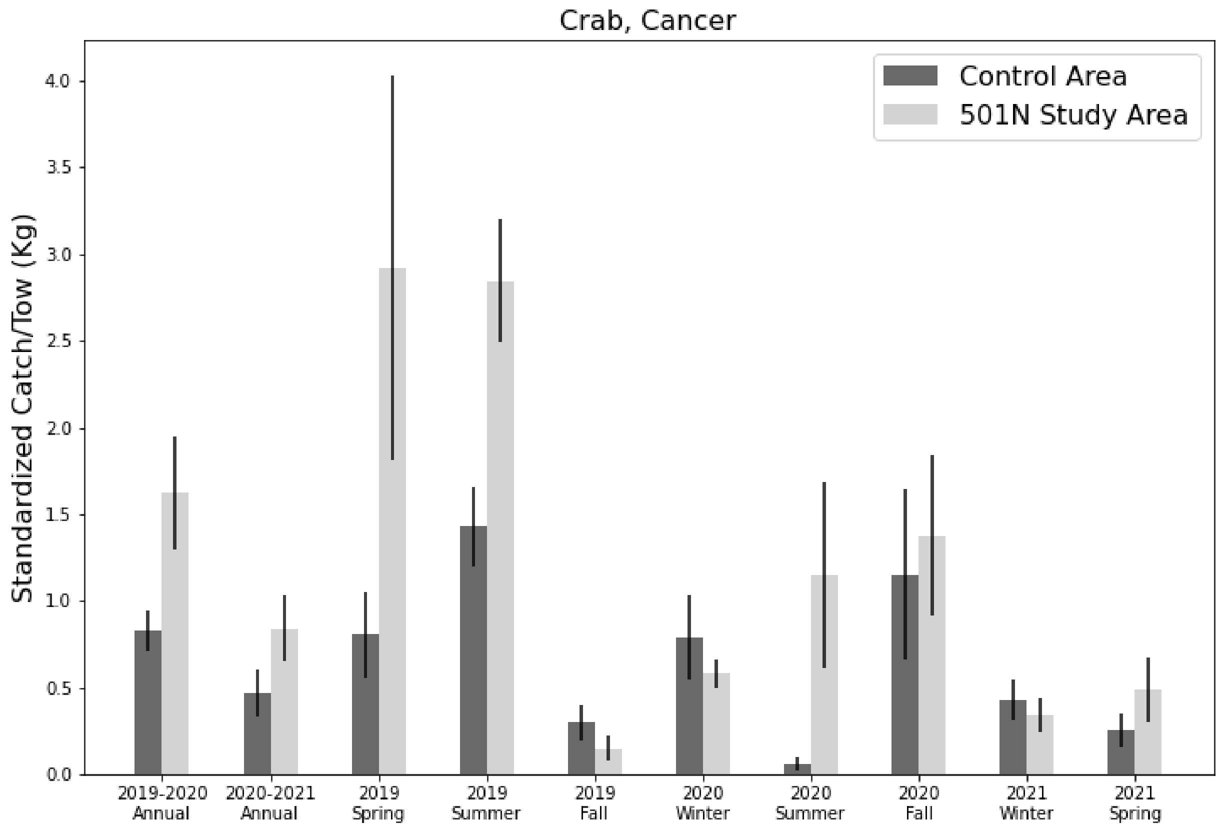


Figure 94: Seasonal catch rates of cancer crab in the 501N Study Area and Control Area.

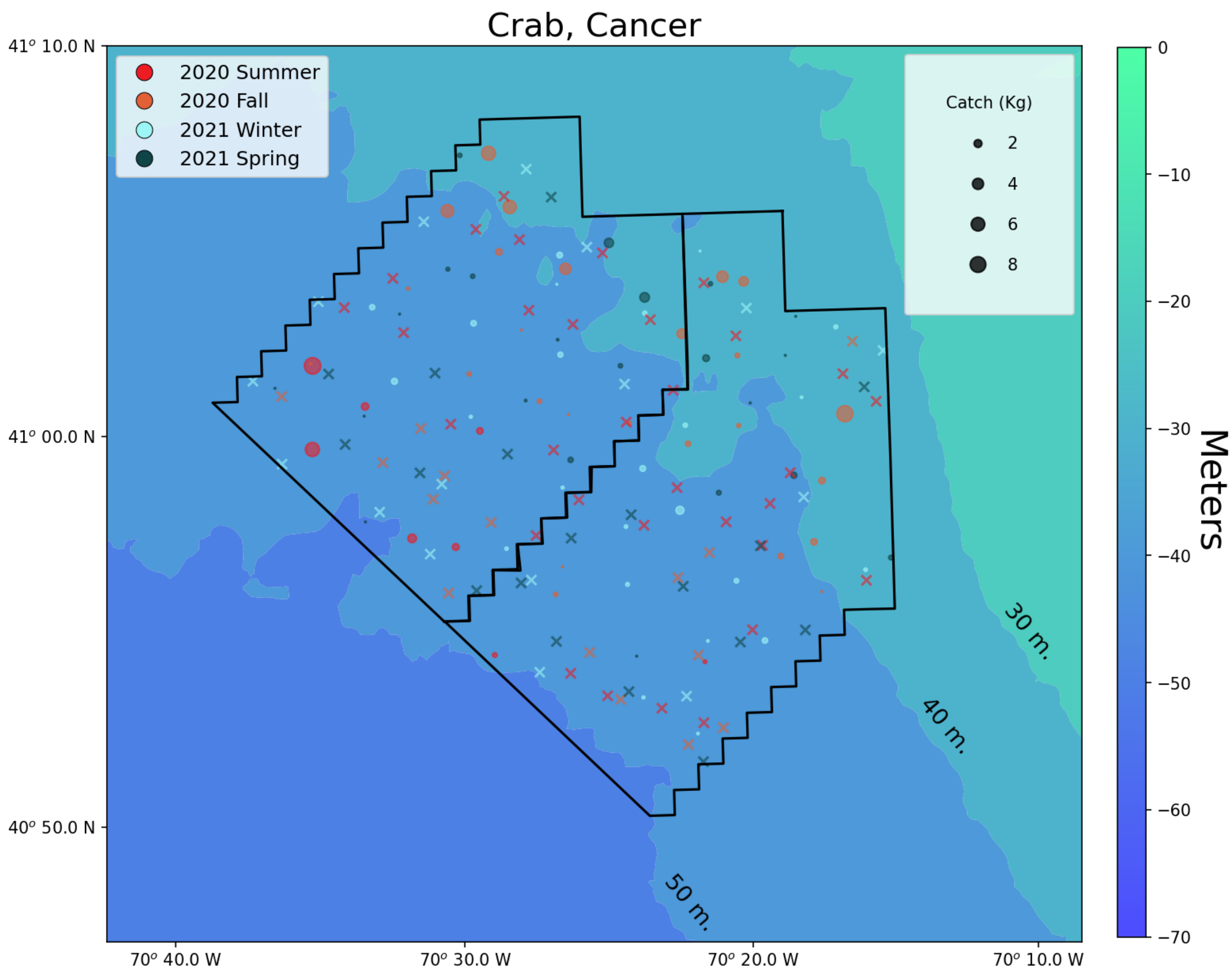


Figure 95: Seasonal distribution of the cancer crab catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

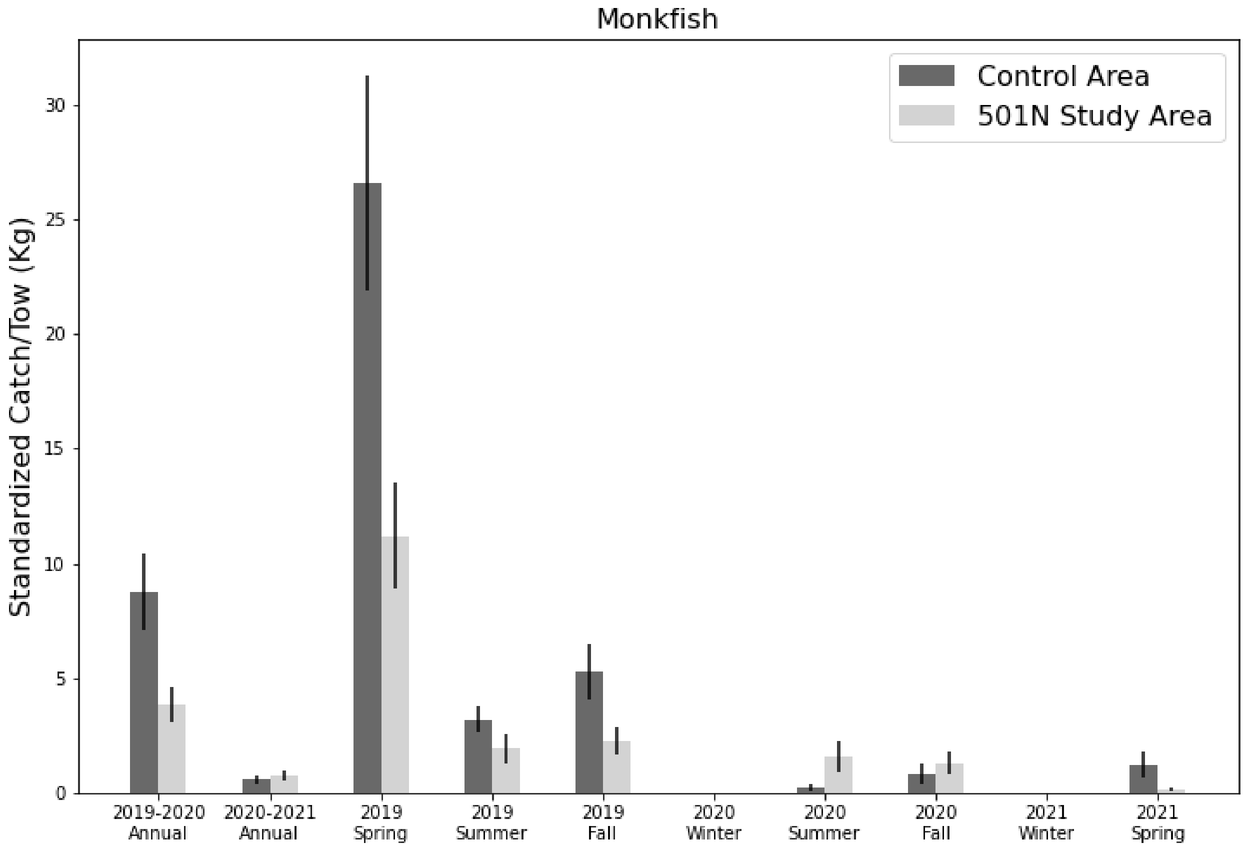


Figure 96: Seasonal catch rates of monkfish in the 501N Study Area and Control Area.

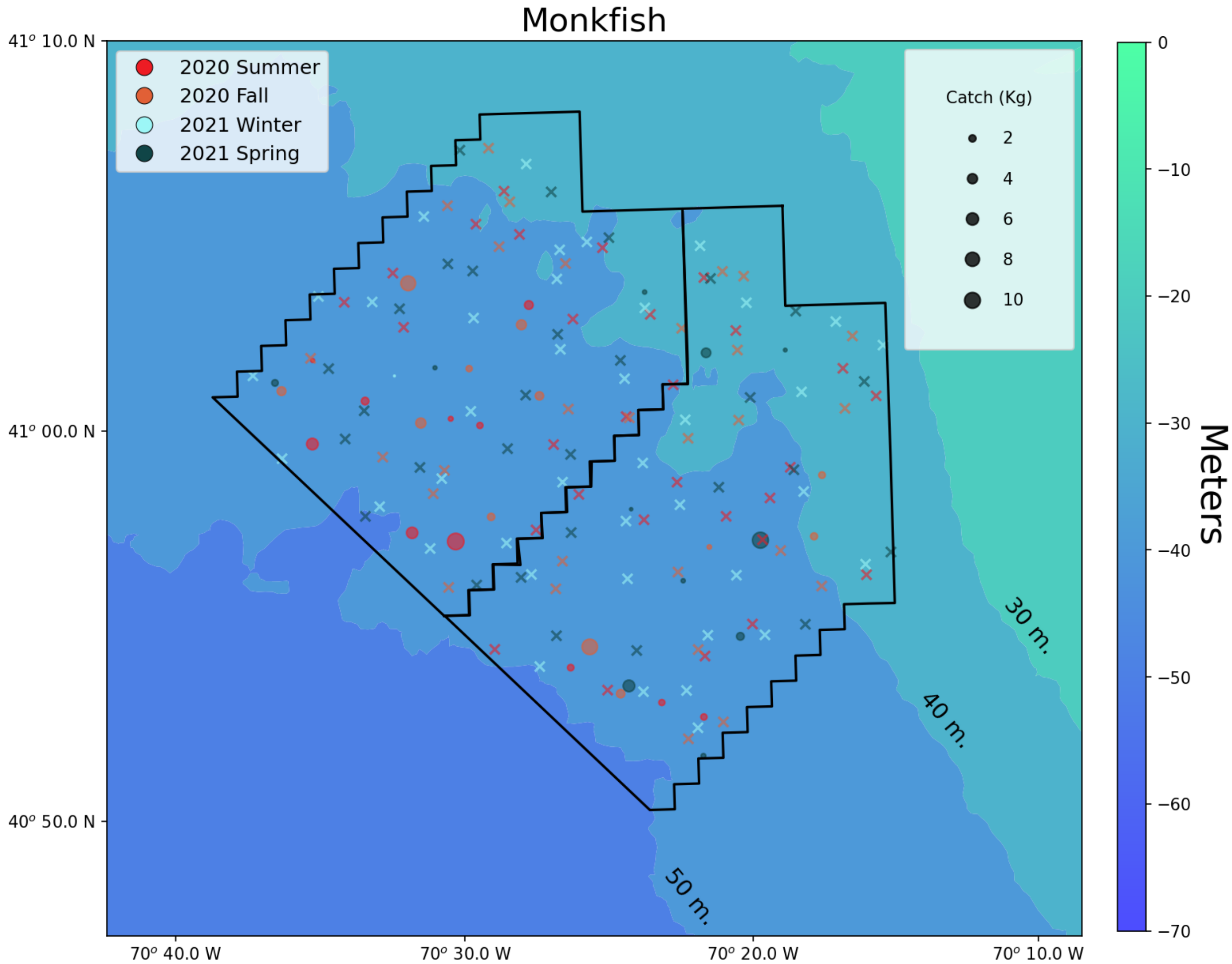


Figure 97: Seasonal distribution of the monkfish catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

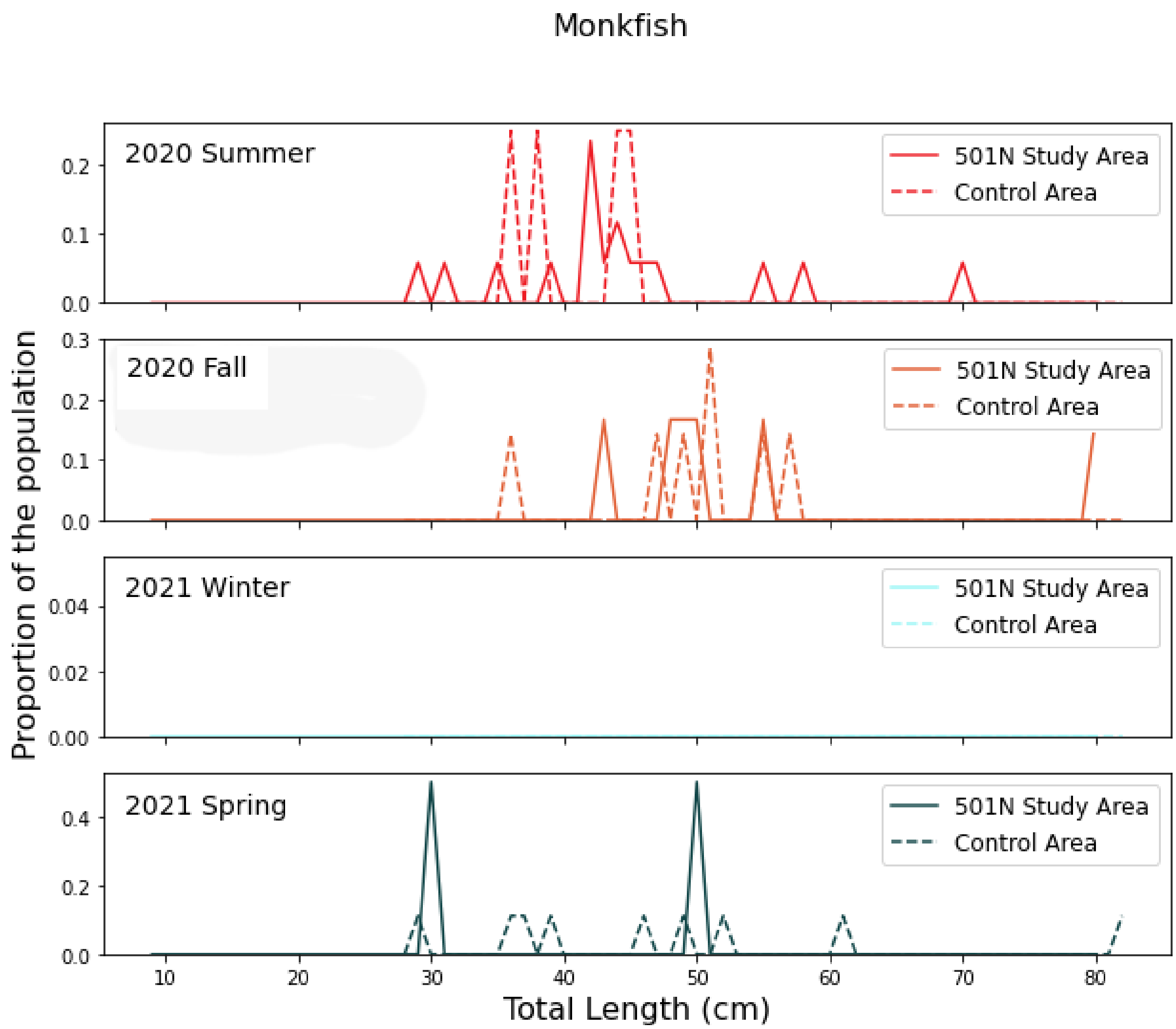


Figure 98: The seasonal length distributions of monkfish in the 501N Study Area and Control Area.

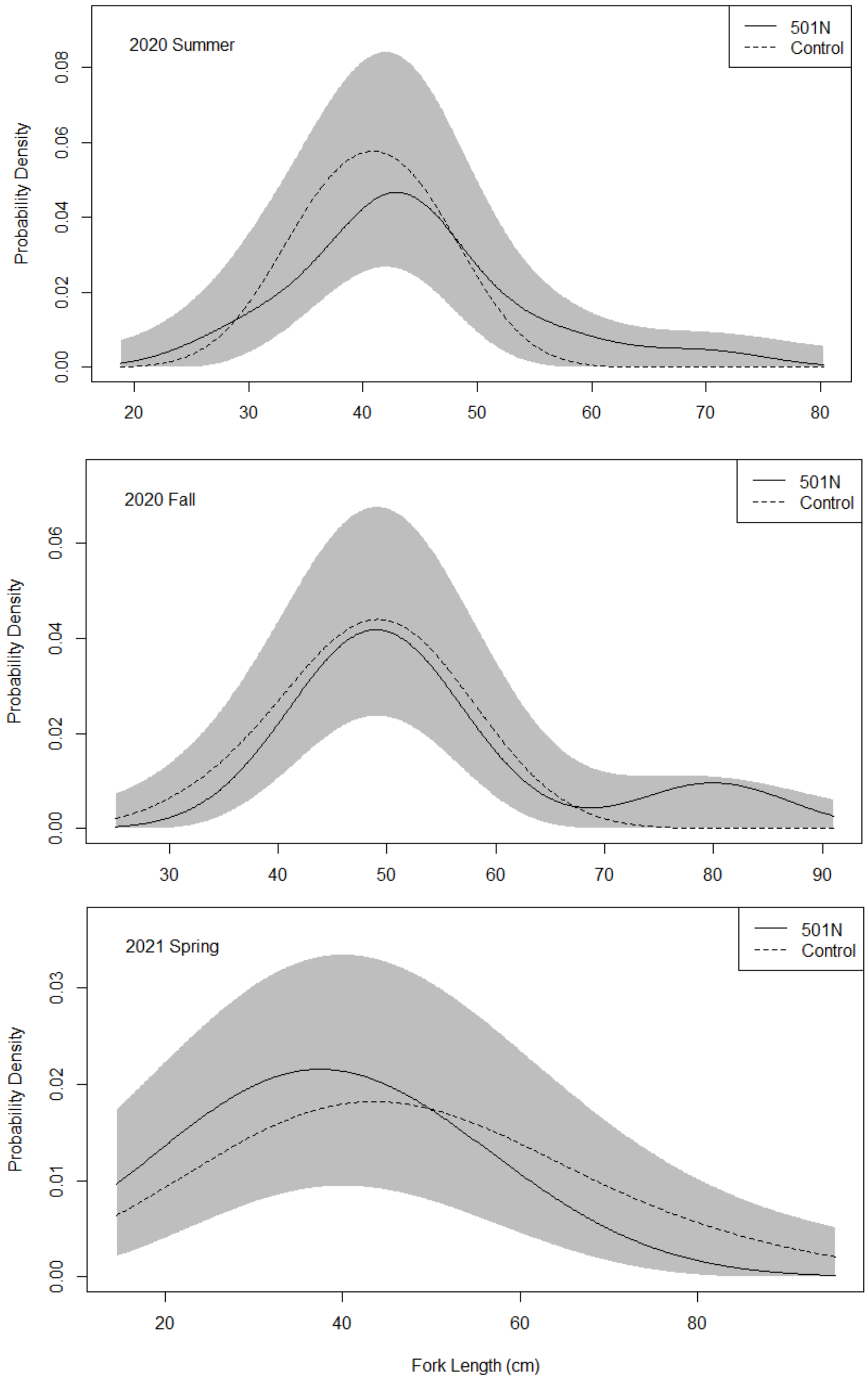
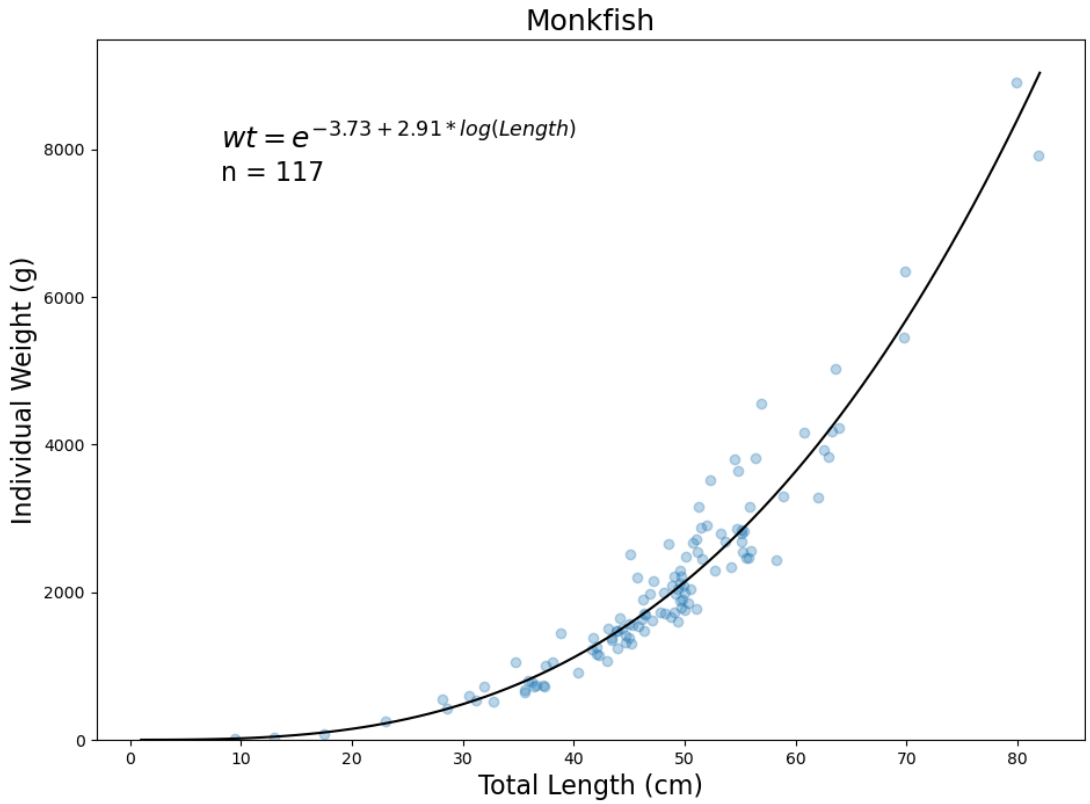


Figure 99: The population structure of monkfish in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



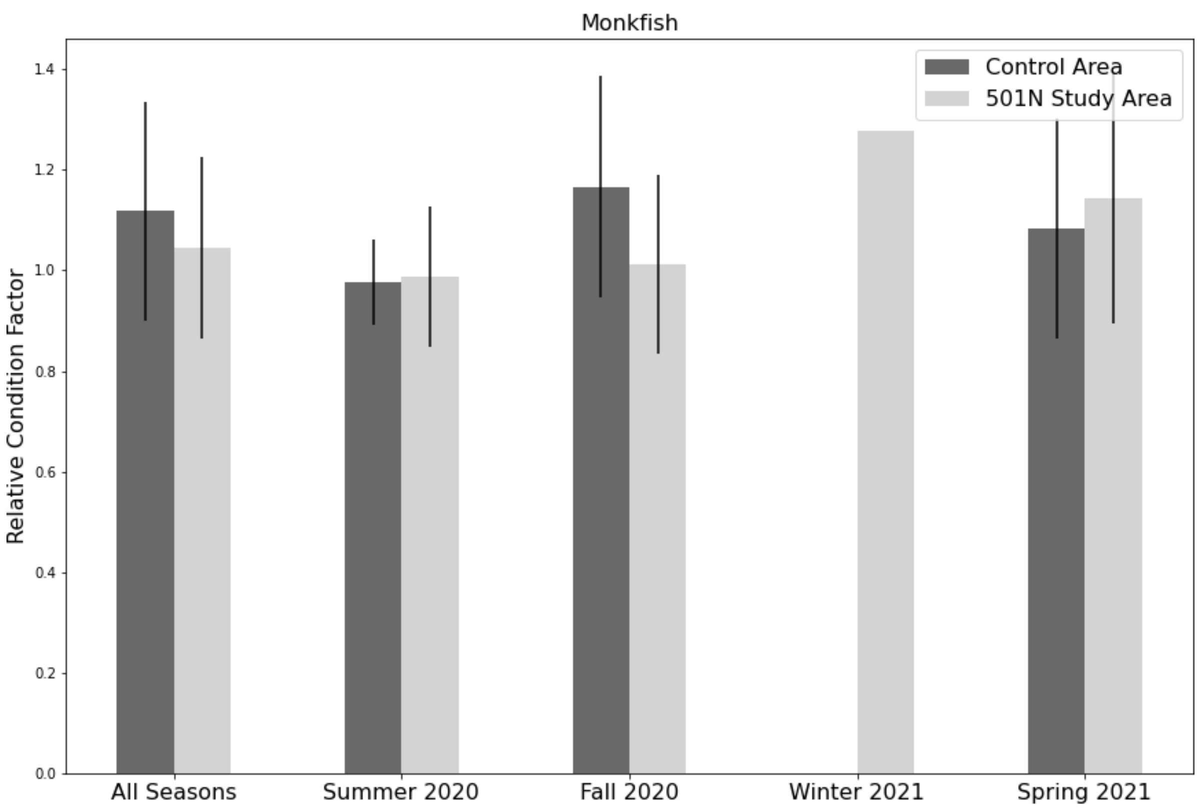


Figure 100: The seasonal condition of monkfish (bottom) as derived from the length-weight relationship (top).

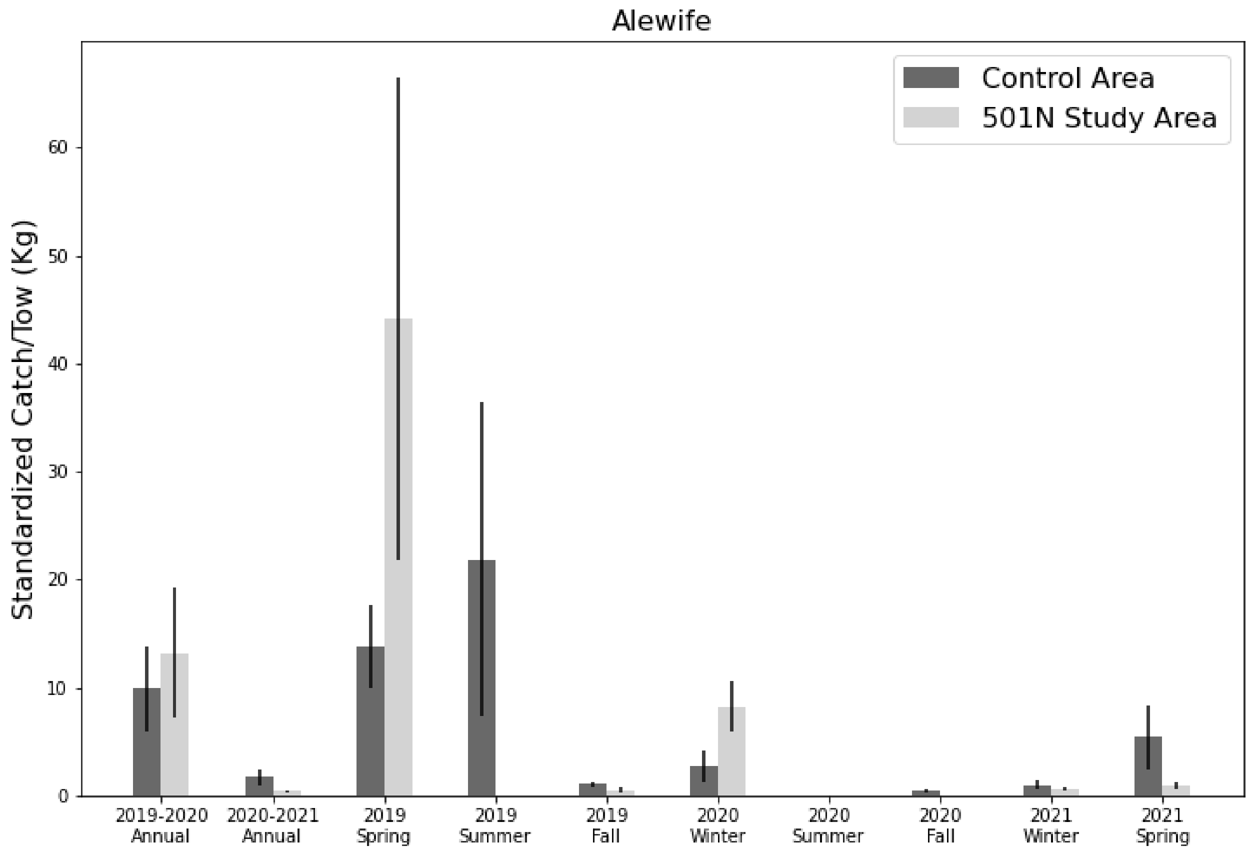


Figure 101: Seasonal catch rates of alewife in the 501N Study Area and Control Area.

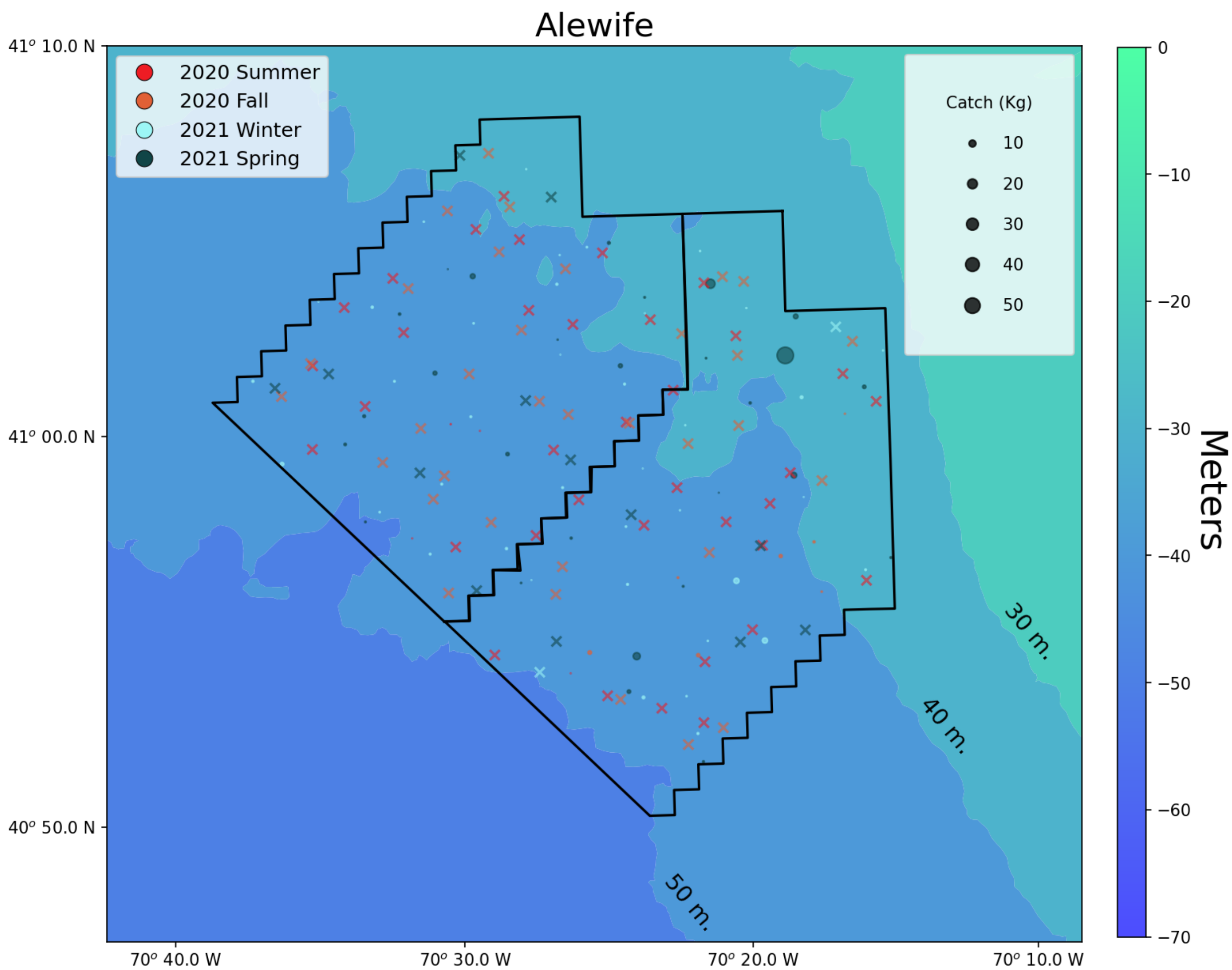


Figure 102: Seasonal distribution of the alewife catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

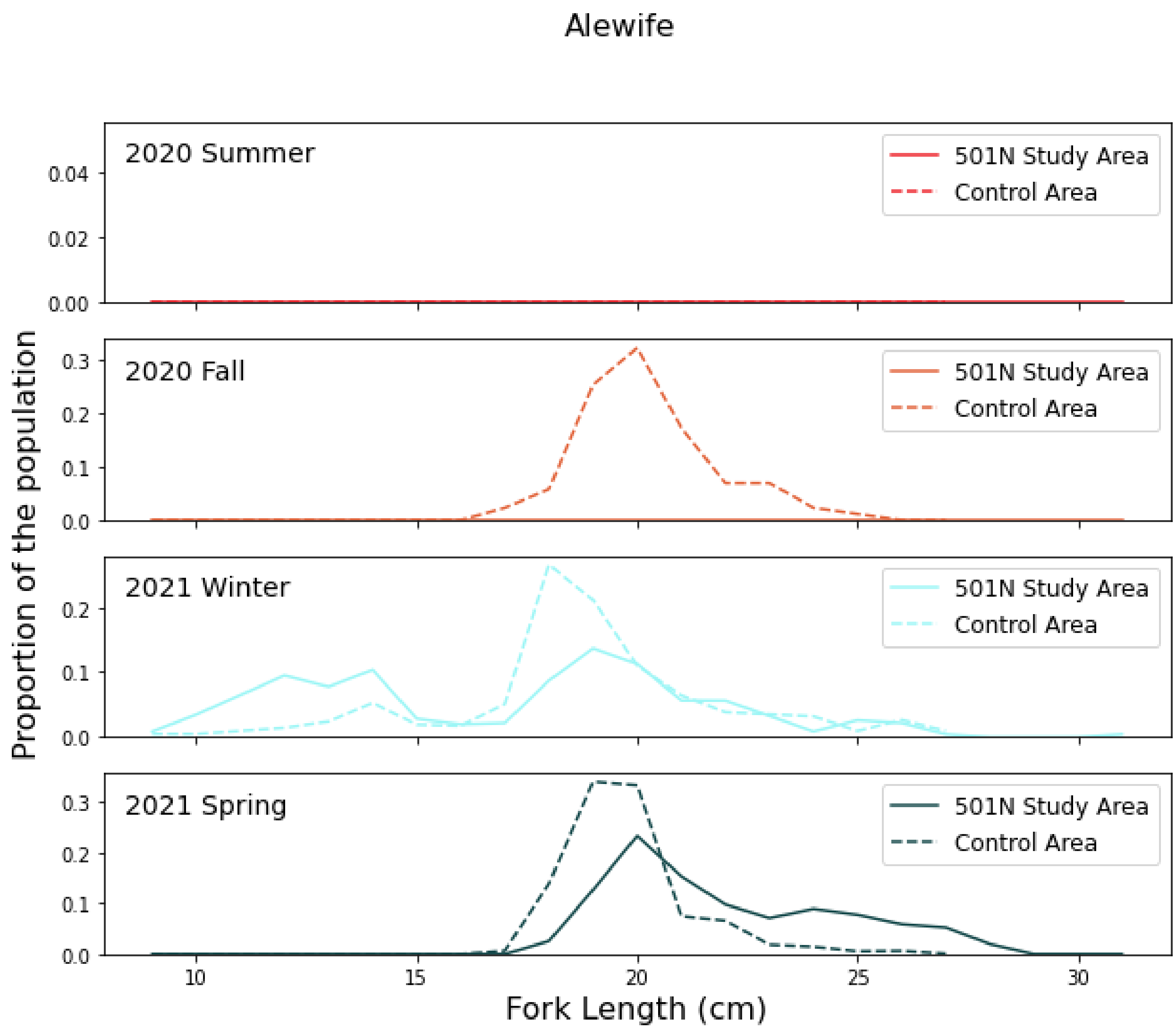


Figure 103: The seasonal length distributions of alewife in the 501N Study Area and Control Area.

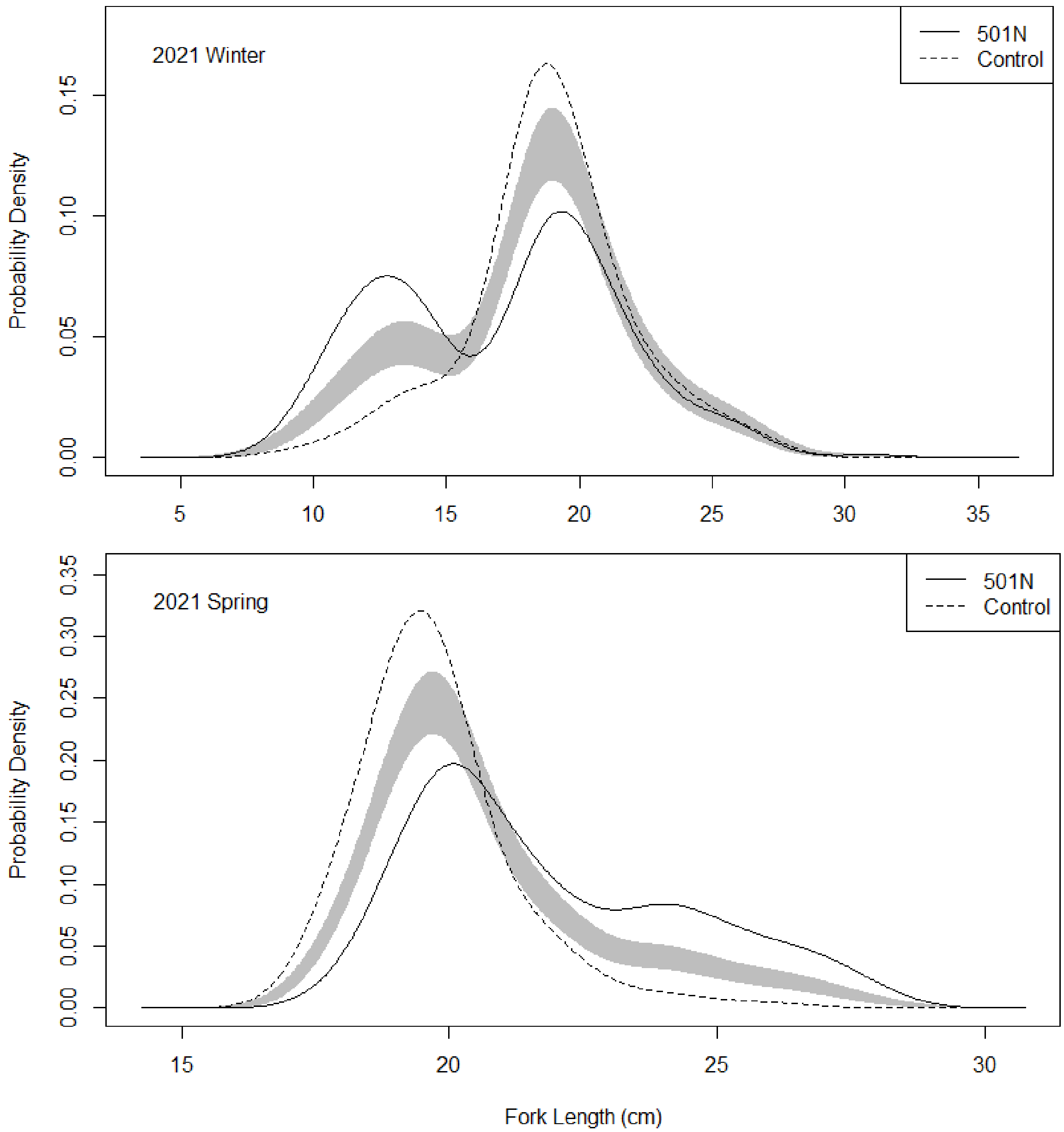
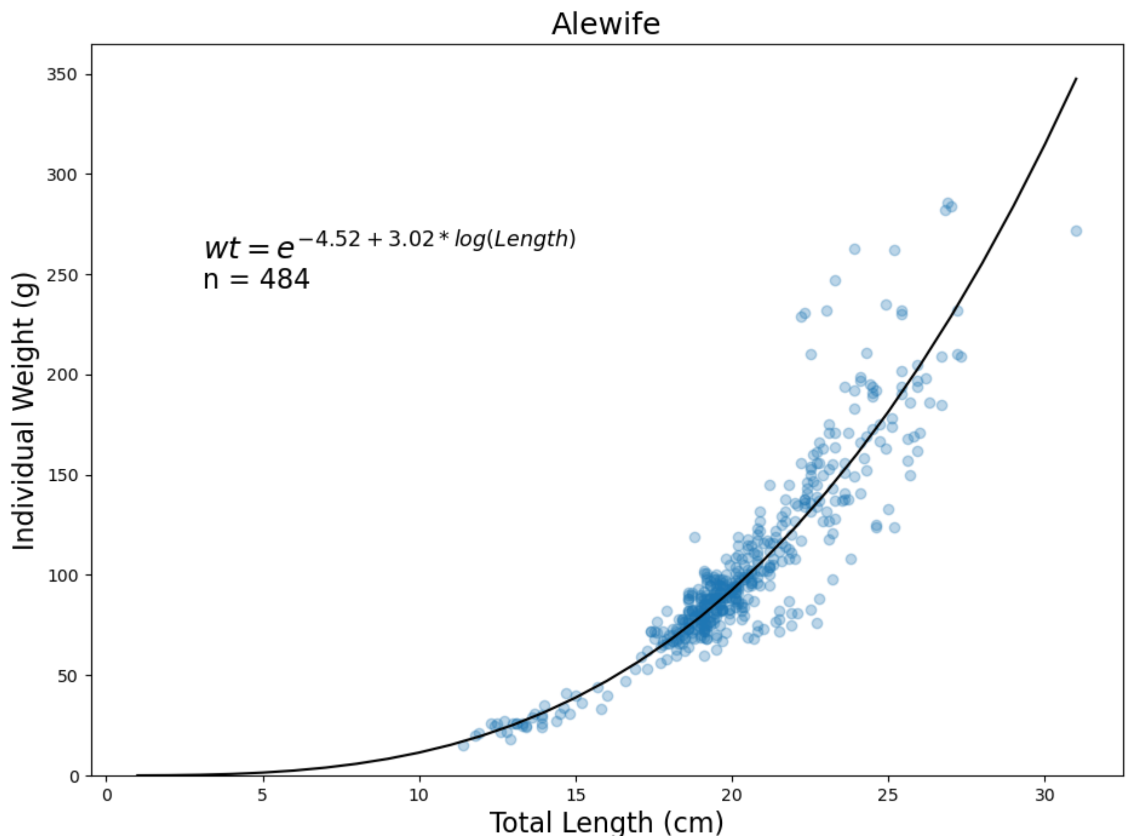


Figure 104: The population structure of alewife in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



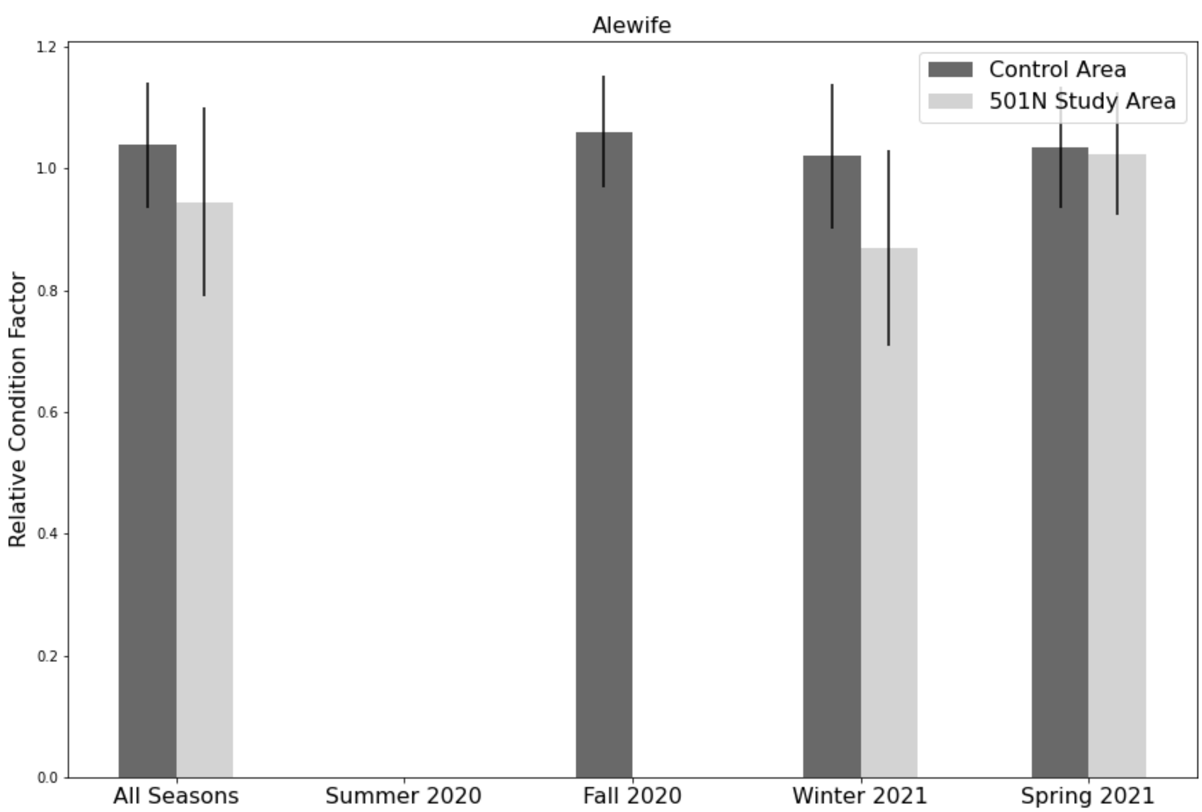


Figure 105: The seasonal condition of alewife (bottom) as derived from the length-weight relationship (top).

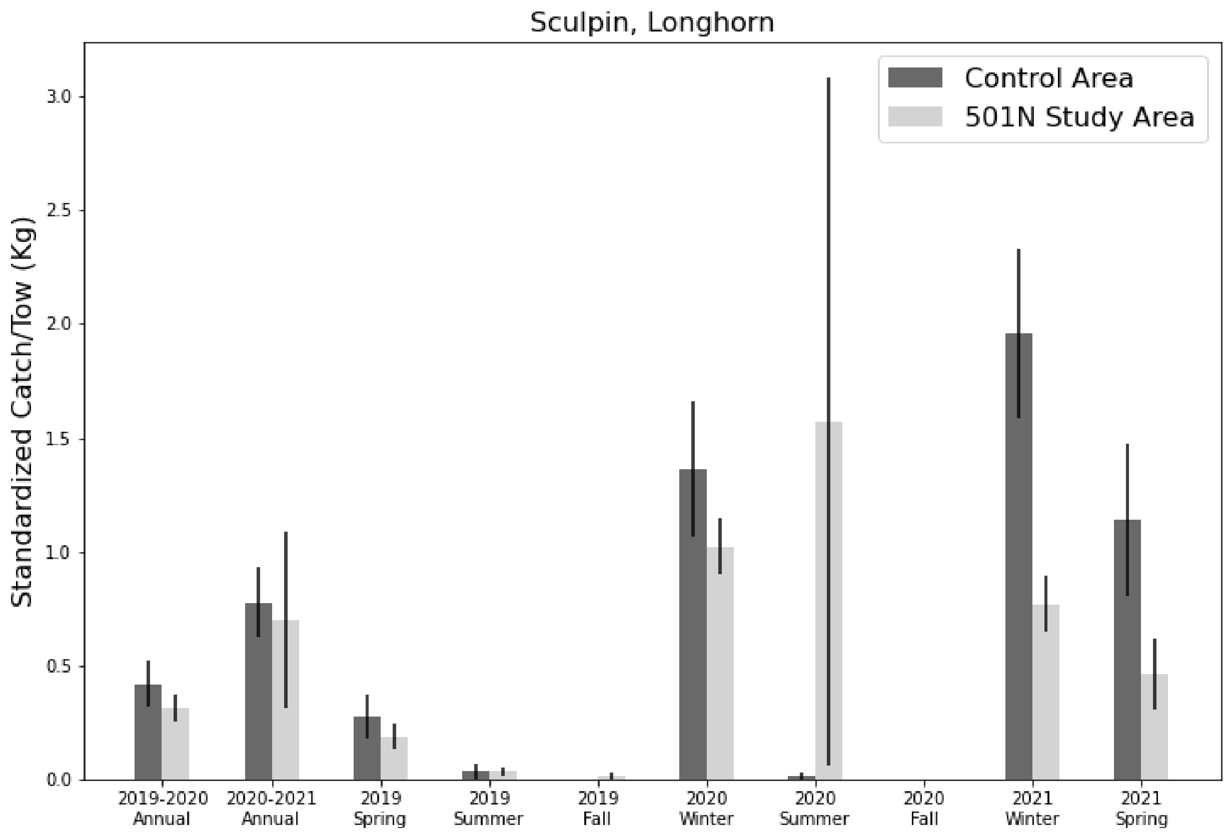


Figure 106: Seasonal catch rates of longhorn sculpin in the 501N Study Area and Control Area.

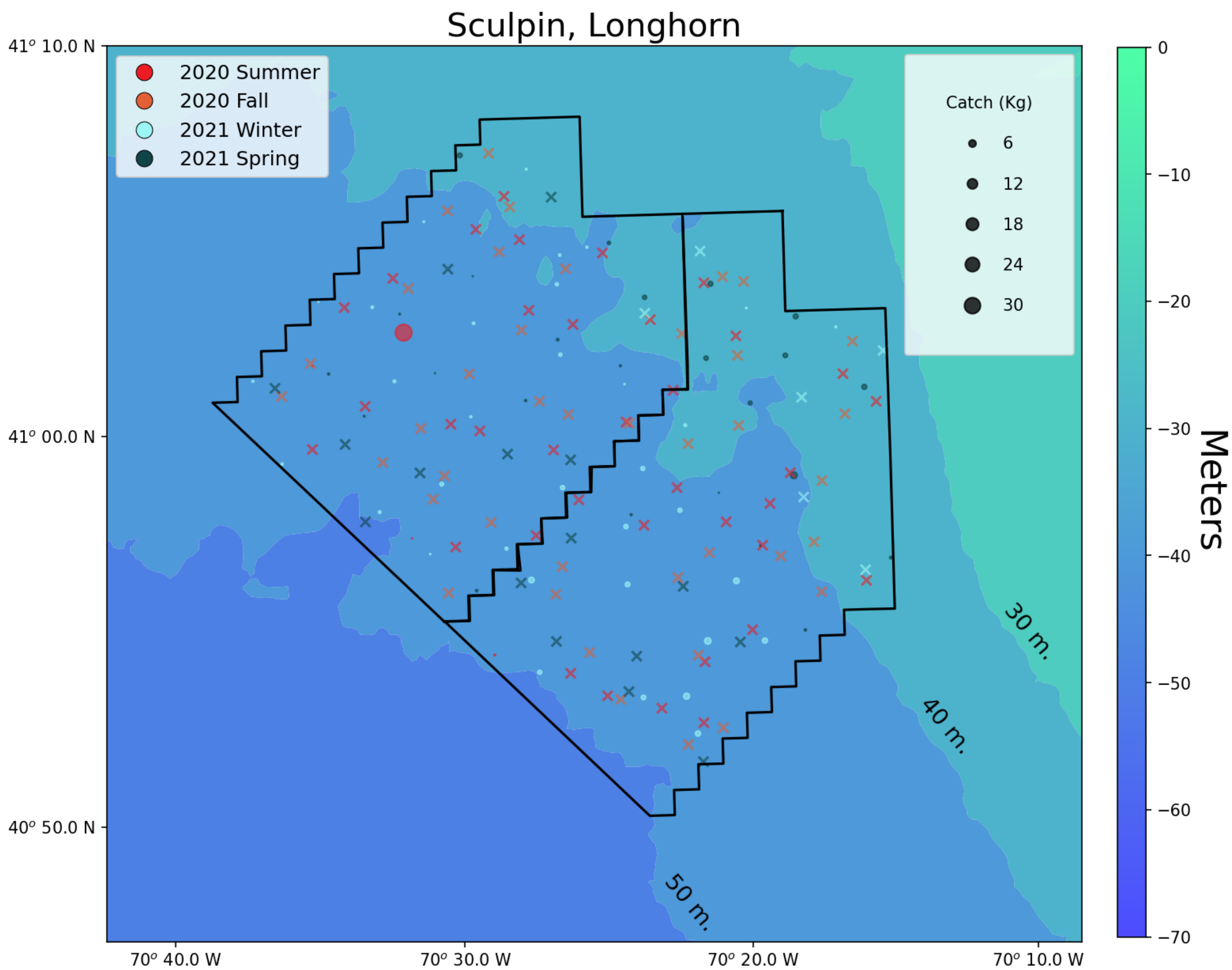


Figure 107: Seasonal distribution of the longhorn sculpin catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

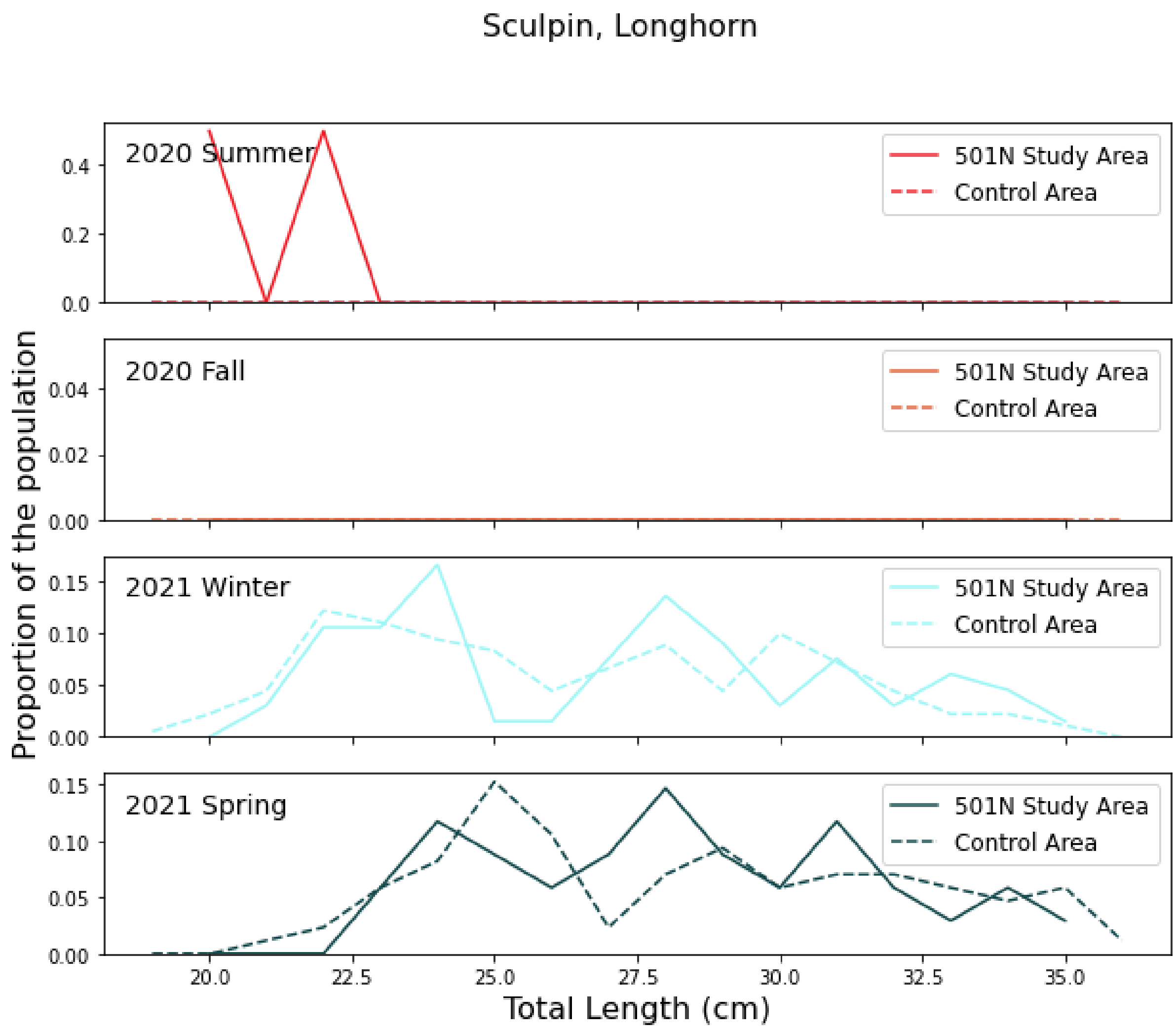


Figure 108: The seasonal length distributions of longhorn sculpin in the 501N Study Area and Control Area.

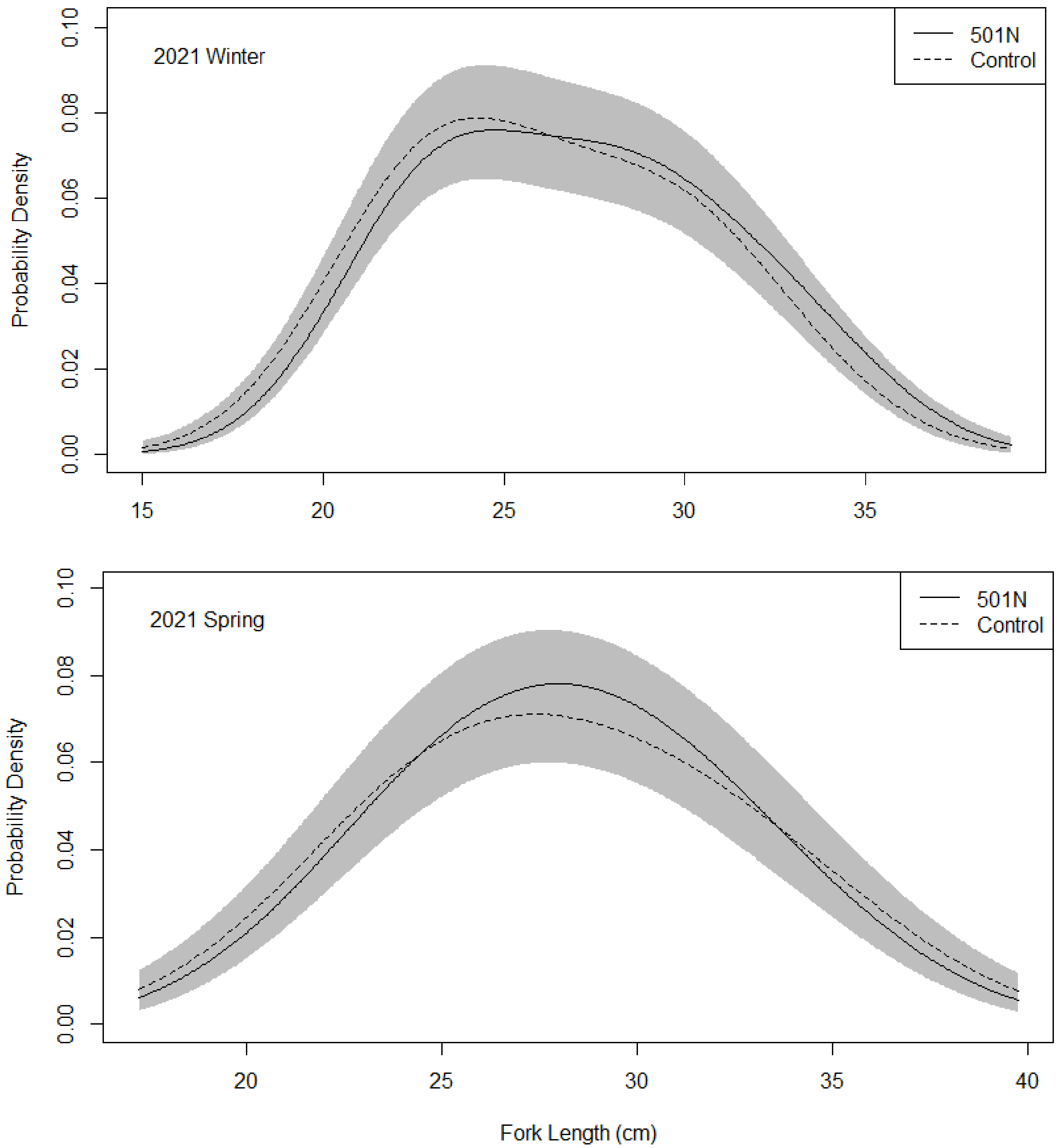
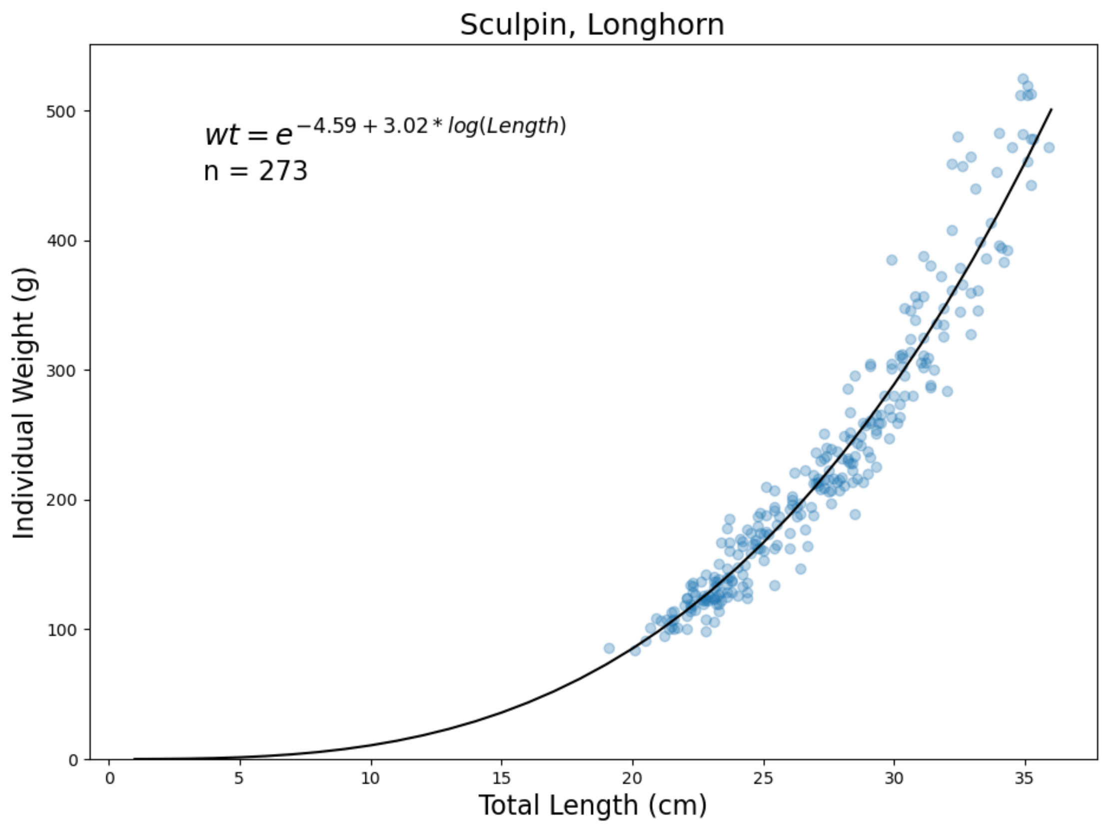


Figure 109: The population structure of longhorn sculpin in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



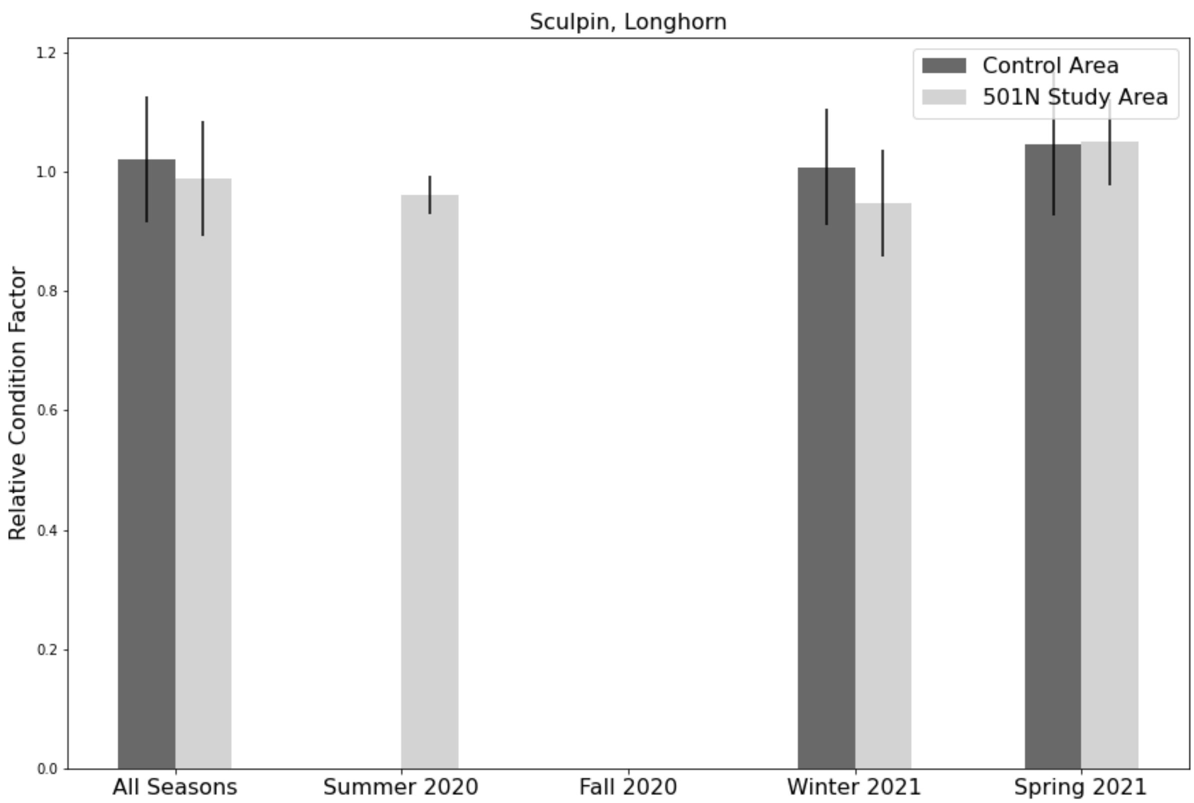


Figure 110: The seasonal condition of longhorn sculpin (bottom) as derived from the length-weight relationship (top).

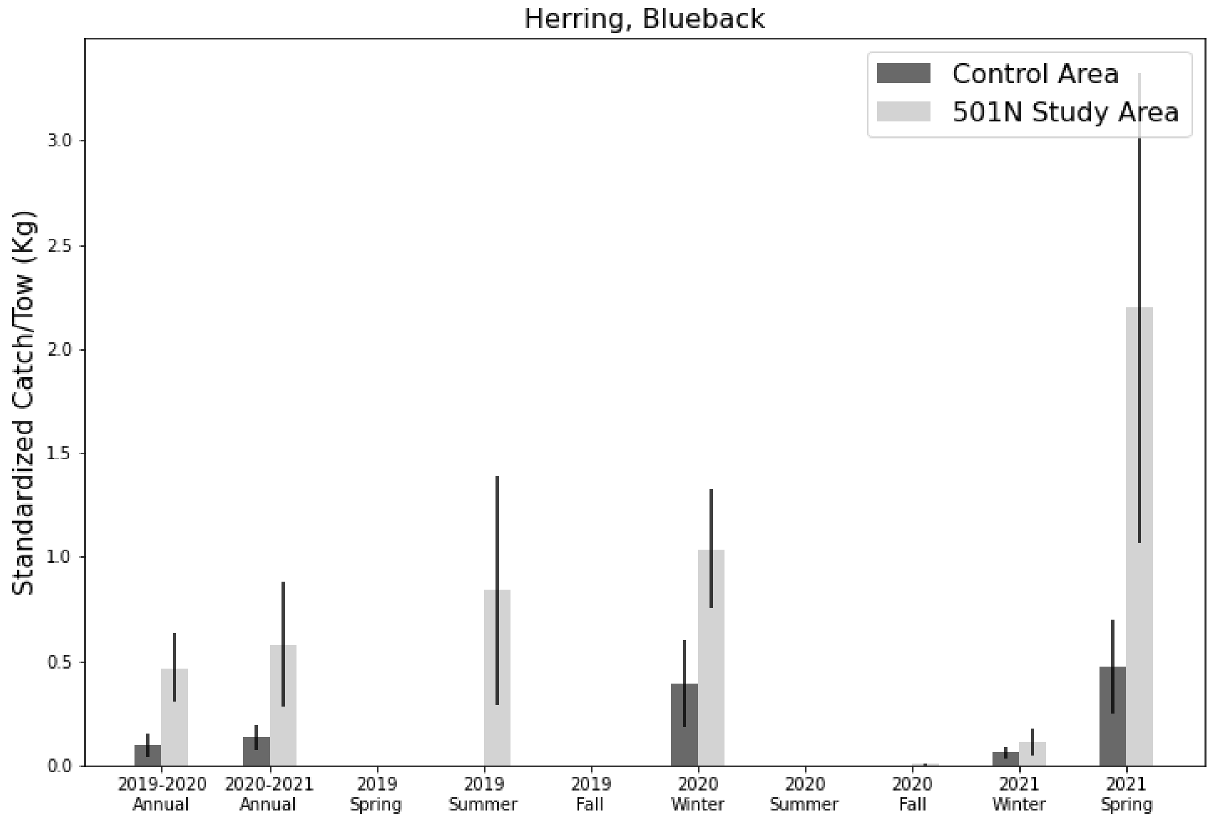


Figure 111: Seasonal catch rates of blueback herring in the 501N Study Area and Control Area.

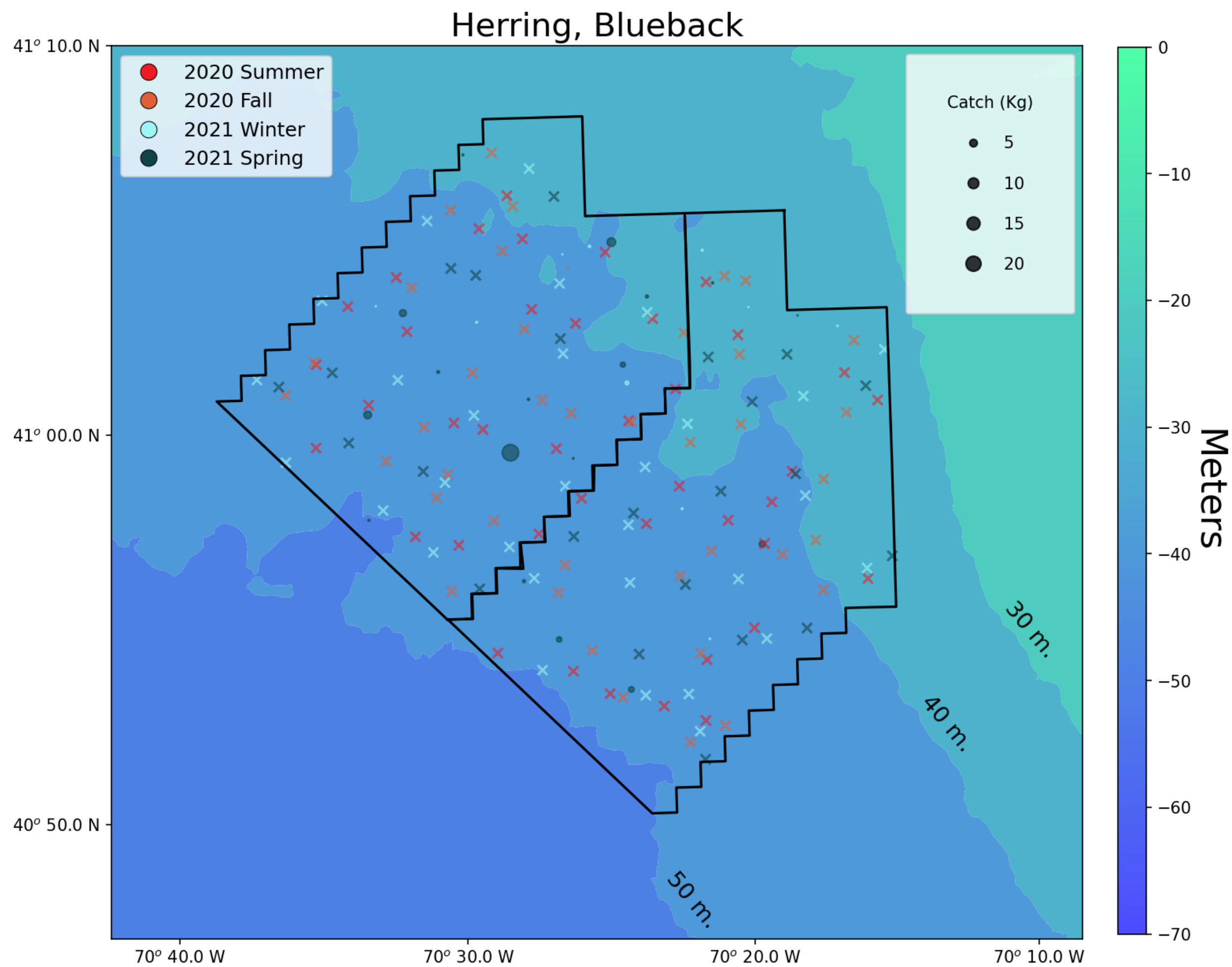


Figure 112: Seasonal distribution of the blueback herring catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

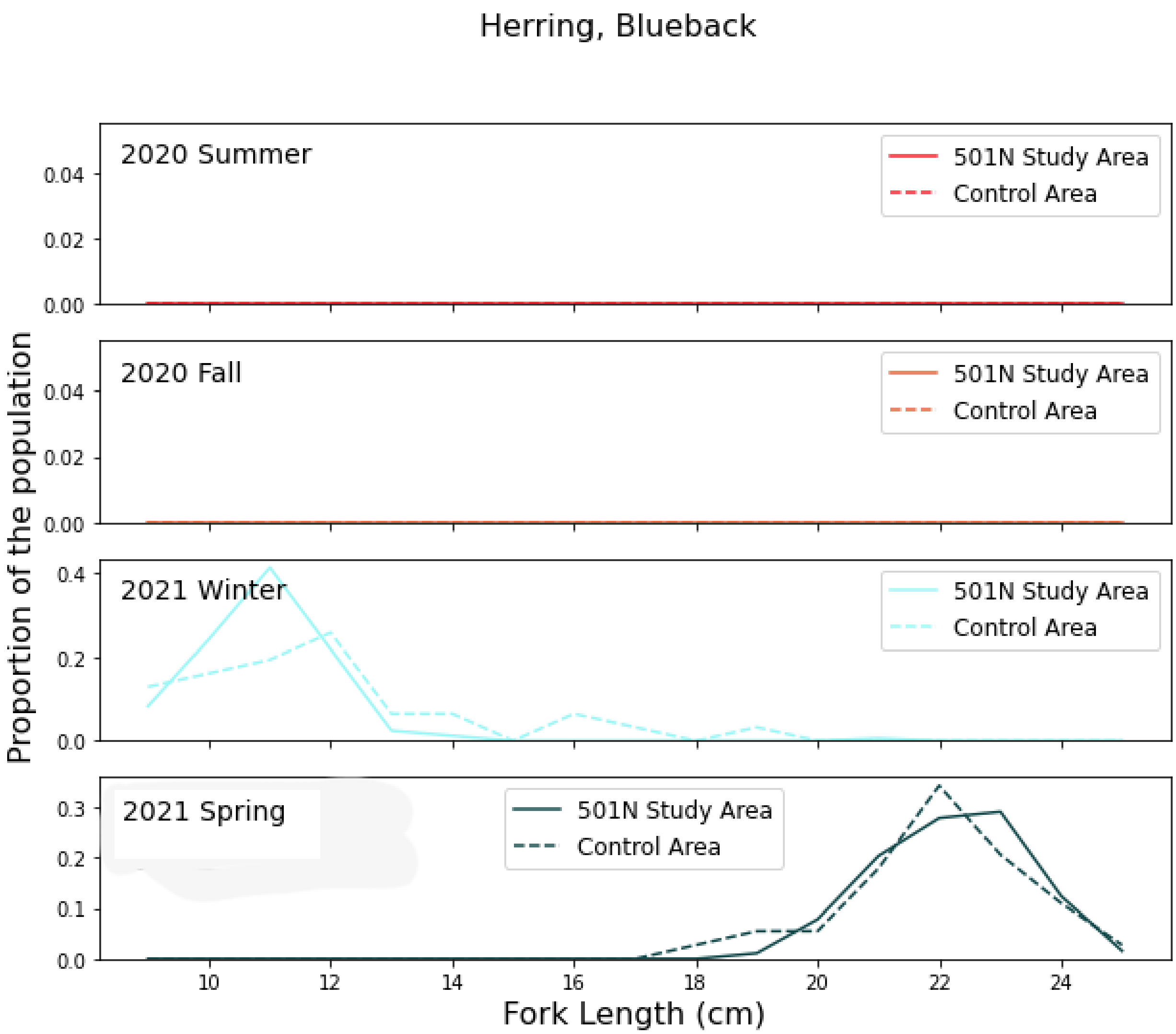


Figure 113: The seasonal length distributions of blueback herring in the 501N Study Area and Control Area.

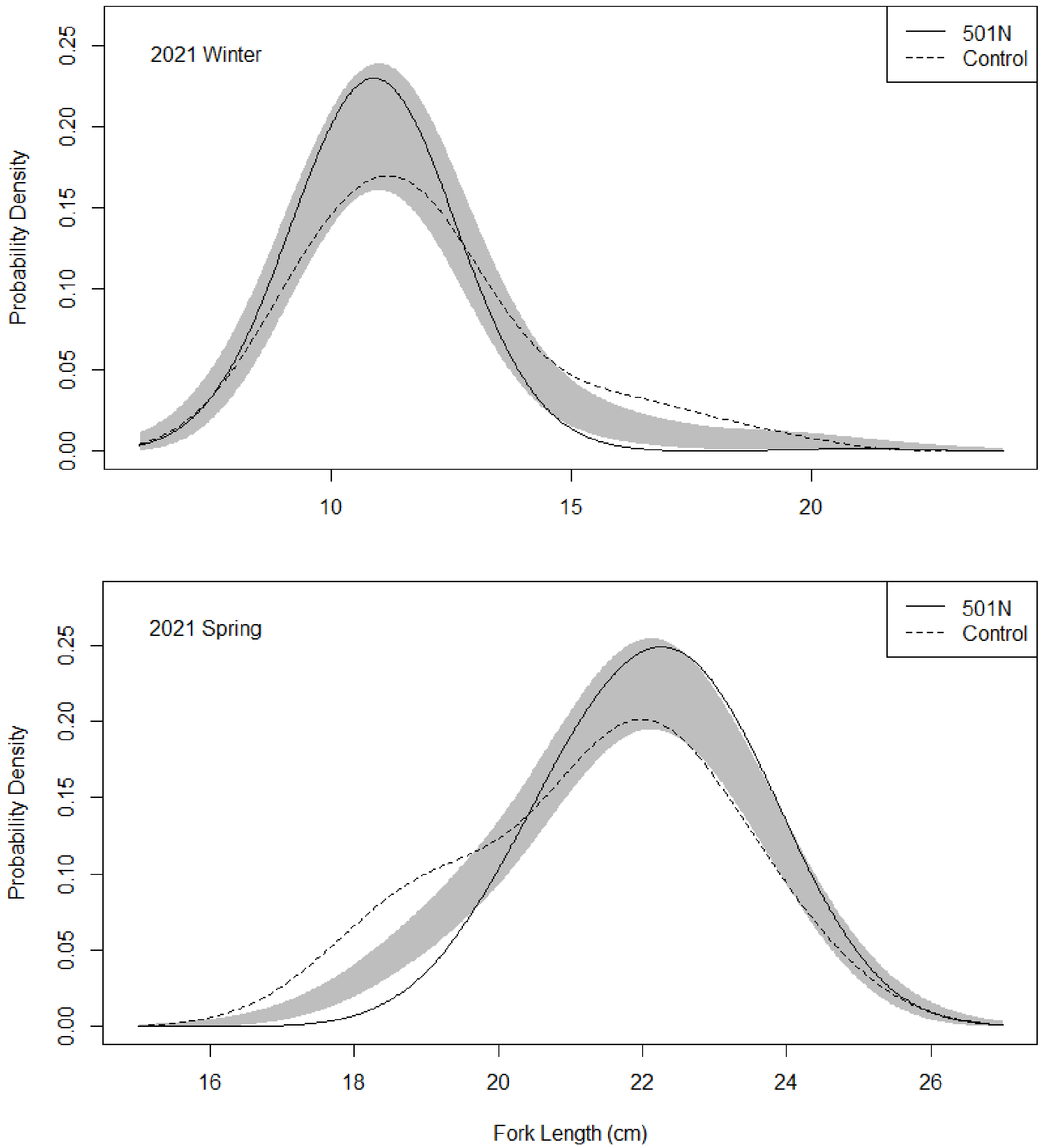
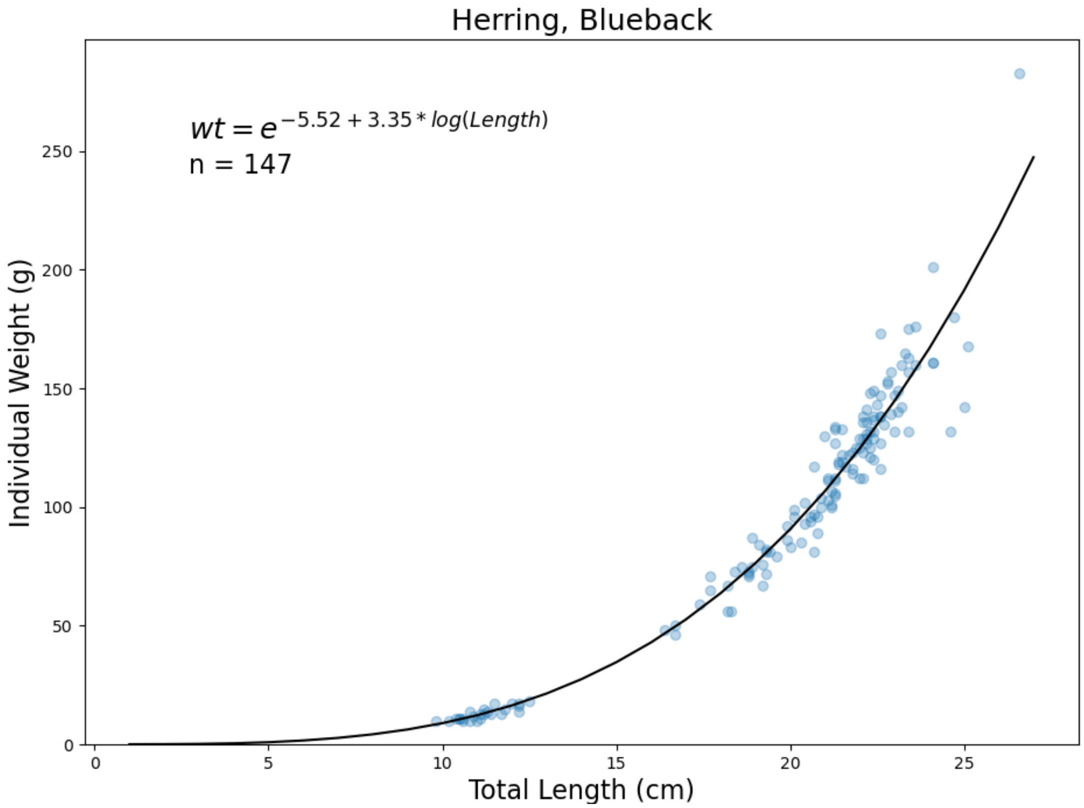


Figure 114: The population structure of blueback herring in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



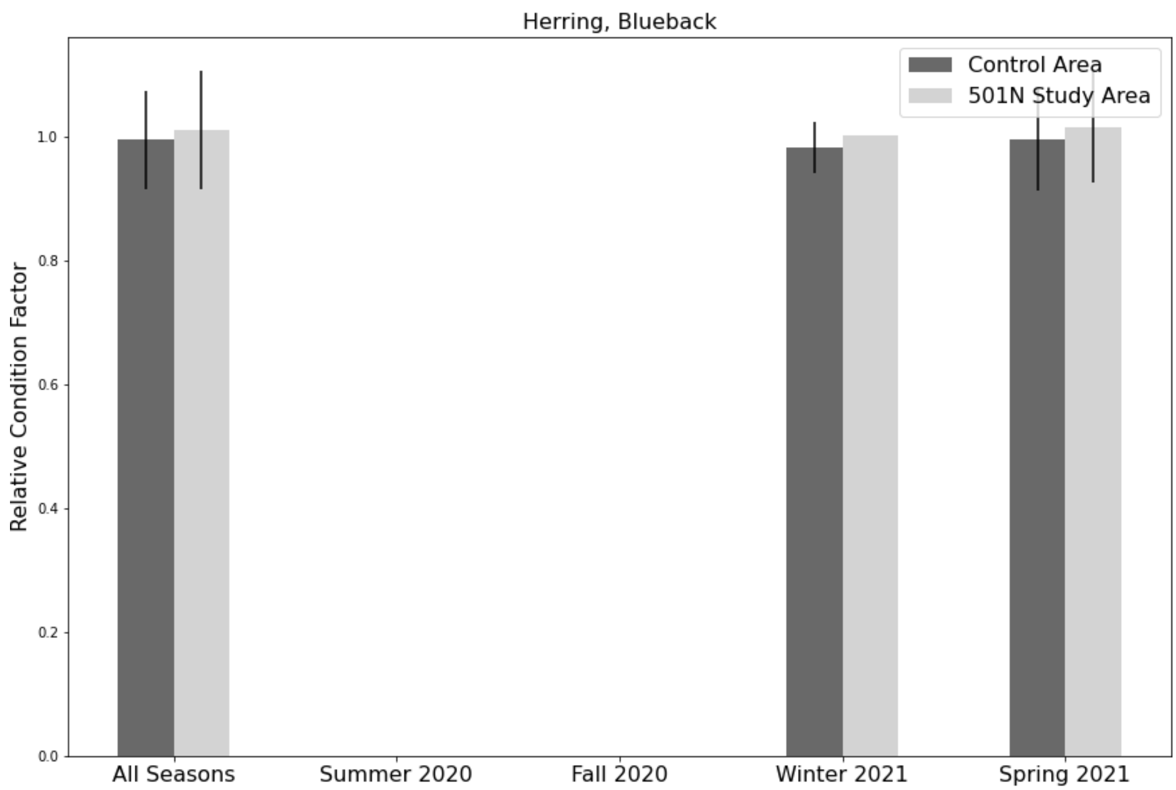


Figure 115: The seasonal condition of blueback herring (bottom) as derived from the length-weight relationship (top).

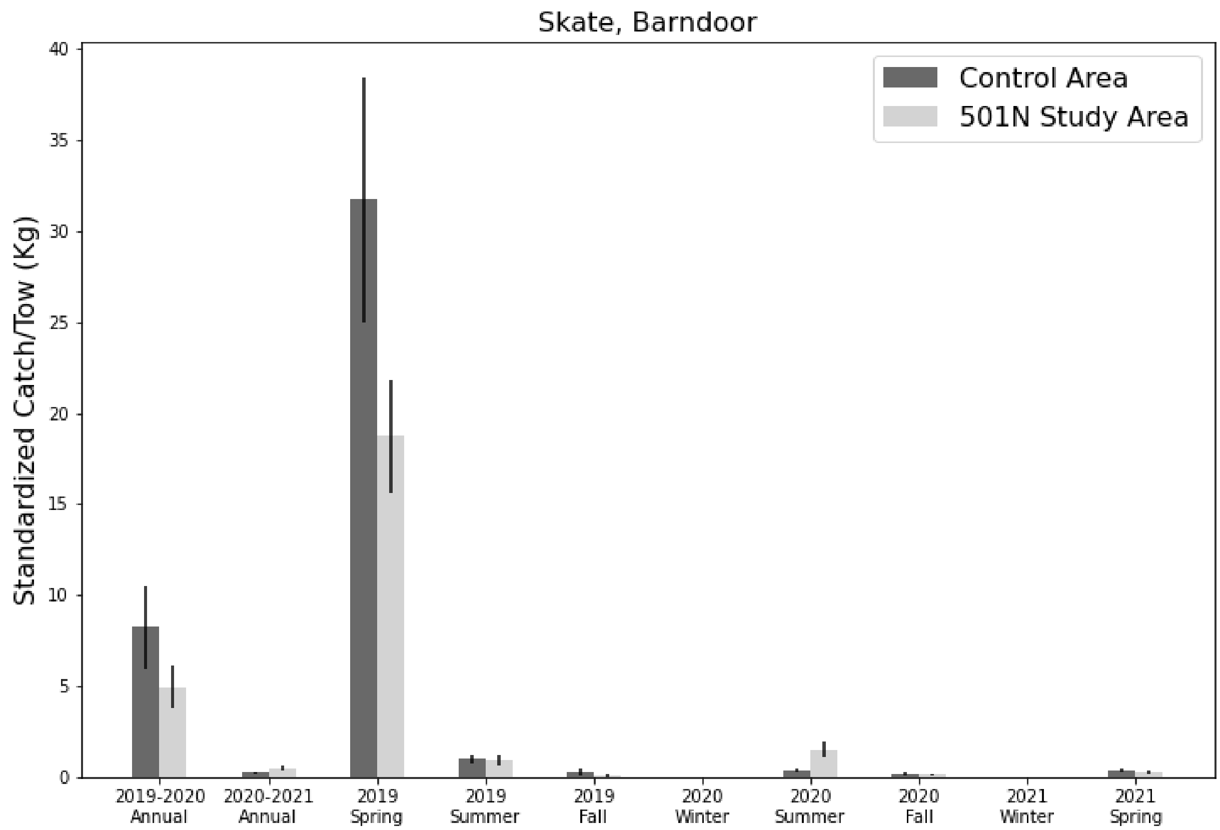


Figure 116: Seasonal catch rates of barndoor skate in the 501N Study Area and Control Area.

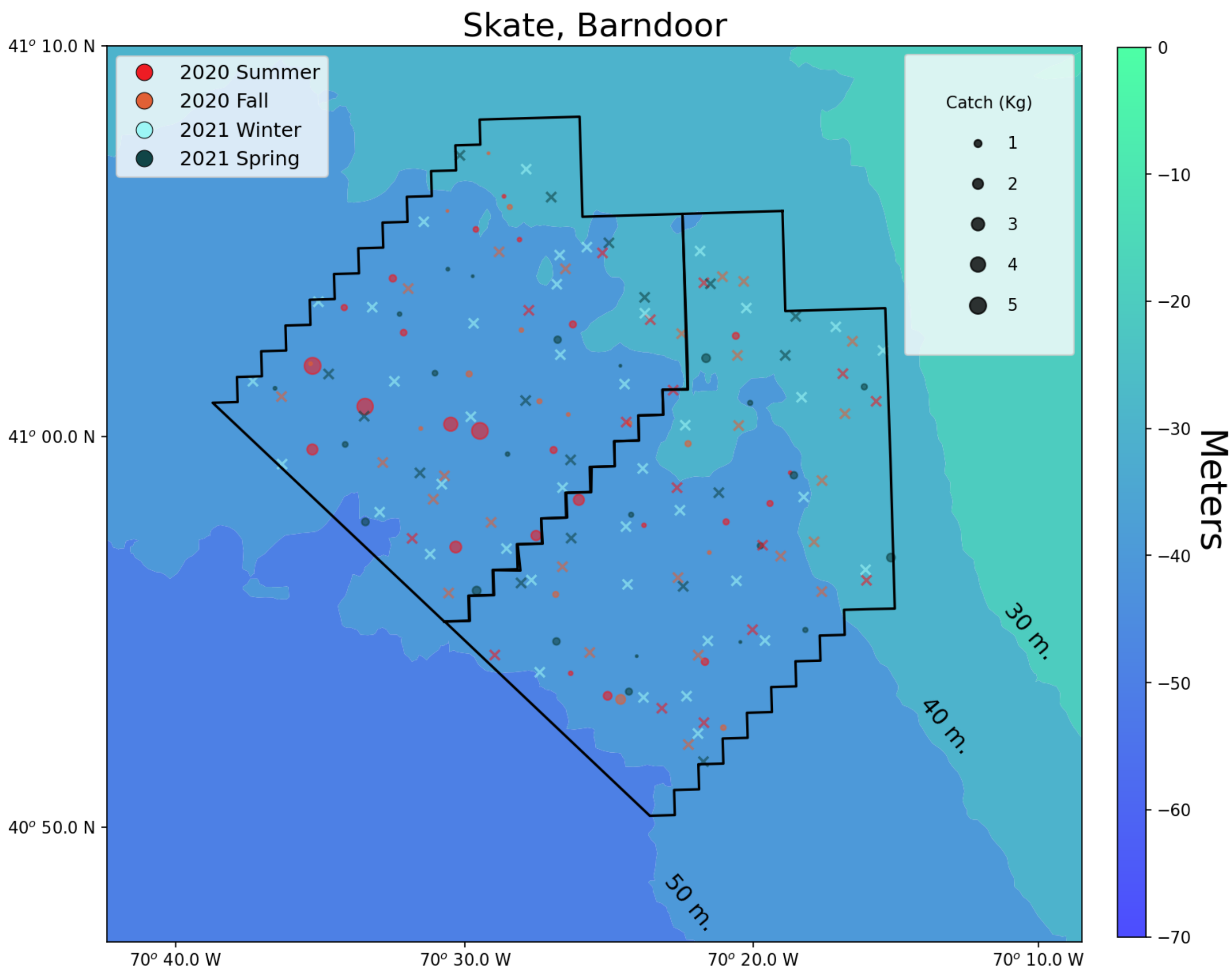


Figure 117: Seasonal distribution of the barndoor skate catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

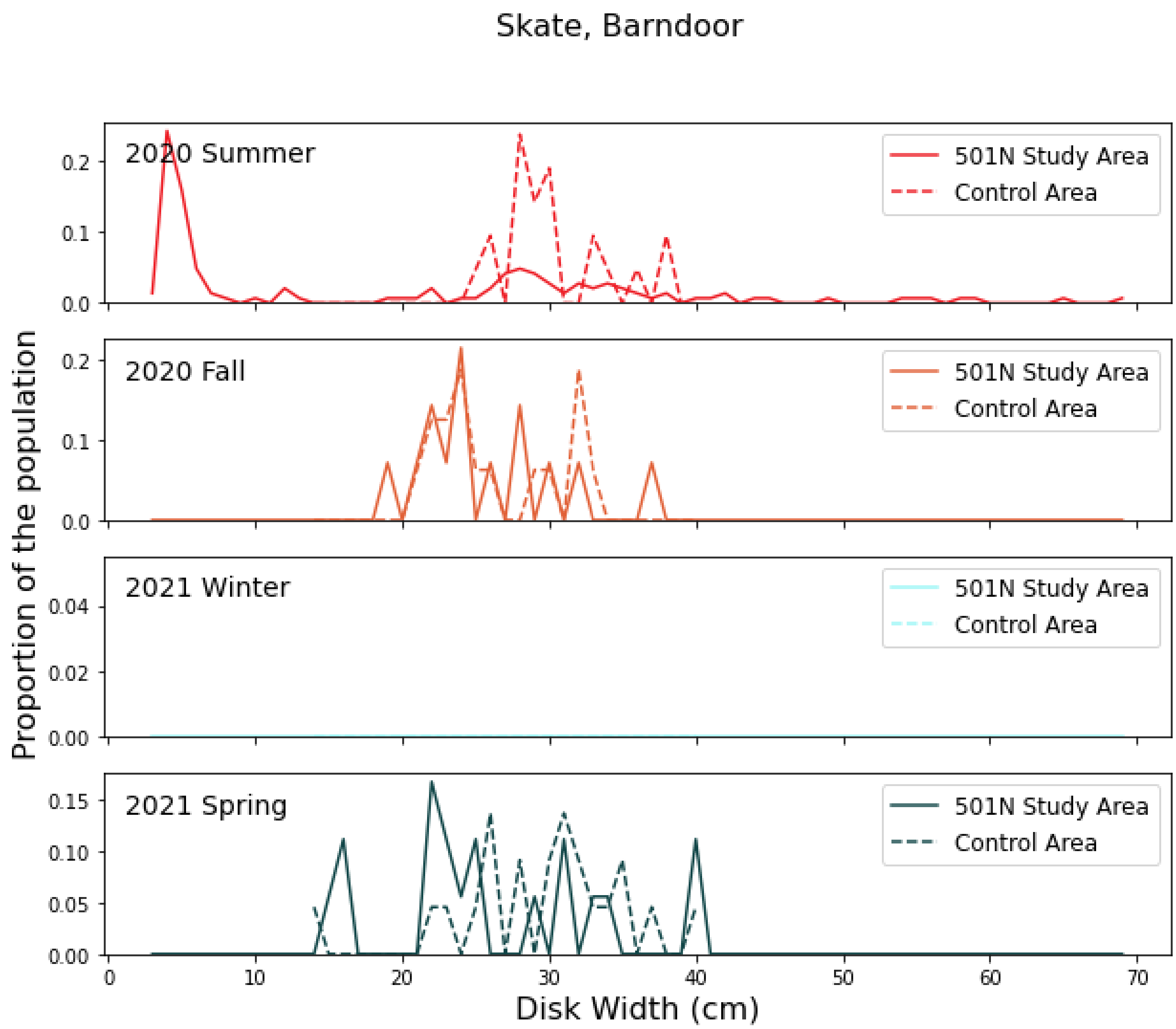


Figure 118: The seasonal length distributions of barndoor skate in the 501N Study Area and Control Area.

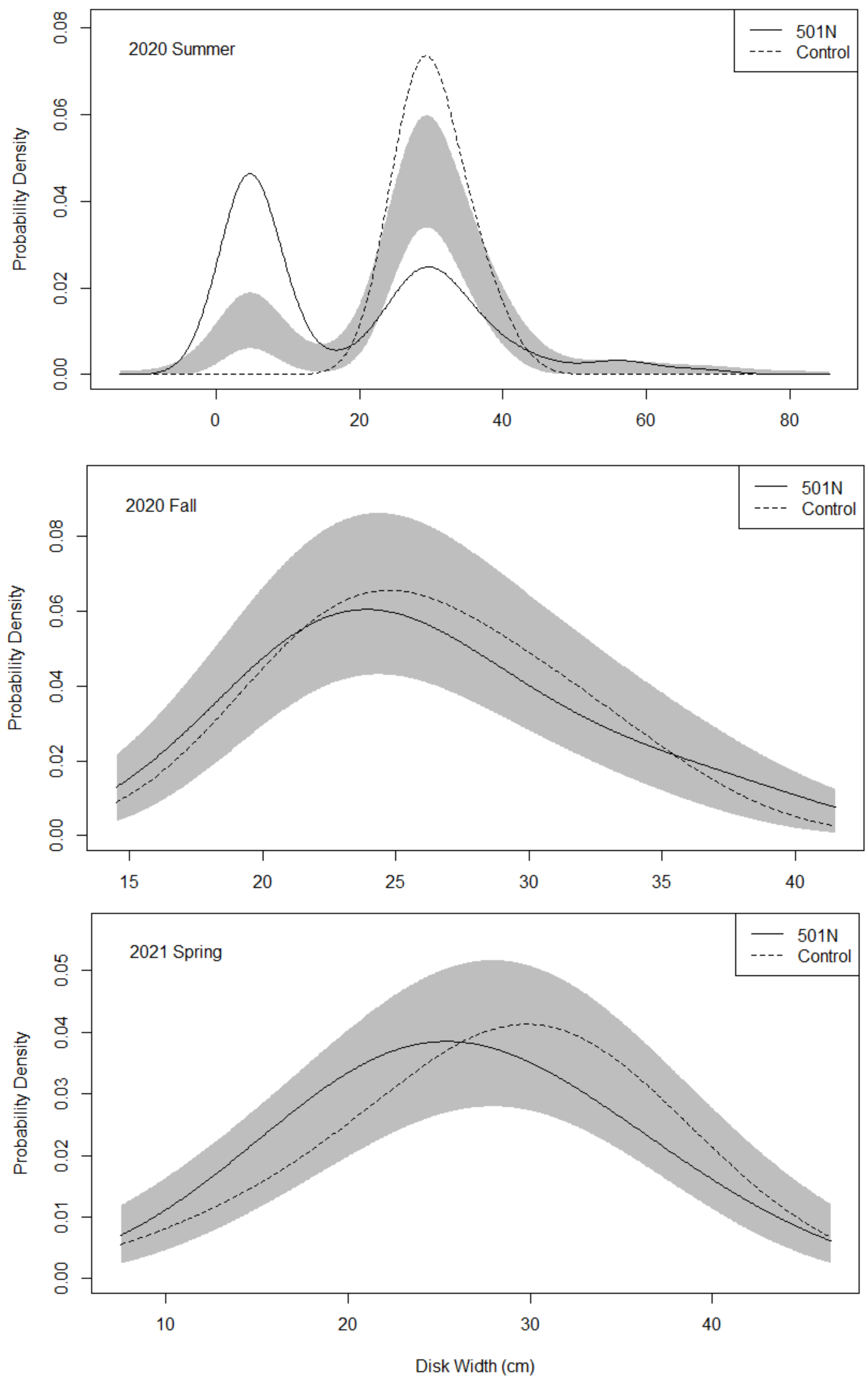
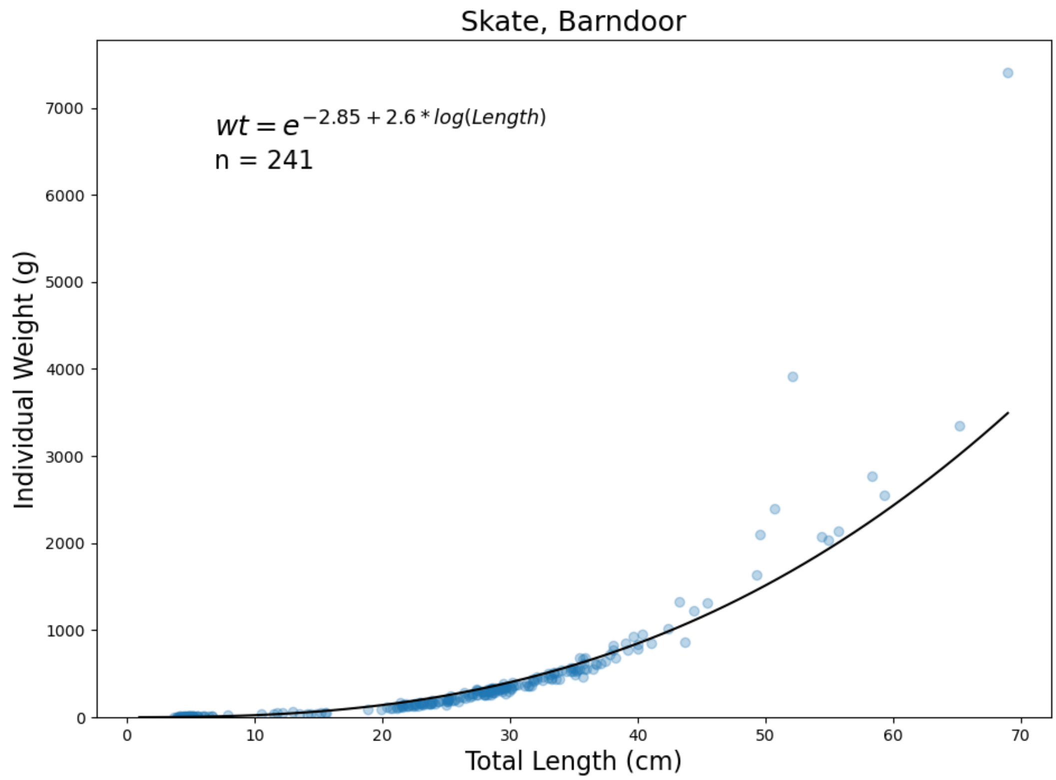


Figure 119: The population structure of barndoor skate in the 501N Study Area and Control Area assessed through kernel density estimates. The gray band represents the null hypothesis of no significant difference between treatments.



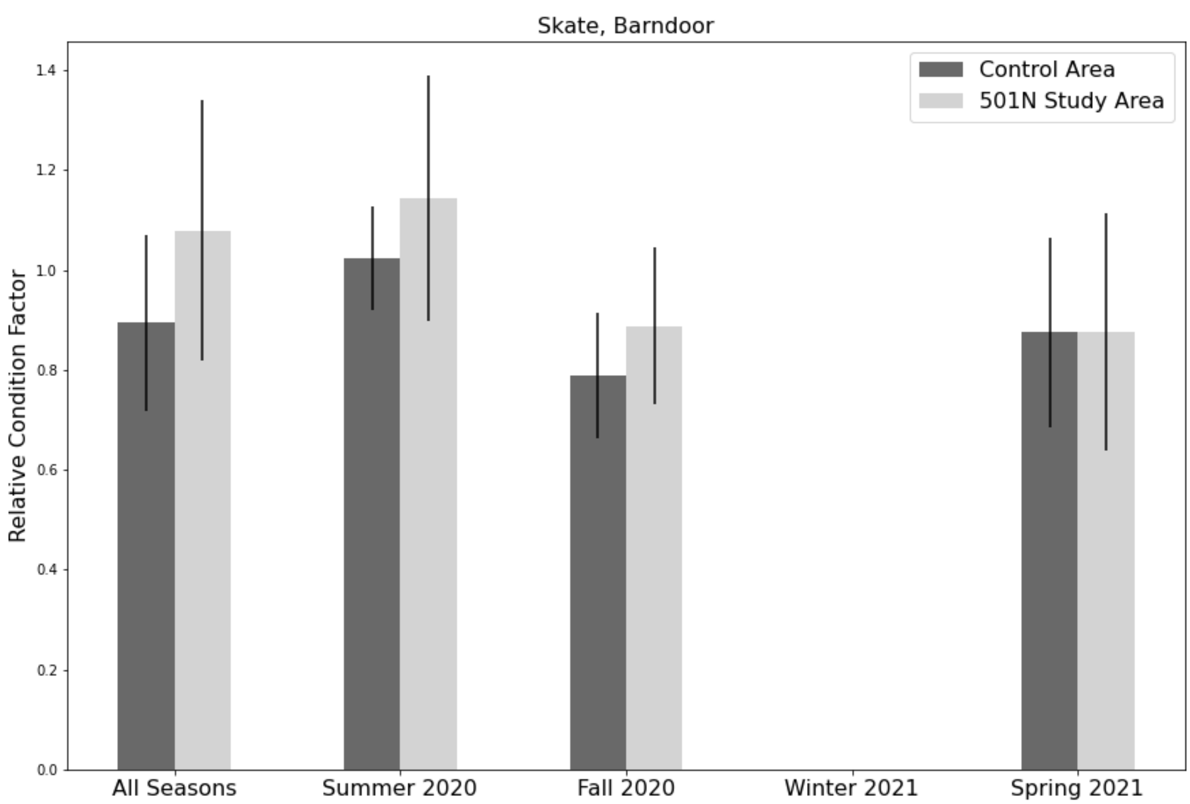


Figure 120: The seasonal condition of barndoor skate (bottom) as derived from the length-weight relationship (top).

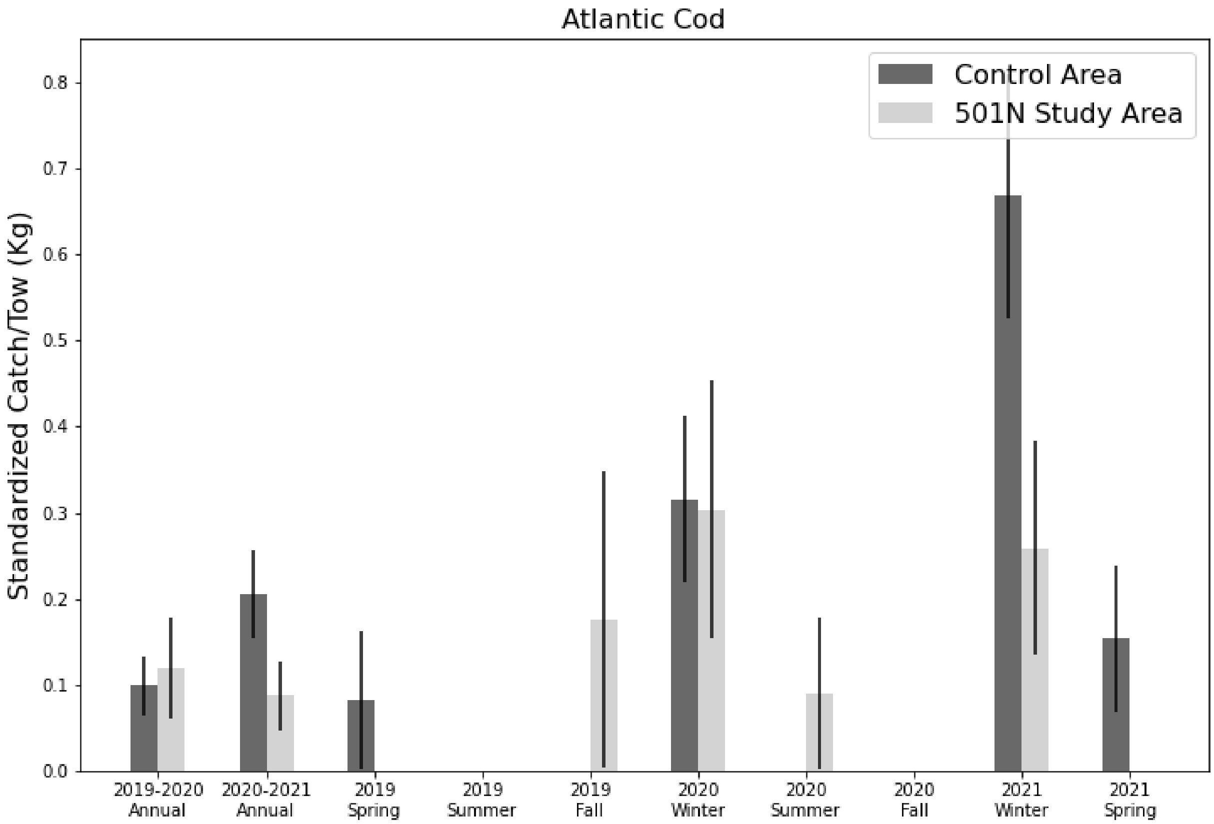


Figure 121: Seasonal catch rates of Atlantic cod in the 501N Study Area and Control Area.

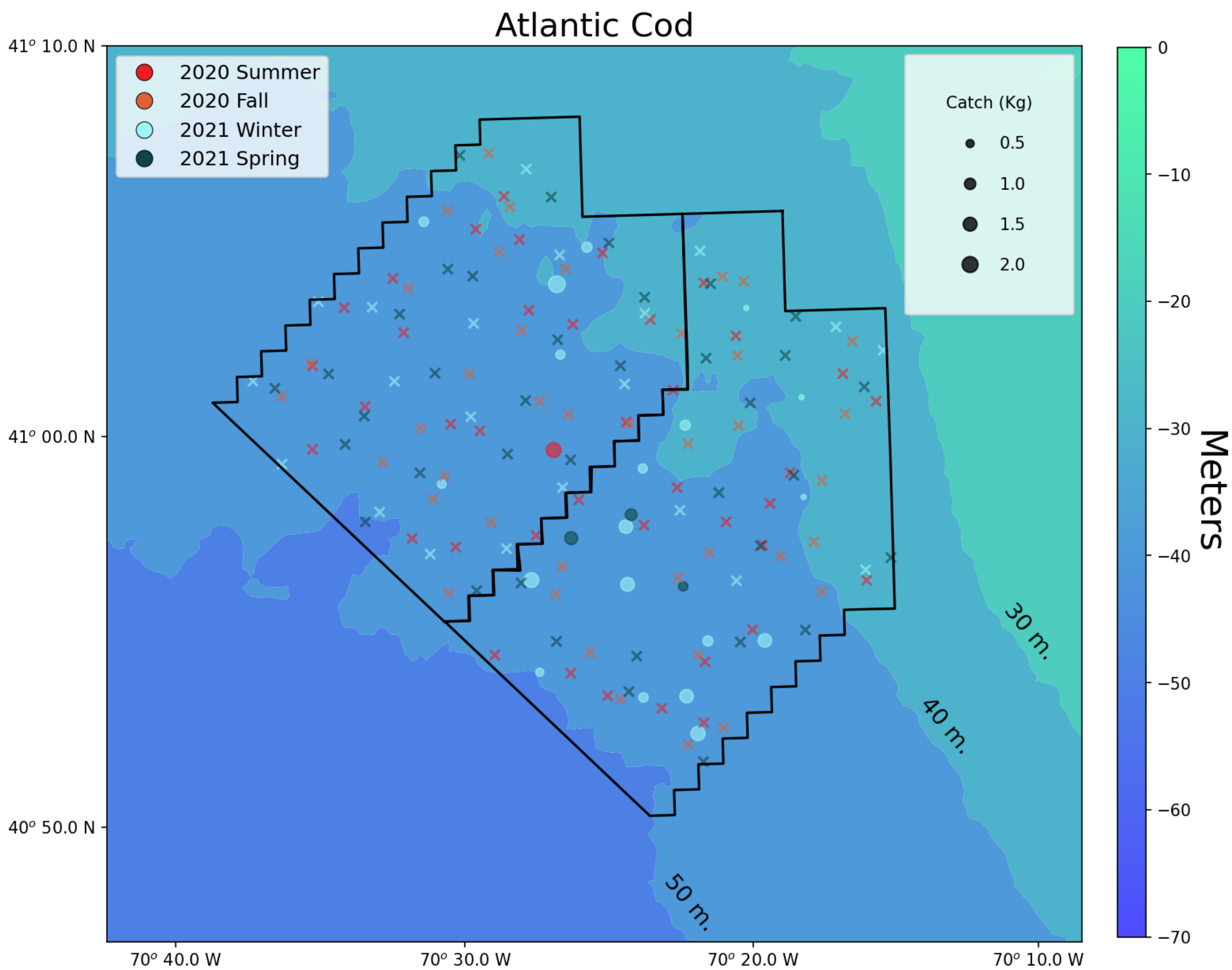


Figure 122: Seasonal distribution of the Atlantic cod catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

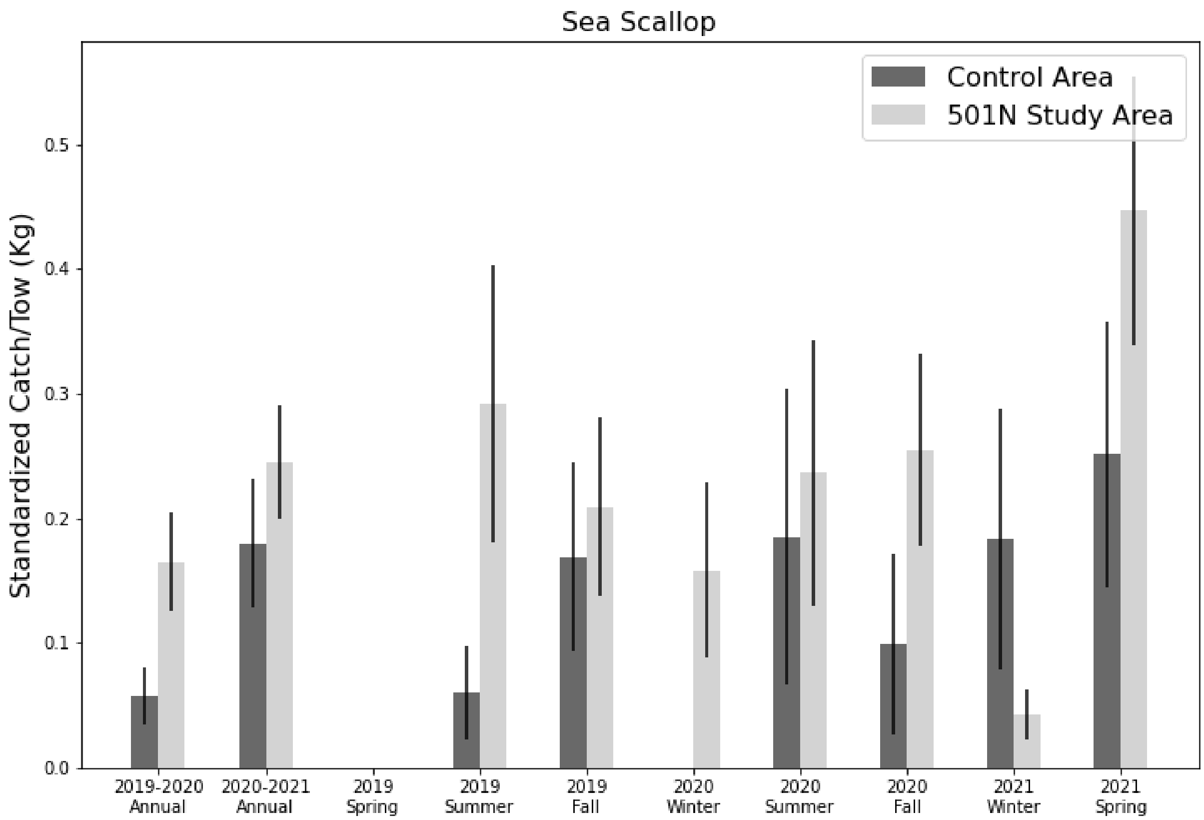


Figure 123: Seasonal catch rates of sea scallop in the 501N Study Area and Control Area.

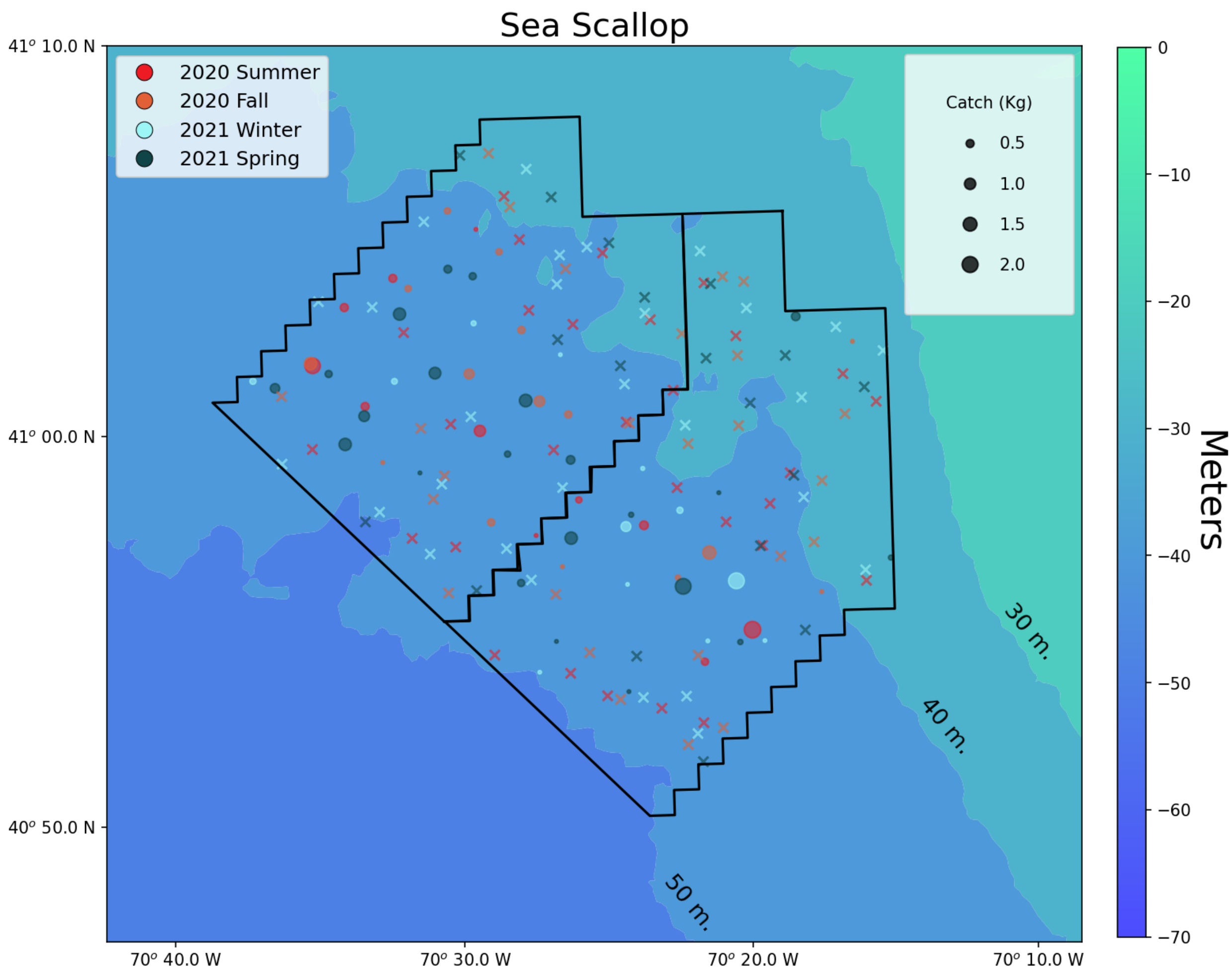
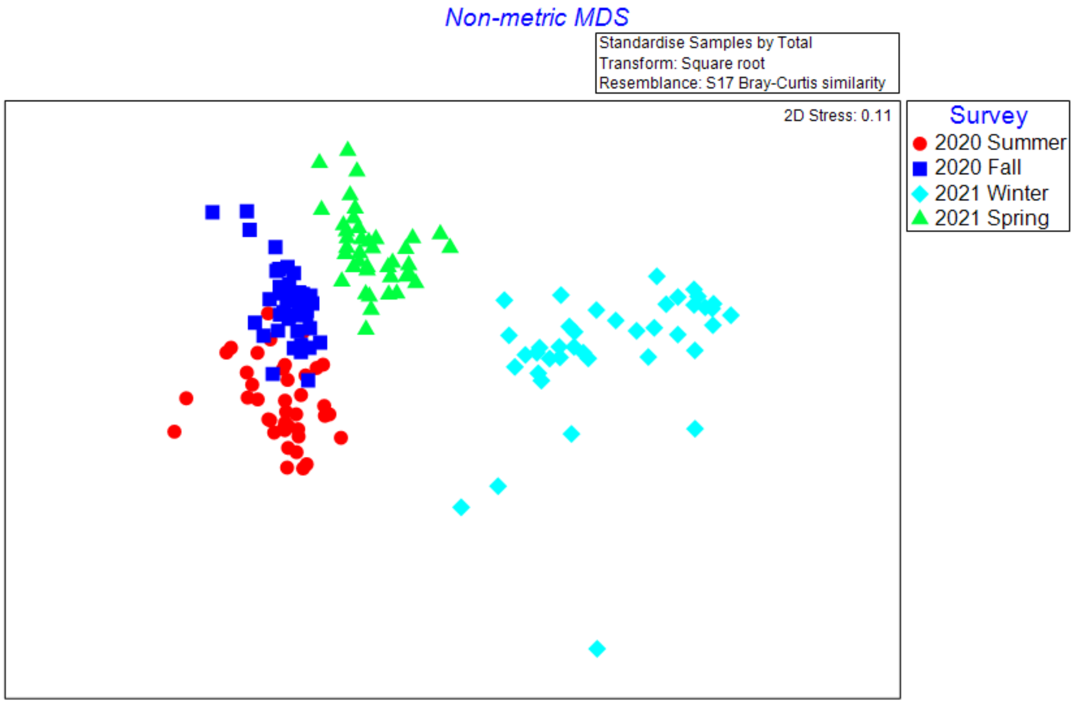


Figure 124: Seasonal distribution of the sea scallop catch in the 501N Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.



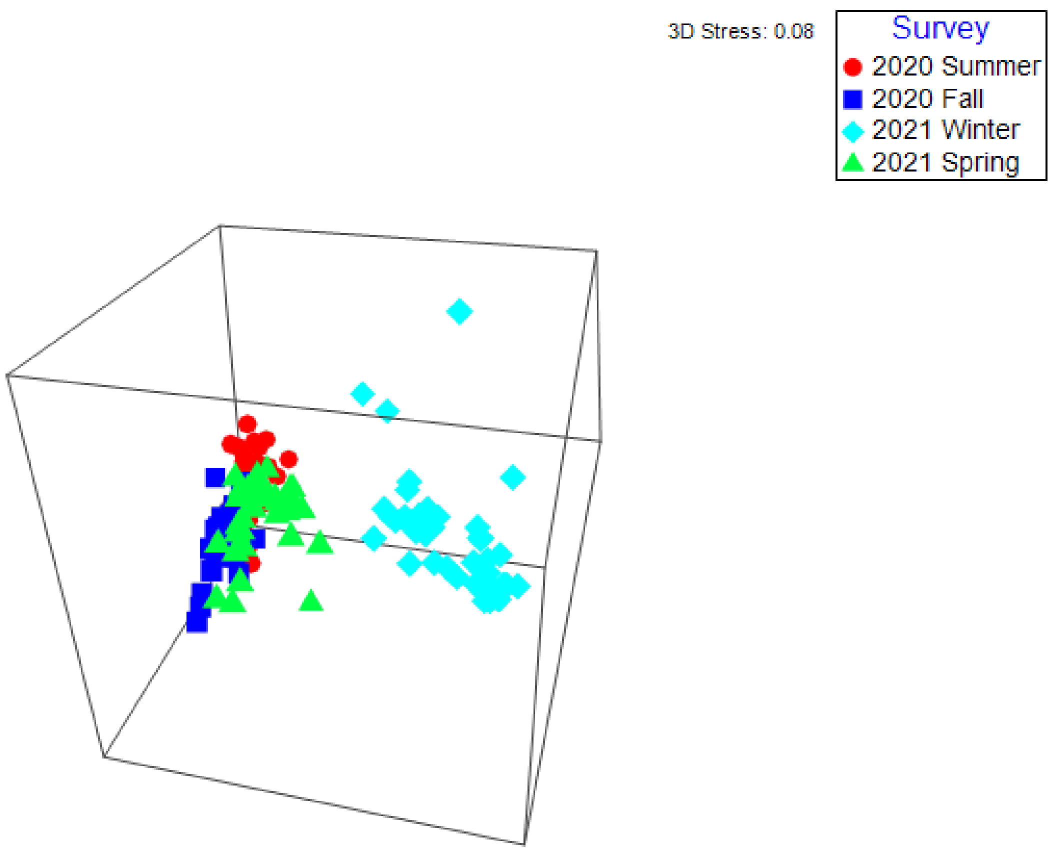


Figure 125: 2D (top) and 3D (bottom) nMDS plots. Data from the 2020/2021 seasons and survey areas is aggregated with the tow markers colored by season to highlight the seasonal clusters in species similarity.

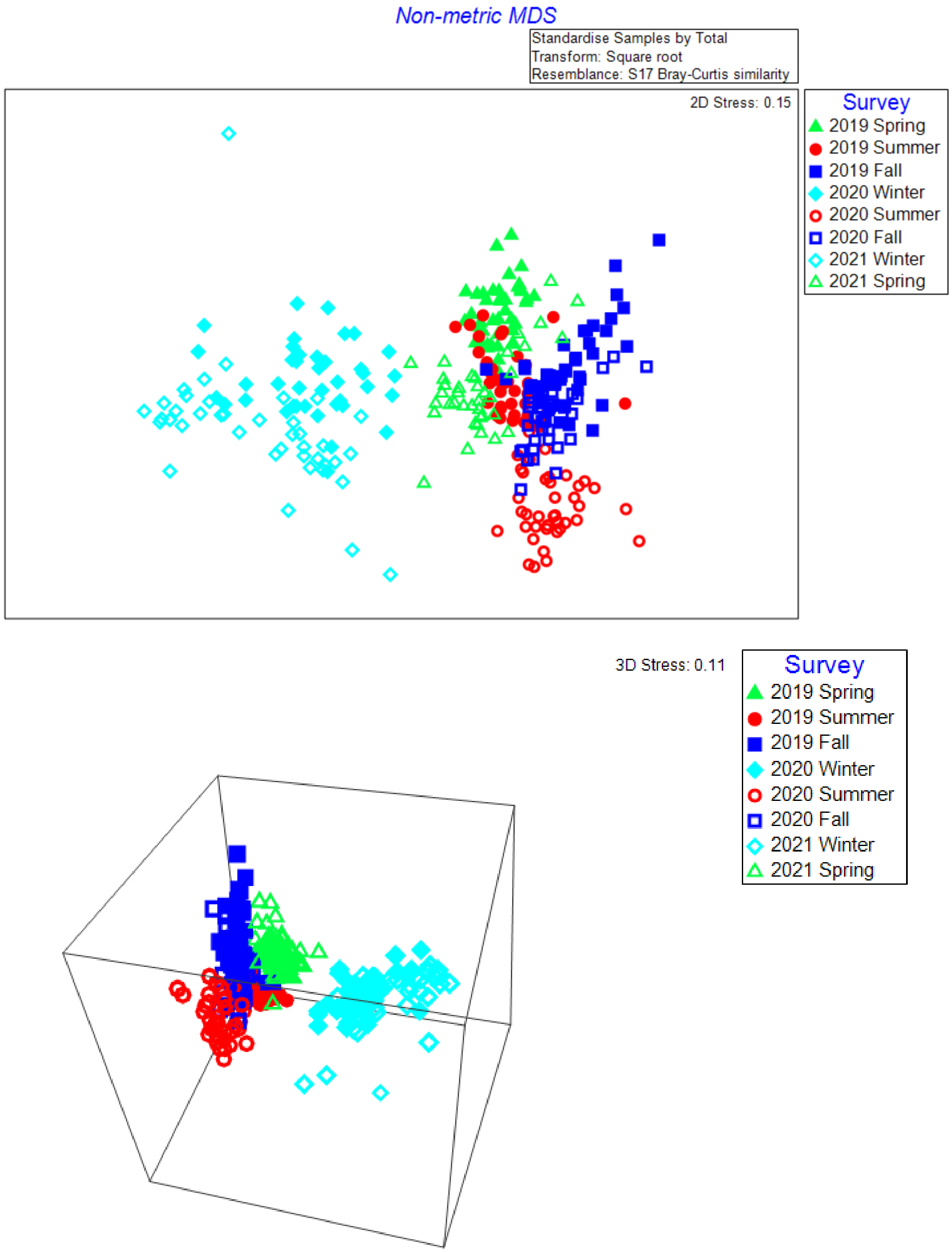


Figure 126: 2D (top) and 3D (bottom) nMDS plots. The data was aggregated from all surveys (2019 – 2021), including all seasons and both survey areas. The tow markers are colored by season to highlight the seasonal clusters in species similarity.

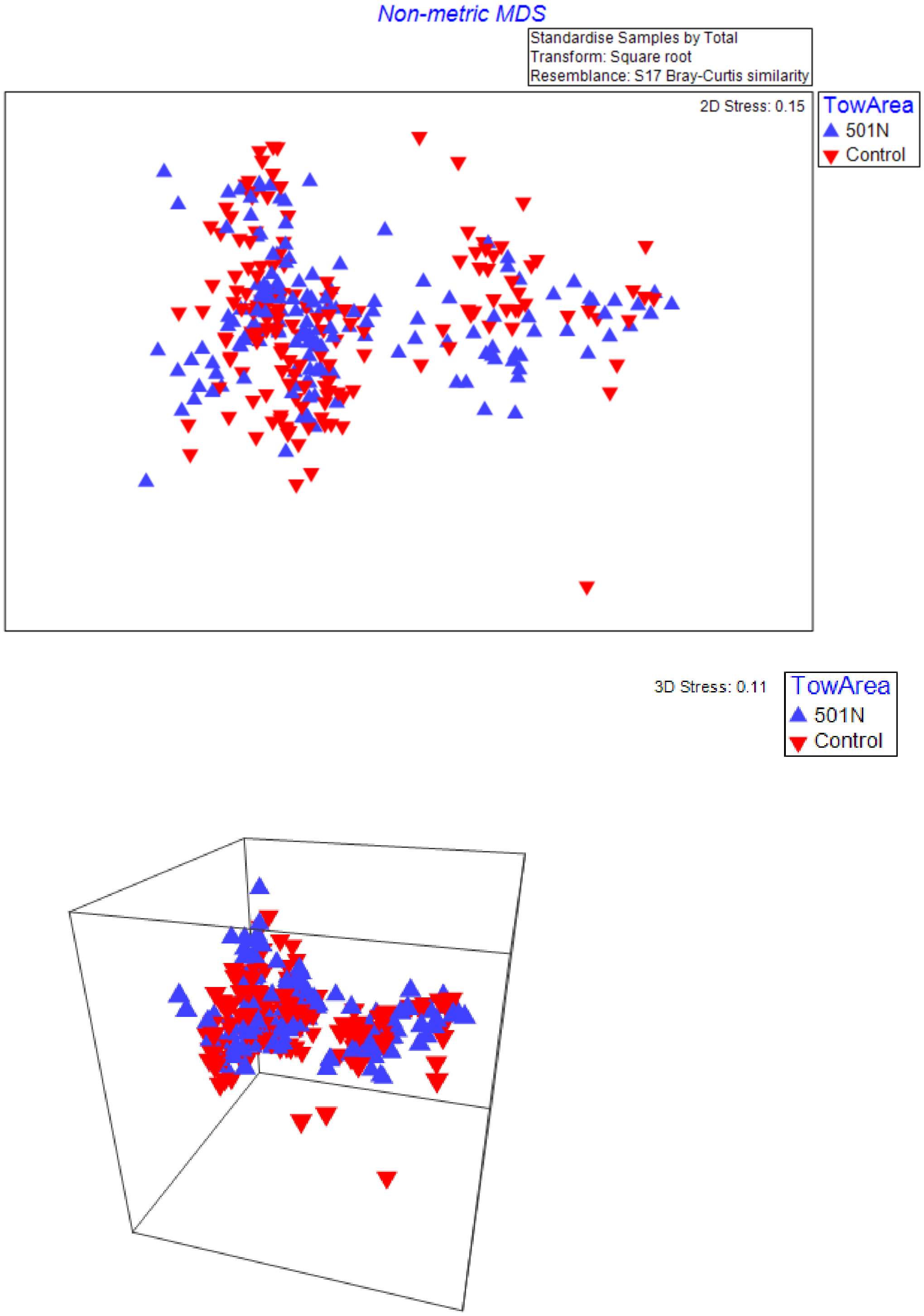


Figure 127: 2D (top) and 3D (bottom) nMDS plots. Data from all seasons and survey areas (2019 – 2021) is aggregated with the tow markers colored by survey area to highlight the lack of clustering between survey areas.

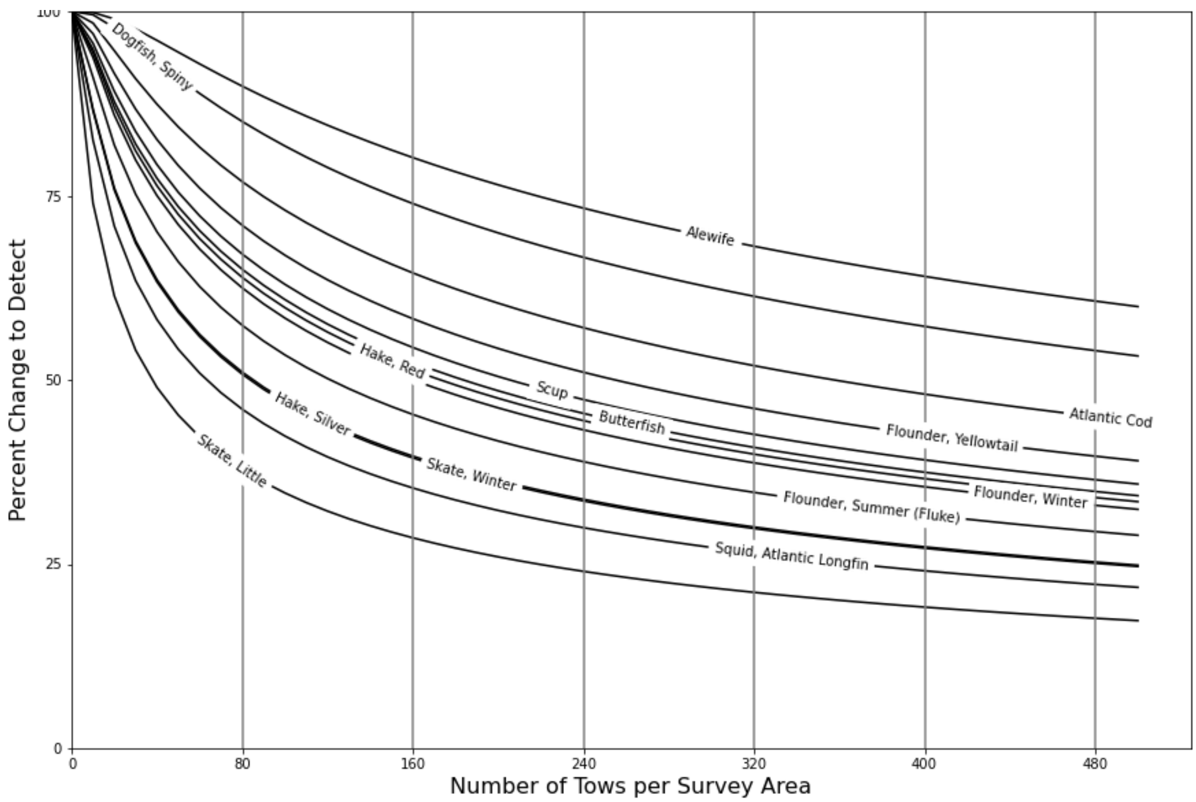


Figure 128: Relationship between survey effort and detectable magnitude of change for several species of commercial interest. The ability to detect the percent change in a species population size is a function of the variability in the catch and the sample size (i.e., number of tows). The current survey effort samples 80 tows per survey area per year.

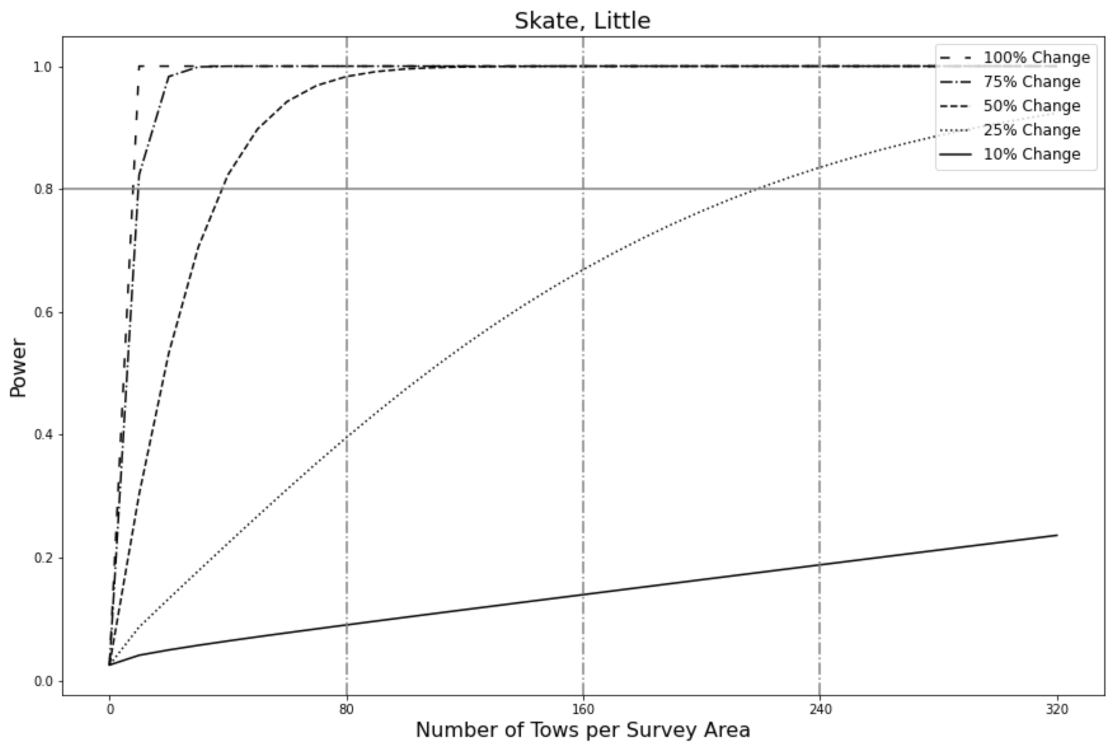


Figure 129: Power analysis relationship between statistical power and sample size in little skate. Dashed vertical gray lines align with years of survey effort. Gray horizontal line highlights an 80% probability of positive detection.

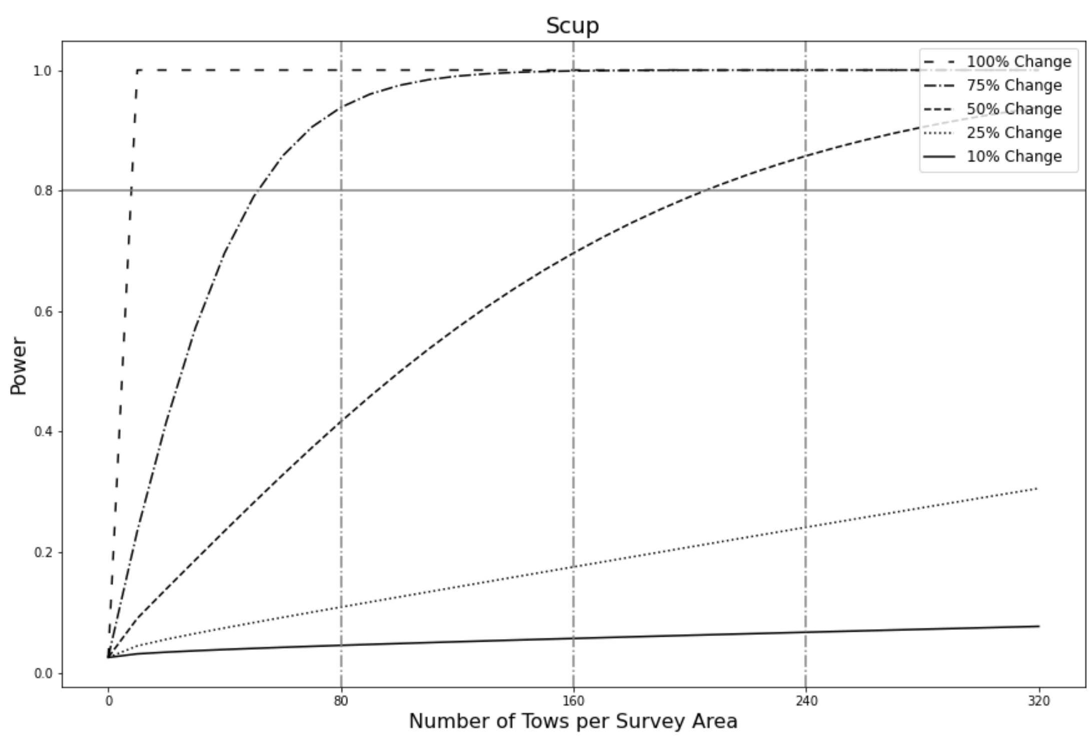


Figure 130: Power analysis relationship between statistical power and sample size in scup. Dashed vertical gray lines align with years of survey effort. Gray horizontal line highlights an 80% probability of positive detection.

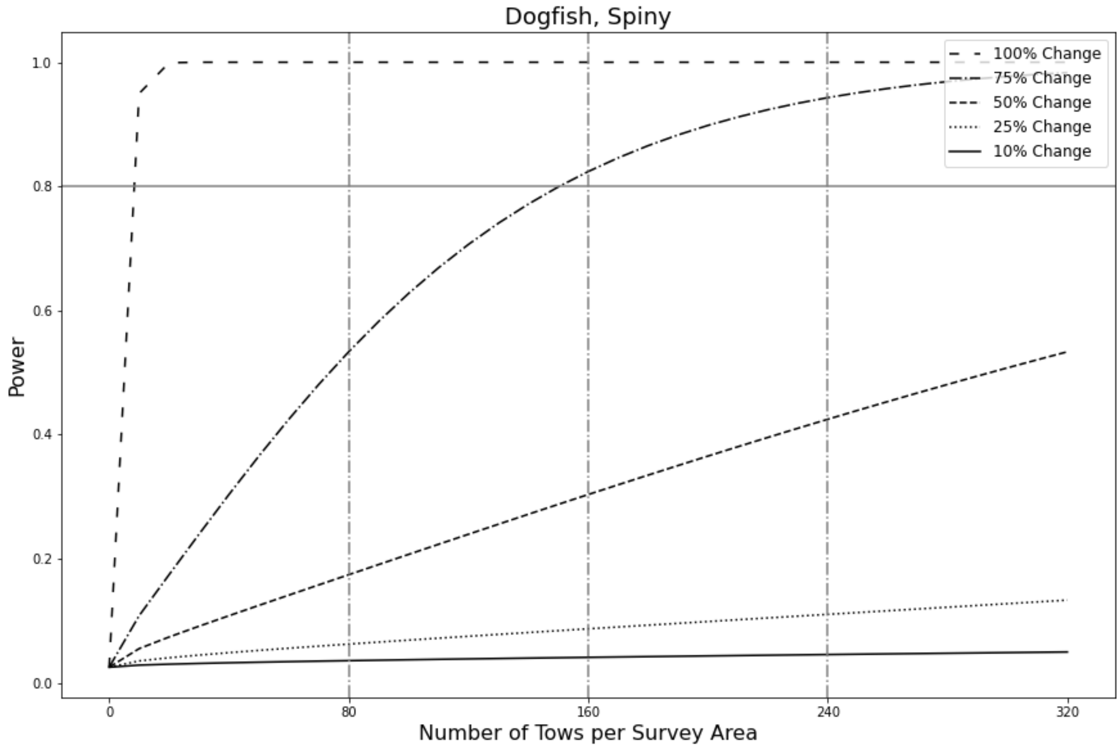


Figure 131: Power analysis relationship between statistical power and sample size in spiny dogfish. Dashed vertical gray lines align with years of survey effort. Gray horizontal line highlights an 80% probability of positive detection.

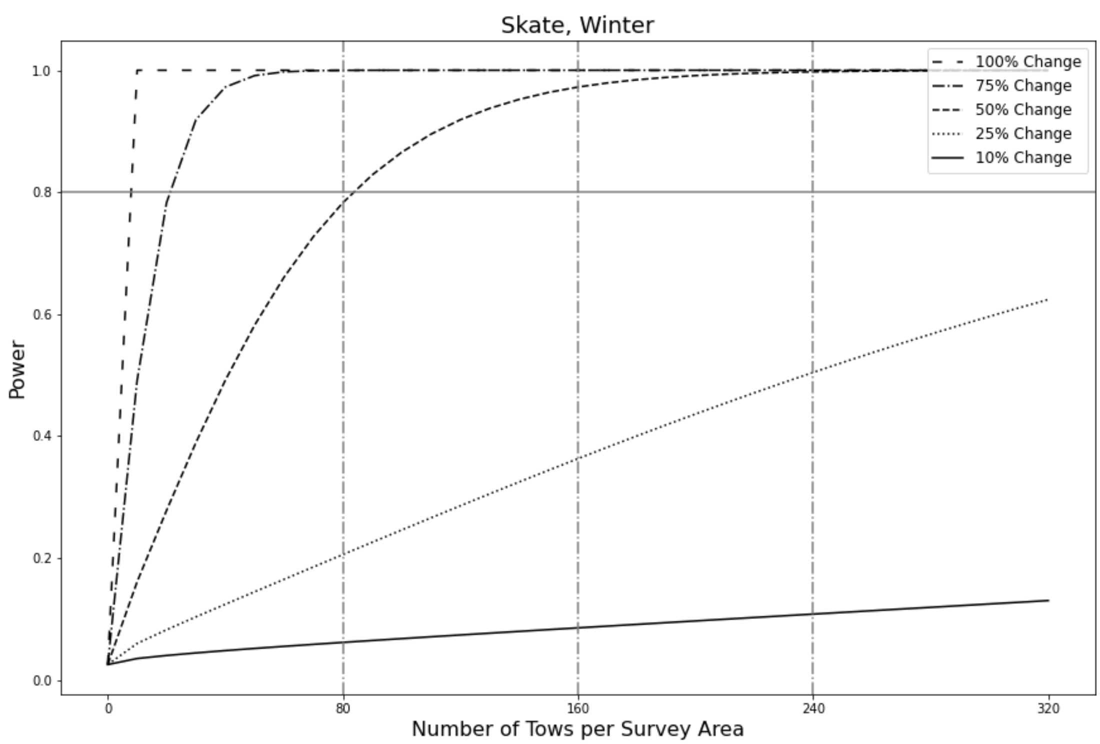


Figure 132: Power analysis relationship between statistical power and sample size in winter skate. Dashed vertical gray lines align with years of survey effort. Gray horizontal line highlights an 80% probability of positive detection.

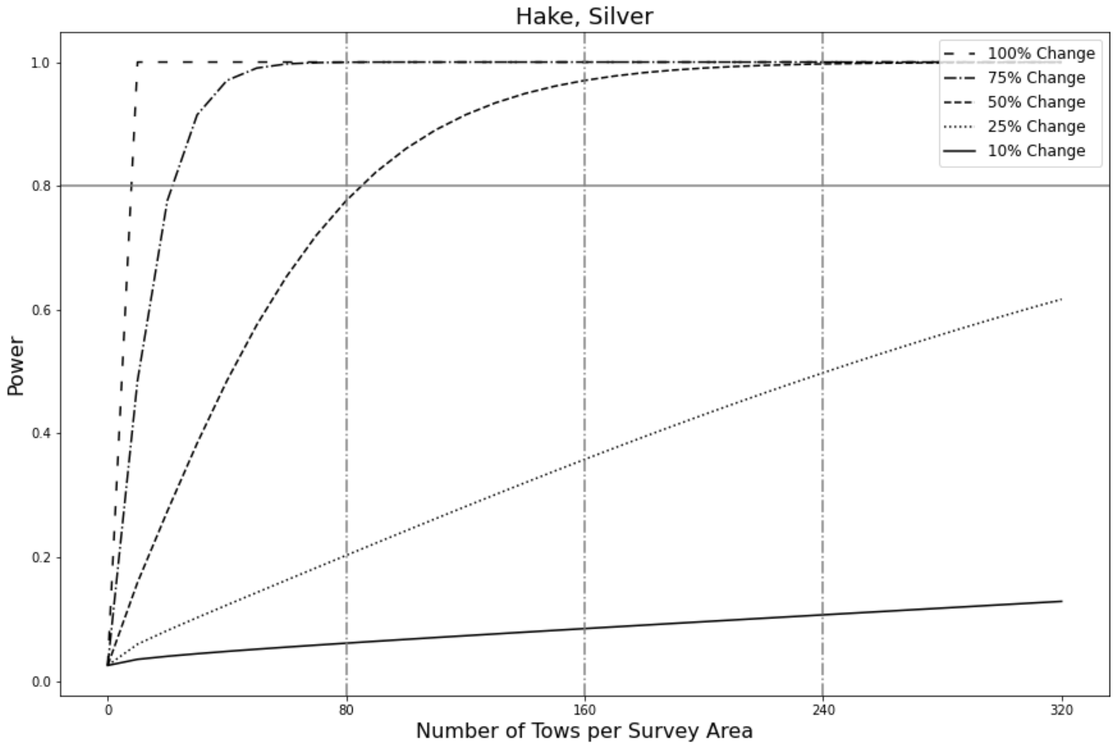


Figure 133: Power analysis relationship between statistical power and sample size in silver hake. Dashed vertical gray lines align with years of survey effort. Gray horizontal line highlights an 80% probability of positive detection.

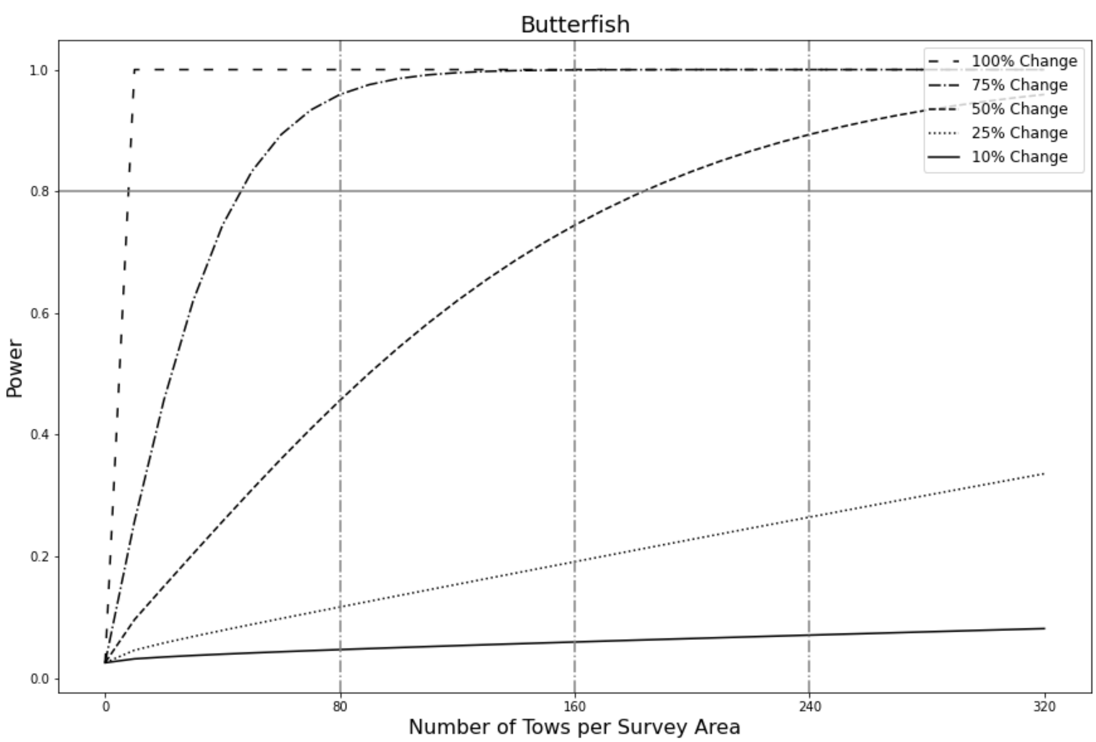


Figure 134: Power analysis relationship between statistical power and sample size in butterfish. Dashed vertical gray lines align with years of survey effort. Gray horizontal line highlights an 80% probability of positive detection.

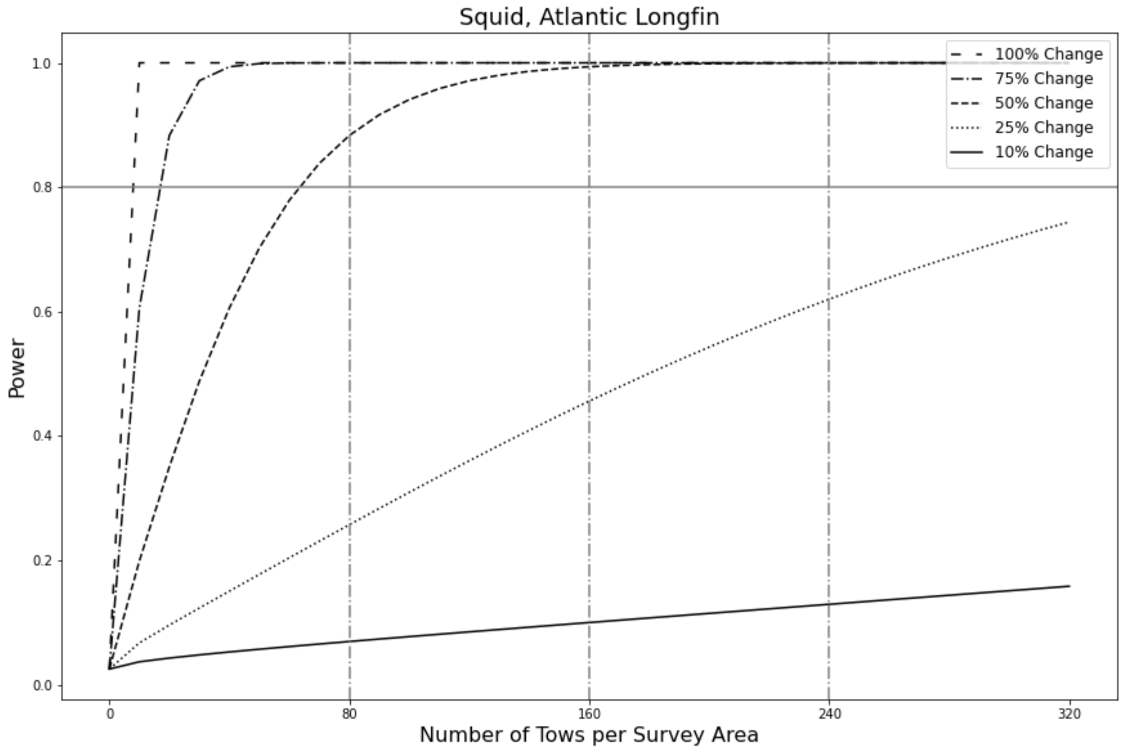


Figure 135: Power analysis relationship between statistical power and sample size in Atlantic longfin squid. Dashed vertical gray lines align with years of survey effort. Gray horizontal line highlights an 80% probability of positive detection.

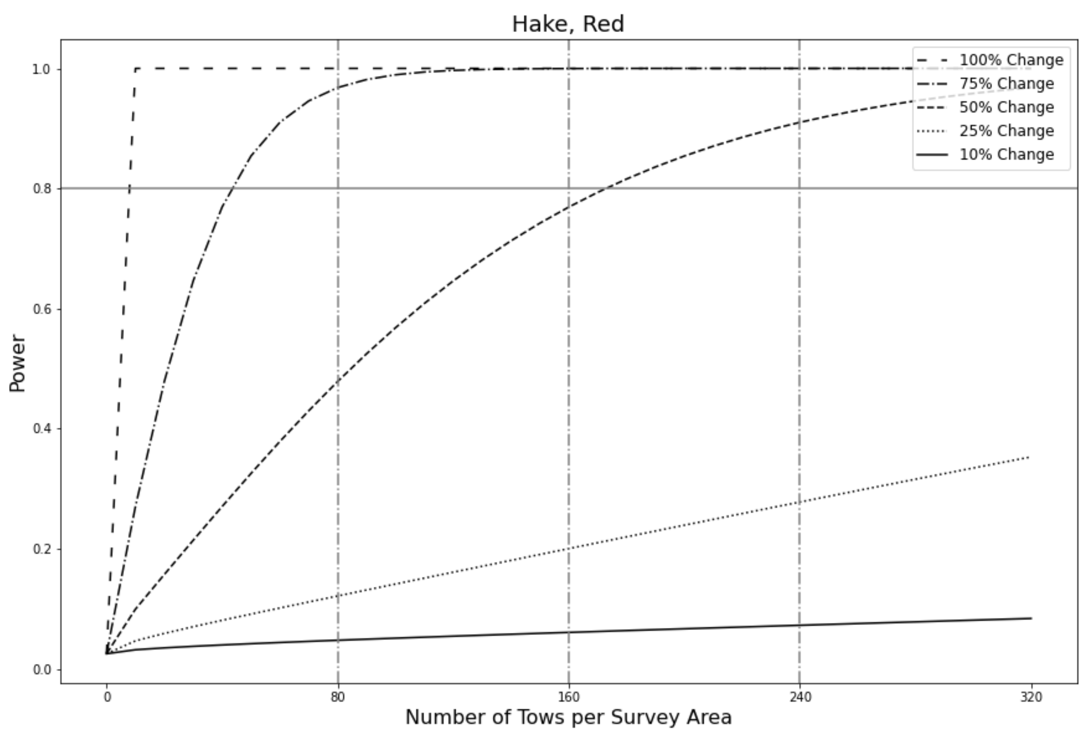


Figure 136: Power analysis relationship between statistical power and sample size in red hake. Dashed vertical gray lines align with years of survey effort. Gray horizontal line highlights an 80% probability of positive detection.

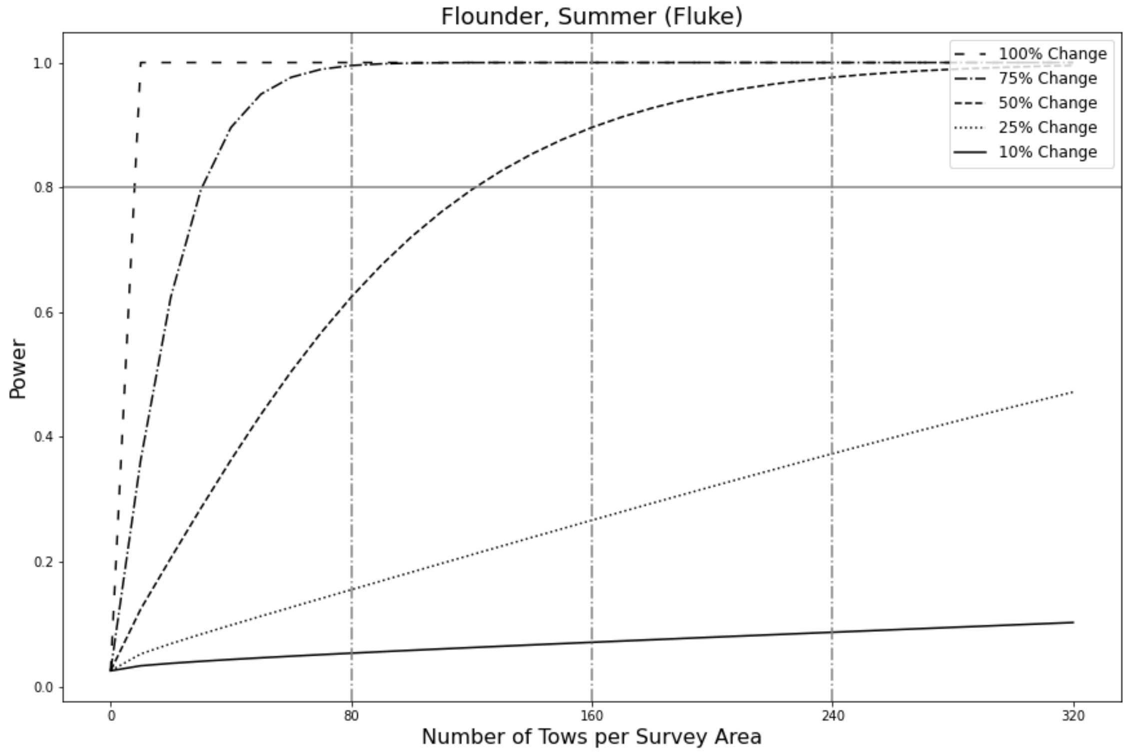


Figure 137: Power analysis relationship between statistical power and sample size in summer flounder. Dashed vertical gray lines align with years of survey effort. Gray horizontal line highlights an 80% probability of positive detection.

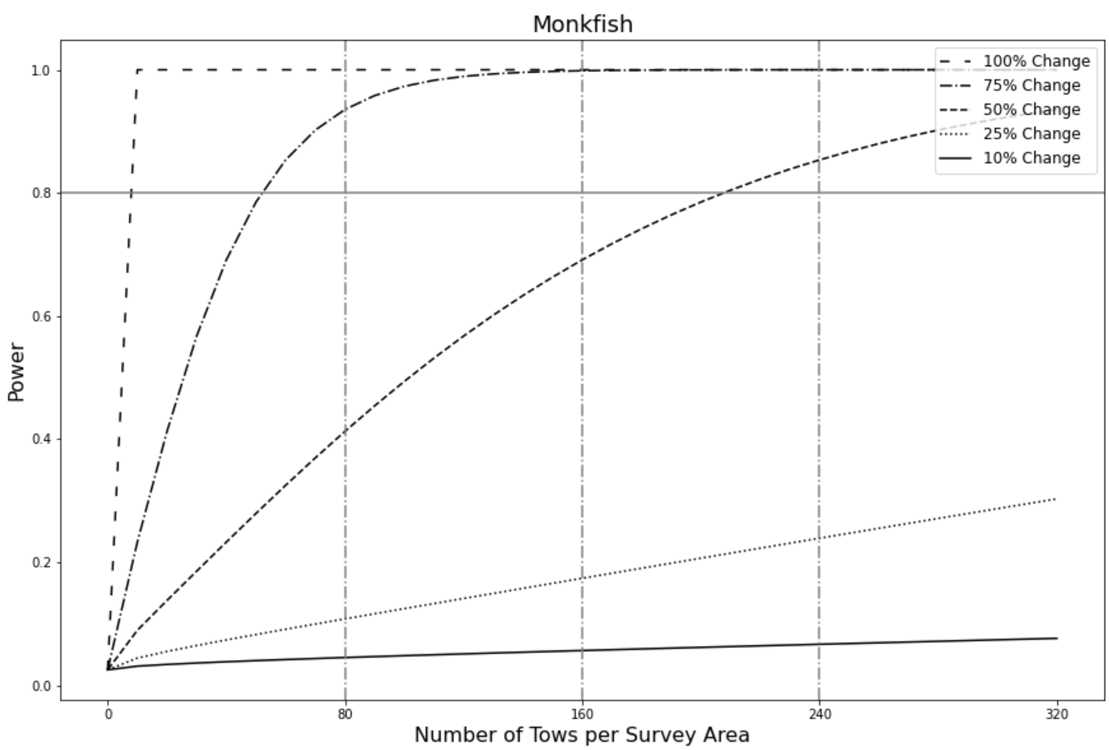


Figure 138: Power analysis relationship between statistical power and sample size in monkfish. Dashed vertical gray lines align with years of survey effort. Gray horizontal line highlights an 80% probability of positive detection.