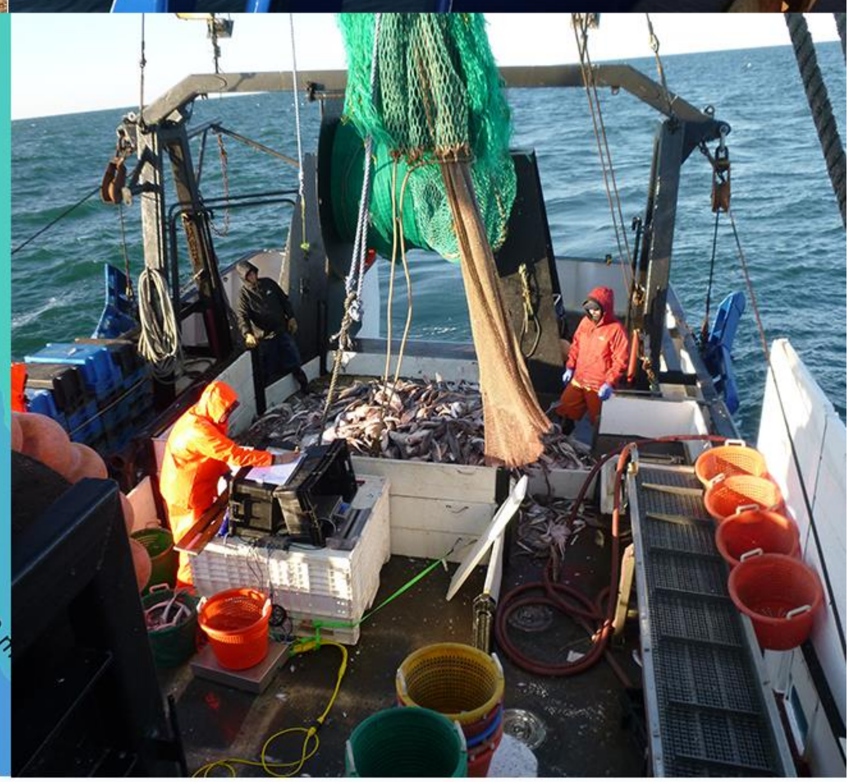
Vineyard Wind Demersal Trawl Survey



Annual Report
2019-2020

501 North Study Area

VINEYARD WIND DEMERSAL TRAWL SURVEY

2019/2020 Annual Report

501 North Study Area

August 2020

Prepared for Vineyard Wind, LLC

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Vineyard Wind Demersal Trawl Survey Annual Report

501 North Study Area

2019/2020 Annual Report

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1. Summary

Vineyard Wind LLC, in collaboration with the University of Massachusetts Dartmouth's School for Marine Science and Technology (SMAST), has developed a monitoring plan to assess the potential environmental impacts of the proposed offshore renewable energy development on the northern portion of Lease Area OCS-A 0501 (the 501 North Study Area) on marine fish and invertebrate communities. One component of the monitoring plan is a bottom trawl survey. The trawl survey is modeled after the Northeast Area Monitoring and Assessment Program (NEAMAP), a regional survey used to assess near-shore fish communities. The data collected from this survey is intended to provide baseline information on species abundance, population characteristics and community structure to be used in a future impact analysis. Vineyard Wind is also conducting fisheries studies within the southern portion of Lease Area OCS-A 0501 (the "501 South Study Area") and within Lease Area OCS-A 0522; these studies are reported separately

Four seasonal trawl surveys were conducted using commercial fishing vessels. Twenty tows were conducted each season in the 501 North 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 random 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 its trawl geometry. The catch was sorted by species. Aggregated weight as well as individual fish lengths and weights were collected.

A total of 160 tows were completed throughout the year split equally between the 501 North Study Area and the Control Area, and among four seasons. The catch data obtained shows a dynamic area with a diversity of marine species. A total of 45 species were collected; however the majority of the catch was comprised of a small subset of the observed species. The four most abundant species (spiny dogfish, little skate, silver hake and red hake) were shared between the two survey areas and accounted for 78% of the total catch weight in the 501 North Study Area and 71% of the total catch weight in the Control Area. The next four most abundant species (winter skate, scup, butterfish and alewife) were similarly shared between regions and added an additional 15% to 20% of the total catch. All species caught displayed seasonal variations in distribution and abundance. The data indicate a unique assemblage of species and abundance in each of four seasons. The spring, summer and fall surveys display significant overlap in species assemblages; however catch rates and the population structure varied. The winter survey appears to be relatively unique in the species assemblage which is primarily dominated by pelagic species. No differences in species assemblages were observed between the two study areas.

The variability of the catch data is inversely related to the ability to detect changes in the population. The results of a power analysis indicated that several species, including little skate, longfin squid, silver hake and fourspot flounder had relatively low variability and therefore high probability of detecting a small to moderate effects (~25% change) under the current monitoring effort. Many of the common species observed, including winter skate, red hake, windowpane flounder, monkfish, summer flounder, scup, yellowtail flounder, winter flounder and butterfish had much higher variability (CV: 1.5 - 2.3). For these species, we would have a high probability of detecting differences only when there are moderate effects (i.e. 30-50% change) under the current monitoring effort. For species exhibiting strong seasonality and high variability (CV's 2.5 – 4), only 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 study or Control Area (100% change). Improving the survey's ability to detect smaller effects would require significant increases in the monitoring effort.

2. Introduction

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

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

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

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

The primary goal of this survey was to provide data related to seasonal fish abundance, distribution, population structure and community structure in and around Vineyard Wind's 501 North 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 (three in 2019 and one in winter 2020).

3. Methodology

The methodology for the survey was adapted from the Atlantic States Marine Fisheries Commission's (ASMFC) NEAMAP nearshore trawl survey. Initiated in 2006, NEAMAP conducts annual spring and fall trawl surveys from Cape Hatteras to Cape Cod. The NEAMAP protocol has gone through extensive peer review and is currently implemented near the Lease Area using a commercial fishing vessel (Bonzek et al., 2008). The current NEAMAP protocol samples at a resolution of ~100 sq. kilometers, which is inadequate to provide scientific information related to potential changes on a smaller scale. Adapting existing methods with increased resolution (see Section 3.1) will enable the survey to fulfill the primary goal of evaluating the impact of windfarm development while improving the consistency between survey platforms. This should facilitate easier sharing and integration of the data with state and federal agencies and allow the data from this survey to be incorporated into existing datasets to enhance our understanding of the region's ecosystem dynamics. Additionally, the methodology is consistent with other ongoing surveys of nearby study areas (Vineyard Wind's 501 South Study Area and 522 Lease Area).

3.1 Survey Design

The current survey is designed to provide baseline data on species abundance, population characteristics and community structure for a future environmental assessment using the BACI framework as recommended by BOEM (BOEM, 2013). Four surveys were conducted to assess the seasonal variability in the resident populations. The seasonal surveys consisted of a spring (April – June), summer (July – September), fall (October – December) and winter (January – March) survey. 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 temperature. The summer survey is intended to characterize the resident summer species which occur during seasonal high water temperatures. The fall survey occurs during decreasing water temperature which typically triggers the offshore movement of many coastal species. Finally, the winter survey occurs during stable cold temperatures in the region.

Tow locations for each survey within the Vineyard Wind 501 North Study Area were selected using a systematic random sampling design. The 501 North Study Area (249.3 km^2) was sub-divided into 20 sub-areas (each ~12.5 km^2), and one trawl tow was made in each of the 20 sub-areas seasonally (80 tows annually). This was designed to ensure adequate spatial coverage throughout the survey area. The starting location within each area was randomly selected (Figure 2).

An area located to the east of the 501 North Study Area was established as a control region (306 km^2). The selected region has similar depth contours, bottom types, and benthic habitats to the 501 North Study Area. An additional 20 tows were completed in the Control Area seasonally (80 tows annually). Tow locations were selected in the same manner as the 501 North Study Area, using the systematic random sampling design.

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

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

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

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. Wingspread was targeted between 13.0 and 14.0 meters (acceptable range: 11.7 – 15.4 m). Door spread was targeted between 32.0 and 33.0 meters (acceptable range: 28.8 – 37.4 m).

During the spring survey, the Notus TrawlMaster net mensuration system (Notus Electronics, St. John's, Newfoundland, Canada) was used to monitor the net geometry. 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. A hydrophone mounted in the hull of the vessel was used to receive the acoustic signals from the net sensors. All sensor data was plotted and saved on a laptop located in the wheelhouse. A water temperature data logger (HOBO TidbiT v2, Onset Computers, Onset, MA) was attached to the door to measure bottom water temperature.

The Notus TrawlMaster system was not the system proposed to conduct this survey; the new dedicated equipment was not available in time for the spring 2019 survey. Instead we acquired sensors and components from colleagues at SMAST, the Massachusetts Division of Marine Fisheries, and trawler FV Guardian. During the first trip some technical issues were experienced with this system. First, the trawl door sensors did not work. It was believed that there was an issue with the batteries in the sensors. Data was collected from the wing and headline sensors; however, readings were sporadic. This posed a challenge in tuning the trawl (Section 4.3).

The Simrad PX net mensuration system (Kongsberg Group, Kongsberg, Norway) was used to monitor the net geometry during the summer, fall and winter surveys (Figure 1). Sensors were similarly placed on the doors, wingend and headline to measure door spread, wing spread and headline height, respectively. Additionally, the new headline sensor also measured bottom water temperature. To ensure the net was on the bottom an additional sensor was placed behind the footrope in the belly of the net. That sensor was equipped with a tilt sensor which reported the angle of the net belly. An angle around 0^{o} indicated the net was on the seafloor. A towed hydrophone was placed over the side of the vessel to receive the acoustic signals from the net sensors. A processing unit, located in the wheelhouse and running the TV80 software, was used to monitor and log the data during tows (Figure 7).

3.4 Survey Operations

The spring survey was conducted on F/V Guardian, an 80' stern trawler operating out of Boston, MA. The summer, fall and winter surveys were conducted on the F/V Heather Lynn, an 84' stern trawler operating out of Point Judith, RI. Both boats are commercial trawling vessels currently operating in the industry. The seasonal surveys were completed between the following dates, during which all planned tows were completed:

- Spring Survey: June 10 – 28, 2019
- Summer Survey: August 17 – 31, 2019
- Fall Survey: November 5 – 16, 2019
- Winter Survey: February 10 – 17, 2020

Surveys were alternated daily between the Control Area and 501 North Study Area. Tows were only conducted during daylight hours. All tows started at least 30 minutes after sunrise and ended 30 minutes before sunset. This was intended to reduce the variability commonly observed during crepuscular periods. Tow duration was 20 minutes at a target tow speed of 3.0 knots (range: 2.8-3.2 knots). Timing of the tow duration was initiated when the wire drums were locked and ended at the beginning of the haulback (i.e. net retrieval). The trawl was towed behind the fishing vessel from steel wires, commonly referred to as trawl warp. The length of the trawl warp is dependent on the water depth and has an impact on the trawl geometry and bottom contact. During the spring survey the length of the trawl warp was set at a ~5:1 ratio between the trawl warp and seafloor depth, in 25 fathom increments. Net geometry data obtained from the spring and summer surveys indicating that the 4:1 ratio prevented overspreading of the net and increased the headline height. The summer, fall and winter surveys used a trawl warp ratio (trawl warp: seafloor depth) of ~4:1, in 25 fathoms increments, to set the warp length.

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 from each species was weighed on a motion-compensated scale (M1100, Marel Corp., Gardabaer, Iceland). Individual fish length (to the nearest centimeter) and weight (to the nearest gram) were collected. Efforts were made to process all animals; however, during large catches sub-sampling was used for some abundant species. Three sub-sampling strategies were employed over the duration of the four seasonal surveys: straight subsampling by weight, mixed subsampling by weight or discard by count.

> Straight subsampling by weight: When catch diversity was relatively low (5-10 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 predominate sub-sampling strategy.

Mixed subsampling by weight: When catch consisted of a large volume of small bodied fish, making sorting difficult, the mixed-subsampling strategy was used. With this strategy the catch of some large animals/species was "pre-sorted" to isolate and sample those species separately. Subsequently, the unsorted catch was placed into baskets and an aggregated tow weight was measured. A sub-sample of the unsorted catch was sorted, and the relative proportions of each species was used to extrapolate the total species weight from the unsorted aggregate catch. Individual lengths and weights of each species were then collected from the sub-sample. This method was used in the spring survey when large volumes of silver hake, red hake and squid were caught.

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 data was manually recorded and entered into a Microsoft Access database.

3.6 Data Analysis

3.6.1 Catch Per Unit Effort (CPUE) Analysis

A catch per unit effort (CPUE) analysis was conducted to assess the influence of season and area (development area vs. Control Area) on the observed catch. Due to some variations in tow duration (minute) between tows, including 5 tows which had shorter tow durations due to high volumes of spiny dogfish, the catch was standardized to a CPUE (kg per 20-minute tow) for each species, *i,* and tow, *j*, using Equation 1.

$$Standardized\ Catch_{ij} = \left(\frac{20}{Tow\ Duration_j}\right) * Catch_{ij} \qquad Eq. 1$$

The generalized linear modelling (GLM) framework was used to model the observed CPUE 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 (501 North and Control Area) to examine catch difference between the two areas.

The response (CPUE) was therefore modelled as:

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

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 (AIC) values were used to examine 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).

3.6.2 Fish Size Structure Analysis

To assess potential differences in the size structures of fish populations between the 501 North 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. The two probability density curves are then compared to a null model, of no difference, and a permutation test to assess statistically significant differences between the two areas. The method was used by Bond et al. (2018) to look at the size structure of fish populations around, and away from, a subsea pipeline. This method is outlined by Langlois et al. (2012).

KDEs were created for each species and season. Bandwidth 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.

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 given length and is typically an indication of fish well-being (Blackwell et al. 2000). Fish with high condition (i.e. plump fish) may indicate favorable environmental condition 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 (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 for its length or of better condition than average, while values less than 1 indicate a fish with 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 was aggregated between surveys and areas, including additional data collected in the Vineyard Wind 501 South Study Area and 522 Lease 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 two-way ANOVA was used to assess the influence of season, survey area and the interaction between the two on fish condition.

3.6.4 Community Structure Analysis

To assess the community dynamics in the 501 North Study Area and Control Area a multivariate analysis was conducted using the Primer-E statistical software package (Primer 7, Quest Research Limited, Auckland, NZ). 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 was transformed to reduce the influence of numerically dominate 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 which 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 (9999 permutation) was used to test against the null hypothesis where similarities within treatments are 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 again 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.

3.6.5 Power Analysis

To ensure the survey's ability to detect changes in fish populations an updated 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 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 Equation 6.

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

Where PC = $(\mu_0 - \mu_1)/\mu_0$, with μ_0 and μ_1 being mean CPUEs of pre-development and post-development respectively. 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. 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 probably 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.

4. Results

4.1 Operational Data

Twenty tows were completed during each survey period in both the 501 North 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 19.9 ± 1.6 minutes (mean ± one standard deviation) in the 501 North Study Area and 20.1 ± 1.0 minutes in the Control Area ($p = 0.2415$, 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, five tows were shortened to prevent damage to the survey trawl. The result was an average tow duration of 18.8 ± 2.8 minute in the 501 North Study Area and 19.6 ± 1.1 minutes in the Control Area. Tow speed averaged 3.0 ± 0.1 knots in the 501 North Study Area and 3.0 ± 0.2 knots in the Control Area ($p = 0.8638$). The average tow speed showed little variation between surveys or survey areas (Figure 8). Tow distances averaged 1.0 ± 0.1 nautical miles for both the 501 North Study Area and the Control Area, and there were no statistical differences between them ($p = 0.1932$). Similarly, the average tow distance showed little variation between surveys or survey area (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 meters). Depth increases to a maximum of 50 meters (28 fathoms) along the southwest boundary. Tow depths ranged from 20 to 27 fathoms (36.6 – 49.4 m.) in the 501 North Study Area and 20 to 28 fathoms (36.6 – 51.2 m) in the Control Area. The distribution of starting depths was shallower in the 501 North Study Area compared to the Control Area (Figure 9). In the 501 North Study Area 75 out of the 80 tows were conducted in 20-25 fathoms of water with the remaining 5 tows conducted in 26-27 fathoms. In the Control Area 60 of the 80 tows were conducted in 20-25 fathoms of water with the remaining 20 tows conducted in 26-28 fathoms. The average starting depth in the 501 North Study Area was 22.7 ± 1.8 fathoms and 23.7 ± 2.3 fathoms in the Control Area (p-value: 0.0032).

4.2 Environmental Data

Bottom water temperature followed seasonal trends in both survey areas. During the spring survey, bottom water temperature averaged 10.0 ± 0.7 °C in the 501 North Study Area and 9.6 ± 0.6 °C in the Control Area. The temperature followed the depth gradient with warmer water observed during shallow tows (11.2°C at 35 m) and colder water during deeper tows (8.9°C at 50 m). During the summer survey the bottom water temperature warmed to an average of 11.4 ± 0.8 °C in the 501 North Study Area and 12.0 ± 0.6 °C in the Control Area. Similar gradients to the spring survey were observed with warmer water observed during shallow tows (13.1°C at 35 m) and colder water during deeper tows (10.9°C at 50 m). Bottom water temperatures were observed to be highest during the fall survey at 14.9 ± 1.0 °C and 15.4 ± 1.0 °C in the 501 North Study Area and Control Area, respectively. In the fall, water temperature tended to vary across the tows. Warmer water (~16°C) was observed in both shallow (38 meters) and deep tows (51 meters). Similarly, cold water tows (12-13°C) were observed between 38 and 50 meters (Table 5). During the winter survey the bottom water temperature cooled to 5.9 ± 0.5 °C and 5.2 ± 0.5 °C in the 501 North Study Area and Control Area, respectively. The water temperatures were observed to decrease as the survey progressed. During the first day (February 4th), bottom water temperature averaged 6.2°C, decreasing to 4.8 °C on the last day (February 15th).

4.3 Trawl Performance

The trawl geometry data indicated that the trawl typically took about 2 to 3 minutes to open and stabilize. Once open, readings tended to be stable through the duration of the tow. Door spread averaged 35.1 ± 1.4 m (range: 31.4 – 38.2 m.) for tows in the 501 North Study Area and 35.7 ± 1.4 (range: 33.2 – 39.0 m.) in the Control Area. During the spring survey door spread readings were not obtained due to equipment malfunctions; otherwise, readings were consistent between the summer, fall and winter surveys (Figure 10). Door spread readings tended to increase with depth due to increased trawl warp (Figure 11). Due to the increased distribution of tows in deeper water in the Control Area, door spread readings were higher in the Control Area compared to the 501 North Study Area (p-value: 0.0288; unpaired t-test). The majority of tows were within the acceptable tolerance limit (108 of the 120 tows), however 12 tows were slightly higher (0.4 – 1.6 m) including 8 during the summer survey and 4 during the winter survey. As previously mentioned, these tows were associated with deeper water which required additional trawl warp (Figure 12). The additional trawl warp allowed the doors to spread further.

Wingspread readings were obtained during all surveys. Wingspread averaged 13.9 ± 0.8 m for tows in the 501 North Study Area (range: 11.3 – 15.8 m) and 14.2 ± 0.7 m for tows in the Control Area (range: 12.9 – 16.4 m) and was not statistically different between two areas ($p = 0.0562$). Wingspread readings were consistent across the surveys (Figure 10). All tows were within the acceptable tolerance limits during the summer, fall and winter surveys. Four tows in the spring survey were higher than the acceptable tolerance limit. Wingspread readings increased with trawl warp and therefore depth, following the trend of the door spread (Figure 11 and 12).

Headline height readings were obtained during all surveys. Headline height averaged 4.5 ± 0.4 m for tows in the 501 North Study Area (range: 3.5 – 5.3 m) and 4.4 ± 0.3 m for tows in the Control Area (range: 3.6 – 5.1; $p = 0.1422$). Headline height was targeted to be between 5.0 and 5.5 m with acceptable deviations between 4.5 and 6.1 m. While wing spread data indicated the net was within acceptable tolerances, during many tows the headline height was lower than desired. The average headline height increased seasonally as adjustments were made to the net and trawl warps (Figure 10). The percentage of tows below the acceptable tolerance limit decreased from 80% in the spring (24 tow out of 30 tows in which readings were obtained) to 23% in the winter (9 out of 39 tows in which readings were obtained). All of these tows during the winter survey, except one, were only 0.1-0.3 m lower than the acceptable range.

While additional improvements are needed, we do not believe this significantly impacted the representation of species in the catch composition. The majority of species are demersal and are well represented in the catch. Additionally, the seasonal surveys caught a significant volume of herring and other pelagic species which traditionally require a high vertical opening in the net. As a result, we believe that the survey results are representative of the fish community in the area. Additional adjustment and tests will be conducted to increase the headline height to within the acceptable range during future surveys.

4.4 Catch Data

4.4.1 Overview

The data obtained from the four seasonal surveys conducted show that the two study regions are dynamic in their species composition and abundance. A total of 45 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 501 North Study Area and Table 7 for the Control Area. Forty-two species were caught in the 501 North Study Area and 41 species were caught in Control Area, with 39 species shared between the two regions. Catch volume ranged from 4.6 kg/tow to 5763.5 kg/tow. The majority of the catch was primarily comprised of a small subset of the observed species. The four most abundant species (spiny dogfish, little skate, silver hake and red hake) were shared between the two regions and accounted for 78.4% and 70.5% of the total catch weight in the 501 North Study Area and Control Area, respectively. The next four most abundant species (winter skate, scup, butterfish and alewife) were similarly shared between regions and added an additional 15.1% and 20% of the catch in the 501 North Study Area and Control Area, respectively. These eight species represented over 90% of catch weight. Data collected from both areas included the catch of both adults and juveniles of most species observed.

4.4.2 Spiny Dogfish

Spiny dogfish (*Squalus acanthias*) was the predominate species observed in both the 501 North Study Area and Control Area accounting for 43.9% and 23.4% of the catch weight, respectively. Annually, catch rates averaged 260.8 ± 91.0 kg/tow (mean ± SEM, range: 0 – 5605.0 kg/tow) in the 501 North Study Area and 141.7 ± 63.7 kg/tow (range: 0 – 4219.7 kg/tow) in the Control Area ($p = 0.0129$, GLM). While 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, summer, and fall with the highest catches observed during the fall survey.

During the spring survey, seasonal catch rates averaged 45.4 ± 15.6 kg/tow in the 501 North Study Area and 65.7 ± 19.8 kg/tow in the Control Area (Figure 13). Dogfish were observed in 18 of the 20 tows in both study areas, with the catch primarily distributed in deeper waters to the south (Figure 14). No length or weight data was collected for spiny dogfish in the spring survey.

The catch rates of dogfish were low during the summer survey averaging 10.5 ± 4.3 kg/tow in the 501 North Study Area and 7.8 ± 1.5 kg/tow in the Control Area (Figure 13). Despite the low catch rates dogfish were still consistently represented. Individuals were observed in 18 of the 20 tows in the 501 North Study Area and 19 of the 20 tows in the Control Area. During the summer the catch of dogfish was distributed through both survey areas (Figure 14). No length or weight data was collected for spiny dogfish in the summer survey.

The catch rates of dogfish were the highest during the fall survey, including many of the largest aggregated tows of the year. The catch rate of dogfish averaged 987.4 ± 316.6 kg/tow in the 501 North Study Area and 493.2 ± 241.6 kg/tow in the Control Area (Figure 13). Dogfish were observed in 19 of the 20 tows in the 501 North Study Area and all 20 tows in the Control Area. The highest catches in the fall were observed in shallower waters to the north (Figure 14). Individuals ranged in size from 46 to 86 cm with a unimodal distribution consisting of a peak at 66 cm (Figure 15). The KDE analysis indicated that while the length distributions were similar between areas there were some significant difference between the two populations ($p = 0.022$). In general, the Control Area had a narrower distribution in the length-frequency curves compared to the 501 North Study Area (Figure 16).

Only three spiny dogfish were caught during the winter survey in the Control Area. No dogfish were caught in the 501 North Study Area.

Dogfish in both areas were of better condition than those of the general population (i.e. including the 501 South Study Area and 522 Study Area; Figure 17). Condition data was only collected during the fall survey. The condition in the 501 North Study Area was 1.01 ± 0.13 (mean ± 1 standard deviation) compared to 1.07 ± 0.12 in the Control Area ($p = 0.0001$).

4.4.3 Little Skate

Little skate (*Leucoraja erinacea*) was the second most abundant species by weight, in the 501 North Study Area (15.1% of the catch) and fourth most abundant in the Control Area (13.1% of the catch). Little skates were common throughout the year, being observed in 78 of the 80 tows in each area. Annually, catch rates average 81.0 ± 8.2 kg/tow (range: 0 – 286.3 kg/tow) in the 501 North Study Area and 78.4 ± 9.1 kg/tow (range: 0 – 366.2 kg/tow) in the Control Area. The catch of little skate was not significantly different between areas ($p = 0.9301$); however there was significant seasonal trends in the catch ($p < 0.0001$). In general, the catch was highest in the summer and fall, moderate in the spring and low in the winter (Figure 18).

During the spring survey the catch of little skate were modest. The seasonal catch rates averaged 57.0 ± 7.7 kg/tow in the 501 North Study Area and 42.5 ± 4.1 kg/tow in the Control Area (Figure 18). Little skates were observed in 19 of the 20 tows in the 501 North Study Area and all 20 tows in the Control Area. The catch was evenly distributed throughout both survey areas (Figure 19). No length or weight data was collected for little skate in the spring survey.

The catch rate of little skate in the summer averaged 138.6 ± 13.7 kg/tow in the 501 North Study Area and 114.1 ± 14.9 kg/tow in the Control Area (Figure 18). Little skates were observed in all 20 tows in the 501 North Study Area and 19 of the 20 tows in the Control Area. During the summer the catch was evenly distributed throughout both survey areas (Figure 19). No length or weight data was collected for little skate in the summer survey.

The catch rate of little skate was the highest during the fall survey with catch rates averaging 128.3 ± 15.3 kg/tow in the 501 North Study Area and 153.4 ± 20.4 kg/tow in the Control Area (Figure 18). Little skates were observed in all 20 tows in the both survey areas. The catch was observed to be distributed throughout both survey areas in the fall (Figure 19). Individuals ranged in size from 12 to 37 cm (disk width) in the fall survey (Figure 20). The KDE analysis indicated that the distribution of skates was slightly larger in the 501 North Study Area with a peak at 28 cm compared to the Control Area with a peak at 26 cm ($p = 0.0001$, Figure 21).

Little skate abundance was low during the winter survey (501 North: 1.8 ± 0.3, Control: 3.5 ± 0.6), however they were still observed in 19 of the 20 tows in both survey areas. Similar to other seasons, the catch was distributed throughout both survey areas (Figure 19). Individuals ranged in size from 9 to 33 cm in the winter survey with a broad size distribution (Figure 20). No significant differences were observed in the size distributions of little skates in the winter survey ($p = 0.51$; Figure 21).

Condition data was only available for the fall and winter surveys. The condition of little skates was lower in the fall (501 North: 0.95 ± 0.11, Control: 0.98 ± 0.12) compared to the winter (501 North: 1.04 ± 0.13, Control: 1.01 ± 0.17, $p = 0.0001$). No significant difference was observed between survey areas ($p = 0.1754$, Figure 22).

4.4.4 Silver Hake

Silver hake (*Merluccius bilinearis*), commonly referred to as whiting, was the most consistent species caught in both areas. Silver hake is a commercially important species in the region. Silver hake were observed in every tow in the 501 North Study Area and 79 of the 80 tows in the Control Area. By weight, silver hake was the third most abundant species in both areas accounting for 10.8% and 15.3% of the catch in the 501 North Study Area and Control Area respectively. Annually, catch rates average 56.0 ± 6.8 kg/tow (range: 1.1 – 295.4 kg/tow) in the 501 North Study Area and 89.6 ± 11.7 kg/tow (range: 0 – 467.1 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 catch of silver hake was highest in the spring with a significant disparity between the two survey areas. The catch of silver hake averaged 103.0 ± 17.6 kg/tow in the 501 North Study Area and 222.8 ± 24.8 kg/tow in the Control Area (Figure 23). Silver hake were observed in all 20 tows in the both survey areas. The catch of silver hake was evenly distributed across both survey areas (Figure 24). Individuals ranged in length from 7 to 49 cm with bimodal peaks at 16 and 26 cm in both study regions (Figure 25). The catch was evenly distributed between the two cohorts in the Control Area while the catch in the 501 North Study Area was shifted toward the larger cohort ($p = 0.037$, Figure 26).

The catch decreased in subsequent seasons along with the disparities between survey areas (Figure 23). During the summer the catch of silver hake averaged 64.8 ± 8.7 kg/tow in the 501 North Study Area and 84.8 ± 12.2 kg/tow in the Control Area (Figure 23). 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 24). Individuals ranged in length from 7 to 49 cm with bimodal peaks at 20 and 26 cm (Figure 25). The size characteristics of the catch was similar between survey areas ($p = 0.07$, Figure 26).

In the fall the catch of silver hake averaged 50.1 ± 10.8 kg/tow in the 501 North Study Area and 48.5 ± 10.0 kg/tow in the Control Area (Figure 23). 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 24). Silver hake ranged in length from 6 to 48 cm with a single peak at 22 to 23 cm (Figure

25). The size characteristics were similar between survey areas with the Control Area catching slightly larger fish ($p < 0.001$, Figure 26).

Low catches were observed in the winter survey, averaging 6.1 ± 1.0 kg/tow in the 501 North Study Area and 2.2 ± 0.8 kg/tow in the Control Area (Figure 23). Silver hake were observed in all 20 tows in the 501 North Study Area and 19 of the 20 tows in the Control Area. The catch of silver hake was evenly distributed across both survey areas (Figure 24). Silver hake caught in the winter survey were primarily small (Figure 25). Individuals ranged in length from 3 to 32 cm with a single peak at 12 to 13 cm. Individuals caught in the Control Area had a narrower, and smaller, size distribution than those in the 501 North Study Area ($p < 0.001$, Figure 26).

Silver hake displayed significant seasonal differences in condition ($p = 0.001$, Figure 27). Condition was highest in the spring (501 North: 1.09 ± 0.15, Control: 1.05 ± 0.17) and lowest in the fall (501 North: 0.93 ± 0.12, Control: 0.98 ± 0.11). The condition of fish was around 1 (i.e. "normal") in the summer and winter. Survey area was not a significant predictor of fish condition ($p = 0.354$).

4.4.5 Red Hake

Red hake (*Urophycis chuss*) was consistently caught in both areas. Red hake were observed in 74 of the 80 tows in the 501 North Study Area and 72 of the 80 tows in the Control Area. By weight, red hake was the second most abundant species in the Control Area, accounting for 18.6% of the catch, and the fourth most abundant species in the 501 North Study Area, accounting for 8.5% of the catch. Annually, catch rates average 43.8 ± 8.4 kg/tow (range: 0 – 425.3 kg/tow) in the 501 North Study Area and 110.4 ± 17.8 kg/tow (range: 0 – 636.2 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: $p < 0.0001$).

The catch of red hake was highest in the spring with a significant disparity between the two survey areas (501 North: 91.4 ± 27.5 kg/tow, Control: 223.4 ± 47.9 kg/tow, Figure 28). Red hake were observed in all 20 tows in both study areas. The catch of red hake appeared to follow the depth gradient with higher catches observed in deeper water (Figure 29). Individuals ranged in length from 5 to 42 cm with a bimodal size distribution peaking at 17 and 27 cm (Figure 30). The proportion of small fish was greater in the Control Area, with similar catches of the larger cohort both study areas (p = 0.038, Figure 31).

The catch rate decreased in subsequent seasons however the disparities between the two areas remained similar. In the spring, summer and fall surveys the catch in the Control Area was ~2.5 times higher than the 501 North Study Area. In the summer the catch rate averaged 58.2 ± 12.3 kg/tow in the 501 North Study Area and 149.5 ± 28.4 kg/tow in the Control Area (Figure 28). Red hake were observed in all 20 tows in both study areas. The catch of red hake appeared to follow the depth gradient with higher catches observed in deeper water (Figure 29). Individuals ranged in length from 18 to 41 cm with a unimodal size distribution peaking at 23 cm. The Control Area had a narrower distribution of individuals around the peak, while the 501 North Study Area had a wider distribution incorporating more large fish (p = 0.001, Figure 31).

In the fall the catch of red hake averaged 26.2 ± 5.0 kg/tow in the 501 North Study Area and 68.5 ± 25.5 kg/tow in the Control Area (Figure 28). Red hake were observed in all 20 tows in both survey areas. The catch of red hake was evenly distributed across the study areas in the fall (Figure 29). Individuals ranged in size from 15 to 47 cm with a unimodal size distribution peaking at 24 to 26 cm. The two areas had similar size distributions with the Control Area's shifted to slightly larger individuals (p = 0.001, Figure 31).

Low catches were observed in the winter survey averaging 0.1 ± 0.03 kg/tow in the 501 North Study Area and 0.1 ± 0.03 kg/tow in the Control Area (Figure 28). Red hake were observed in 14 of the 20 tows in the 501 North Study Area and 12 of the 20 tows in the Control Area. The catch of red hake was evenly distributed across both study areas (Figure 29). Red hake caught in the winter were primarily small. Individuals ranged in size from 6 to 25 cm with a broad distribution of individuals between 7 and 17 cm (Figure 30). No differences in the two survey areas were observed (p = 0.635, Figure 31).

Red hake displayed significant seasonal differences in condition (Figure 32, p = 0.001). Condition was highest in the winter (501 North: 1.14 ± 0.32, Control: 1.08 ± 0.45) and lowest in the fall (501 North: 0.92 ± 0.09, Control: 0.94 ± 0.11). The condition of fish was around 1 (i.e. "normal") in the spring and summer. Survey area was not a significant predictor of fish condition (p = 0.5322).

4.4.6 Butterfish

Butterfish (*Peprilus triacanthus*) was consistently caught in both areas. Butterfish were observed in 72 of the 80 tows in the 501 North Study Area and 70 of the 80 tows in the Control Area. By weight, butterfish was the fifth most abundant species in the Control Area, accounting for 5.4% of the catch, and the seventh most abundant species in the 501 North Study Area, accounting for 3.6% of the catch. Annually, catch rates average 18.5 ± 4.1 kg/tow (range: 0 – 231.2 kg/tow) in the 501 North Study Area and 31.8 ± 8.3 kg/tow (range: 0 – 468.4 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: $p < 0.0001$).

In the spring the catch of butterfish was similar between the two survey areas (Figure 33). Catch rates averaged 22.9 ± 6.9 kg/tow in the 501 North Study Area and 22.0± 7.9 kg/tow in the Control Area (Figure 33). Butterfish were observed in all 20 tows in the both study areas. The catch of butterfish appeared to follow the depth gradient with higher catches observed in deeper water (Figure 34). Individuals ranged from 7 to 27 cm in length, with a bimodal size distribution peaking at 10 and 17 cm (Figure 35). The proportion of large fish was similar between the two survey areas while the Control Area had a wide size distribution in the smaller cohort ($p = 0.032$, Figure 36).

The catch rate of butterfish was highest in the summer with catch rates averaging 41.9 ± 13.1 kg/tow in the 501 North Study Area and 98.8± 27.5 kg/tow in the Control Area (Figure 33). Butterfish were observed in 18 of the 20 tows in the 501 North Study Area and all 20 tows in the Control Area. The catch of butterfish was evenly distributed across both study areas (Figure 34). Individuals ranged from 8 to 19 cm in length, with a narrow unimodal size distribution peaking at 13 cm (Figure 35). The two areas had similar size distributions with the 501 North Study Area's shifted to slightly larger individuals ($p = 0.031$, Figure 36).

In the fall the catch of butterfish averaged 7.4 ± 1.1 kg/tow in the 501 North Study Area and 5.6 ± 1.3 kg/tow in the Control Area (Figure 33). Butterfish were observed in all 20 tows in both survey areas. The catch of butterfish was evenly distributed across both study areas (Figure 34). Individuals ranged in size from 3 to 20 cm with a bimodal size distribution. The larger cohort of fish peaked at 15 cm in both survey areas. In the 501 North Study Area the younger cohort peaked at 5 cm while the Control Area peaked at 7 cm ($p = 0.0001$, Figure 36).

Low catches were observed in the winter survey averaging 1.9 ± 0.5 kg/tow in the 501 North Study Area and 0.7 ± 0.4 kg/tow in the Control Area (Figure 33). Butterfish were observed in 14 of the 20 tows in the 501 North Study Area and 10 of the 20 tows in the Control Area. The catch of butterfish was evenly distributed across both study areas (Figure 34). During the winter the population again returned to a unimodal distribution with a peak around 12 cm (Figure 35). The shape of the distributions was similar between survey areas with the Control Area shifted toward smaller fish by ~2 cm ($p = 0.0001$, Figure 36).

Butterfish displayed seasonal differences in condition ($p = 0.001$, Figure 37). Condition was highest in the spring and summer (501 North: 1.01 ± 0.34 and 1.06 ± 0.14, Control: 1.06 ± 0.23 and 1.03 ± 0.12) and lowest in the winter (501 North: 0.99 ± 0.15, Control: 0.90 ± 0.21). Condition was higher in the 501 North Study Area in the summer, fall and winter ($p = 0.0001$).

4.4.7 Scup

Scup (*Stenotomus chrysops*) was the sixth most abundant species in both survey areas despite only being caught in the summer and fall. The annual catch rate averaged 20.9 ± 5.0 kg/tow (range: 0 – 273.6 kg/tow) in the 501 North Study Area and 32.7 ± 7.2 kg/tow (range: 0 – 279.0 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: $p < 0.0001$).

In the summer, the catch was similar between survey areas in the summer averaging 14.0 ± 7.3 kg/tow in the 501 North Study Area and 16.8 ± 7.0 kg/tow in the Control Area (Figure 38). Scup were caught in 11 of the 20 tows in the 501 North Study Area and 16 of the 20 tows in the Control Area. The catch of scup was highest in the northern shallow tows (Figure 39). In general, the population structure of scup was similar between the two survey areas and seasons. In the summer, scup ranged in size from 16 to 32 cm with a unimodal peak around 21 cm (Figure 40). The shape of the distributions was similar between survey areas with the Control Area shifted toward larger fish ($p = 0.0001$, Figure 41).

The catch of scup was highest in the fall with a significant disparity between the two survey areas (501 North: 69.8 ± 13.9 kg/tow, Control: 114.0 ± 18.6 kg/tow, Figure 38). Scup were caught in every tow in both survey areas. The catch of scup was distributed throughout both survey areas (Figure 39). Individuals ranged in size from 7 to 32 cm with a unimodal peak. (Figure 40). The distribution shifted towards larger fish in the fall survey with the peak of the distribution at 22-23 cm. The shape of the distributions was similar between survey areas with the Control Area shifted toward larger fish (p = 0.0001, Figure 41).

No scup were caught in the spring and winter.

The condition of scup was not significantly different between seasons (p = 0.1536) or survey area (p = 0.24, Figure 42). Generally, condition was higher in the fall (501 North: 1.02 ± 0.09, Control: 1.04 ± 0.09) and lower in the summer (501 North: 0.93 ± 0.08, Control: 0.94 ± 0.09).

4.4.8 Winter Skate

Winter skate (*Leucoraja ocellata*) was consistently caught in both areas during the spring, summer and fall surveys. Annually, catch rates average 30.2 ± 5.7 kg/tow (range: 0 – 286.3 kg/tow) in the 501 North Study Area and 29.4 ± 5.1 kg/tow (range: 0 – 214.0 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 = 0.8822).

The catch rate was highest in the spring averaging 90.6 ± 15.2 kg/tow in the 501 North Study Area and 74.4 ± 10.4 kg/tow in the Control Area (Figure 43). Winter skates were caught in every tow in both survey areas. The catch of winter skate was distributed throughout both survey areas (Figure 44). No length or weight data was collected during the spring or summer surveys.

During the summer the catch was reduced to a few individuals in limited tows. Catch rates averaged 2.1 ± 0.5 kg/tow in the 501 North Study Area and 1.7 ± 0.6 kg/tow in the Control Area (Figure 43). Winter skates were caught in 13 of the 20 tows in the 501 North Study Area and 7 of the 20 tows in the Control Area. The catch of winter skate was distributed throughout both survey areas (Figure 44).

Catch rates increased in the fall averaging 28.1 ± 5.5 kg/tow in the 501 North Study Area and 41.6 ± 10.8 kg/tow in the Control Area (Figure 43). Winter skates were caught in 17 of the 20 tows in the 501 North Study Area and 18 of the 20 tows in the Control Area. The catch was highest in the southern deeper tows (Figure 44). Individuals had a wide size distribution ranging from 16 to 61 cm (disk width) without a definitive peak (Figure 45). The distribution of the catch was shifted towards smaller individuals in the Control Area, compared to the 501 North Study Area (p = 0.0001, Figure 46).

Only three winter skates were caught in the winter survey.

There was no significant difference in the condition of skates between the two areas (p = 0.2729, Figure 47).

4.4.9 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. Annually, catch rates average 12.4 ± 5.7 kg/tow (range: 0 – 415.2 kg/tow) in the 501 North Study Area and 10.1 ± 4.1 kg/tow (range: 0 – 307.8 kg/tow) in the Control Area. The GLM analysis indicated that season was a significant predictor of catch rate (p = 0.0179) but not survey area (p = 0.1511).

Alewife were caught in every tow during the spring survey. The catch rate was highest in the spring with a large disparity between survey area (501 North: 41.0 ± 21.7 kg/tow, Control: 13.4 ± 4.0 kg/tow, Figure 48). This was primarily due to three large tows in the 501 North Study Area with catch rates of 83.5, 173.6 and 415.2 kg/tow. These higher catch rates were primarily associated with deeper water to the south (Figure 49). The 501 North Study Area was dominated by juvenile alewife (modal peak at 14 cm) while the Control Area was primarily adults (modal peak at 22-23 cm, p = 0.0001. Figure 50). The disparity in the population structure is due to the three large tows previously mentioned, which were dominated by juvenile fish (Figure 51).

During the summer only two individuals were caught in the 501 North Study Area. In the Control Area 9 of the 20 tows had alewife including two tow with catches of 83.6 and 307.8 kg (501 North: 0.02 ± 0.01 kg/tow, Control: 23.1 ± 15.8 kg/tow). In the Control Area, alewife ranged in size from 9 to 21 cm with a unimodal peak between 17 and 18 cm (Figure 50). Similar to the spring survey, alewife were primarily found in the southern half of the Control Area (Figure 49).

The catch of alewife was low but more consistent in the fall (501 North: 0.5 ± 0.2 kg/tow, Control: 1.1 ± 0.3 kg/tow Figure 48). Alewife were caught in 9 of the 20 tows in the 501 North Study Area and 13 of the 20 tows in the Control Area. Alewife ranged in size from 16 to 27 cm with a unimodal peak around 19 to 20 cm (Figure 50). The population structure was similar between survey areas (p = 0.26, Figure 51).

During the winter survey catch rates were higher in the 501 North Study Area (8.2 ± 2.4 kg/tow) compared to the Control Area (2.7 ± 1.5 kg/tow). Alewife were caught in every tow in the 501 North Study Area and 19 of the 20 tows in the Control Area. The catch was distributed throughout both survey areas (Figure 49). Individuals ranged in size from 9 to 27 cm with bimodal peaks at 14 and 19 cm. 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 51). The 501 North Study Area was moderately skewed toward the larger fish.

Alewife displayed seasonal and survey area differences in condition (Season: p = 0.001, Area: p = 0.0001, Figure 52). Condition was highest in fish caught in the summer (Control: 1.11 ± 0.1; No fish were caught in the 501 North Study Area). In the spring condition differed between the two survey areas (501 North: 0.90 ± 0.19, Control: 1.0 ± 0.20). This could be due to the difference in the population structure. The 501 North Study Area was primarily dominated by juvenile fish while the Control Area was adult fish. In the fall, fish appeared to be in above average condition in the Control Area (1.05 ± 0.10) and average condition in the 501 North Study Area (1.0 ± 0.20). Condition in both survey areas was below average during the winter survey (501 North: 0.95 ± 0.14, Control: 0.95 ± 0.12)

4.4.10 Monkfish

Monkfish (*Lophius americanus*), a commercially important species, were consistently caught in both survey areas during the spring, summer and fall. Annually, catch rates average 3.6 ± 0.7 kg/tow (range: 0 – 34.4 kg/tow) in the 501 North Study Area and 8.5 ± 1.6 kg/tow (range: 0 – 61.8 kg/tow) in the Control Area. The GLM analysis indicated that season and survey area were significant predictors of catch rate (p = 0.0001; p = 0.0001).

The catch rate of monkfish was highest in the spring with a large disparity between survey area (501 North: 10.1 ± 2.2 kg/tow, Control: 24.9 ± 4.4 kg/tow, Figure 53). Monkfish were caught in every tow in both survey areas. The catch was dispersed throughout both survey areas (Figure 54). Monkfish had a wide size distribution (20 - 80 cm) with a peak between 30 and 35 cm (Figure 55). The population structure was similar between survey areas however the Control Area's distribution was shifted toward larger individuals (>50 cm), compared to the 501 North Study Area ($p = 0.003$, Figure 56).

Catch rates were reduced in the summer survey however they were still caught in every tow in the Control Area and 14 of the 20 tows in the 501 North Study Area. As a result, the average catch rate was higher in the Control Area (3.6 ± 0.7 kg/tow) compared to the 501 North Study Area (2.0 ± 0.6 kg/tow). Monkfish were observed throughout both survey areas (Figure 54). The size distribution of monkfish was similar between survey areas ($p = 0.503$). Monkfish had a wide size distribution (20 - 80 cm) with a peak around 40 cm (Figure 55).

In the fall survey the catch of monkfish was higher in the Control Area (5.4 ± 1.3 kg/tow) compared to the 501 North Study Area (2.5 ± 0.6 kg/tow). Monkfish were caught in 16 of the 20 tows in the Control Area and 13 of the 20 tows in the 501 North Study Area. Similar to the other seasons, monkfish were observed throughout both survey areas (Figure 54). The monkfish size distribution similarly consisted of a wide size distribution (20 - 80 cm) with a peak around 40 - 42 cm. The size distribution of monkfish was not significantly different between the two survey areas ($p = 0.081$).

No monkfish were caught in the winter survey.

The condition of monkfish was not significantly different between seasons or survey areas (Season: $p = 0.7054$, Survey Area: $p = 0.5264$). During all surveys and areas the condition was around 1 (Figure 57).

4.4.11 Atlantic Longfin Squid

Atlantic longfin squid (*Doryteuthis pealei*), a commercially important species commonly called Loligo squid, were consistently caught in both survey areas during the spring, summer and fall. Annually, catch rates averaged 4.2 ± 0.5 kg/tow (range: 0 – 27.1 kg/tow) in the 501 North Study Area and 3.6 ± 0.5 kg/tow (range: 0 – 17.3 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 ($p = 0.1245$). No squid eggs (i.e. “squid mops”) were observed during any of the surveys.

During the spring survey, longfin squid were caught in every tow in the Control Area and 19 of the 20 tows in the 501 North Study Area. The catch rate was highest during this survey with higher catches observed in the 501 North Study Area compared to the Control Area (501 North: 8.8 ± 1.5 kg/tow, Control: 5.4 ± 1.1 kg/tow, Figure 58). The catch was dispersed throughout both survey areas (Figure 59). Individuals ranged in size from 3 to 27 cm (mantle length) with a unimodal peak between 8 and 10 cm (Figure 60). The size distribution of squid in the 501 North Study Area was shifted toward larger individuals compared to the Control Area ($p = 0.0001$, Figure 61).

Longfin squid were caught during every tow in the summer survey with catch rates similar to those observed in the spring (501 North: 4.8 ± 0.5 kg/tow, Control: 6.5 ± 0.6 kg/tow, Figure 58). Higher catches were observed in the northern half of both survey areas (Figure 59). Individuals ranged in size from 3 to 24 cm mantle length with a bimodal distribution with peaks at 5 and 12 cm (Figure 60). The size structure was similar between areas with the 501 North Study Area catching a greater proportion of small squid in the catch ($p = 0.0001$, Figure 61).

The squid were still present in the fall survey but at lower abundances (501 North: 3.1 ± 0.4 kg/tow, Control: 2.4 ± 0.8 kg/tow, Figure 58). Squid were caught in 18 of the 20 tows in the Control Area and 19 of the 20 tows in the 501 North Study Area. The catch was distributed throughout both survey areas (Figure 59). Individuals ranged in size from 3 to 26 cm with a unimodal size distribution peak between 8 and 11 cm (Figure 60). The size distribution was similar between the two survey areas ($p = 0.708$, Figure 61).

Longfin squid were mostly absent from the winter survey (501 North: 0.03 ± 0.01 kg/tow, Control: 0.02 ± 0.01 kg/tow, Figure 58). Squid were only observed in 5 tows in the 501 North Study Area and 3 tows in the Control Area (Figure 59). Seven squid were caught in the 501 North Study Area and 9 squid were caught in the Control Area. Individuals ranging in size from 4 to 27 cm (Figure 60).

Longfin squid displayed seasonal variation in condition ($p = 0.0001$) which was similar between the two survey areas ($p = 0.3973$, Figure 62). Condition was highest in the fall (501 North: 1.13 ± 0.23, Control: 1.13 ± 0.27) and winter (501 North: 1.14 ± 0.23) and lowest in the spring (501 North: 0.97 ± 0.19, Control: 1.01 ± 0.22) and summer (501 North: 0.99 ± 0.16, Control: 0.98 ± 0.27).

4.4.12 Shortfin Squid

Shortfin squid (Illex illecebrosus), also called Illex squid, was the other commercially important squid species observed during the survey. Shortfin squid were only observed in the spring survey during which they were caught in 14 of the 20 tows in both areas. Annually, catch rates average 0.3 ± 0.1 kg/tow (range: 0 – 10.3 kg/tow) in the 501 North Study Area and 0.8 ± 0.3 kg/tow (range: 0 – 14.9 kg/tow) in the Control Area (p = 0.0031). However, the seasonal catch rate in the spring was 1.3 ± 0.6 kg/tow in the 501 North Study Area and 3.1 ± 1.1 kg/tow in the Control Area (Figure 63). The catch was distributed throughout both survey areas (Figure 64). Individuals ranged in size from 4 to 27 cm with a unimodal size distribution peak between 14 and 15 cm (Figure 65). The size distribution of squid was similar between areas with the catch in the Control Area shifted slightly toward smaller squid compared to the 501 North Study Area (p = 0.0001, Figure 66). Measurements of condition was limited to the spring. Squid condition was lower in the 501 North Study Area (0.96 ± 0.27) compared to the Control Area (1.11 ± 0.35, p = 0.0134, Figure 67). As previously mentioned, no squid eggs (i.e. “squid mops”) were observed during any of the surveys.

4.4.13 Fourspot flounder

Fourspot flounder (*Paralichthys oblongus*) was the most common flatfish species observed during the survey. Fourspot flounder were observed in every tow in the spring, summer and fall surveys. During those three surveys the catch characteristics were consistent between surveys and survey areas. Annually, catch rates average 2.5 ± 0.3 kg/tow (range: 0 – 12.6 kg/tow) in the 501 North Study Area and 2.6 ± 0.3 kg/tow (range: 0 – 11.5 kg/tow) in the Control Area. The GLM analysis indicated that season was a significant predictors of catch rate (p = 0.0001) but not survey area (p = 0.6514, Figure 68).

During the spring survey catch rates averaged 3.6 ± 0.7 kg/tow in the 501 North Study Area and 2.9 ± 0.6 kg/tow in the Control Area (Figure 68). The catch was dispersed throughout both survey areas with higher catches observed in deeper tows to the south (Figure 69). Individuals ranged in size from 10 to 41 cm with a unimodal peak between 28 and 29 cm (Figure 70). The size distribution of fourspot flounder in the 501 North Study Area was shifted toward larger individuals compared to the Control Area (p = 0.0001, Figure 71).

The catch rate of fourspot flounder was highest during the summer survey (501 North: 3.7 ± 0.6 kg/tow, Control: 3.9 ± 0.5 kg/tow, Figure 68). The catch was distributed throughout both survey areas (Figure 69). Individuals ranged in size from 8 to 41 cm mantle length with a unimodal peak between 28 and 29 cm (Figure 70). The size structure of the population was similar between both areas (p = 0.126, Figure 71).

Catch rates averaged 2.5 ± 0.4 kg/tow in the 501 North Study Area and 3.7 ± 0.8 kg/tow in the Control Area during the fall survey (Figure 68). The catch was distributed throughout both survey areas (Figure 69). Individuals ranged in size from 6 to 41 cm with a wider size distribution then previously observed in other seasons (Figure 70). The proportion of large fish (> 20 cm) was similar between survey areas, however the Control Area had a higher proportion of small fish (< 20 cm), compared to the control (p = 0.0001, Figure 71).

No fourspot flounder were observed during the winter survey.

The survey area was not a significant predictor of condition in fourspot flounder (p = 0.8466), but there were some seasonal differences (p = 0.0001, Figure 72). Condition was highest in the fall (501 North: 1.06 ± 0.11, Control: 1.05 ± 0.12) and lowest in the summer (501 North: 0.96 ± 0.11, Control: 0.98 ± 0.12).

4.4.14 Summer Flounder

Summer flounder (*Paralichthys dentatus*), also known as fluke, is a commercially important flatfish commonly observed during the survey. Summer flounder were observed during the spring, summer and fall surveys. Annually, catch rates average 1.0 ± 0.2 kg/tow (range: 0 – 10.6 kg/tow) in the 501 North Study Area and 2.6 ± 0.5 kg/tow (range: 0 – 25.2 kg/tow) in the Control Area. The GLM analysis indicated that season and survey area were significant predictors of catch rate (p = 0.0001, p = 0.0001, Figure 73).

During the spring survey catch rates averaged 1.7 ± 0.5 kg/tow in the 501 North Study Area and 1.5 ± 0.6 kg/tow in the Control Area (Figure 73). Summer flounder were observed in 13 of the 20 tows in the 501 North Study Area and 8 of the 20 tows in the Control Area. The catch was primarily associated with the northern, shallower region of both survey areas (Figure 74). Twenty individuals were caught in both survey areas with a wide length distribution ranging from 23 to

70 cm (Figure 75). The distribution of lengths was similar between both survey areas (p = 0.794, Figure 76).

The highest catch rates of summer flounder were observed in the Control Area during the summer survey (501 North: 0.6 ± 0.3 kg/tow, Control: 7.0 ± 1.6 kg/tow, Figure 73). Summer flounder were only observed in 5 of the 20 tows in the 501 North Study Area and 14 of the 20 tows in the Control Area. The highest catches in both areas were in the northern half of the survey areas (Figure 74). Only 6 individuals were caught in the 501 North Study Area with lengths ranging from 46 to 64 cm. Fifty-two individuals were caught in the Control Area with lengths ranging from 27 to 76 cm (Figure 75). The distribution of lengths was similar between survey areas (p = 0.11, Figure 76).

Catch rates averaged 1.6 ± 0.4 kg/tow in the 501 North Study Area and 1.7 ± 0.5 kg/tow in the Control Area during the fall survey (Figure 73). Summer flounder were observed in 13 of the 20 tows in the 501 North Study Area and 14 of the 20 tows in the Control Area. Unlike the spring and summer, the catch of summer flounder was more evenly distributed throughout the survey areas (Figure 74). In the 501 North Study Area, 31 flounder were caught ranging in size from 30 to 93 cm (Figure 75). Thirty summer flounder were caught in the Control Area ranging in size from 33 to 68 cm. Fish caught in the 501 North Study Area had a slightly smaller size distribution than those in the Control Area (p = 0.018, Figure 76).

One summer flounder was caught during the winter survey (33 cm).

Summer flounder exhibited seasonal variations in condition (p = 0.0317, Figure 77). The condition of summer flounder was slightly higher than 1 during the spring (501 North: 1.02 ± 0.18, Control: 1.03 ± 0.11) and summer surveys (501 North: 1.01 ± 0.11, Control: 1.04 ± 0.13). Fish condition was lowest during the fall survey (501 North: 0.95 ± 0.08, Control: 0.97 ± 0.11). The survey area was not a significant predictor of condition in summer flounder (p = 0.9253).

4.4.15 Windowpane Flounder

Windowpane flounder (*Scophtalmus aquosus*), also known as sand dab, is a federally regulated groundfish. Windowpane flounder in the survey areas belong to the Southern New England/Mid-Atlantic stock. Windowpane flounder were observed in all survey periods and in both survey areas. Annually, catch rates average 0.8 ± 0.2 kg/tow (range: 0 – 5.2 kg/tow) in the 501 North Study Area and 0.8 ± 0.2 kg/tow (range: 0 – 9.6 kg/tow) in the Control Area. The GLM analysis indicated that season was significant predictors of catch rate (p = 0.0001) but not survey area (p = 0.3057).

Windowpane flounder were only observed in the 501 North Study Area during the spring survey. The seasonal catch rate in the study area was low (0.1 ± 0.03 kg/tow, Figure 78). Windowpane flounder were observed in 8 of the 20 tows in the 501 North Study Area which were distributed around the study area (Figure 79). Only 8 individuals were caught with lengths ranging from 22 to 30 cm (Figure 80).

The catch rate increased during the summer survey to 0.8 ± 0.2 kg/tow in the 501 North Study Area and 0.6 ± 0.2 kg/tow in the Control Area (Figure 78). Windowpane were caught in 15 of the 20 tows in the 501 North Study Area and 10 of the 20 tows in the Control Area. The catch was primarily associated with tows in the northern half of the survey areas (Figure 79). Windowpane ranged in size from 13 to 35 cm with bimodal peaks at 15 and 26 cm (Figure 80). The catch in the 501 North Study Area had proportionally more small fish compared to the Control Area (p = 0.002, Figure 81).

The highest catch rates of windowpane flounder were observed during the fall survey (501 North: 2.3 ± 0.4 kg/tow, Control: 2.6 ± 0.5 kg/tow, Figure 78). Windowpane flounder were only observed in 17 of the 20 tows in the 501 North Study Area and all 20 tows in the Control Area. The catch was distributed throughout both survey areas with the highest catches observed in the northern half of the survey areas (Figure 79). Windowpane flounder ranged in size from 13 to 33 cm with a unimodal peak around 23 to 24 cm (Figure 80). The distribution of lengths was similar between both survey areas with the Control Area shifted slightly toward smaller fish (p = 0.003, Figure 81).

Catch rates were low during the winter survey averaging 0.1 ± 0.03 kg/tow in both study areas (Figure 78). Windowpane flounder were observed in 7 of the 20 tows in the 501 North Study Area and 5 of the 20 tows in the Control Area. Unlike the other surveys, the catch of windowpane flounder was more evenly distributed throughout the survey areas (Figure 79). Only 9 windowpane flounder were captured in the 501 North Study Area and 7 windowpane flounder were captured in the Control Area. Individuals ranged in size from 8 to 31 cm (Figure 80). The size distribution of fish was similar between survey areas (p = 0.539, Figure 81).

Windowpane flounder exhibited seasonal and survey area variations in condition (p = 0.0001 and 0.0001, respectively, Figure 82). The condition of windowpane flounder was highest in the summer (501 North: 1.01 ± 0.1, Control: 1.07 ± 0.18) and lowest in the fall (501 North: 0.88 ± 0.06, Control: 0.96 ± 0.08). In general, the condition of windowpane flounder was higher in the Control Area compared to the 501 North Study Area (p = 0.0001).

4.4.16 Winter Flounder

Winter flounder (*Pseudopleuronectes americnus*), also known as blackback flounder, is a federally regulated groundfish commonly caught at low levels during the spring, summer and fall surveys. Annually, catch rates average 1.3 ± 0.3 kg/tow (range: 0 – 14.9 kg/tow) in the 501 North Study Area and 0.5 ± 0.1 kg/tow (range: 0 – 8.2 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, Survey Area: p = 0.0033).

Catch rates in the spring averaged 1.8 ± 0.7 kg/tow in the 501 North Study Area and 0.1 ± 0.04 kg/tow in the Control Area (Figure 83). Winter flounder were observed in the 16 of the 20 tows in the 501 North Study Area but only 5 of the 20 tows in the Control Area during the spring survey. The catch was observed to be distributed throughout both study areas (Figure 84). Winter flounder ranged in size from 13 to 46 cm with a wide size distribution peaking around 30 to 35 cm (Figure 85). While the catch rate was significantly higher in the 501 North Study Area the size distribution of fish was not significantly different between study areas (p = 0.064, Figure 86).

During the summer survey the catch rate in the Control Area increased to match that of the 501 North Study Area (501 North: 1.6 ± 0.5 kg/tow, Control: 1.6 ± 0.5 kg/tow, Figure 83). The catch rate in the 501 North Study Area was similar to that observed in the spring survey. Winter flounder were caught in 13 of the 20 tows in the 501 North Study Area and 15 of the 20 tows in the Control Area. The catch was distributed throughout the 501 North Study Area (Figure 84). Higher catches were observed in the northern half of the Control Area. Winter flounder ranged in size from 9 to 40 cm with unimodal peak at 30 cm (Figure 85). The size distribution of fish was not significantly different between study areas (p = 0.851, Figure 86).

The highest catch rates of winter flounder were observed in the 501 North Study Area during the fall survey (1.9 ± 0.5 kg/tow). The catch rate in the Control Area was significantly smaller at 0.2

± 0.1 kg/tow (Figure 83). Winter flounder were observed in 15 of the 20 tows in the 501 North Study Area and only 3 of the 20 tows in the Control Area. The catch was distributed throughout both survey areas (Figure 84). Winter flounder ranged in size from 21 to 44 cm. In the 501 North Study Area had a wide size distribution with a unimodal peak around 21 to 22 cm (Figure 85). Only three fish were caught in the Control Area during this season.

Only three winter flounder were caught during the winter survey (Figure 83). Two winter flounder were caught in the Control Area, both in the same tow (18 and 27 cm). Only 1 winter flounder was caught in the 501 North Study Area (33 cm).

Winter flounder did not exhibit any seasonal and survey area variations in condition ($p = 0.1323$ and 0.8635, respectively, Figure 87).

4.4.17 Yellowtail Flounder

Yellowtail flounder (*Pleuronectes ferrugineus*) is a federally regulated groundfish commonly caught at low levels throughout the seasonal surveys. Annually, catch rates average 0.2 ± 0.04 kg/tow (range: 0 – 2.6 kg/tow) in the 501 North Study Area and 0.1 ± 0.03 kg/tow (range: 0 – 1.2 kg/tow) in the Control Area. The GLM analysis indicated that season and survey area were significant predictors of catch rate (Season: $p = 0.0001$, Survey Area: $p = 0.0052$).

The highest catch rate of yellowtail flounder was observed in the 501 North Study Area during the spring survey (501 North: 0.5 ± 0.2 kg/tow, Control: 0.2 ± 0.1 kg/tow, Figure 88). Yellowtail flounder were observed in 14 of the 20 tows in the 501 North Study Area and 9 of the 20 tows in the Control Area during the spring survey. Yellowtail flounder were observed to be distributed around both study areas (Figure 89). Individuals ranged in size from 15 to 47 cm with a wide size distribution (Figure 90). Only 10 individuals were caught in the Control Area. While the catch rate was significantly higher in the 501 North Study Area the size distribution of fish was not significantly different between study areas ($p = 0.912$, Figure 91).

During the summer survey the catch rates were similar between the two study areas (501 North: 0.2 ± 0.05 kg/tow, Control: 0.3 ± 0.08 kg/tow, Figure 88). Yellowtail flounder were caught in 15 of the 20 tows in the 501 North Study Area and 10 of the 20 tows in the Control Area. The catch was distributed throughout the 501 North Study Area (Figure 89). Eleven individuals were caught in the 501 North Study Area and 1 individual (22 cm) was caught in the Control Area. Yellowtail flounder in the 501 North Study Area ranged in size from 24 to 30 cm with unimodal peak at 25 cm (Figure 90).

Only 8 yellowtail flounder were caught during the winter survey (Figure 88). Six individuals were caught in the 501 North Study Area during 6 of the 20 tows. Two individuals were caught in the Control Area during 2 tows. Individuals ranged in size from 20 to 28 cm (Figure 90).

Yellowtail flounder exhibited seasonal variations in condition ($p = 0.0034$, Figure 92). The condition of yellowtail flounder was highest during the spring (501 North: 1.02 ± 0.23, Control: 1.05 ± 0.14) and summer (501 North: 1.01 ± 0.10, Control: 1.07 ± 0.18, Figure 92). Fish condition was lowest during the fall (501 North: 0.89 ± 0.06, Control: 0.96) and winter (501 North: 0.93 ± 0.04, Control: 0.79). The survey area was not a significant predictor of condition in yellowtail flounder ($p = 0.1795$).

4.4.18 Gulfstream Flounder

Gulfstream flounder (*Citharichthys arctifrons*) was commonly caught at low levels throughout the spring and summer surveys. Annually, catch rates average 0.2 ± 0.07 kg/tow (range: 0 – 5.3 kg/tow) in the 501 North Study Area and 0.3 ± 0.06 kg/tow (range: 0 – 3.0 kg/tow) in the Control Area (Figure 93). The GLM analysis indicated that season was a significant predictor of catch rate ($p = 0.0001$) but not survey area ($p = 0.2442$).

The catch rate of gulfstream flounder during the spring survey averaged 0.4 ± 0.1 kg/tow in the 501 North Study Area and 0.3 ± 0.1 kg/tow in the Control Area (Figure 93). Gulfstream flounder were caught in 15 of the 20 tows in both areas. Higher catches were associated with tows in the southern region of both survey areas (Figure 94). Individuals ranged in size from 11 to 20 cm with a unimodal peak at 15 in the Control Area and at 17 cm in the 501 North Study Area (Figure 95). The shifts in the peak were significantly different between the two survey areas ($p = 0.0001$, Figure 96).

The average catch rate of gulfstream flounder was highest during the summer survey (501 North: 0.45 ± 0.26 kg/tow, Control: 0.60 ± 0.18 kg/tow, Figure 93). Gulfstream flounder were caught in 15 of the 20 tows in both areas. Similar to the spring, higher catches were associated with tows in the southern region of both survey areas (Figure 94). Individuals ranged in size from 11 to 19 cm with a unimodal peak at 17 cm (Figure 95). The size distribution of fish was not significantly different between study areas (p = 0.219, Figure 96).

During the fall survey the catch rate of gulfstream flounder declined significantly (501 North: 0.01 ± 0.01 kg/tow, Control: 0.06 ± 0.03 kg/tow, Figure 93). Only 1 individual was caught in the 501 North Study Area (17 cm). A total of 41 individuals were caught in the Control Area over 5 tows. Those 5 tows were all located along the southern boundary of the Control Area (Figure 94). Individuals ranged in size from 11 to 18 cm (Figure 95).

Only 2 gulfstream flounder were caught during the winter survey. One individual was caught in each of the study areas. Both individuals were 17 cm in length.

Gulfstream flounder exhibited seasonal variations in condition (p = 0.0001, Figure 97). The condition of gulfstream flounder was highest during the spring (501 North: 1.01 ± 0.15, Control: 1.12 ± 0.23). The condition was mixed during the summer (501 North: 1.03 ± 0.17, Control: 0.94 ± 0.15) and fall (Control: 1.05 ± 0.17). Fish condition was lowest during the winter (501 North: 0.89 ± 0.10). The survey area was not a significant predictor of condition in windowpane flounder (p = 0.5647).

4.4.19 Haddock

Haddock (*Melanogrammus aeglefinus*) was the eighth most abundant species in the Control Area. This was due to two large tows (1166 and 804 kg), both in the Control Area, during the spring survey which encompassed 96% of the annual total haddock catch. Haddock were only caught during the spring survey, except for one individual caught during the summer survey. Catch rates during the spring survey averaged 3.7 ± 3.7 kg/tow (range: 0 – 77.3 kg/tow) in the 501 North Study Area and 103.0 ± 68.8 kg/tow (range: 0 – 1166.3 kg/tow) in the Control Area (Figure 98). Haddock were caught in 8 of the 20 tows in the Control Area and only in 1 of the 20 tows in the 501 North Study Area. All haddock were caught along the southern boundary in deeper water (Figure 99). Individuals ranged in size from 27 to 59 cm with a unimodal peak around 47 to 48 in the Control Area (Figure 100). The size distribution of fish was not significantly different between study areas (p = 0.641, Figure 101).

Only 1 haddock was caught in the Control Area during the summer survey (54 cm). No haddock were observed during the fall or winter surveys.

The condition of haddock was not significantly different between survey areas (p = 0.1572). During the spring survey the mean condition was 1 for both areas (501 North: 1.00 ± 0.09, Control: 1.00 ± 0.10, Figure 102).

4.4.20 Smooth Dogfish

Smooth dogfish (*Mustelus canis*) were frequently caught during the spring and summer surveys. Annually, catch rates average 3.8 ± 1.6 kg/tow (range: 0 – 111.8 kg/tow) in the 501 North Study Area and 0.7 ± 0.3 kg/tow (range: 0 – 14.7 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 = 0.0033).

Smooth dogfish were most common during the spring survey. The seasonal catch rates averaged 14.6 ± 5.8 kg/tow in the 501 North Study Area and 2.2 ± 0.9 kg/tow in the Control Area (Figure 103). Smooth dogfish were observed in the 17 of the 20 tows in the 501 North Study Area but only 6 of the 20 tows in the Control Area. The catch of smooth dogfish was largely aggregated in the southern half of both study areas (Figure 104). Smooth dogfish length and weights were not collected during the spring or summer surveys.

The catch of smooth dogfish was significantly lower during the summer survey. The seasonal catch rates averaged 0.6 ± 0.4 kg/tow in the 501 North Study Area and 0.7 ± 0.3 kg/tow in the Control Area (Figure 103). Smooth dogfish were observed in only 3 of the 20 tows in the 501 North Study Area 5 of the 20 tows in the Control Area. The catch of smooth dogfish was distributed around both survey areas (Figure 104).

4.4.21 Barndoor Skate

Barndoor skates (*Dipturus laevis*) were frequently caught during the spring and summer surveys. Annually, catch rates average 4.5 ± 1.1 kg/tow (range: 0 – 55.2 kg/tow) in the 501 North Study Area and 8.2 ± 2.2 kg/tow (range: 0 – 99.8 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 = 0.0033).

Barndoor skates were caught in every tow in the 501 North Study Area and 19 of the 20 tows in the Control Area during the spring survey. The catch rates were highest during the spring survey. The seasonal catch rates averaged 17.0 ± 3.1 kg/tow in the 501 North Study Area and 31.5 ± 6.7 kg/tow in the Control Area (Figure 105). Higher catch rates were observed in the southern half of both survey areas (Figure 106). Barndoor skate length and weights were not collected during the spring or summer surveys.

The catch of barndoor skate was significantly lower during the summer survey. The seasonal catch rates averaged 1.0 ± 0.3 kg/tow in the 501 North Study Area and 1.0 ± 0.3 kg/tow in the Control Area (Figure 105). Barndoor skates were still observed in 16 of the 20 tows in the 501 North Study Area and 15 of the 20 tows in the Control Area. The catch of barndoor skate was distributed around both survey areas (Figure 106).

The catch of barndoor skate was low and infrequent during the fall survey. The seasonal catch rates averaged 0.3 ± 0.1 kg/tow in the 501 North Study Area and 0.4 ± 0.2 kg/tow in the Control Area (Figure 105). Barndoor skates were only observed in 4 of the 20 tows in the 501 North Study Area and 6 of the 20 tows in the Control Area. The catch of barndoor skate was distributed around both survey areas (Figure 106).

A total of 21 individuals were caught during the winter survey, 5 in the 501 North Study Area and 16 in the Control Area. Barndoor skates ranged in size from 21 to 43 cm.

4.4.22 Northern Sea Robin

Northern Sea Robin (*Prionotus carolinus*) were commonly caught during the fall survey. Annually, catch rates average 1.1 ± 0.3 kg/tow (range: 0 – 15.9 kg/tow) in the 501 North Study Area and 7.1 ± 4.5 kg/tow (range: 0 – 348.6 kg/tow) in the Control Area. The GLM analysis indicated that season and survey area were significant predictors of catch rate (Season: $p = 0.0269$, Survey Area: $p = 0.0060$).

The catch of sea robins was infrequent during the spring and summer surveys. Only 8 individuals were caught during the spring survey. Six individuals were caught in the 501 North Study Area in 4 tows. The remaining 2 individuals were caught in the Control Area during 2 tows. The seasonal catch rates averaged 0.04 ± 0.02 kg/tow in the 501 North Study Area and 0.01 ± 0.01 kg/tow in the Control Area (Figure 107). The individuals ranged in size from 13 to 27 cm (Figure 109).

The catch of sea robins increased during the summer survey. The seasonal catch rates averaged 0.5 ± 0.3 kg/tow in the 501 North Study Area and 0.4 ± 0.3 kg/tow in the Control Area (Figure 107). Sea robins were observed in 6 of the 20 tows in both study areas. The catch of sea robin was primarily focused in the northern half of both survey areas (Figure 108). Individuals ranged in length from 21 to 31 cm with a unimodal peak around 28 to 29 cm (Figure 109). The length distributions were not significantly different between the two study areas (p = 0.196, Figure 110).

The highest catch rates of sea robins were observed during the fall survey. The two survey areas had a large disparity in the catch with catch rates averaging 3.8 ± 1.1 kg/tow in the 501 North Study Area and 27.9 ± 17.7 kg/tow in the Control Area (Figure 107). Sea robins were observed in 16 of the 20 tows in the 501 North Study Area and 18 of the 20 tows in the Control Area. The largest catches were observed along the southern boundaries of the study areas, including one tow with 348 kg in the Control Area (Figure 108). Individuals ranged in length from 10 to 32 cm (Figure 109, 111). The 501 North Study Area had a unimodal peak at 22 cm while the Control Area's peak was at 26 cm. The shift in the length distributions were significantly different between the two study areas (p = 0.0001, Figure 110).

No sea robins were caught during the winter survey.

4.4.23 Atlantic Herring

Atlantic herring (*Clupea harengus*) were caught in every tow during the winter survey. Catch rates during the winter survey averaged 9.6 ± 3.3 kg/tow in the 501 North Study Area and 27.0 ± 9.9 kg/tow in the Control Area (Figure 112). The catch of Atlantic herring was distributed throughout both survey areas (Figure 113). Individuals ranged in size from 12 to 22 cm with peaks at 15 cm and 20 cm (Figure 114). Fish caught in the Control Area were predominately associated with the smaller peak whereas fish in the 501 North Study Area were distributed between the two peaks (p = 0.0001, Figure 115).

Only 10 herring were caught in the 501 North in 4 tows during the spring survey. A single individual was caught in the Control Area during the summer survey. Similarly, only a single individual was caught in both study areas during the fall survey.

The condition of Atlantic herring was not significantly different between survey areas (p = 0.1144). During the winter survey the condition was 1 (501 North: 1.00 ± 0.10, Control: 0.99 ± 0.15, Figure 116).

4.4.24 Blueback Herring

Blueback herring (*Alosa aestivalis*) were frequently observed during the winter survey. Catch rates during the winter survey averaged 1.04 ± 0.3 kg/tow in the 501 North Study Area and 0.4 ± 0.2 kg/tow in the Control Area (Figure 117). The catch of blueback herring was distributed throughout both survey areas (Figure 118). Individuals ranged in size from 7 to 25 cm with peaks at 14 cm and 20 cm (Figure 119). Fish caught in the Control Area were solely associated with the larger peak while fish in the 501 North Study Area were distributed evenly between the two peaks (p = 0.0001, Figure 120).

Blueback herring were caught in 3 tows in the 501 North Study Area during the summer survey. Seasonal catch rates averaged 0.8 ± 0.6 kg/tow in the 501 North Study Area with no herring caught in the Control Area (Figure 117). Individuals ranged in fish from 20 to 36 cm (Figure 119).

No blueback herring were caught in the spring or fall surveys.

The condition of blueback herring was not significantly different between survey areas (p = 0.324). During the winter survey the mean condition was 1 for both areas (501 North: 1.00 ± 0.11, Control: 0.99 ± 0.10, Figure 121).

4.4.25 American Shad

American shad (*Alosa sapidissima*) were frequently observed during the winter survey and sporadically observed during the other surveys. Annually, catch rates average 0.4 ± 0.1 kg/tow (range: 0 – 5.0 kg/tow) in the 501 North Study Area and 1.6 ± 1.0 kg/tow (range: 0 – 76.2 kg/tow) in the Control Area. The GLM analysis indicated that season and survey area were significant predictors of catch rate (Season: p = 0.0105, Survey Area: p = 0.0300).

Shad were most abundant during the winter survey with catch rates averaging 1.03 ± 0.3 kg/tow in the 501 North Study Area and 5.9 ± 3.8 kg/tow in the Control Area (Figure 122). Shad were caught in 15 of the 20 tows in the 501 North Study Area and 14 of the 20 tows in the Control Area.

The catch of shad was distributed throughout both survey areas (Figure 123). Individuals ranged in size from 11 to 25 cm with peaks at 14 cm and 23 cm (Figure 124). Fish caught in the Control Area were solely associated with the larger peak while fish in the 501 North Study Area were distributed evenly between the two peaks.

Shad were sporadically caught during the spring survey with catch rates averaging 0.4 ± 0.2 kg/tow in the 501 North Study Area and 0.2 ± 0.1 kg/tow in the Control Area (Figure 122). Shad were caught in 9 of the 20 tows in the 501 North Study Area and 6 of the 20 tows in the Control Area. The catch of shad was distributed throughout both survey areas (Figure 123). Individuals ranged in size from 13 to 20 cm with a peak at 17 (Figure 124).

During the summer survey only one shad was caught in the 501 North Study Area (Figure 123). Forty-four individuals were caught in the Control Area during 2 tows.

Fall had the lowest catch of shad (Figure 122). Ten individuals were caught in the 501 North Study Area during 4 tows. Only 2 individuals were caught in the Control Area during 2 tows.

The condition of shad was not significantly different in the fall or winter (Figure 125). During the spring survey, the condition of shad was lower in the 501 North Study Area, however catch rates were low.

4.4.26 Atlantic Mackerel

Atlantic mackerel (*Scomber scombrus*) were caught intermittently during all surveys. Annually, catch rates average 2.6 ± 2.0 kg/tow (range: 0 – 157.4 kg/tow) in the 501 North Study Area and 0.1 ± 0.02 kg/tow (range: 0 – 1.2 kg/tow) in the Control Area. The GLM analysis indicated that season and survey area were significant predictors of catch rate (Season: $p = 0.0156$, Survey Area: $p = 0.0075$).

The highest catches of mackerel were observed during the spring survey. The catch rate in the 501 North Study Area was significantly higher than that observed in the Control Area (501 North: 10.5 ± 7.8 kg/tow, Control: 0.1 ± 0.04 kg/tow, Figure 126). This trend is primarily driven by several tows with catches exceeding 10 kilograms including one large tow of 157 kilograms. Mackerel were caught in 10 of the 20 tows in the 501 North Study Area and 6 of the 20 tows in the Control

Area. The catch of mackerel was distributed throughout both survey areas with the largest catches along the northern boundary (Figure 127). Individuals ranged in size from 20 to 34 cm with a peak in the 501 North Study Area at 24 cm (Figure 128, 129, 130). Only 7 individuals were caught in the Control Area.

Mackerel were caught sporadically throughout the summer, fall and winter surveys. During the summer survey 17 fish were caught. One fish was caught in the 501 North Study Area. The remaining 16 fish were caught in the Control Area. Individuals ranged in size from 19 to 26 cm. Only 5 fish were caught during the fall survey. Two fish were caught in the 501 North Study Area and 3 fish were caught in the Control Area. A total of 25 fish were caught in the winter survey, 5 in the 501 North Study Area and 20 in the Control Area.

4.4.27 Longhorn Sculpin

Longhorn sculpin (*Myoxocephalus octodecimspinosus*) were frequently observed during the spring and winter surveys. Annually, catch rates average 0.3 ± 0.1 kg/tow (range: 0 – 2.3 kg/tow) in the 501 North Study Area and 0.4 ± 0.1 kg/tow (range: 0 – 6.2 kg/tow) in the Control Area. The GLM analysis indicated that season was significant predictors of catch rate ($p = 0.0001$) and survey area was moderately significant ($p = 0.0464$).

Longhorn sculpin were most abundant during the winter survey with catch rates averaging 1.02 ± 0.1 kg/tow in the 501 North Study Area and 1.4 ± 0.3 kg/tow in the Control Area (Figure 131). Sculpin were caught in all 20 tows in the 501 North Study Area and 19 of the 20 tows in the Control Area. The catch of sculpin was distributed throughout both survey areas (Figure 132). Individuals ranged in size from 11 to 36 cm (Figure 133). The Control Area had a single peak at 29 cm while the 501 North Study Area had peaks at 24 cm and 28 cm ($p = 0.003$, Figure 134).

Sculpin were also frequently caught during the spring survey but at lower abundances. Catch rates averaging 0.2 ± 0.1 kg/tow in the 501 North Study Area and 0.3 ± 0.1 kg/tow in the Control Area (Figure 131). Sculpin were caught in 11 of the 20 tows in the 501 North Study Area and 9 of the 20 tows in the Control Area. The catch was distributed throughout both survey areas (Figure 132). Individuals ranged in size from 12 to 35 cm with a wide size distribution (Figure 133, 134, 135).

During the summer survey only eight sculpin were caught. Seven sculpin were caught in the 501 North Study Area during three tows and one individual was caught in the Control Area. Only one individual was caught during the fall survey in the 501 North Study Area.

4.4.28 Spotted Hake

Spotted hake (*Urophycis regia*) is a congener to red hake with a similar appearance. Effort was made during every survey to separate red and spotted hake however due to the large volumes of red hake some individuals may have been missed. As a result, estimates of spotted hake abundance may be underestimated; however, spotted hake were not abundant. Annually, catch rates average 0.2 ± 0.1 kg/tow (range: 0 – 5.1 kg/tow) in the 501 North Study Area and 0.4 ± 0.2 kg/tow (range: 0 – 9.8 kg/tow) in the Control Area.

The highest catches of spotted hake were observed in the summer (501 North Study Area: 0.05 ± 0.02 kg/tow, Control: 1.4 ± 0.6 kg/tow, Figure 136). Spotted hake were caught in 3 of the 20 tows in the 501 North Study Area and 7 of the 20 tows in the Control Area. The highest catches were observed along the northern boundary in both study areas (Figure 137). Individuals ranged in size from 16 to 39 cm with a unimodal peak around 25 cm (Figure 138).

Spotted hake were also observed during the winter survey but at low abundances (Figure 136). In the 501 North Study Area, 11 individuals were caught in 8 tows. In the Control Area, 29 individuals were caught in 7 tows. Individuals ranged in size from 7 to 24 cm (Figure 138).

4.4.29 Cancer Crab

Cancer crab (*Cancer sp.*), an aggregation Jonah crab (*Cancer borealis*) and Atlantic rock crab (*Cancer irroratus*), were frequently observed throughout all four of the seasonal surveys. Annually, catch rates average 1.5 ± 0.3 kg/tow (range: 0 – 14.2 kg/tow) in the 501 North Study Area and 0.8 ± 0.1 kg/tow (range: 0 – 4.4 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: $p = 0.0003$).

Crabs were most abundant during the spring and summer surveys. The average catch rate in the spring was 2.3 ± 0.9 kg/tow in the 501 North Study Area and 0.8 ± 0.2 kg/tow in the Control Area (Figure 139). Crabs were caught in 15 of the 20 tows in the 501 North Study Area and 9 of the 20 tows in the Control Area. During the summer survey the catch rate averaged 2.9 ± 0.4 kg/tow in the 501 North Study Area and 1.5 ± 0.2 kg/tow in the Control Area (Figure 139). Crabs were caught in 19 of the 20 tows in the 501 North Study Area and 18 of the 20 tows in the Control Area.

The catch of crabs was lowest in the fall. The average catch rate was 0.2 ± 0.1 kg/tow in the 501 North Study Area and 0.3 ± 0.1 kg/tow in the Control Area (Figure 139). Crabs were caught in 6 of the 20 tows in the 501 North Study Area and 10 of the 20 tows in the Control Area.

The crab catch was modest in the winter. The average catch rate was 0.6 ± 0.1 kg/tow in the 501 North Study Area and 0.8 ± 0.2 kg/tow in the Control Area (Figure 139). Crabs were caught in 17 of the 20 tows in the 501 North Study Area and 11 of the 20 tows in the Control Area (Figure 140).

4.4.30 Atlantic Sea Scallop

Atlantic sea scallop (*Placopecten magellanicus*) is a commercially important shellfish which was caught in both study areas. Due to their sedentary life history the catch is perceived to be a reflection of the abundance on the seafloor since there should not be changes in seasonal abundance. Annually, the total catch of scallops was 13.3 kilograms in the 501 North Study Area which consisted of 108 individuals in 24 tows. The total catch of scallops in the Control Area was 4.7 kilograms which consisted of 18 individuals in 10 tows (Figure 141).

4.4.31 American Lobster

American lobster (*Homarus americanus*) is a commercially important crustacean which was occasionally caught in both study areas. Annually, the total catch of lobster was 3.3 kilograms in the 501 North Study Area which consisted of 12 individuals in 12 tows. The total catch of lobster in the Control Area was 10.3 kilograms which consisted of 15 individuals in 12 tows. All lobster were caught during the spring and summer surveys.

4.4.32 Bluefish

Bluefish (*Pomatomus saltatrix*) were frequently caught during the fall survey. The catch rate in the fall survey averaged 0.7 ± 0.2 kg/tow (range: 0 – 3.3 kg/tow) in the 501 North Study Area and 1.4 ± 0.4 kg/tow (range: 0 – 5.6 kg/tow) in the Control Area. A total of 44 fish were caught during the fall survey, 16 in the 501 North Study Area and 28 in the Control Area. The catch was distributed throughout both survey areas. Individuals ranged in size from 33 to 51 cm.

One bluefish was caught during the summer survey in the Control Area (43 cm).

4.4.33 Ocean Pout

Ocean pout (*Zoarces americanus*) were caught during the spring and summer surveys. Annually, catch rates average 0.4 ± 0.1 kg/tow (range: 0 – 8.6 kg/tow) in the 501 North Study Area and 0.1 ± 0.03 kg/tow (range: 0 – 1.2 kg/tow) in the Control Area. A total of 42 fish were caught in the 501 North Study Area the majority in the spring (39 individuals). The remaining three individuals were caught in the summer survey. In the Control Area 14 individuals were caught, 11 during the spring and 3 in the summer. Individuals ranged in size from 30 to 52 cm.

4.4.34 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. Annually, catch rates average 0.1 ± 0.06 kg/tow (range: 0 – 3.5 kg/tow) in the 501 North Study Area and 0.1 ± 0.03 kg/tow (range: 0 – 1.5 kg/tow) in the Control Area. A total of 10 fish were caught in the 501 North Study Area. One fish was caught during the fall survey while the remaining 9 fish were caught during the winter survey. A total of 14 fish were caught in the Control Area. One fish was caught in the spring survey while the remaining 13 fish were caught during the winter survey. Individuals ranged in size from 20 to 69 cm.

4.4.35 Black Sea Bass

Black sea bass (*Centropristis striata*) were primarily caught during the fall survey with one individual caught in the spring survey. During the fall survey the catch rates averaged 0.08 ± 0.03 kg/tow (range: 0 – 0.4 kg/tow) in the 501 North Study Area and 0.03 ± 0.02 kg/tow (range: 0 – 0.4 kg/tow) in the Control Area. Black sea bass were caught in 7 of the 20 tows in the 501 North Study Area and 3 of the 20 tows in the Control Area during the fall survey. As previously mentioned, one individual was caught during the spring survey in the Control Area. A total of 14 black sea bass were caught in the 501 North Study Area and 8 were caught in the Control Area. Individuals ranged in size from 10 to 26 cm with most fish between 18 and 22 cm.

4.4.36 Weakfish

Weakfish (*Cynoscion regalis*) were only caught during the fall survey. During the fall survey the catch rates averaged 0.3 ± 0.1 kg/tow (range: 0 – 1.2 kg/tow) in the 501 North Study Area and 0.2 ± 0.1 kg/tow (range: 0 – 1.9 kg/tow) in the Control Area. Weakfish were caught in 7 of the 20 tows in the 501 North Study Area and 6 of the 20 tows in the Control Area. Twelve weakfish were caught in the 501 North Study Area and 8 were caught in the Control Area. Individuals ranged in size from 25 to 50 cm.

4.4.37 Atlantic Menhaden

Atlantic menhaden (*Brevoortia tyrannus*) were caught during 4 tows. Menhaden were caught in two tows in the 501 North Study Area during the spring survey (10.1 and 20.6 kg/tow). In the Control Area menhaden were caught during one tow in the spring survey (0.9 kg/tow) and one tow in the fall survey (6.2 kg/tow). Menhaden ranged in size from 27 to 32 cm.

4.4.38 Other species

Four American plaice (*Hippoglossoides platessoides*) were caught, all in the 501 North Study Area and all during the fall survey (22 - 30 cm).

Four conger eel (*Conger oceanicus*) were caught, one in the 501 North Study Area in the spring and three in the Control Area (one in the summer and two in the fall).

Three sea ravens (*Hemitripterus americanus*) were caught over the course of the four seasonal surveys. Two were caught in the 501 North Study Area, one during the summer and one in the winter. One sea raven was caught in the Control Area during the winter survey. Lengths ranged from 13 – 23 cm.

Three thresher sharks (*Alopias vulpinus*) were caught during the summer survey. Two sharks were caught in the 501 North Study Area. Both animals were estimated at 2.5 m long (fork length). One shark was caught in the Control Area, estimated at 2.0 m long. All sharks were immediately returned to the sea and were observed in good condition when swimming away.

Two Atlantic cutlass fish (*Trichiurus lepturus*) was caught in the Control Area during the fall survey (both 72 cm.)

One thorny skate (*Amblyraja radiata*) was caught in the Control Area during the summer survey.

One cunner (*Tautogolabrus undulatus*) was caught in the 501 North Study Area during the spring survey.

One northern kingfish (*Menticirrhus saxatilis*) was caught in the 501 North Study Area during the fall survey (20 cm).

4.5 Community Structure

The community structure within the 501 North Study Area and Control Area together displayed seasonal changes in species composition. The analysis of similarities test (ANOSIM) yielded an R statistic of 0.791 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. Pairwise tests indicate that the winter had a clear difference in species composition compared to the spring, summer and fall surveys (R = 0.994, 0.995 and 0.998, respectively). Winter tows were primarily associated with Atlantic herring, silver hake, little skate, alewife and longhorn sculpin.

The spring, summer and fall surveys exhibited more similarities between seasons (R range: 0.613 – 0.757). Spring survey tows were associated with silver hake, winter skate, red hake, little skate, barndoor skate and spiny dogfish. Summer survey tows were associated with little skate, silver hake, red hake and butterfish. Finally, fall tows were associated with little skate, spiny dogfish, scup, silver hake and red hake. The nMDS plot shows four clusters of points each associated with a seasonal survey (Figure 142). Clusters associated with the spring, summer and fall tows are close to each other while the cluster encompassing tows from the winter survey are spatially isolated. This indicates that each season is sampling a unique assemblage of species. The spring, summer and fall seasons have significant overlap in the species in which they collect; however the winter survey appears to be relatively unique in the species assemblage that it collects.

There were no significant differences in community structure between the two survey areas. The two areas yielded an R statistic of 0.024 which indicated no difference in species composition.

The species with the highest similarities between areas were silver hake, little skate, red hake, butterfish, spiny dogfish and winter skate. The nMDS plot show no distinct clustering of points related to the survey area (Figure 143).

4.6 Power Analysis

Catch data collected from the seasonal surveys exhibited a high level of variability resulting in coefficients of variance (CVs) ranging from 0.97 (little skate) to 9.61 (Atlantic mackerel, 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 results of the power analysis indicated that several species, including little skate, longfin squid, silver hake and fourspot flounder had relatively low variability (CV = ~1) and therefore high probability of detecting a small to moderate change. Detecting a 25% change in the two areas with 80% confidence would require 170-270 tows per area, which under the current sampling intensity (80 tows/area/year) would require 2-3 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 changes (i.e. a 10% change), the sample size would have to be increased 10-fold (1329 – 2011 tows per area, Figure 144).

Many of the common species observed, including winter skate, red hake, windowpane flounder, monkfish, summer flounder, scup, yellowtail flounder, winter flounder and butterfish had CV's between 1.5 and 2.3. These species would have a high probability of detecting a moderate change (i.e. 30-50% change). Detecting a 50% change in the two areas with 80% confidence would require 70-176 tows per area, which under the current sampling intensity (80 tows/area/year) would require 1-2 years of sampling before and after impact. To detect a 25% change, the sampling would have to be increased to 410 – 1023 tows.

Spiny dogfish, shortfin squid, alewife, blueback herring and Atlantic herring exhibited strong seasonality which lead to high variability (CV's 2.5 – 4). These species would have a high probability of detecting moderate to large change (i.e. 50-75% change). Detecting a 75% change in the two areas with 80% confidence would require 50-130 tows per area, which under the current sampling intensity (80 tows/area/year) would require 1-2 years of sampling before and after impact. To detect a 50% change the sampling would have to be increased to 204 – 526 tows. To detect a 25% change the sampling would have to be increased to 1189 – 3057 tows.

The current sampling effort has the statistical power to detect a complete disappearance of each and every species from either study area (100% change). The relationship between power and the sample size for the ten most abundant species, by weight, can be found in Figures 145 – 154.

5. Discussion

The bottom trawl surveys employed the survey trawl and operational protocol that are consistent with the Northeast Area Monitoring and Assessment Program (NEAMAP) conducted by Virginia Institute of Marine Science (VIMS) during the last decade. This allows for possible data integration with several inshore surveys in addition to the dedicated use for the evaluation of wind energy development by Vineyard Wind. The survey trawls were fabricated by Reidars Trawl Gear and Marine Supply based on the approved net and rigging plan. The company has fabricated the survey trawls for other survey programs which ensures consistency in material, dimension and workmanship of the survey gear. The survey trawl was inspected and restored before each survey to ensure that the survey gear meets the quality and specifications.

Even though we had a pressing time schedule to start the first survey (spring 2019 survey), SMAST successfully completed all four seasonal surveys onboard two commercial fishing vessels within the time frame. Both "Guardian" and "Heather Lynn" functioned well for the intended surveys. Overall, surveys went smoothly as planned. The data from these surveys will provide an important part of the baseline data for Before-And-After-Control -Impact (BACI) analysis in the future.

The selection of the Control Area was made through extensive discussion between Vineyard Wind and SMAST, which is also conducting other surveys in the area. While the Control Area seems a suitable control to evaluate the 501 North Study Area, some differences in CPUE were noted for some species between the areas. Depth strata of the survey areas seem an important driver affecting catch rate for some species. Due to pending development of the Control Area, which is leased to Equinor, the Control Area for future surveys is being reevaluated.

We were able to consistently monitor and record trawl geometry from the second survey (summer survey) when the new gear monitoring equipment was acquired. The measurement from the new monitoring equipment (Simrad PX) was much more stable and consistent than the earlier equipment used for the initial spring survey, giving repeatable data from tow to tow. Overall, the trawl performed well with its geometry within acceptable specifications. Headline height was slightly lower than the standard value from other surveys. Further adjustments to the length of bridles and the depth-to-warp ratio will be made in future surveys to increase the headline height to a comparable value.

While the surveys revealed high species diversity in both survey areas, registering a total of 45 species, the majority of the catch was comprised of a small number of dominant species. The four most abundant species (spiny dogfish, little skate, silver hake and red hake) accounted for more than 70% of the total catch weight, and together with the next four species (winter skate, scup, butterfish and alewife), they contributed to more than 90% of total catch for both areas. However, less abundant species are just as important, these surveys provide baseline data on species diversity, and changes in species distribution with time and anthropogenic activities, including wind energy development. Southern New England is a borderline area for many species, which are prone to changes in distribution due to climate change, especially water temperature. Species such as Atlantic cutlass fish are rarely seen off southern Massachusetts. Changes in abundance of such species in subsequent surveys may provide useful evidence of species' northward movement due to climate change.

Preliminary assessment of power analysis using the collected data indicate that the current bottom trawl survey effort would provide reasonable "power" to detect small to medium scales of change in abundance for some abundant species, if changes in abundance do occur. With data from future surveys, it will likely reduce CVs for many species, thus giving more confidence and providing higher "power" for such prediction.

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Table 1: 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)	Trawl Warp (fm)
1	Spring 2019	501N	6/11/2019	Obscured	16-20	S	1.25-2.5	6:41	N 41° 06.919	W 70° 30.011	20	7:01	N 41° 06.619	W 70° 28.859	21	100
2	Spring 2019	501N	6/11/2019	Overcast	11-15	S	1.25-2.5	8:16	N 41° 06.985	W 70° 28.225	20	8:36	N 41° 06.309	W 70° 27.281	20	100
3	Spring 2019	501N	6/11/2019	Overcast	7-10	S	1.25-2.5	9:42	N 41° 06.359	W 70° 26.810	20	10:02	N 41° 07.273	W 70° 26.653	19	100
4	Spring 2019	501N	6/11/2019	Rain	7-10	S	1.25-2.5	11:05	N 41° 05.676	W 70° 25.935	20	11:27	N 41° 04.878	W 70° 26.796	21	100
5	Spring 2019	501N	6/11/2019	Overcast	7-10	S	1.25-2.5	12:47	N 41° 05.267	W 70° 25.599	21	13:07	N 41° 04.295	W 70° 25.820	22	100
6	Spring 2019	501N	6/11/2019	Overcast	7-10	S	1.25-2.5	14:20	N 41° 02.662	W 70° 27.500	23	14:40	N 41° 03.321	W 70° 26.502	22	100
7	Spring 2019	501N	6/11/2019	Clear	7-10	S	0.5-1.25	15:50	N 41° 03.582	W 70° 26.013	22	16:10	N 41° 02.617	W 70° 26.149	21	100
8	Spring 2019	Control	6/12/2019	Clear	3-6	W	0.5-1.25	6:17	N 41° 01.111	W 70° 21.855	20	6:37	N 41° 00.192	W 70° 22.468	20	100
9	Spring 2019	Control	6/12/2019	Clear	7-10	W	0.5-1.25	7:48	N 40° 58.904	W 70° 22.565	21	8:08	N 40° 59.989	W 70° 22.593	20	100
10	Spring 2019	Control	6/12/2019	Clear	3-6	W	0.5-1.25	9:19	N 40° 59.884	W 70° 20.909	20	9:40	N 40° 59.164	W 70° 20.085	22	100
11	Spring 2019	Control	6/12/2019	Clear	3-6	W	0.5-1.25	11:02	N 40° 58.982	W 70° 21.711	20	11:23	N 40° 58.034	W 70° 21.564	22	100
12	Spring 2019	Control	6/12/2019	Clear	3-6	W	0.1-0.5	12:47	N 40° 56.360	W 70° 18.174	21	13:08	N 40° 57.414	W 70° 18.198	20	100
13	Spring 2019	Control	6/12/2019	Clear	3-6	W	0.5-1.25	14:12	N 40° 58.804	W 70° 17.424	20	14:33	N 40° 57.832	W 70° 17.533	20	100
14	Spring 2019	Control	6/12/2019	Clear	3-6	W	0.1-0.5	15:58	N 40° 56.619	W 70° 16.358	20	16:22	N 40° 55.906	W 70° 17.506	21	100
15	Spring 2019	Control	6/12/2019	Partly Cloudy	3-6	W	0.1-0.5	17:22	N 40° 54.208	W 70° 17.949	22	17:43	N 40° 54.780	W 70° 18.972	22	100
16	Spring 2019	501N	6/13/2019	Overcast	16-20	SE	1.25-2.5	6:57	N 41° 03.571	W 70° 30.502	22	7:17	N 41° 04.300	W 70° 31.355	22	100
17	Spring 2019	501N	6/13/2019	Rain	16-20	SE	1.25-2.5	8:26	N 70° 32.277	W 70° 32.277	23	8:48	N 41° 03.806	W 70° 32.604	23	100
18	Spring 2019	501N	6/13/2019	Rain	21-26	SE	1.25-2.5	10:16	N 41° 03.695	W 70° 33.540	22	10:38	N 41° 03.042	W 70° 34.591	23	100
19	Spring 2019	501N	6/13/2019	Rain	27-33	SE	1.25-2.5	11:44	N 41° 02.894	W 70° 36.999	23	12:05	N 41° 02.257	W 70° 34.996	23	100
20	Spring 2019	501N	6/14/2019	Clear	7-10	SW	1.25-2.5	6:09	N 41° 01.413	W 70° 32.249	24	6:30	N 41° 01.291	W 70° 31.023	25	125
21	Spring 2019	501N	6/14/2019	Mostly Cloudy	7-10	SW	1.25-2.5	8:09	N 41° 00.865	W 70° 31.311	25	8:31	N 41° 00.491	W 70° 30.075	25	125
22	Spring 2019	501N	6/14/2019	Mostly Cloudy	7-10	SW	1.25-2.5	9:53	N 40° 59.611	W 70° 26.764	22	10:12	N 41° 00.047	W 70° 25.745	22	125
23	Spring 2019	501N	6/14/2019	Partly Cloudy	11-15	SW	1.25-2.5	11:10	N 41° 00.182	W 70° 24.396	21	11:29	N 41° 01.050	W 70° 24.072	21	100
24	Spring 2019	501N	6/14/2019	Partly Cloudy	11-15	SW	1.25-2.5	12:21	N 41° 01.540	W 70° 23.045	21	12:41	N 41° 02.401	W 70° 23.613	21	100
25	Spring 2019	501N	6/14/2019	Partly Cloudy	16-20	SW	1.25-2.5	13:49	N 41° 02.510	W 70° 22.261	20	14:09	N 41° 02.917	W 70° 23.483	20	100
26	Spring 2019	Control	6/14/2019	Clear	16-20	SW	1.25-2.5	15:34	N 40° 57.280	W 70° 24.724	23	15:54	N 40° 57.963	W 70° 23.722	22	125
27	Spring 2019	Control	6/15/2019	Clear	11-15	W	1.25-2.5	6:17	N 40° 56.145	W 70° 24.651	24	6:38	N 40° 55.295	W 70° 23.941	24	125
28	Spring 2019	Control	6/15/2019	Clear	11-15	W	1.25-2.5	8:16	N 40° 53.832	W 70° 21.682	24	8:36	N 40° 53.753	W 70° 20.424	23	125
29	Spring 2019	Control	6/15/2019	Clear	11-15	W	1.25-2.5	9:55	N 40° 53.985	W 70° 18.596	22	10:15	N 40° 53.193	W 70° 19.375	23	125
30	Spring 2019	Control	6/15/2019	Clear	7-10	W	1.25-2.5	11:40	N 40° 51.533	W 70° 21.516	25	12:00	N 40° 50.932	W 70° 22.487	25	125
31	Spring 2019	Control	6/15/2019	Clear	7-10	W	0.5-1.25	14:28	N 40° 51.048	W 70° 22.425	26	14:48	N 40° 50.169	W 70° 22.567	26	125
32	Spring 2019	Control	6/15/2019	Clear	11-15	W	0.5-1.25	16:29	N 40° 51.400	W 70° 24.184	26	16:49	N 40° 52.371	W 70° 24.081	26	125
33	Spring 2019	501N	6/23/2019	Clear	11-15	W	0.5-1.25	9:19	N 41° 01.093	W 70° 31.798	25	9:40	N 41° 00.466	W 70° 32.834	26	125
34	Spring 2019	501N	6/23/2019	Clear	11-15	W	0.5-1.25	12:30	N 41° 00.424	W 70° 33.235	25	12:51	N 40° 59.622	W 70° 34.001	25	125
35	Spring 2019	501N	6/23/2019	Clear	11-15	W	0.5-1.25	14:38	N 41° 00.642	W 70° 35.511	25	15:00	N 40° 59.630	W 70° 35.863	26	125
36	Spring 2019	Control	6/23/2019	Clear	11-15	W	0.5-1.25	16:49	N 40° 56.316	W 70° 26.038	23	17:09	N 40° 56.144	W 70° 24.788	23	125
37	Spring 2019	Control	6/23/2019	Clear	11-15	W	0.5-1.25	18:49	N 40° 55.999	W 70° 23.498	23	19:09	N 40° 55.455	W 70° 24.491	23	125
38	Spring 2019	Control	6/24/2019	Clear	11-15	SW	0.5-1.25	7:07	N 40° 52.562	W 70° 23.117	25	7:27	N 40° 52.611	W 70° 25.311	26	125
39	Spring 2019	Control	6/24/2019	Clear	11-15	SW	0.5-1.25	9:28	N 40° 52.194	W 70° 28.313	27	9:49	N 40° 53.260	W 70° 29.156	27	125
40	Spring 2019	Control	6/24/2019	Clear	7-10	SW	0.5-1.25	11:30	N 40° 54.213	W 70° 29.649	26	11:51	N 40° 55.154	W 70° 29.184	26	125

Note: fm = fathom

Table 2: 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)	Trawl Warp (fm)
1	Summer 2019	501N	8/18/2019	Obscured	3-6	SW	0.1-0.5	8:58	N 41° 08.018	W 70° 29.801	20	9:18	N 41° 08.053	W 70° 28.630	21	75
2	Summer 2019	501N	8/18/2019	Overcast	3-6	SW	0.1-0.5	10:59	N 41° 08.161	W 70° 26.863	21	11:19	N 41° 07.182	W 70° 26.977	21	75
3	Summer 2019	501N	8/18/2019	Overcast	0	SW	0.1-0.5	12:46	N 41° 04.433	W 70° 26.863	22	13:06	N 41° 03.849	W 70° 27.404	22	75
4	Summer 2019	501N	8/18/2019	Mostly Cloudy	1-2	SW	0.1-0.5	14:14	N 41° 05.113	W 70° 29.302	22	14:34	N 41° 04.243	W 70° 30.061	22	75
5	Summer 2019	501N	8/18/2019	Partly Cloudy	3-6	SW	0.1-0.5	15:42	N 41° 03.985	W 70° 29.302	24	16:02	N 41° 04.868	W 70° 31.962	24	75
6	Summer 2019	501N	8/18/2019	Partly Cloudy	3-6	SW	0.1-0.5	17:03	N 41° 05.527	W 70° 30.098	22	17:23	N 41° 06.490	W 70° 30.032	22	75
7	Summer 2019	Control	8/19/2019	Partly Cloudy	1-2	SW	0.1-0.5	7:09	N 40° 59.634	W 70° 22.081	22	7:29	N 40° 39.566	W 70° 42.492	21	75
8	Summer 2019	Control	8/19/2019	Obscured	1-2	SW	0.1-0.5	8:42	N 41° 01.416	W 70° 21.338	22	9:02	N 41° 00.656	W 70° 20.551	22	75
9	Summer 2019	Control	8/19/2019	Obscured	3-6	SW	0.1-0.5	10:14	N 41° 00.260	W 70° 20.008	22	10:34	N 40° 59.286	W 70° 20.051	23	75
10	Summer 2019	Control	8/19/2019	Overcast	3-6	SW	0.1-0.5	11:53	N 40° 38.874	W 70° 18.525	22	12:13	N 40° 58.054	W 70° 17.961	22	75
11	Summer 2019	Control	8/19/2019	Clear	1-2	SW	0.1-0.5	13:44	N 40° 56.755	W 70° 19.073	22	14:05	N 40° 55.841	W 70° 18.311	22	75
12	Summer 2019	Control	8/19/2019	Clear	3-6	SW	0.1-0.5	15:22	N 40° 55.367	W 70° 17.824	21	15:42	N 40° 55.839	W 70° 16.176	21	75
13	Summer 2019	Control	8/19/2019	Clear	7-10	SW	0.1-0.5	16:40	N 40° 55.909	W 70° 15.914	20	17:00	N 40° 53.987	W 70° 16.346	21	75
14	Summer 2019	Control	8/20/2019	Partly Cloudy	7-10	W	0.5-1.25	7:51	N 40° 52.580	W 70° 19.842	24	8:11	N 40° 53.267	W 70° 20.792	24	95
15	Summer 2019	Control	8/20/2019	Clear	7-10	W	0.5-1.25	9:23	N 40° 50.912	W 70° 21.289	26	9:44	N 40° 51.859	W 70° 21.360	26	95
16	Summer 2019	Control	8/20/2019	Clear	7-10	W	0.5-1.25	11:08	N 40° 52.684	W 70° 21.826	25	11:28	N 40° 53.673	W 70° 21.938	25	95
17	Summer 2019	Control	8/20/2019	Clear	7-10	W	0.5-1.25	13:26	N 40° 55.953	W 70° 20.998	23	13:45	N 40° 55.371	W 70° 19.921	23	95
18	Summer 2019	Control	8/20/2019	Clear	7-10	W	0.1-0.5	14:47	N 40° 56.336	W 70° 22.081	23	15:07	N 40° 56.779	W 70° 23.218	23	95
19	Summer 2019	Control	8/20/2019	Partly Cloudy	3-6	W	0.1-0.5	15:57	N 40° 56.741	W 70° 22.333	23	16:17	N 40° 57.384	W 70° 22.978	23	95
20	Summer 2019	Control	8/20/2019	Partly Cloudy	3-6	W	0.1-0.5	17:09	N 40° 57.844	W 70° 23.645	23	17:31	N 40° 58.109	W 70° 24.853	23	95
21	Summer 2019	501N	8/21/2019	Clear	3-6	S	0.1-0.5	7:12	N 41° 06.068	W 70° 22.177	20	7:32	N 41° 05.047	W 70° 22.405	22	75
22	Summer 2019	501N	8/21/2019	Mostly Cloudy	7-10	S	0.1-0.5	8:30	N 41° 04.057	W 70° 22.752	21	8:50	N 41° 03.067	W 70° 22.789	20	75
23	Summer 2019	501N	8/21/2019	Obscured	7-10	S	0.1-0.5	9:55	N 41° 02.936	W 70° 24.588	21	10:15	N 41° 02.013	W 70° 24.349	22	75
24	Summer 2019	501N	8/21/2019	Overcast	10-15	S	0.5-1.25	10:49	N 41° 03.069	W 70° 24.586	22	11:09	N 41° 02.152	W 70° 24.913	22	95
25	Summer 2019	501N	8/21/2019	Overcast	10-15	S	0.5-1.25	12:34	N 41° 02.947	W 70° 28.278	23	12:54	N 41° 02.131	W 70° 27.584	22	95
26	Summer 2019	501N	8/21/2019	Mostly Cloudy	10-15	S	0.5-1.25	13:45	N 41° 01.938	W 70° 29.171	23	14:05	N 41° 01.587	W 70° 30.357	25	100
27	Summer 2019	501N	8/21/2019	Mostly Cloudy	16-20	S	0.5-1.25	14:53	N 41° 02.546	W 70° 30.234	25	15:13	N 41° 03.065	W 70° 31.284	23	100
28	Summer 2019	501N	8/22/2019	Mostly Cloudy	7-10	SW	0.5-1.25	7:06	N 41° 00.231	W 70° 30.918	25	7:26	N 41° 00.371	W 70° 32.224	26	100
29	Summer 2019	501N	8/22/2019	Mostly Cloudy	7-10	SW	0.5-1.25	8:40	N 40° 59.919	W 70° 33.488	26	8:59	N 40° 59.891	W 70° 34.866	26	100
30	Summer 2019	501N	8/22/2019	Partly Cloudy	7-10	SW	0.5-1.25	9:59	N 41° 00.509	W 70° 36.836	25	10:18	N 41° 00.819	W 70° 38.119	24	100
31	Summer 2019	501N	8/22/2019	Partly Cloudy	7-10	SW	0.5-1.25	11:22	N 41° 02.723	W 70° 35.459	24	11:42	N 41° 03.372	W 70° 32.636	24	100
32	Summer 2019	501N	8/22/2019	Partly Cloudy	7-10	SW	0.5-1.25	12:42	N 41° 04.053	W 70° 33.917	23	13:02	N 41° 04.348	W 70° 32.636	24	100
33	Summer 2019	501N	8/26/2019	Clear	16-20	NE	1.25-2.5	9:18	N 40° 59.543	W 70° 26.132	23	9:38	N 41° 00.321	W 70° 25.718	22	95
34	Summer 2019	501N	8/26/2019	Partly Cloudy	16-20	NE	1.25-2.5	10:37	N 40° 58.992	W 70° 26.537	23	10:57	N 40° 59.494	W 70° 27.599	23	95
35	Summer 2019	Control	8/26/2019	Partly Cloudy	16-20	NE	1.25-2.5	12:14	N 40° 55.827	W 70° 25.018	24	12:34	N 40° 55.638	W 70° 26.284	24	100
36	Summer 2019	Control	8/26/2019	Mostly Cloudy	16-20	NE	1.25-2.5	13:44	N 40° 55.965	W 70° 28.890	26	14:04	N 40° 55.722	W 70° 27.617	26	100
37	Summer 2019	Control	8/26/2019	Partly Cloudy	16-20	NE	1.25-2.5	14:57	N 40° 54.732	W 70° 24.470	27	15:17	N 40° 55.350	W 70° 27.959	26	100
38	Summer 2019	Control	8/26/2019	Clear	16-20	NE	1.25-2.5	16:10	N 40° 52.198	W 70° 26.352	27	16:30	N 40° 52.882	W 70° 25.469	27	100
39	Summer 2019	Control	8/27/2019	Clear	3-6	E	0.5-1.25	7:01	N 40° 50.177	W 70° 24.109	27	7:21	N 40° 50.059	W 70° 25.421	27	100
40	Summer 2019	Control	8/27/2019	Clear	3-6	E	0.5-1.25	8:39	N 40° 51.532	W 70° 27.178	28	8:59	N 40° 52.239	W 70° 28.064	28	100

Note: fm = fathom

Table 3: 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)	Trawl Warp (fm)
1	Fall 2019	501N	11/6/2019	Clear	16-20	N	0.5-1.25	7:27	N 41° 04.919	W 70° 30.109	22	7:47	N 41° 05.459	W 70° 31.573	22	100
2	Fall 2019	501N	11/6/2019	Clear	16 -20	N	0.5-1.25	8:43	N 41° 04.865	W 70° 29.346	21	9:03	N 41° 05.199	W 70° 28.973	22	100
3	Fall 2019	501N	11/6/2019	Clear	16-20	N	0.5-1.25	10:09	N 41° 05.724	W 70° 29.661	22	10:29	N 41° 05.825	W 70° 28.445	21	100
4	Fall 2019	501N	11/6/2019	Clear	7-10	N	0.5-1.25	11:27	N 41° 06.845	W 70° 29.275	21	11:47	N 41° 06.923	W 70° 27.967	21	100
5	Fall 2019	501N	11/6/2019	Clear	7-10	N	0.5-1.25	13:08	N 41° 07.084	W 70° 29.372	21	13:23	N 41° 06.923	W 70° 27.967	21	100
6	Fall 2019	501N	11/6/2019	Clear	7-10	N	0.5-1.25	14:39	N 41° 05.321	W 70° 25.724	21	14:59	N 41° 04.380	W 70° 25.254	22	100
7	Fall 2019	501N	11/6/2019	Clear	7-10	N	0.5-1.25	16:11	N 41° 03.155	W 70° 26.493	22	16:27	N 41° 03.344	W 70° 27.513	23	100
8	Fall 2019	Control	11/7/2019	Partly Cloudy	3-6	W	0.5-1.25	6:27	N 40° 53.106	W 70° 17.270	23	6:42	N 40° 52.916	W 70° 18.077	24	100
9	Fall 2019	Control	11/7/2019	Partly Cloudy	3-6	W	0.5-1.25	7:25	N 40° 54.902	W 70° 26.493	21	7:45	N 40° 55.067	W 70° 17.591	21	100
10	Fall 2019	Control	11/7/2019	Mostly Cloudy	11-15	W	0.5-1.25	8:24	N 40° 55.562	W 70° 17.967	21	8:44	N 40° 56.139	W 70° 19.001	22	100
11	Fall 2019	Control	11/7/2019	Mostly Cloudy	16-20	SW	0.5-1.25	9:48	N 40° 56.788	W 70° 17.780	21	10:08	N 40° 57.594	W 70° 17.006	20	100
12	Fall 2019	Control	11/7/2019	Mostly Cloudy	16-20	SW	0.5-1.25	10:23	N 40° 57.967	W 70° 16.573	20	10:43	N 40° 58.885	W 70° 15.976	19	100
13	Fall 2019	Control	11/7/2019	Overcast	16-20	SW	0.5-1.25	11:44	N 40° 57.997	W 70° 20.477	23	12:04	N 40° 57.945	W 70° 21.738	23	100
14	Fall 2019	Control	11/7/2019	Overcast	16-20	SW	0.5-1.25	13:22	N 40° 59.521	W 70° 19.477	23	13:42	N 41° 00.109	W 70° 18.514	21	100
15	Fall 2019	Control	11/7/2019	Overcast	21-26	SW	1.25-2.5	14:54	N 41° 01.594	W 70° 19.782	22	15:14	N 41° 01.995	W 70° 20.903	21	100
16	Fall 2019	501N	11/7/2019	Overcast	21-26	SW	1.25-2.5	15:56	N 41° 02.058	W 70° 23.155	21	16:16	N 41° 01.916	W 70° 24.430	22	100
17	Fall 2019	501N	11/9/2019	Partly Cloudy	11-15	N	1.25-2.5	6:37	N 41° 03.806	W 70° 36.392	24	6:57	N 41° 03.735	W 70° 34.978	23	100
18	Fall 2019	501N	11/9/2019	Partly Cloudy	7-10	N	1.25-2.5	7:57	N 41° 02.186	W 70° 34.756	24	8:17	N 41° 02.268	W 70° 35.911	24	100
19	Fall 2019	501N	11/9/2019	Partly Cloudy	7-10	N	0.5-1.25	9:06	N 41° 02.076	W 70° 34.031	24	9:26	N 41° 01.730	W 70° 32.735	25	100
20	Fall 2019	501N	11/9/2019	Partly Cloudy	7-10	N	0.5-1.25	10:12	N 41° 02.073	W 70° 31.301	25	10:32	N 41° 02.335	W 70° 30.046	24	100
21	Fall 2019	501N	11/9/2019	Partly Cloudy	7-10	N	0.5-1.25	11:17	N 41° 02.136	W 70° 29.778	24	11:39	N 41° 03.161	W 70° 29.339	24	100
22	Fall 2019	501N	11/9/2019	Clear	7-10	N	0.5-1.25	12:33	N 41° 01.446	W 70° 28.585	22	12:53	N 41° 00.815	W 70° 28.351	23	100
23	Fall 2019	501N	11/9/2019	Clear	3-6	N	0.1-0.5	13:57	N 41° 01.446	W 70° 28.941	23	14:12	N 41° 01.290	W 70° 29.962	24	100
24	Fall 2019	501N	11/9/2019	Clear	3-6	N	0.1-0.5	15:12	N 40° 59.757	W 70° 28.507	24	15:22	N 40° 59.685	W 70° 27.928	24	100
25	Fall 2019	Control	11/10/2019	Partly Cloudy	11-15	SW	0.5-1.25	6:26	N 40° 52.323	W 70° 20.477	25	6:46	N 40° 51.944	W 70° 22.023	26	100
26	Fall 2019	Control	11/10/2019	Mostly Cloudy	11-15	SW	0.5-1.25	7:29	N 40° 53.001	W 70° 22.090	25	7:49	N 40° 53.438	W 70° 23.222	25	100
27	Fall 2019	Control	11/10/2019	Mostly Cloudy	11-15	SW	0.5-1.25	8:35	N 40° 54.274	W 70° 22.652	24	8:55	N 40° 55.291	W 70° 22.403	23	100
28	Fall 2019	Control	11/10/2019	Overcast	11-15	SW	0.5-1.25	9:53	N 40° 55.494	W 70° 22.440	23	10:13	N 40° 56.330	W 70° 21.727	23	100
29	Fall 2019	Control	11/10/2019	Overcast	11-15	SW	0.5-1.25	11:16	N 40° 54.882	W 70° 25.409	25	11:36	N 40° 54.305	W 70° 26.467	25	100
30	Fall 2019	Control	11/10/2019	Mostly Cloudy	7-10	SW	0.5-1.25	12:28	N 40° 56.278	W 70° 27.602	25	12:48	N 40° 57.181	W 70° 28.080	24	100
31	Fall 2019	Control	11/10/2019	Partly Cloudy	11-15	SW	0.5-1.25	13:40	N 40° 58.132	W 70° 24.699	23	14:00	N 40° 58.793	W 70° 23.744	22	100
32	Fall 2019	Control	11/10/2019	Partly Cloudy	16-20	SW	0.5-1.25	14:59	N 40° 58.797	W 70° 24.955	24	15:19	N 40° 58.872	W 70° 26.302	23	100
33	Fall 2019	501N	11/14/2019	Mostly Cloudy	3-6	W	0.1-0.5	6:59	N 41° 00.267	W 70° 24.166	23	7:19	N 41° 00.689	W 70° 24.744	23	100
34	Fall 2019	501N	11/14/2019	Mostly Cloudy	7-10	W	0.1-0.5	8:21	N 41° 04.495	W 70° 21.707	22	8:41	N 41° 03.818	W 70° 22.552	21	100
35	Fall 2019	501N	11/14/2019	Overcast	7-10	W	0.5-1.25	11:26	N 40° 55.739	W 70° 36.392	26	11:46	N 40° 54.818	W 70° 30.578	27	100
36	Fall 2019	Control	11/14/2019	Mostly Cloudy	11-15	W	0.5-1.25	12:51	N 40° 53.637	W 70° 28.309	27	13:11	N 40° 53.594	W 70° 26.943	26	100
37	Fall 2019	Control	11/14/2019	Overcast	11-15	W	0.5-1.25	14:12	N 40° 51.510	W 70° 26.808	28	14:32	N 40° 50.629	W 70° 26.234	28	125
38	Fall 2019	Control	11/14/2019	Overcast	16-20	W	0.5-1.25	15:48	N 40° 50.324	W 70° 24.153	27	16:08	N 40° 57.206	W 70° 23.908	27	100
39	Fall 2019	Control	11/15/2019	Overcast	11-15	W	1.25-2.5	6:57	N 40° 59.750	W 70° 34.310	26	7:17	N 40° 59.876	W 70° 33.033	27	100
40	Fall 2019	501N	11/15/2019	Rain	11-15	W	1.25-2.5	8:22	N 40° 59.984	W 70° 35.858	27	8:42	N 40° 59.570	W 70° 36.868	26	100

Note: fm = fathom

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

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 Speed (knots)	Tow Distance (nm.)	Start Depth (fm)	Bottom Temp. (^oC)	Headline Height (m.)	Wing Spread (m.)	Spread Door (m.)
1	Spring 2019	501N	20.5	2.86	0.98	20	10.2			
2	Spring 2019	501N	20.1	2.92	0.98	20	10.4			
3	Spring 2019	501N	19.1	2.94	0.94	20	10.7			
4	Spring 2019	501N	20.0	3.02	1.01	20	10.7			
5	Spring 2019	501N	20.8	2.86	0.99	21	10.7			
6	Spring 2019	501N	20.6	2.98	1.02	23	10.1			
7	Spring 2019	501N	20.7	2.90	1.00	22	10.3			
8	Spring 2019	Control	20.7	3.00	1.03	20	9.8	4.2	13.7	
9	Spring 2019	Control	21.9	3.04	1.11	21	9.8	3.9	14.7	
10	Spring 2019	Control	20.6	2.79	0.96	20	10.3	4.8	14.7	
11	Spring 2019	Control	20.6	2.84	0.97	20	10.0	5.0	15.9	
12	Spring 2019	Control	22.1	2.85	1.05	21	10.4	4.3		
13	Spring 2019	Control	21.4	2.76	0.98	20	11.0	4.2		
14	Spring 2019	Control	24.3	2.81	1.14	20	10.8	4.1		
15	Spring 2019	Control	20.9	2.82	0.98	22	9.4	4.3		
16	Spring 2019	501N	20.6	2.90	1.00	22	9.8	4.2	15.3	
17	Spring 2019	501N	21.6	2.77	1.00	23	9.6	4.0		
18	Spring 2019	501N	22.1	2.82	1.04	22	9.6		15.6	
19	Spring 2019	501N	22.1	2.73	1.00	23	9.6	4.2	12.5	
20	Spring 2019	501N	20.5	2.78	0.95	24	9.4	4.0		
21	Spring 2019	501N	21.5	2.86	1.03	25	9.3	4.5	12.5	
22	Spring 2019	501N	19.6	2.74	0.90	22	9.6	3.5	14.1	
23	Spring 2019	501N	19.2	2.86	0.91	21	10.2	5.1	12.9	
24	Spring 2019	501N	19.7	2.89	0.95	21	10.9		11.4	
25	Spring 2019	501N	20.1	3.02	1.01	20	11.2	3.5	11.3	
26	Spring 2019	Control	19.8	3.02	1.00	23	9.8	4.2		
27	Spring 2019	Control	21.3	2.87	1.02	24	9.3	4.1	14.5	
28	Spring 2019	Control	20.2	2.85	0.96	24	9.4	4.2	15.8	
29	Spring 2019	Control	21.0	2.84	0.99	22	9.5	3.6	14.6	
30	Spring 2019	Control	20.3	2.84	0.96	25	9.1	3.7		
31	Spring 2019	Control	19.0	2.81	0.89	26	9.2	4.4	16.2	
32	Spring 2019	Control	21.3	2.82	1.00	26	9.1	3.6	14.6	
33	Spring 2019	501N	20.8	2.84	0.98	25	9.1	4.0	15.5	
34	Spring 2019	501N	21.1	2.82	0.99	25	8.9	4.2	15.8	
35	Spring 2019	501N	22.4	2.81	1.05	25	9.0	4.1	14.1	
36	Spring 2019	Control	21.0	2.81	0.98	23	9.2	4.9	15.1	
37	Spring 2019	Control	20.2	2.78	0.93	23	9.6	5.1	15.4	
38	Spring 2019	Control	19.4	2.82	0.91	25	9.1		14.1	
39	Spring 2019	Control	21.1	2.79	0.98	27	9.0	4.0	15.8	
40	Spring 2019	Control	21.0	2.88	1.01	26	8.9	3.6		
1	Summer 2019	501N	20.0	2.7	0.90	20	12.0	5.0		33.1
2	Summer 2019	501N	21.8	2.9	1.04	21	12.1	4.6		34.2
3	Summer 2019	501N	19.2	2.9	0.93	22	11.2	5.1	13.3	33.6
4	Summer 2019	501N	20.6	3.0	1.05	22	10.8	4.6	13.2	34.4
5	Summer 2019	501N	20.6	2.9	1.00	24	10.6	5.0	13.3	33.2
6	Summer 2019	501N	19.9	3.0	0.99	22	11.0	4.7	12.9	34.0
7	Summer 2019	Control	20.3	3.0	1.00	22	12.0	4.5	13.3	33.6
8	Summer 2019	Control	19.9	3.0	0.98	22	12.2	4.6		33.8
9	Summer 2019	Control	20.3	2.9	0.98	22	12.6	4.8	13.1	33.4
10	Summer 2019	Control	19.6	2.9	0.95	22	12.6	4.8	12.9	34.0

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 Speed (knots)	Tow Distance (nm.)	Start Depth (fm)	Bottom Temp. (^oC)	Headline Height (m.)	Wing Spread (m.)	Spread Door (m.)
11	Summer 2019	Control	21.1	3.1	1.09	22	12.4	4.6	14.2	34.6
12	Summer 2019	Control	20.2	2.8	0.96	21	12.6	4.7	13.9	34.1
13	Summer 2019	Control	20.1	3.0	1.02	20	13.1	4.7	13.4	34.5
14	Summer 2019	Control	20.2	3.0	1.00	24	12.7	4.4	13.6	36.6
15	Summer 2019	Control	20.3	2.9	1.00	26	11.7	4.3	14.6	36.2
16	Summer 2019	Control	19.4	3.1	1.00	25	12.5	4.2	14.2	35.3
17	Summer 2019	Control	18.9	3.2	1.01	23	12.3	4.3	13.9	37.0
18	Summer 2019	Control	19.7	3.0	0.98	23	11.7	4.2	14.5	36.4
19	Summer 2019	Control	19.2	3.1	0.98	23	11.8	4.2	14.5	36.2
20	Summer 2019	Control	21.7	2.9	1.06	23	11.8	4.4	14.7	36.3
21	Summer 2019	501N	20.0	3.0	1.00	20	12.4	4.7	14.5	34.4
22	Summer 2019	501N	20.1	3.0	0.99	21	11.9	4.4	13.8	33.9
23	Summer 2019	501N	19.5	2.9	0.96	21	11.5	5.2	13.4	34.9
24	Summer 2019	501N	19.5	3.0	0.97	22	11.4	4.2	13.7	36.2
25	Summer 2019	501N	19.3	3.0	0.98	23	11.1	4.3	14.0	37.0
26	Summer 2019	501N	19.7	3.0	0.97	23	11.2	4.2	14.1	37.3
27	Summer 2019	501N	19.7	3.0	0.97	25	11.1	4.3	14.4	36.3
28	Summer 2019	501N	20.3	3.1	1.04	25	10.4	4.3	14.2	38.1
29	Summer 2019	501N	20.0	3.2	1.05	26	10.3	4.3	14.2	37.9
30	Summer 2019	501N	19.7	3.2	1.04	25	10.5	4.2	14.6	38.2
31	Summer 2019	501N	20.0	3.0	0.98	24	10.5	4.3	14.6	37.8
32	Summer 2019	501N	20.0	3.1	1.03	23	11.0	4.3	14.3	37.9
33	Summer 2019	501N	21.1	2.7	0.94	23	12.4	4.5	14.5	35.5
34	Summer 2019	501N	19.8	3.0	1.00	23	13.5	4.1		35.8
35	Summer 2019	Control	20.2	3.0	1.02	24	11.5	4.8		37.1
36	Summer 2019	Control	19.8	3.1	1.01	26	10.9	4.3		38.6
37	Summer 2019	Control	20.0	4.0	1.32	27	11.1	4.3	14.8	38.0
38	Summer 2019	Control	19.7	3.0	0.99	27	11.7	4.9	14.6	38.1
39	Summer 2019	Control	20.2	3.0	1.02	27	12.0	4.3	15.1	36.8
40	Summer 2019	Control	19.3	3.0	0.98	28	11.1	4.4	14.0	37.2
1	Fall 2019	501N	20.1	3.0	1.0	22	14.6	4.7	14.2	36.0
2	Fall 2019	501N	21.3	3.1	1.1	21	15.0	4.2	14.4	35.6
3	Fall 2019	501N	19.5	3.3	1.1	22	14.9	4.2	13.9	35.0
4	Fall 2019	501N	19.7	3.0	1.0	21	15.0	4.1		34.7
5	Fall 2019	501N	13.9	3.2	0.7	21	14.8	4.2		34.9
6	Fall 2019	501N	20.1	3.1	1.0	21	14.8	4.0		35.3
7	Fall 2019	501N	16.3	3.0	0.8	22	14.4	4.4		35.6
8	Fall 2019	Control	15.0	2.9	0.7	23	16.1	4.7	14.0	34.6
9	Fall 2019	Control	19.7	3.0	1.0	21	16.2	4.2		35.7
10	Fall 2019	Control	19.7	3.0	1.0	21	16.2	4.1		35.9
11	Fall 2019	Control	19.3	3.1	1.0	21	15.3	4.6		35.2
12	Fall 2019	Control	20.5	3.0	1.0	20	14.8	4.0		35.8
13	Fall 2019	Control	19.8	3.0	1.0	23	15.0	4.6	13.1	33.2
14	Fall 2019	Control	20.0	3.0	1.0	23	14.3	4.1	13.5	34.9
15	Fall 2019	Control	19.8	2.9	1.0	22	14.2	4.2	13.6	35.1
16	Fall 2019	501N	19.9	3.0	1.0	21	14.3	4.4	13.7	35.7
17	Fall 2019	501N	20.7	3.3	1.1	24	15.8	4.1	13.6	35.1
18	Fall 2019	501N	19.4	2.7	0.9	24	15.8	4.5	13.1	33.5
19	Fall 2019	501N	19.5	3.2	1.0	24	16.0	4.6	13.2	
20	Fall 2019	501N	19.5	3.1	1.0	25	16.1	4.7	13.3	34.4

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 Speed (knots)	Tow Distance (nm.)	Start Depth (fm)	Bottom Temp. (^oC)	Headline Height (m.)	Wing Spread (m.)	Spread Door (m.)
21	Fall 2019	501N	21.7	3.0	1.1	24	16.3	4.2	13.2	34.2
22	Fall 2019	501N	20.0	3.2	1.1	22	15.8	4.2	13.4	34.9
23	Fall 2019	501N	15.0	3.2	0.8	23	15.8	4.1	13.5	35.2
24	Fall 2019	501N	10.2	2.7	0.5	24	14.0	4.3	13.0	33.4
25	Fall 2019	Control	20.0	2.9	1.0	25	16.1	4.6	13.7	35.8
26	Fall 2019	Control	20.1	2.9	1.0	25	16.3	5.0	13.7	35.5
27	Fall 2019	Control	20.1	3.1	1.0	24	16.2	4.1	13.6	35.5
28	Fall 2019	Control	19.6	3.1	1.0	23	15.9	4.0	13.7	35.8
29	Fall 2019	Control	20.8	3.2	1.1	25	16.4	4.2	13.8	35.8
30	Fall 2019	Control	19.3	3.1	1.0	25	16.0	4.1	13.6	35.4
31	Fall 2019	Control	19.6	3.0	1.0	23	13.7	4.4	13.5	34.8
32	Fall 2019	Control	19.5	3.2	1.0	24	13.8	4.3	13.8	35.9
33	Fall 2019	501N	19.6	2.9	0.6	23	12.9	4.4	13.9	34.3
34	Fall 2019	501N	20.0	2.9	1.0	22	12.8	4.7		34.3
35	Fall 2019	501N	20.0	3.1	1.0	26	14.3	5.1	13.5	33.9
36	Fall 2019	Control	19.8	3.1	1.0	27	15.5	4.4	14.6	34.6
37	Fall 2019	Control	19.6	3.2	1.0	28	16.3	4.6	14.0	36.0
38	Fall 2019	Control	19.6	2.9	1.0	27	15.7	4.2	13.9	33.9
39	Fall 2019	Control	19.4	3.2	1.0	26	13.6	4.8	13.7	34.2
40	Fall 2019	501N	19.6	2.8	0.9	27	13.6	4.6	13.7	34.4
1	Winter 2020	501N	19.4	3.0	1.0	20	6.2	5.0	13.4	33.3
2	Winter 2020	501N	19.9	3.1	1.0	21	6.3	4.6	14.1	35.5
3	Winter 2020	501N	19.6	2.9	0.9	22	6.2	4.5	14.3	35.2
4	Winter 2020	501N	20.5	3.0	1.0	24	6.1	4.7	14.1	35.0
5	Winter 2020	501N	20.3	3.0	1.0	23	6.3	4.8	14.1	35.0
6	Winter 2020	501N	20.0	3.0	1.0	24	6.1	4.7	14.1	35.8
7	Winter 2020	501N	20.9	3.0	1.0	24	6.0	4.8	14.1	35.3
8	Winter 2020	501N	19.8	3.1	1.0	24	5.9	4.6	14.2	35.5
9	Winter 2020	501N	20.5	3.1	1.1	25	6.2	5.0	13.9	35.1
10	Winter 2020	501N	20.0	3.1	1.0	27	6.2	5.3	13.8	31.4
11	Winter 2020	501N	19.8	3.2	1.1	26	6.2	4.3	14.8	37.8
12	Winter 2020	Control	20.0	3.0	1.0	27	5.0	4.4	15.1	37.2
13	Winter 2020	Control	19.9	3.0	1.0	27	5.6	4.4	14.9	38.0
14	Winter 2020	Control	20.3	3.0	1.0	27	5.3	4.5	14.6	37.4
15	Winter 2020	Control	20.4	3.1	1.0	25	5.0	4.6	14.3	35.6
16	Winter 2020	Control	19.8	2.9	1.0	25	5.0	4.4	14.2	37.1
17	Winter 2020	Control	20.7	2.9	1.0	24	5.3	4.5	14.1	37.1
18	Winter 2020	Control	20.4	3.0	1.0	23	5.9	4.4	13.9	36.5
19	Winter 2020	Control	19.8	3.3	1.1	24	6.0	3.9	14.2	37.0
20	Winter 2020	Control	19.6	3.0	1.0	25	5.8	4.3	14.4	35.9
21	Winter 2020	Control	19.7	3.1	1.0	26	5.2	4.2	14.9	38.1
22	Winter 2020	Control	19.8	3.1	1.0	27	5.8	4.4	14.7	37.1
33	Winter 2020	Control	20.3	3.0	1.0	22	5.5	4.6	13.6	33.3
34	Winter 2020	501N	20.0	3.1	1.0	23	5.8	4.7	14.2	35.2
35	Winter 2020	501N	20.1	2.8	0.9	23	5.9	4.9	14.2	35.5
36	Winter 2020	501N	20.0	3.1	1.0	24	5.8	4.7	14.4	36.7
37	Winter 2020	501N	19.4	3.1	1.0	24	5.7	5.0	13.5	33.2
38	Winter 2020	501N	19.6	2.9	1.0	22	5.4	4.9	13.9	34.4
39	Winter 2020	501N	19.6	3.1	1.0	21	5.6	4.7	14.0	34.8
40	Winter 2020	501N	19.9	3.0	1.0	22	5.4	4.5	15.3	35.3

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 Speed (knots)	Tow Distance (nm.)	Start Depth (fm)	Bottom Temp. (^oC)	Headline Height (m.)	Wing Spread (m.)	Spread Door (m.)
41	Winter 2020	501N	20.3	3.1	1.1	21	4.9	4.6	14.1	35.0
42	Winter 2020	501N	20.6	3.0	1.0	21	4.6	4.6	14.3	34.8
43	Winter 2020	Control	19.4	3.0	1.0	27	5.8		15.4	39.0
44	Winter 2020	Control	20.3	2.8	0.9	22	4.6	4.5	14.2	35.1
45	Winter 2020	Control	20.4	2.9	1.0	22	4.7	4.7	13.9	34.1
46	Winter 2020	Control	19.8	2.9	0.9	23	4.5	4.9	13.9	34.5
47	Winter 2020	Control	20.3	2.9	1.0	22	4.6	4.7	14.1	34.7
48	Winter 2020	Control	20.3	3.2	1.1	21	4.6	4.6	14.0	34.8
49	Winter 2020	Control	20.2	2.9	1.0	22	4.8	4.9	13.9	34.5
50	Winter 2020	Control	19.6	2.8	0.9	24	4.9	4.6	13.9	34.6
Summary Statistics										
	Control	**Minimum**	15.0	2.8	0.7	20.0	4.5	3.6	12.9	33.2
		Maximum	24.3	4.0	1.3	28.0	16.4	5.1	16.2	39.0
		Average	20.1	3.0	1.0	23.7	10.6	4.4	14.2	35.7
		St. Dev	1.0	0.2	0.1	2.3	3.8	0.3	0.7	1.4
	501N	**Minimum**	10.2	2.7	0.5	20.0	4.6	3.5	11.3	31.4
		Maximum	22.4	3.3	1.1	27.0	16.3	5.3	15.8	38.2
		Average	19.9	3.0	1.0	22.7	10.5	4.5	13.9	35.1
		St. Dev.	1.6	0.1	0.1	1.8	3.3	0.4	0.8	1.4
		T-Test	0.2415	0.8638	0.1932	0.0032	0.9367	0.1422	0.0562	0.0288

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

Species Name	Scientific Name	Total Weight (Kg)	Catch/Tow (Kg) Mean	Catch/Tow (Kg) SEM*	% of Total Catch	Tows with Species Present
Dogfish, Spiny	*Squalus acanthias*	18392.5	260.8	91.0	43.9	55
Skate, Little	*Leucoraja erinacea*	6326.4	81.0	8.2	15.1	78
Hake, Silver	*Merluccius bilinearis*	4512.5	56.0	6.8	10.8	80
Hake, Red	*Urophycis chuss*	3574.1	43.8	8.4	8.5	74
Skate, Winter	*Leucoraja ocellata*	2257.9	28.0	4.4	5.4	50
Scup	*Stenotomus chrysops*	1559.6	20.9	5.0	3.7	31
Butterfish	*Peprilus triacanthus*	1487.0	18.5	4.1	3.6	72
Alewife	*Alosa pseudoharengus*	1035.6	12.4	5.7	2.5	51
Skate, Barndoor	*Dipturus laevis*	376.8	4.5	1.1	0.9	40
Squid, Atlantic Longfin	*Doryteuthis pealei*	337.2	4.2	0.5	0.8	63
Dogfish, Smooth	*Mustelus canis*	323.5	3.8	1.6	0.8	20
Monkfish	*Lophius americanus*	296.3	3.6	0.7	0.7	47
Mackerel, Atlantic	*Scomber scombrus*	197.0	2.5	2.0	0.5	16
Flounder, Fourspot	*Paralichthys oblongus*	195.5	2.5	0.3	0.5	60
Herring, Atlantic	*Clupea harengus*	194.3	2.4	0.9	0.5	25
Crab, Cancer	*Cancer irroratus*	121.3	1.5	0.3	0.3	57
Flounder, Winter	*Pleuronectes americanus*	104.1	1.3	0.3	0.2	45
Sea Robin, Northern	*Prionotus carolinus*	79.5	1.1	0.3	0.2	26
Haddock	*Melanogrammus aeglefinus*	77.3	0.9	0.9	0.2	1
Flounder, Summer (Fluke)	*Paralichthys dentatus*	71.8	0.9	0.2	0.2	32
Flounder, Windowpane	*Scophtalmus aquosus*	61.1	0.8	0.2	0.1	47
Herring, Blueback	*Alosa aestivalis*	38.2	0.5	0.2	0.1	17
Menhaden, Atlantic	*Brevoortia tyrannus*	32.3	0.4	0.3	0.1	2
Shad, American	*Alosa sapidissima*	29.8	0.4	0.1	0.1	29
Ocean Pout	*Zoarces americanus*	29.6	0.3	0.1	0.1	14
Squid, Shortfin	*Illex illecebrosus*	27.8	0.3	0.2	0.1	14
Sculpin, Longhorn	*Myoxocephalus octodecimspinosus*	24.9	0.3	0.1	0.1	35
Flounder, Yellowtail	*Pleuronectes ferrugineus*	17.7	0.2	0.0	0.0	42
Flounder, Gulfstream	*Citharichthys arctifrons*	17.0	0.2	0.1	0.0	33
Bluefish	*Pomatomus saltatrix*	14.2	0.2	0.1	0.0	9
Hake, Spotted	*Urophycis regia*	13.4	0.2	0.1	0.0	12
Sea Scallop	*Placopecten magellanicus*	13.3	0.2	0.0	0.0	24
Atlantic Cod	*Gadus morhua*	9.5	0.1	0.1	0.0	6
Weakfish	*Cynoscion regalis*	4.5	0.1	0.0	0.0	7

*SEM - Standard Error of the Mean

Table 6 (Cont.): Total and mean catch weight of species observed in the 501 North Study Area.

Species Name	Scientific Name	Total Weight (Kg)	Catch/Tow (Kg)		% of Total Catch	Tows with Species Present
			Mean	SEM*		
Lobster, American	*Homarus americanus*	3.3	0.0	0.0	0.0	7
Shark, Thresher	*Alopias vulpinus*	2.0	0.0	0.0	0.0	2
Black Sea Bass	*Centropristis striata*	1.4	0.0	0.0	0.0	7
Cunner	*Tautogolabrus undulatus*	0.5	0.0	0.0	0.0	1
Flounder, American Plaice	*Hippoglossoides platessoides*	0.5	0.0	0.0	0.0	1
American Eel	*Anguilla rostrata*	0.4	0.0	0.0	0.0	1
Sea Raven	*Hemitripterus americanus*	0.2	0.0	0.0	0.0	2
Kingfish, Northern	*Menticirrhus saxatilis*	0.1	0.0	0.0	0.0	1
Total		41861.6				

*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) Mean	Catch/Tow (Kg) SEM*	% of Total Catch	Tows with Species Present
Dogfish, Spiny	*Squalus acanthias*	11174.5	141.7	63.7	23.4	59
Hake, Red	*Urophycis chuss*	8879.7	110.4	17.8	18.6	72
Hake, Silver	*Merluccius bilinearis*	7318.7	89.5	11.7	15.3	79
Skate, Little	*Leucoraja erinacea*	6278.7	78.4	9.1	13.1	78
Butterfish	*Peprilus triacanthus*	2563.8	31.8	8.3	5.4	70
Scup	*Stenotomus chrysops*	2543.8	32.7	7.2	5.3	37
Skate, Winter	*Leucoraja ocellata*	2401.6	29.4	5.1	5.0	47
Haddock	*Melanogrammus aeglefinus*	2042.4	25.8	17.6	4.3	9
Alewife	*Alosa pseudoharengus*	803.4	10.1	4.1	1.7	61
Monkfish	*Lophius americanus*	697.1	8.4	1.6	1.5	56
Skate, Barndoor	*Dipturus laevis*	651.0	7.9	2.2	1.4	41
Sea Robin, Northern	*Prionotus carolinus*	556.1	7.1	4.5	1.2	26
Herring, Atlantic	*Clupea harengus*	540.3	6.7	2.8	1.1	22
Squid, Atlantic Longfin	*Doryteuthis pealei*	288.9	3.6	0.5	0.6	60
Flounder, Fourspot	*Paralichthys oblongus*	209.7	2.6	0.3	0.4	60
Flounder, Summer (Fluke)	*Paralichthys dentatus*	205.6	2.6	0.5	0.4	36
Shad, American	*Alosa sapidissima*	127.5	1.6	1.0	0.3	24
Crab, Cancer	*Cancer irroratus*	67.6	0.8	0.1	0.1	48
Flounder, Windowpane	*Scophtalmus aquosus*	65.6	0.8	0.2	0.1	35
Squid, Shortfin	*Illex illecebrosus*	64.5	0.8	0.3	0.1	14
Dogfish, Smooth	*Mustelus canis*	58.4	0.7	0.3	0.1	11
Flounder, Winter	*Pleuronectes americanus*	37.0	0.5	0.1	0.1	24
Sculpin, Longhorn	*Myoxocephalus octodecimspinosus*	33.0	0.4	0.1	0.1	29
Hake, Spotted	*Urophycis regia*	30.4	0.4	0.2	0.1	15
Bluefish	*Pomatomus saltatrix*	28.7	0.4	0.1	0.1	14
Flounder, Gulfstream	*Citharichthys arctifrons*	23.4	0.3	0.1	0.0	36
Lobster, American	*Homarus americanus*	10.3	0.1	0.0	0.0	11
Flounder, Yellowtail	*Pleuronectes ferrugineus*	9.2	0.1	0.0	0.0	22
Atlantic Cod	*Gadus morhua*	7.9	0.1	0.0	0.0	11
Herring, Blueback	*Alosa aestivalis*	7.8	0.1	0.1	0.0	6
Ocean Pout	*Macrozoarces americanus*	7.8	0.1	0.0	0.0	11
Menhaden, Atlantic	*Brevoortia tyrannus*	7.1	0.1	0.1	0.0	2
Mackerel, Atlantic	*Scomber scombrus*	6.9	0.1	0.0	0.0	21

*SEM - Standard Error of the Mean

Table 7 (Cont.): 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*		
Sea Scallop	*Placopecten magellanicus*	4.7	0.1	0.0	0.0	10
Weakfish	*Cynoscion regalis*	4.3	0.1	0.0	0.0	6
American Eel	*Anguilla rostrata*	1.4	0.0	0.0	0.0	2
Shark, Thresher	*Alopias vulpinus*	1.0	0.0	0.0	0.0	1
Black Sea Bass	*Centropristis striata*	1.0	0.0	0.0	0.0	5
Skate, Thorny	*Amblyraja radiata*	0.8	0.0	0.0	0.0	1
Cutlassfish, Atlantic	*Trichiurus lepturus*	0.3	0.0	0.0	0.0	1
Sea Raven	*Hemitripterus americanus*	0.3	0.0	0.0	0.0	1
Total		47761.8				

*SEM - Standard Error of the Mean

Table 8: Coefficient of variance (CV) and the total number of tows required to detect 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.

Species	CV	Total number of tows needed per survey area				
		10%	25%	50%	75%	100%
Skate, Little	0.97	1329	178	30	7	0
Flounder, Fourspot	1.10	1716	230	39	9	0
Squid, Atlantic Longfin	1.15	1860	249	42	10	0
Hake, Silver	1.19	2011	269	46	11	0
Skate, Winter	1.47	3061	410	70	17	0
Crab, Cancer	1.63	3739	501	86	21	0
Hake, Red	1.66	3896	522	90	22	0
Flounder, Windowpane	1.84	4763	638	110	27	1
Monkfish	1.85	4854	651	112	28	1
Sculpin, Longhorn	2.03	5816	780	134	33	1
Flounder, Summer	2.05	5927	795	136	34	1
Scup	2.08	6094	817	140	35	1
Flounder, Yellowtail	2.11	6313	846	145	36	1
Flounder, Winter	2.15	6549	878	151	37	1
Butterfish	2.32	7630	1023	176	44	1
Flounder, Gulfstream	2.38	8019	1075	185	46	1
Skate, Barndoor	2.50	8866	1189	204	51	2
Sea Scallop	2.64	9826	1318	227	56	2
Bluefish	3.06	13205	1771	305	76	3
Dogfish, Spiny	3.48	17130	2297	395	98	3
Lobster, American	3.77	20146	2702	465	116	4
Ocean Pout	3.84	20867	2799	482	120	4
Squid, Shortfin	3.85	20920	2806	483	120	4
Alewife	3.92	21685	2908	501	125	5
Herring, Blueback	3.93	21794	2923	503	125	5
Atlantic Cod	3.93	21803	2924	503	125	5
Black Sea Bass	4.01	22795	3057	526	131	5
Herring, Atlantic	4.04	23042	3090	532	133	5
Weakfish	4.05	23220	3114	536	134	5
Hake, Spotted	4.42	27675	3712	639	159	6
Dogfish, Smooth	4.56	29398	3943	679	169	6
Shad, American	6.44	58680	7870	1355	338	13
Sea Robin, Northern	7.07	70682	9480	1633	408	16
Shark, Thresher	7.23	74006	9926	1709	427	17
Menhaden, Atlantic	7.88	87817	11779	2029	507	20
Sea Raven	8.30	97511	13079	2253	563	22
Haddock	8.34	98461	13206	2274	568	22
Flounder, American Plaice	8.89	111714	14984	2581	645	25
Cutlassfish, Atlantic	8.89	111714	14984	2581	645	25
Cunner	8.89	111714	14984	2581	645	25
Kingfish, Northern	8.89	111714	14984	2581	645	25
Skate, Thorny	8.89	111714	14984	2581	645	25
Conger Eel	9.24	120719	16192	2789	697	28
Mackerel, Atlantic	9.61	130638	17522	3018	754	30

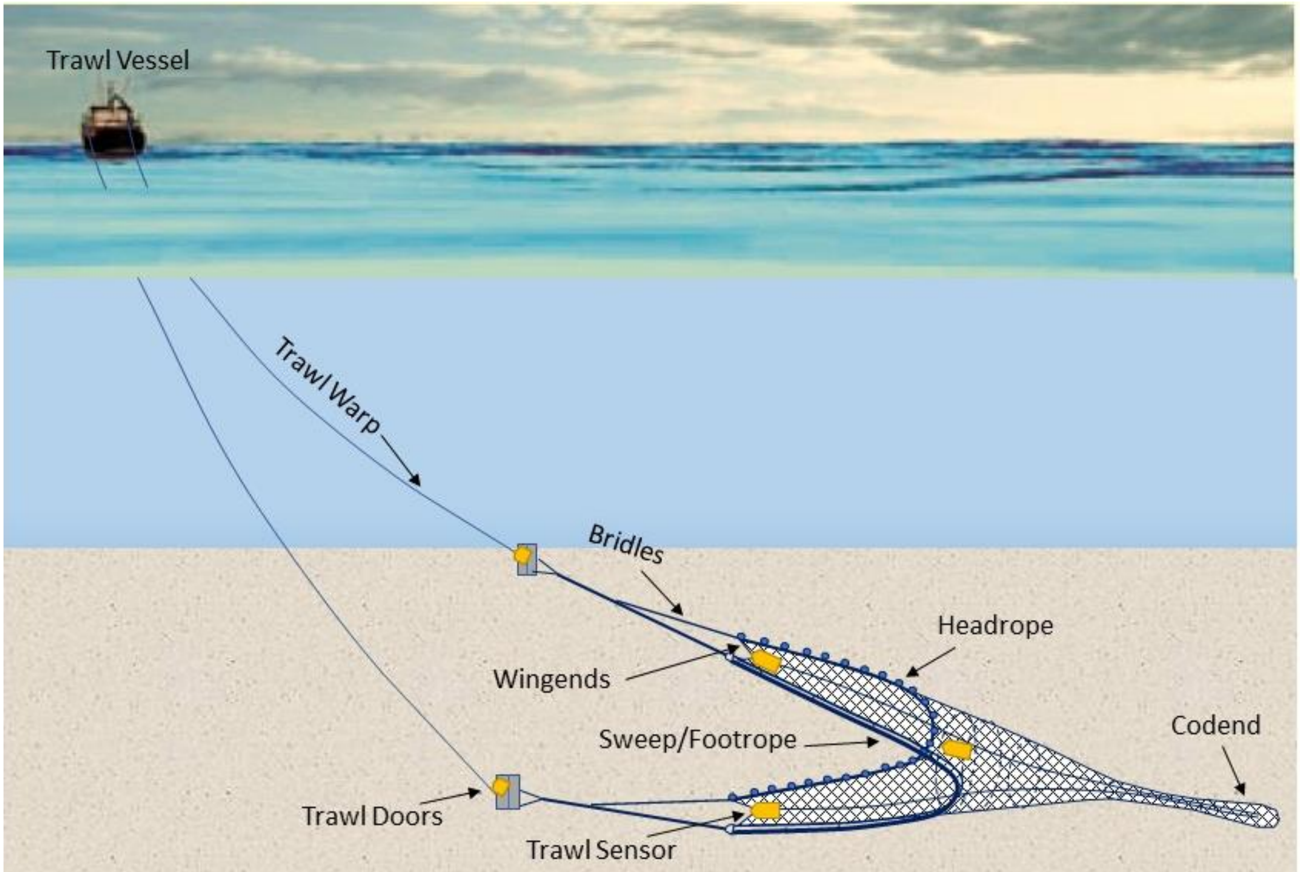


Figure 1: General schematic (not to scale) of a demersal otter trawl. Yellow rectangles indicate geometry sensors.

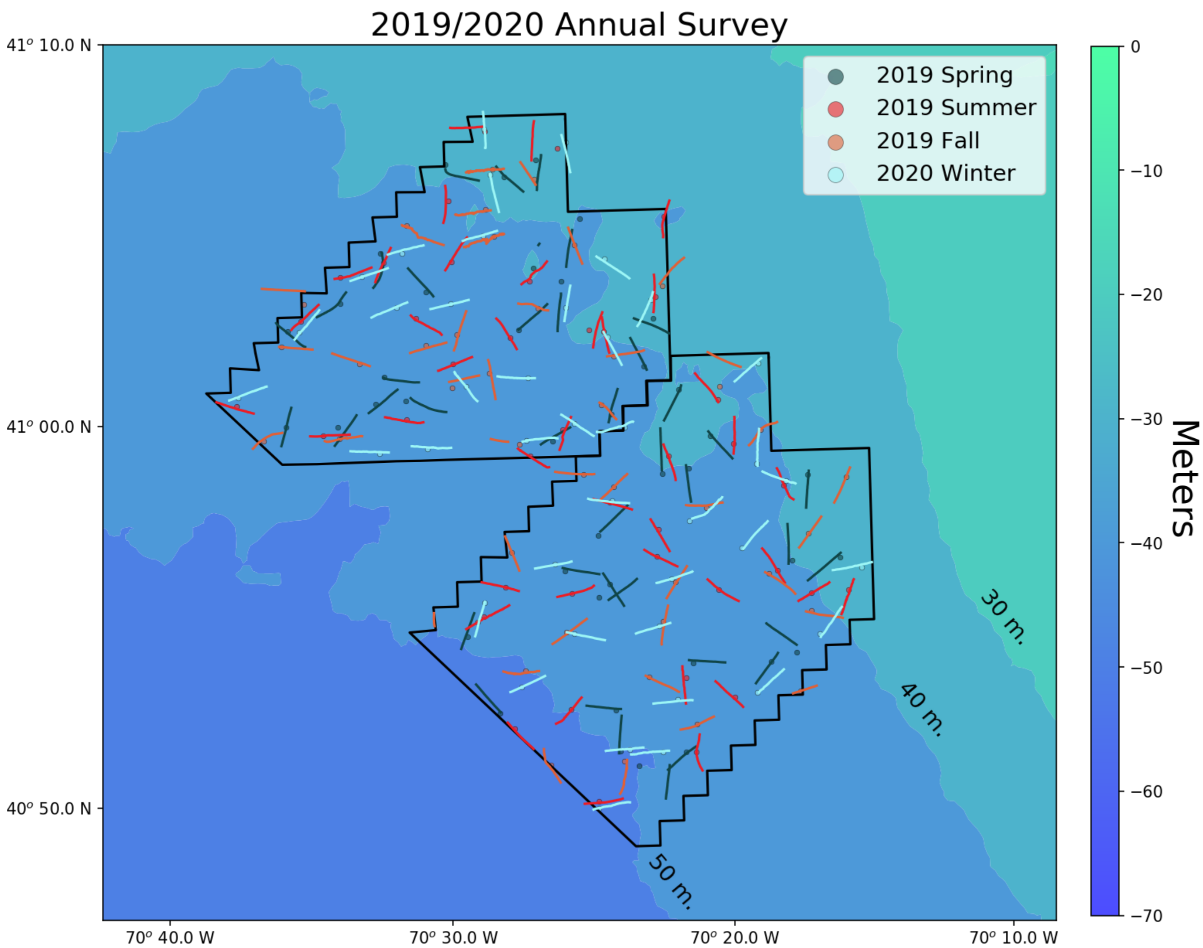


Figure 2: Tow locations (dots) and trawl tracks (lines) from the 501 North Study Area (left) and the Control Area (right).

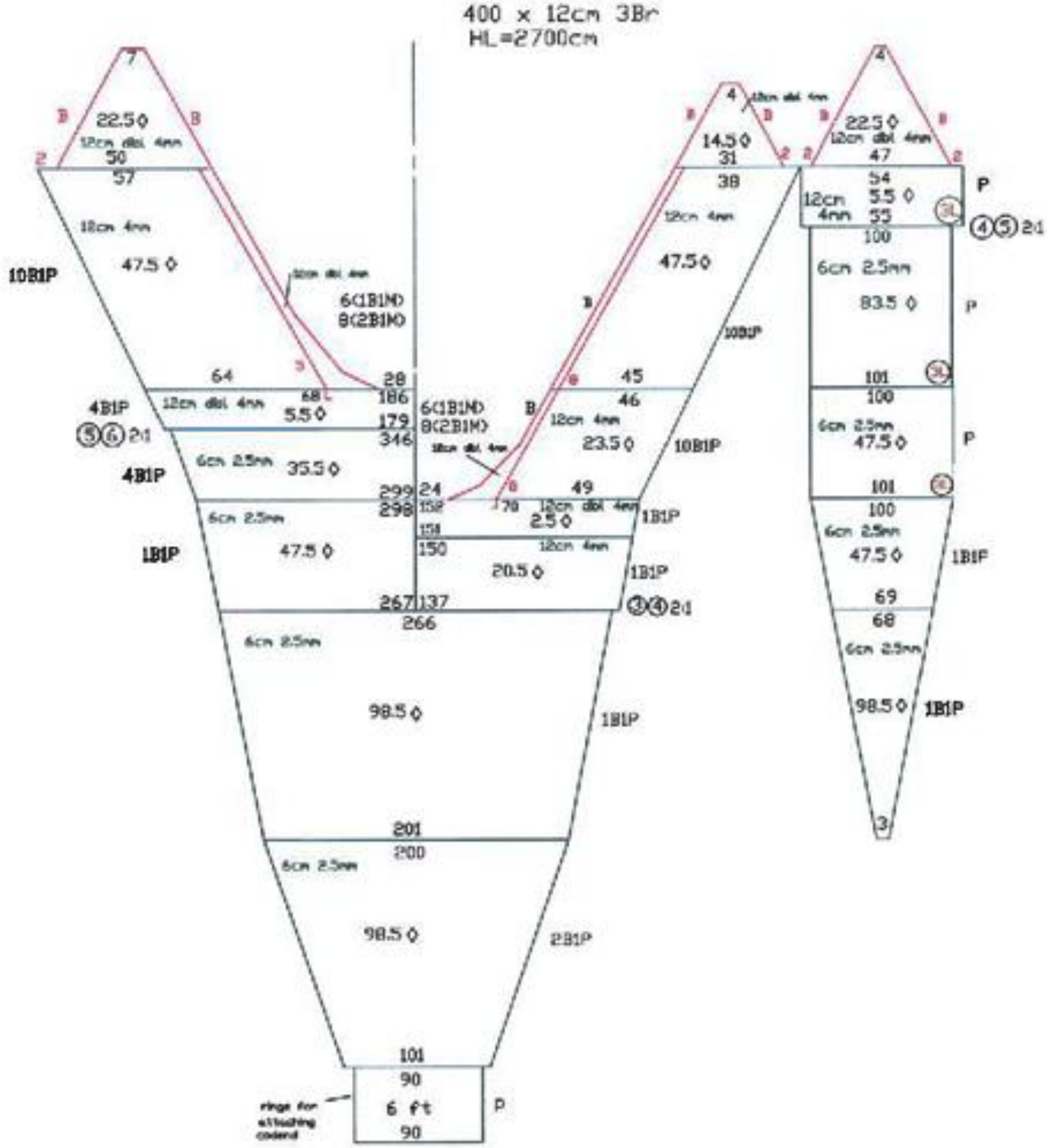


Figure 3: Schematic net plan for the NEAMAP trawl (Bonzek et al. 2008).

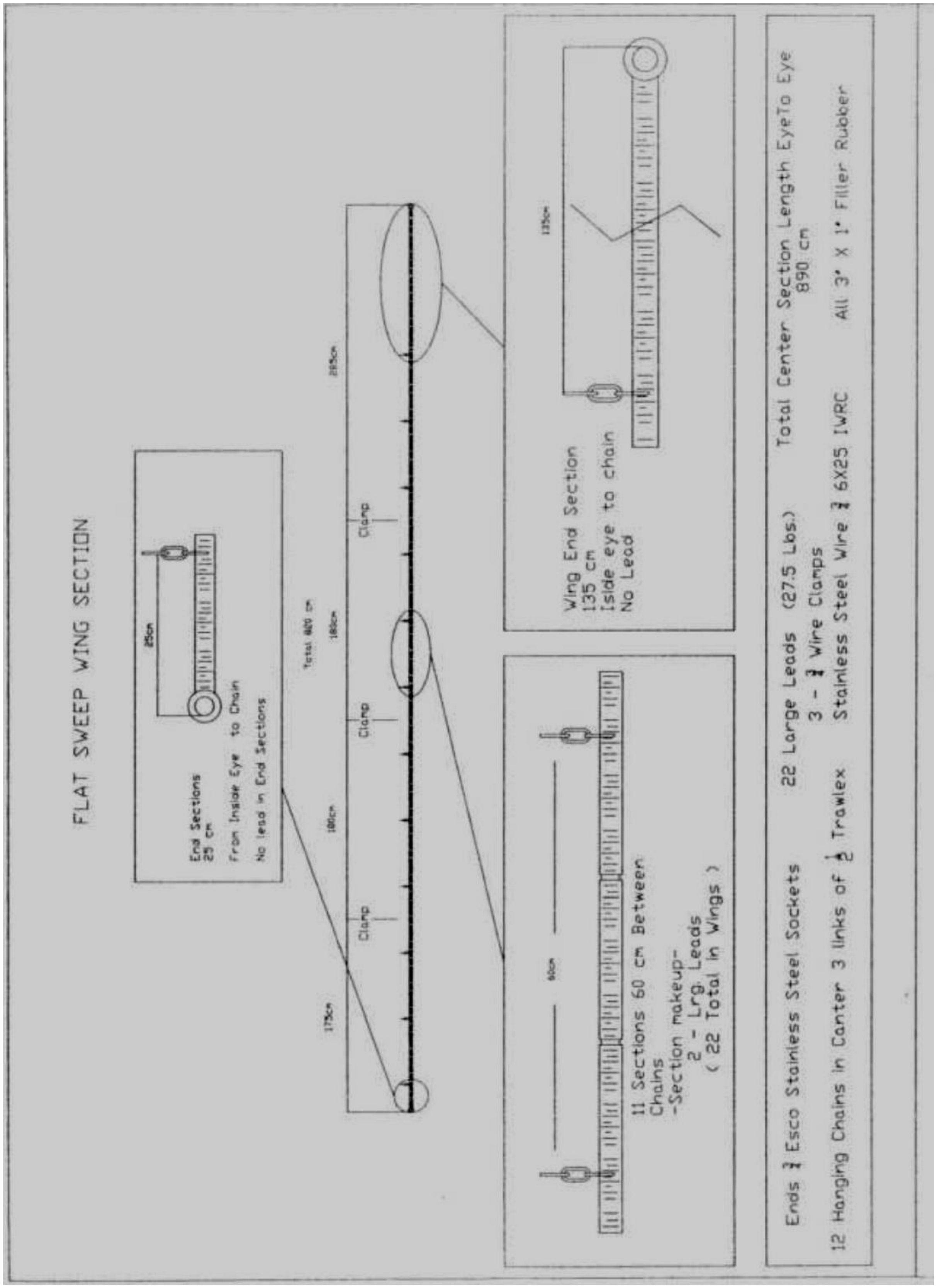


Figure 4: Sweep diagram for the survey trawl (Bonzek et al. 2008).

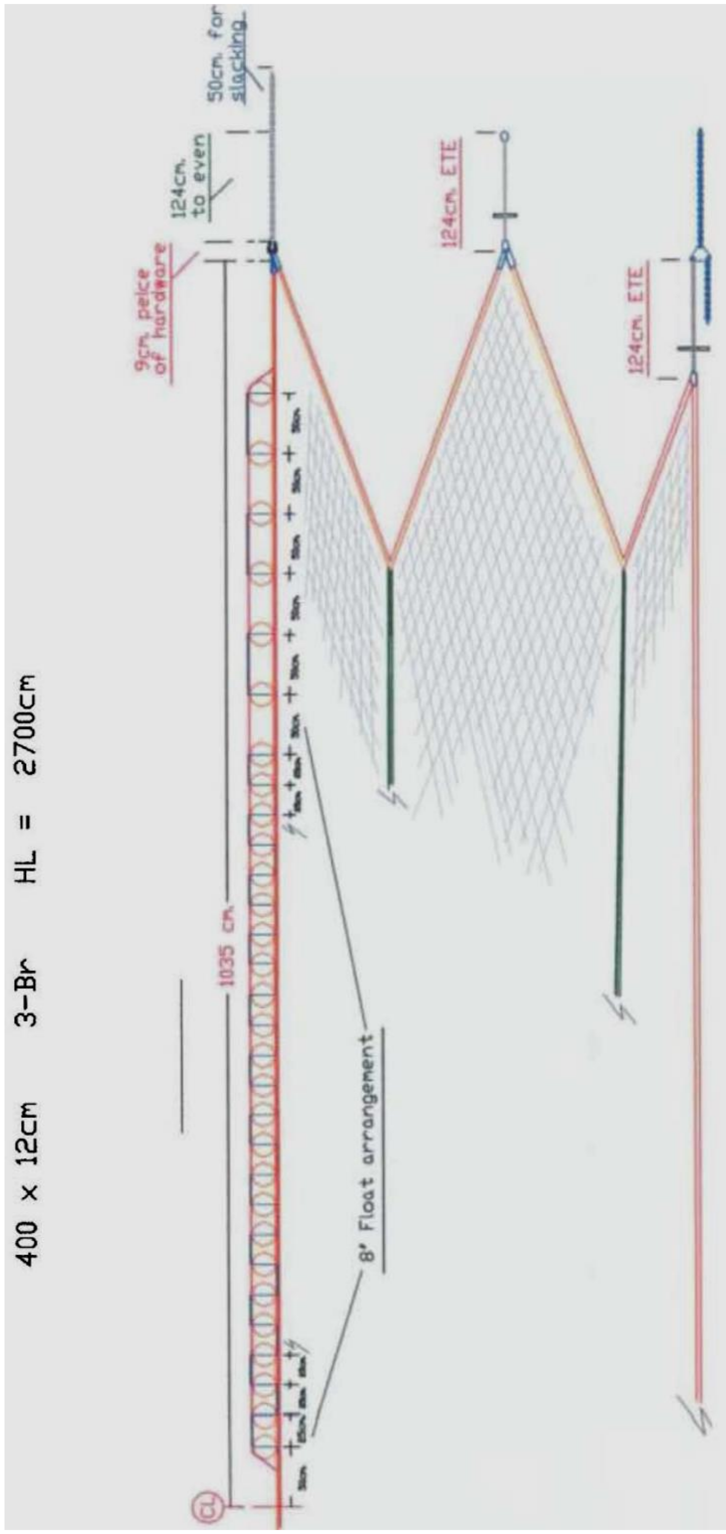


Figure 5: Headrope and rigging plan for the survey trawl (Bonzek et al. 2008).

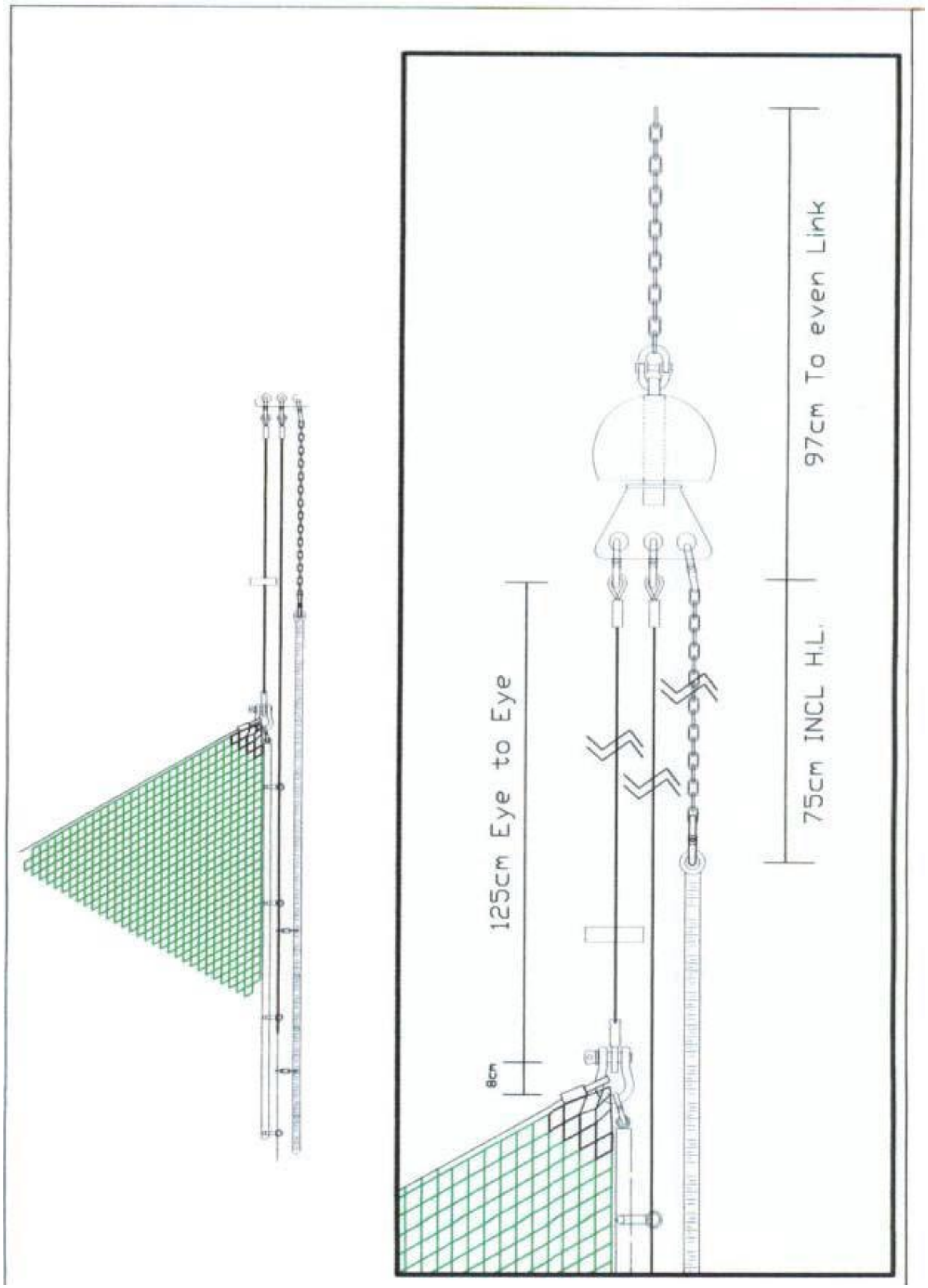


Figure 6: Lower wing and bobbin schematic for the survey trawl (Bonzek et al. 2008).

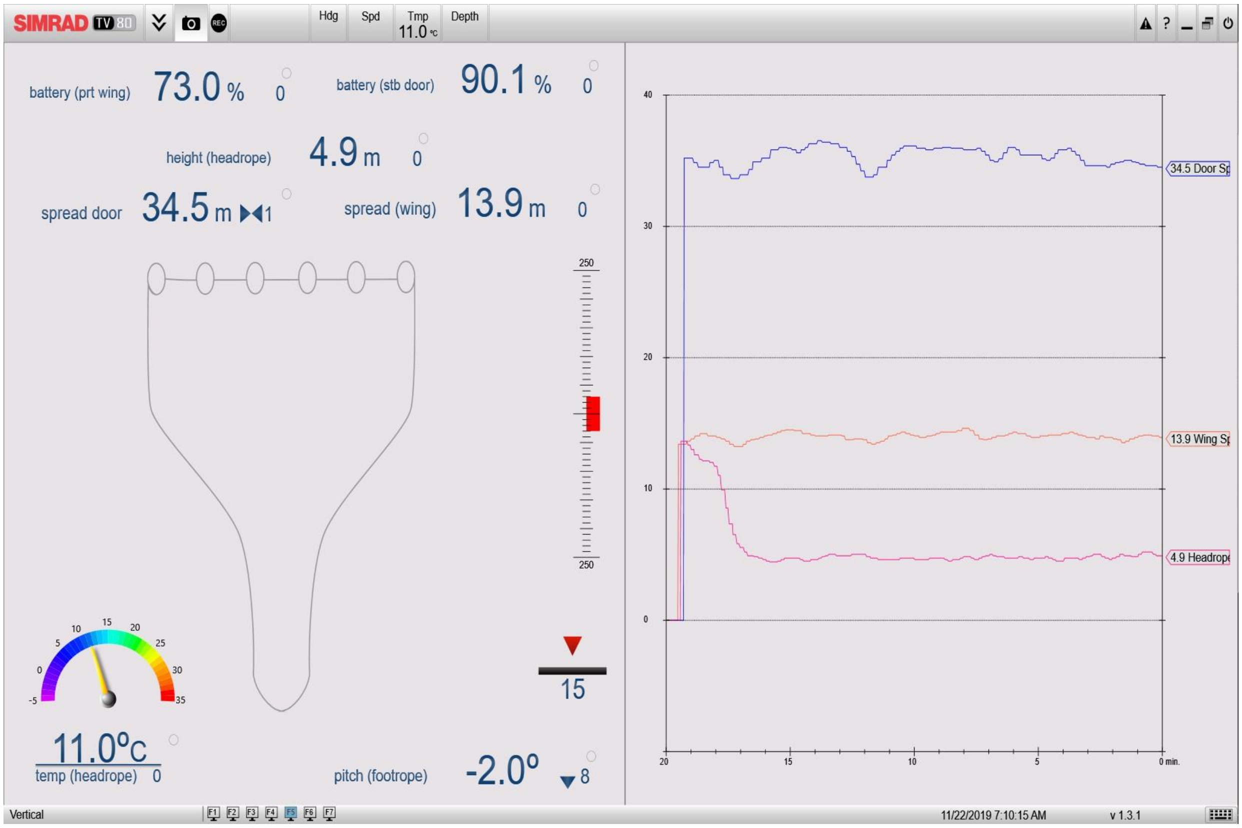


Figure 7: Screenshot of the SIMRAD TV80 software monitoring the trawl parameters.

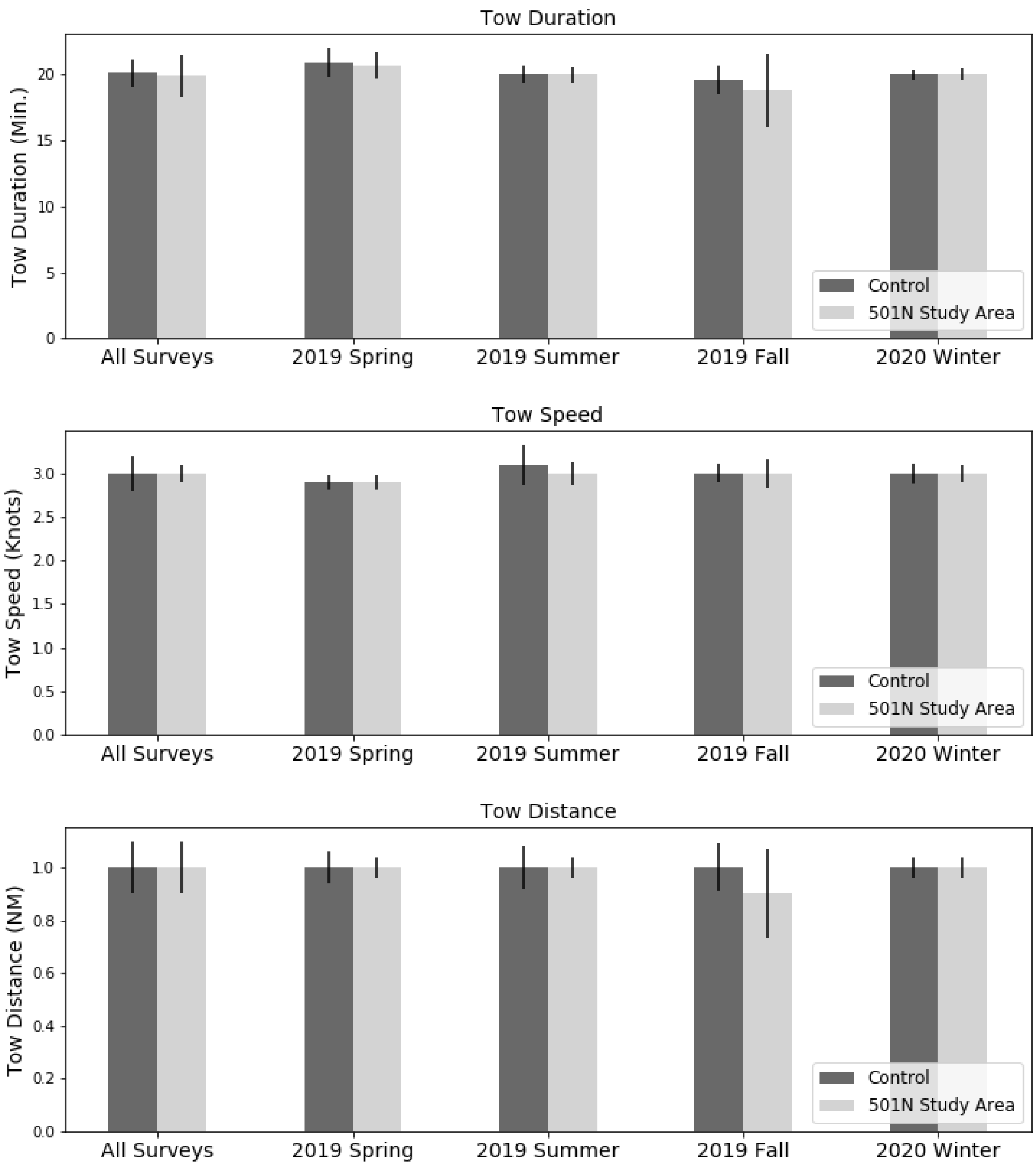


Figure 8: Operational data from the seasonal surveys including tow duration, tow speed and tow distance.

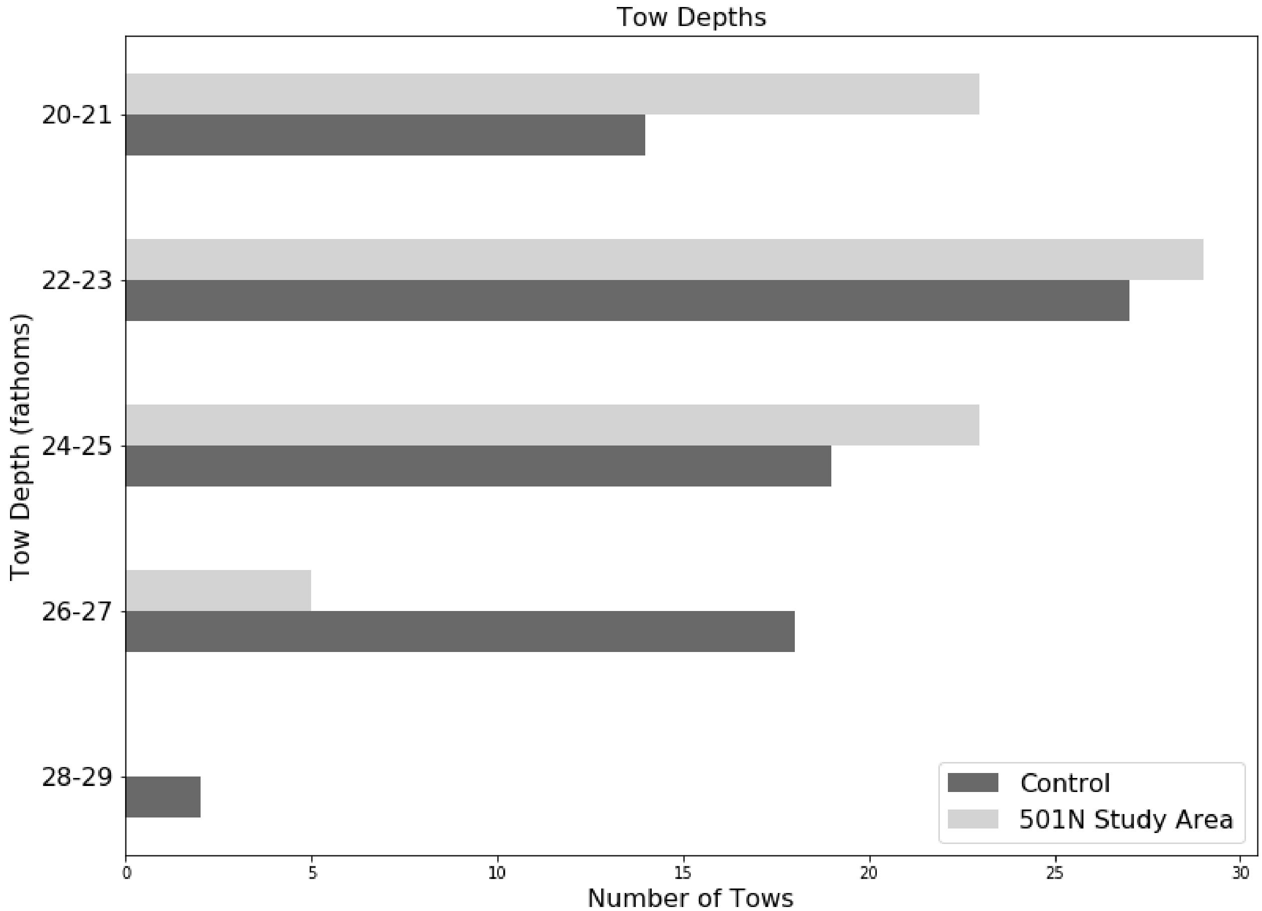


Figure 9: Distribution of tow depths at the start of each tow.

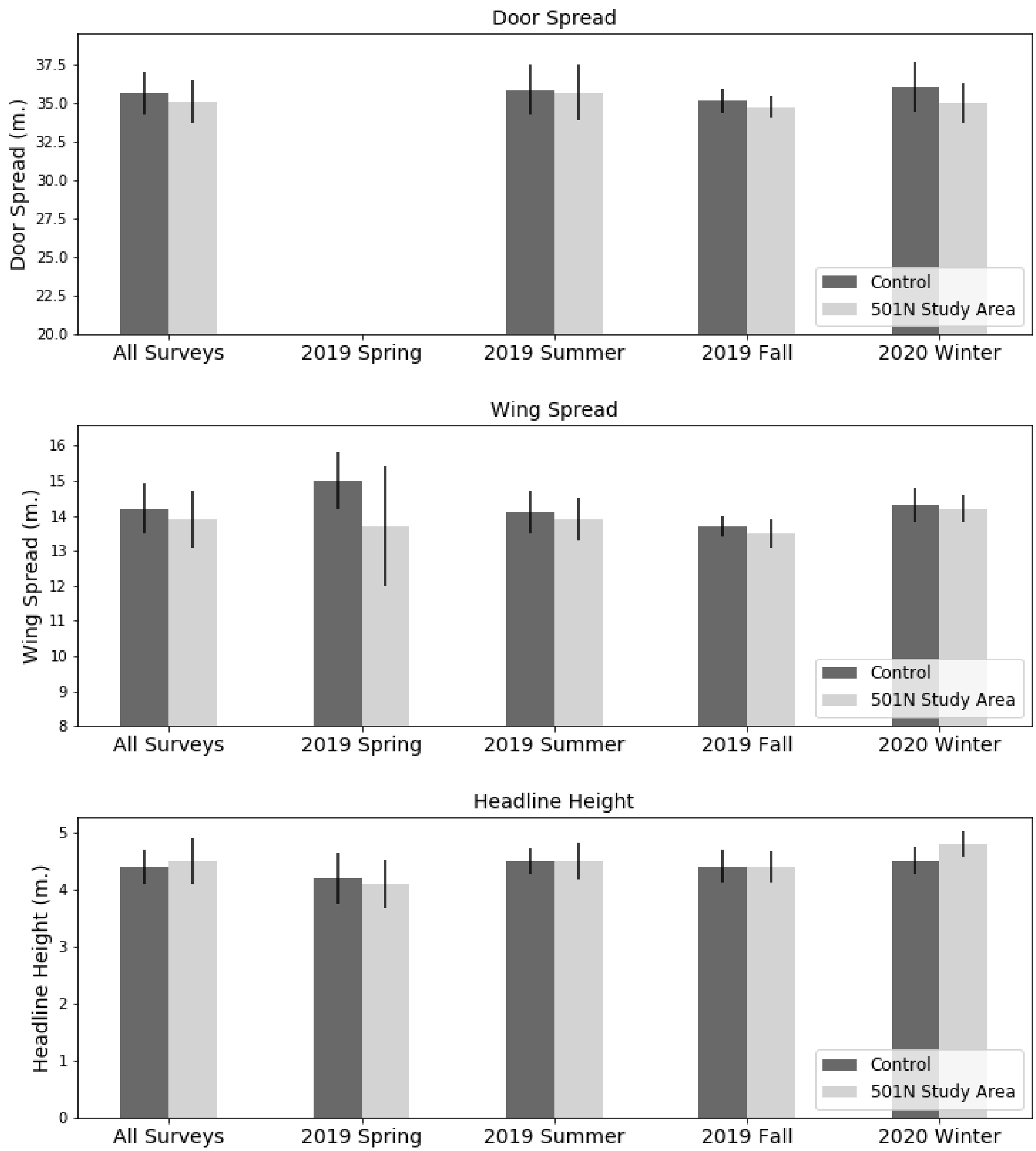


Figure 10: Seasonal averages of the trawl parameters including door spread, wing spread and headline height.

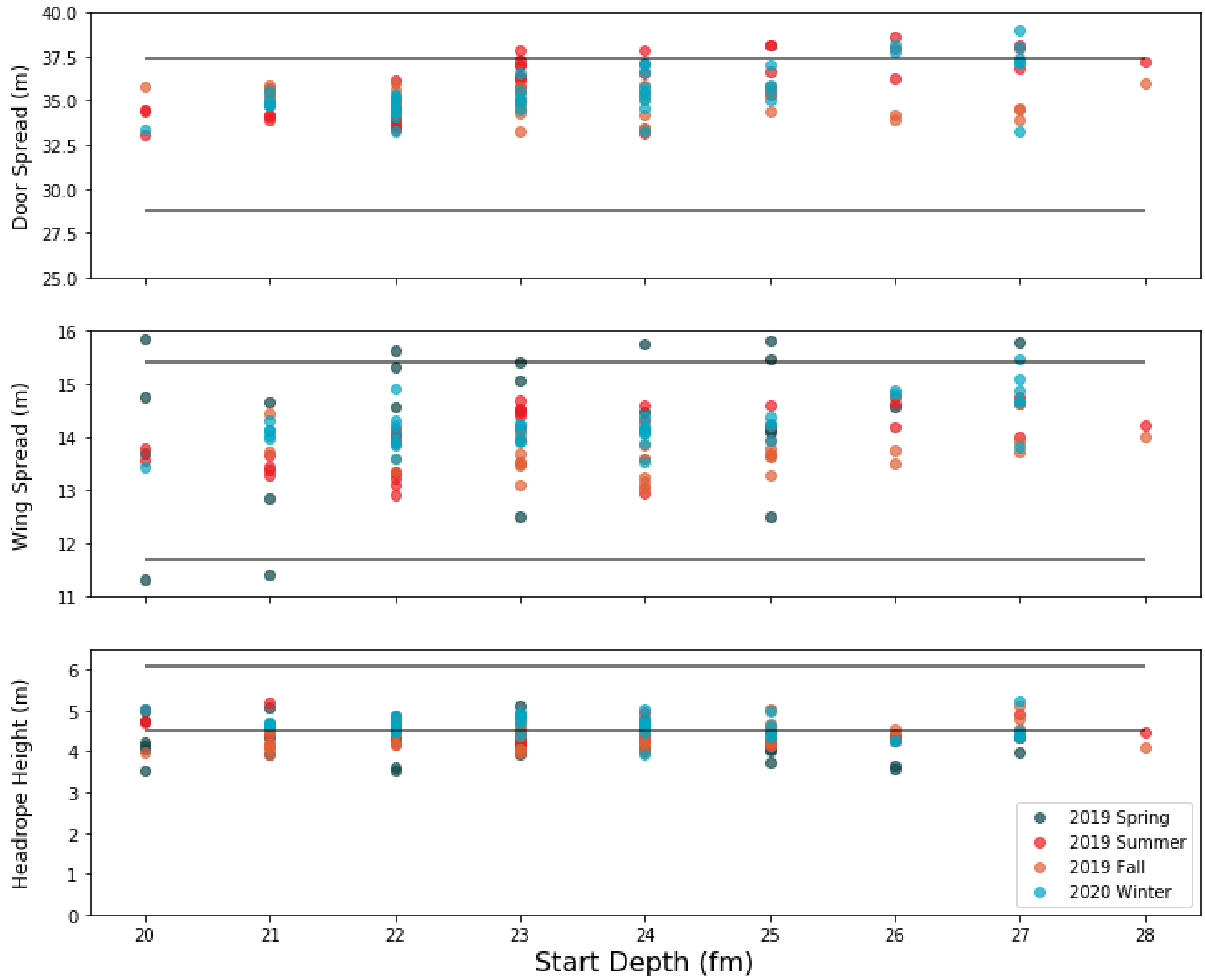


Figure 11: Trawl parameters with respect to the tow starting depth.

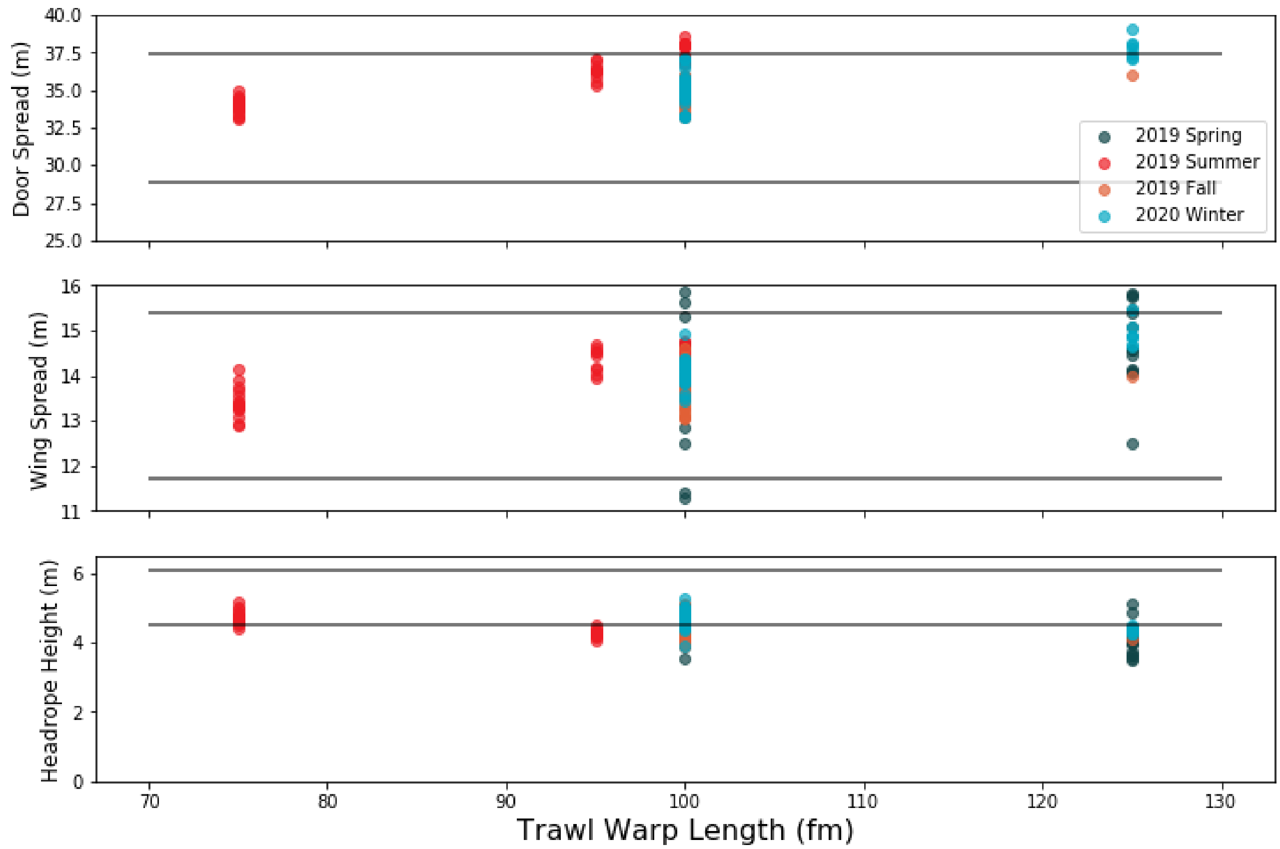


Figure 12: Trawl parameters with respect to trawl warp.

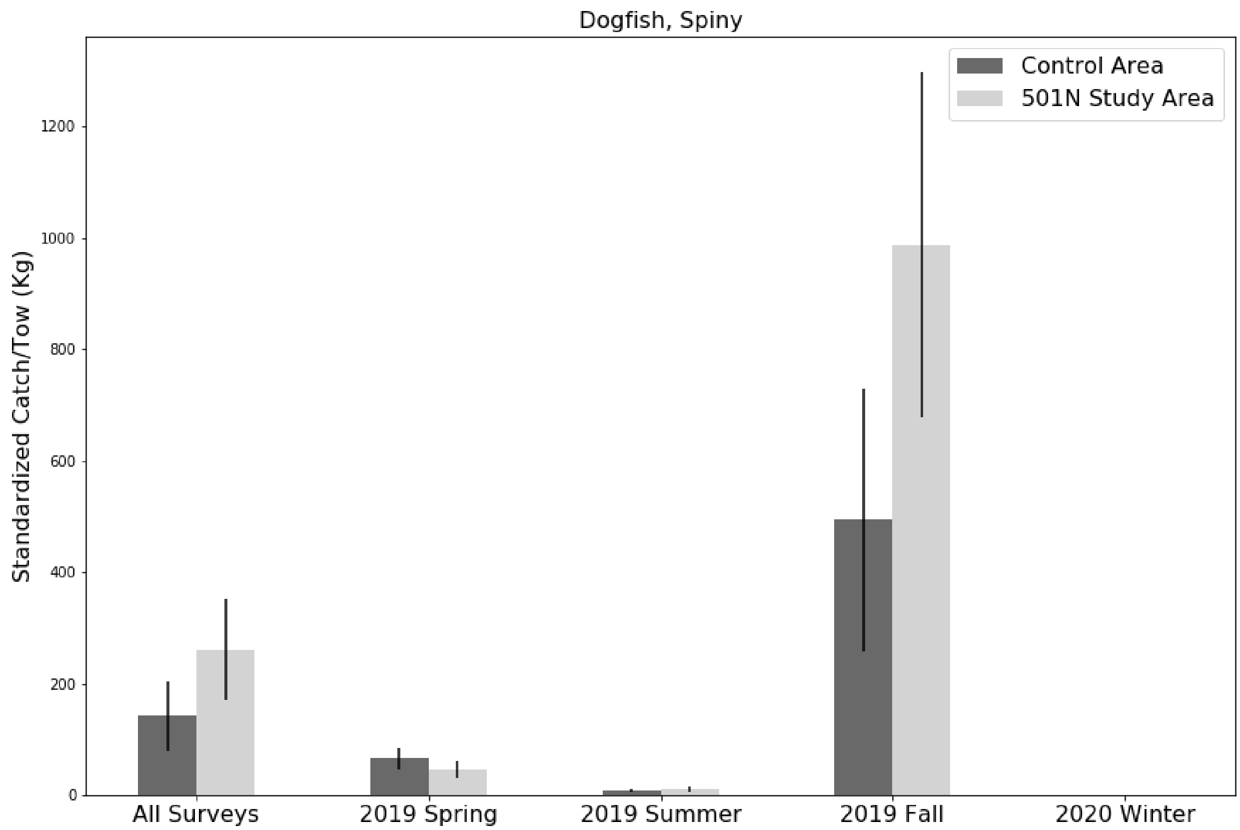


Figure 13: Seasonal catch rates of spiny dogfish in the 501 North Study Area and Control Area.

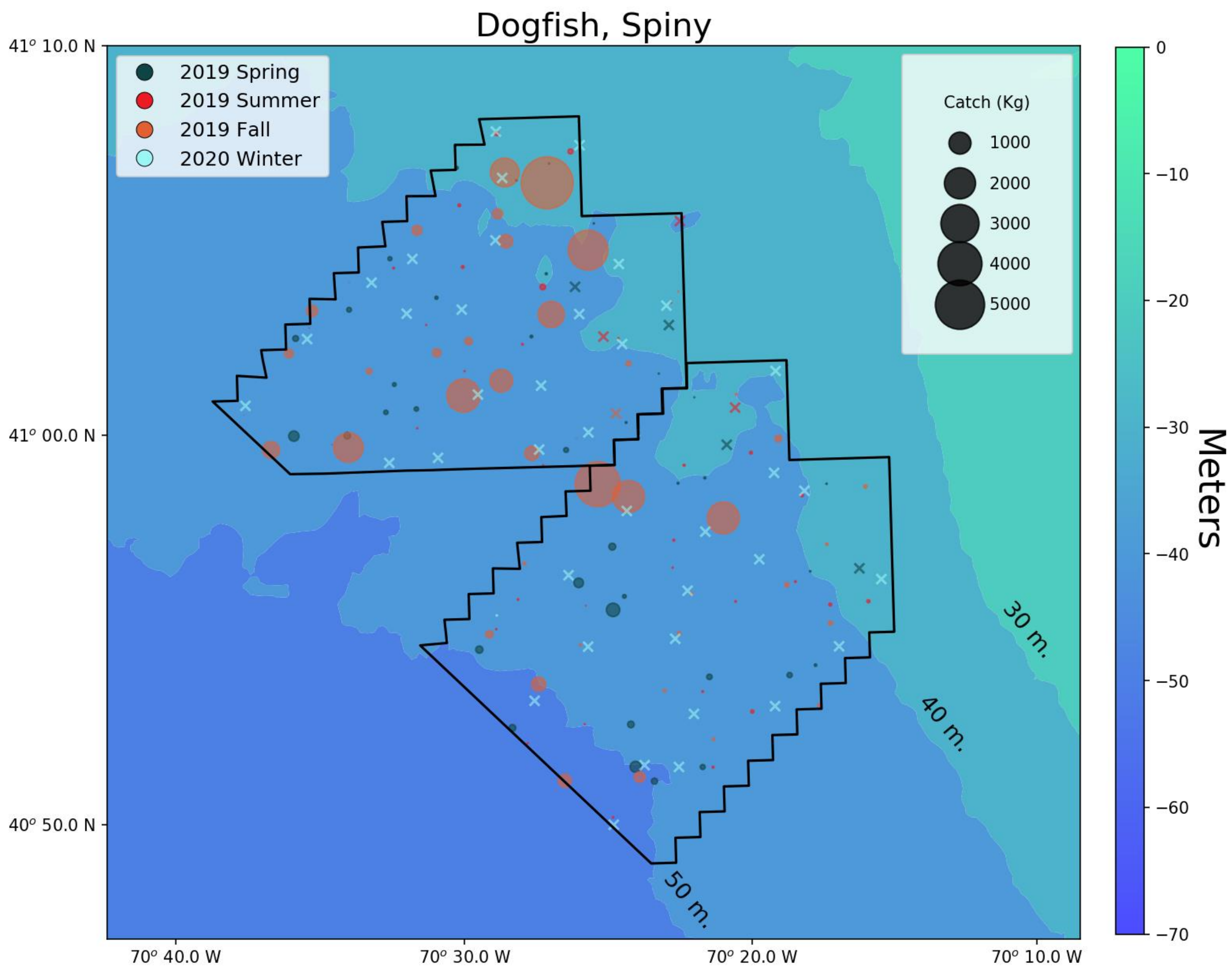


Figure 14: Seasonal distribution of the spiny dogfish catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an x.

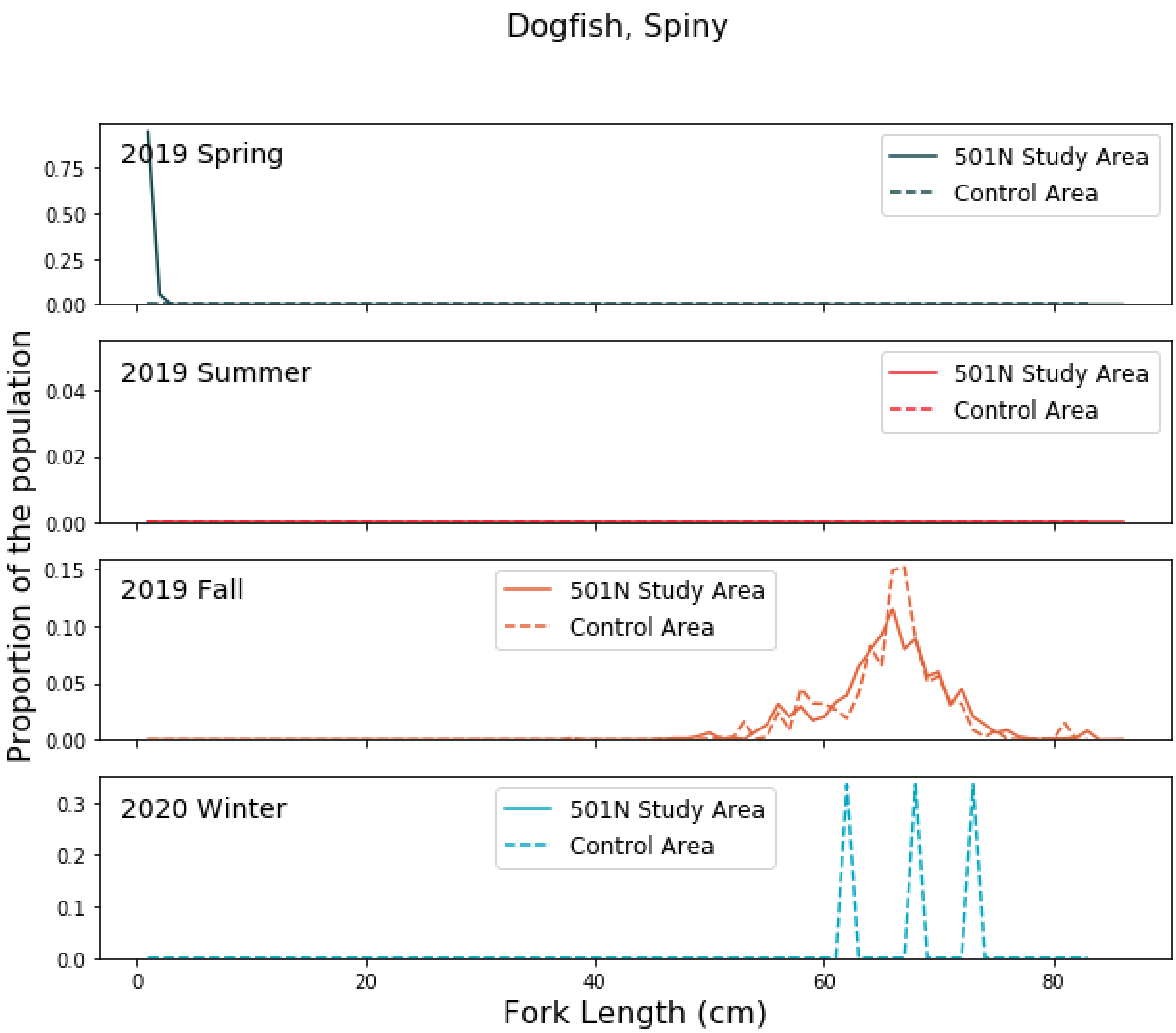


Figure 15: The seasonal length distributions of spiny dogfish in the 501 North Study Area and Control Area.

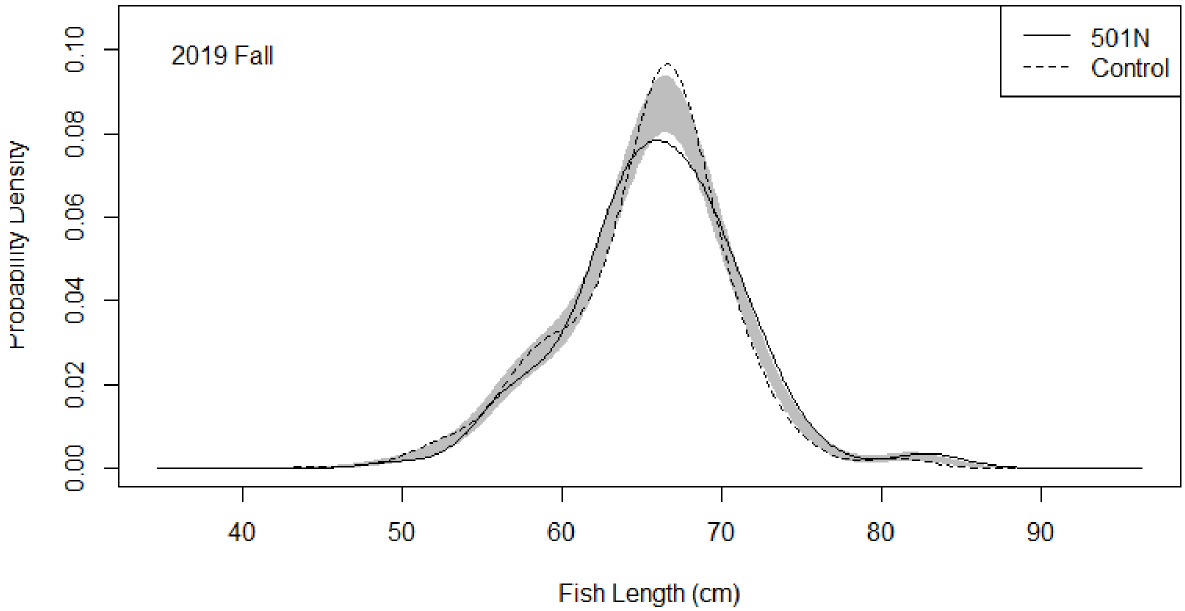
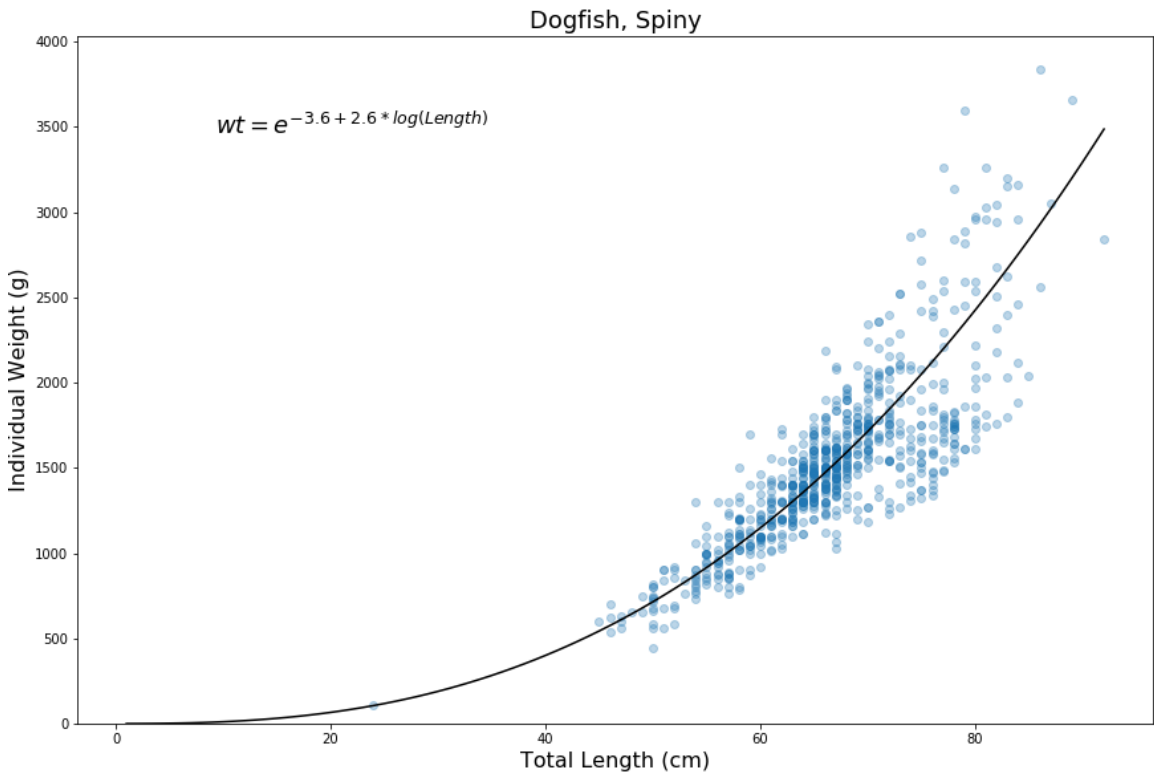


Figure 16: The population structure of spiny dogfish in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



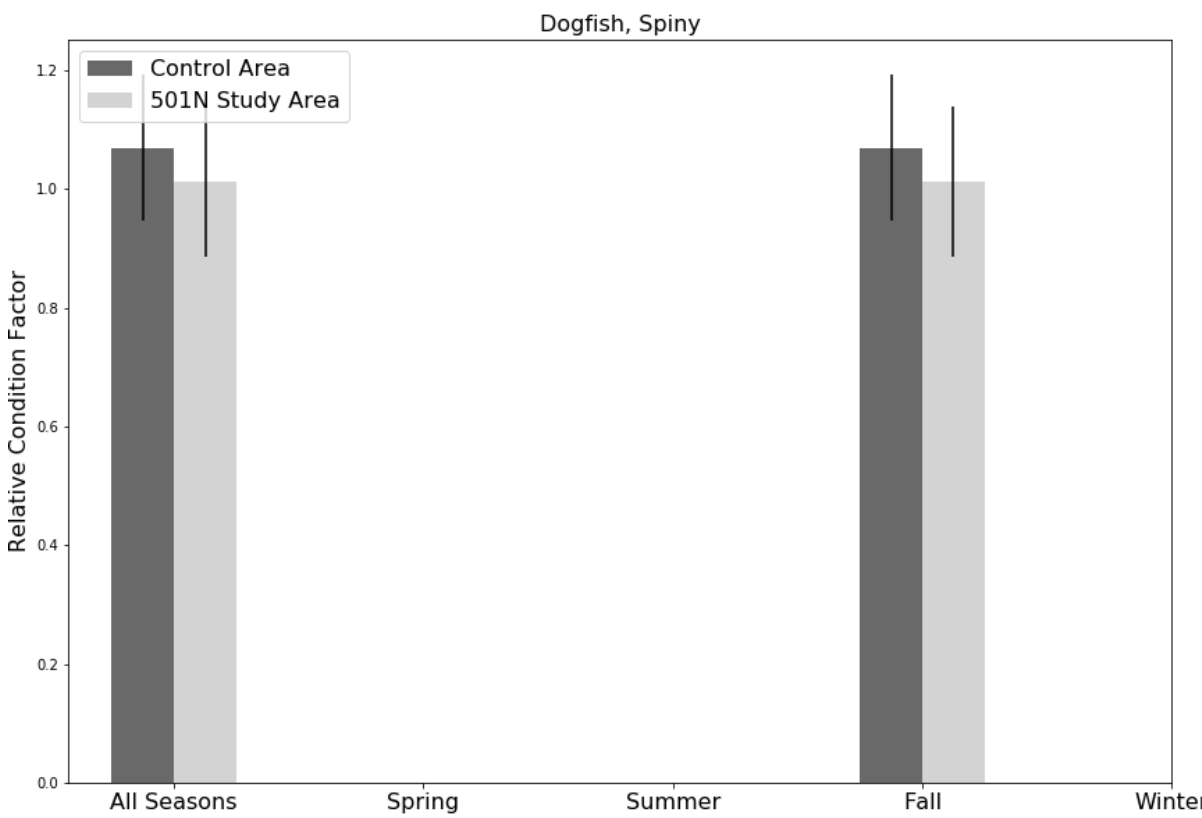


Figure 17: The seasonal condition of spiny dogfish (bottom) as derived from the length-weight relationship (top).

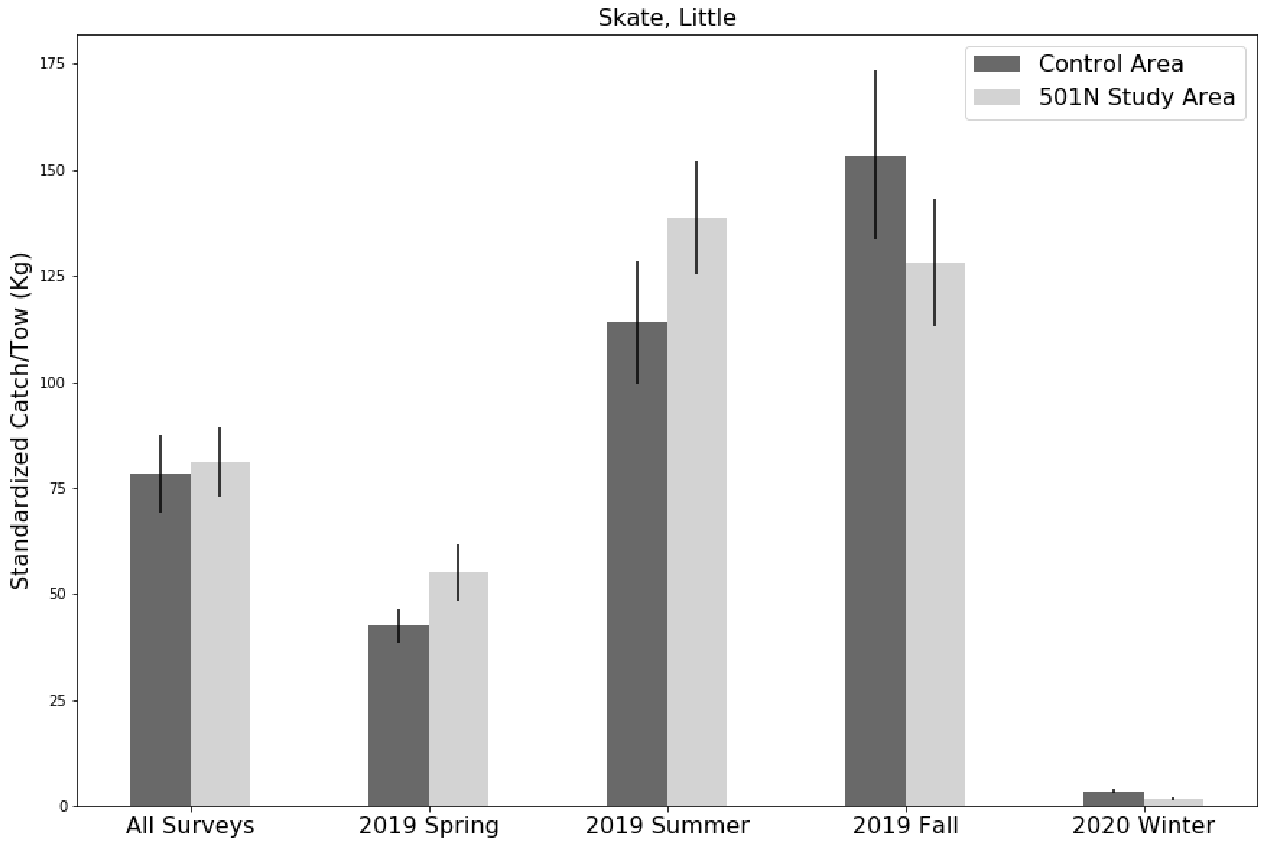


Figure 18: Seasonal catch rates of little skate in the 501 North Study Area and Control Area.

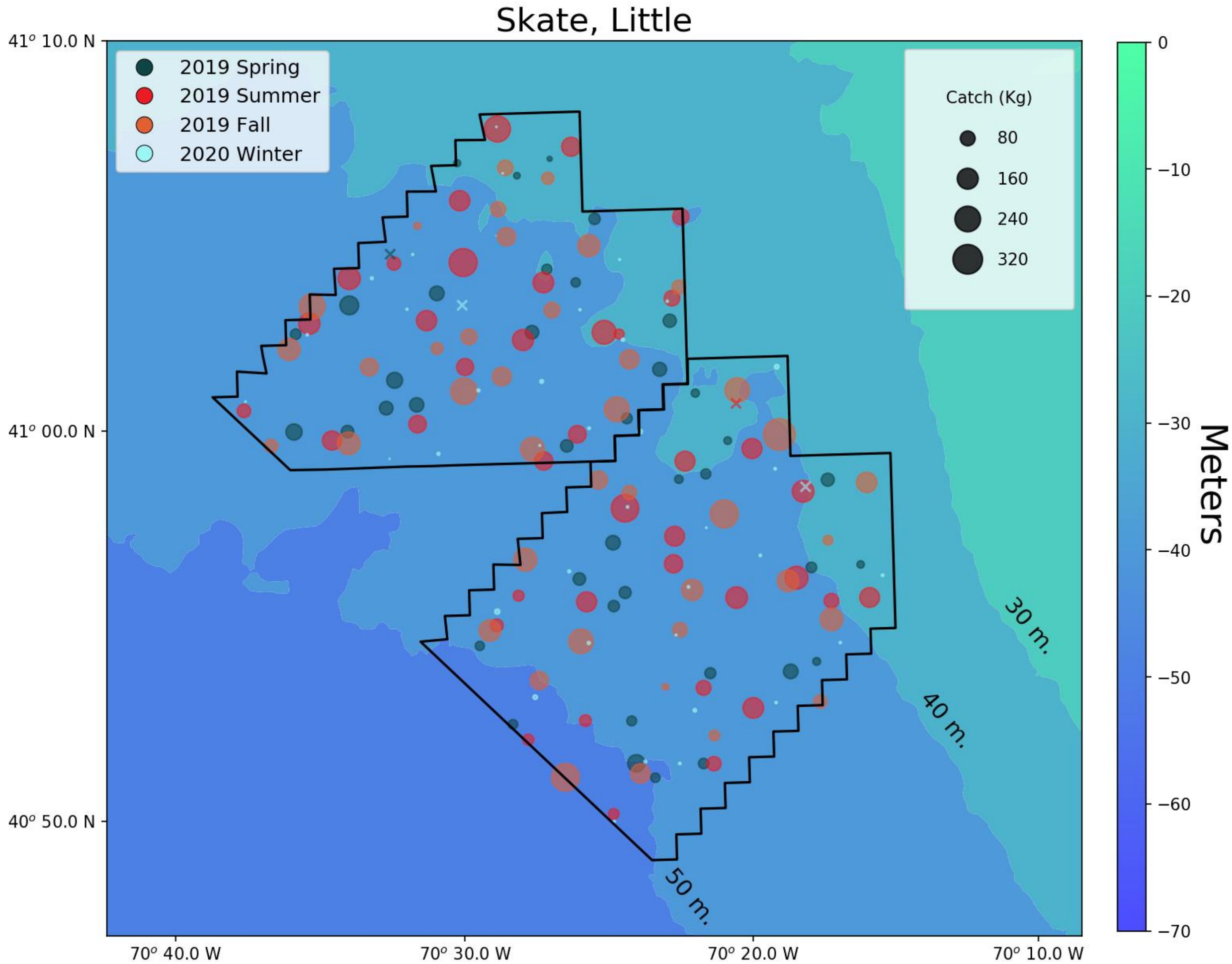


Figure 19: Seasonal distribution of the little skate catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

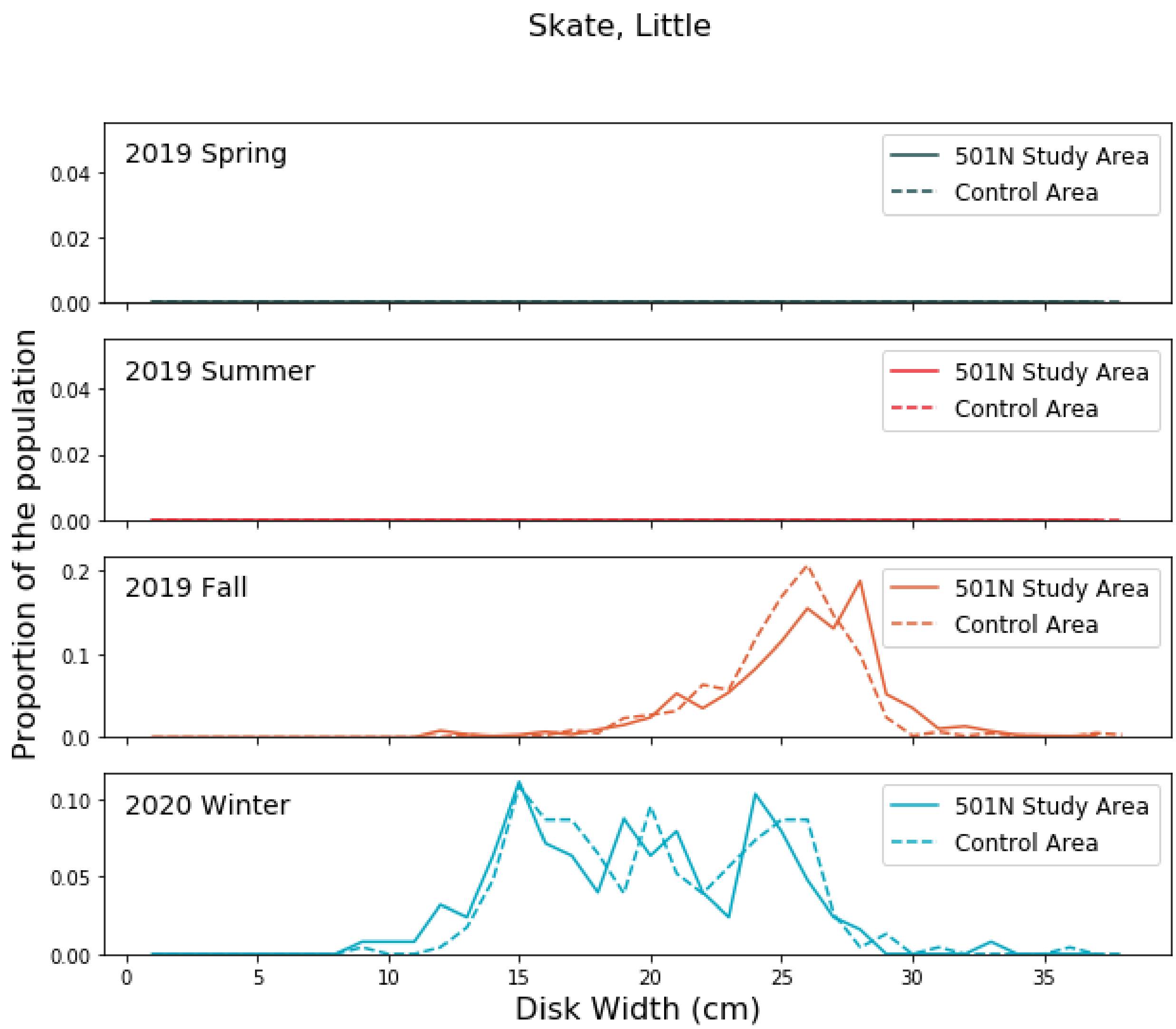


Figure 20: The seasonal length distributions of little skate in the 501 North Study Area and Control Area.

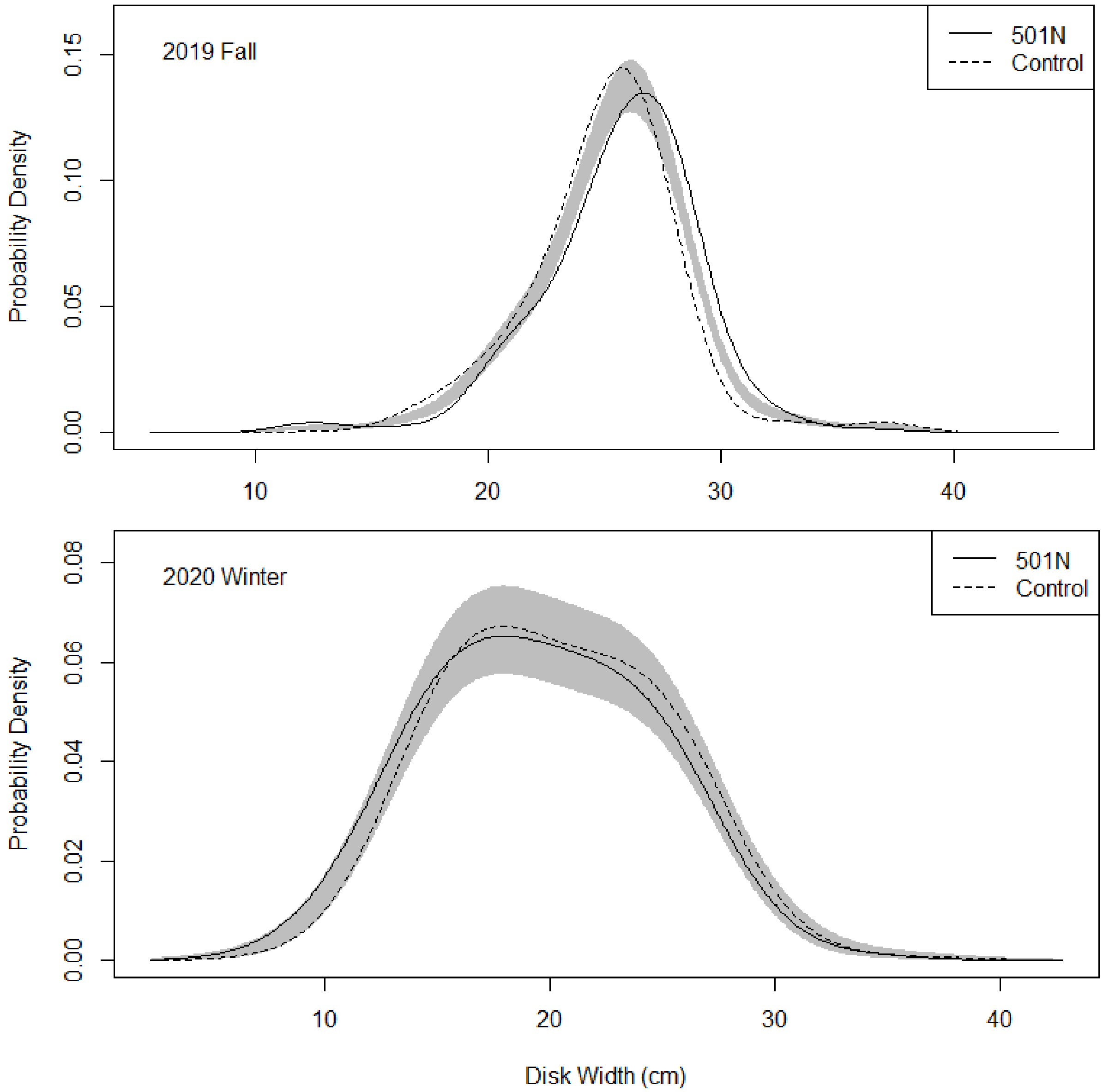


Figure 21: The population structure of little skate in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.

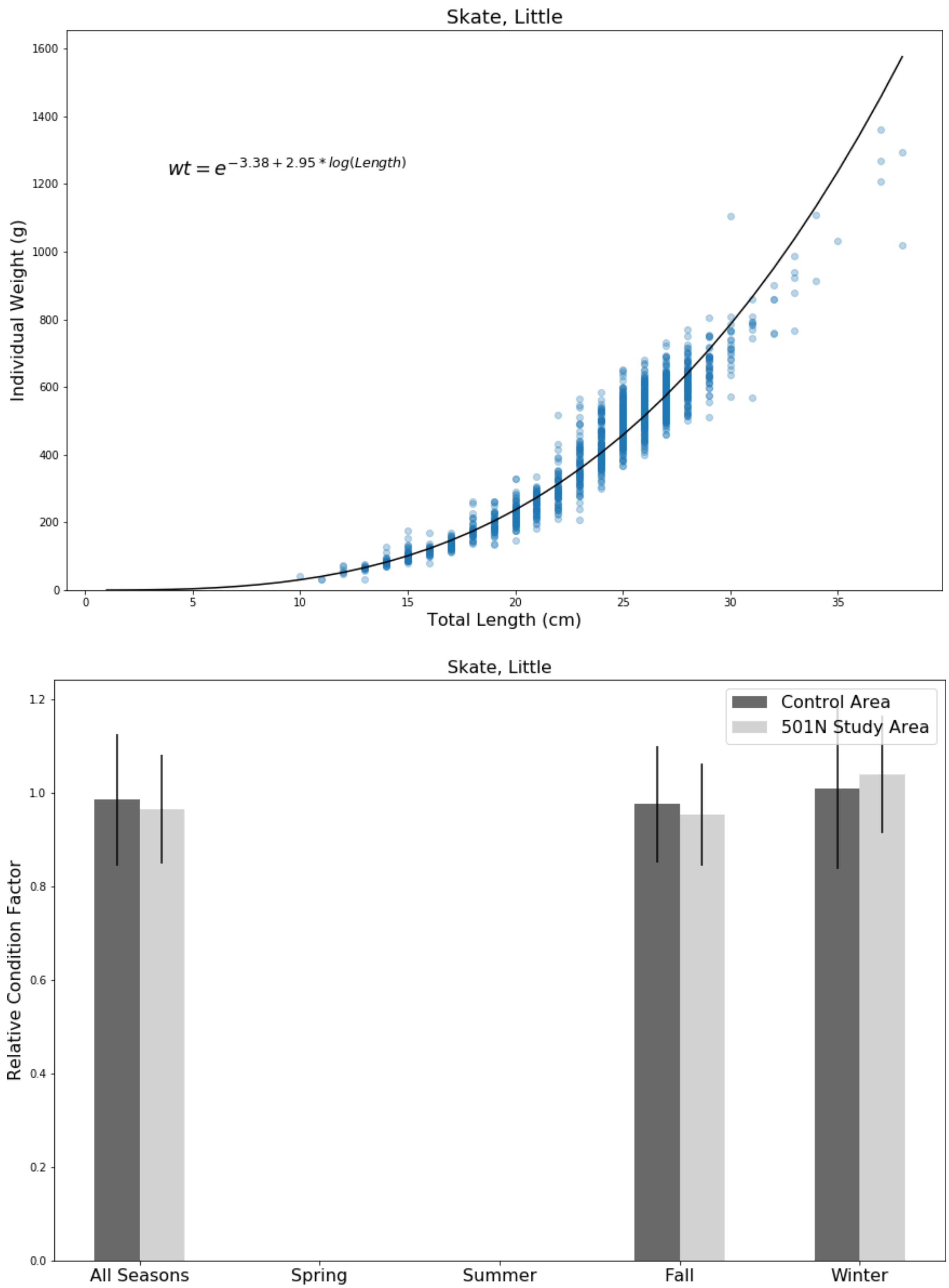


Figure 22: The seasonal condition of little skate (bottom) as derived from the length-weight relationship (top).

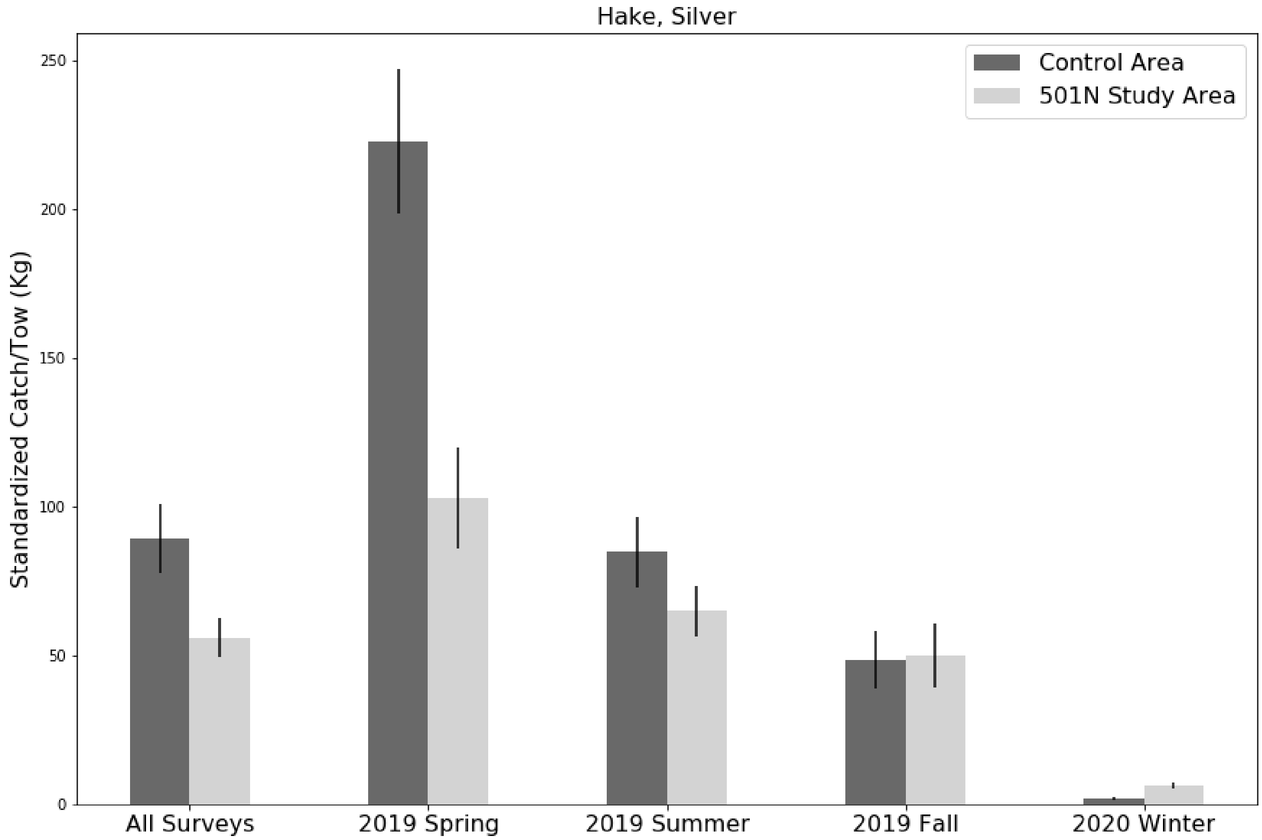


Figure 23: Seasonal catch rates of silver hake in the 501 North Study Area and Control Area.

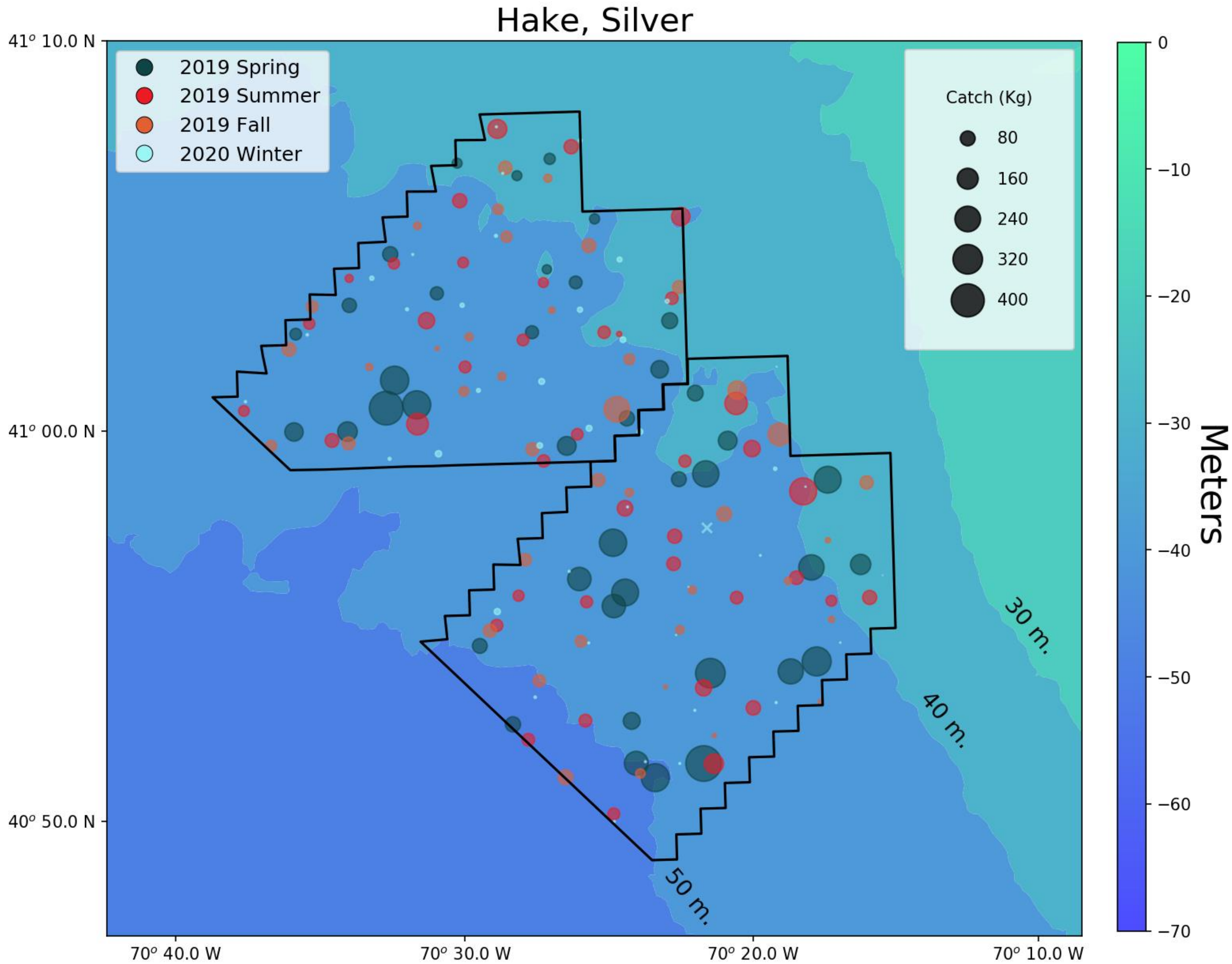


Figure 24: Seasonal distribution of the silver hake catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

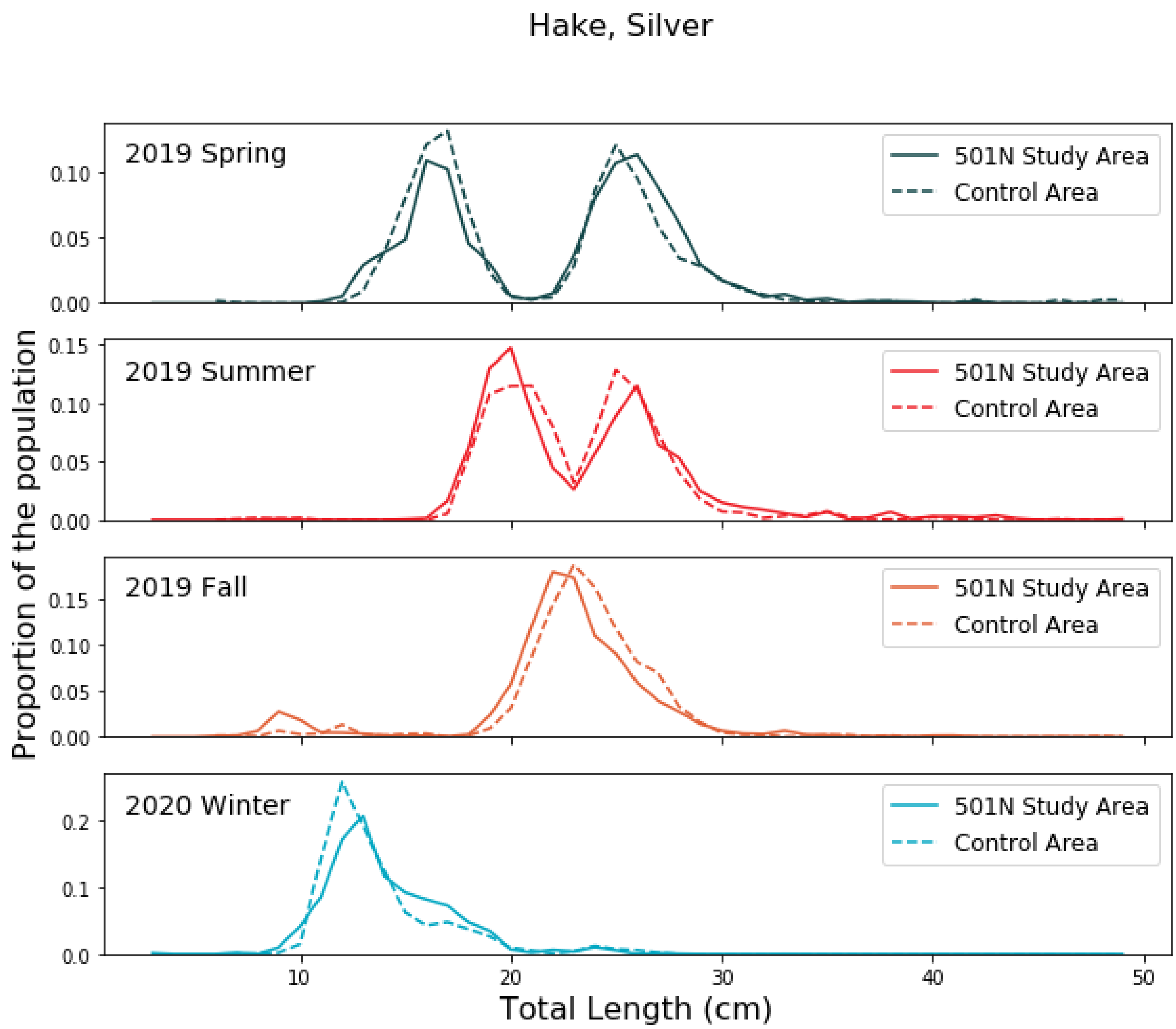


Figure 25: The seasonal length distributions of silver hake in the 501 North Study Area and Control Area.

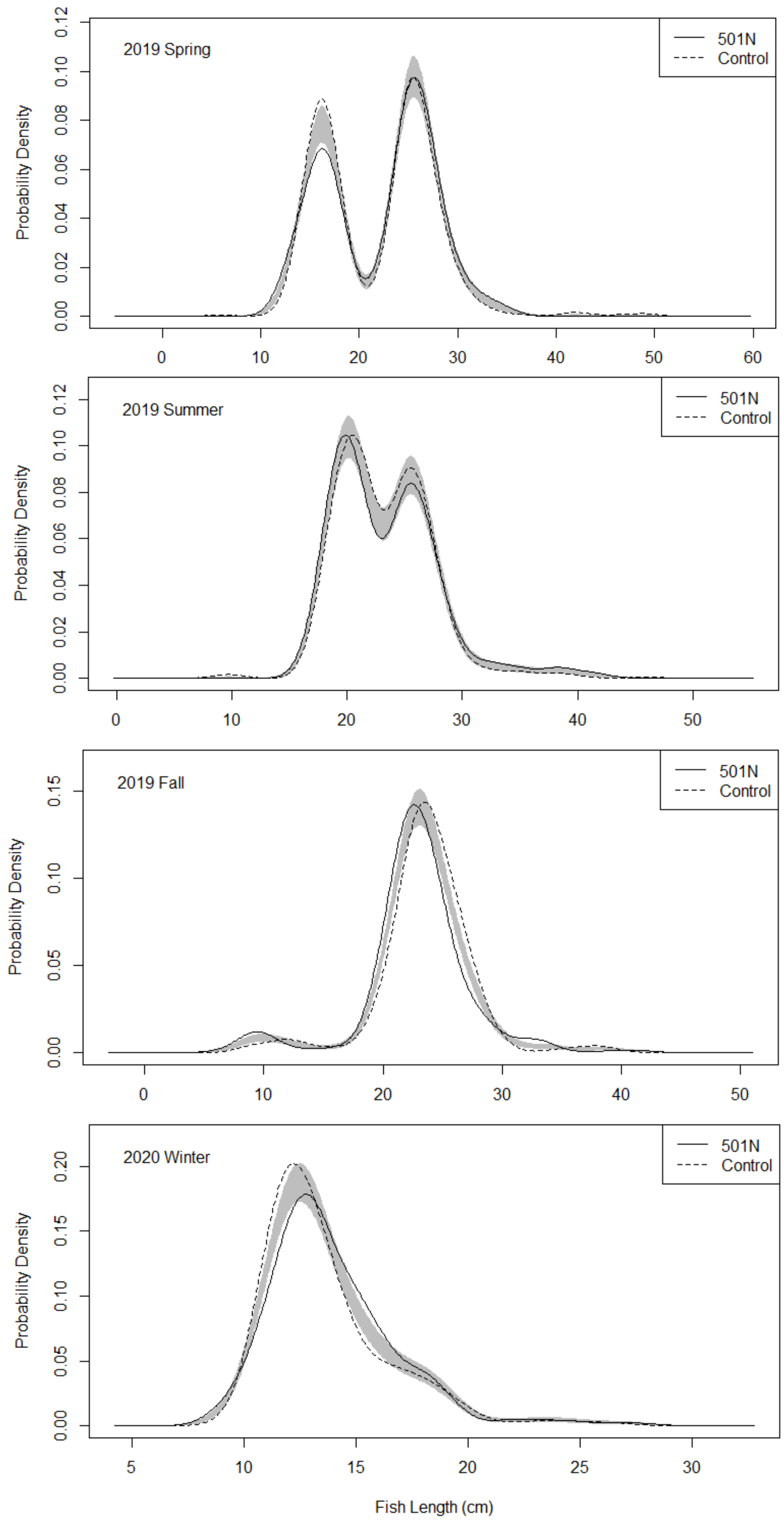
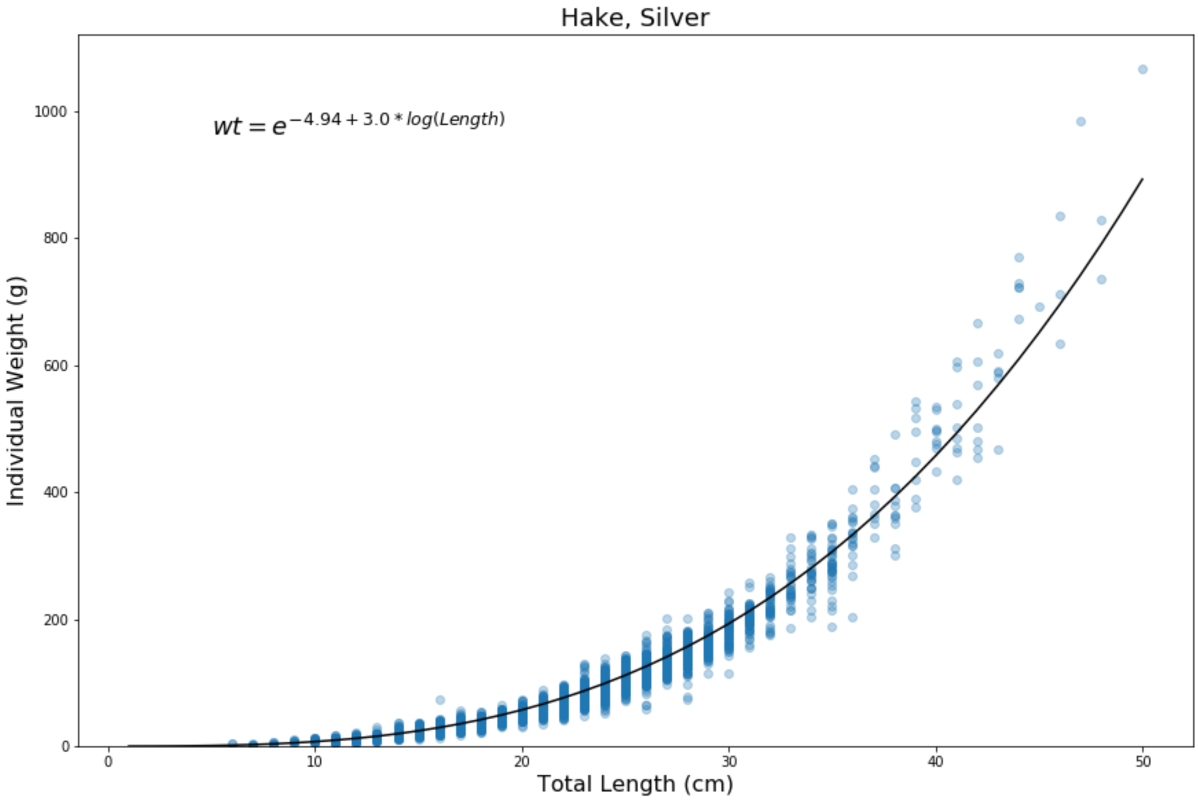


Figure 26: The population structure of silver hake in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



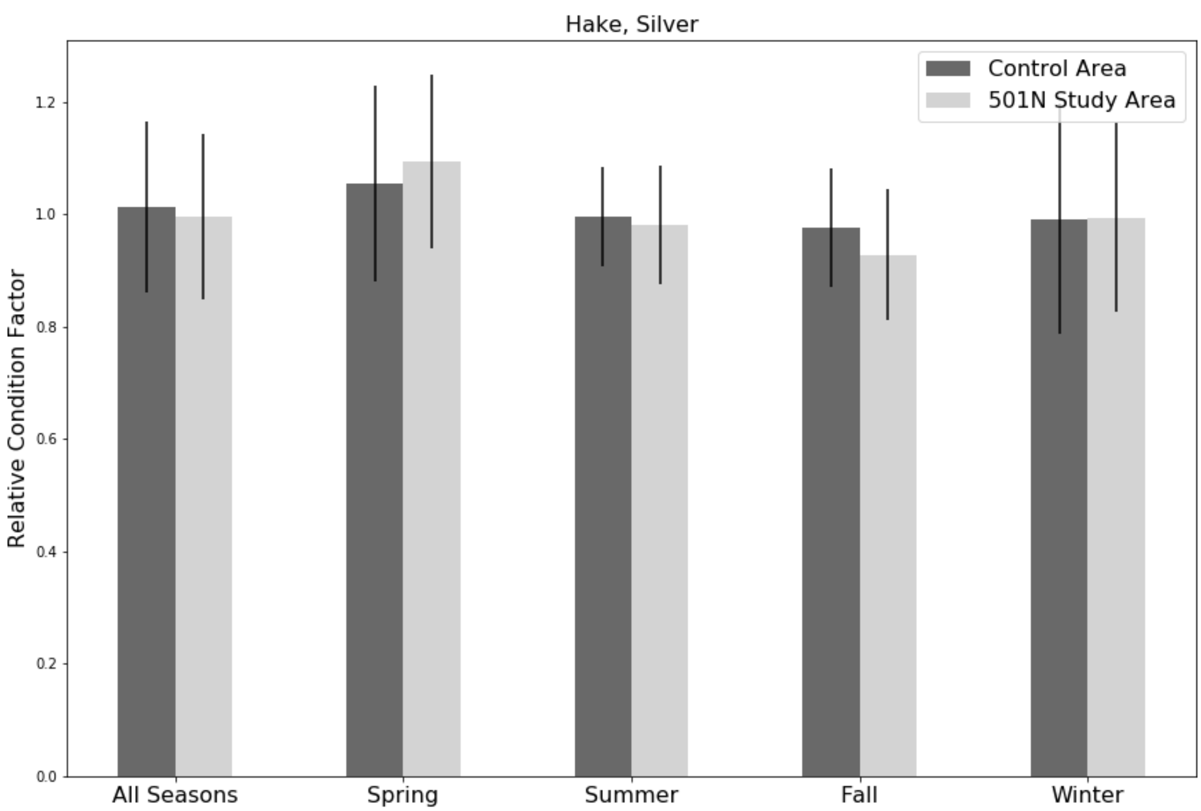


Figure 27: The seasonal condition of silver hake (bottom) as derived from the length-weight relationship (top).

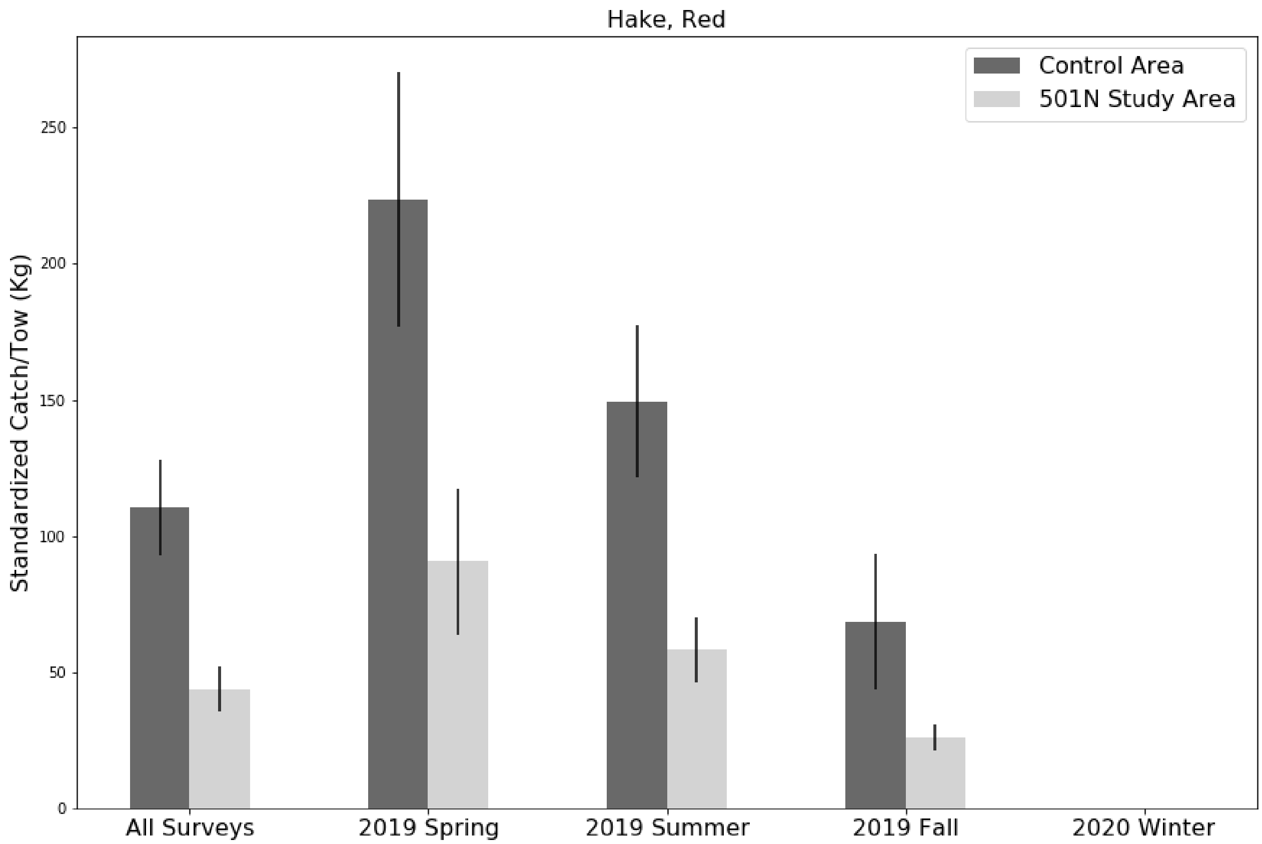


Figure 28: Seasonal catch rates of red hake in the 501 North Study Area and Control Area.

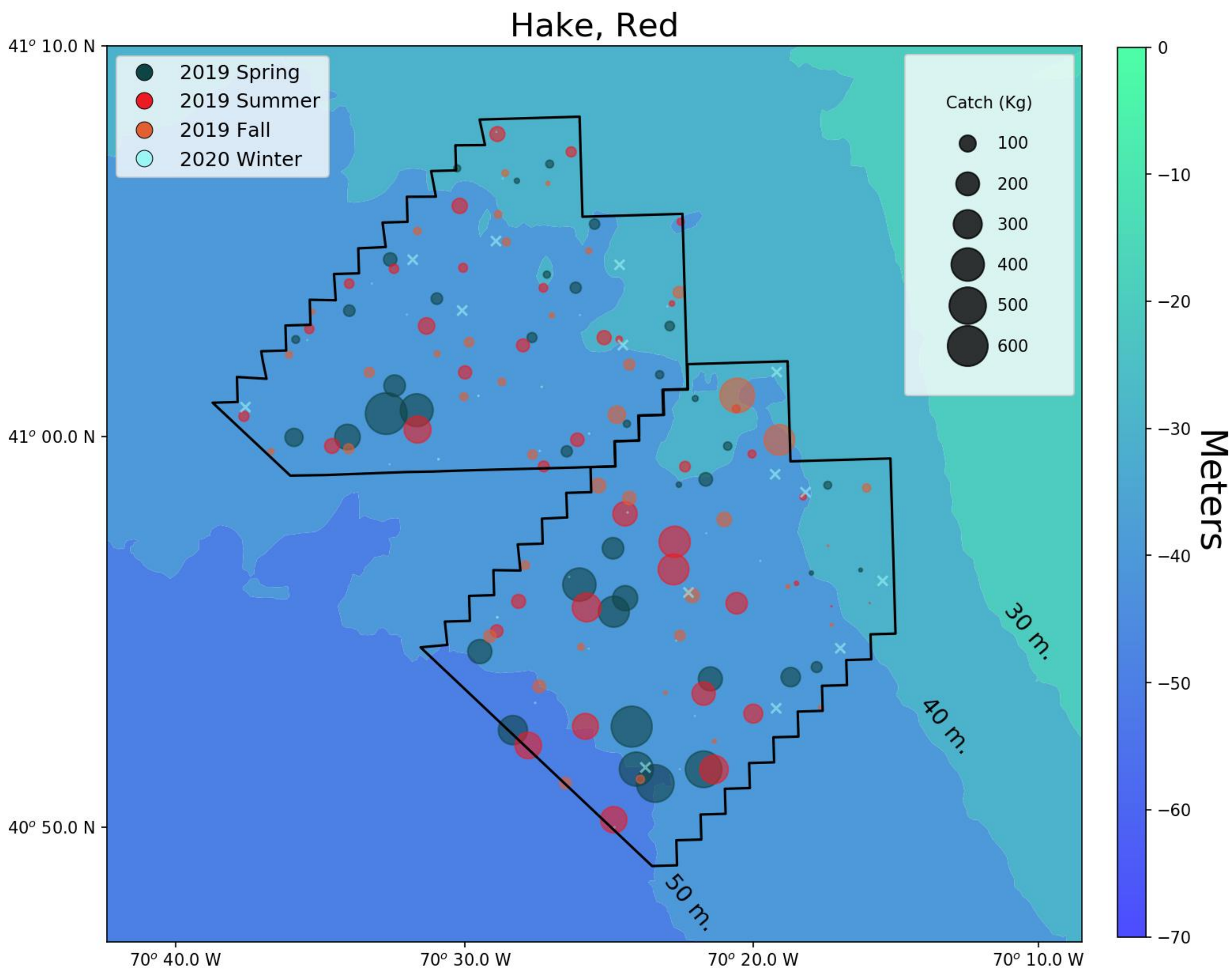


Figure 29: Seasonal distribution of the red hake catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

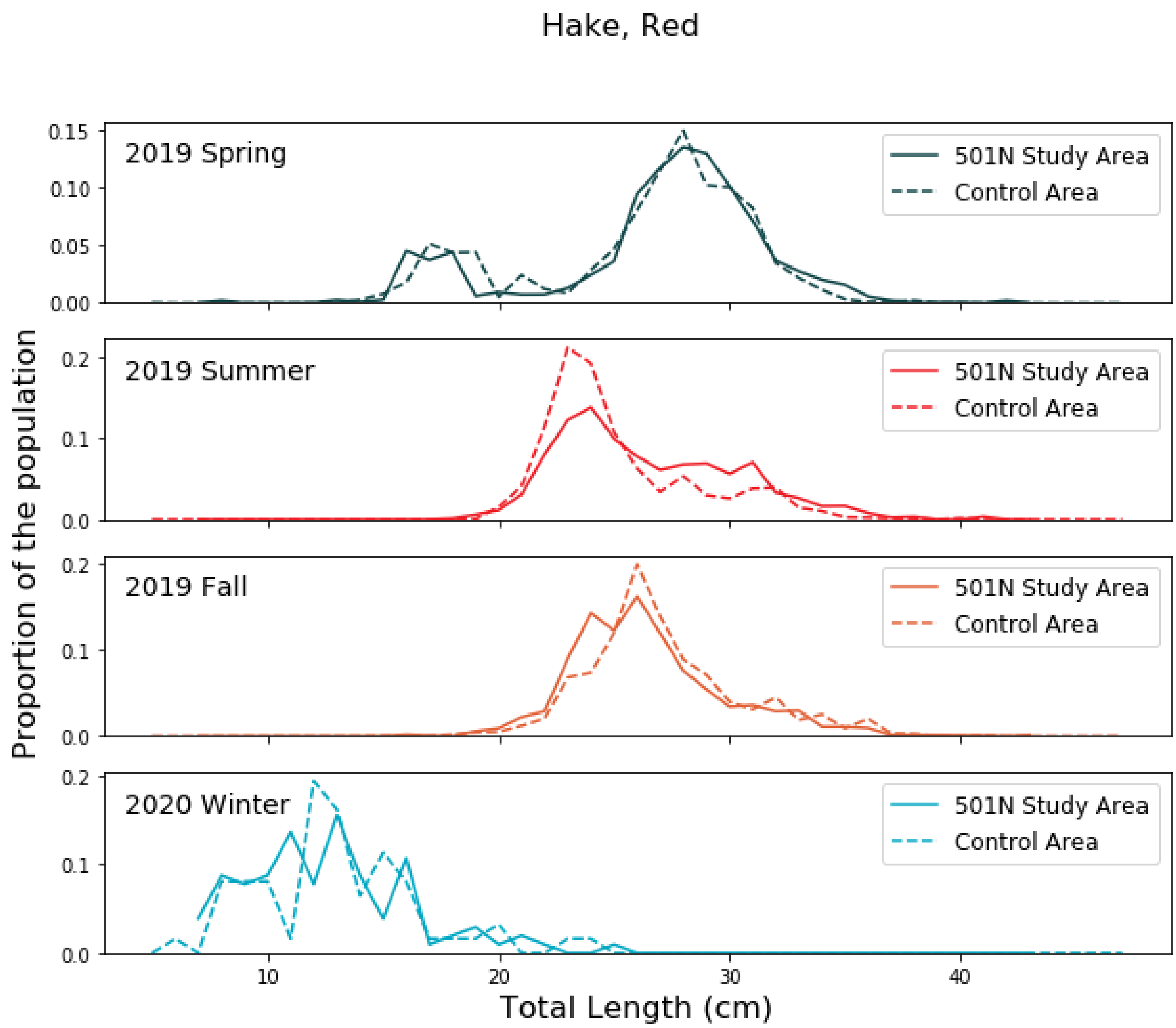


Figure 30: The seasonal length distributions of red hake in the 501 North Study Area and Control Area.

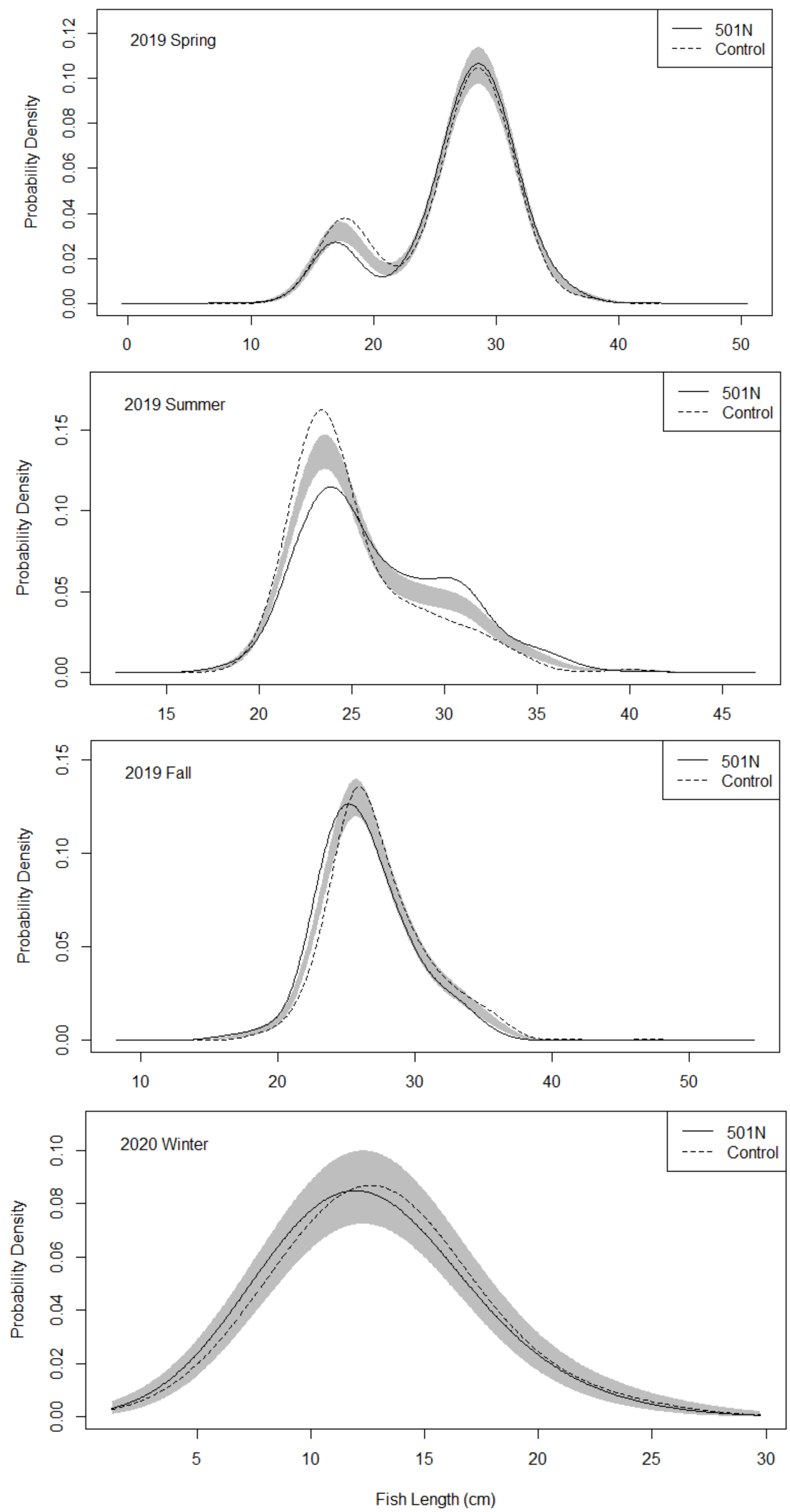


Figure 31: The population structure of red hake in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.

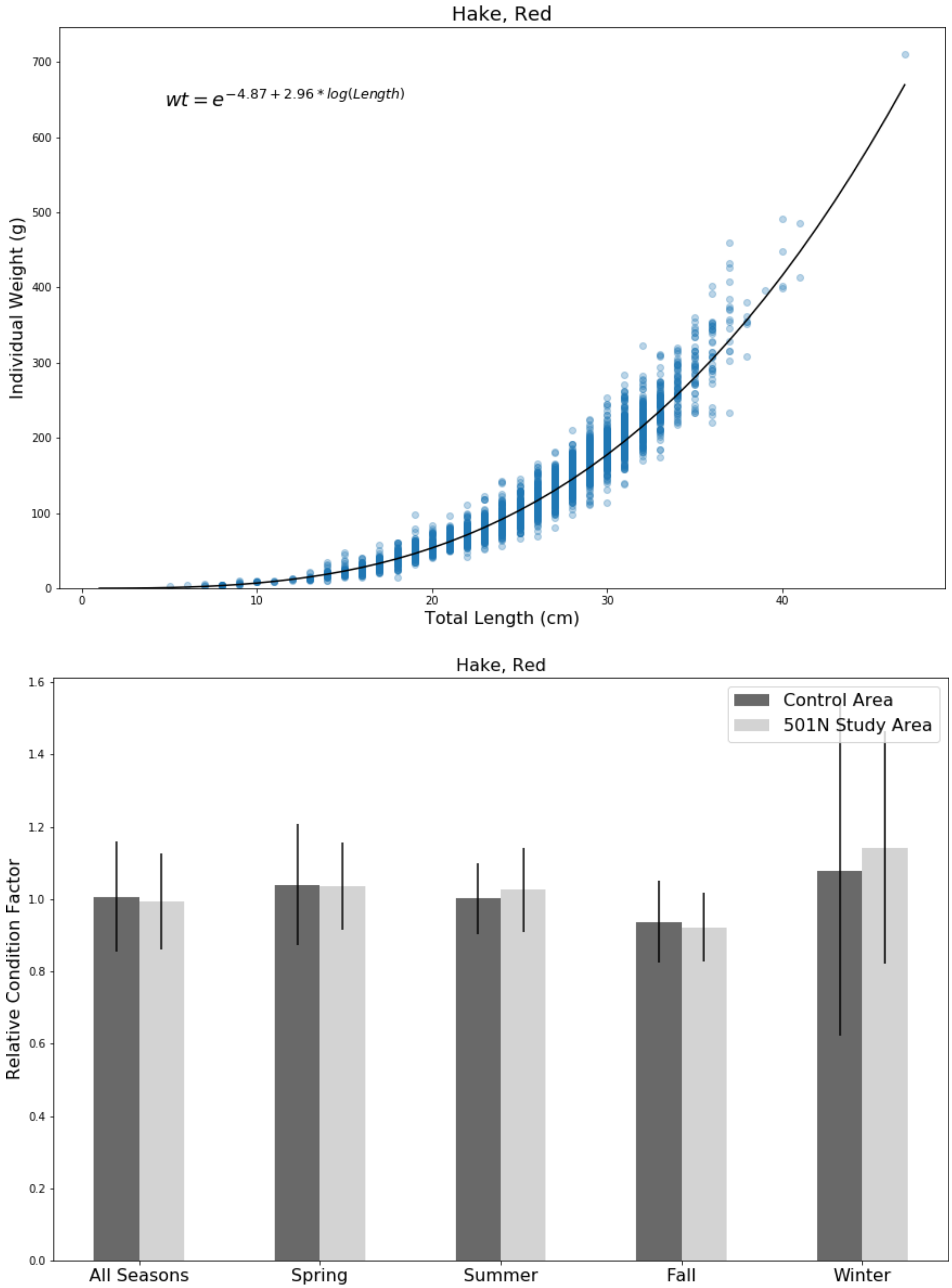


Figure 32: The seasonal condition of red hake (bottom) as derived from the length-weight relationship (top).

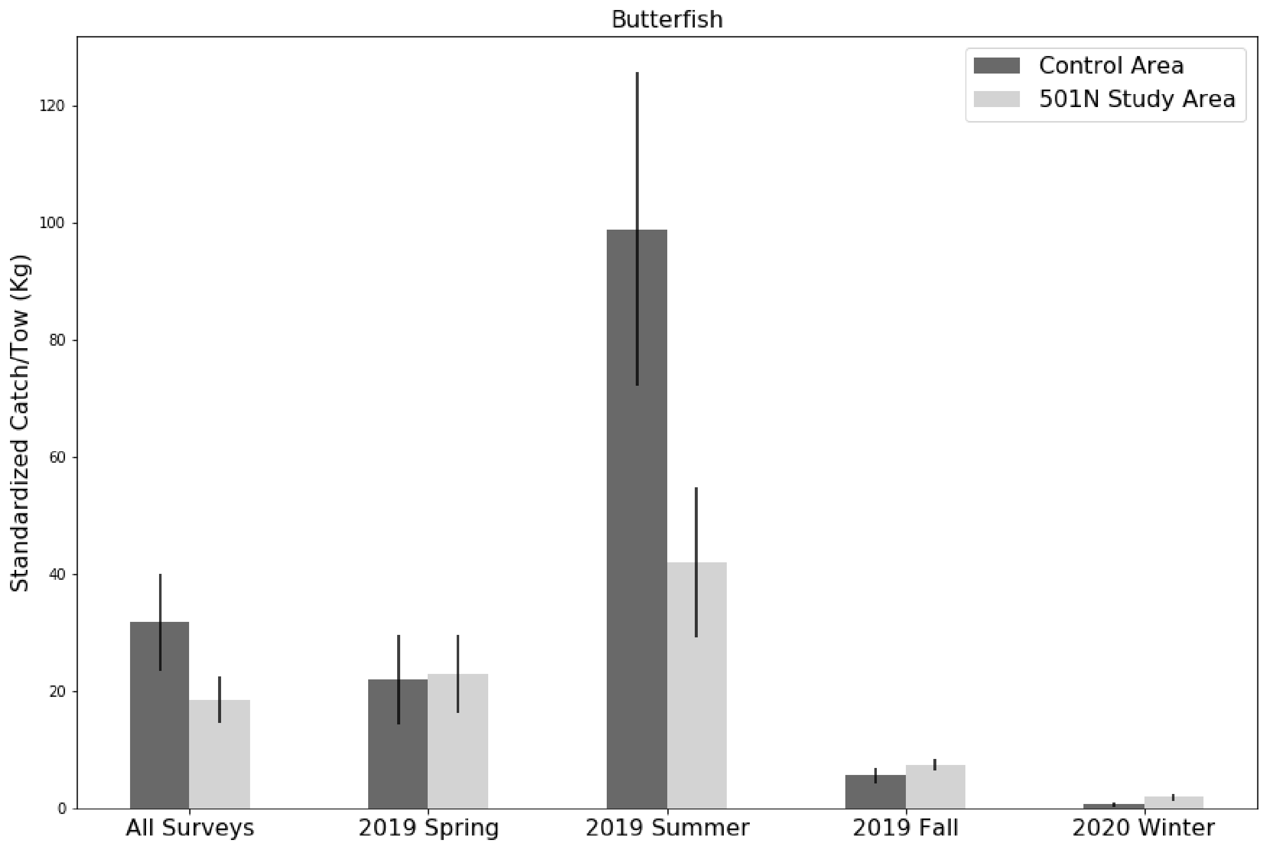


Figure 33: Seasonal catch rates of butterfish in the 501 North Study Area and Control Area.

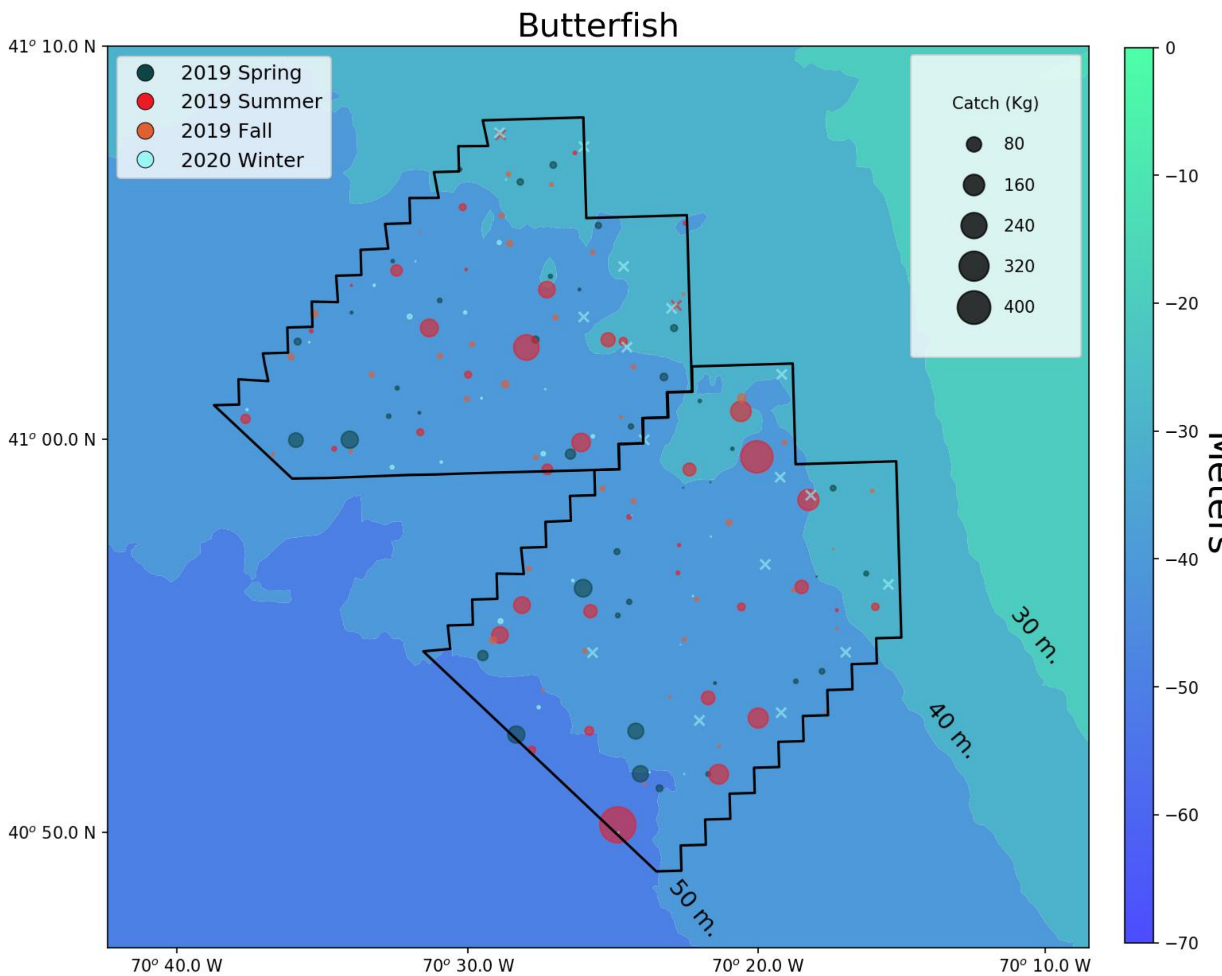


Figure 34: Seasonal distribution of the butterfish catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

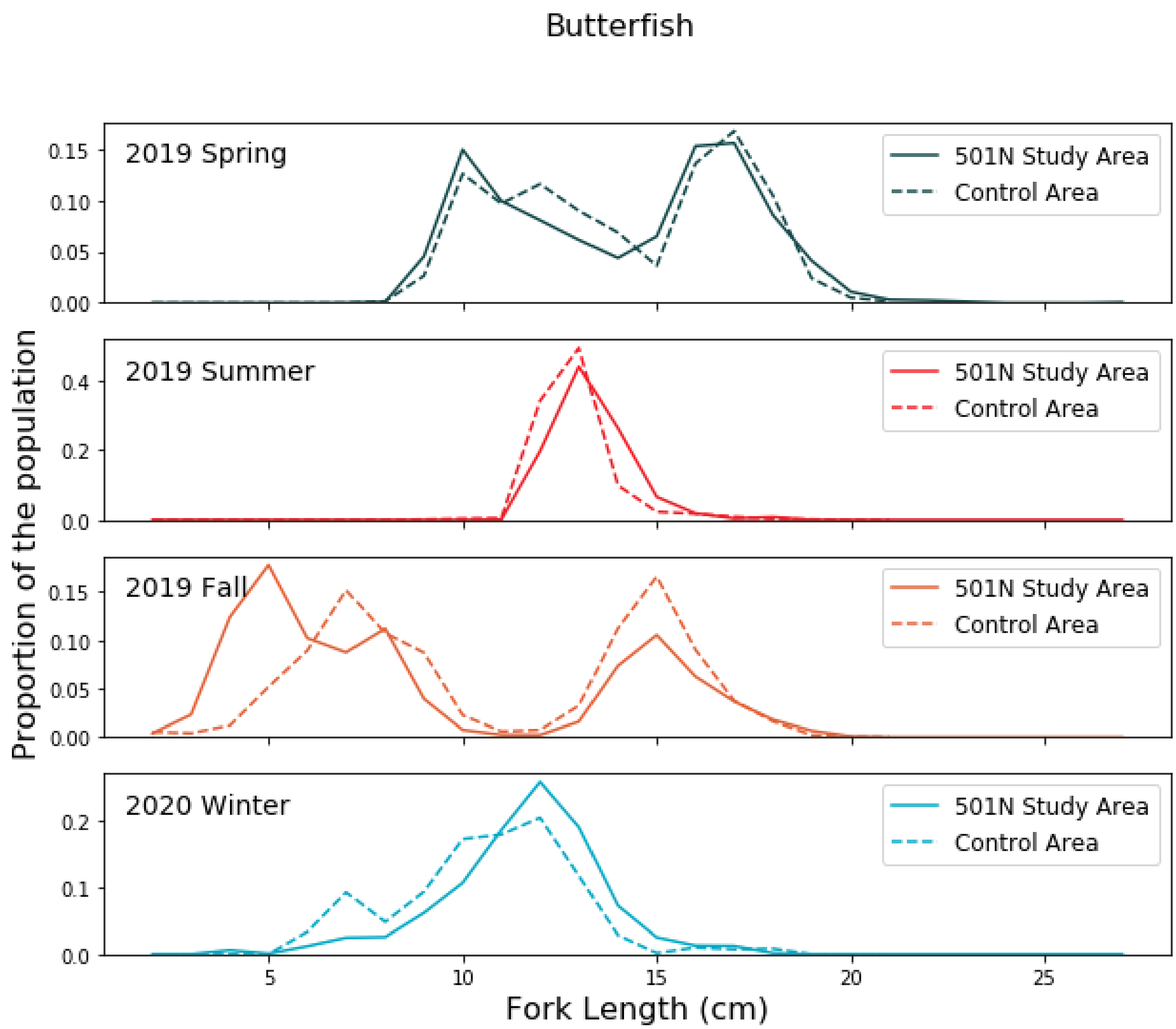


Figure 35: The seasonal length distributions of butterfish in the 501 North Study Area and Control Area.

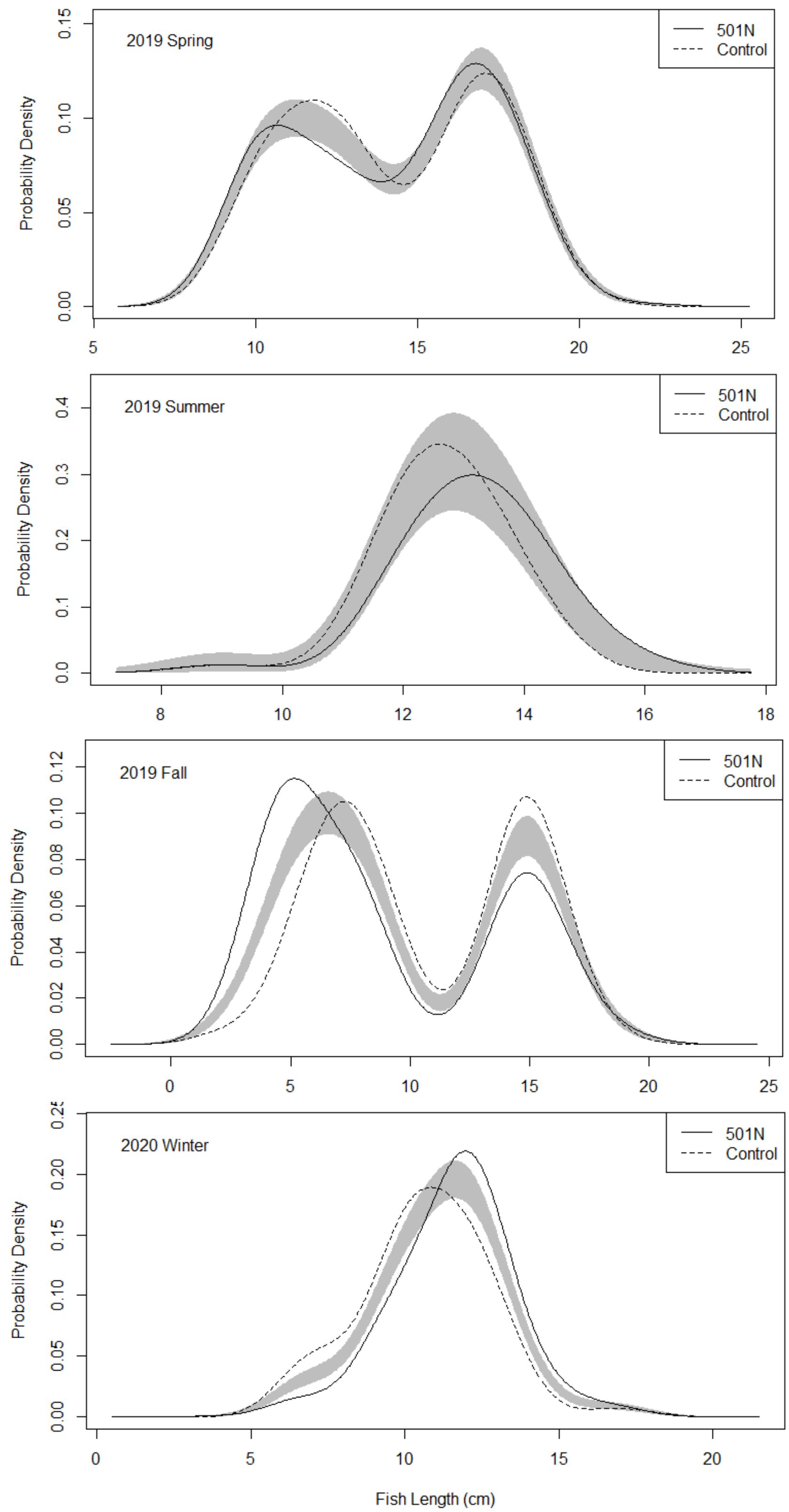


Figure 36: The population structure of butterfish in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.

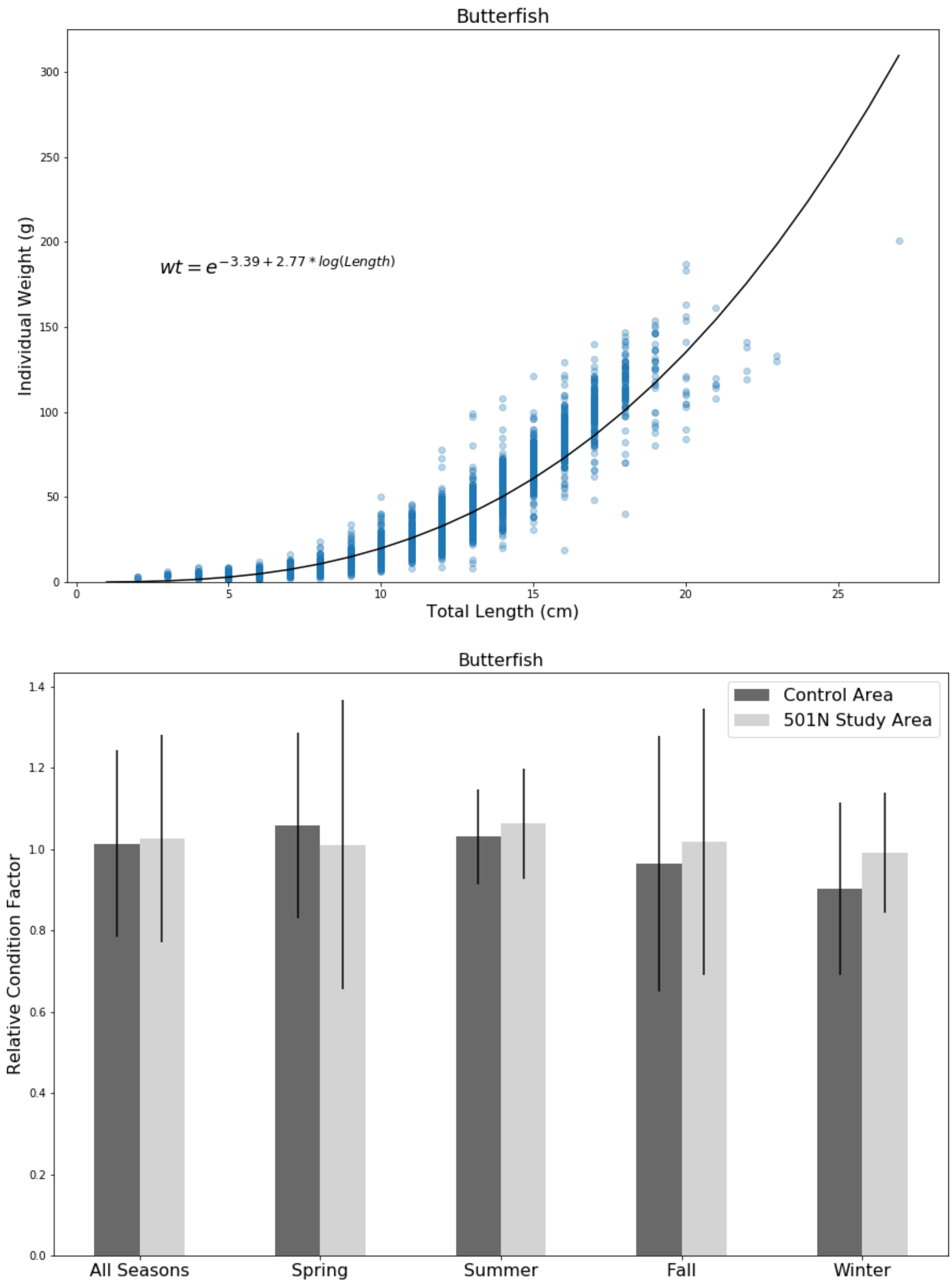


Figure 37: The seasonal condition of butterfish (bottom) as derived from the length-weight relationship (top).

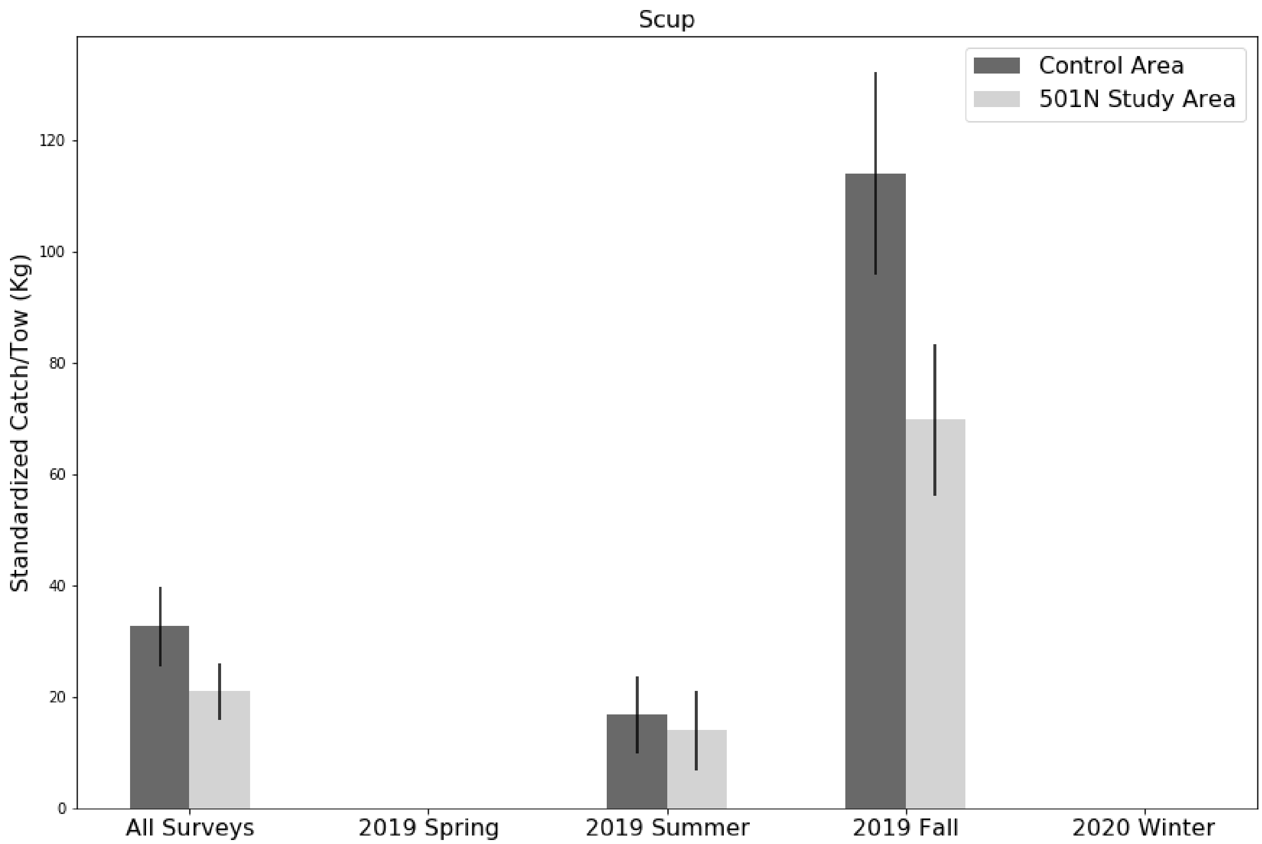


Figure 38: Seasonal catch rates of scup in the 501 North Study Area and Control Area.

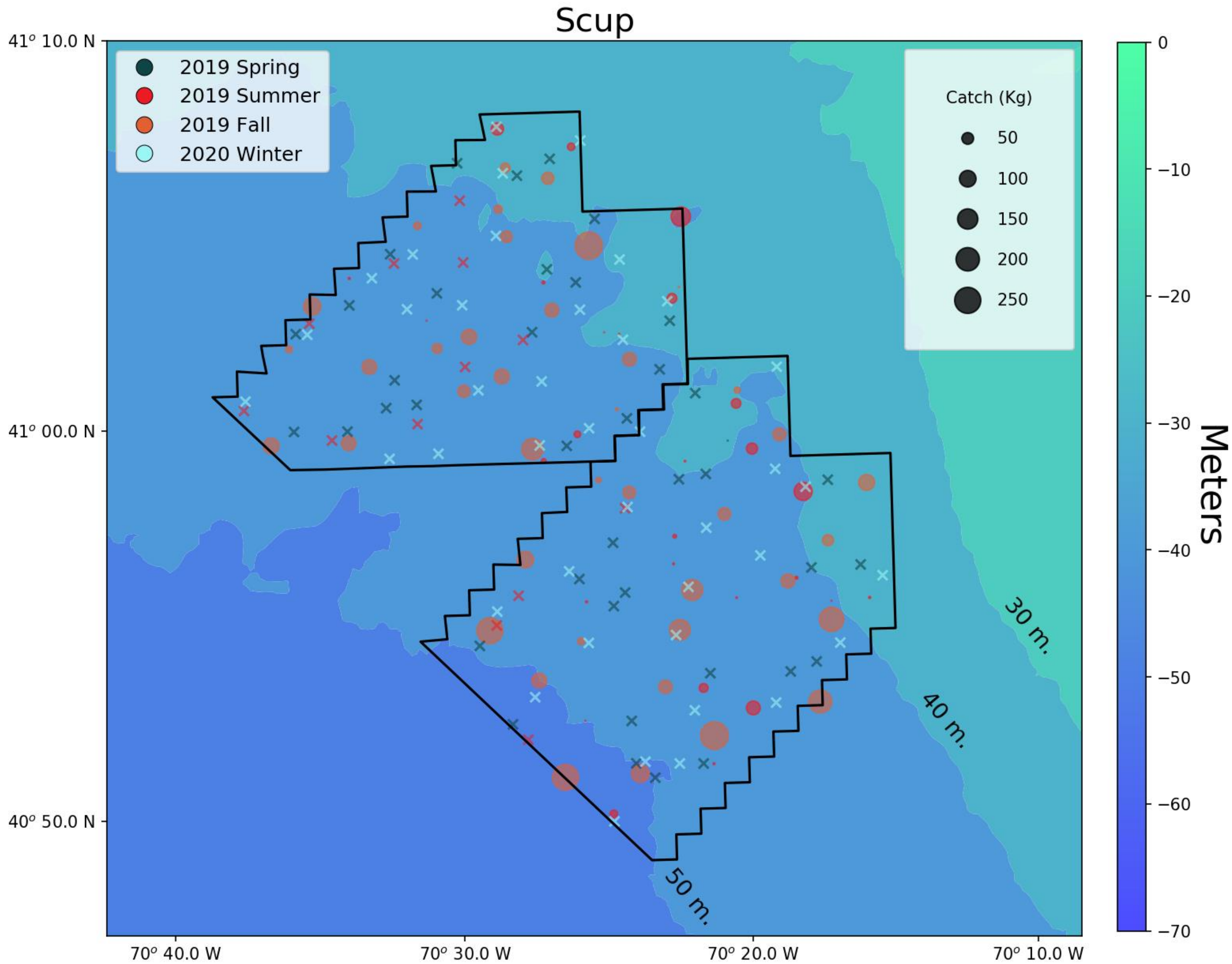


Figure 39: Seasonal distribution of the scup catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

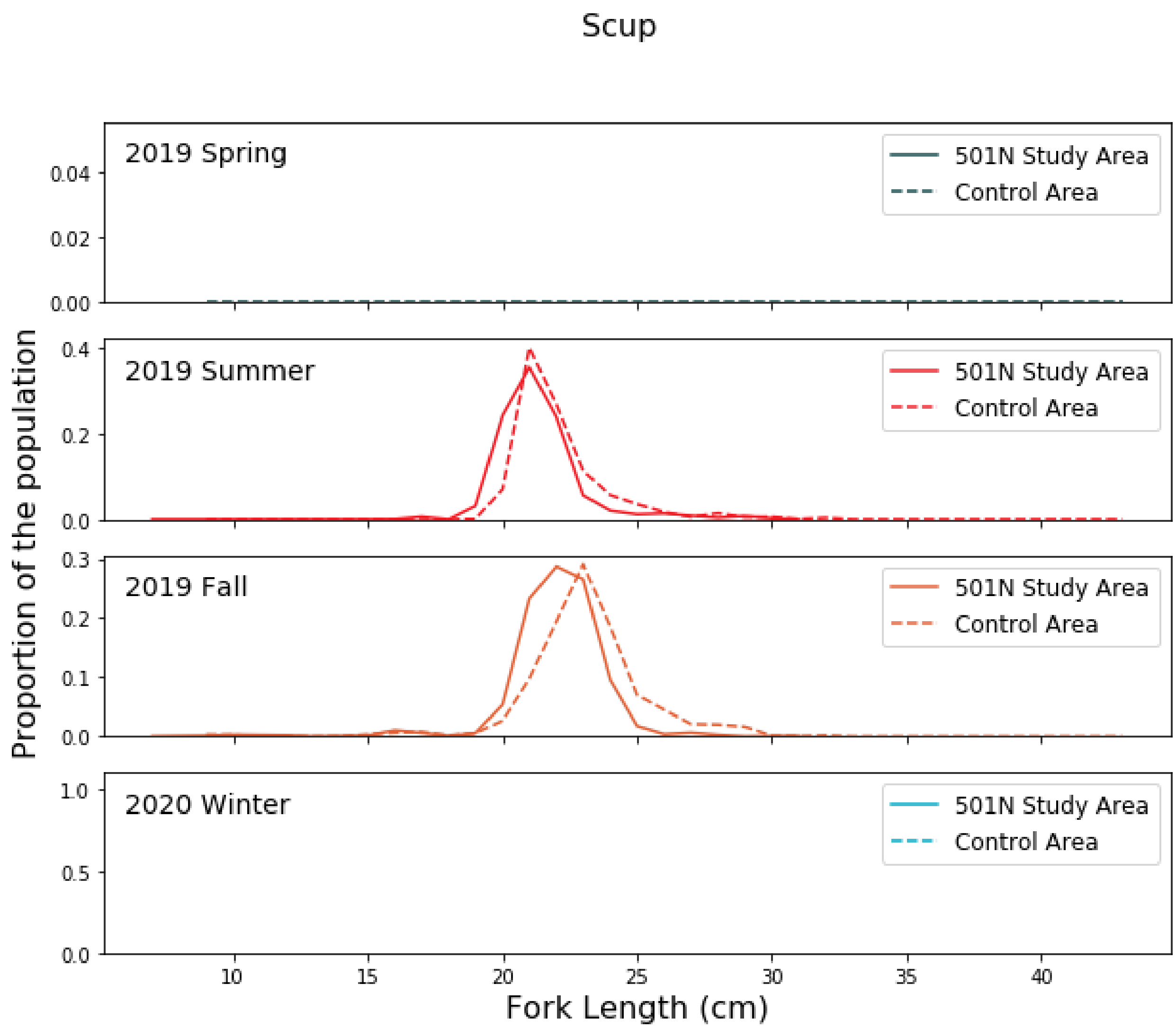


Figure 40: The seasonal length distributions of scup in the 501 North Study Area and Control Area.

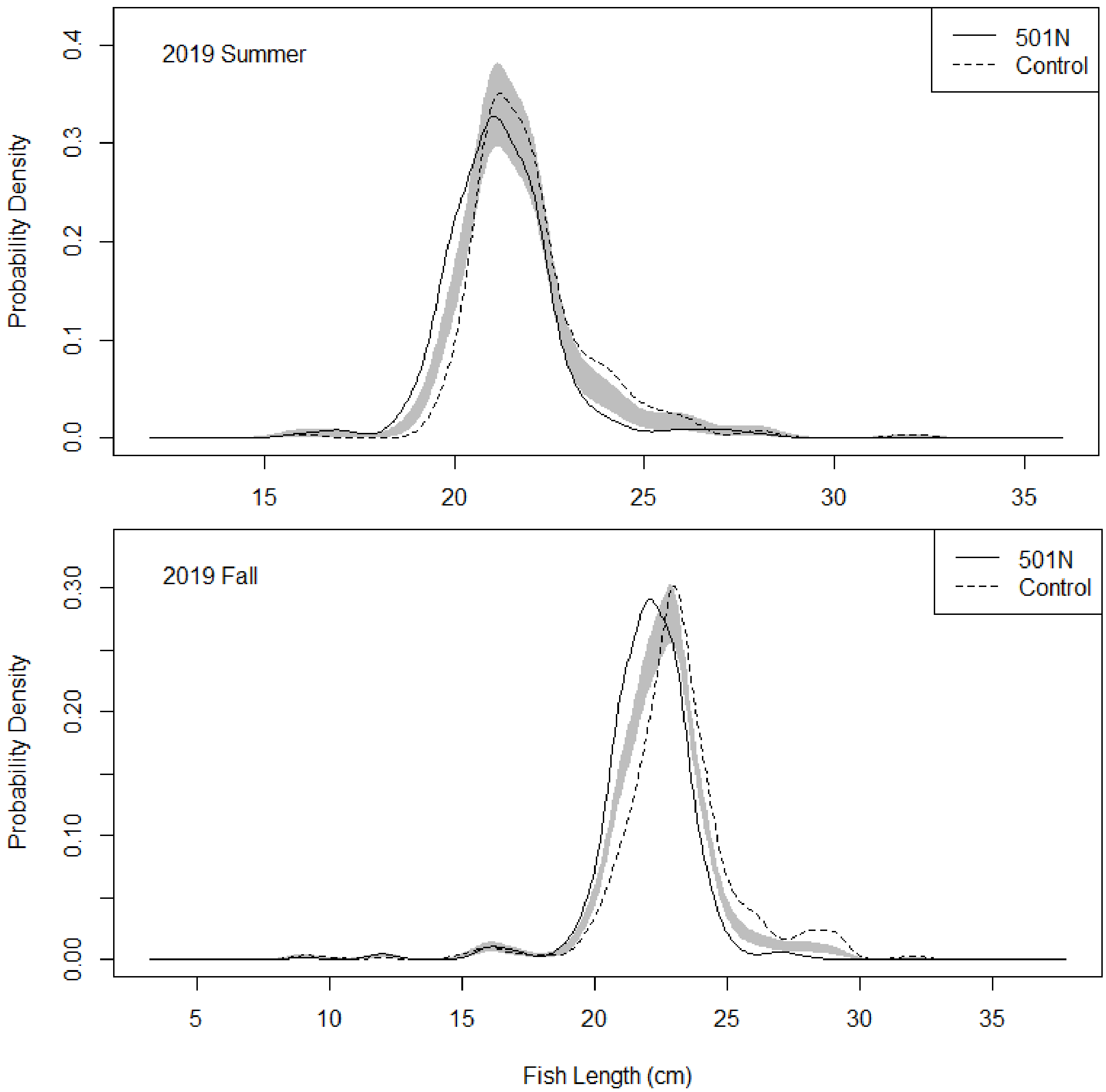
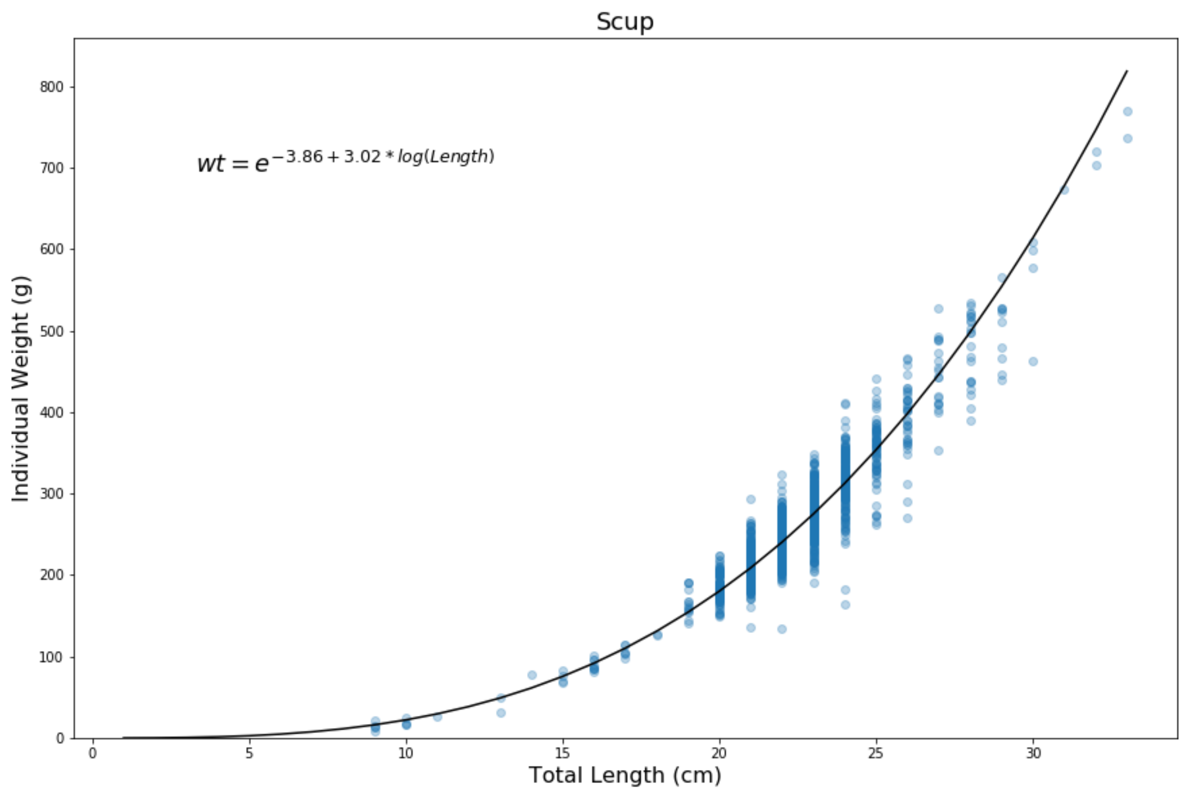


Figure 41: The population structure of scup in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



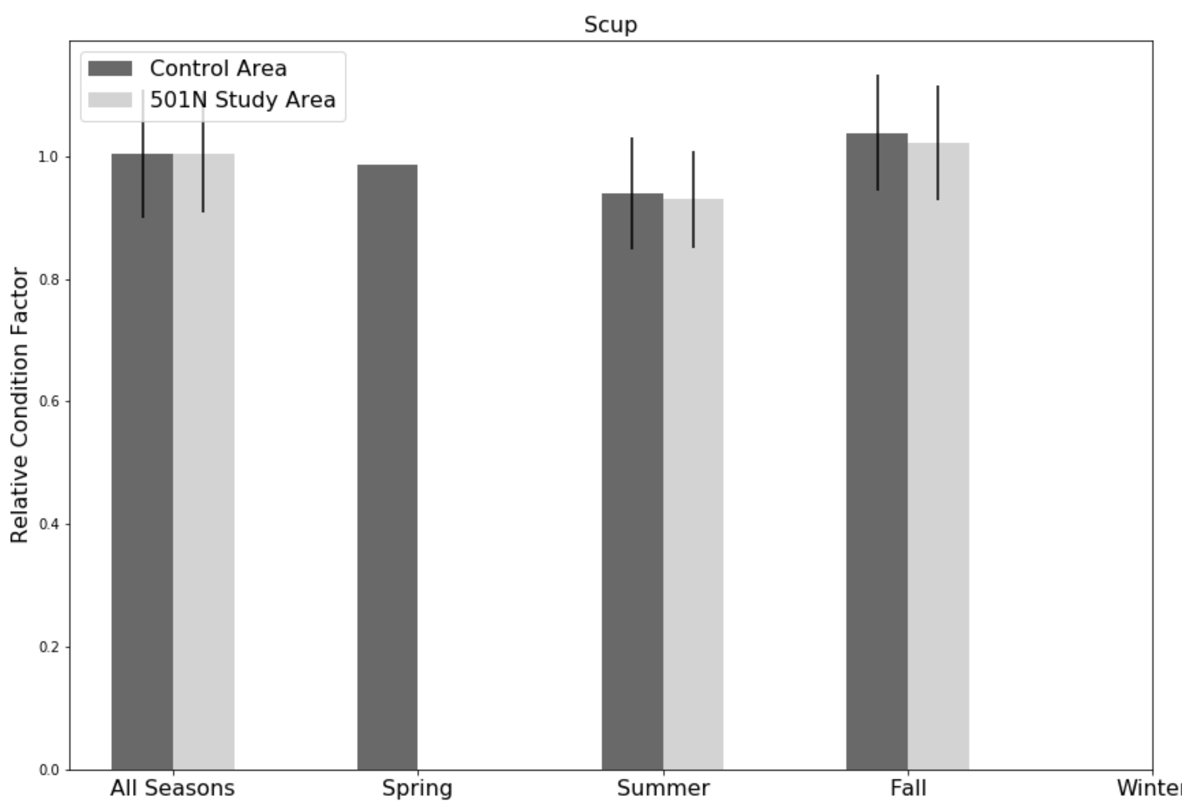


Figure 42: The seasonal condition of scup (bottom) as derived from the length-weight relationship (top).

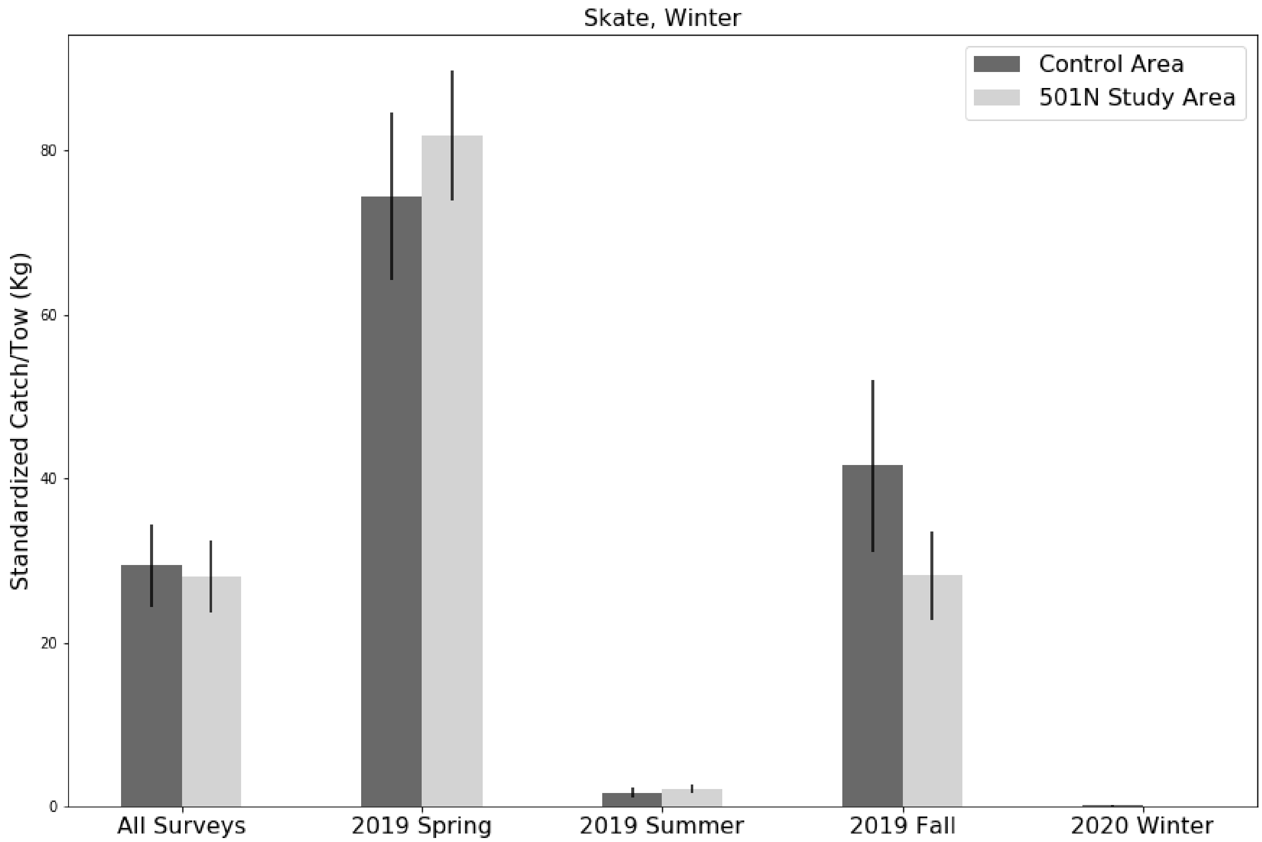


Figure 43: Seasonal catch rates of winter skate in the 501 North Study Area and Control Area.

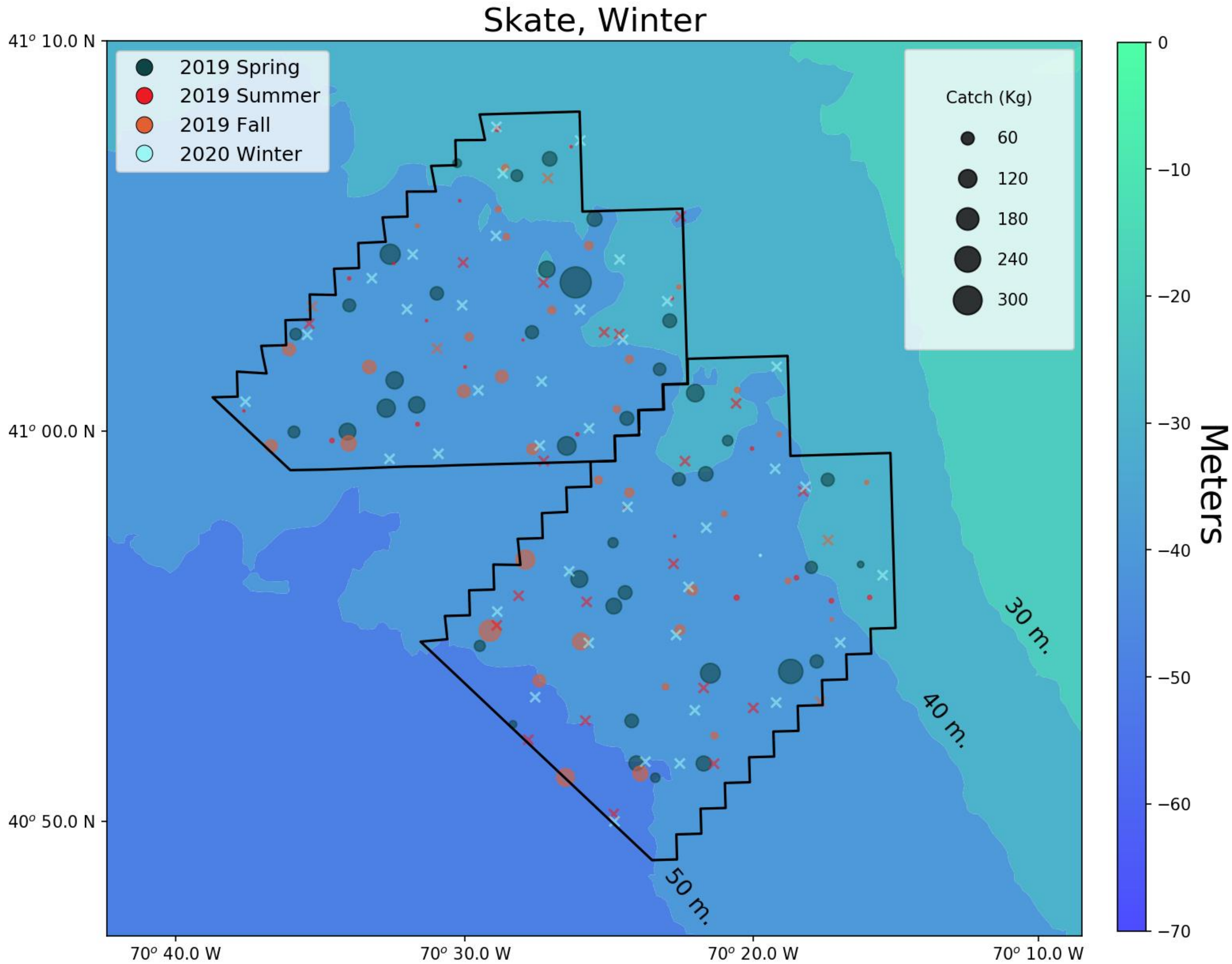


Figure 44: Seasonal distribution of the winter skate catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

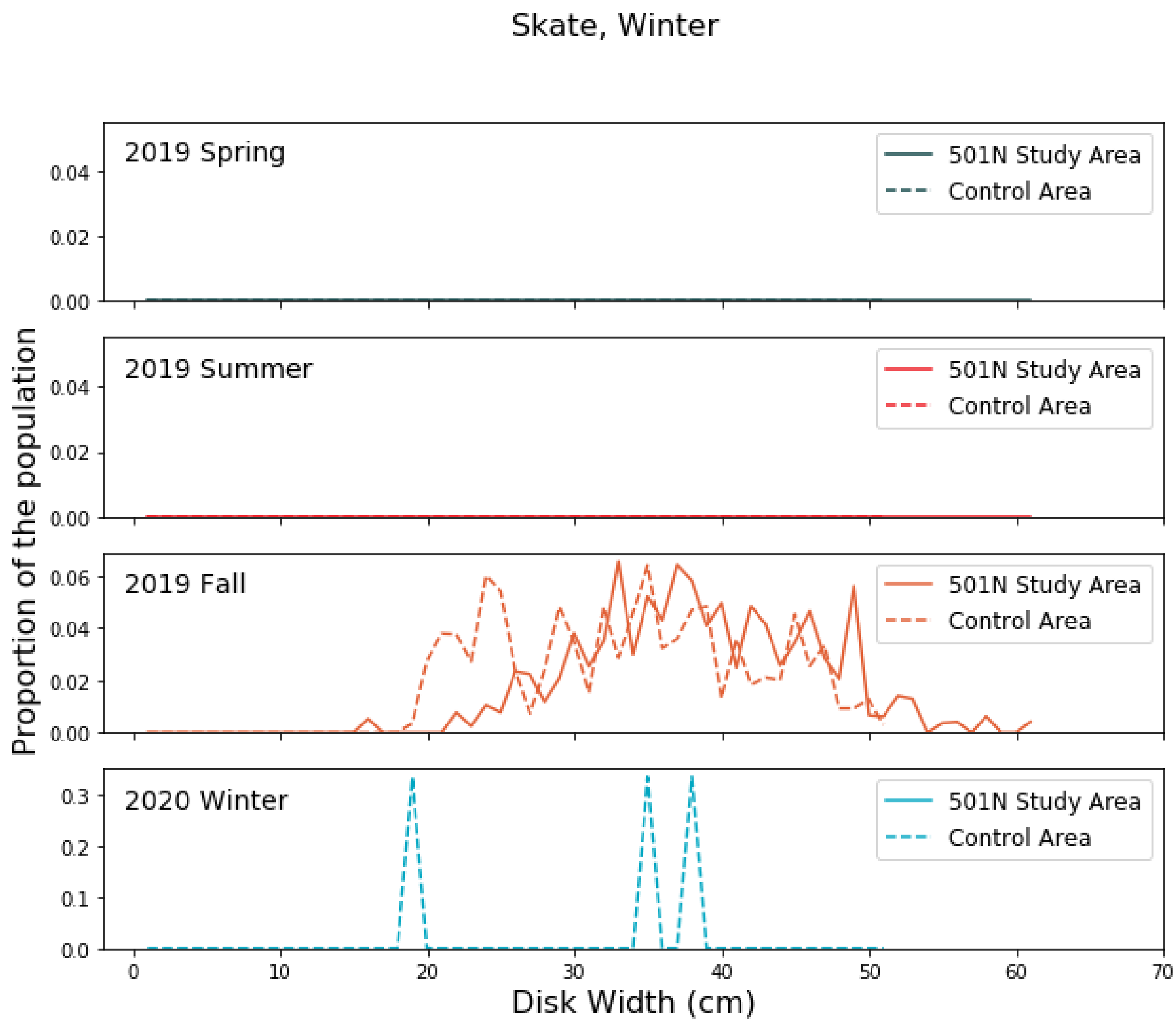


Figure 45: The seasonal length distributions of winter skate in the 501 North Study Area and Control Area.

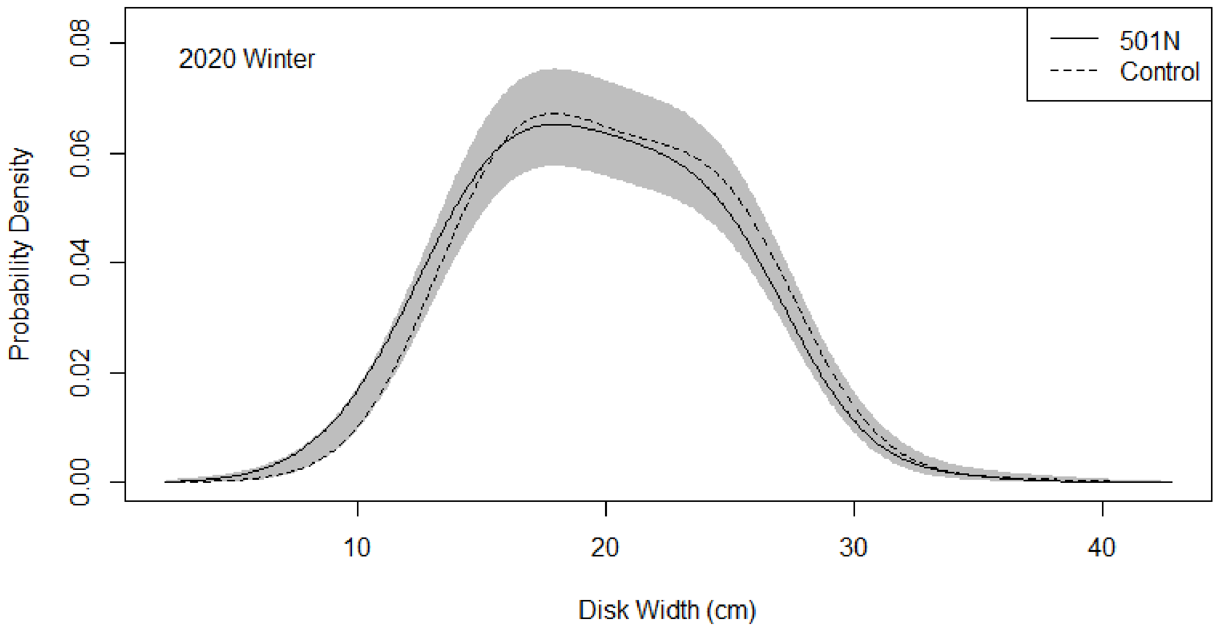
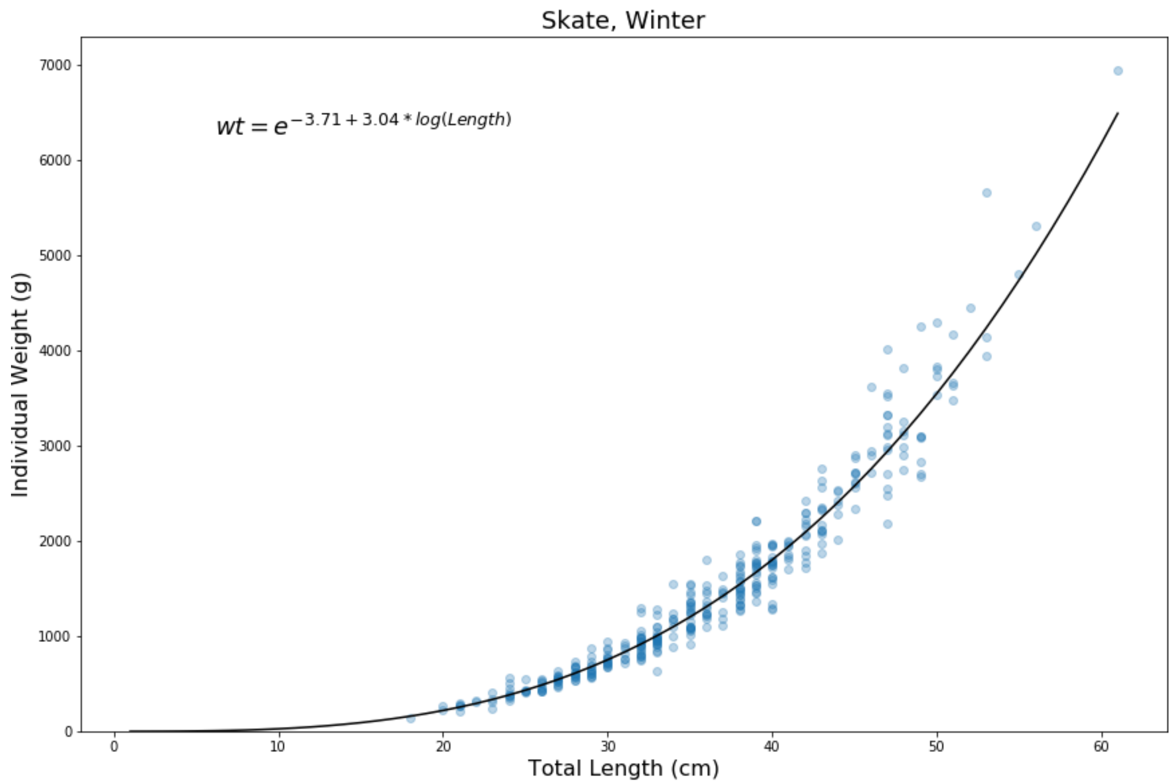


Figure 46: The population structure of winter skate in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



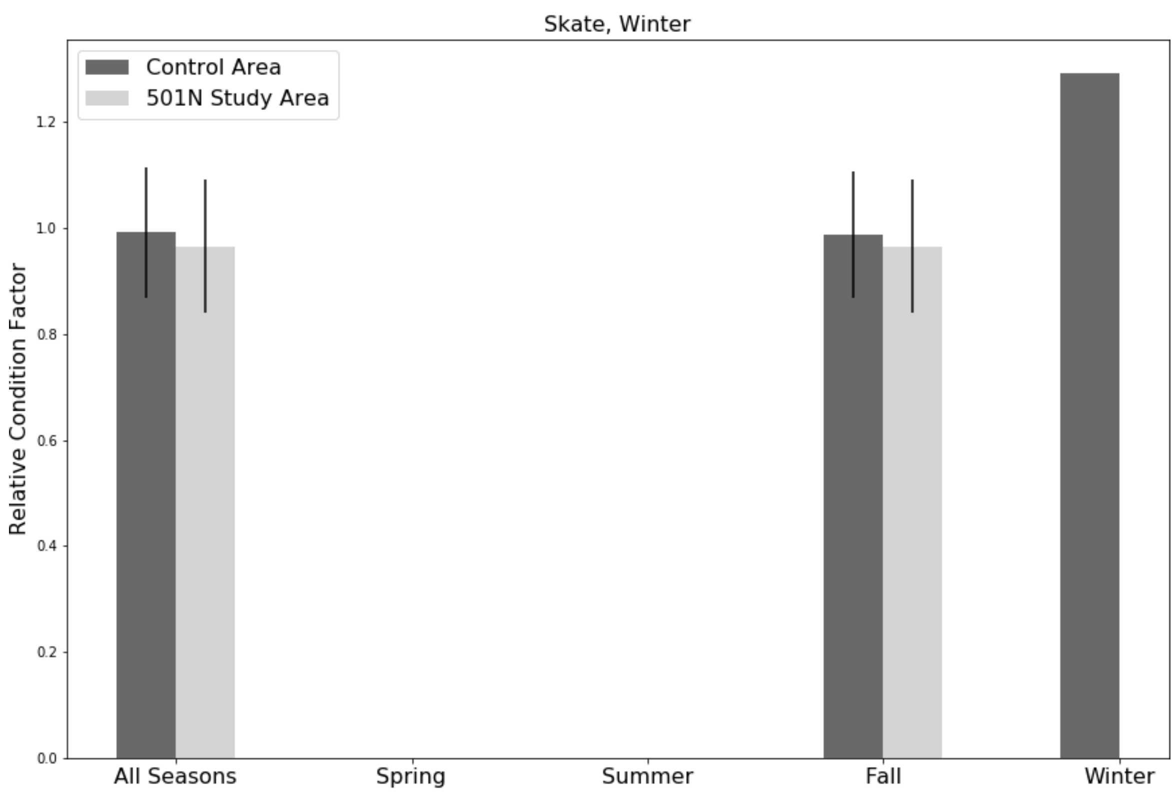


Figure 47: The seasonal condition of winter skate (bottom) as derived from the length-weight relationship (top).

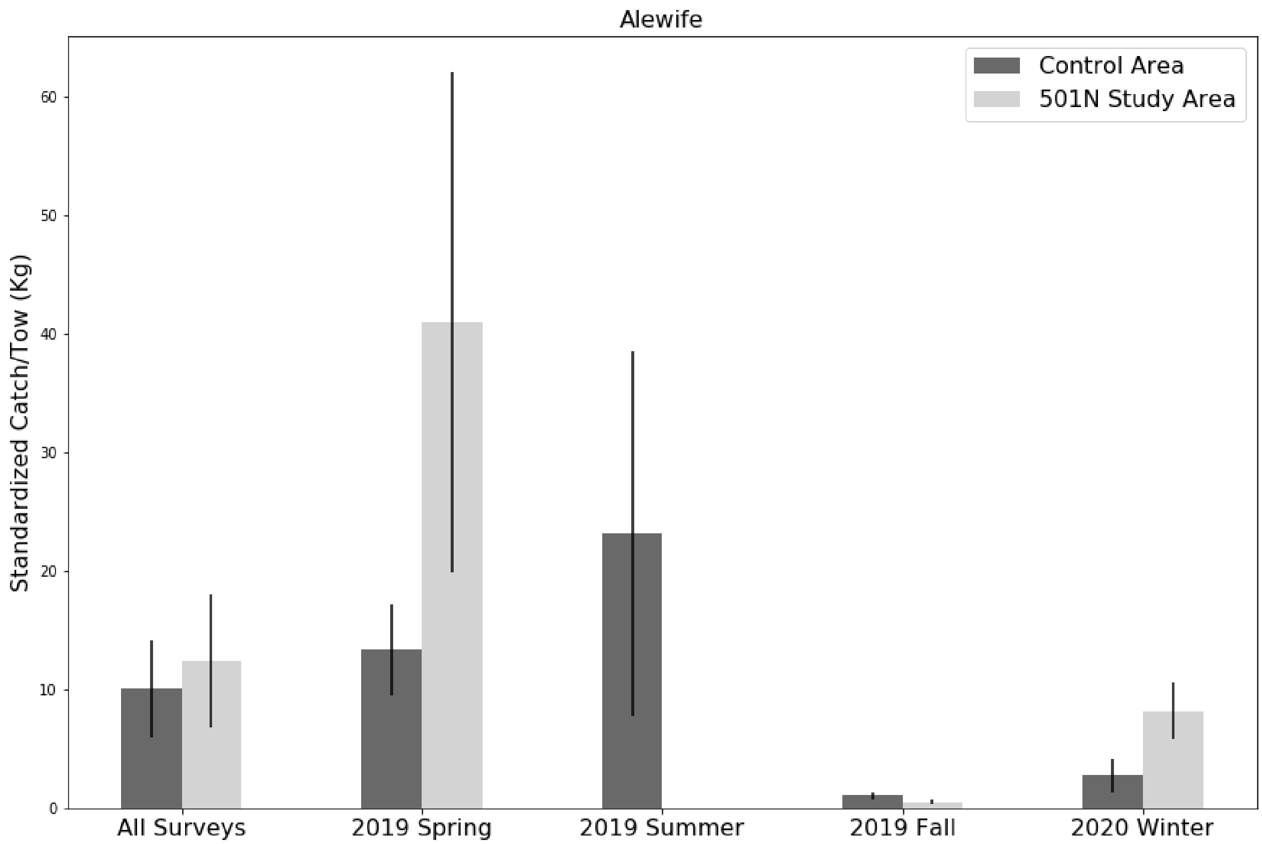


Figure 48: Seasonal catch rates of alewife in the 501 North Study Area and Control Area.

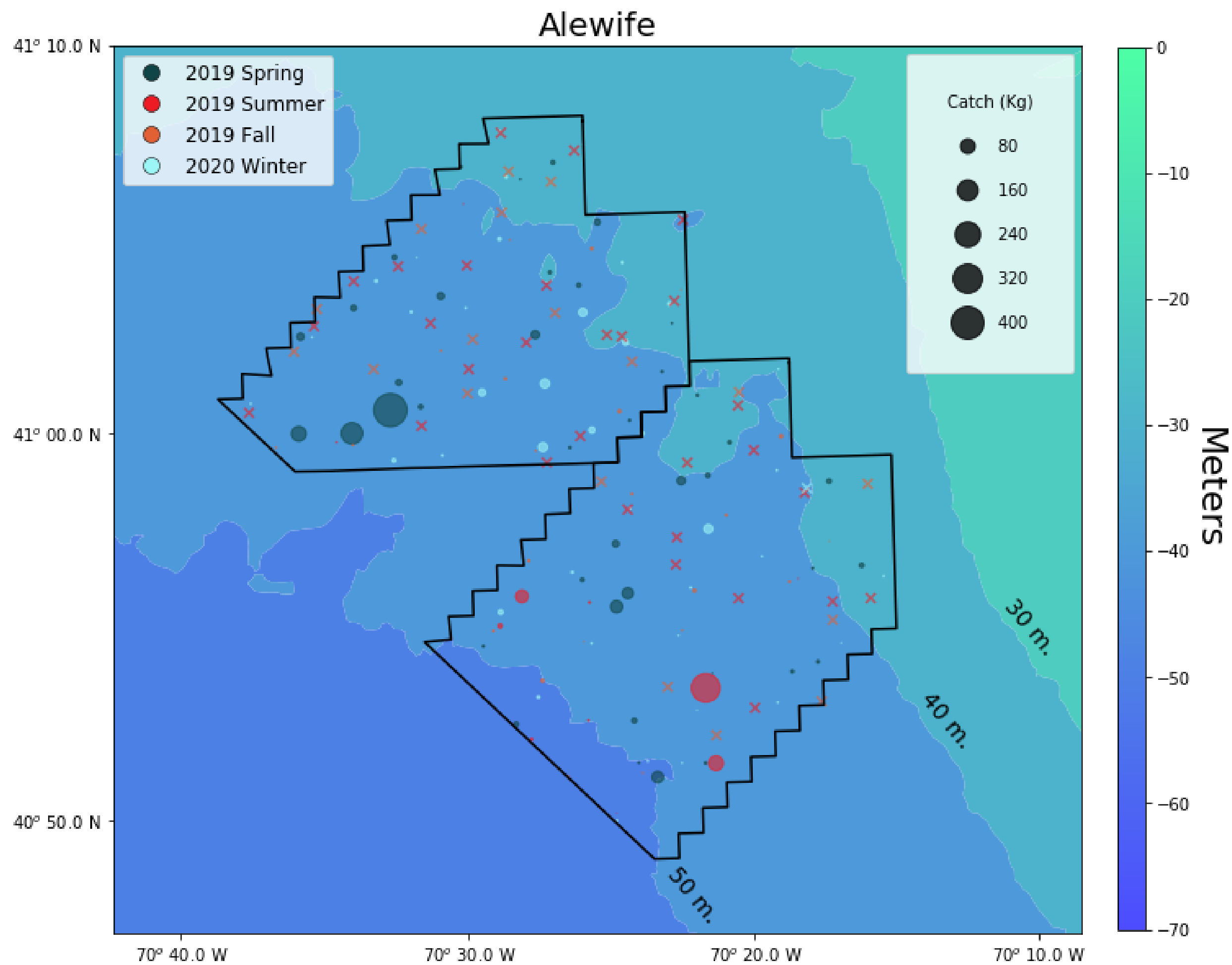


Figure 49: Seasonal distribution of the alewife catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

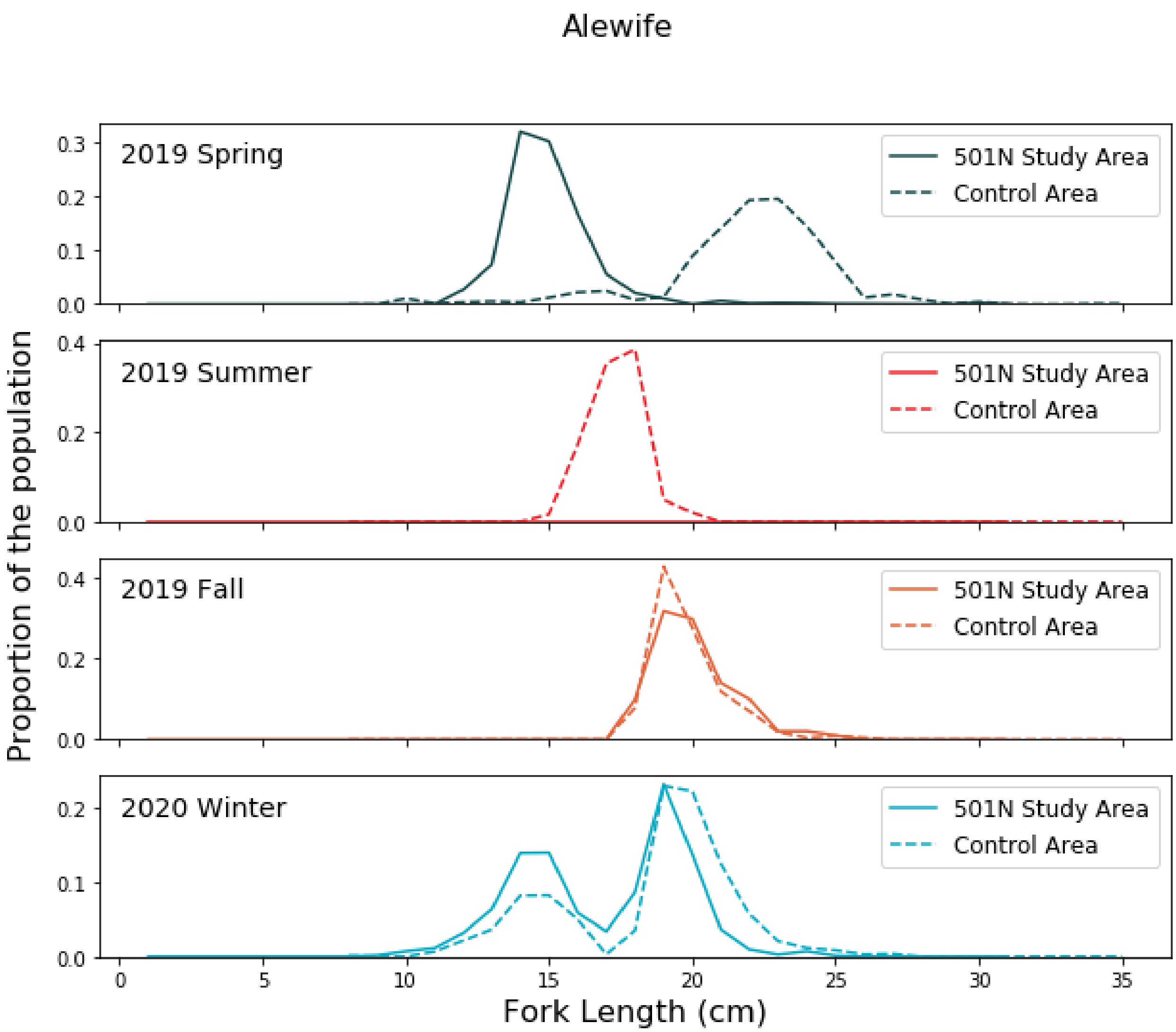


Figure 50: The seasonal length distributions of alewife in the 501 North Study Area and Control Area.

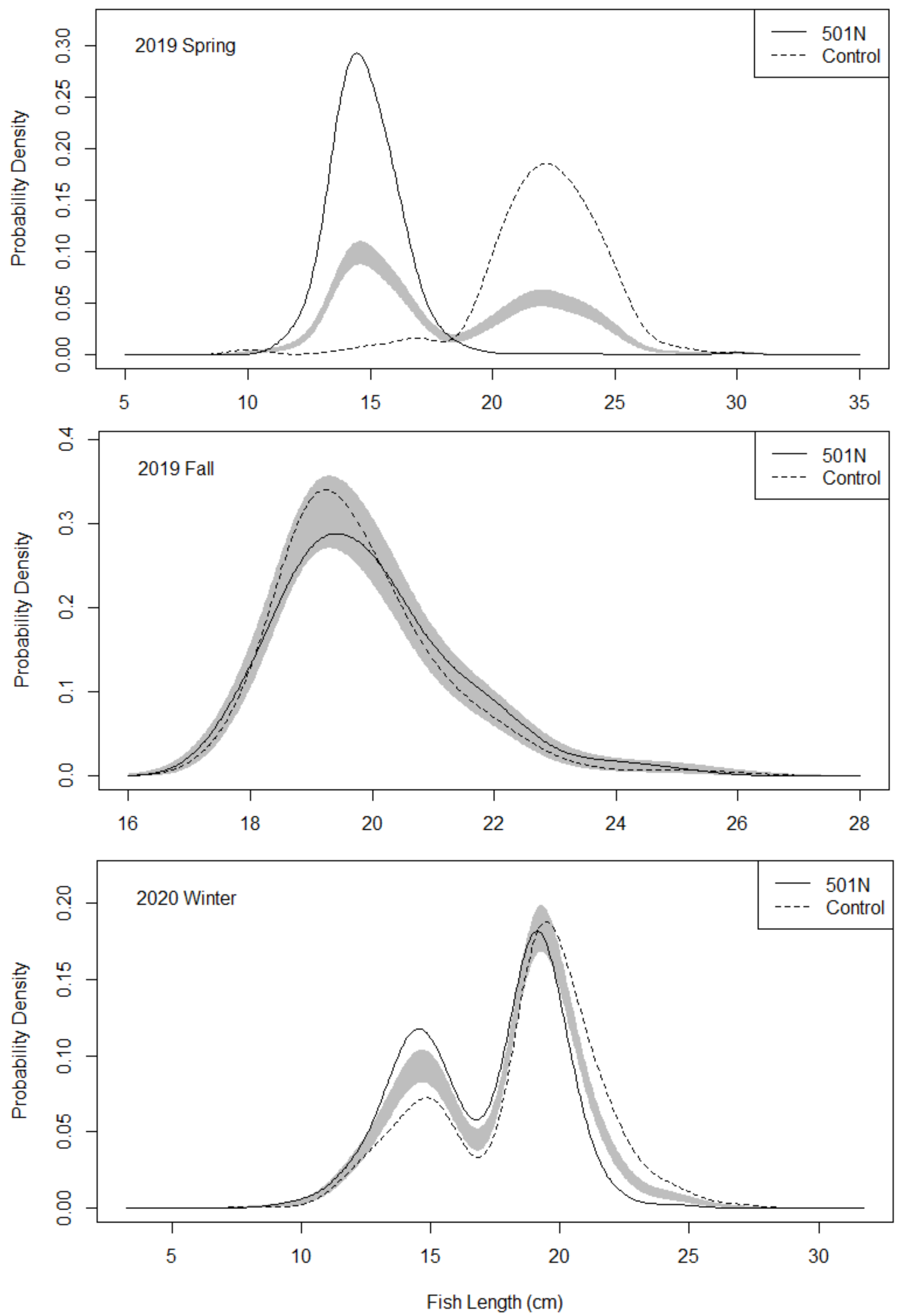


Figure 51: The population structure of alewife in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.

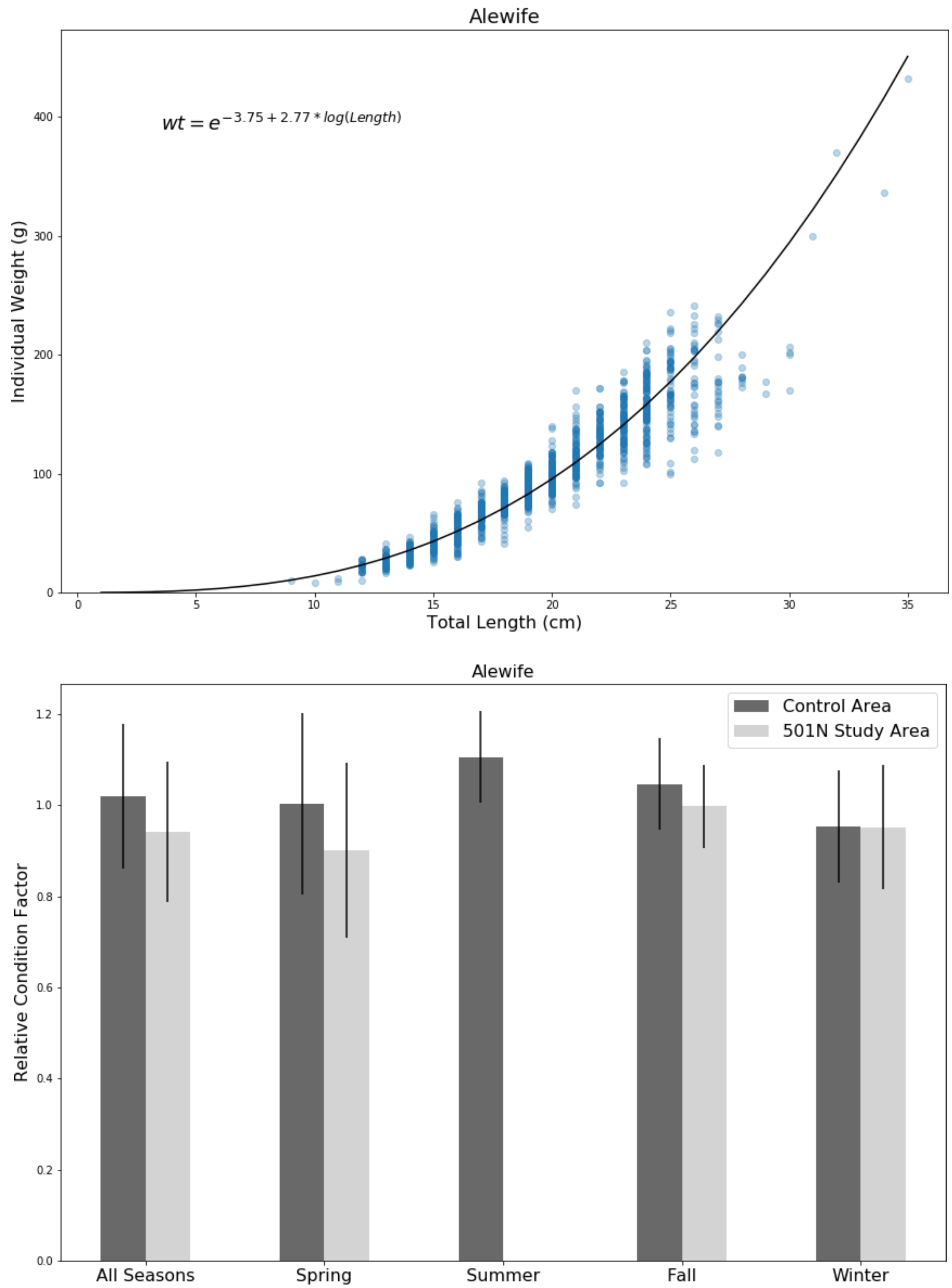


Figure 52: The seasonal condition of alewife (bottom) as derived from the length-weight relationship (top).

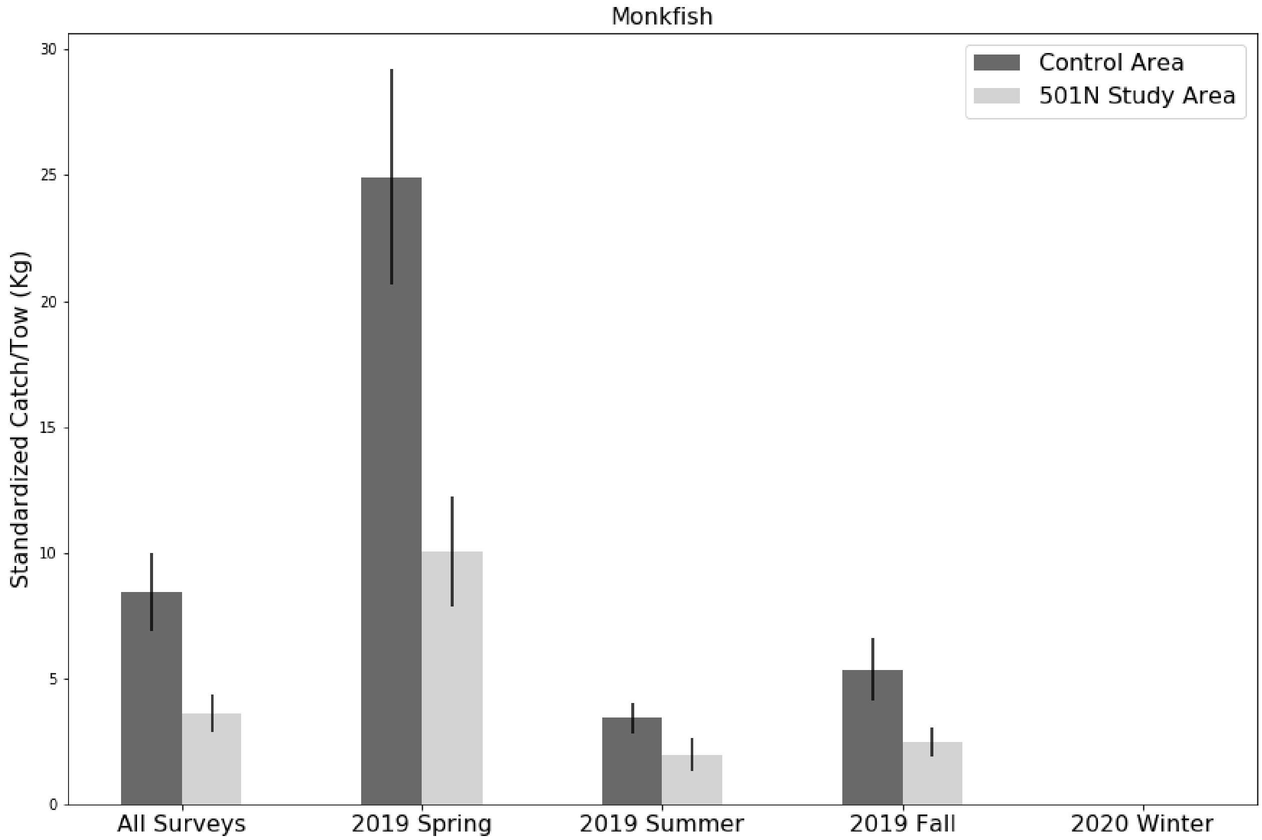


Figure 53: Seasonal catch rates of monkfish in the 501 North Study Area and Control Area.

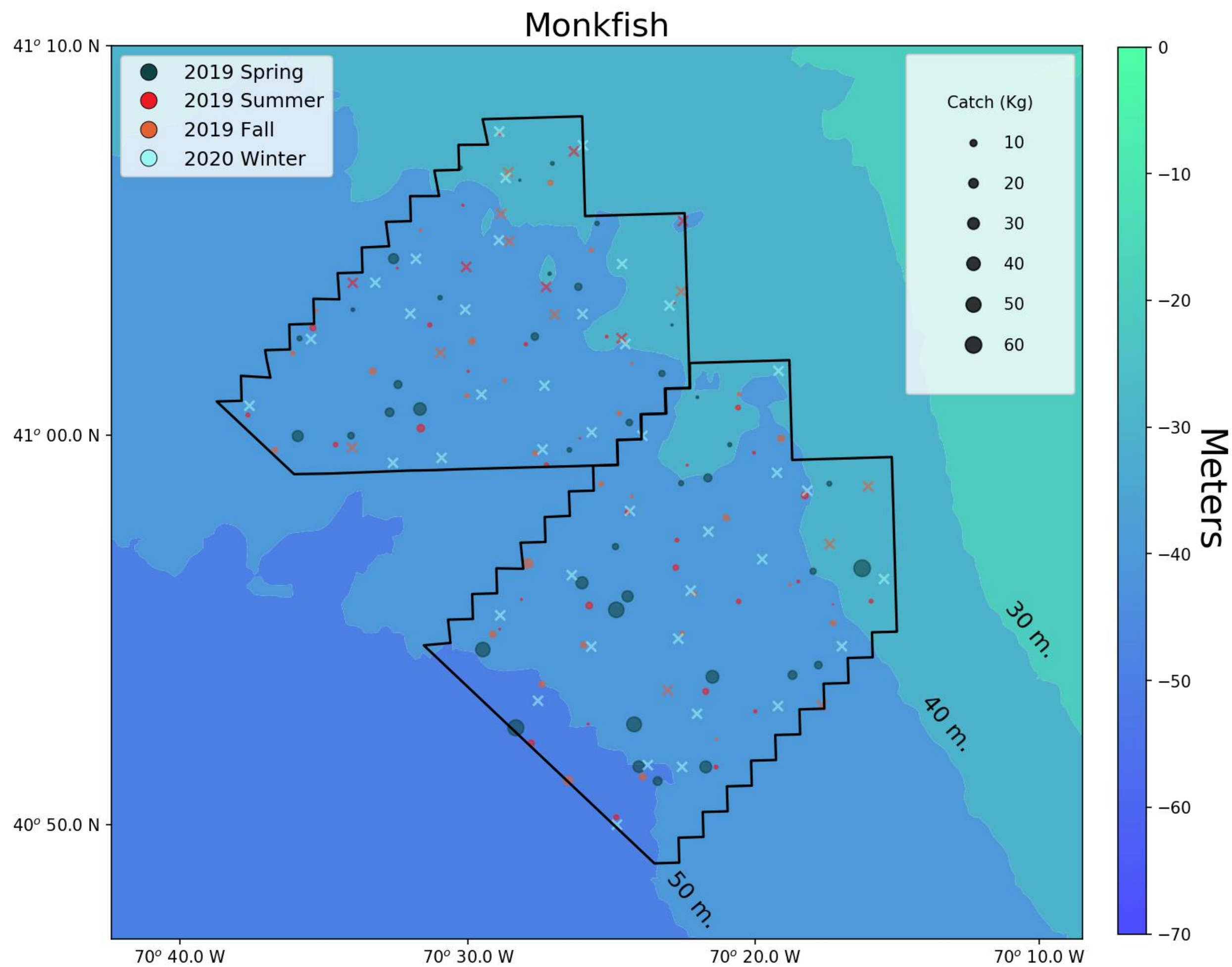


Figure 54: Seasonal distribution of the monkfish catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

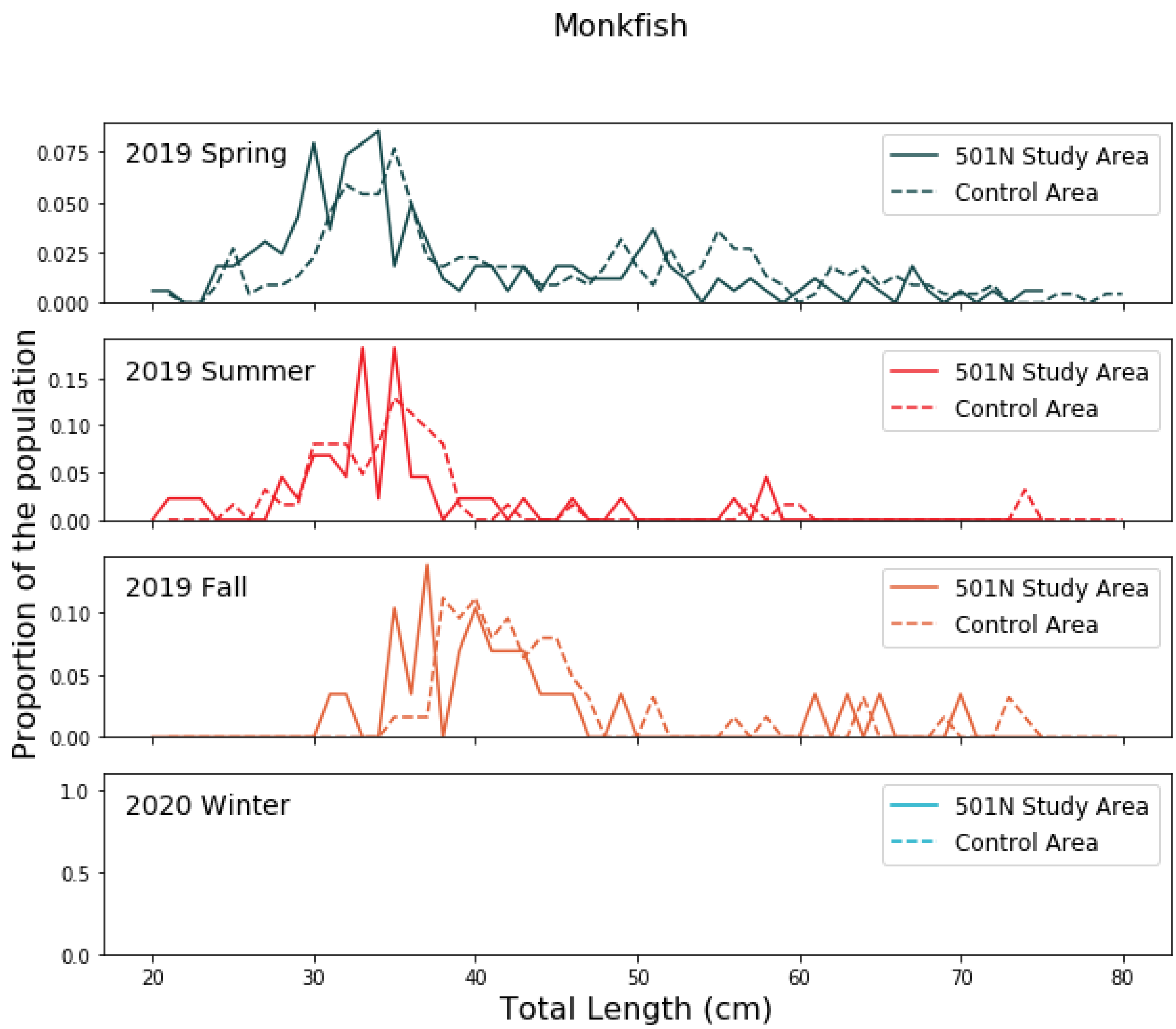


Figure 55: The seasonal length distributions of monkfish in the 501 North Study Area and Control Area.

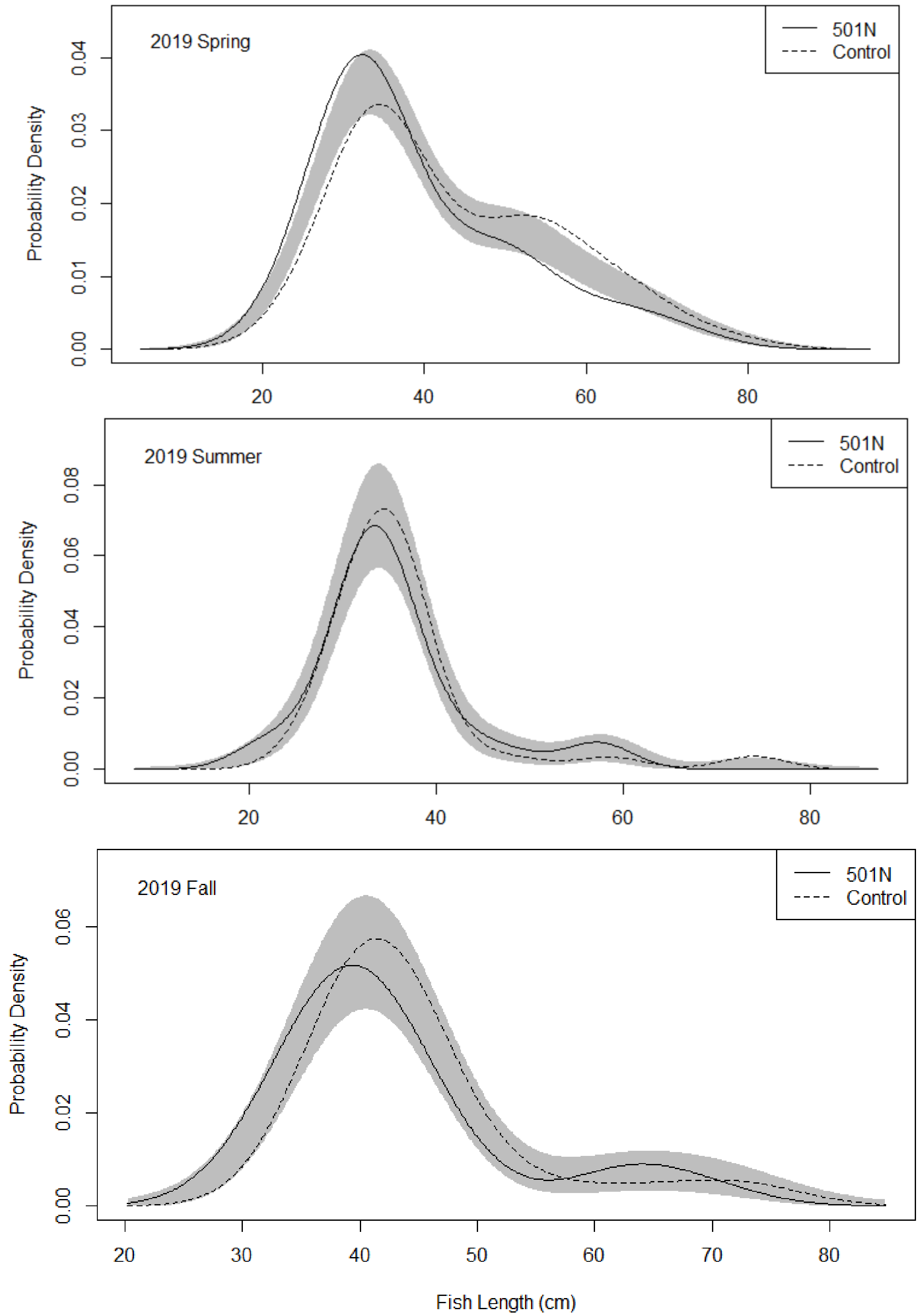


Figure 56: The population structure of monkfish in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.

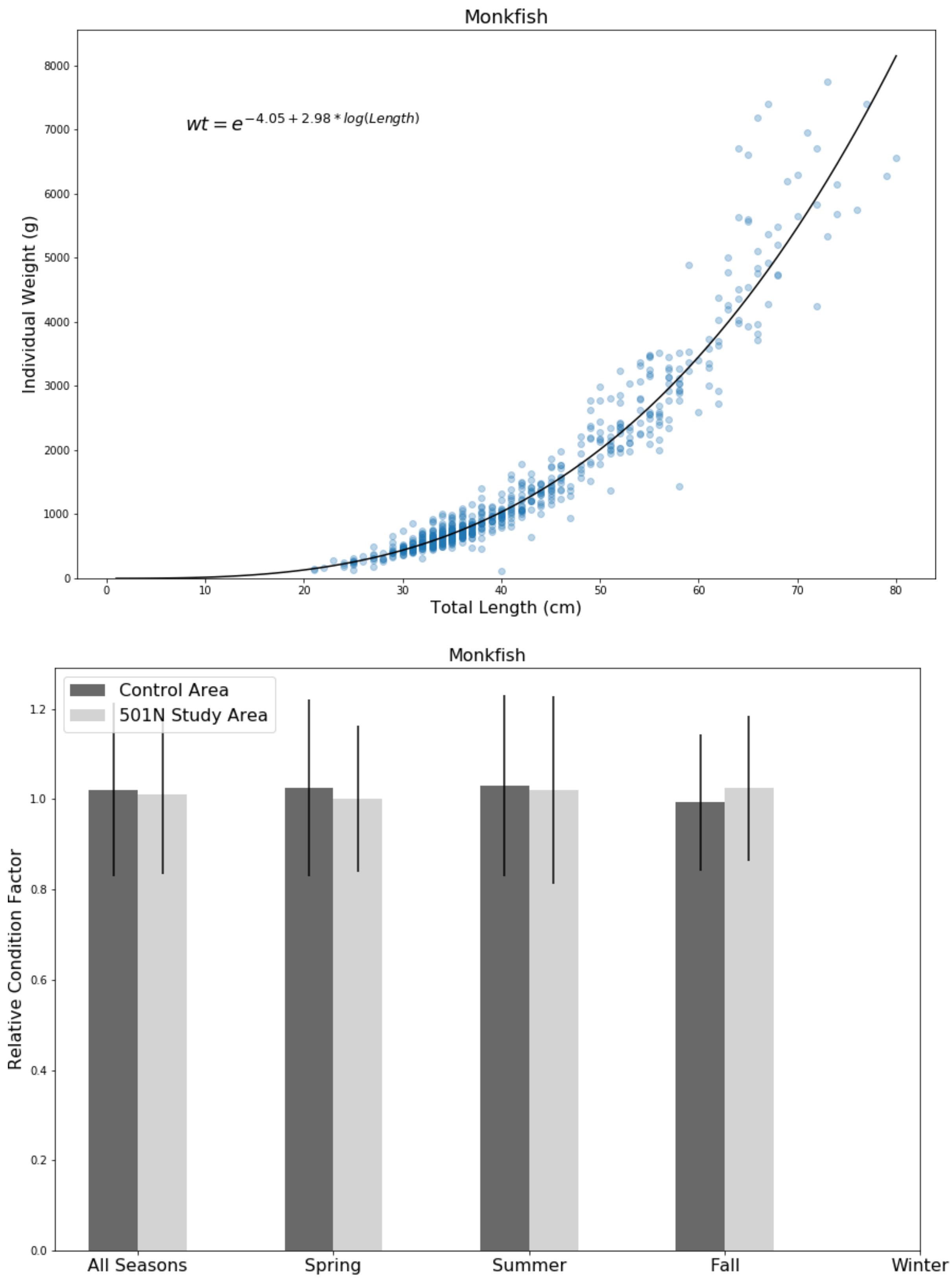


Figure 57: The seasonal condition of monkfish (bottom) as derived from the length-weight relationship (top).

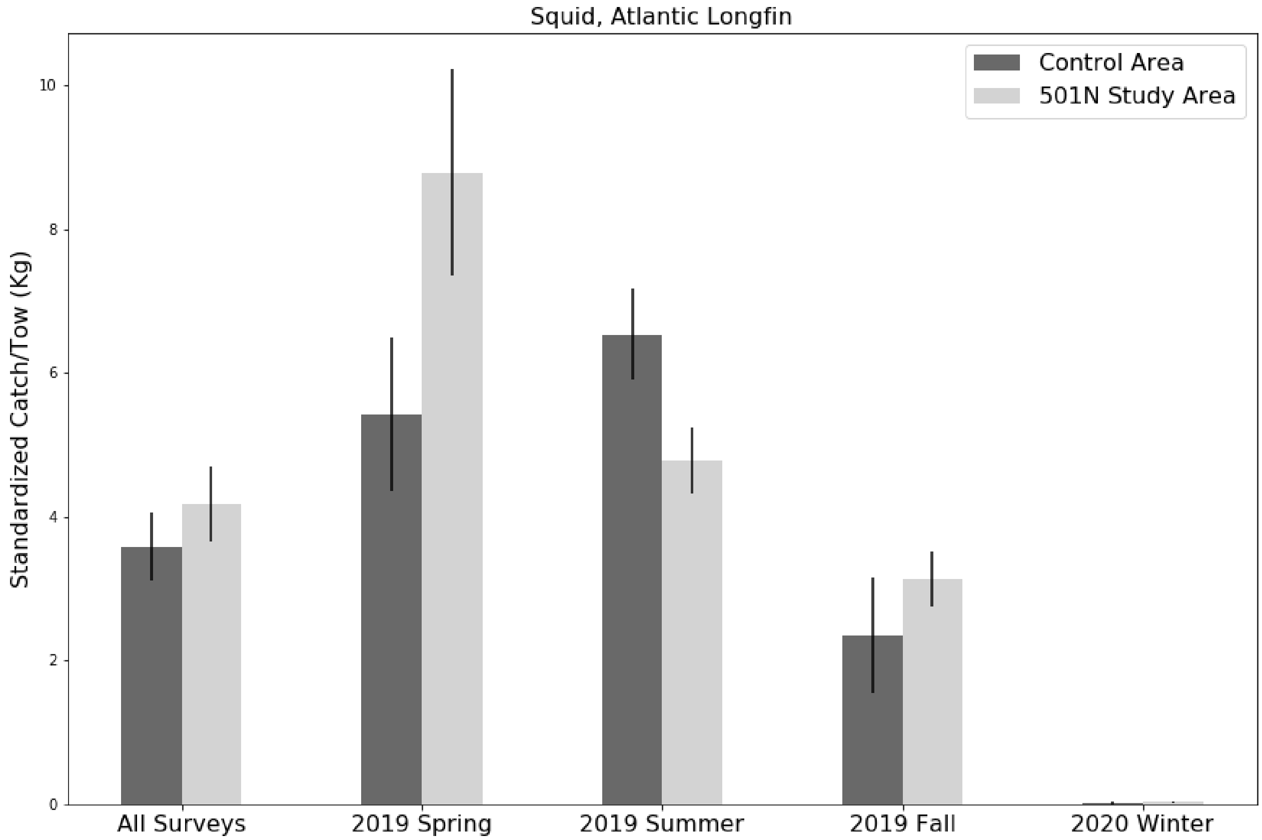


Figure 58: Seasonal catch rates of Atlantic longfin squid in the 501 North Study Area and Control Area.

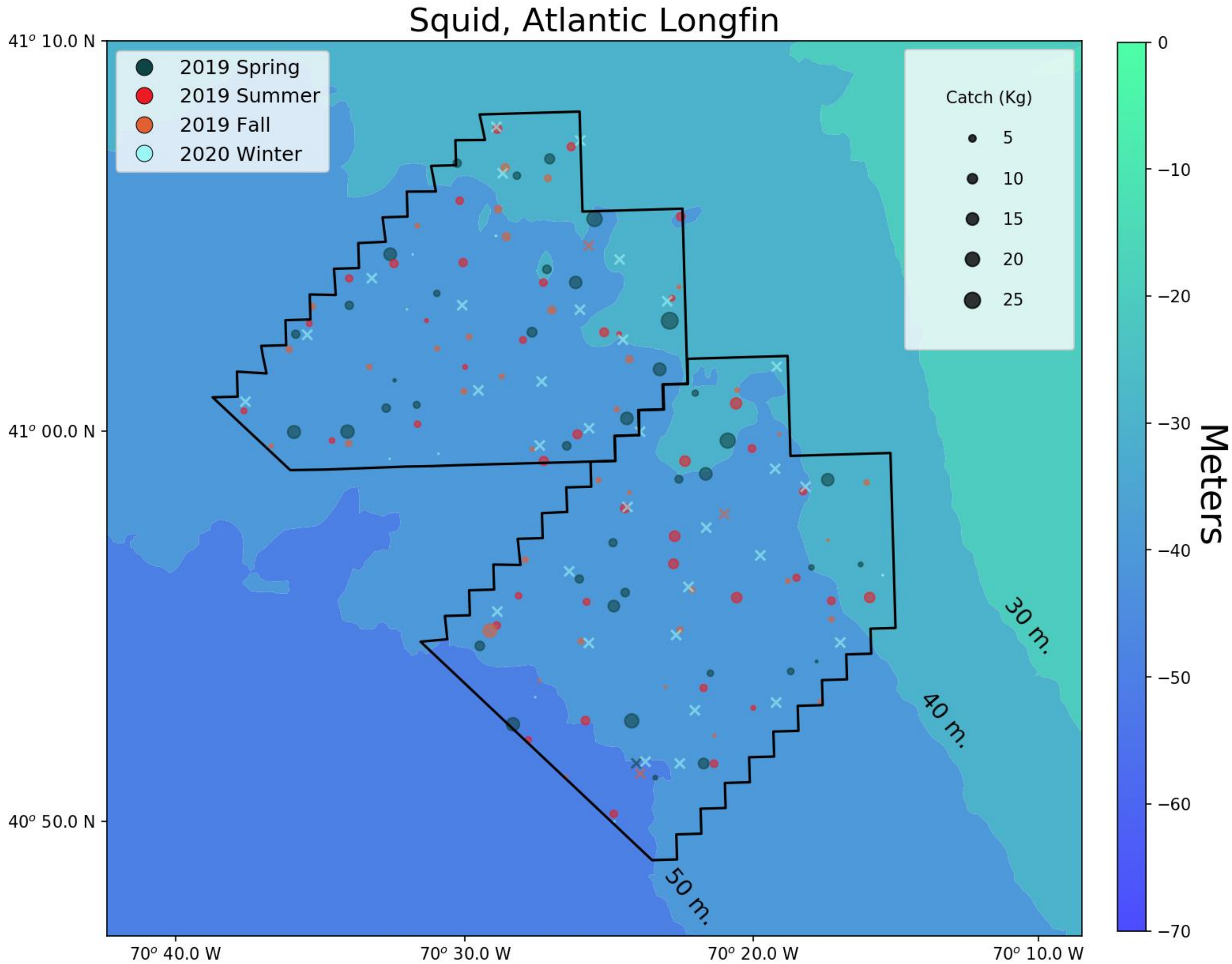


Figure 59: Seasonal distribution of the Atlantic longfin squid catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

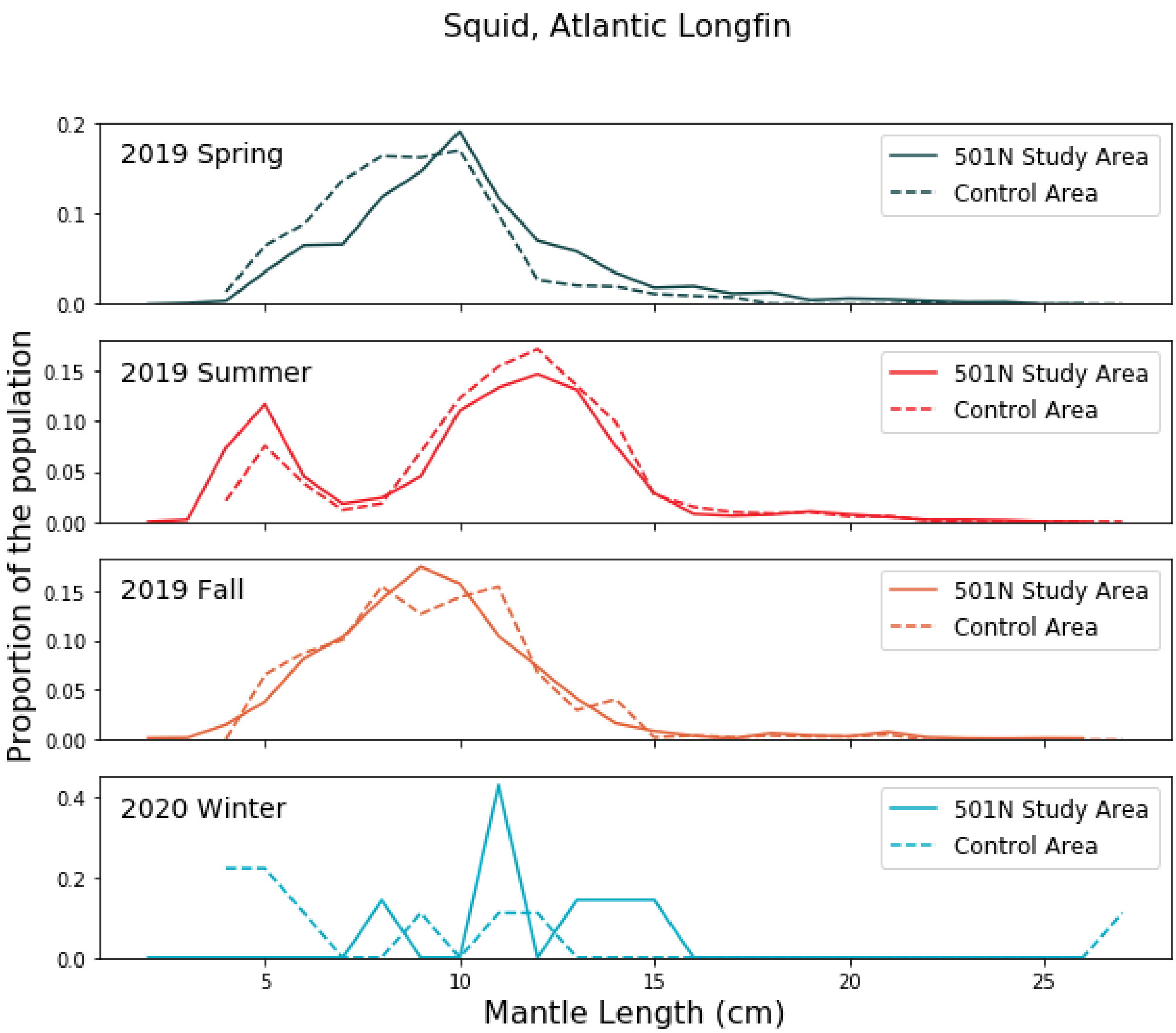


Figure 60: The seasonal length distributions of Atlantic longfin squid in the 501 North Study Area and Control Area.

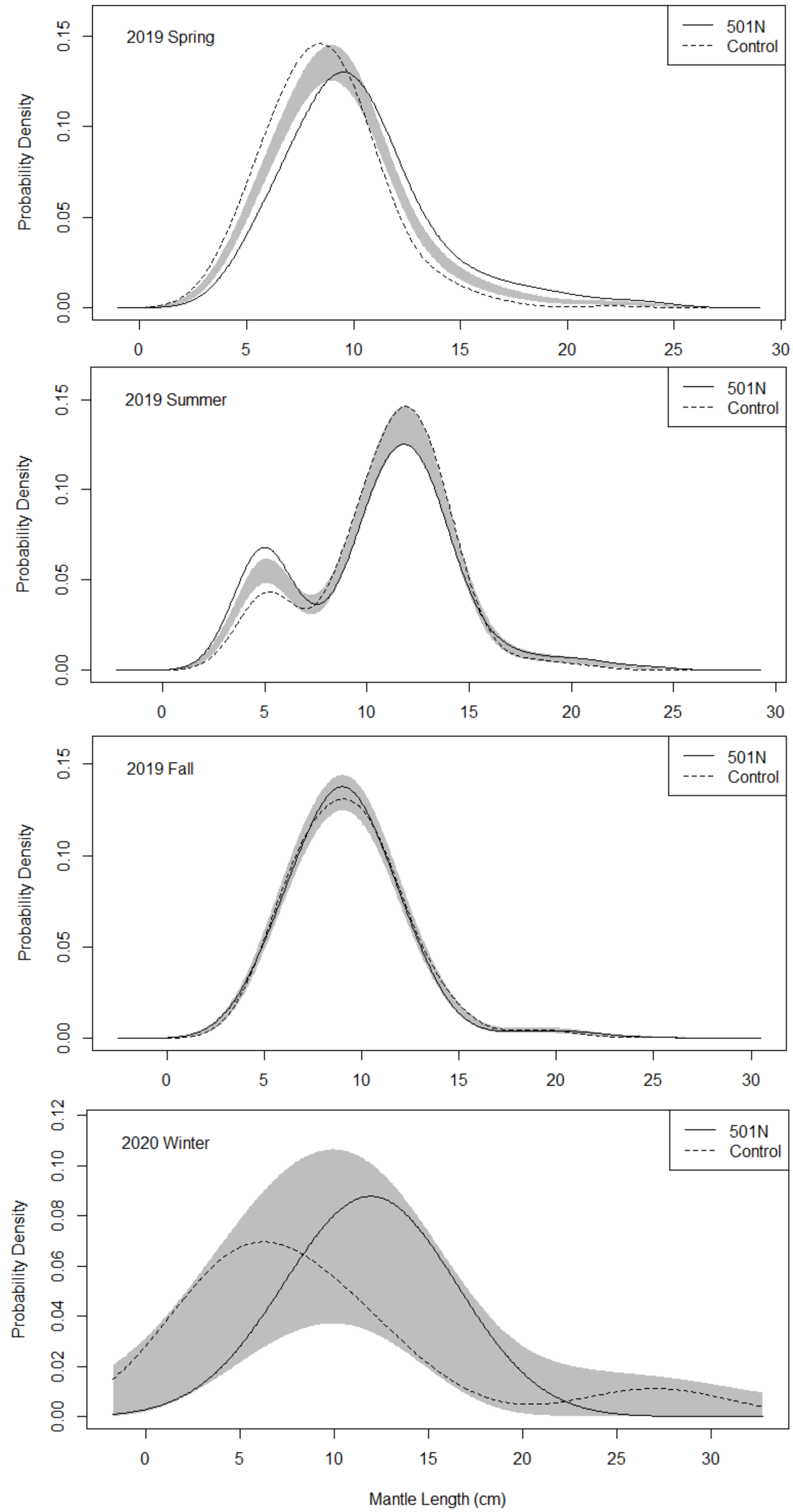
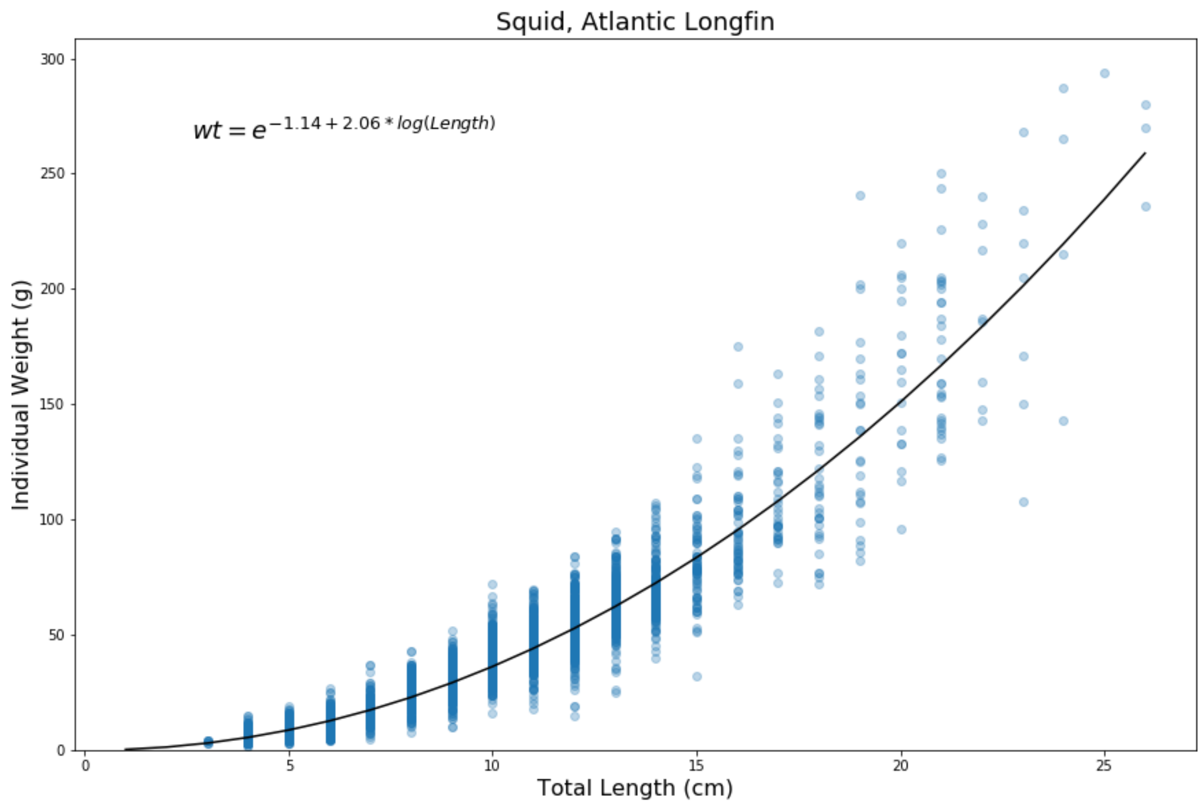


Figure 61: The population structure of Atlantic longfin squid in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



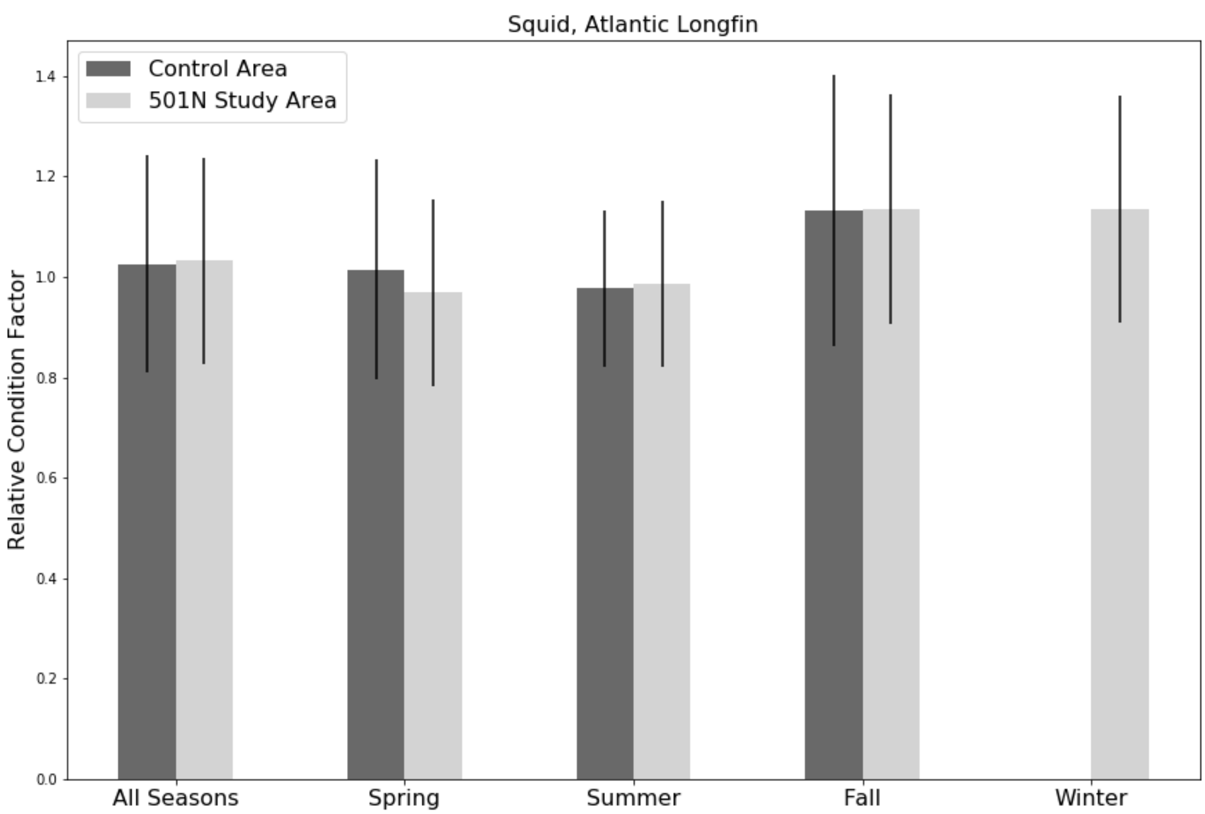


Figure 62: The seasonal condition of Atlantic longfin squid (bottom) as derived from the length-weight relationship (top).

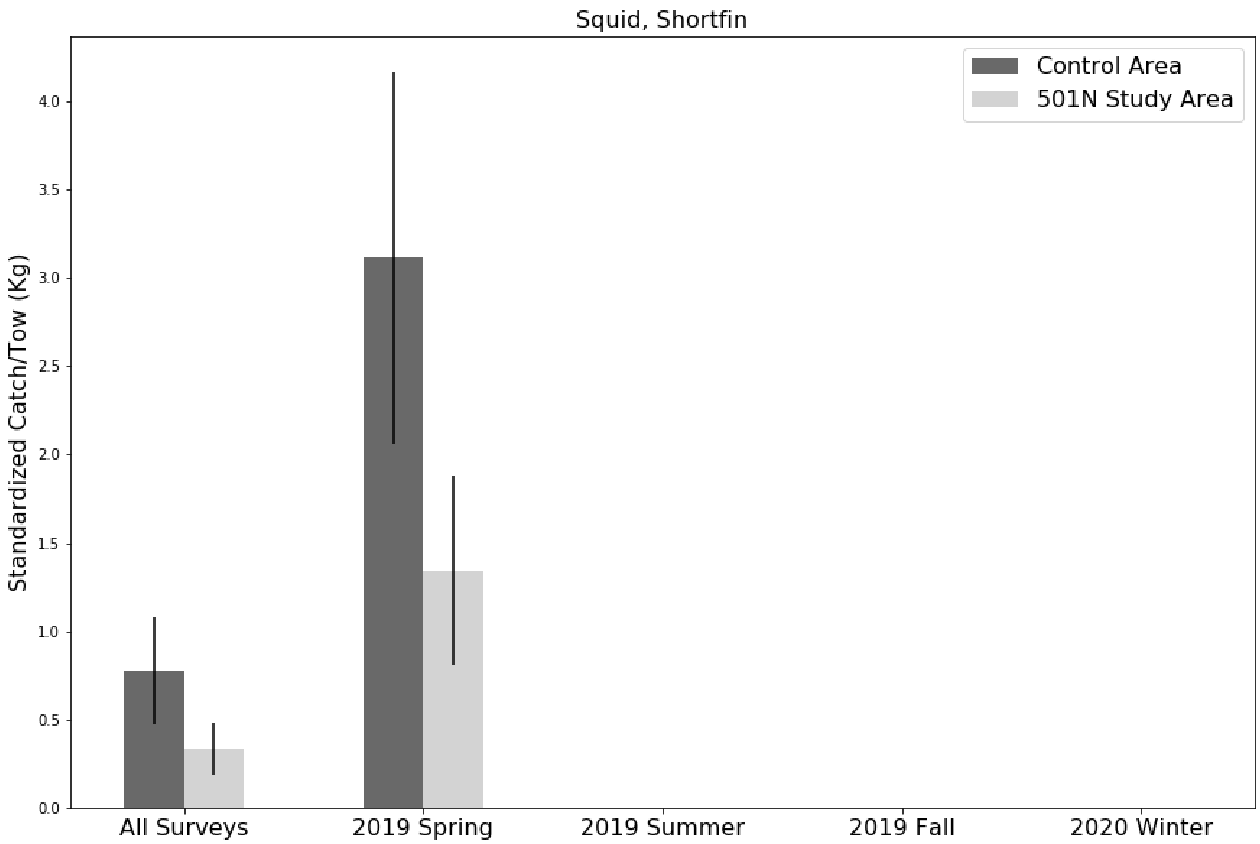


Figure 63: Seasonal catch rates of shortfin squid in the 501 North Study Area and Control Area.

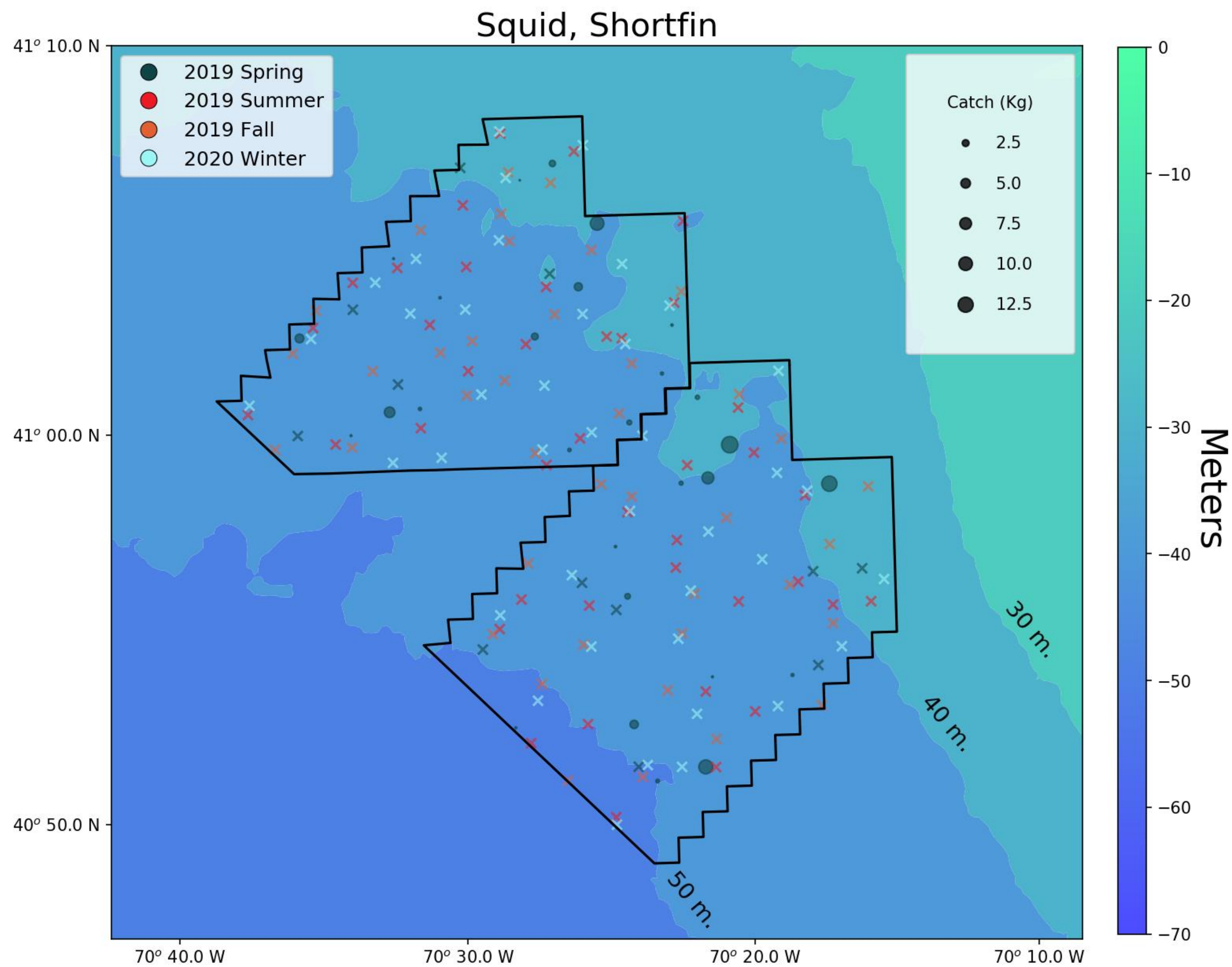


Figure 64: Seasonal distribution of the shortfin squid catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

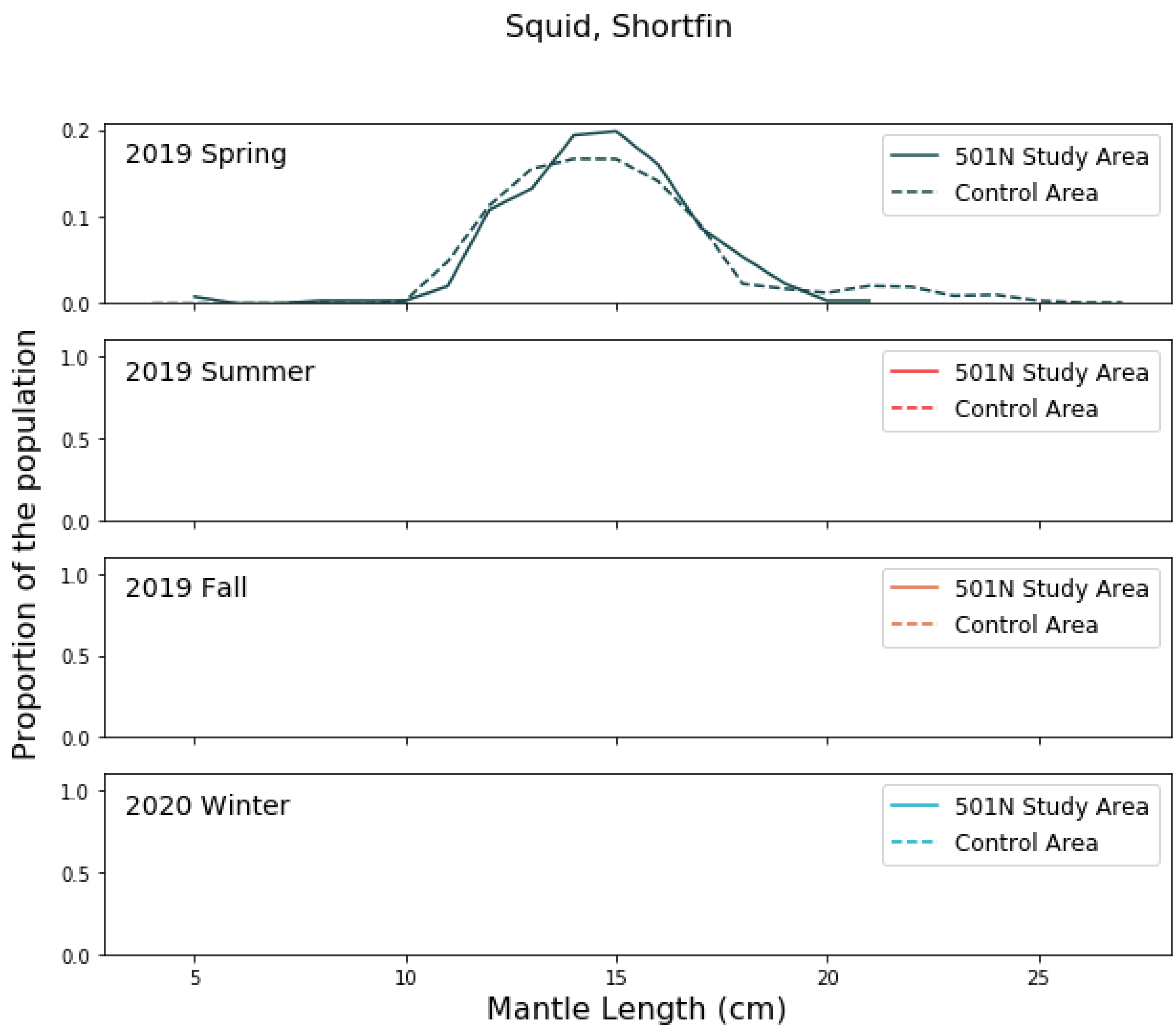


Figure 65: The seasonal length distributions of shortfin squid in the 501 North Study Area and Control Area.

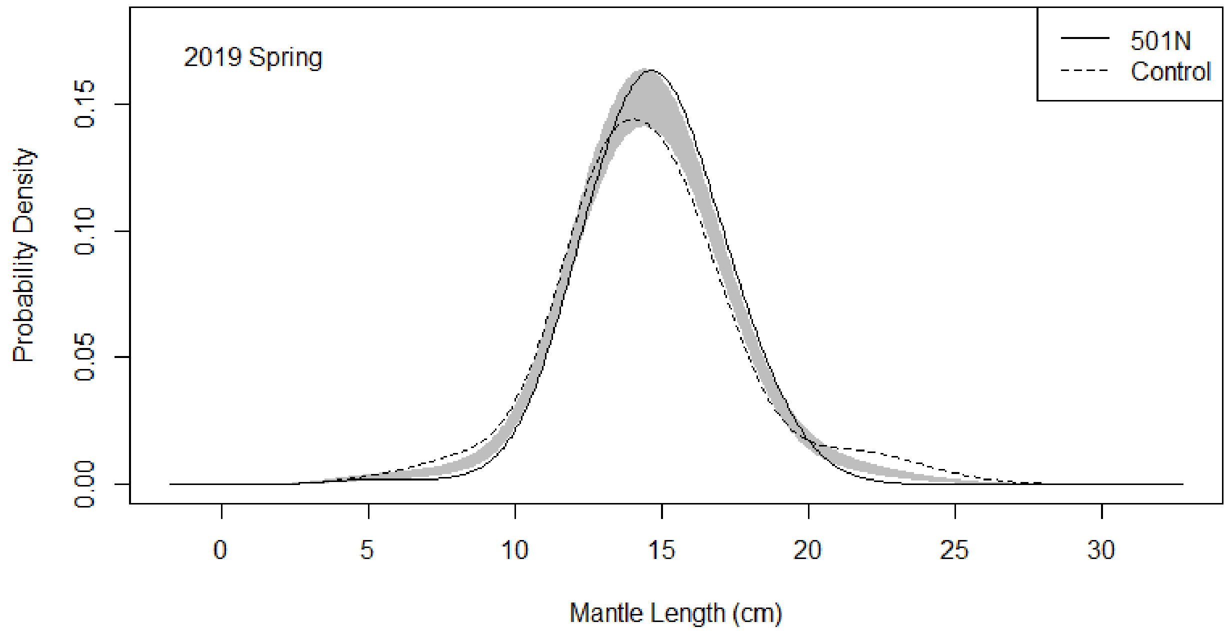
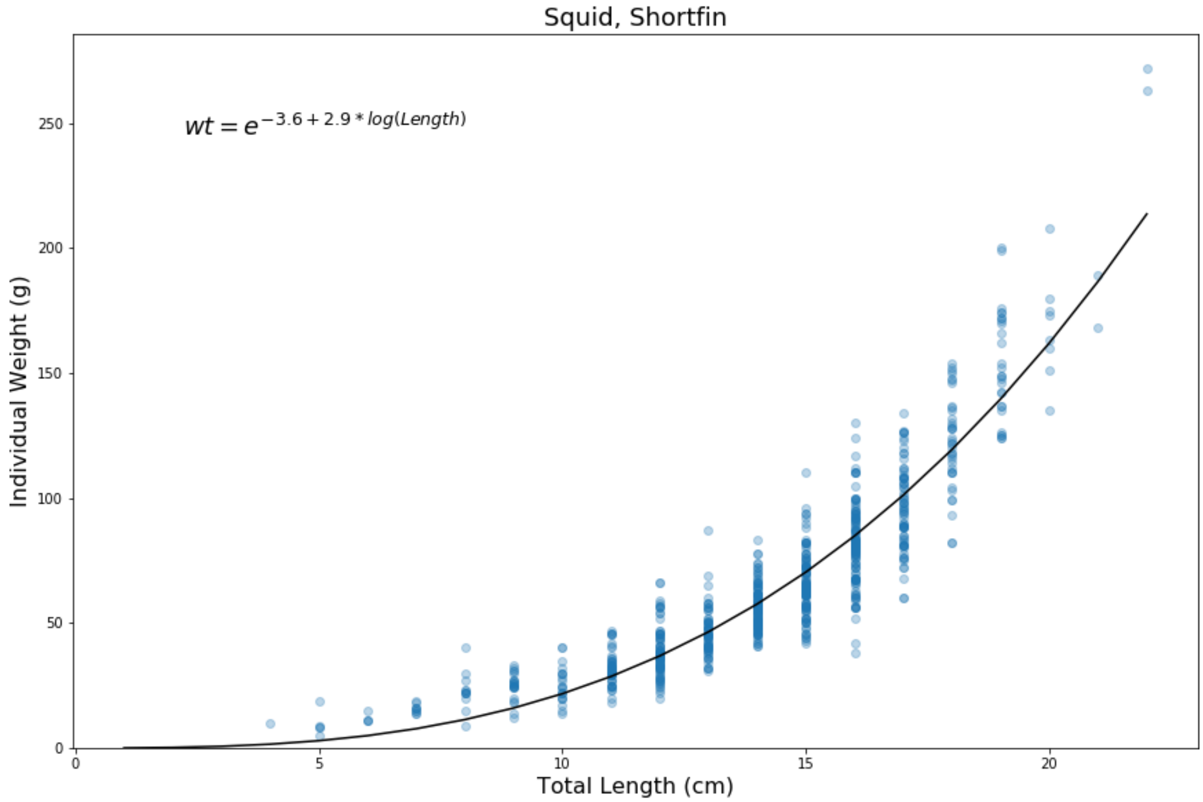


Figure 66: The population structure of shortfin squid in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



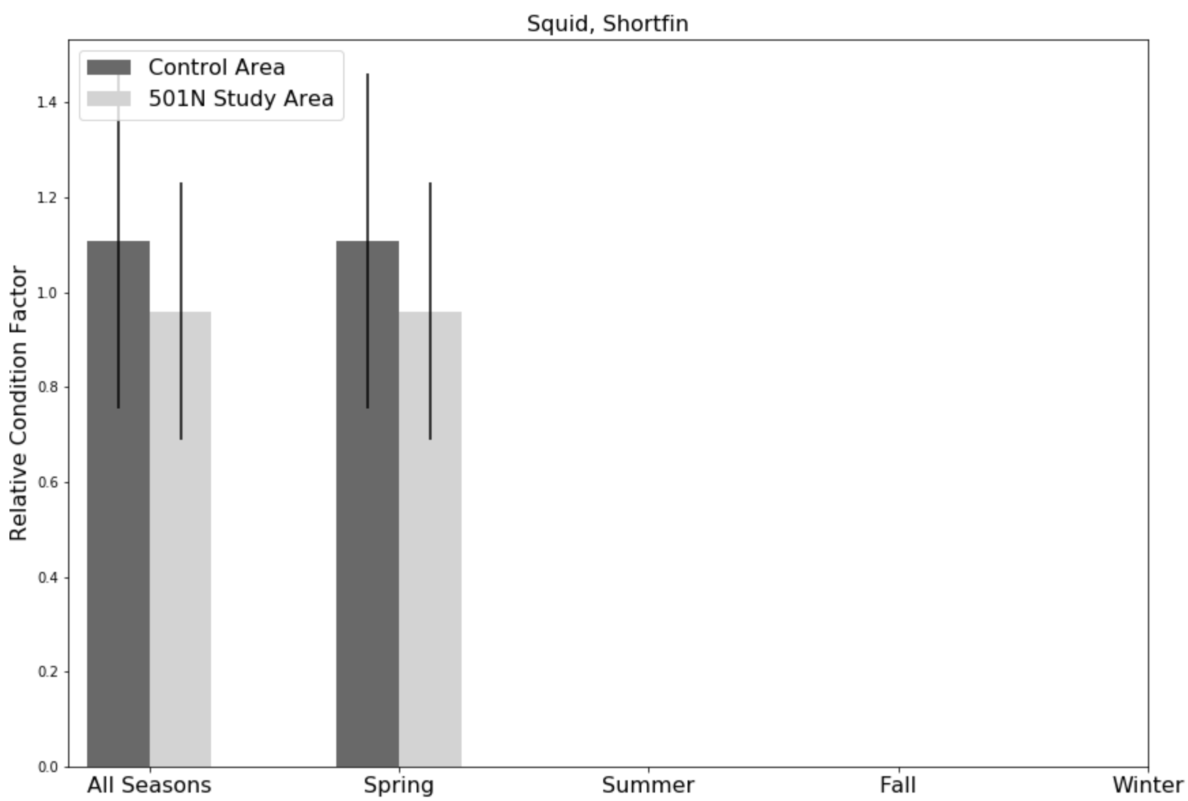


Figure 67: The seasonal condition of shortfin squid (bottom) as derived from the length-weight relationship (top).

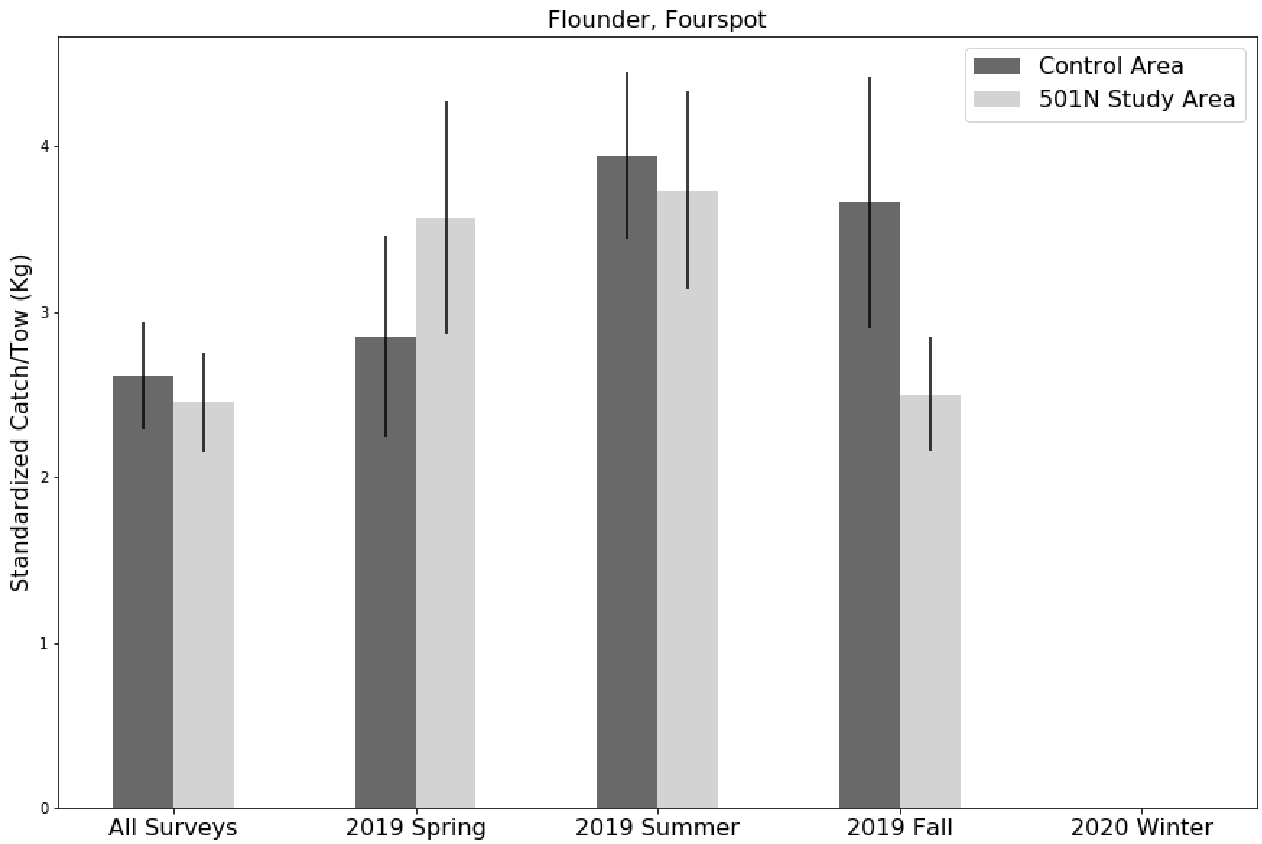


Figure 68: Seasonal catch rates of fourspot flounder in the 501 North Study Area and Control Area.

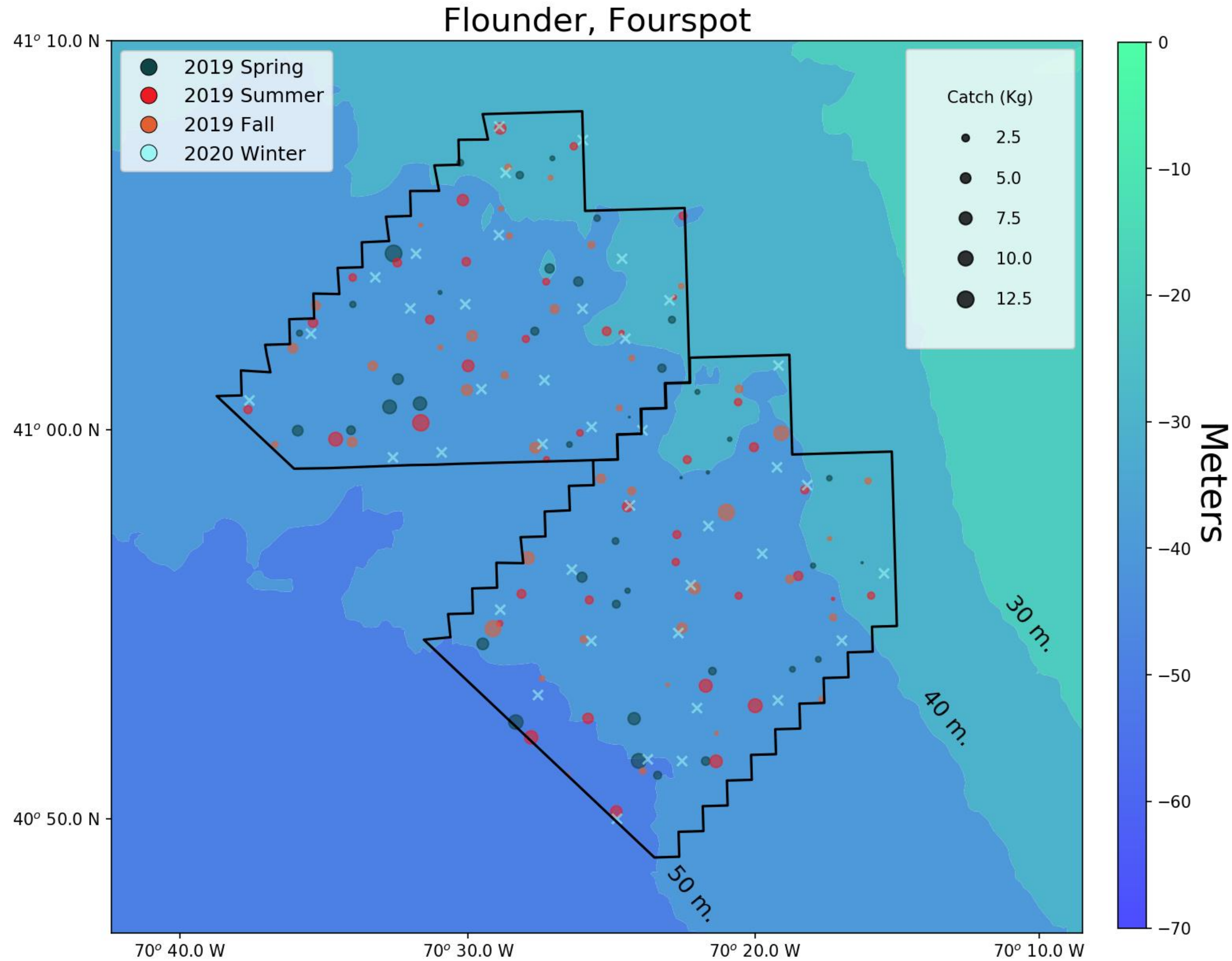


Figure 69: Seasonal distribution of the fourspot flounder catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

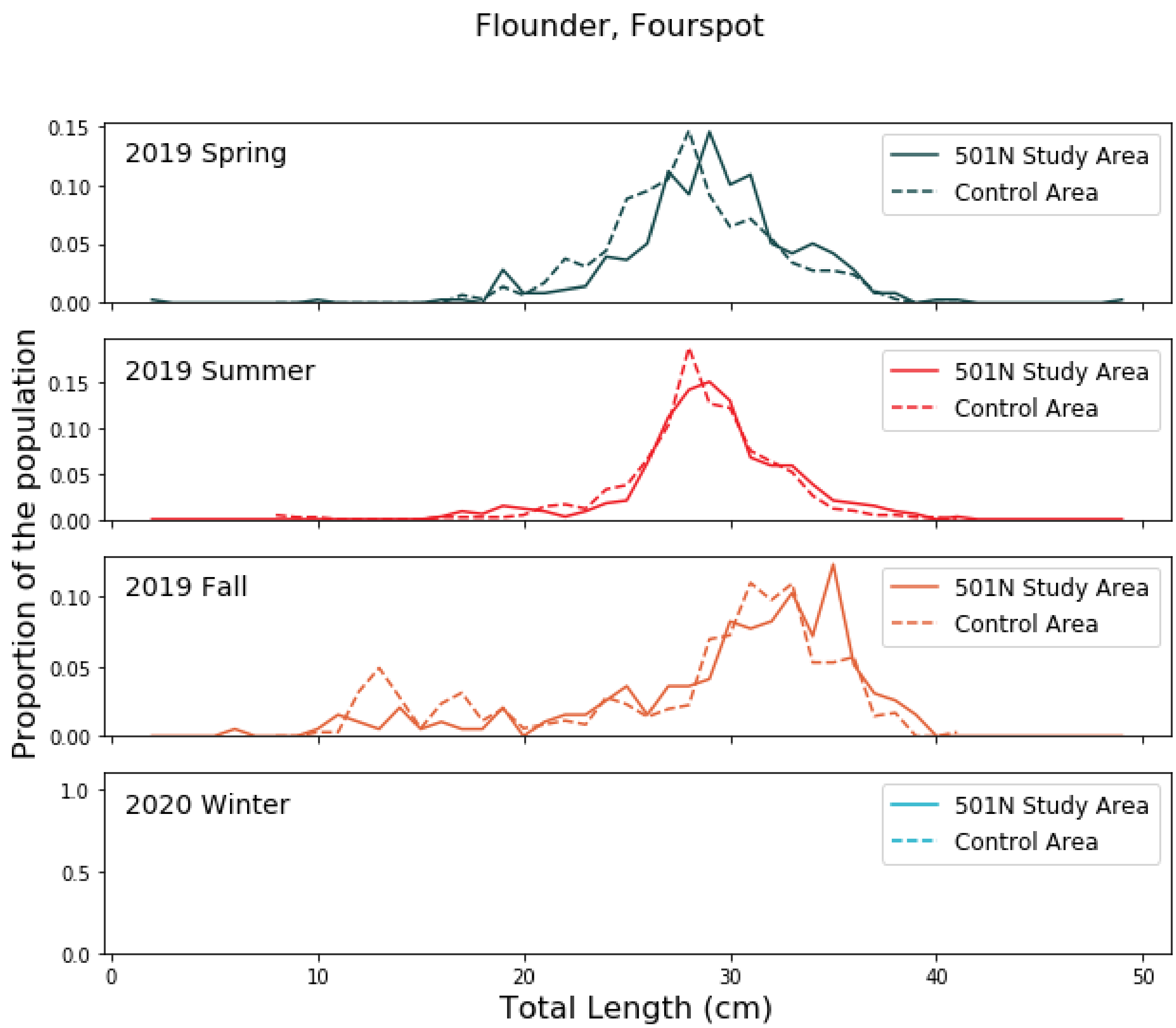


Figure 70: The seasonal length distributions of fourspot flounder in the 501 North Study Area and Control Area.

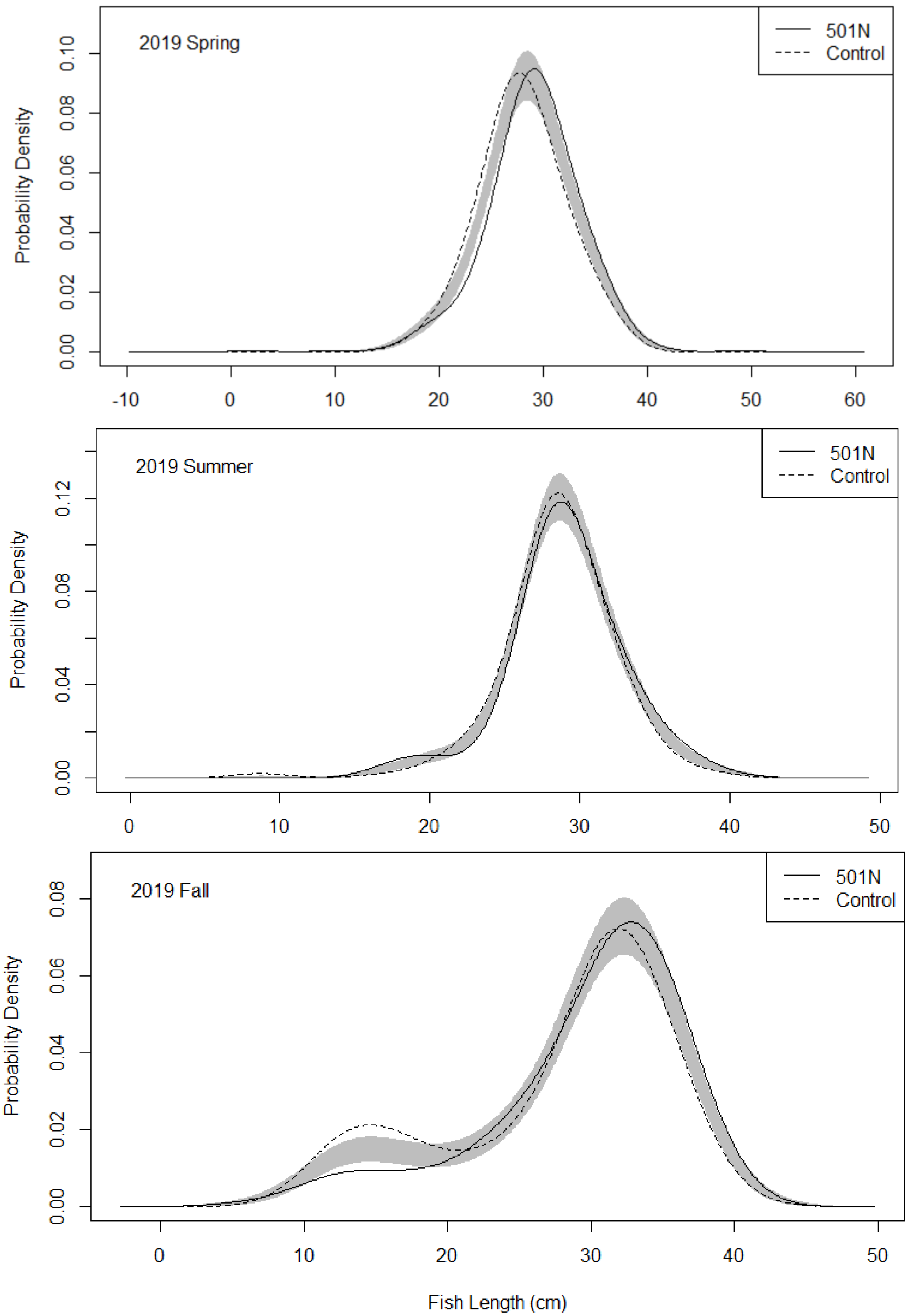
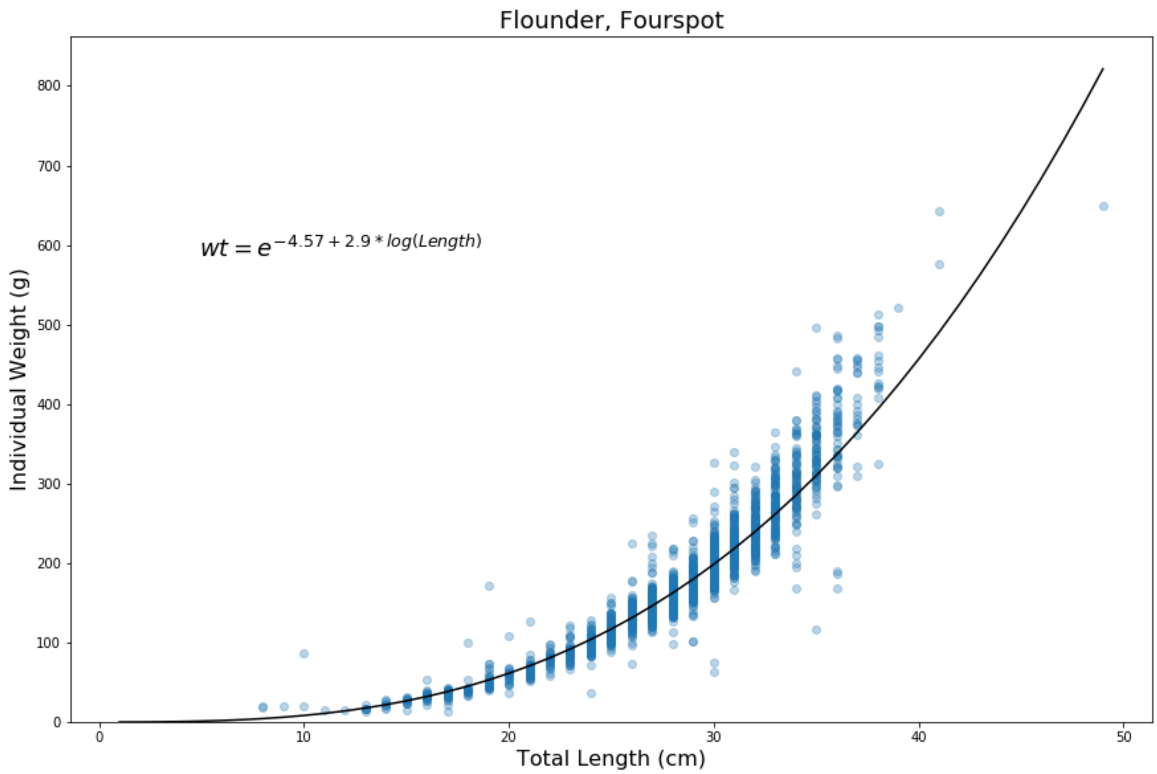


Figure 71: The population structure of fourspot flounder in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



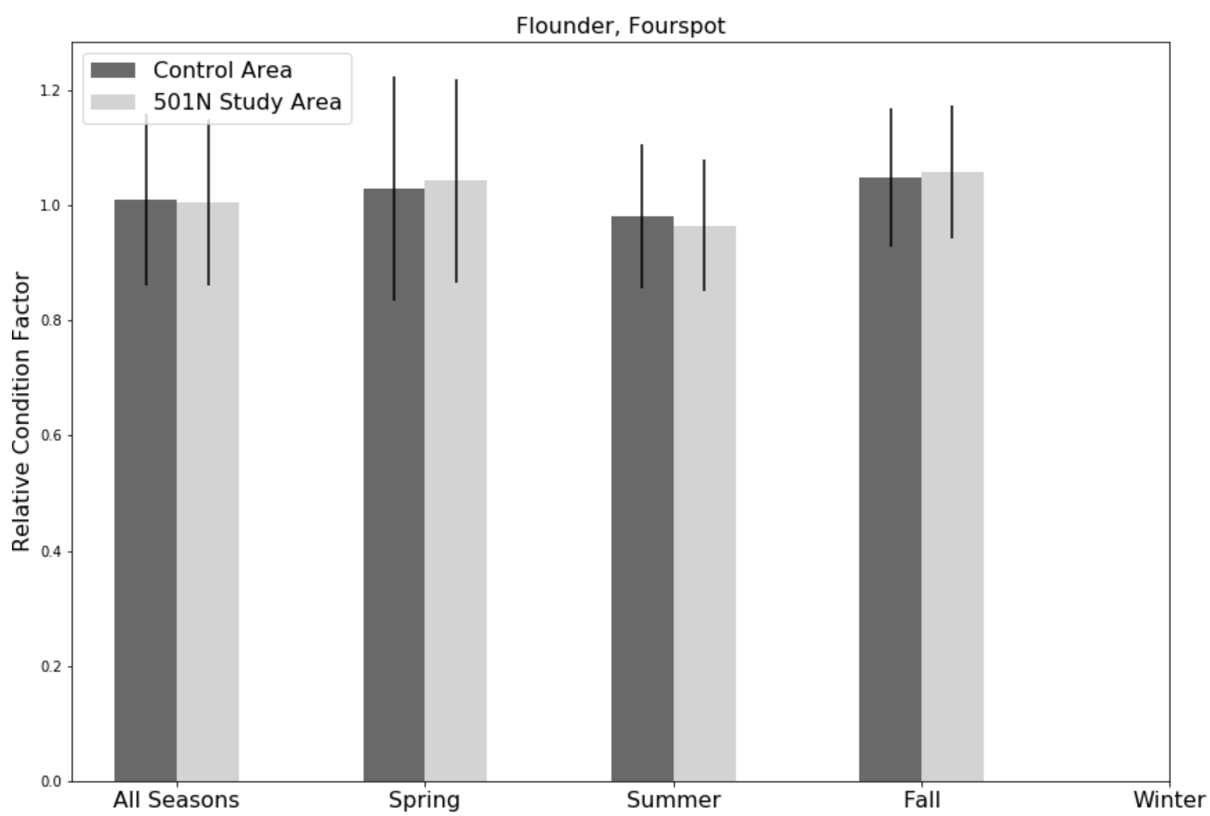


Figure 72: The seasonal condition of fourspot flounder (bottom) as derived from the length-weight relationship (top).

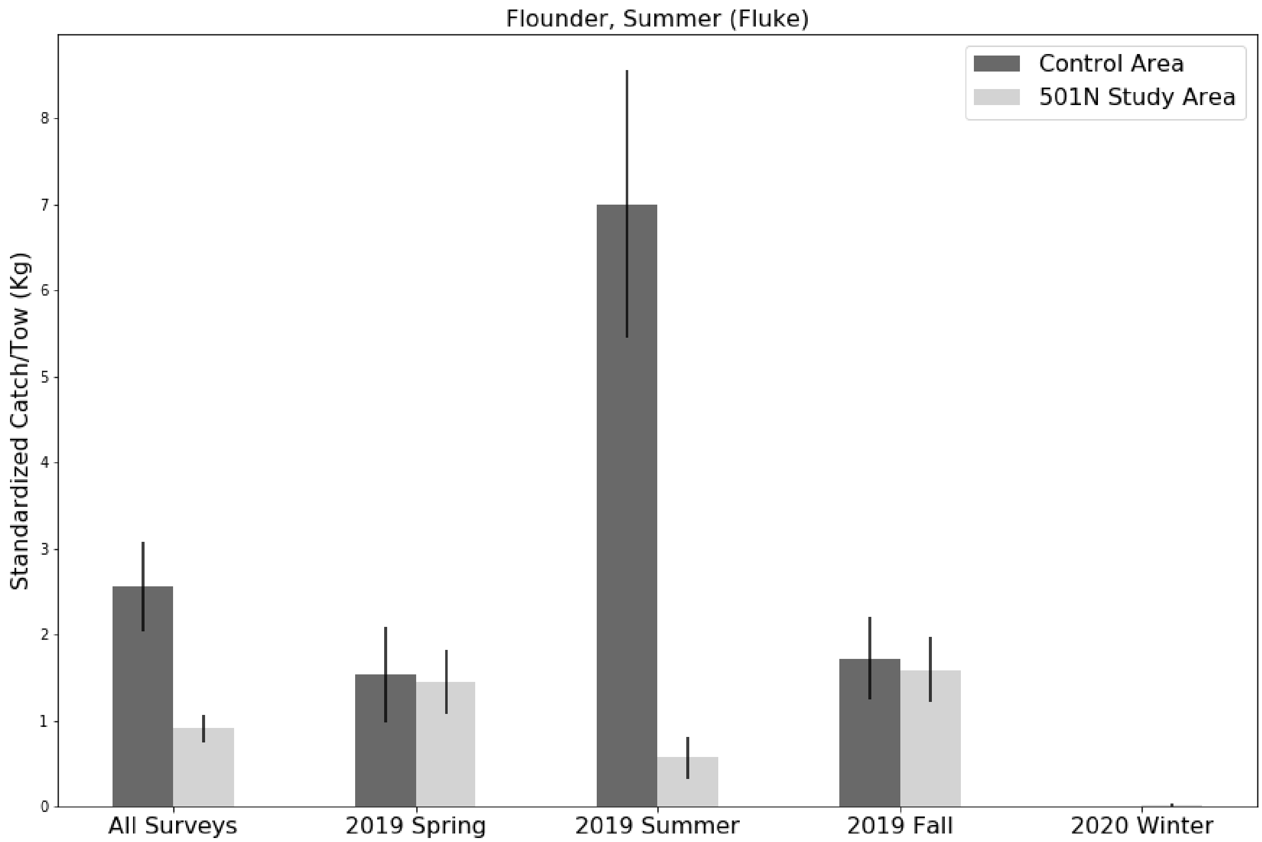


Figure 73: Seasonal catch rates of summer flounder in the 501 North Study Area and Control Area.

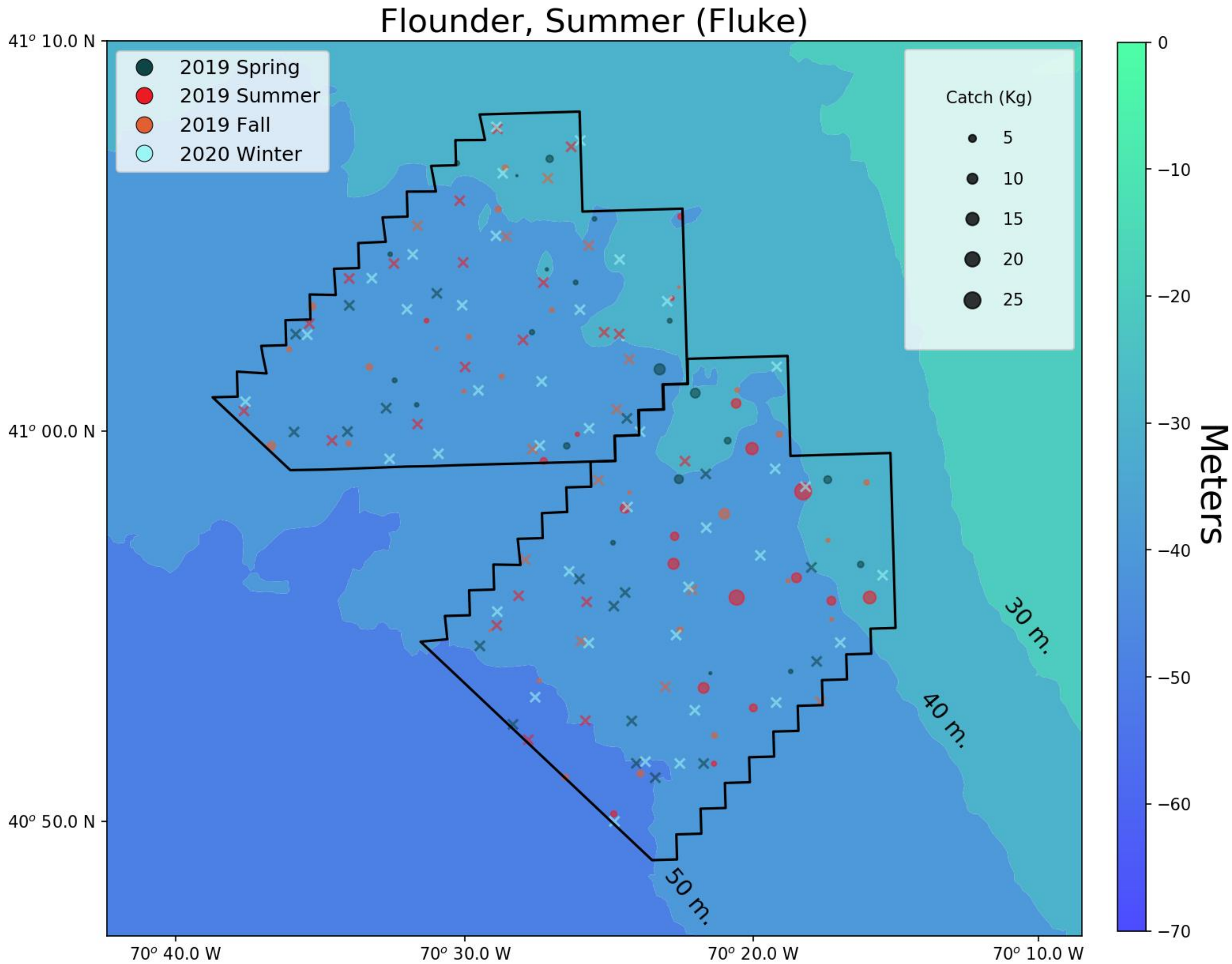


Figure 74: Seasonal distribution of the summer flounder catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

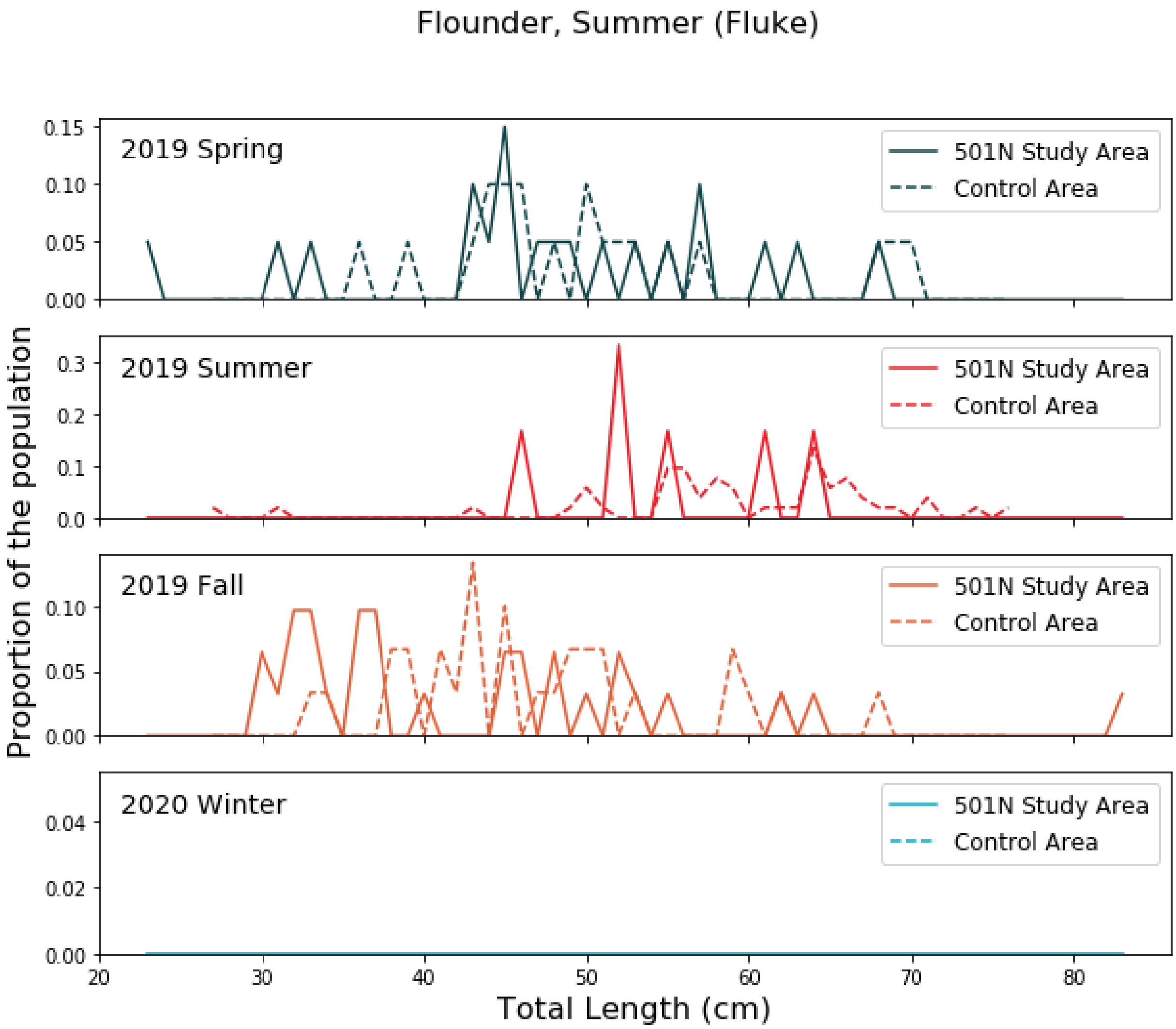


Figure 75: The seasonal length distributions of summer flounder in the 501 North Study Area and Control Area.

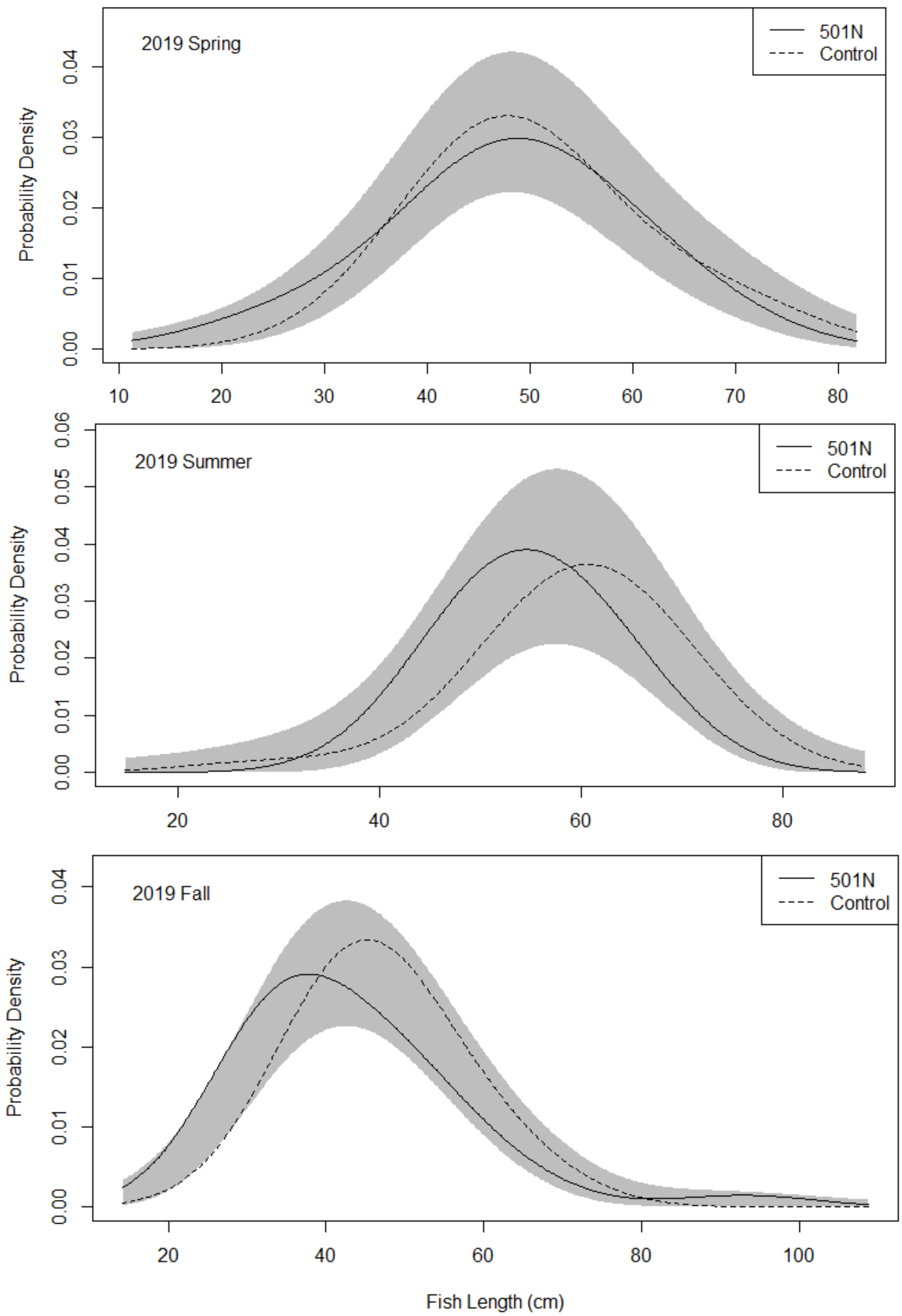


Figure 76: The population structure of summer flounder in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.

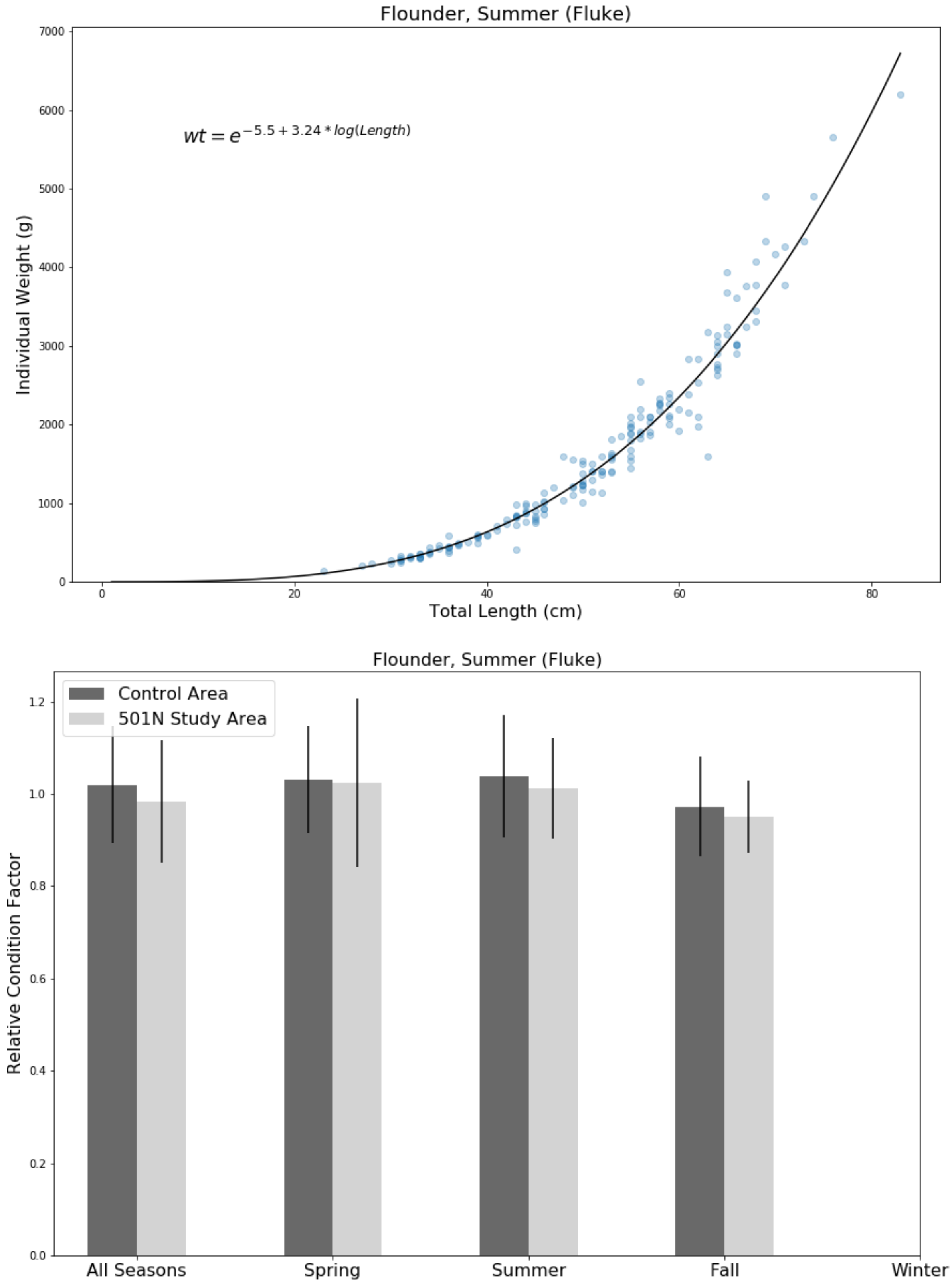


Figure 77: The seasonal condition of summer flounder (bottom) as derived from the length-weight relationship (top).

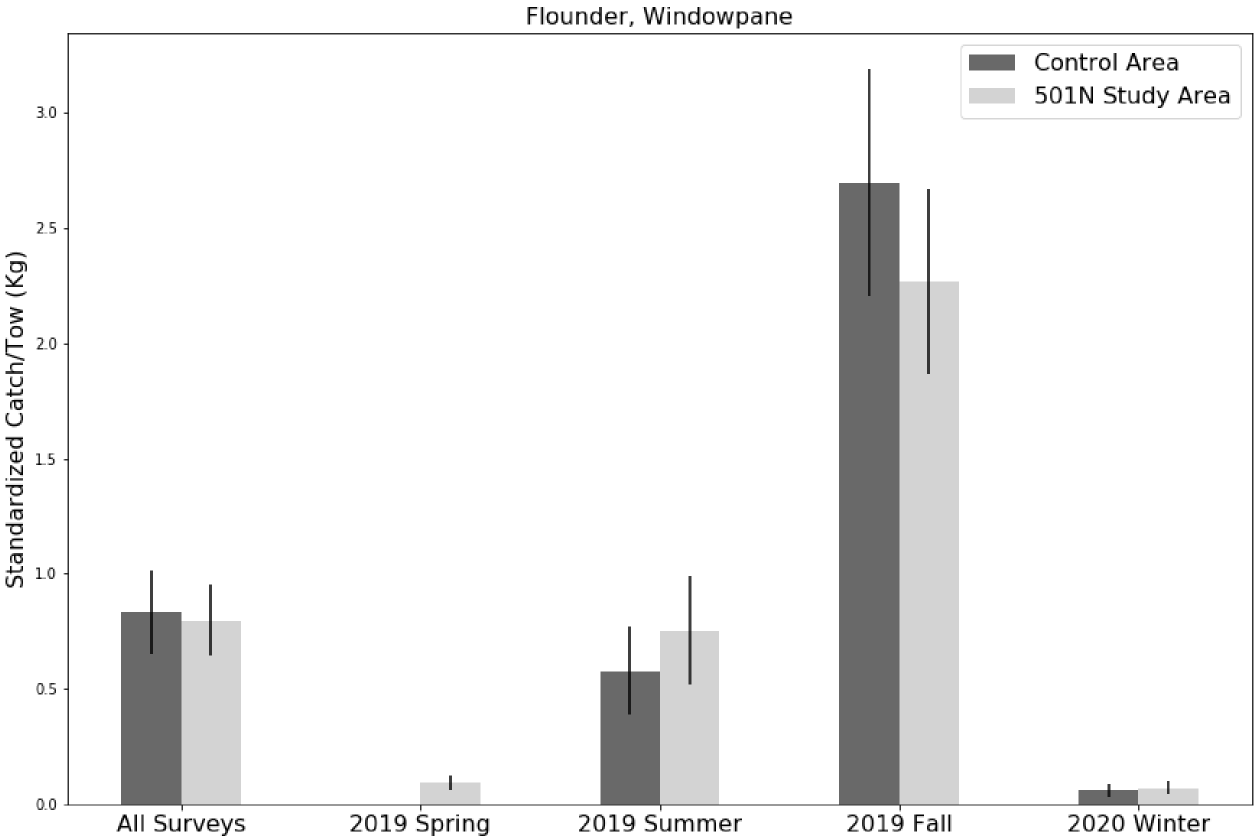


Figure 78: Seasonal catch rates of windowpane flounder in the 501 North Study Area and Control Area.

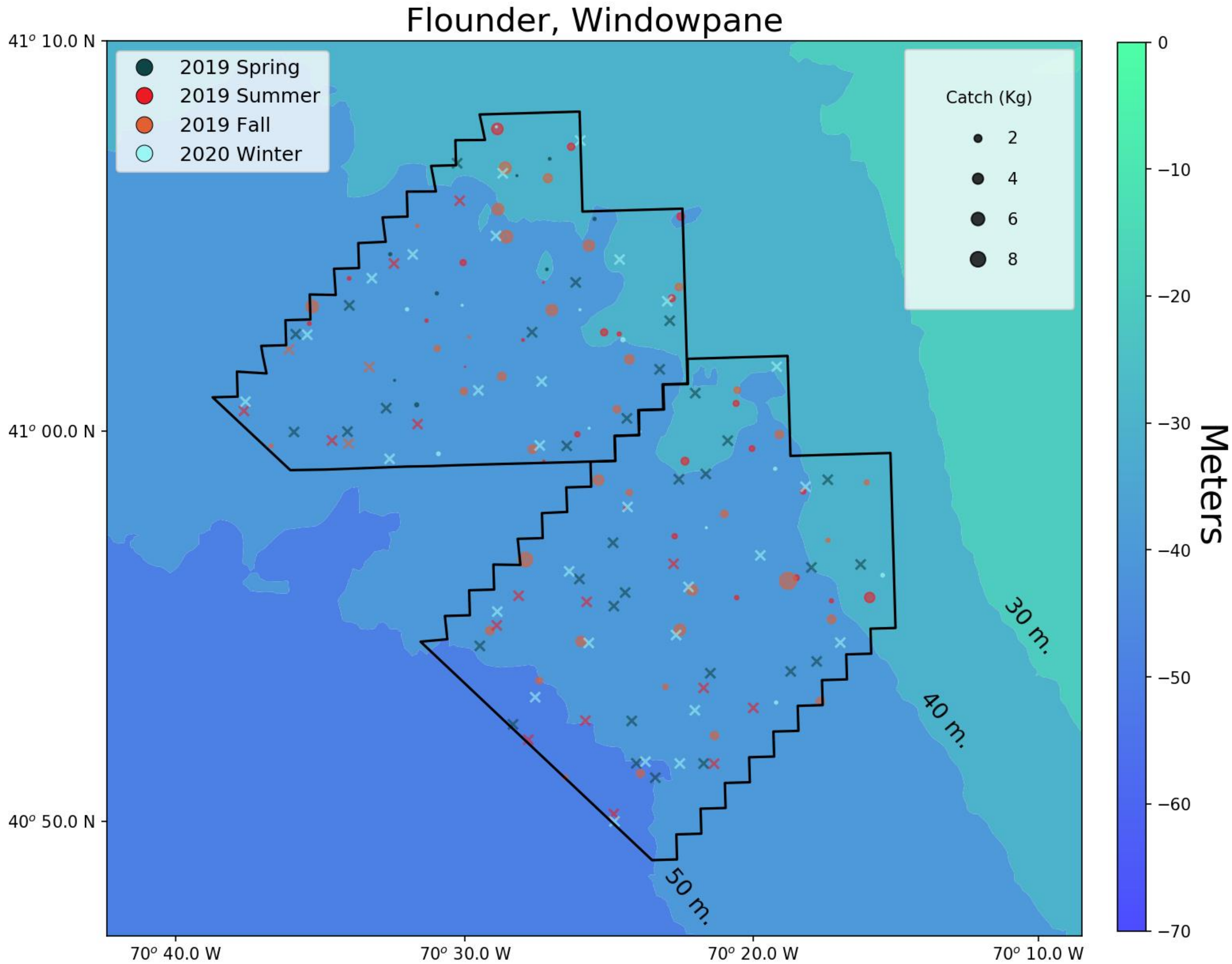


Figure 79: Seasonal distribution of the windowpane flounder catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

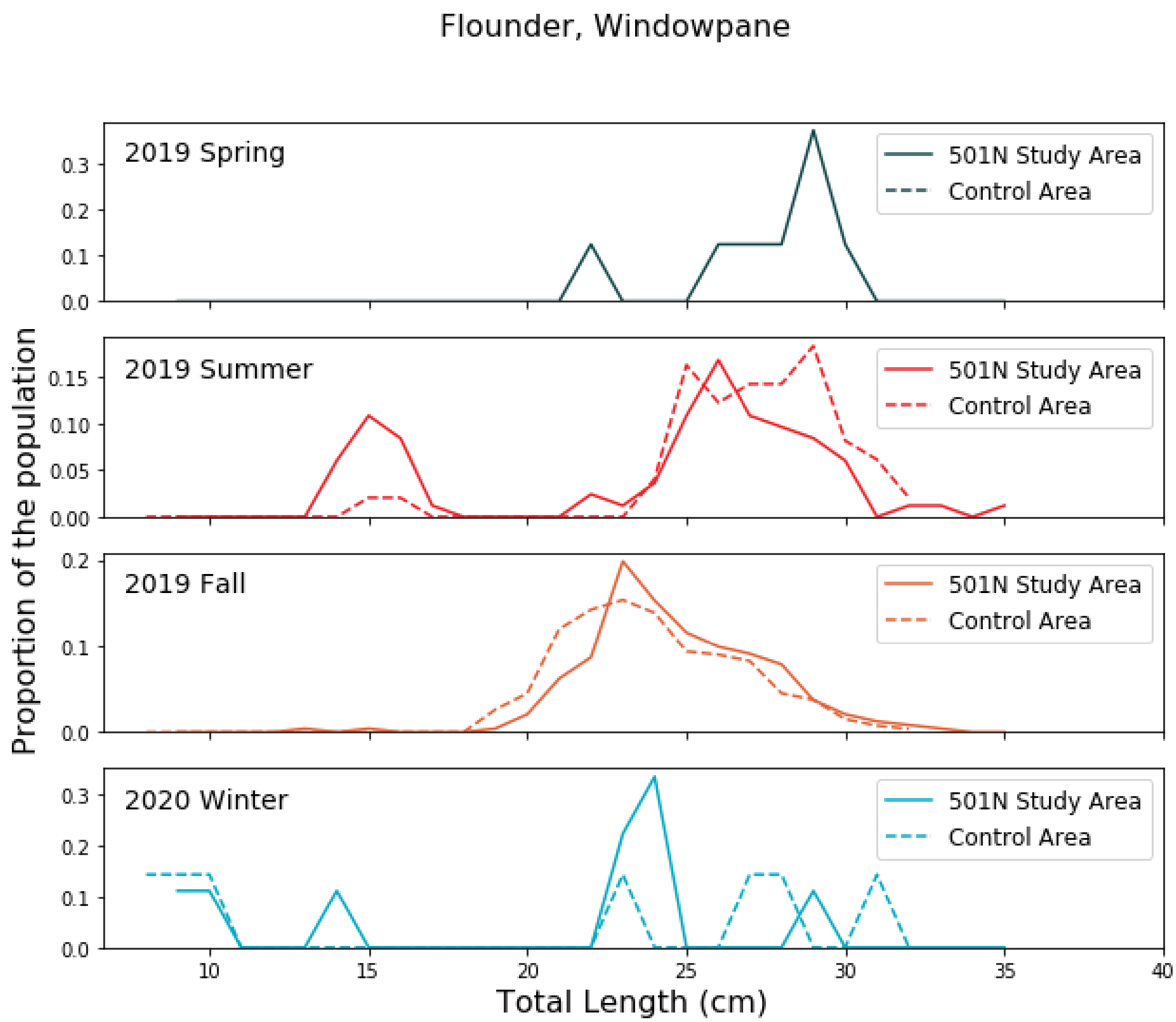


Figure 80: The seasonal length distributions of windowpane flounder in the 501 North Study Area and Control Area.

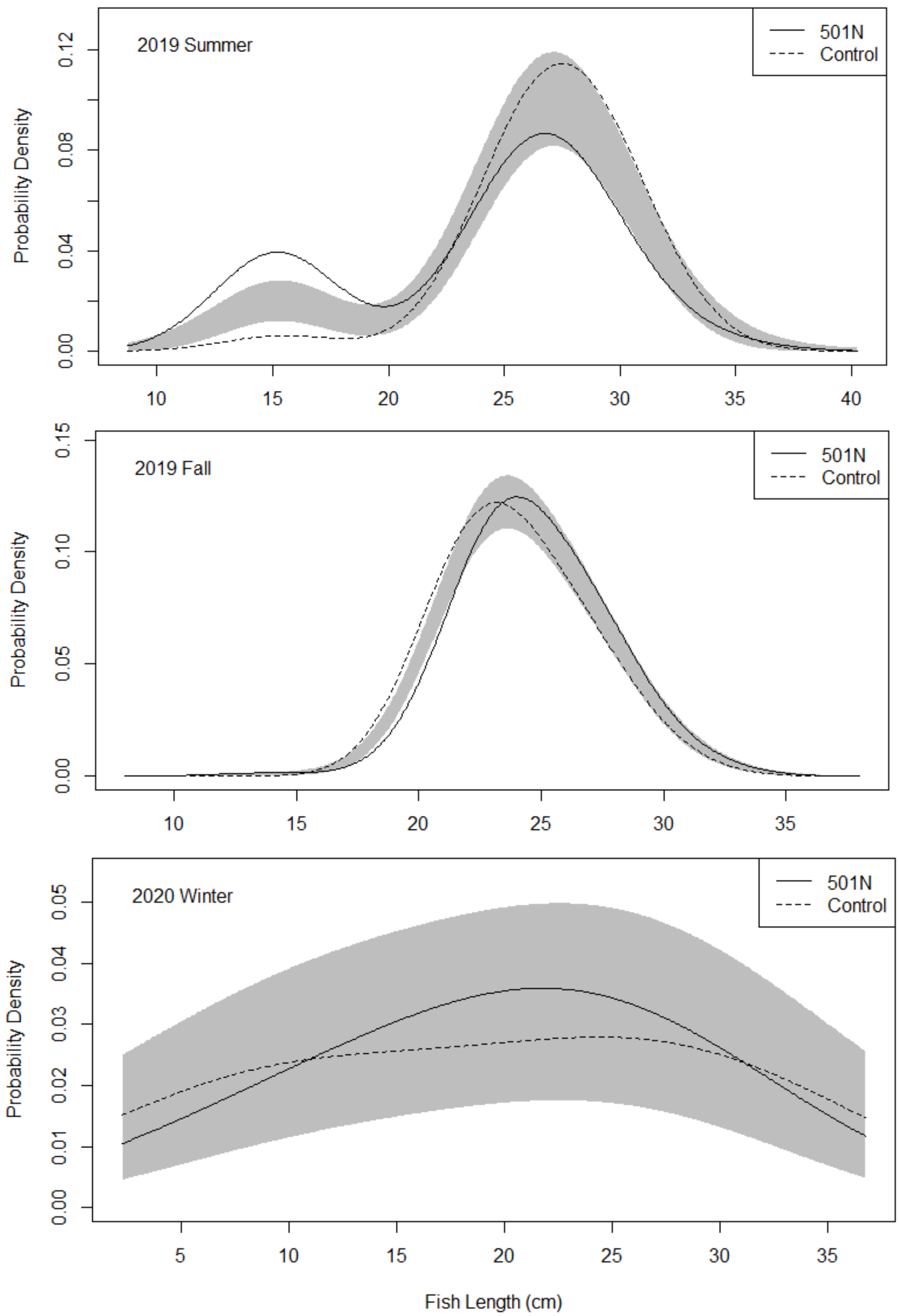


Figure 81: The population structure of windowpane flounder in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.

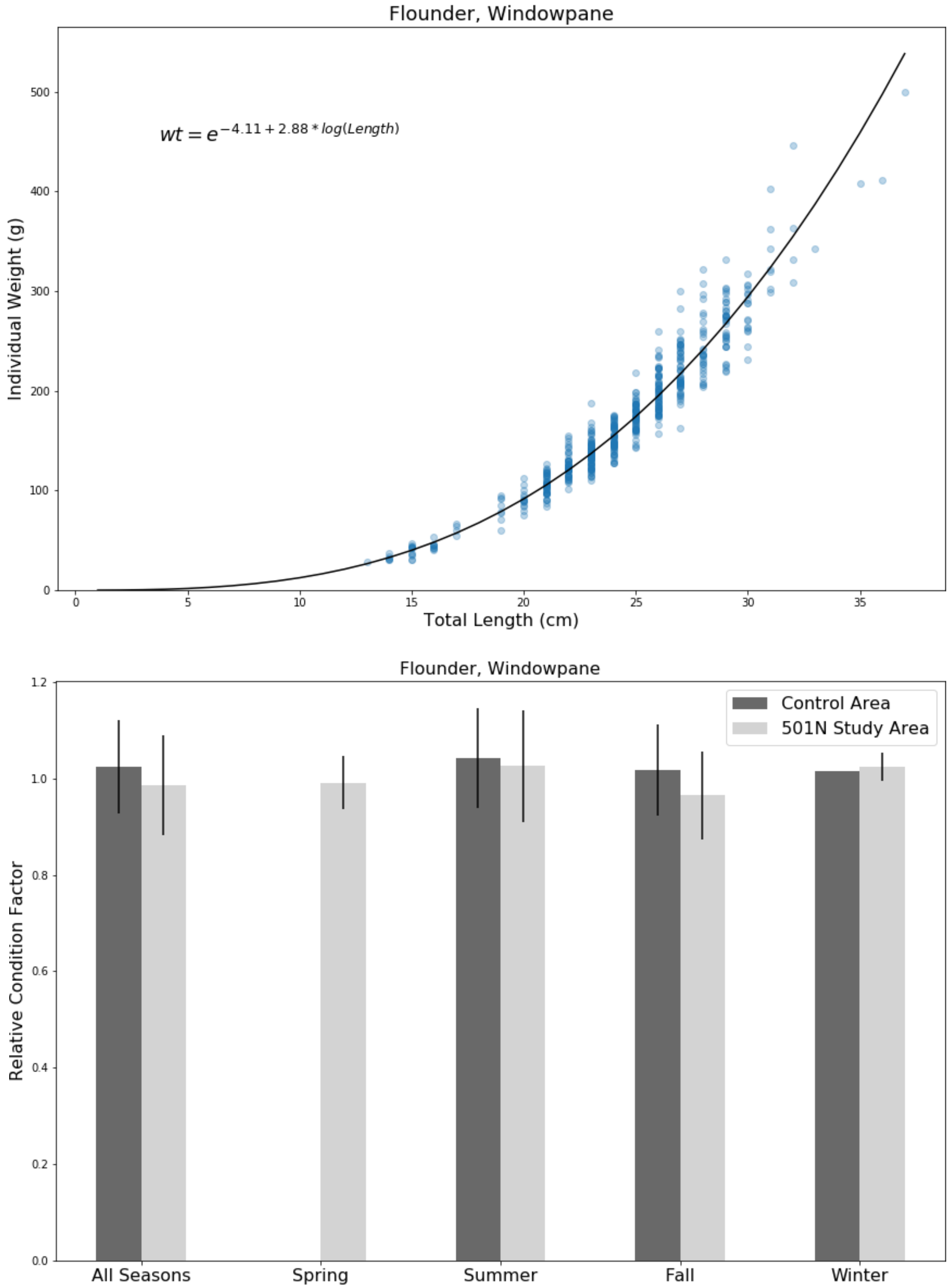


Figure 82: The seasonal condition of windowpane flounder (bottom) as derived from the length-weight relationship (top).

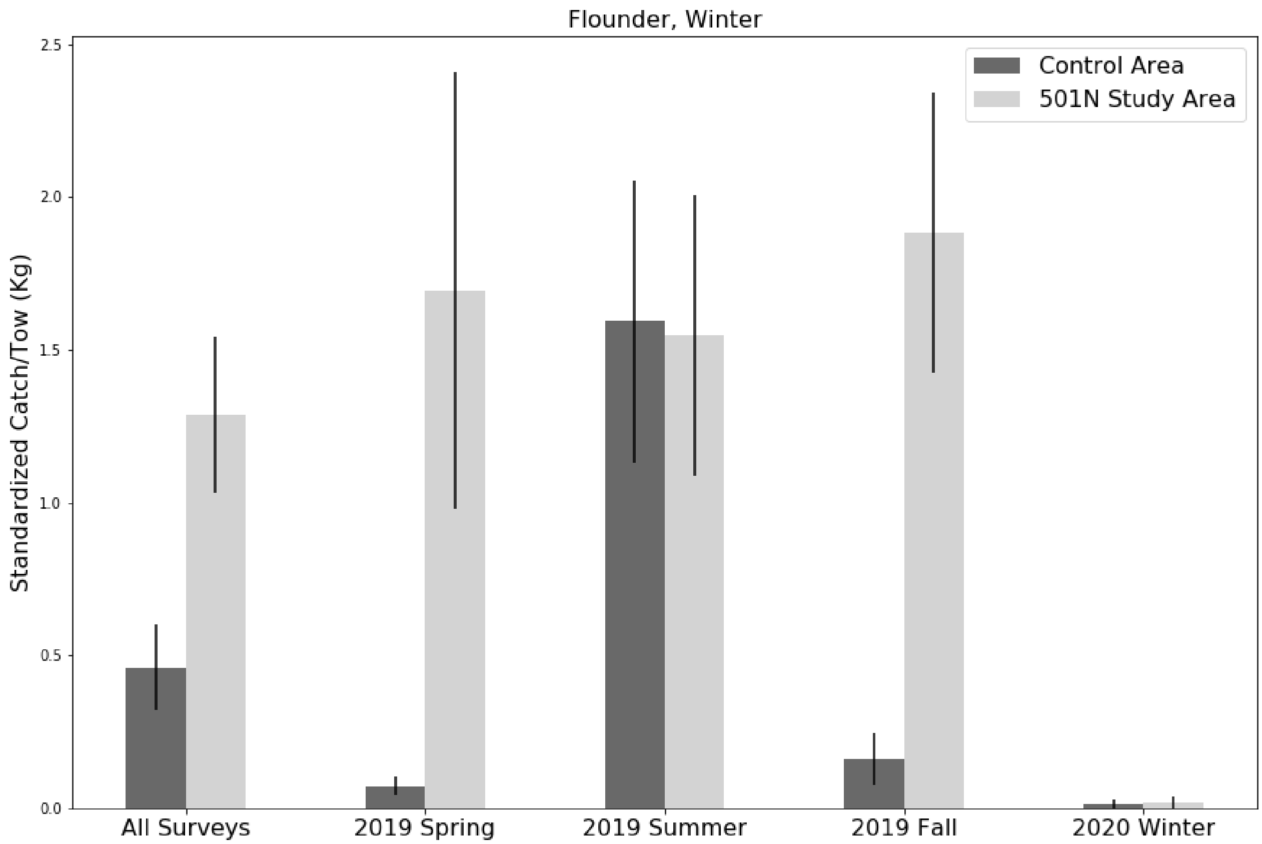


Figure 83: Seasonal catch rates of winter flounder in the 501 North Study Area and Control Area.

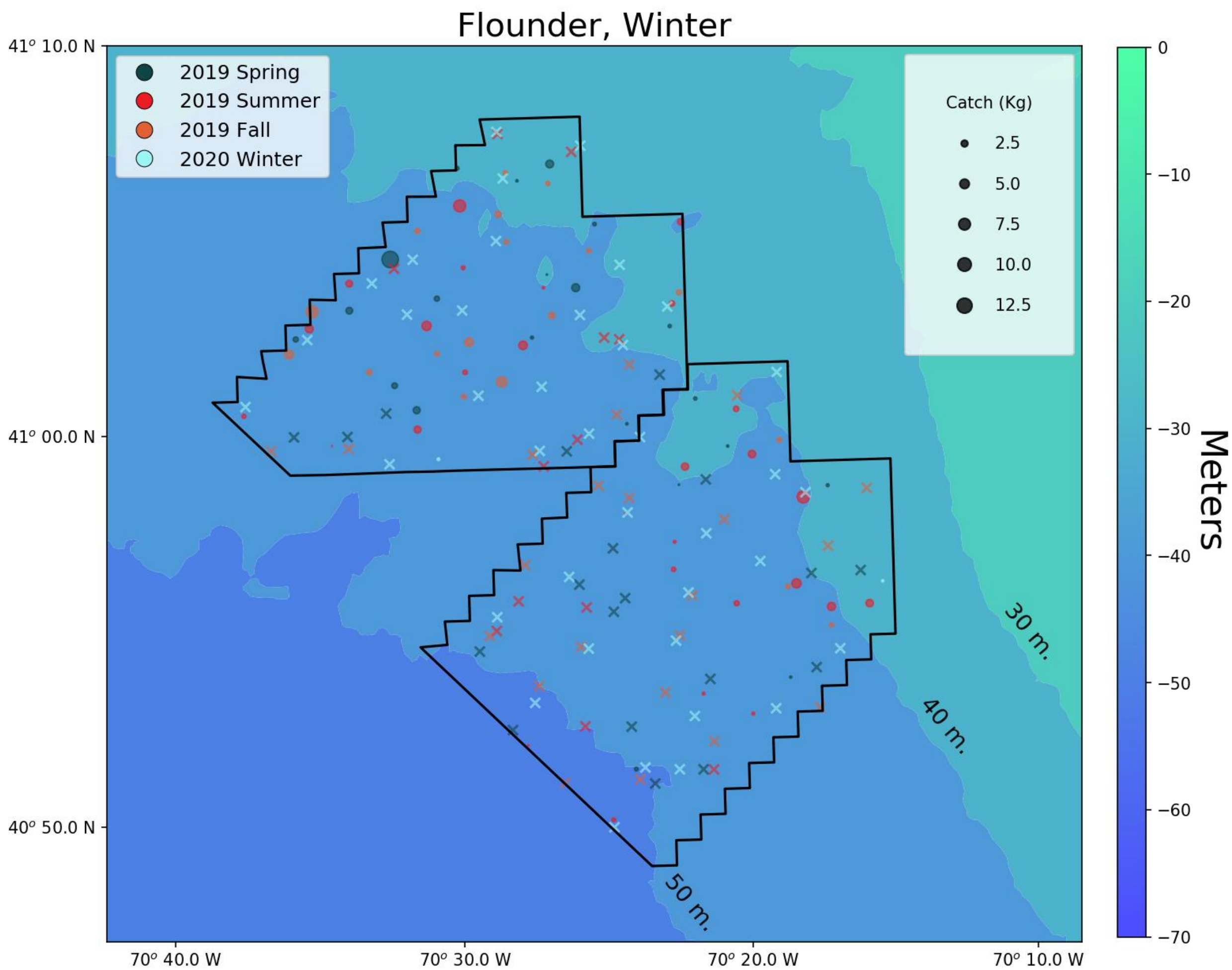


Figure 84: Seasonal distribution of the winter flounder catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

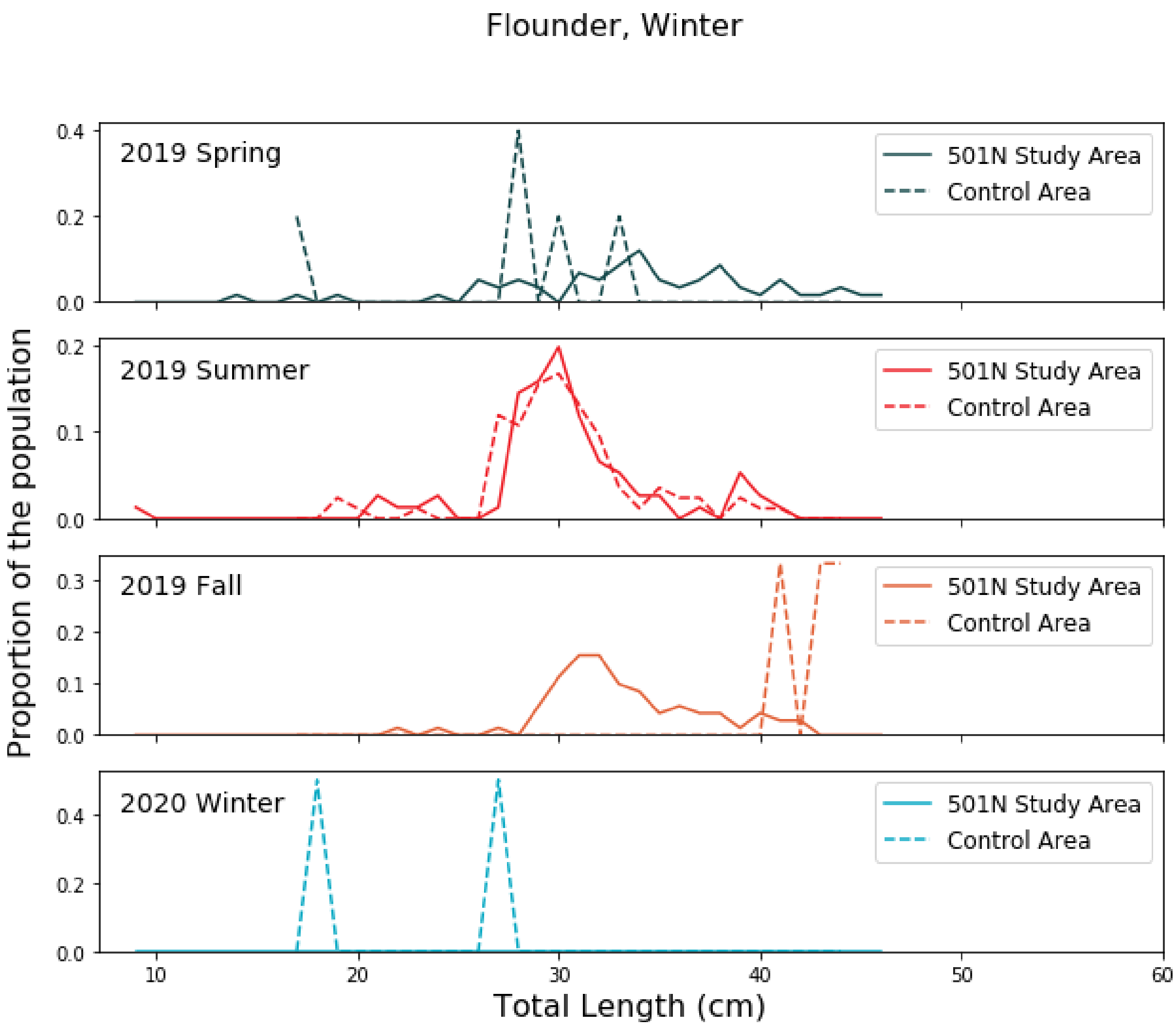


Figure 85: The seasonal length distributions of winter flounder in the 501 North Study Area and Control Area.

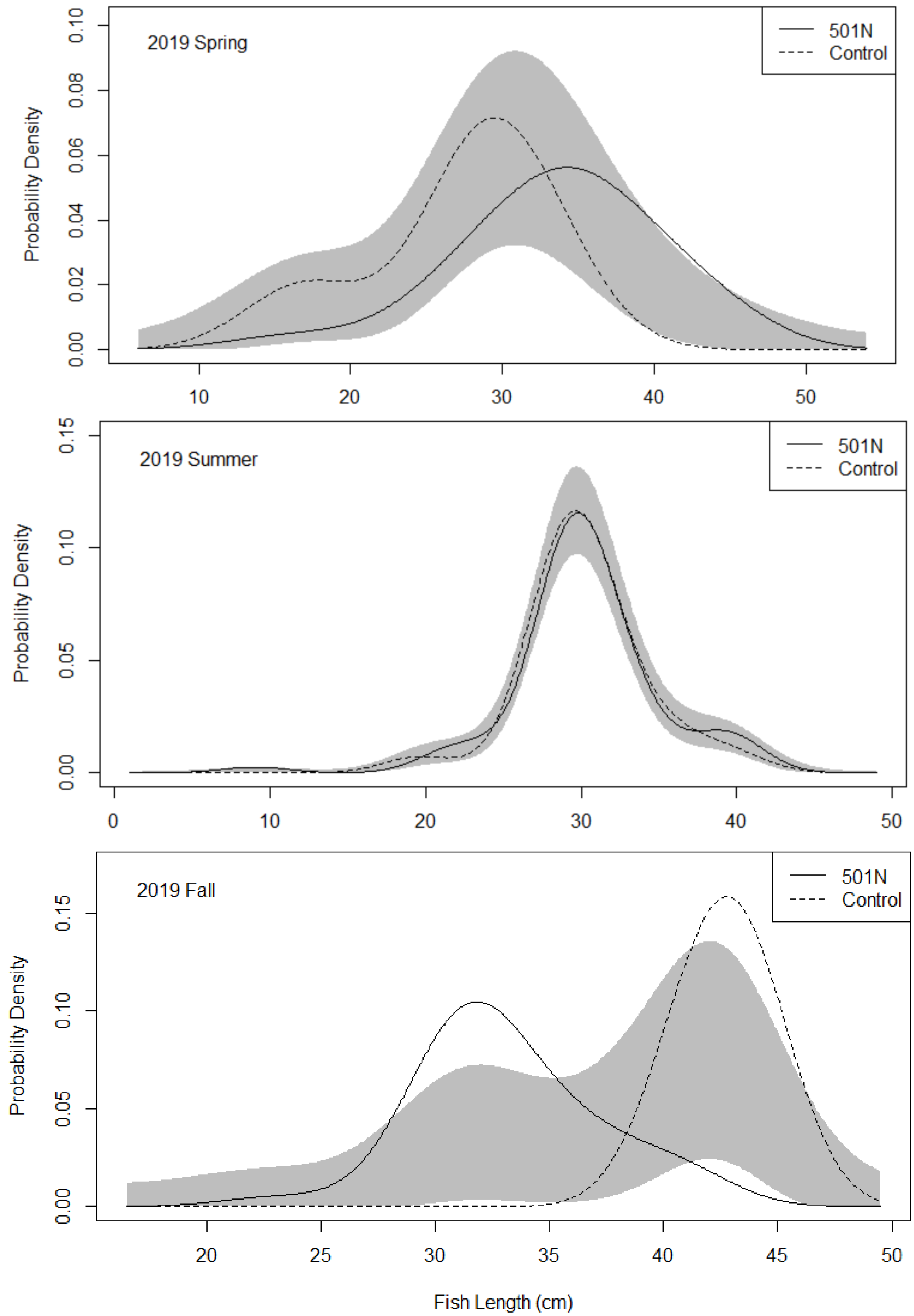
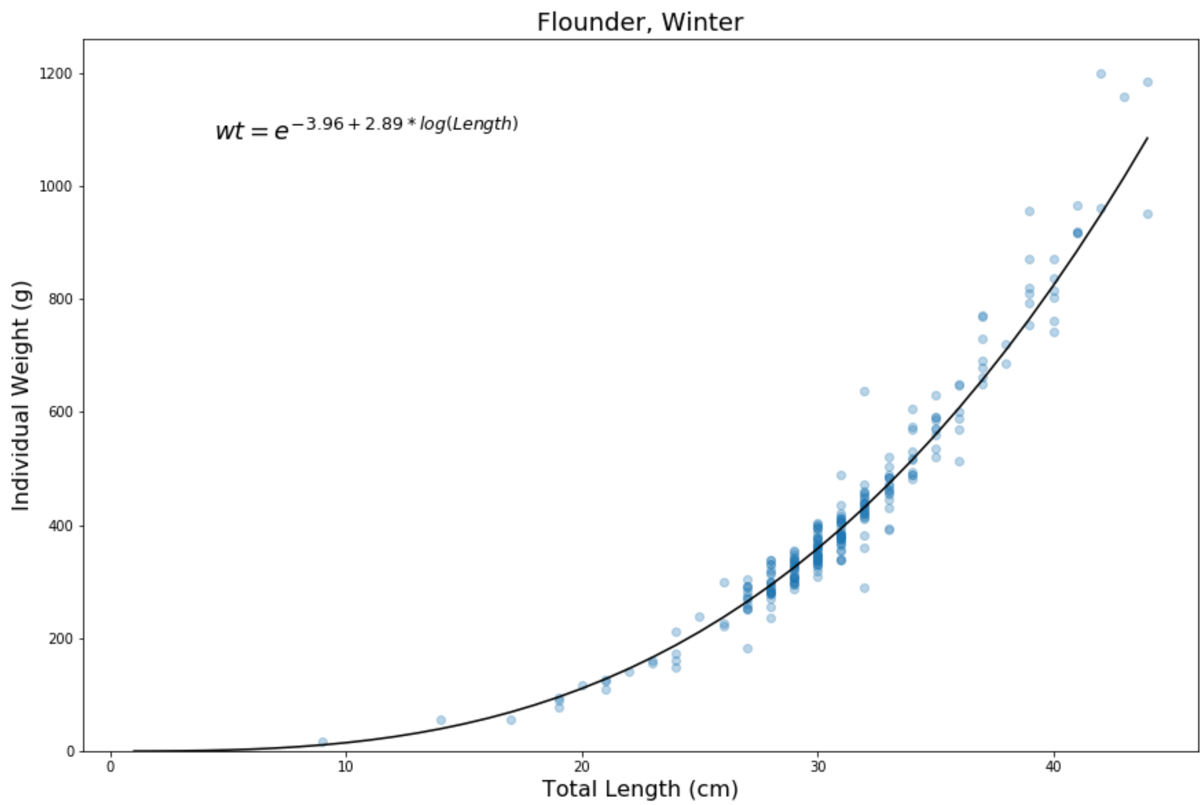


Figure 86: The population structure of winter flounder in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



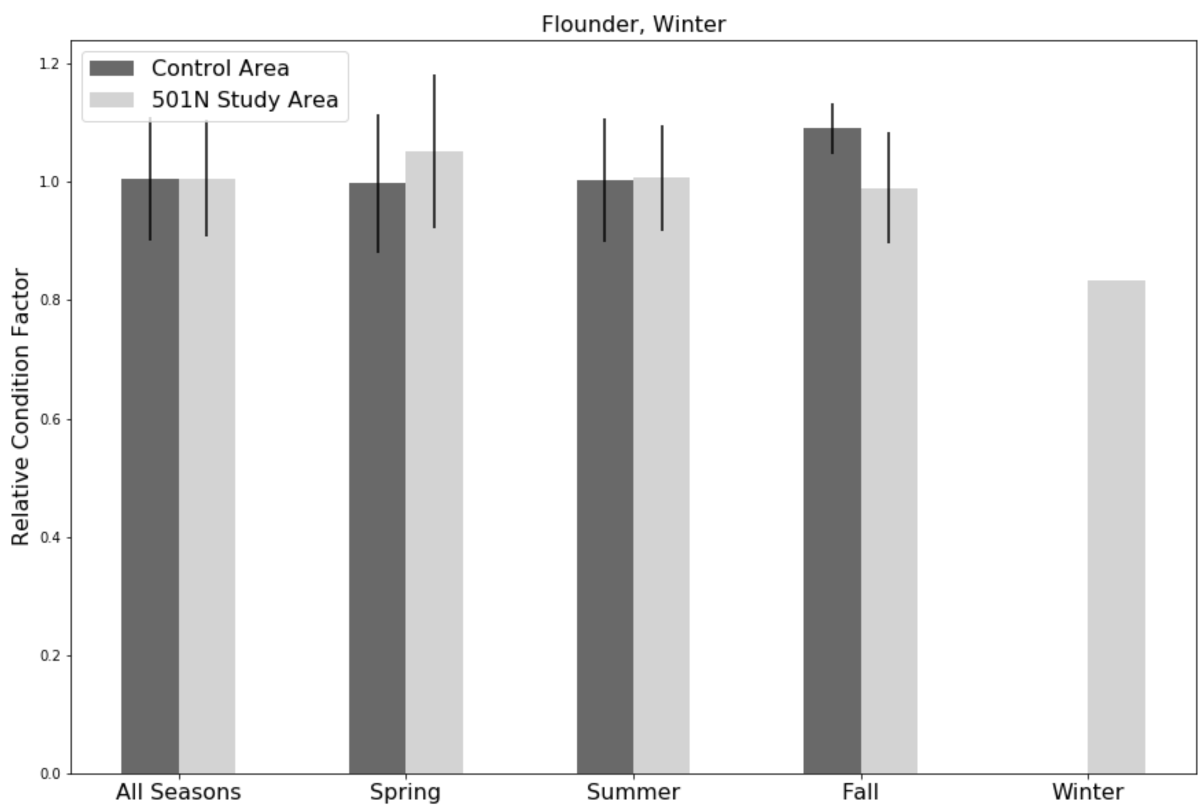


Figure 87: The seasonal condition of winter flounder (bottom) as derived from the length-weight relationship (top).

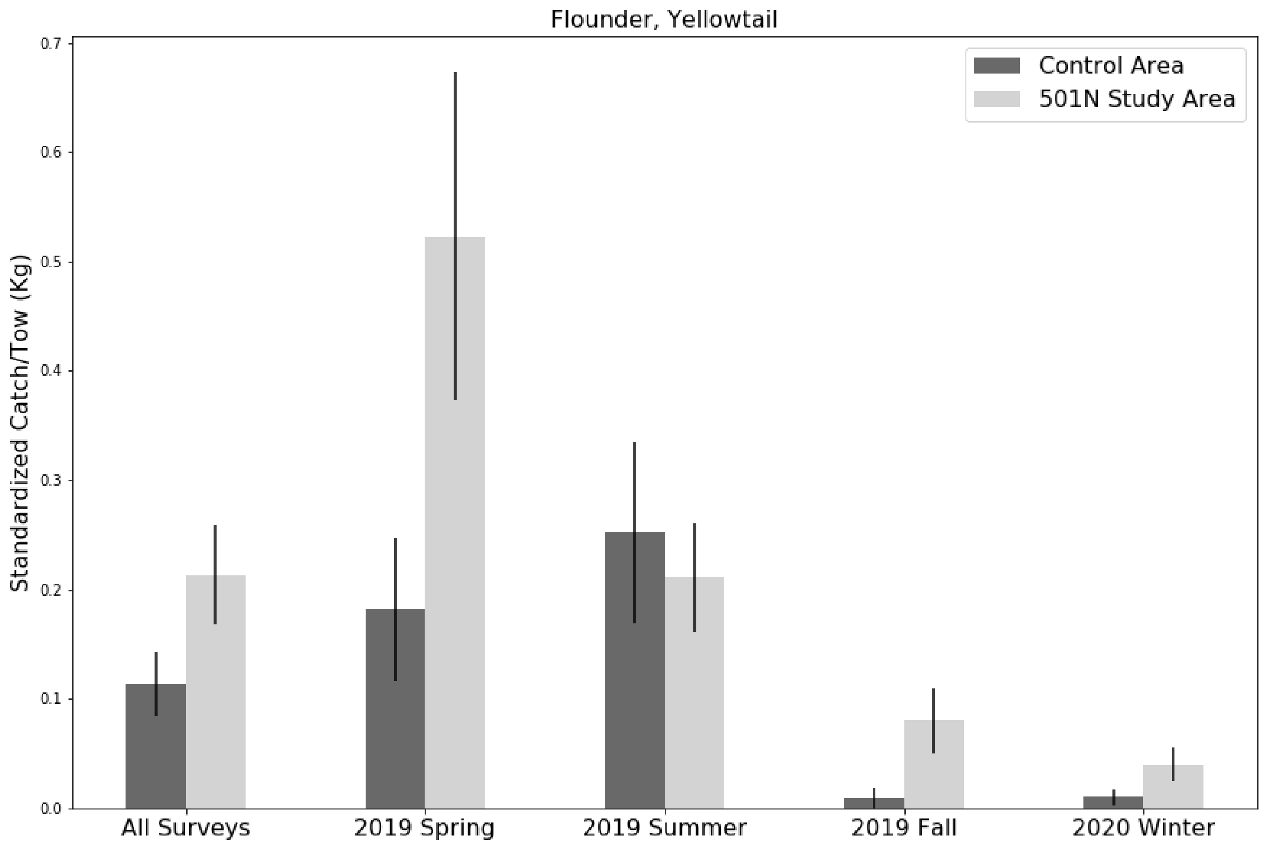


Figure 88: Seasonal catch rates of yellowtail flounder in the 501 North Study Area and Control Area.

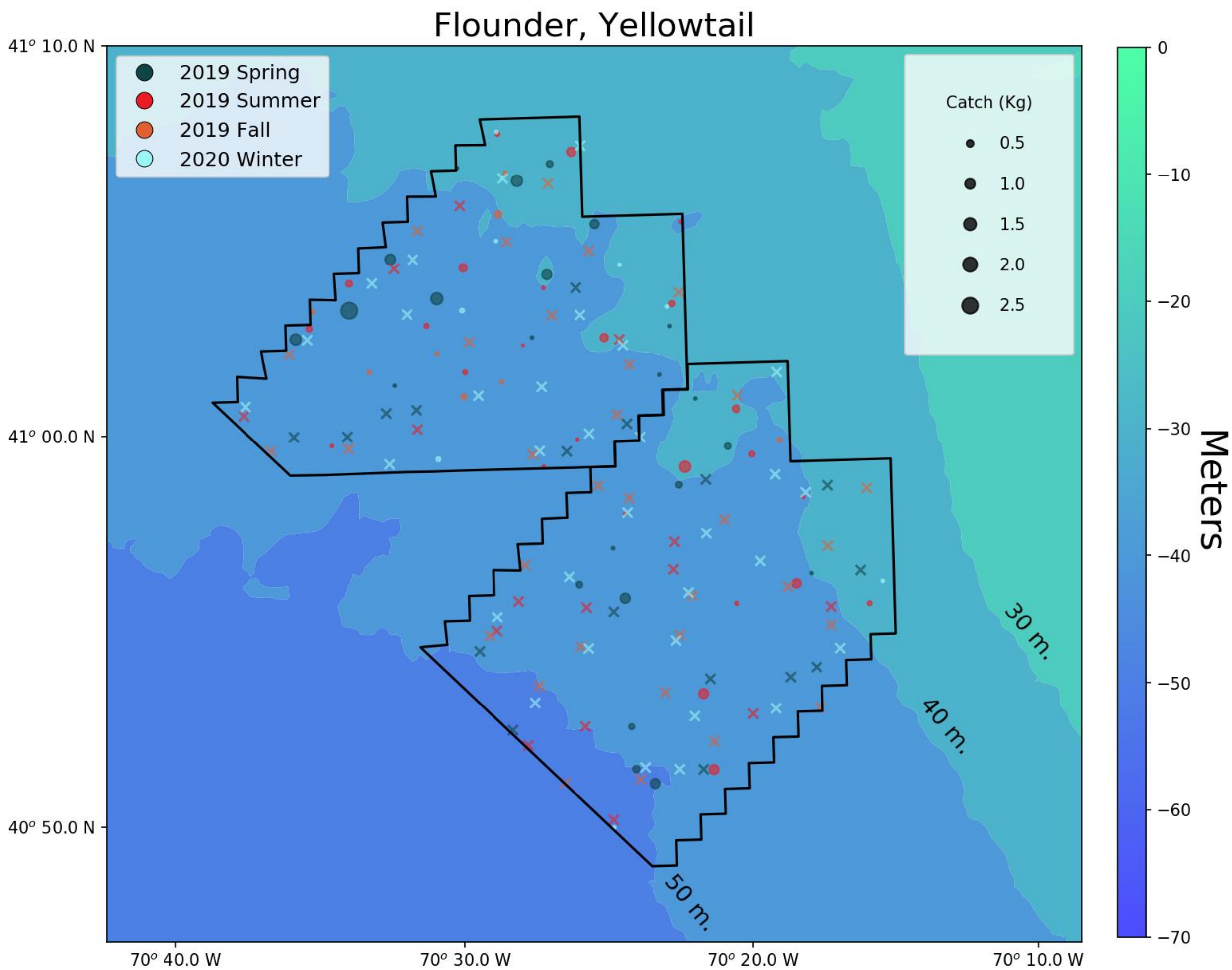


Figure 89: Seasonal distribution of the yellowtail flounder catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

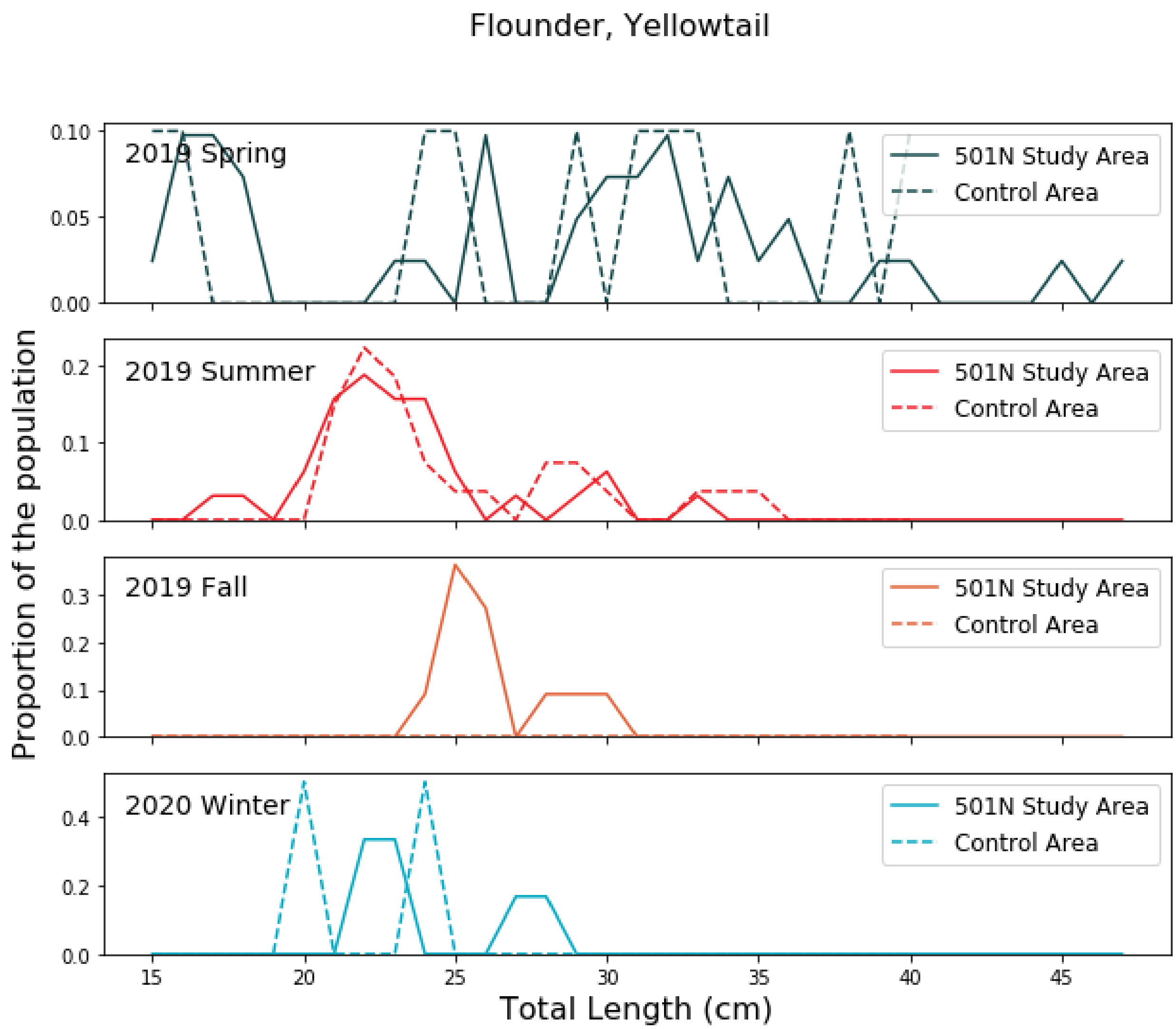


Figure 90: The seasonal length distributions of yellowtail flounder in the 501 North Study Area and Control Area.

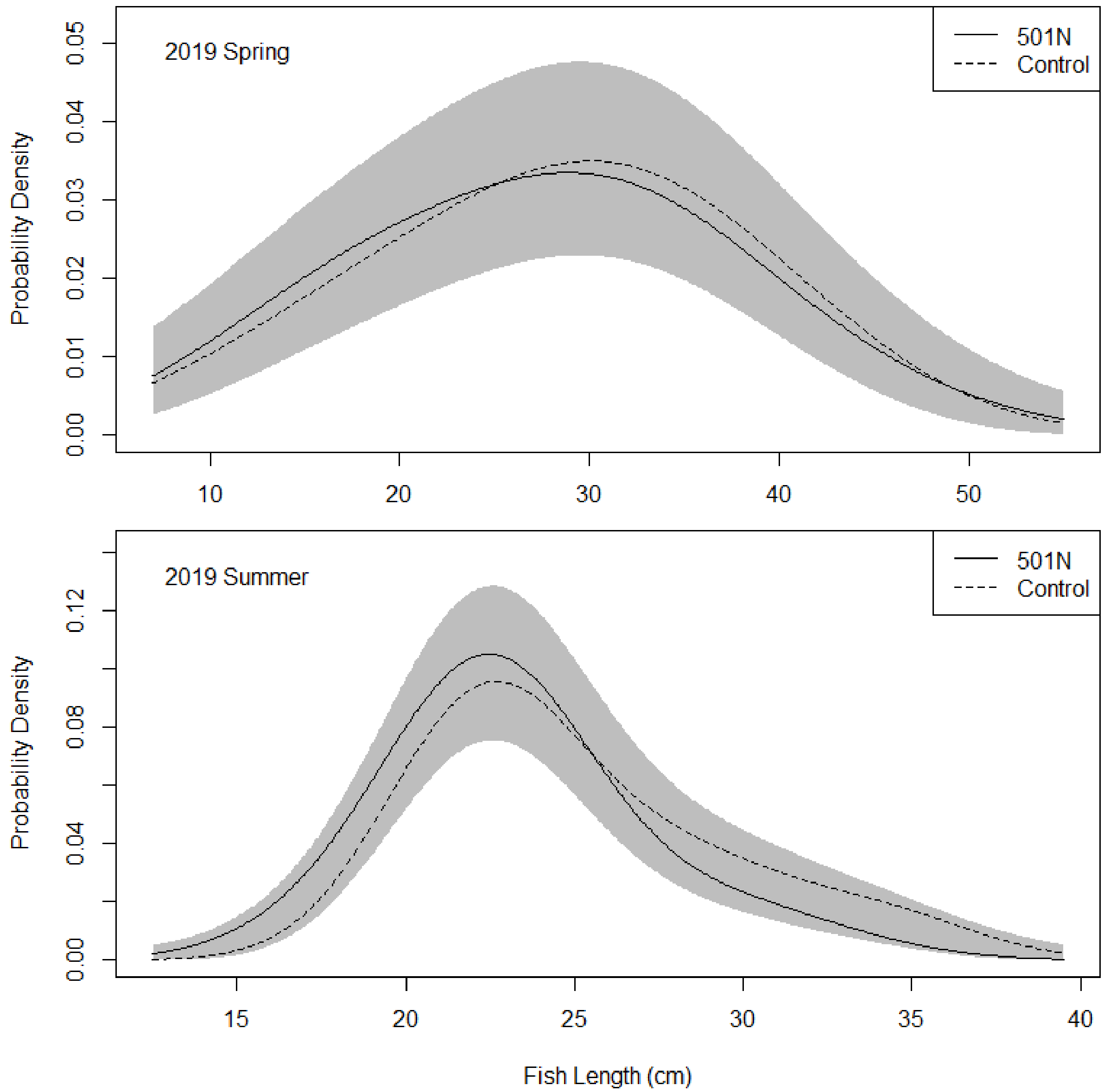


Figure 91: The population structure of yellowtail flounder in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.

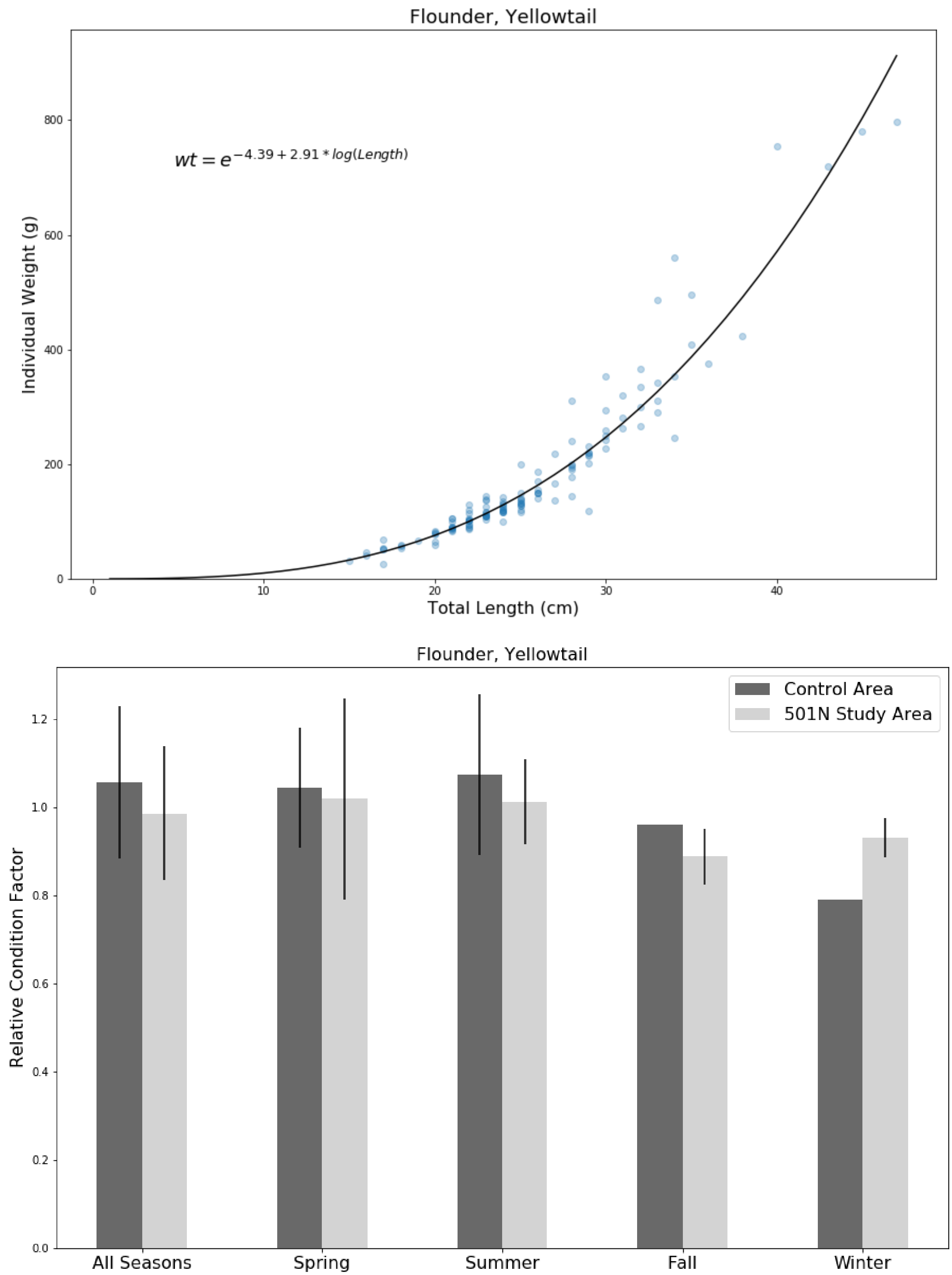


Figure 92: The seasonal condition of yellowtail flounder (bottom) as derived from the length-weight relationship (top).

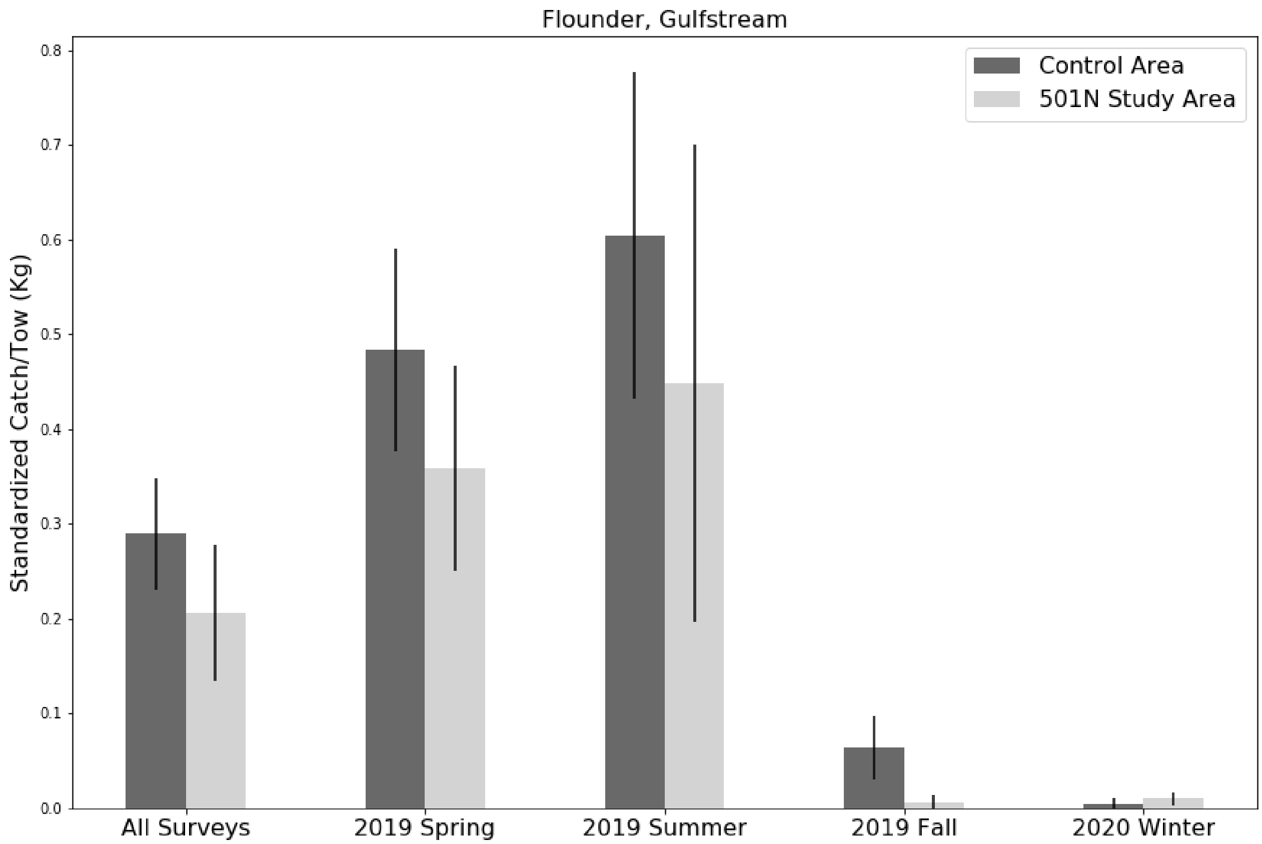


Figure 93: Seasonal catch rates of gulfstream flounder in the 501 North Study Area and Control Area.

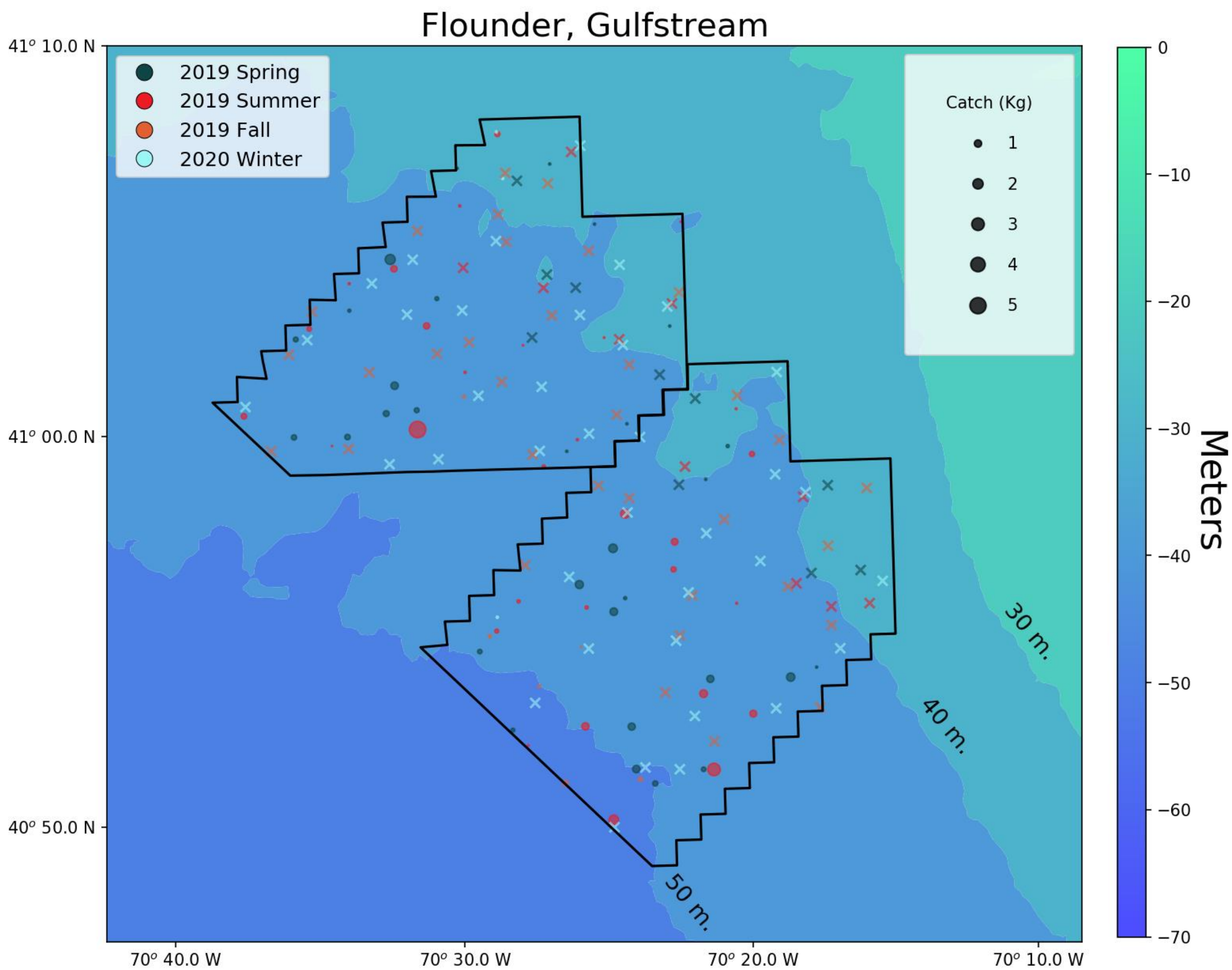


Figure 94: Seasonal distribution of the gulfstream flounder catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

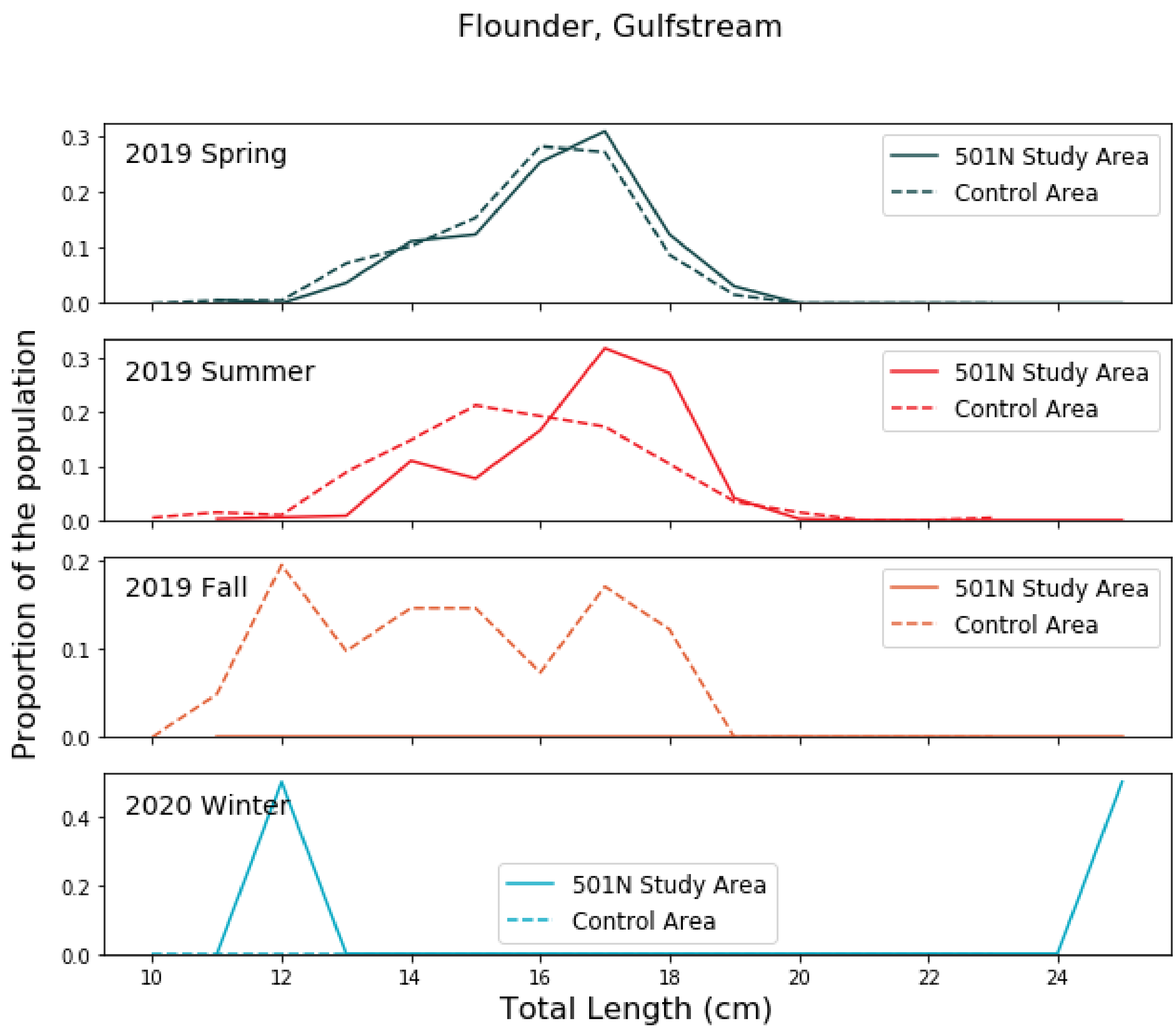


Figure 95: The seasonal length distributions of gulfstream flounder in the 501 North Study Area and Control Area.

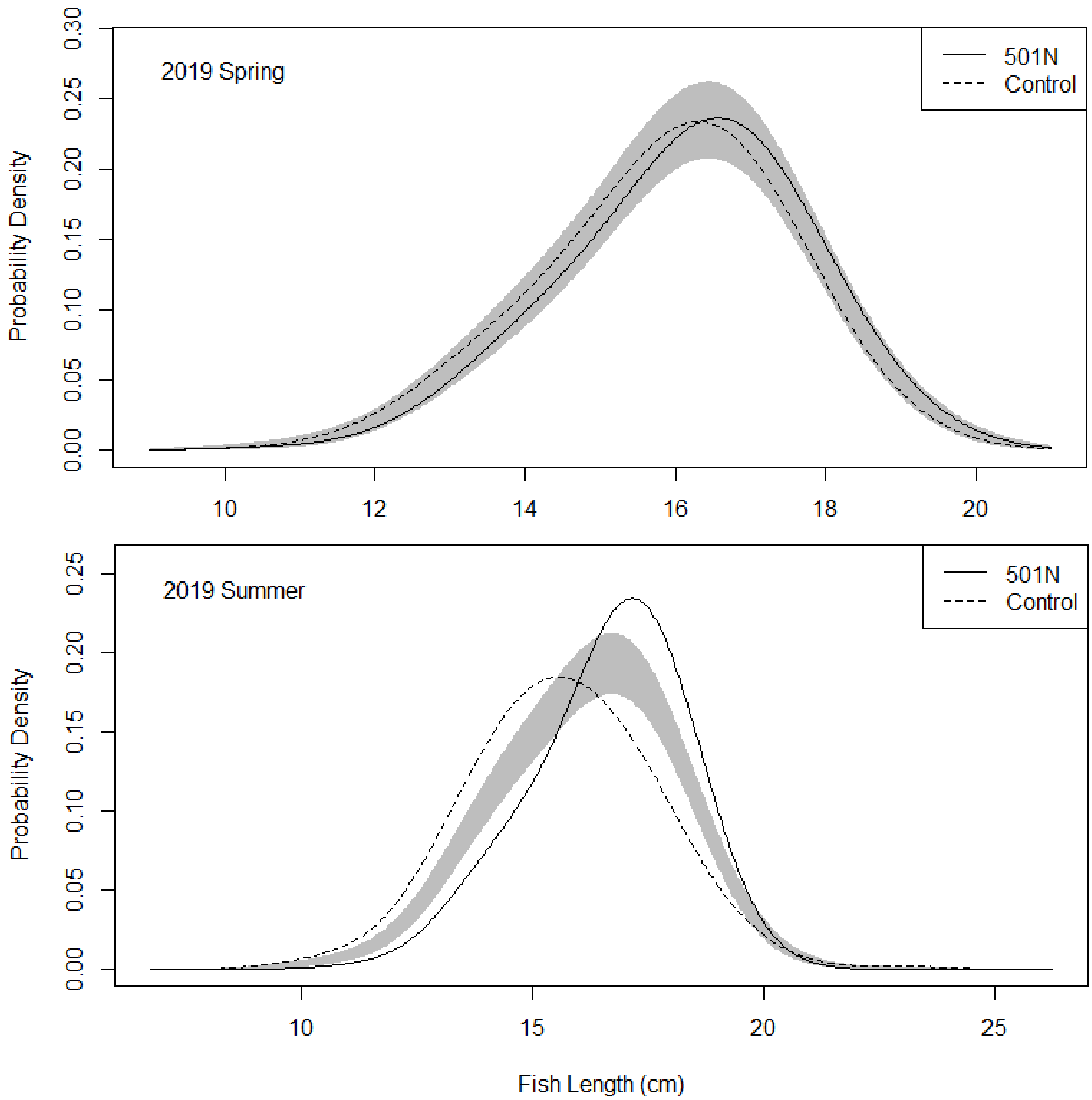
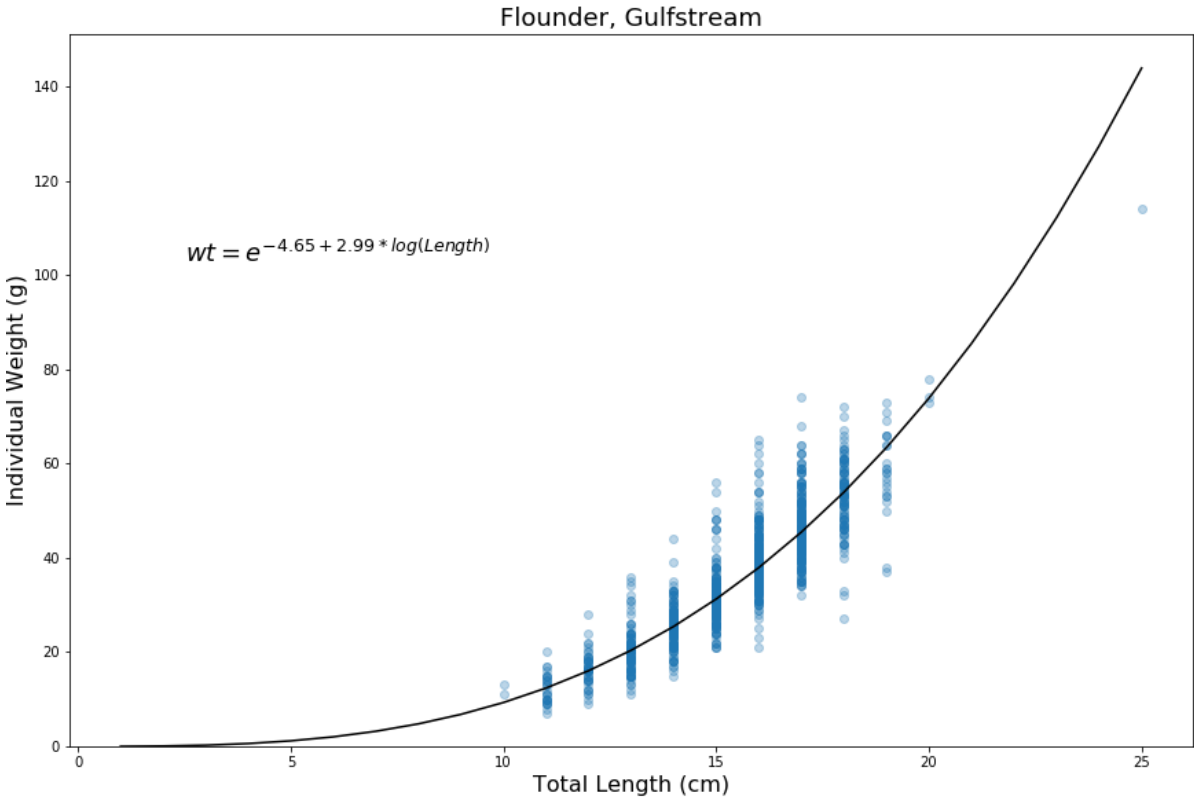


Figure 96: The population structure of gulfstream flounder in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



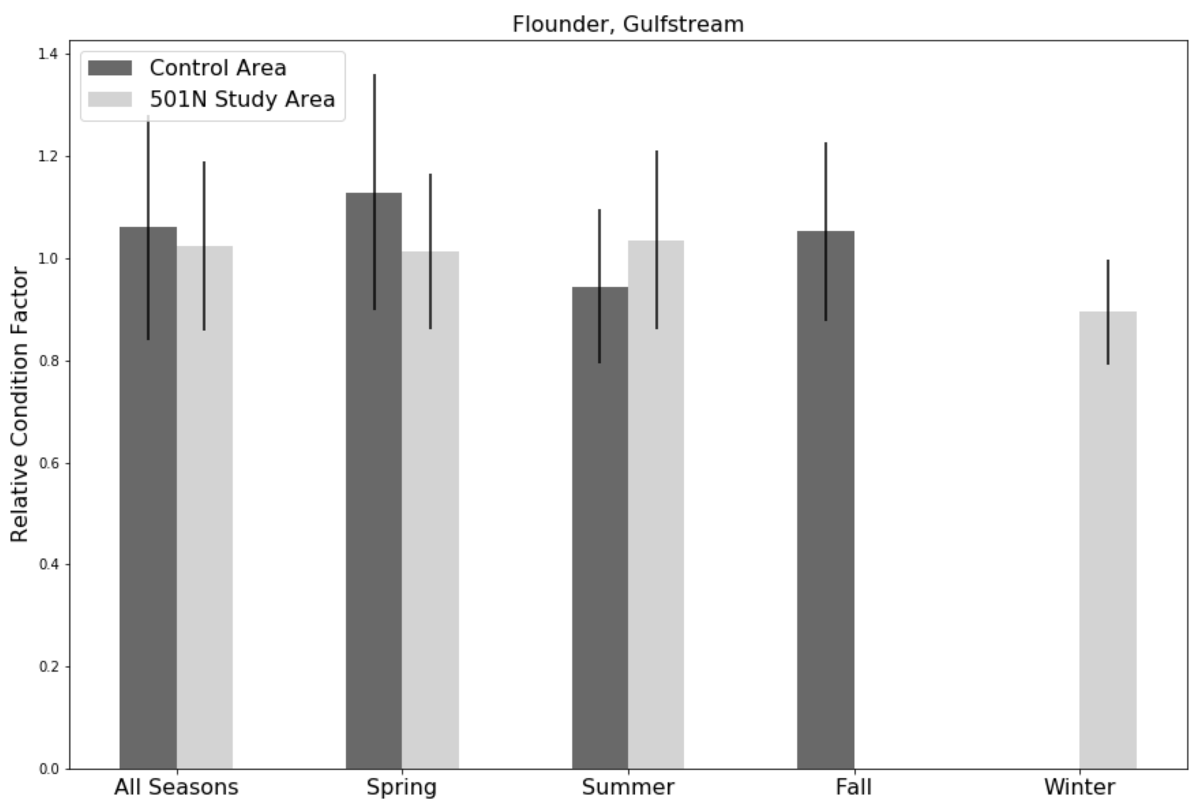


Figure 97: The seasonal condition of gulfstream flounder (bottom) as derived from the length-weight relationship (top).

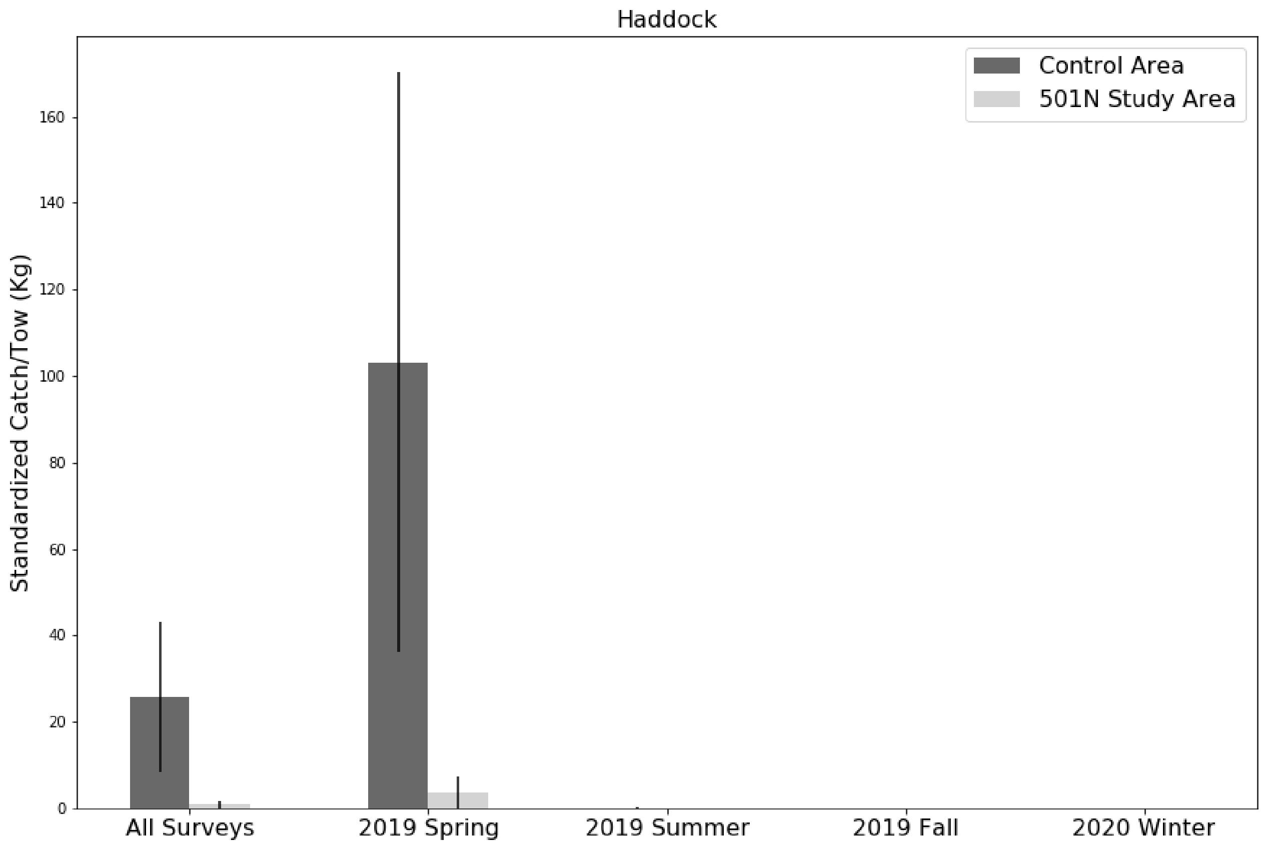


Figure 98: Seasonal catch rates of haddock in the 501 North Study Area and Control Area.

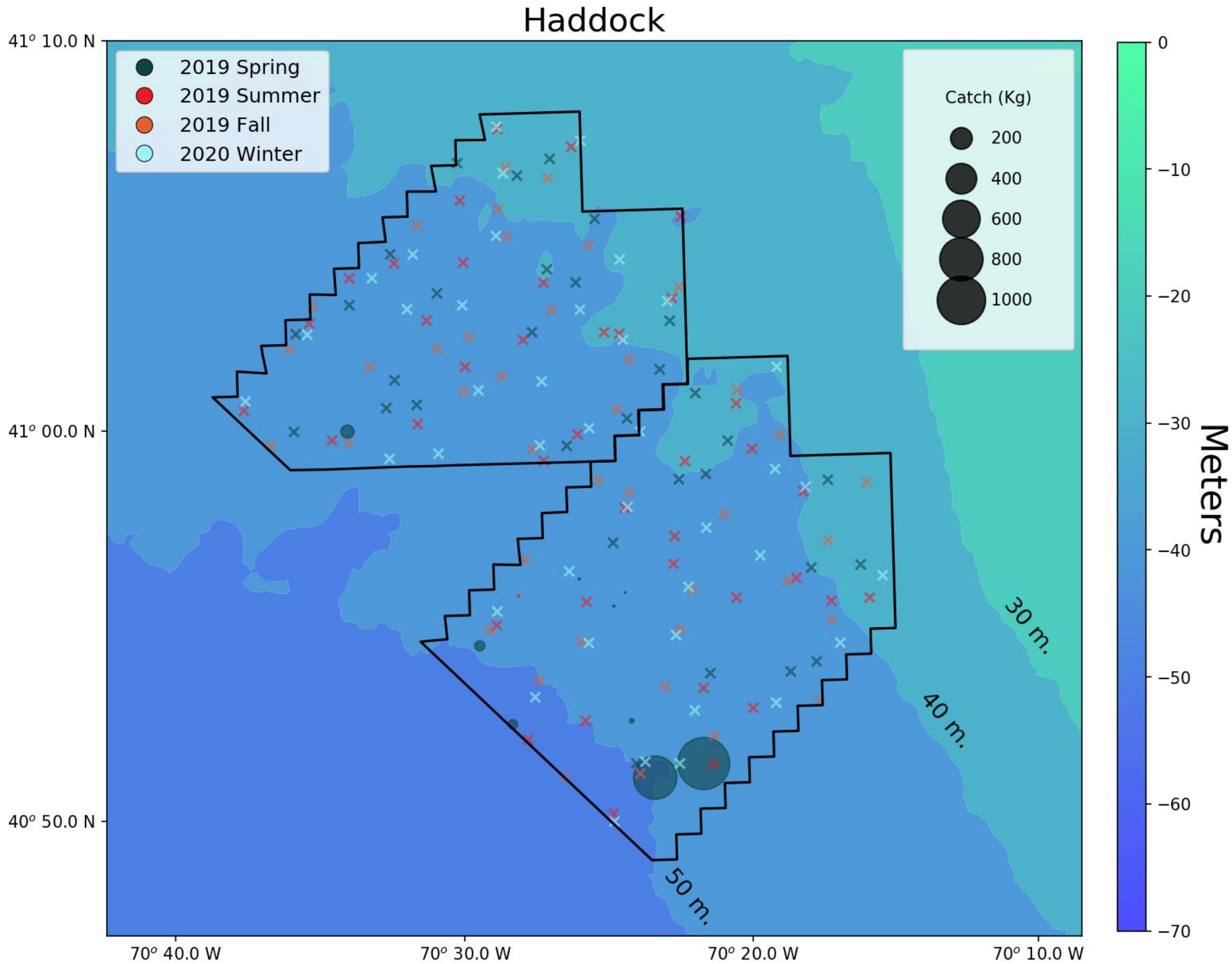


Figure 99: Seasonal distribution of the haddock catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

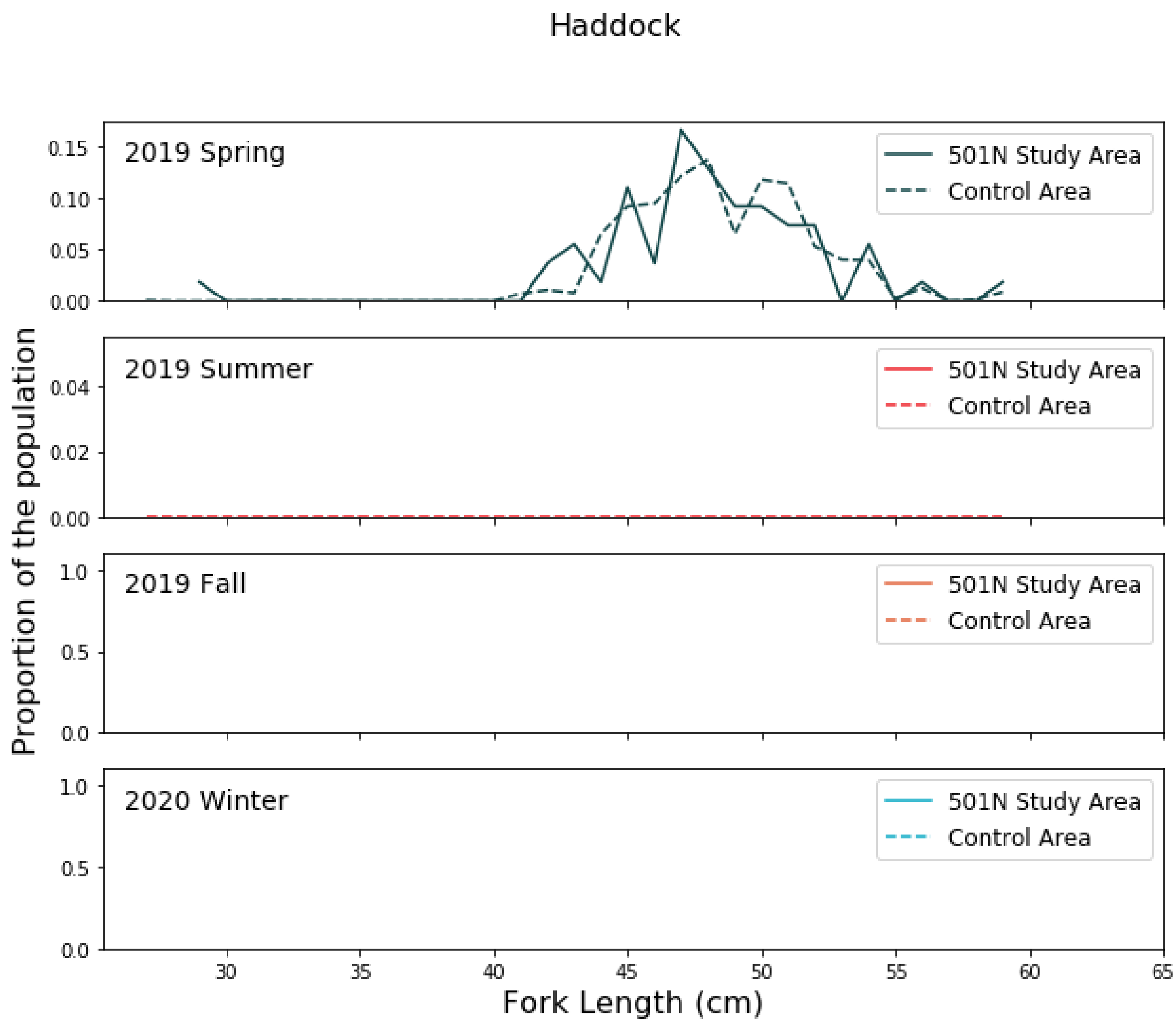


Figure 100: The seasonal length distributions of haddock in the 501 North Study Area and Control Area.

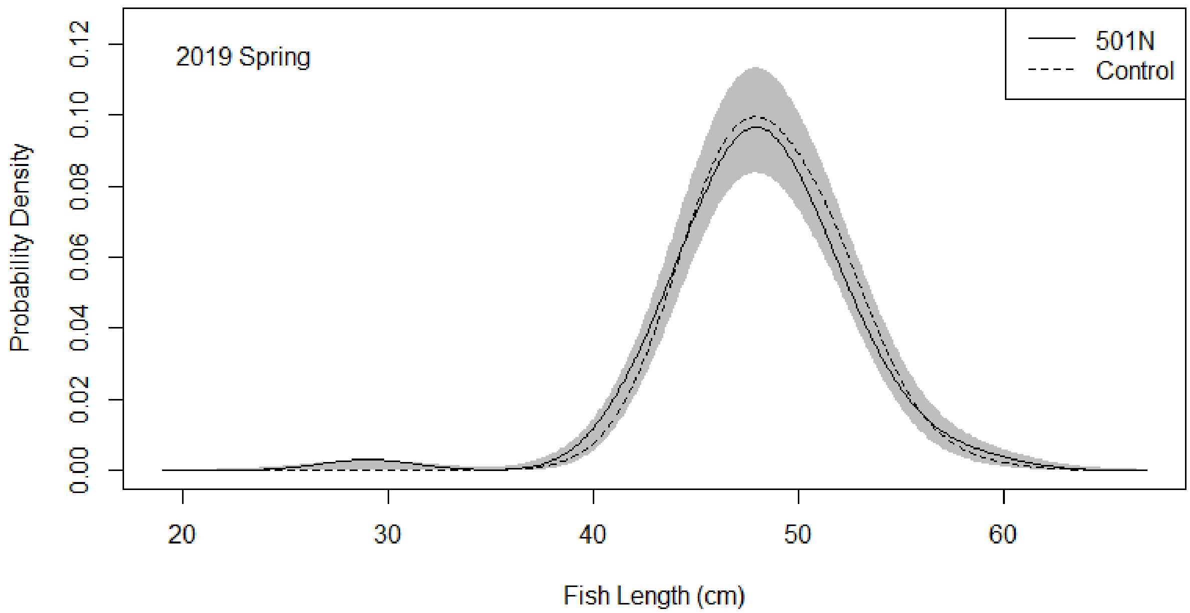
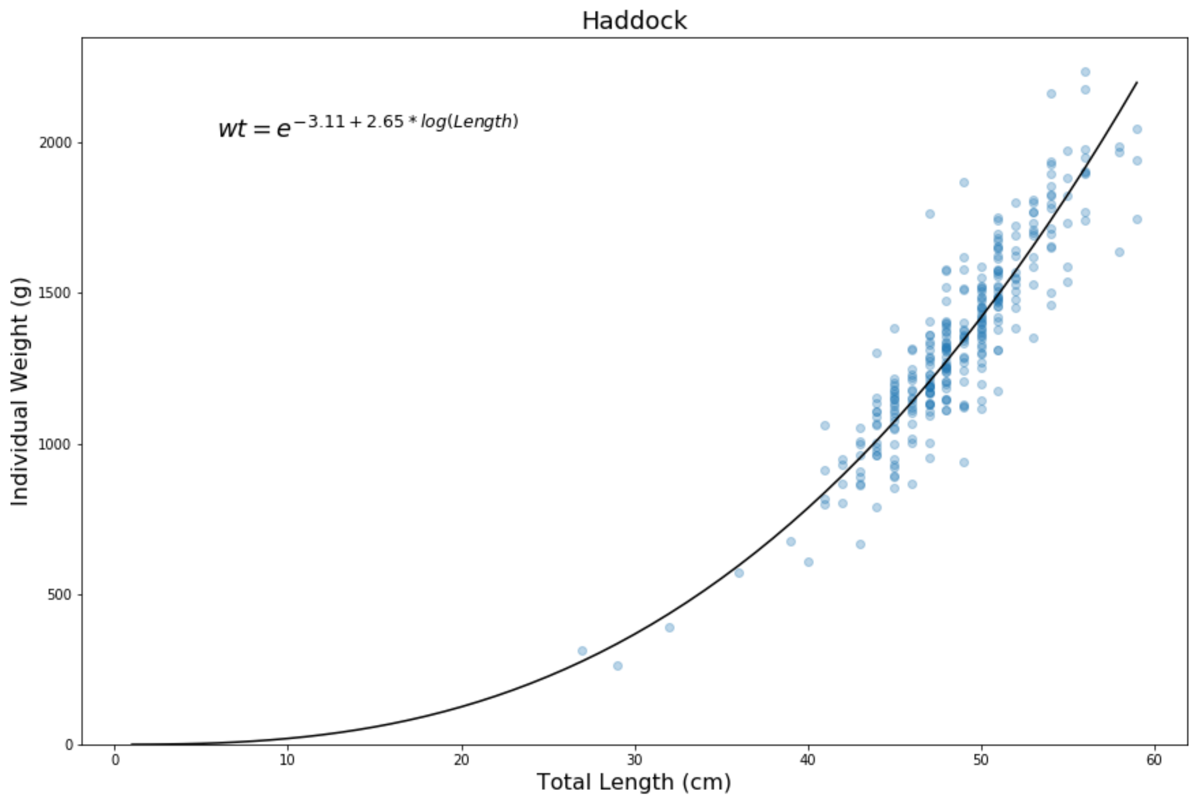


Figure 101: The population structure of haddock in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



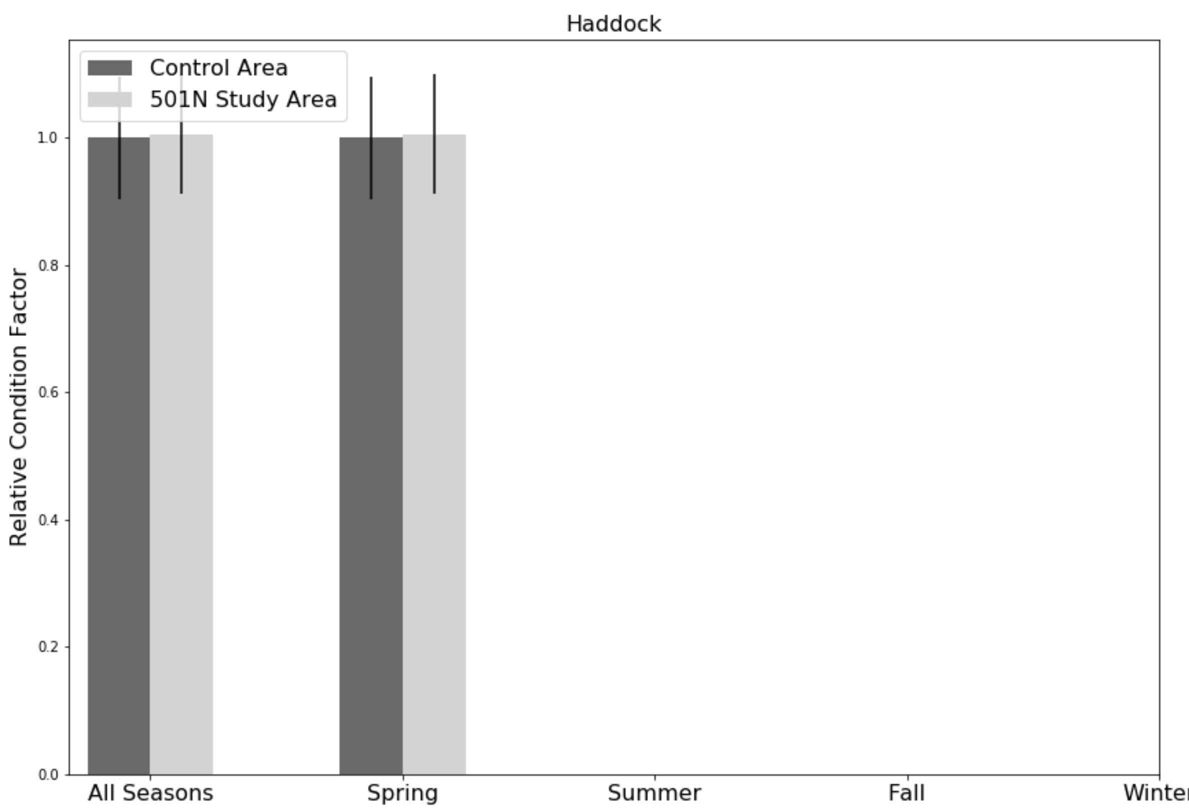


Figure 102: The seasonal condition of haddock (bottom) as derived from the length-weight relationship (top).

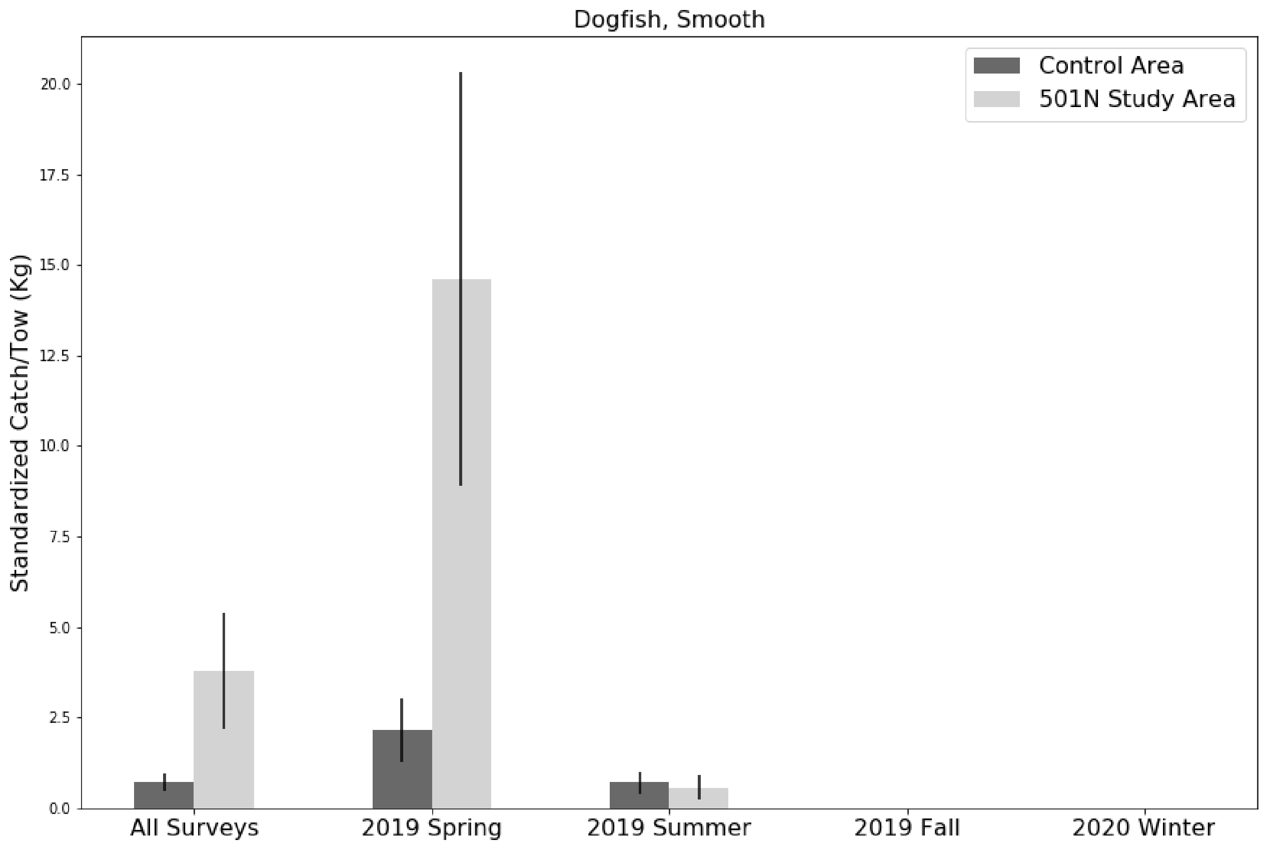


Figure 103: Seasonal catch rates of smooth dogfish in the 501 North Study Area and Control Area.

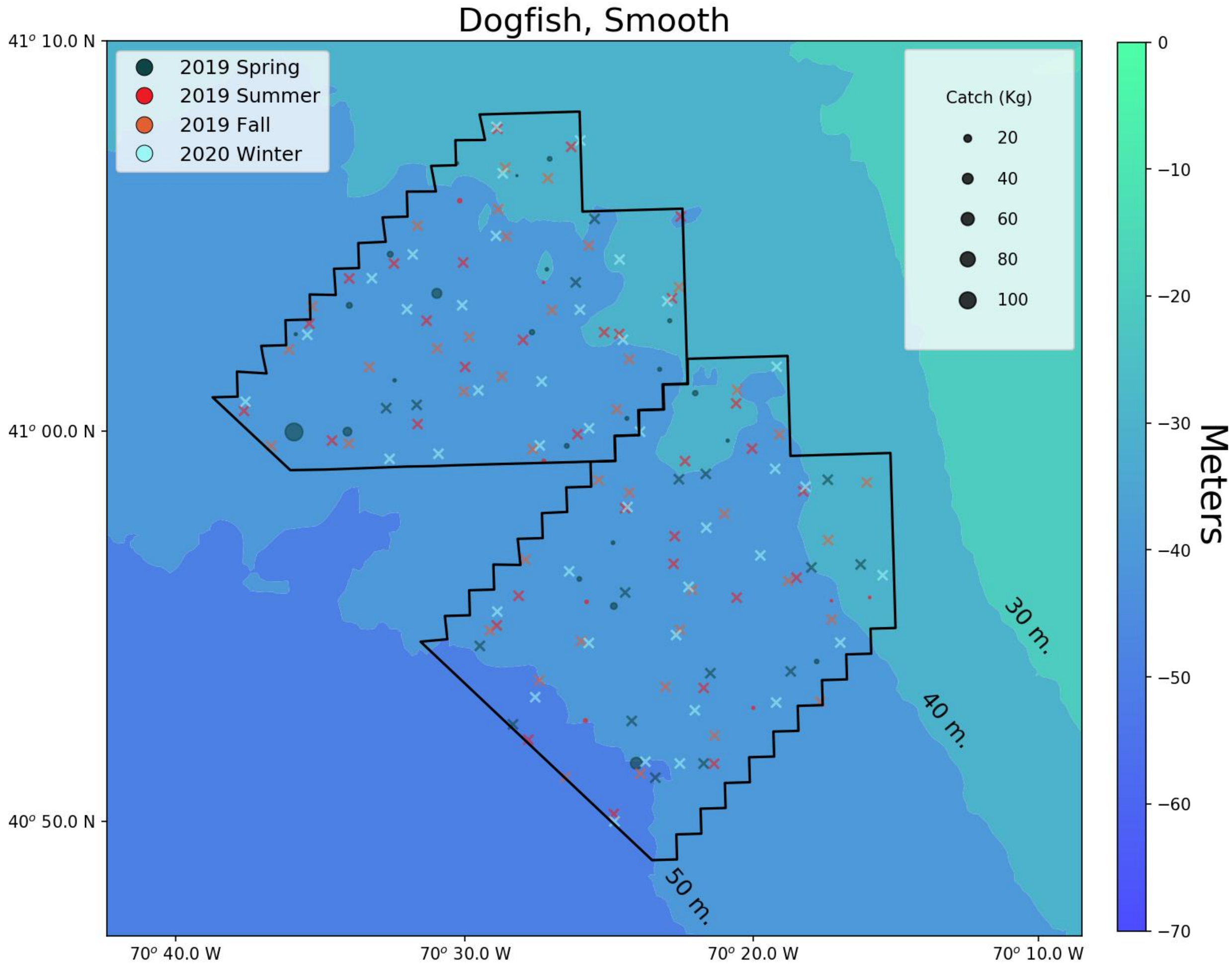


Figure 104: Seasonal distribution of the smooth dogfish catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

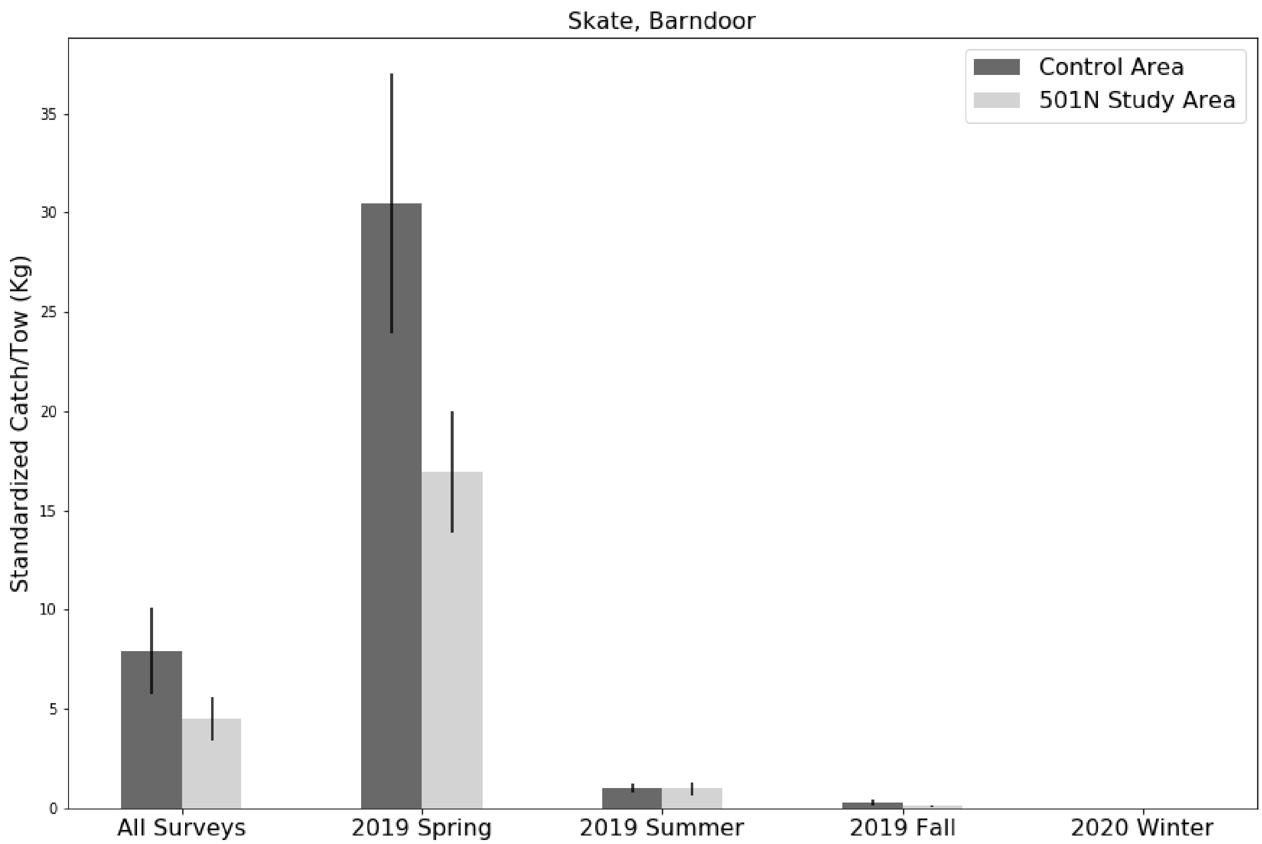


Figure 105: Seasonal catch rates of barndoor skate in the 501 North Study Area and Control Area.

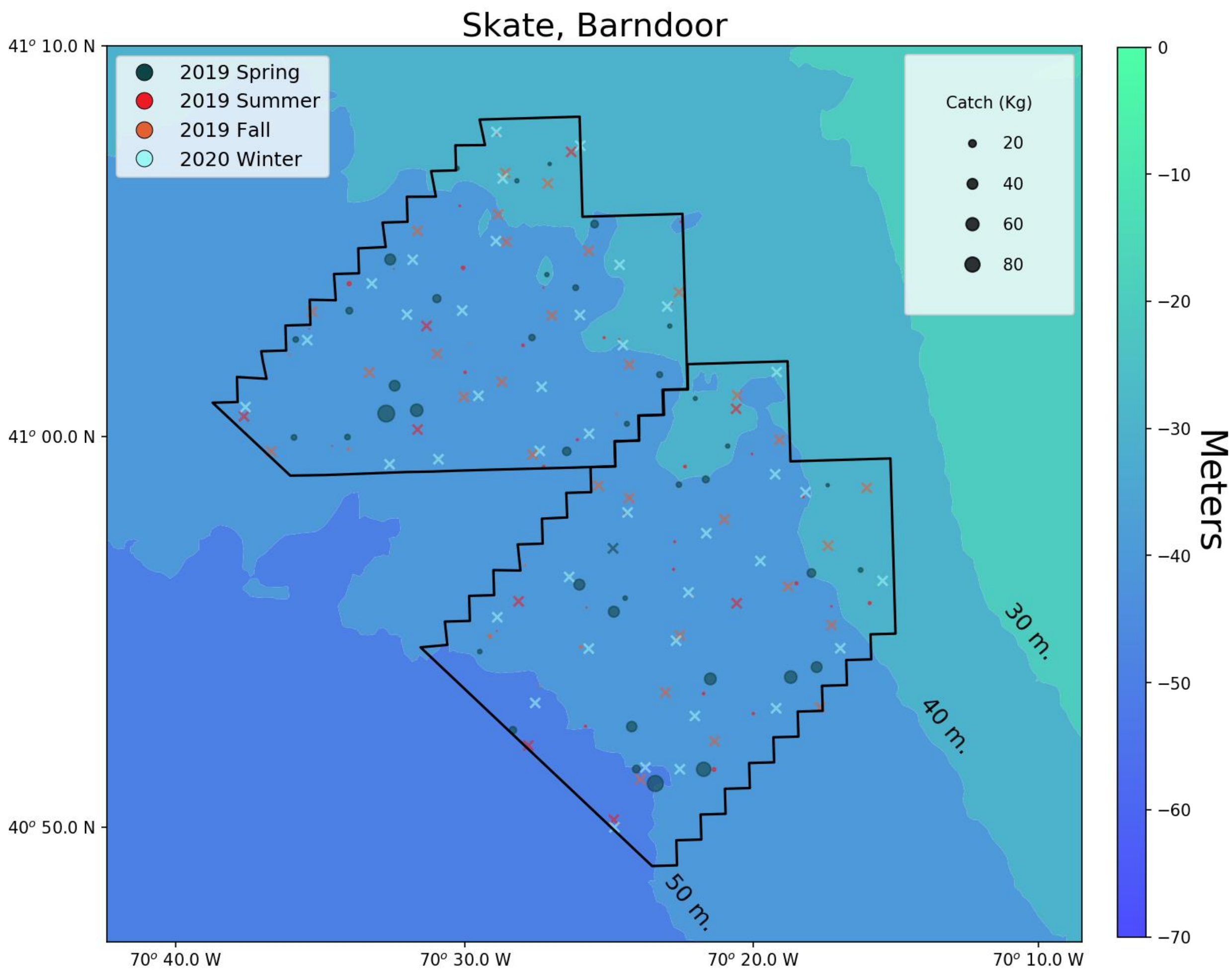


Figure 106: Seasonal distribution of the barndoor skate catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

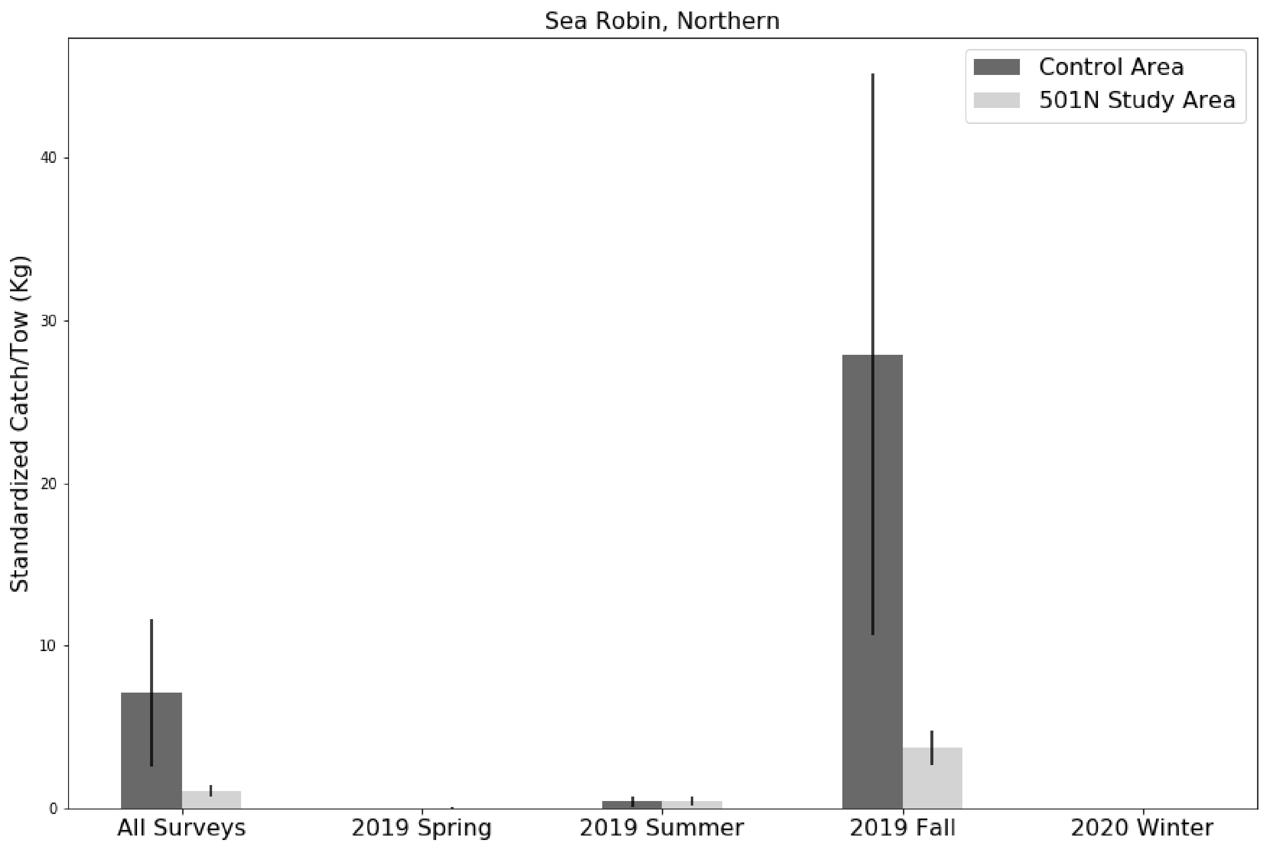


Figure 107: Seasonal catch rates of northern sea robin in the 501 North Study Area and Control Area.

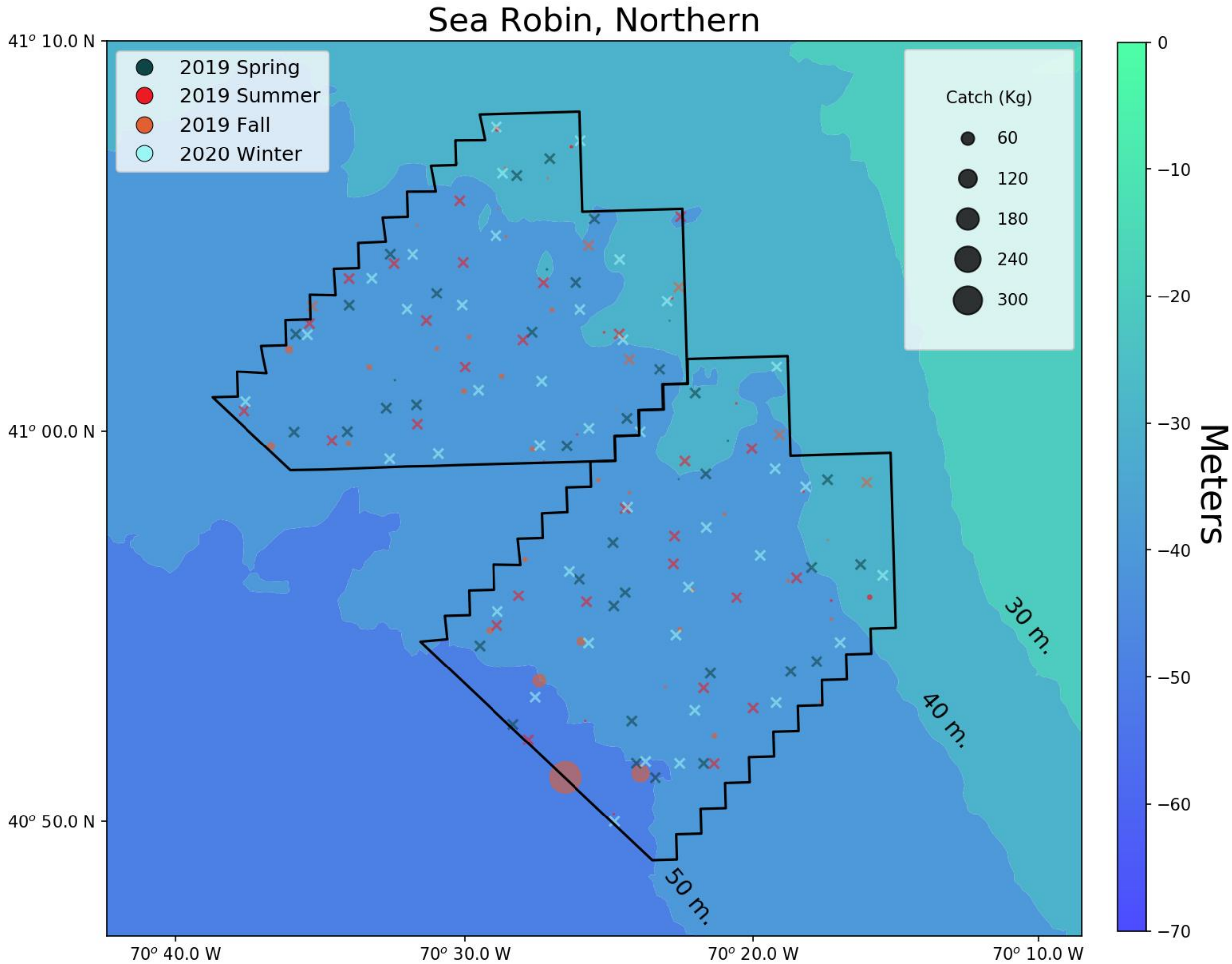


Figure 108: Seasonal distribution of the northern sea robin catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

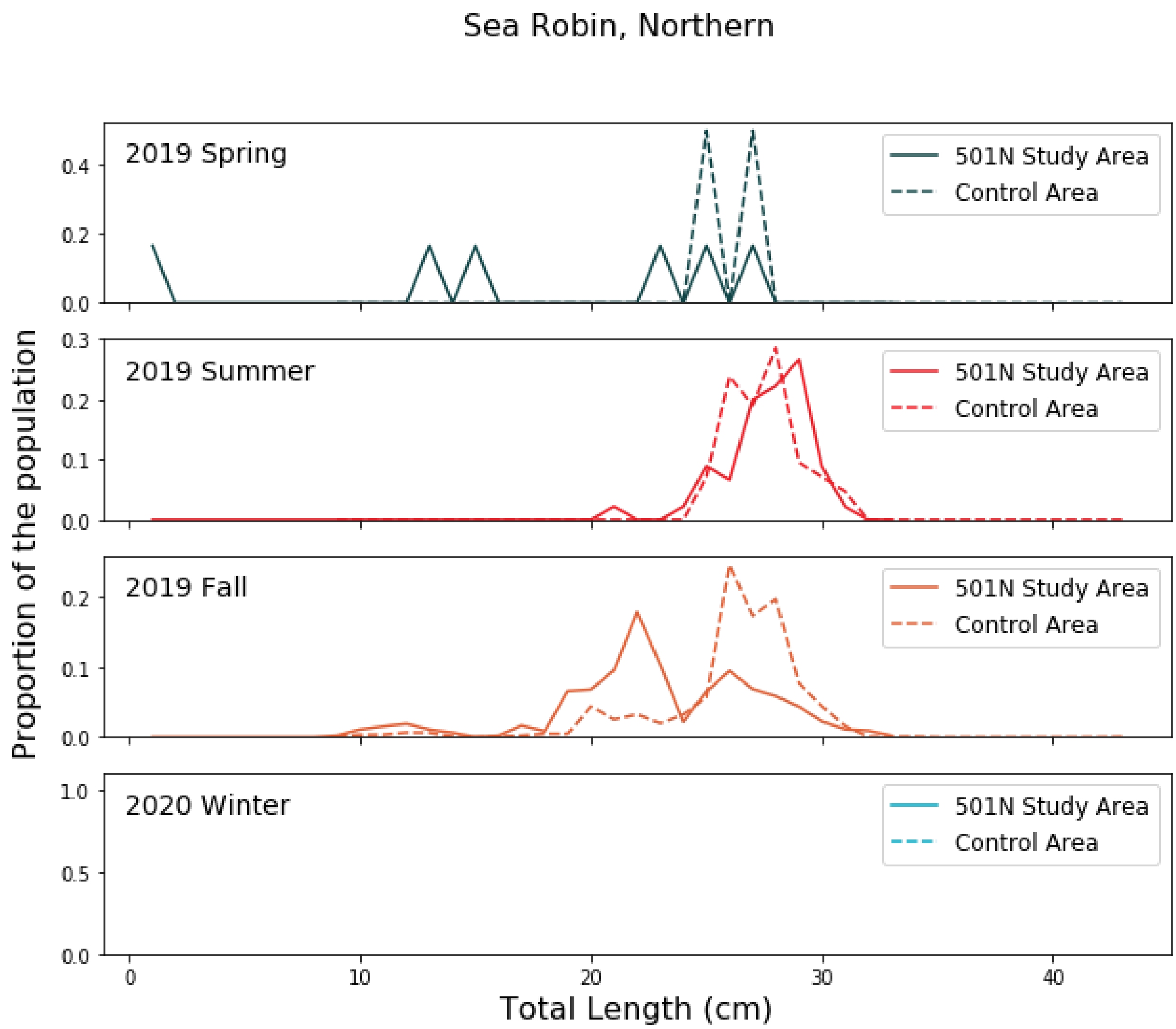


Figure 109: The seasonal length distributions of northern sea robin in the 501 North Study Area and Control Area.

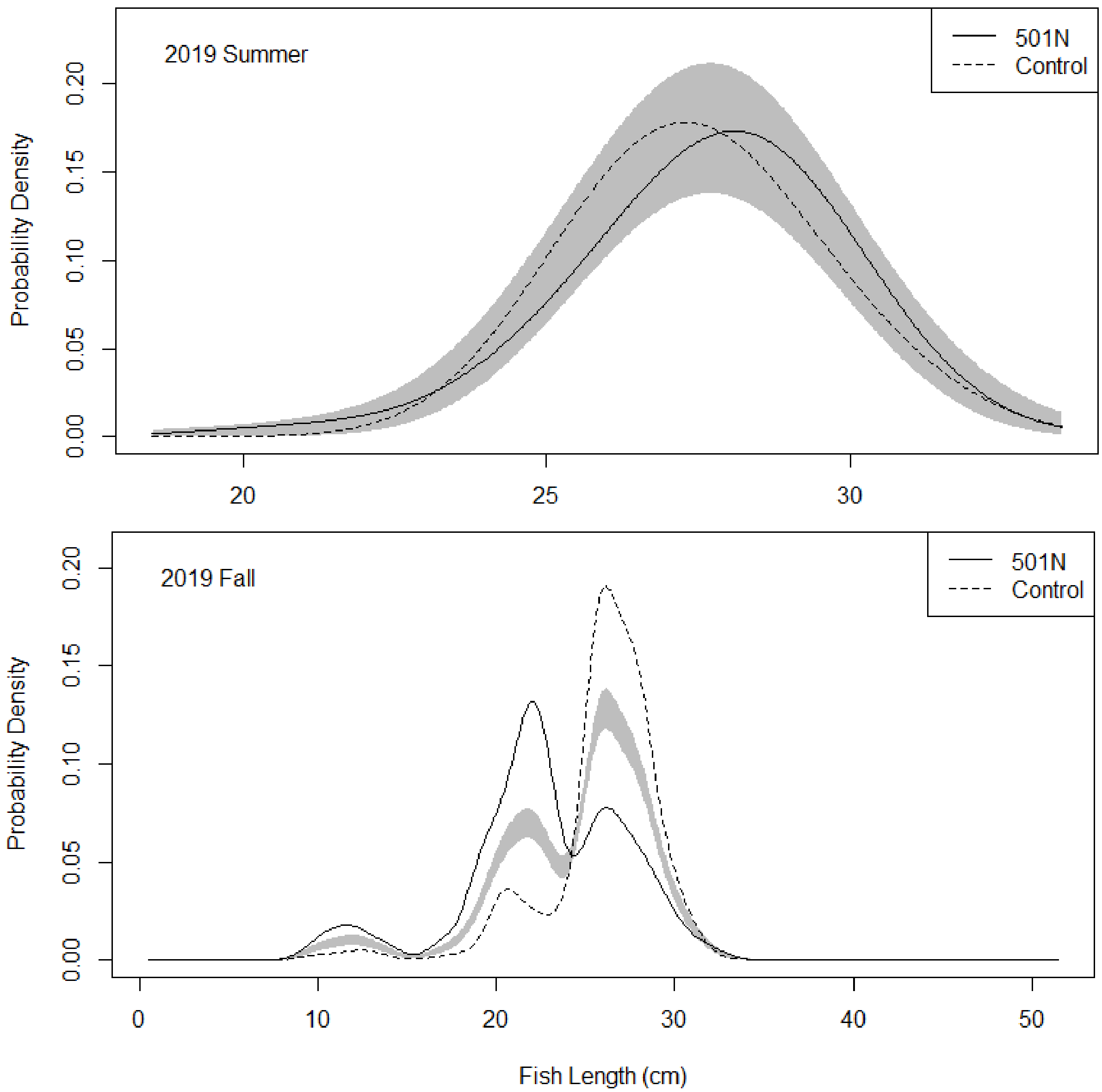
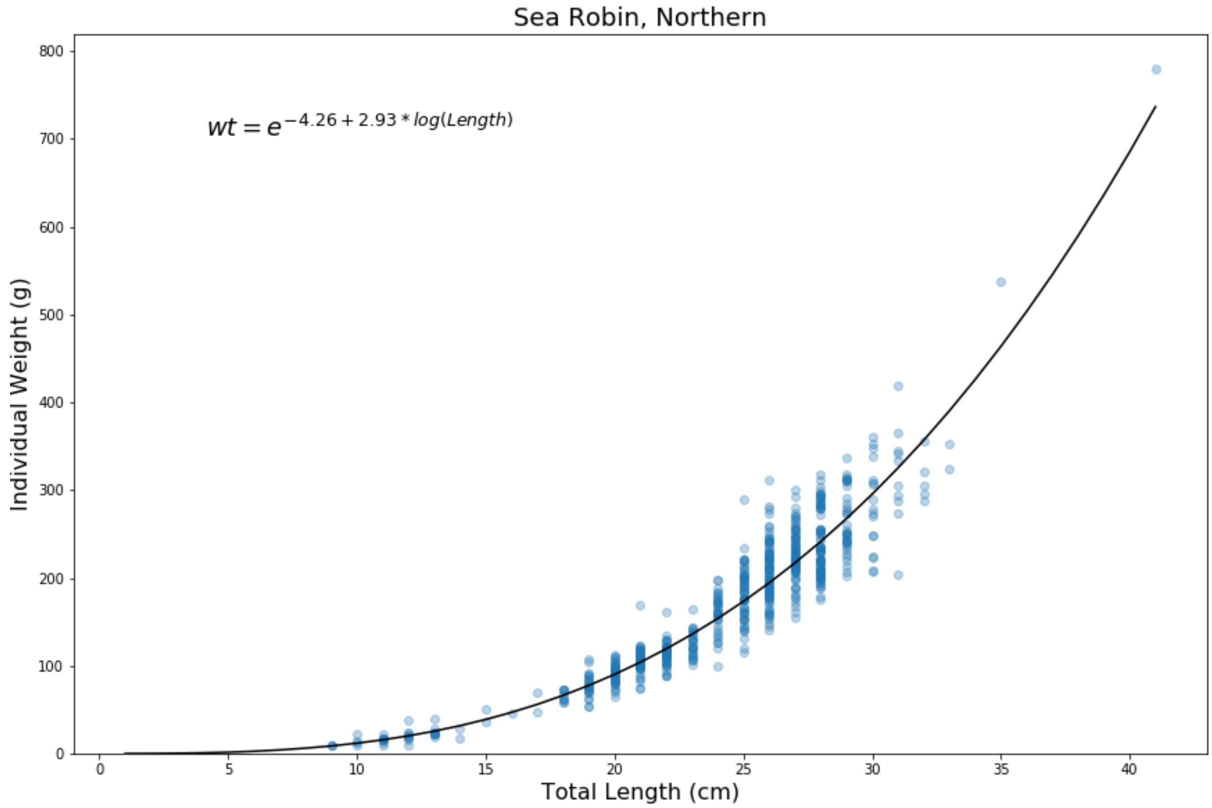


Figure 110: The population structure of northern sea robin in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



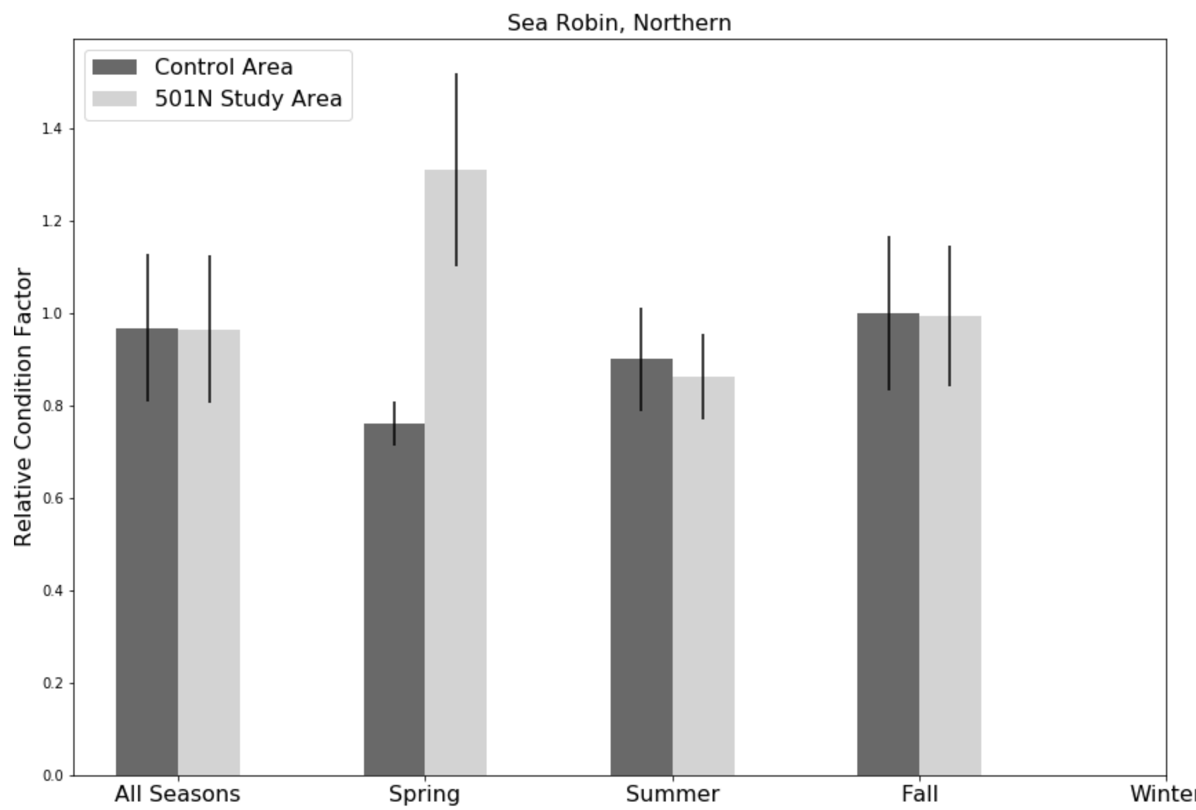


Figure 111: The seasonal condition of northern sea robin (bottom) as derived from the length-weight relationship (top).

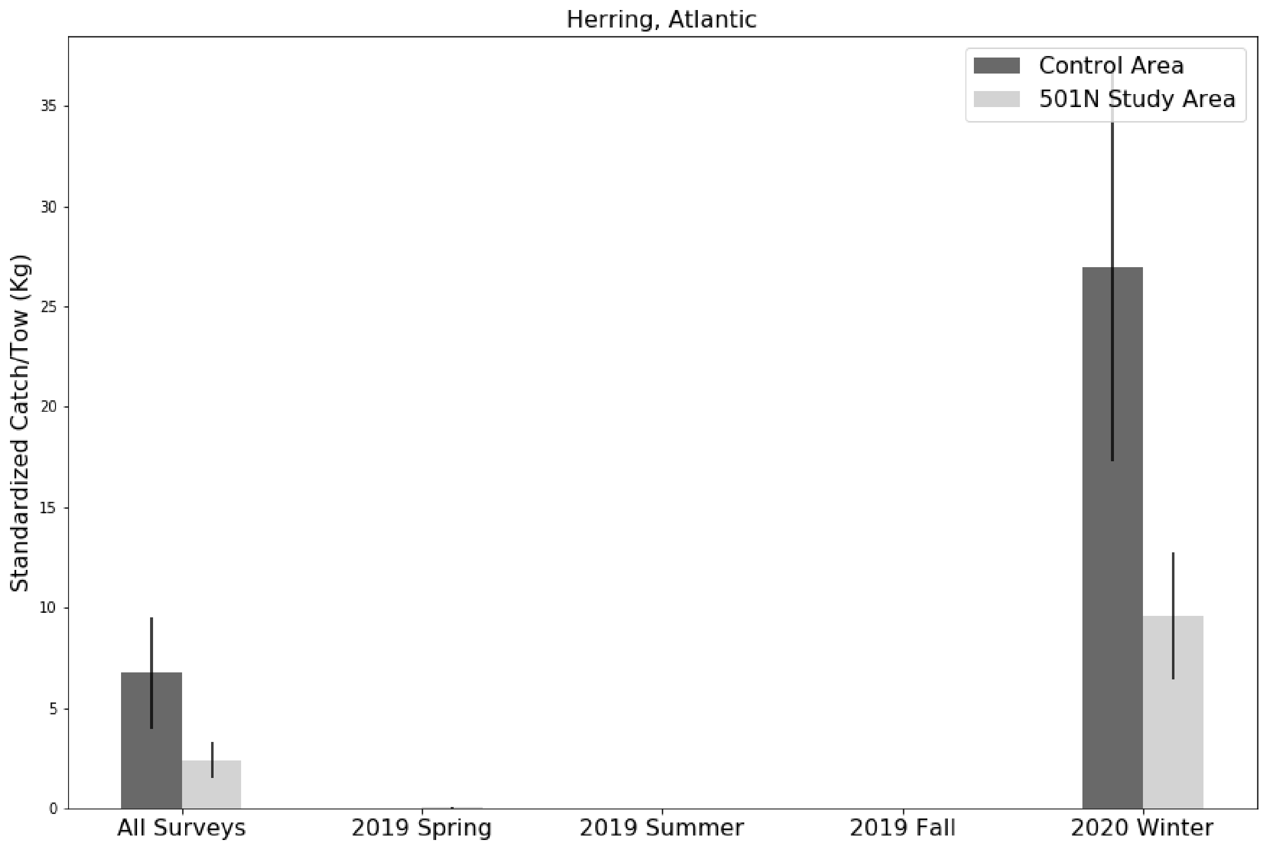


Figure 112: Seasonal catch rates of Atlantic herring in the 501 North Study Area and Control Area.

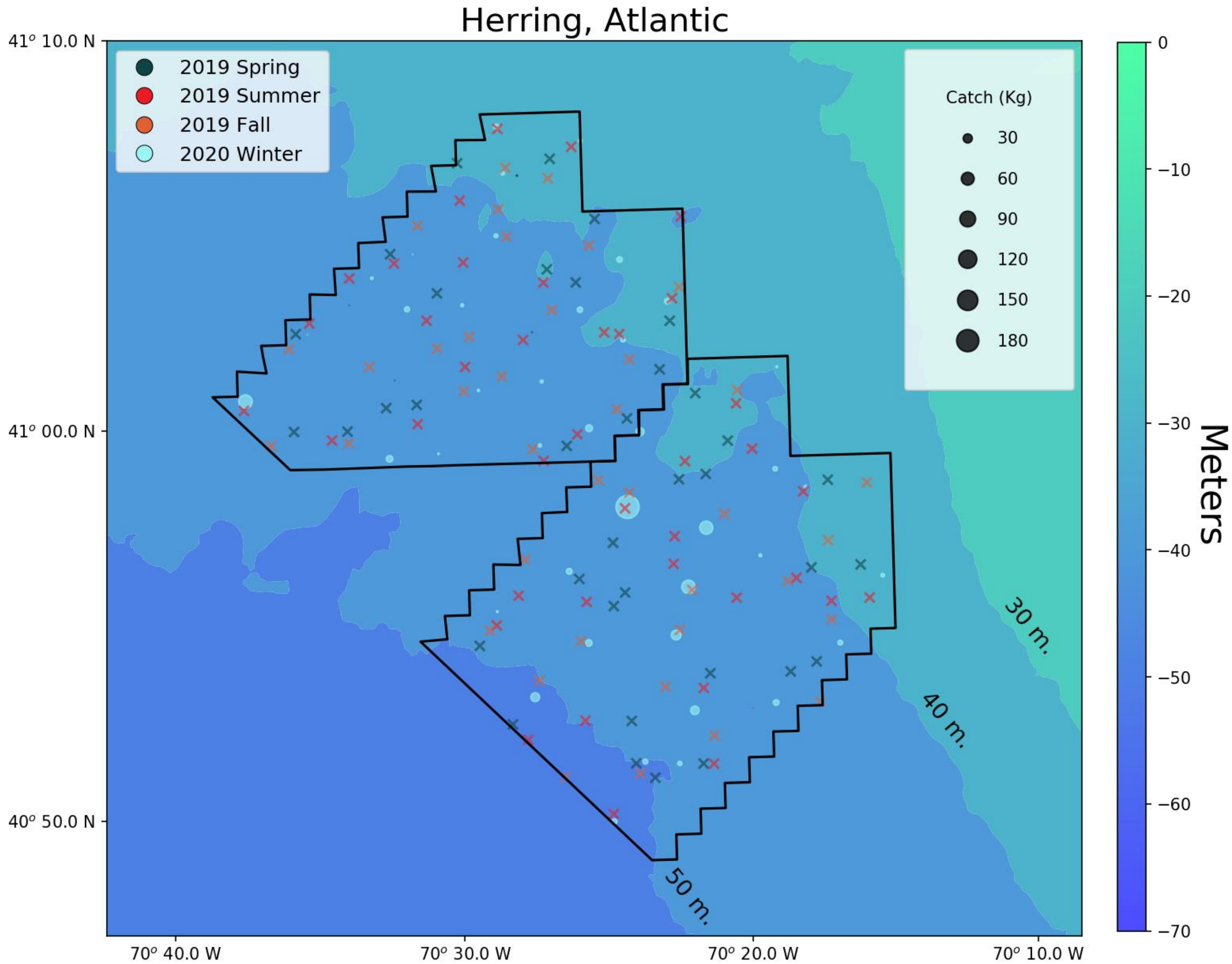


Figure 113: Seasonal distribution of the Atlantic herring catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

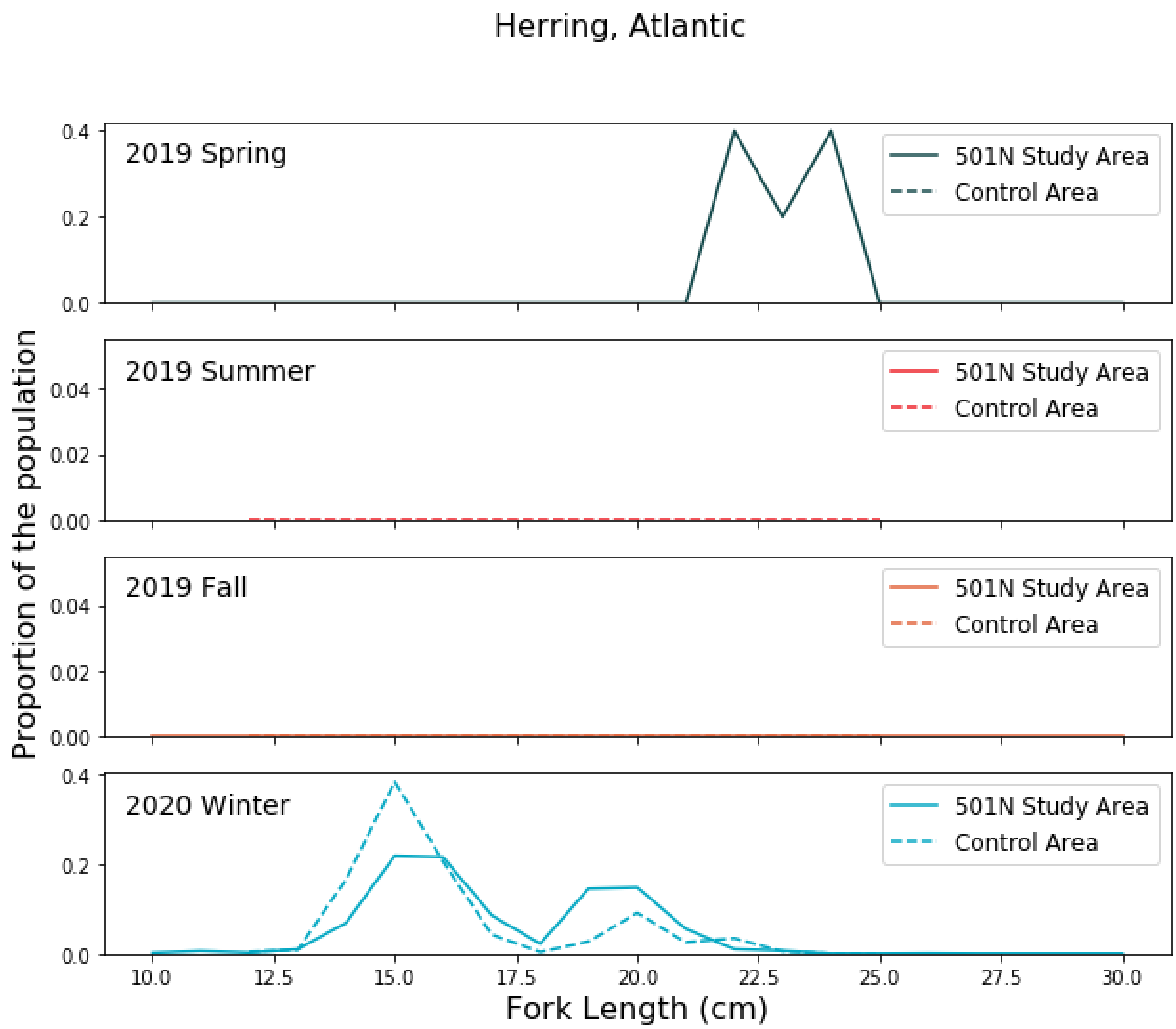


Figure 114: The seasonal length distributions of Atlantic herring in the 501 North Study Area and Control Area.

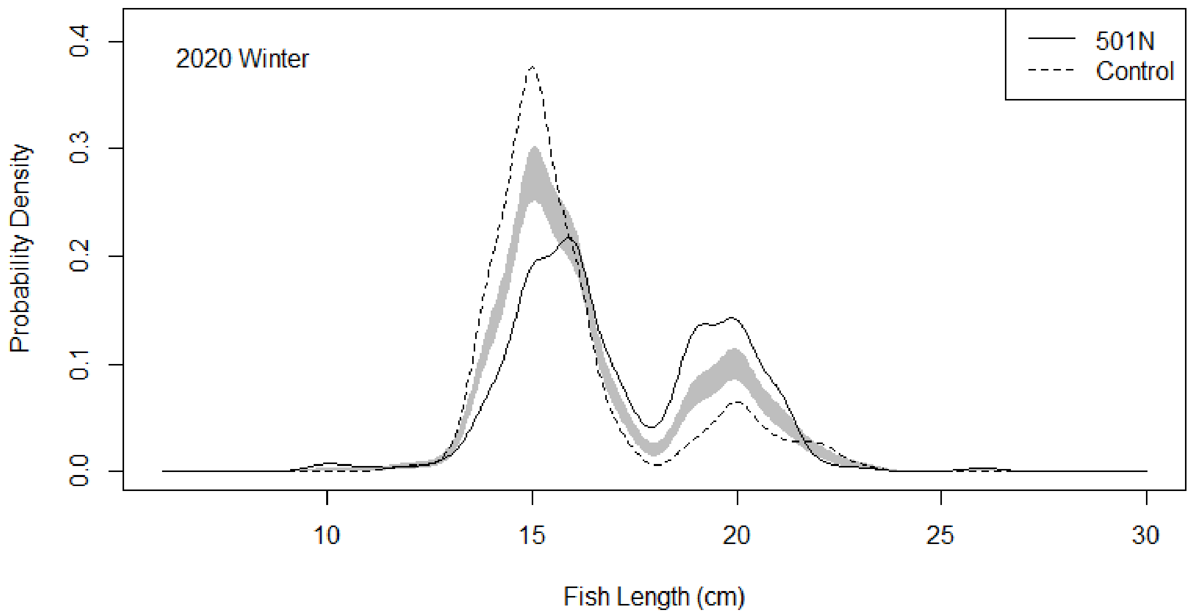
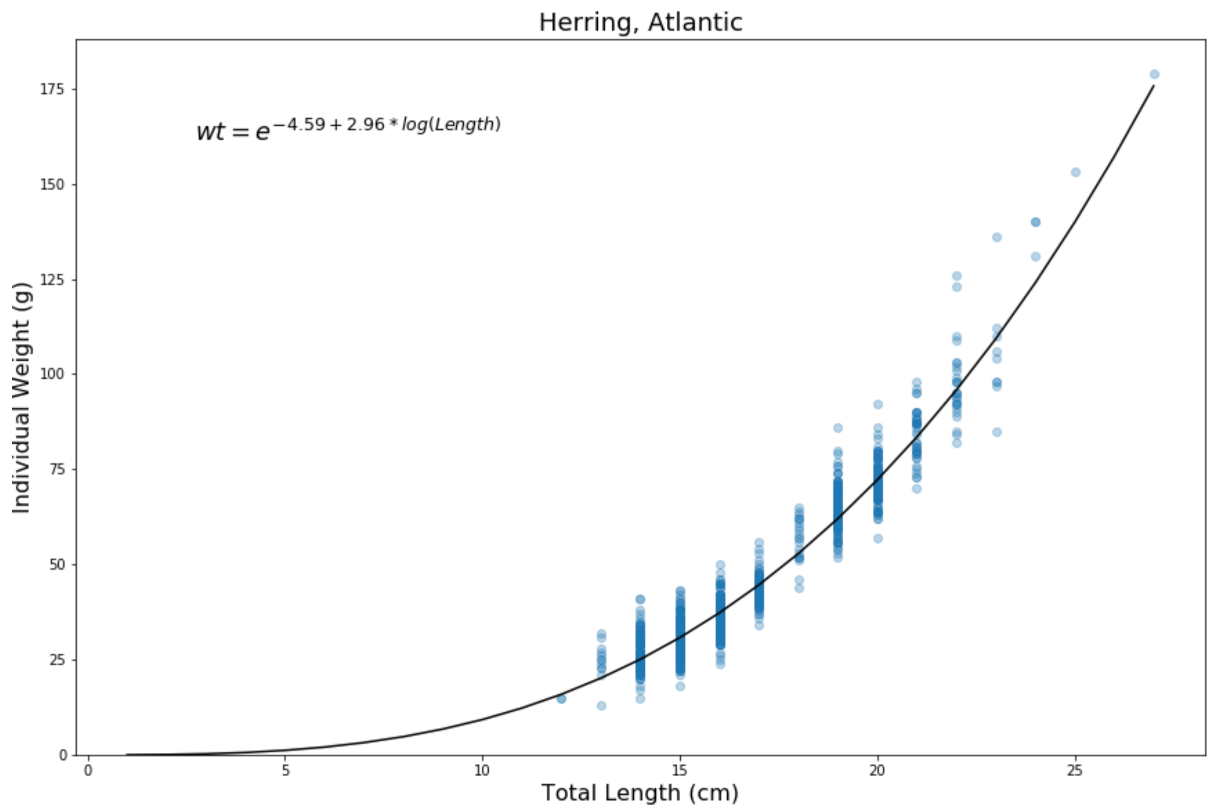


Figure 115: The population structure of Atlantic herring in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



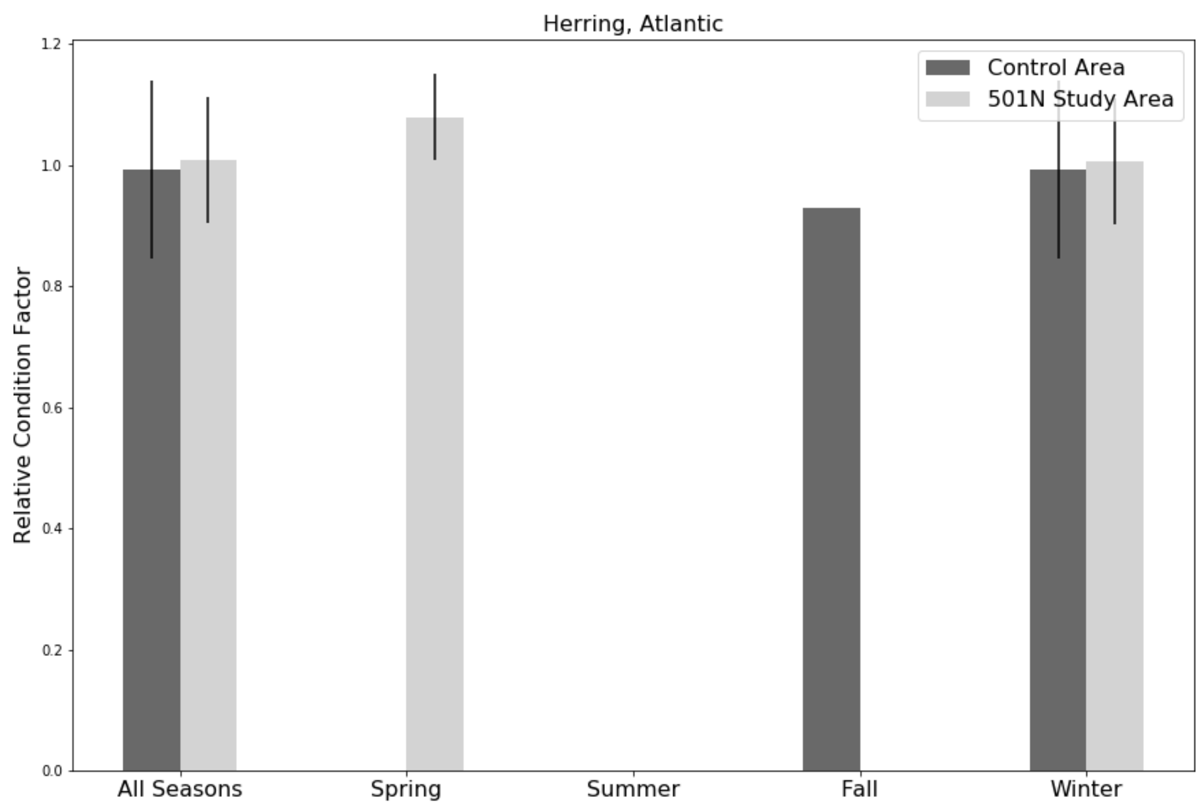


Figure 116: The seasonal condition of Atlantic herring (bottom) as derived from the length-weight relationship (top).

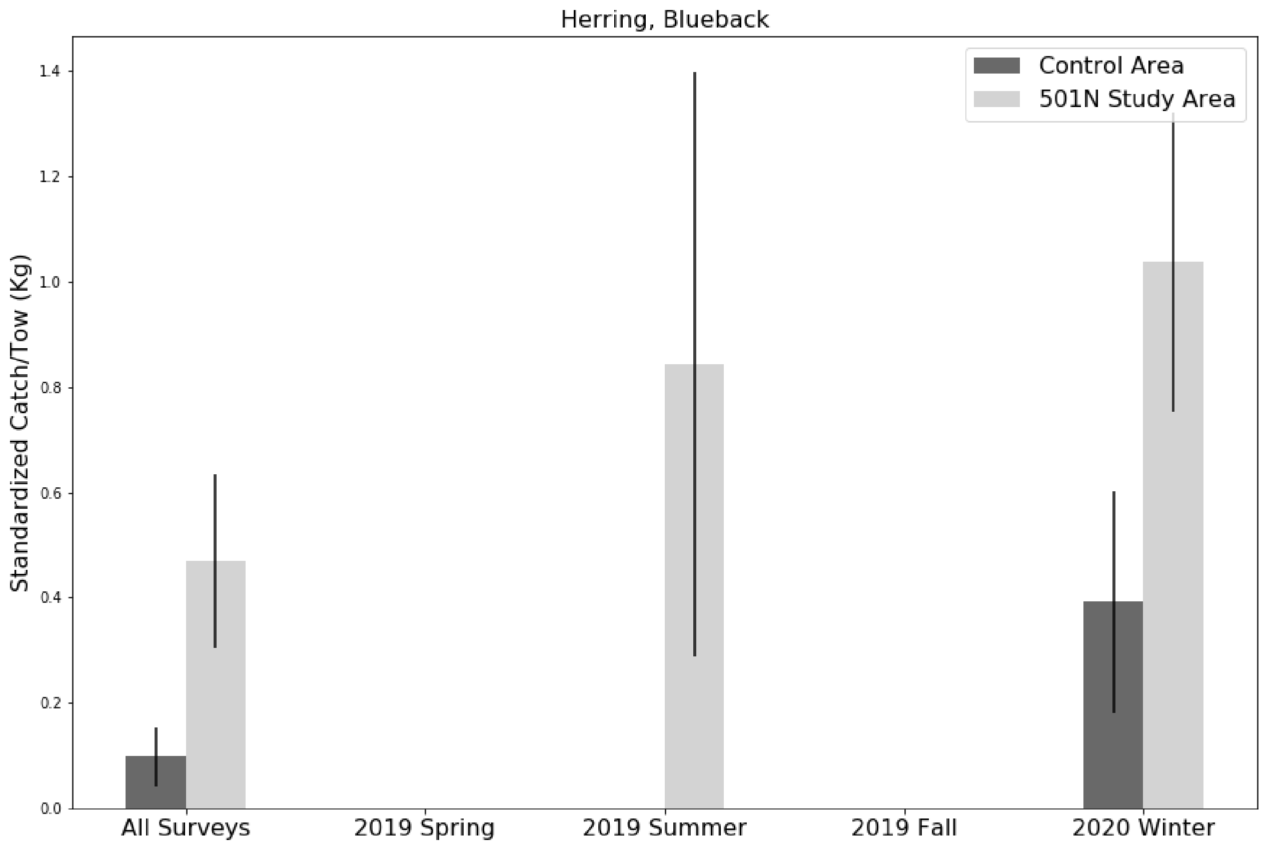


Figure 117: Seasonal catch rates of blueback herring in the 501 North Study Area and Control Area.

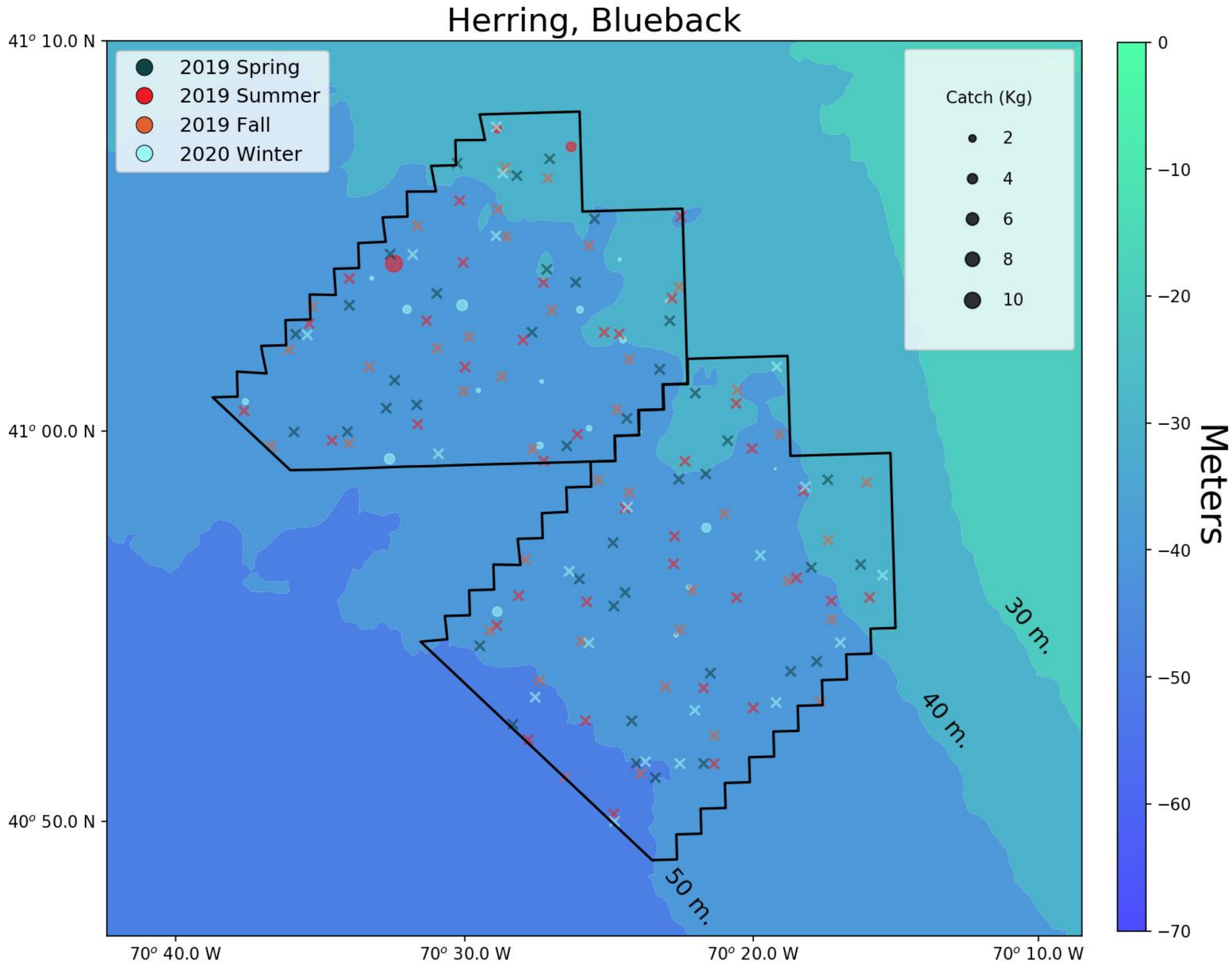


Figure 118: Seasonal distribution of the blueback herring catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

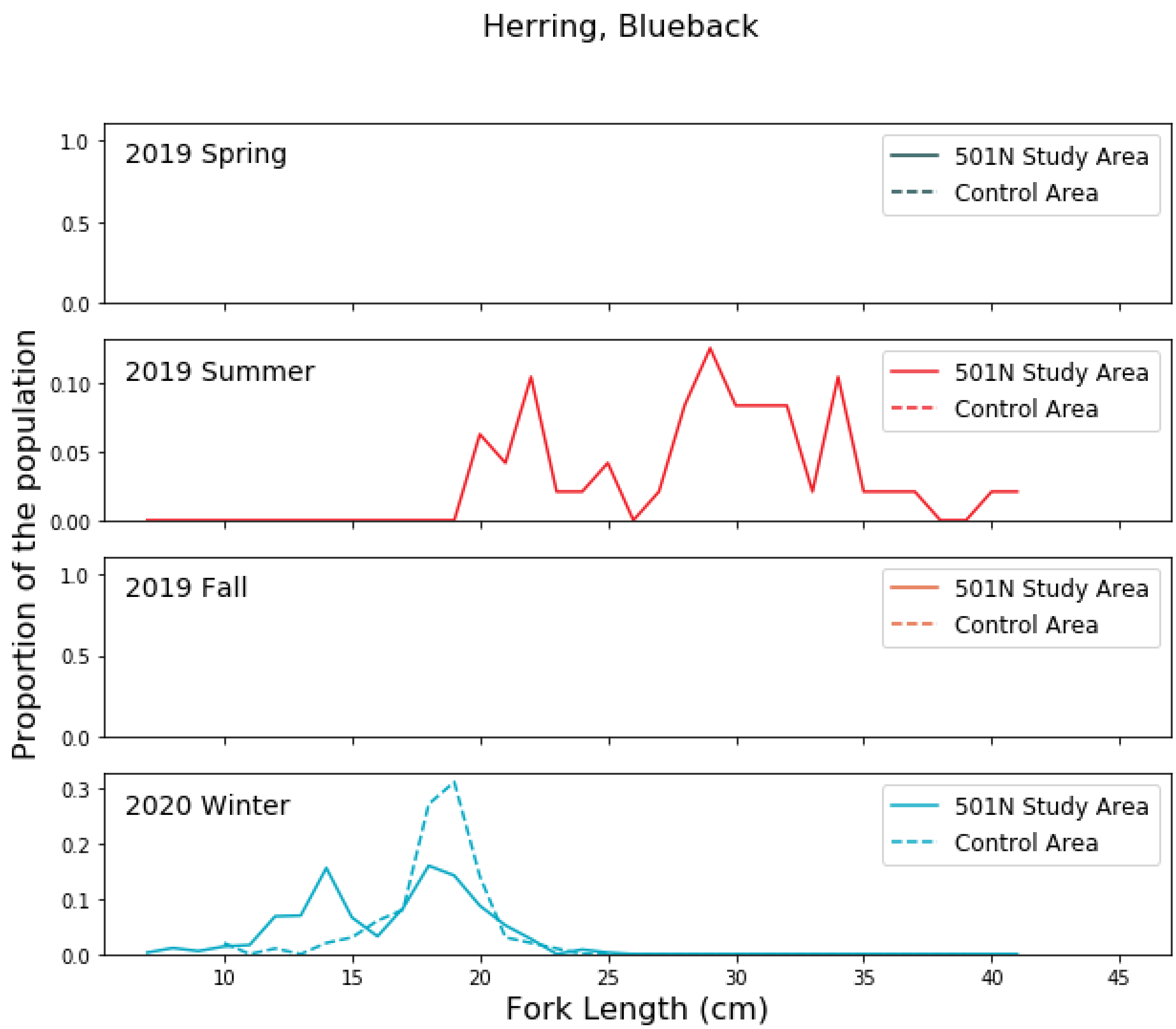


Figure 119: The seasonal length distributions of blueback herring in the 501 North Study Area and Control Area.

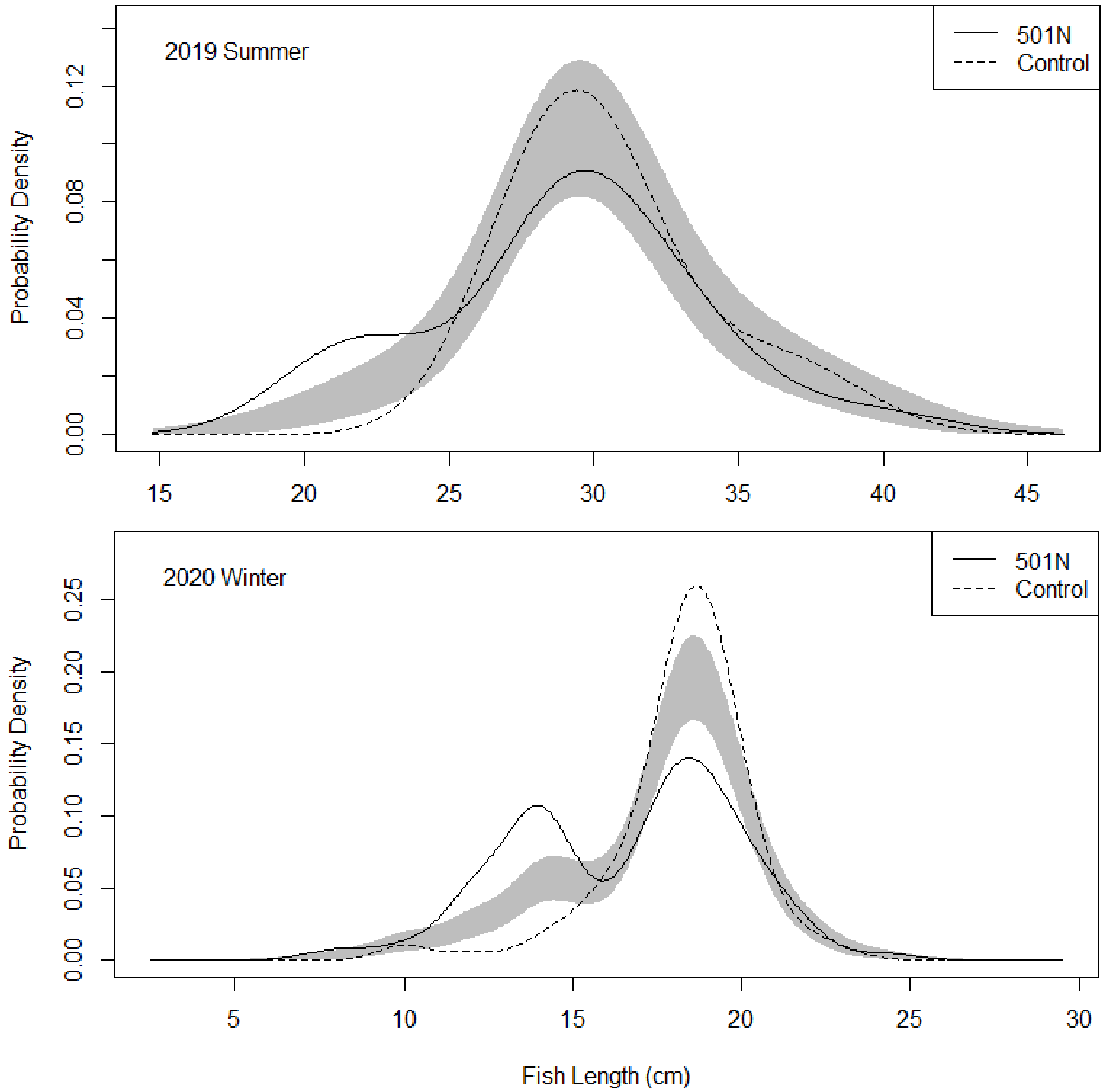
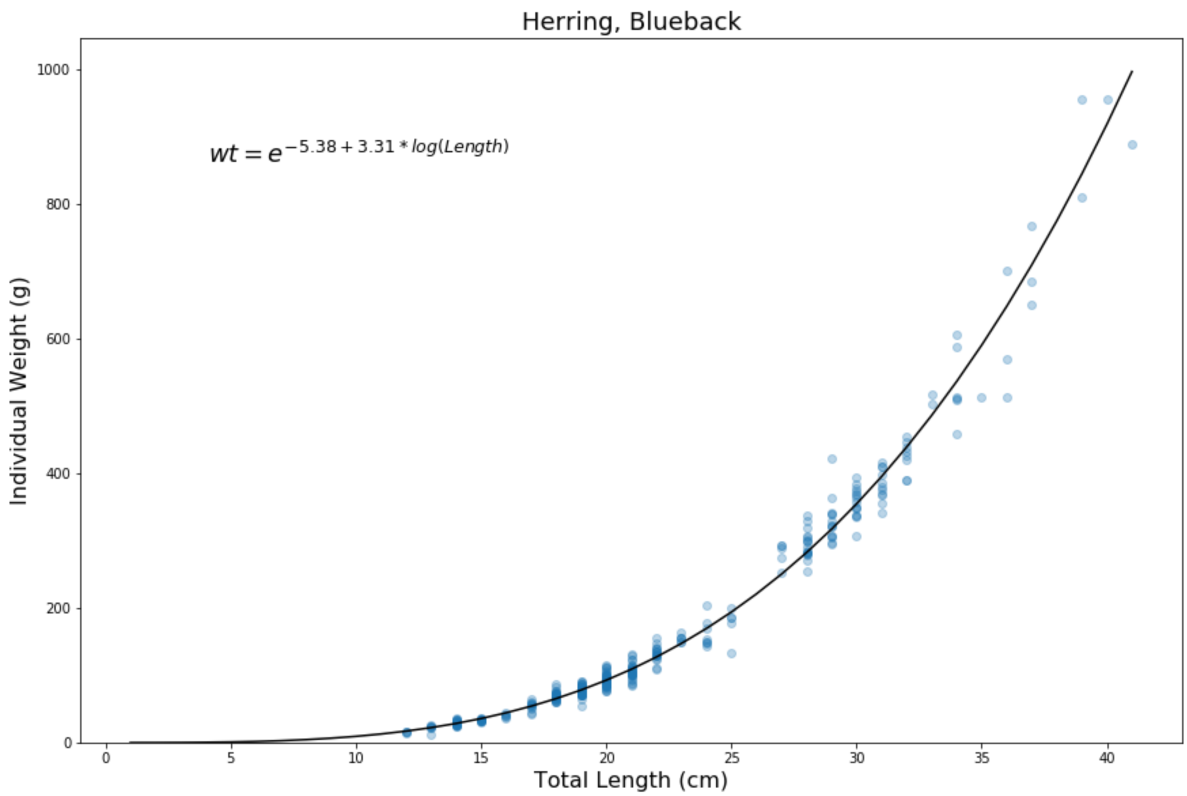


Figure 120: The population structure of blueback herring in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.



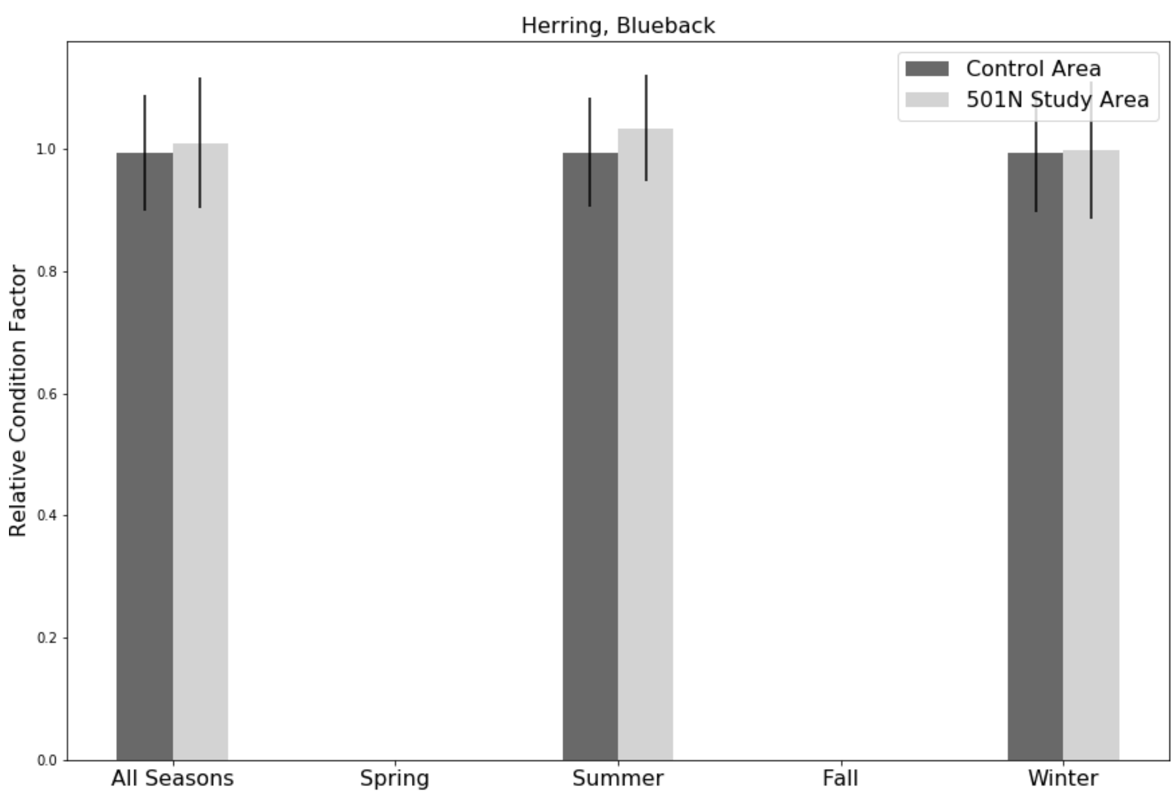


Figure 121: The seasonal condition of blueback herring (bottom) as derived from the length-weight relationship (top).

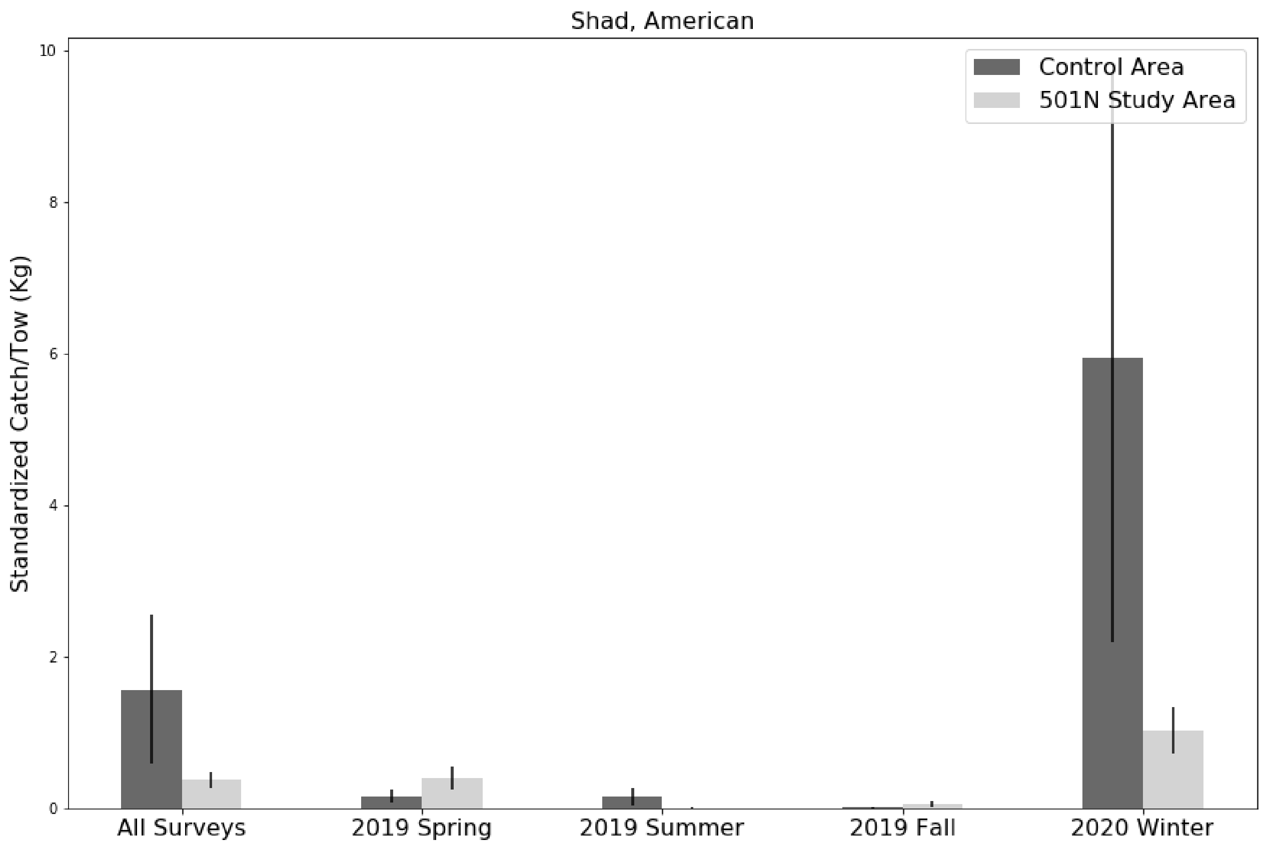


Figure 122: Seasonal catch rates of American shad in the 501 North Study Area and Control Area.

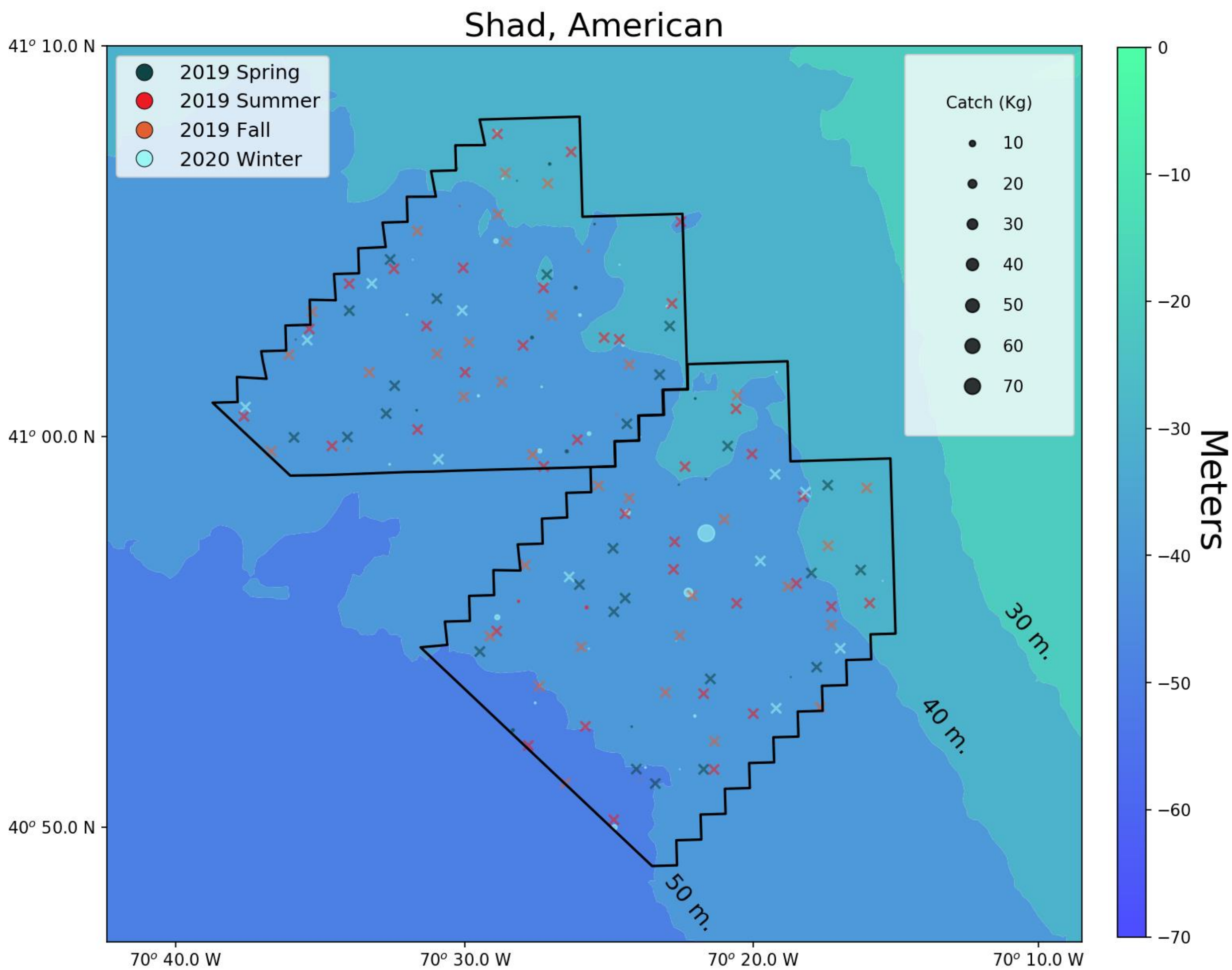


Figure 123: Seasonal distribution of the American shad catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

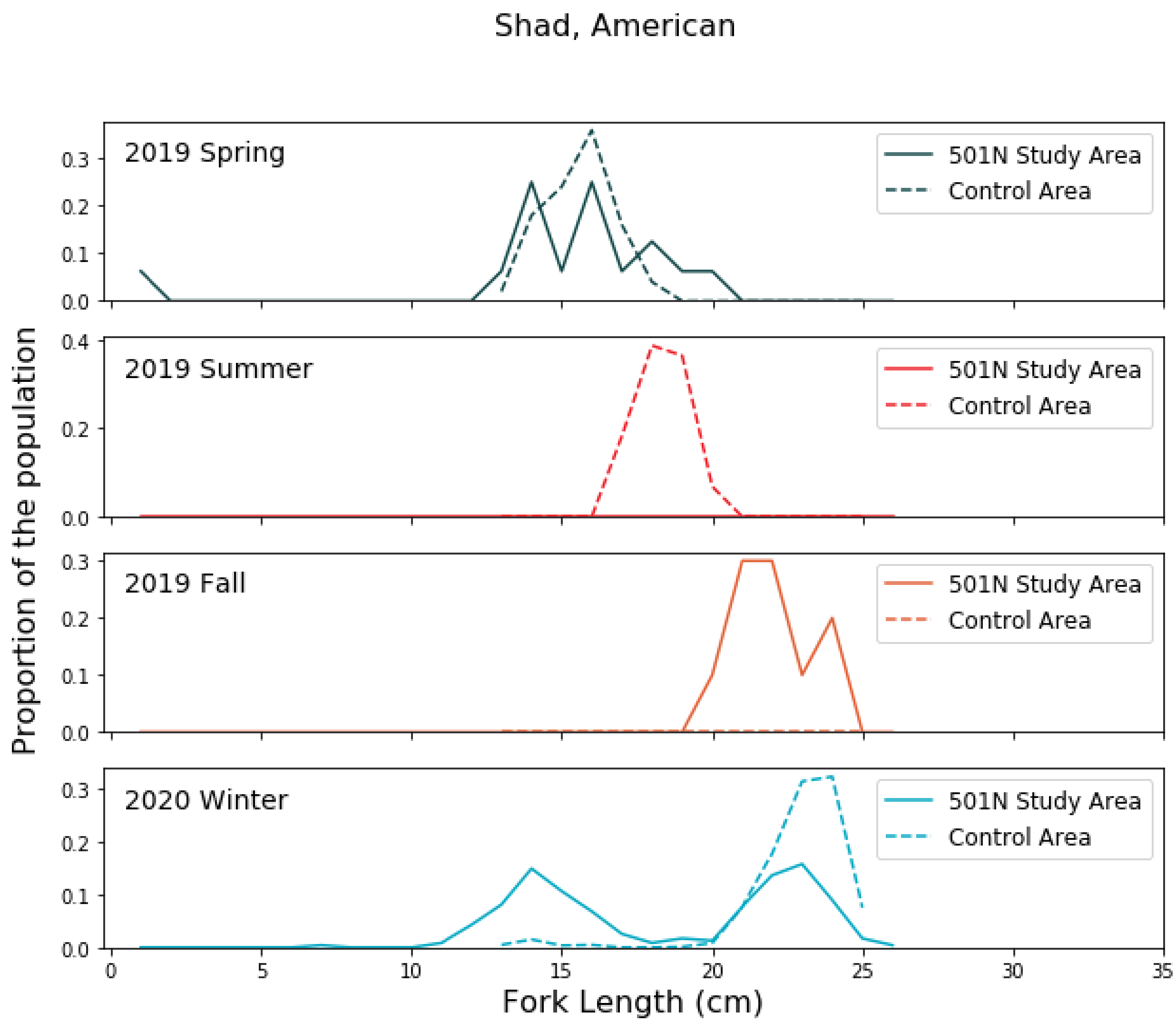


Figure 124: The seasonal length distributions of American shad in the 501 North Study Area and Control Area.

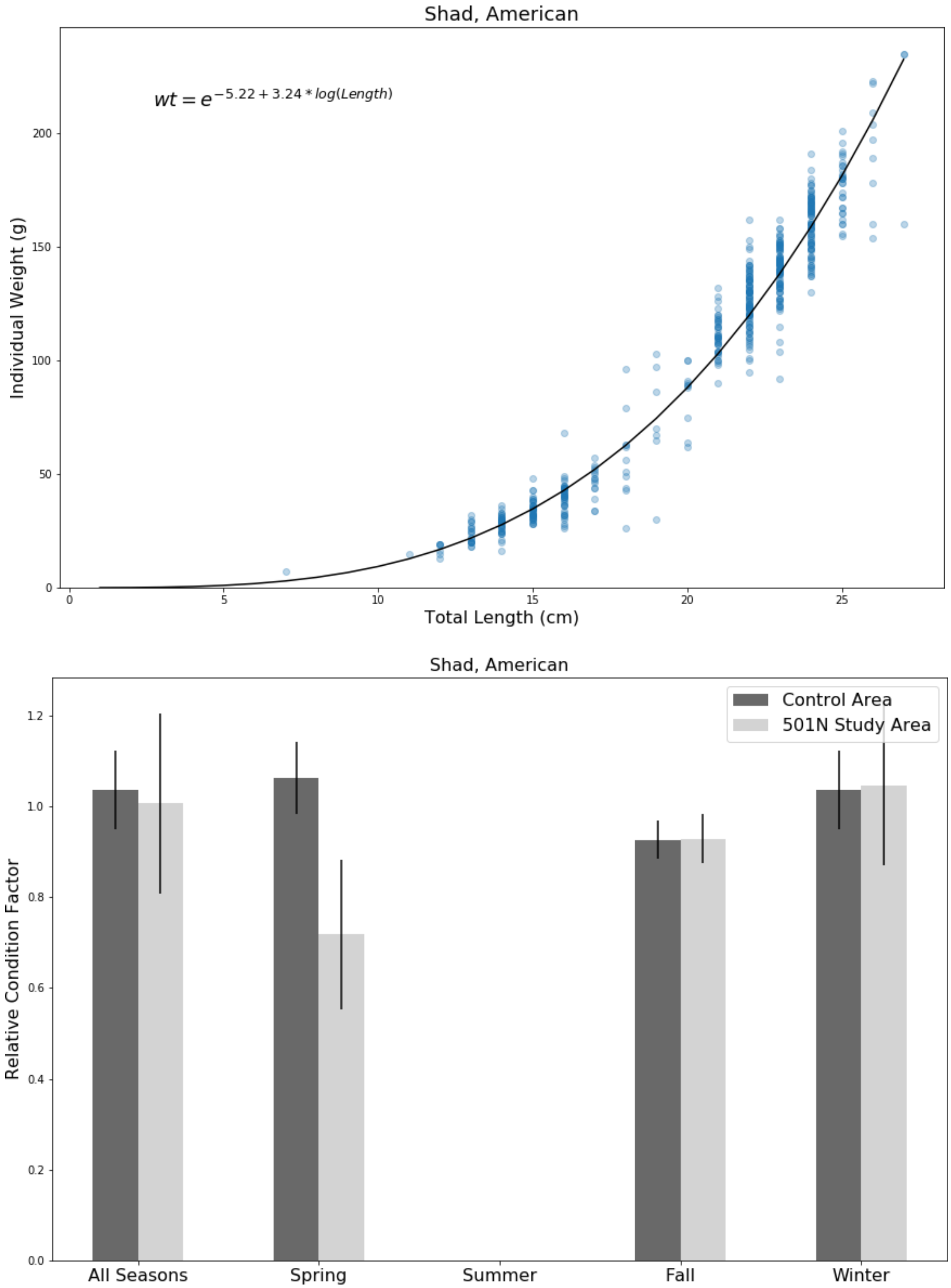


Figure 125: The seasonal condition of American shad (bottom) as derived from the length-weight relationship (top).

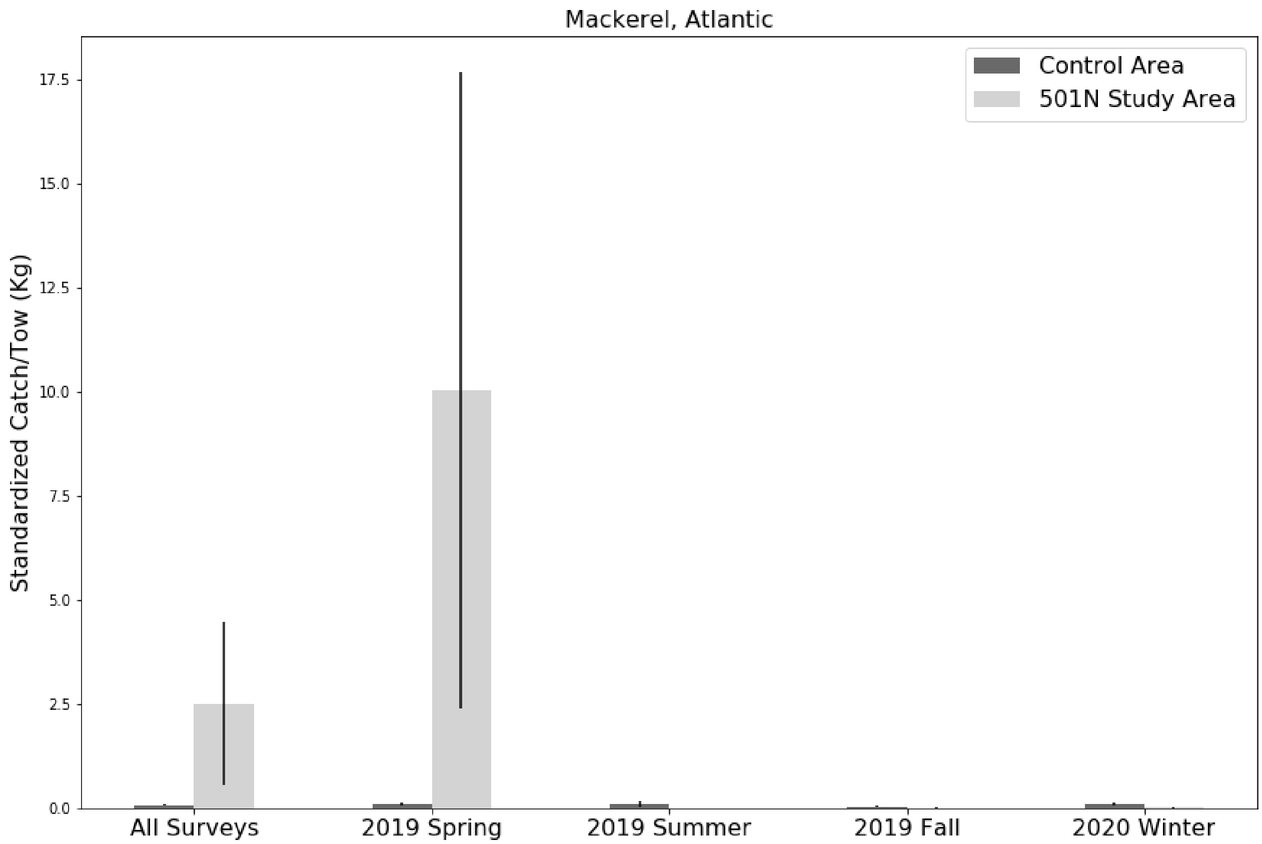


Figure 126: Seasonal catch rates of Atlantic mackerel in the 501 North Study Area and Control Area.

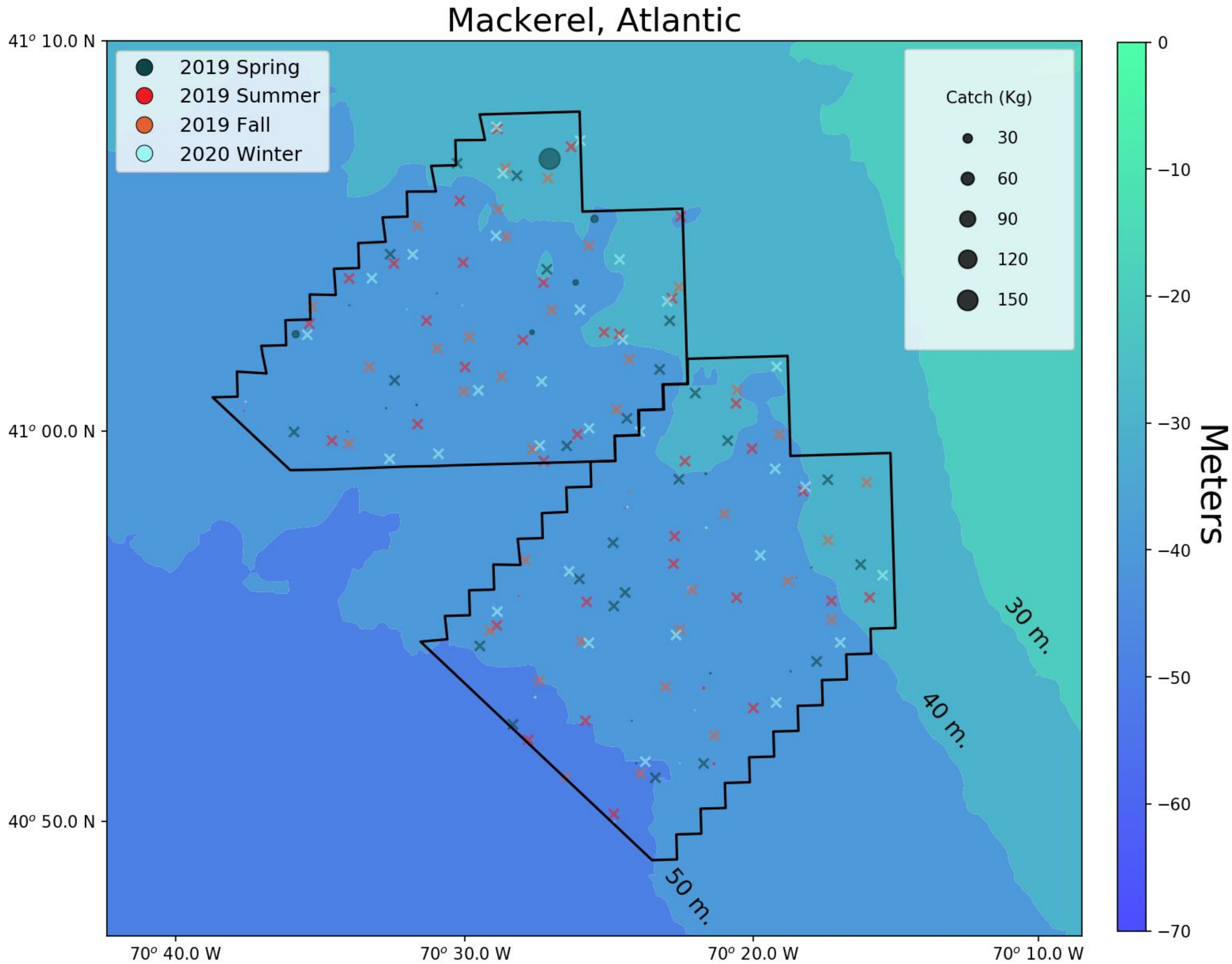


Figure 127: Seasonal distribution of the Atlantic mackerel catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

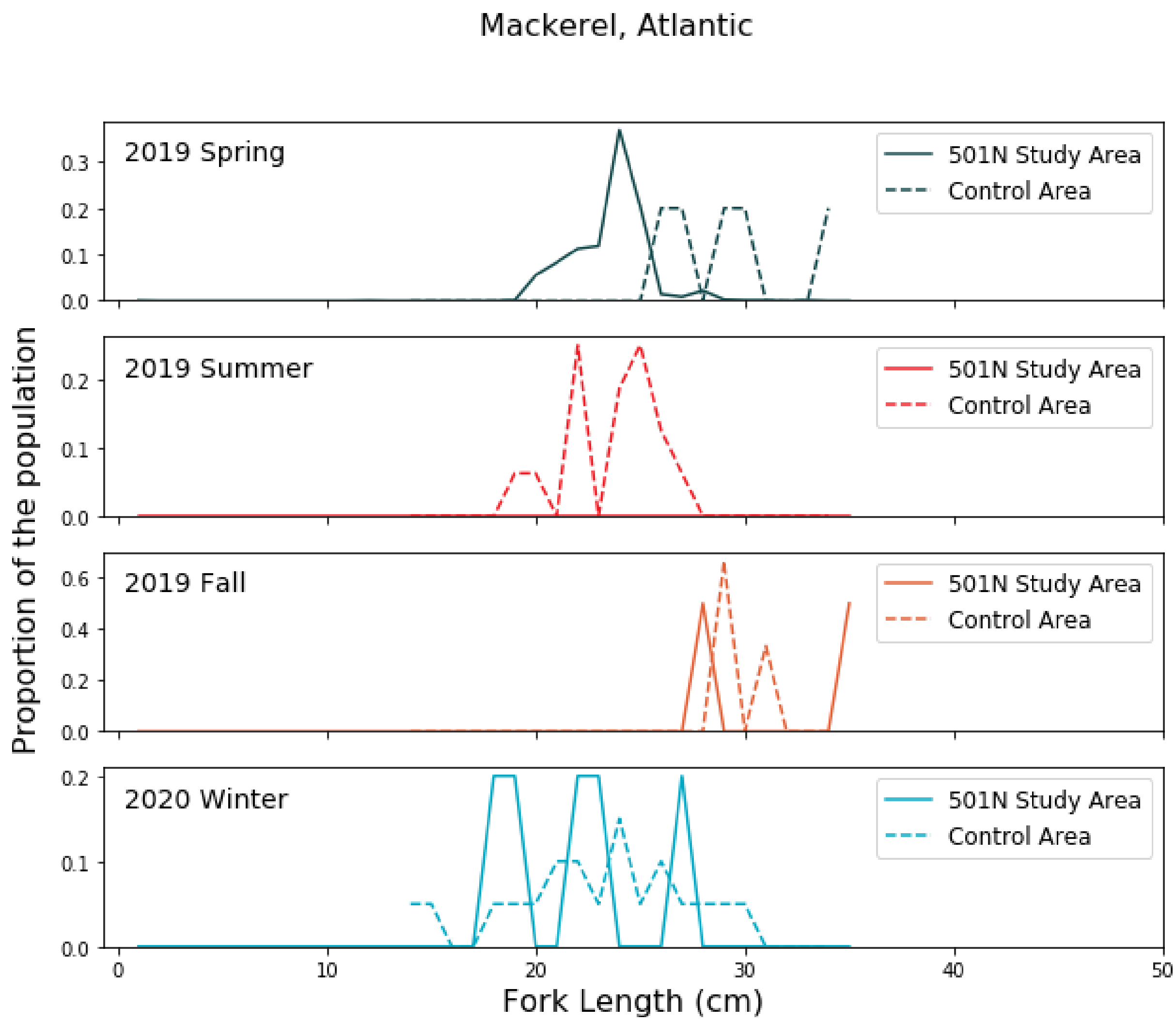


Figure 128: The seasonal length distributions of Atlantic mackerel in the 501 North Study Area and Control Area.

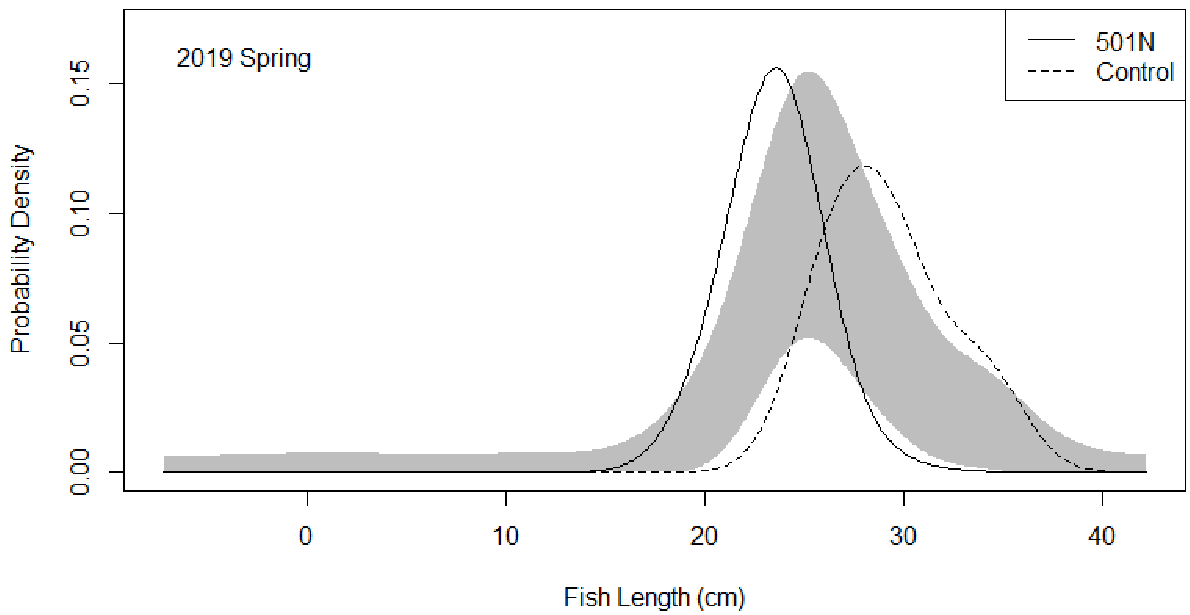


Figure 129: The population structure of Atlantic mackerel in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.

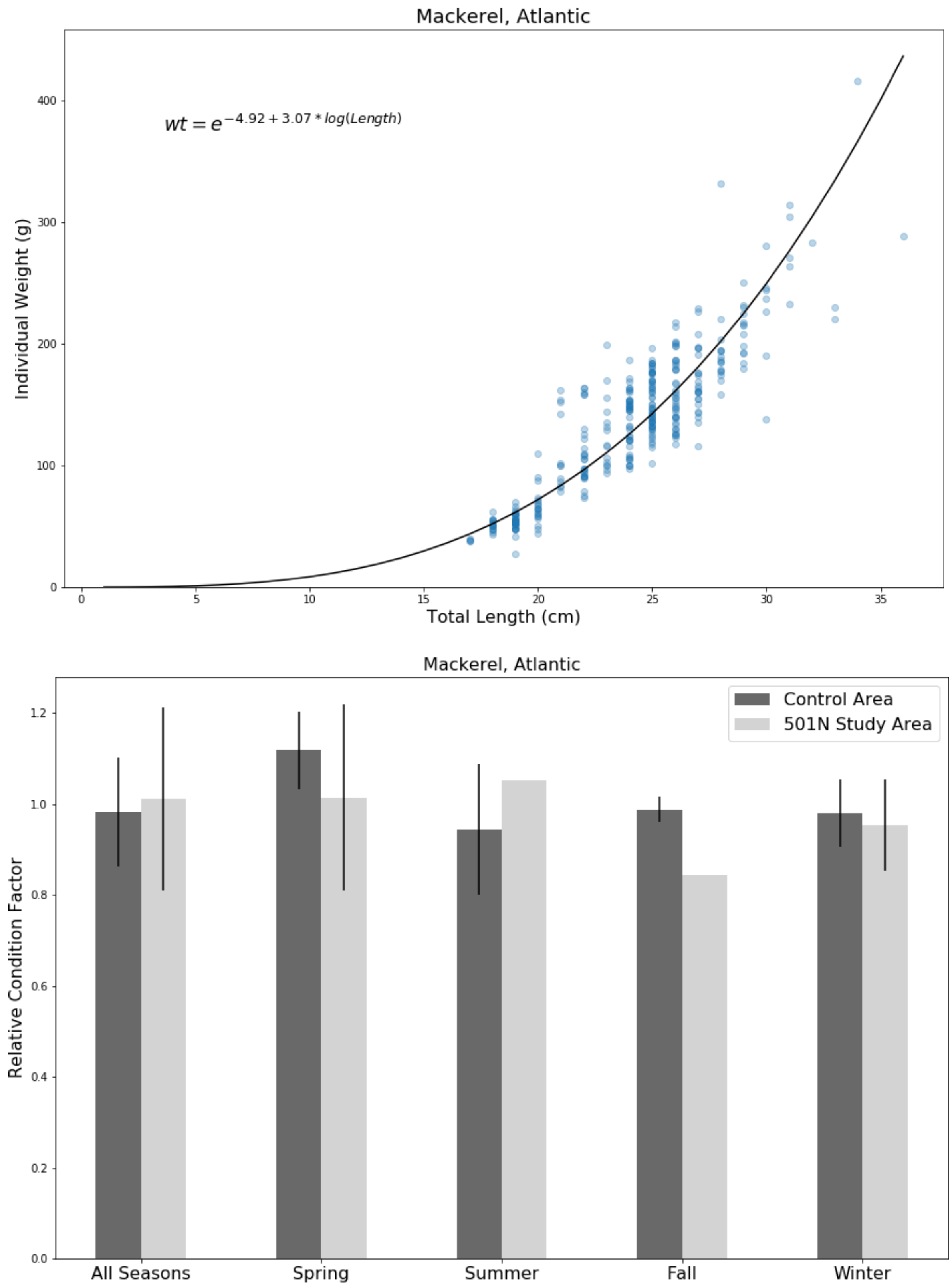


Figure 130: The seasonal condition of Atlantic mackerel (bottom) as derived from the length-weight relationship (top).

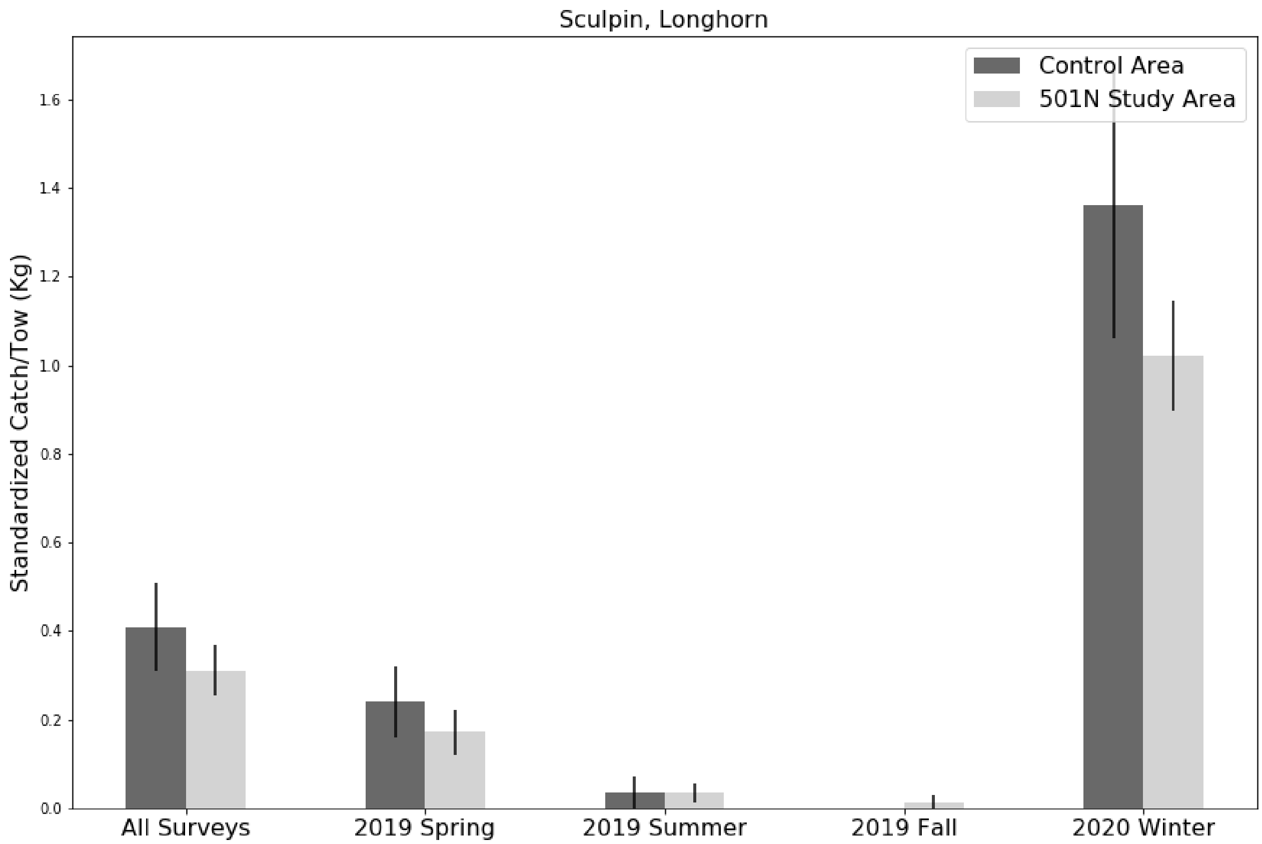


Figure 131: Seasonal catch rates of longhorn sculpin in the 501 North Study Area and Control Area.

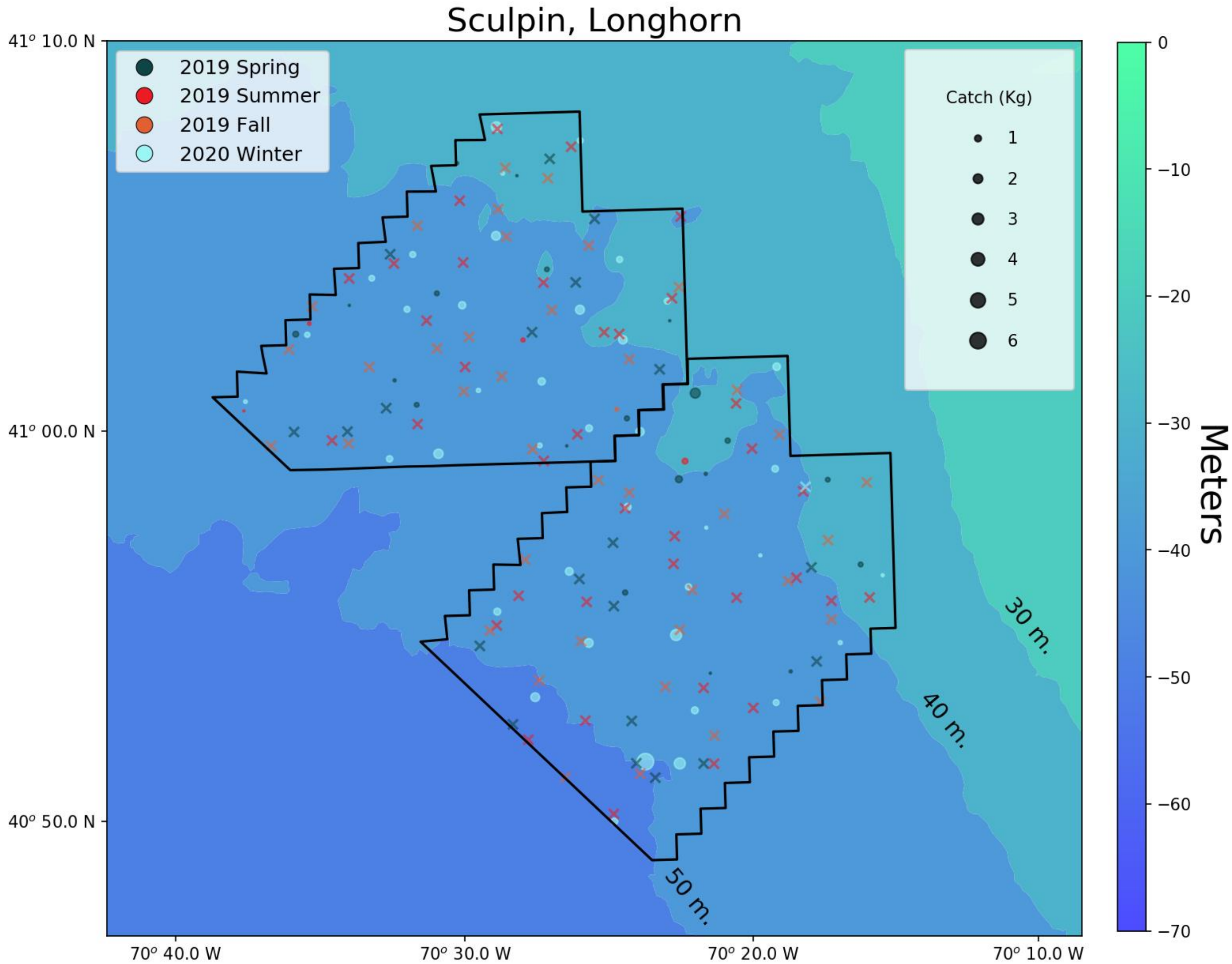


Figure 132: Seasonal distribution of the longhorn sculpin catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

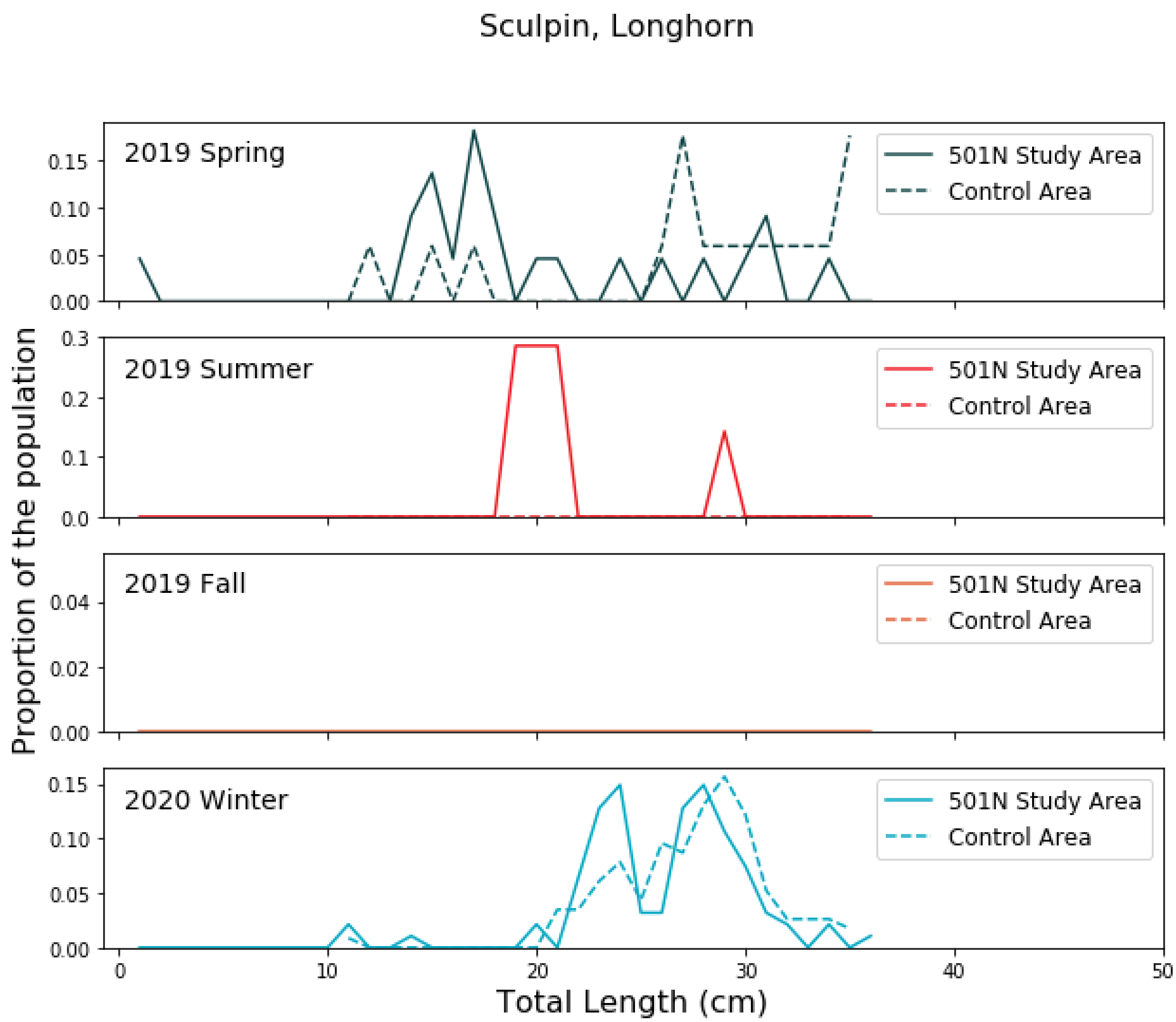


Figure 133: The seasonal length distributions of longhorn sculpin in the 501 North Study Area and Control Area.

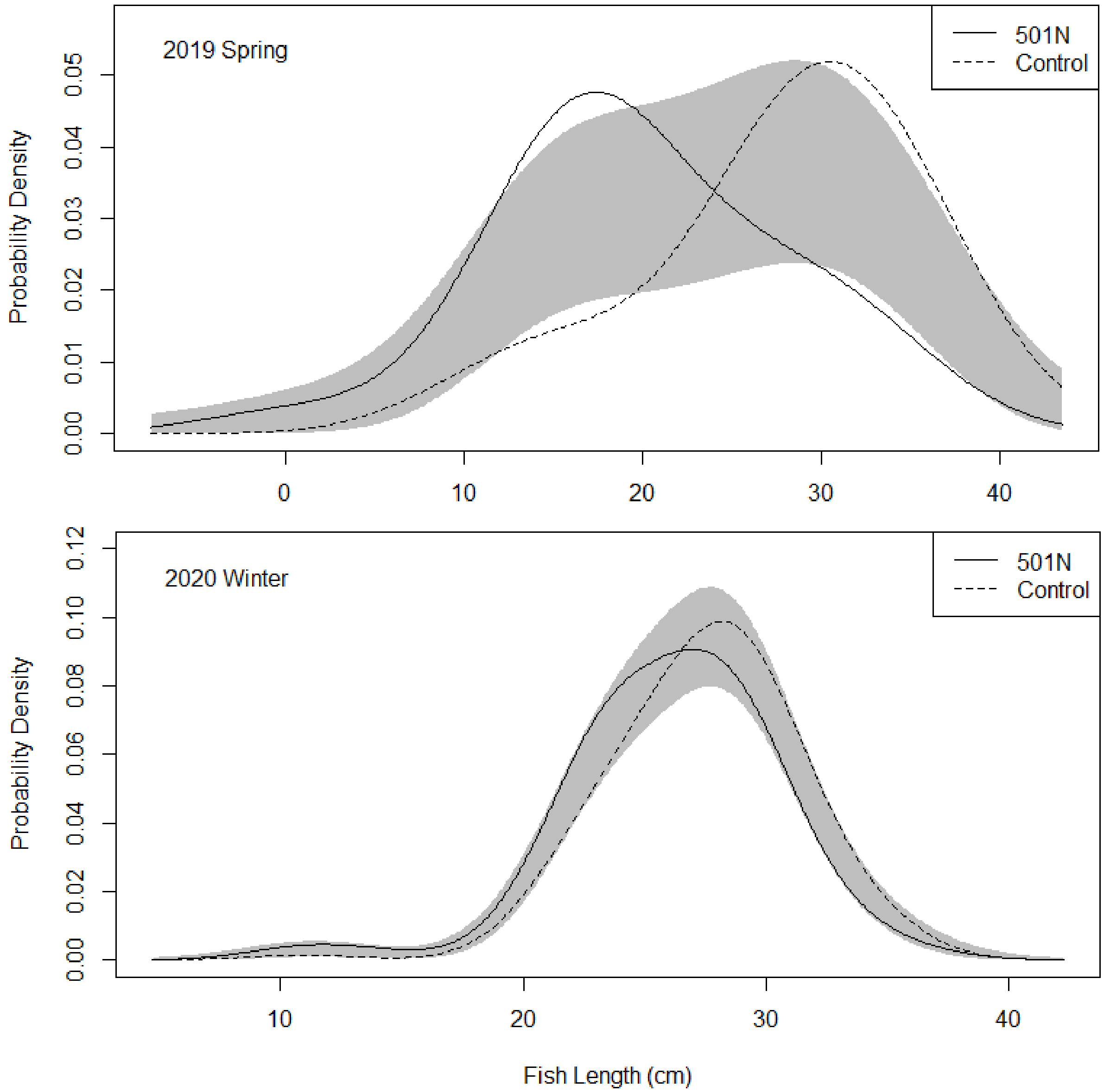


Figure 134: The population structure of longhorn sculpin in the 501 North Study Area and Control Area assessed through kernel density estimates. The grey band represents the null hypothesis of no significant difference between treatments.

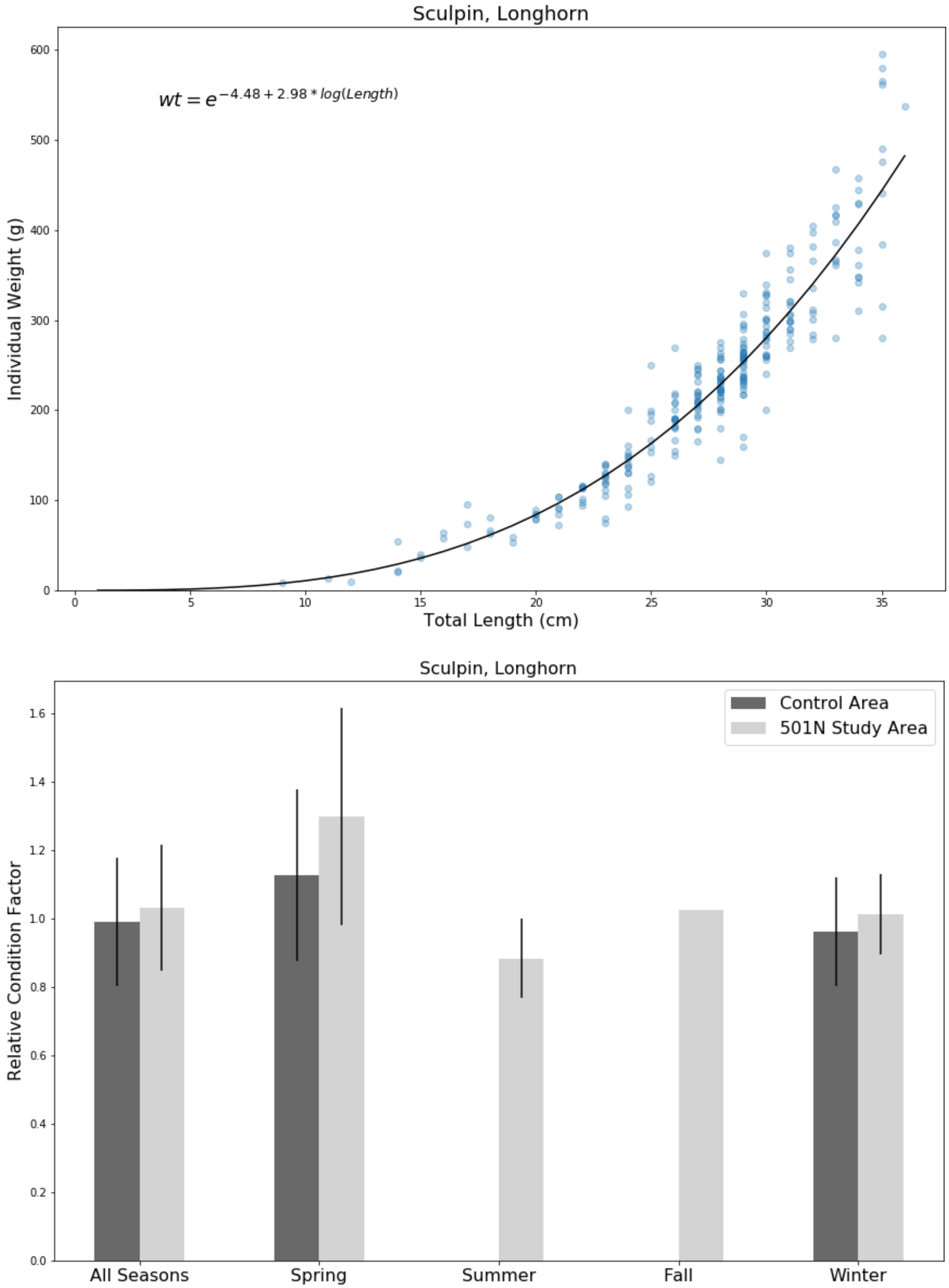


Figure 135: The seasonal condition of longhorn sculpin (bottom) as derived from the length-weight relationship (top).

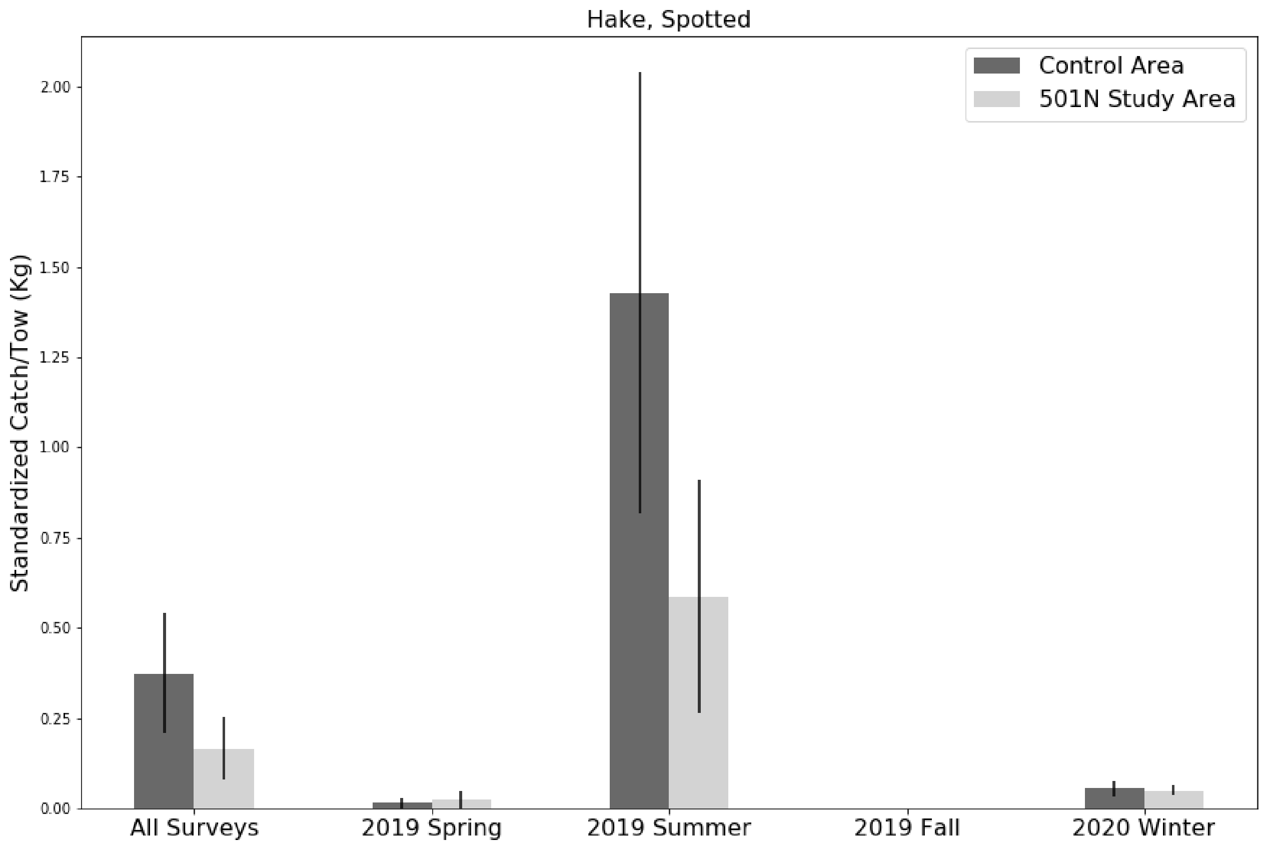


Figure 136: Seasonal catch rates of spotted hake in the 501 North Study Area and Control Area.

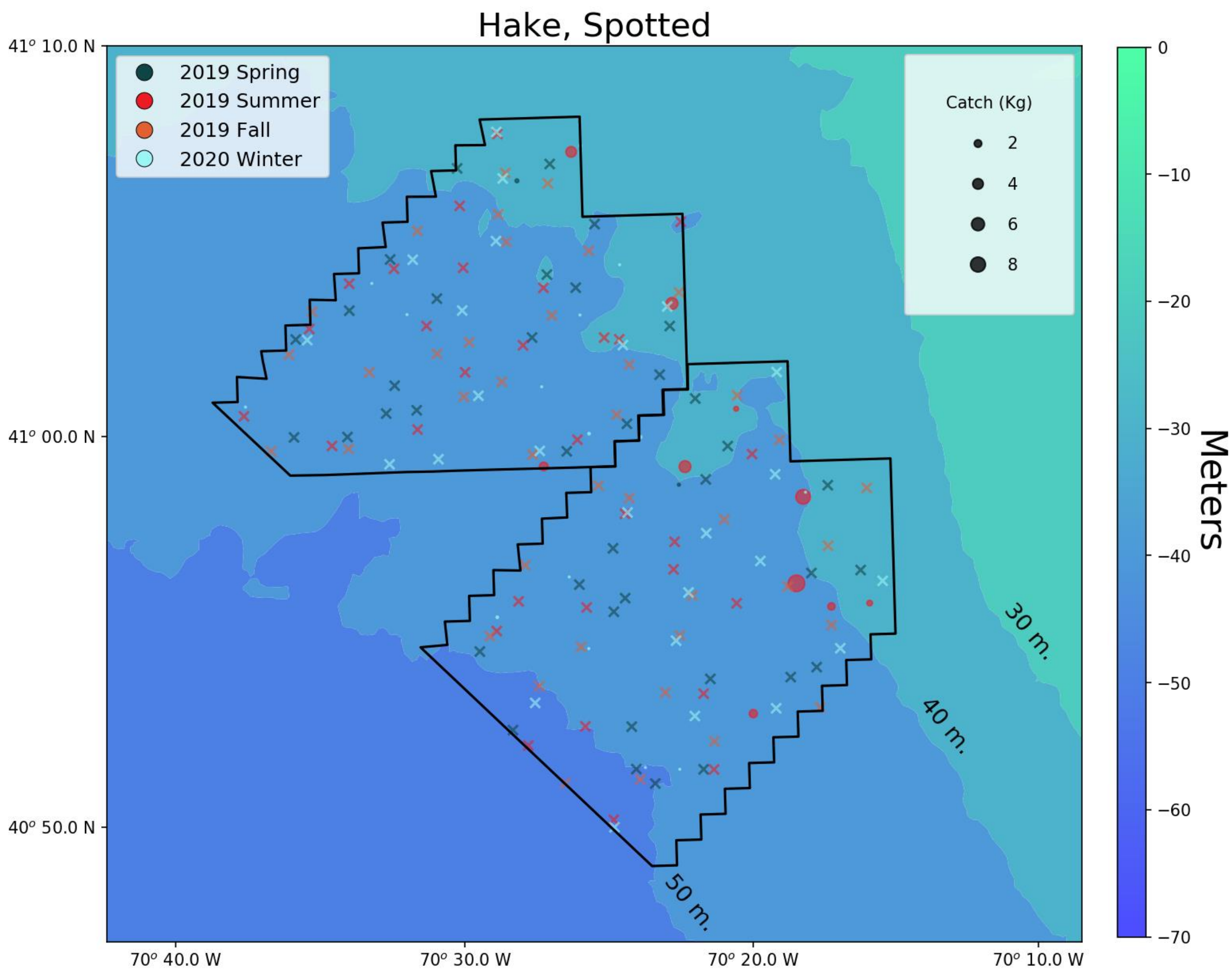


Figure 137: Seasonal distribution of the spotted hake catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

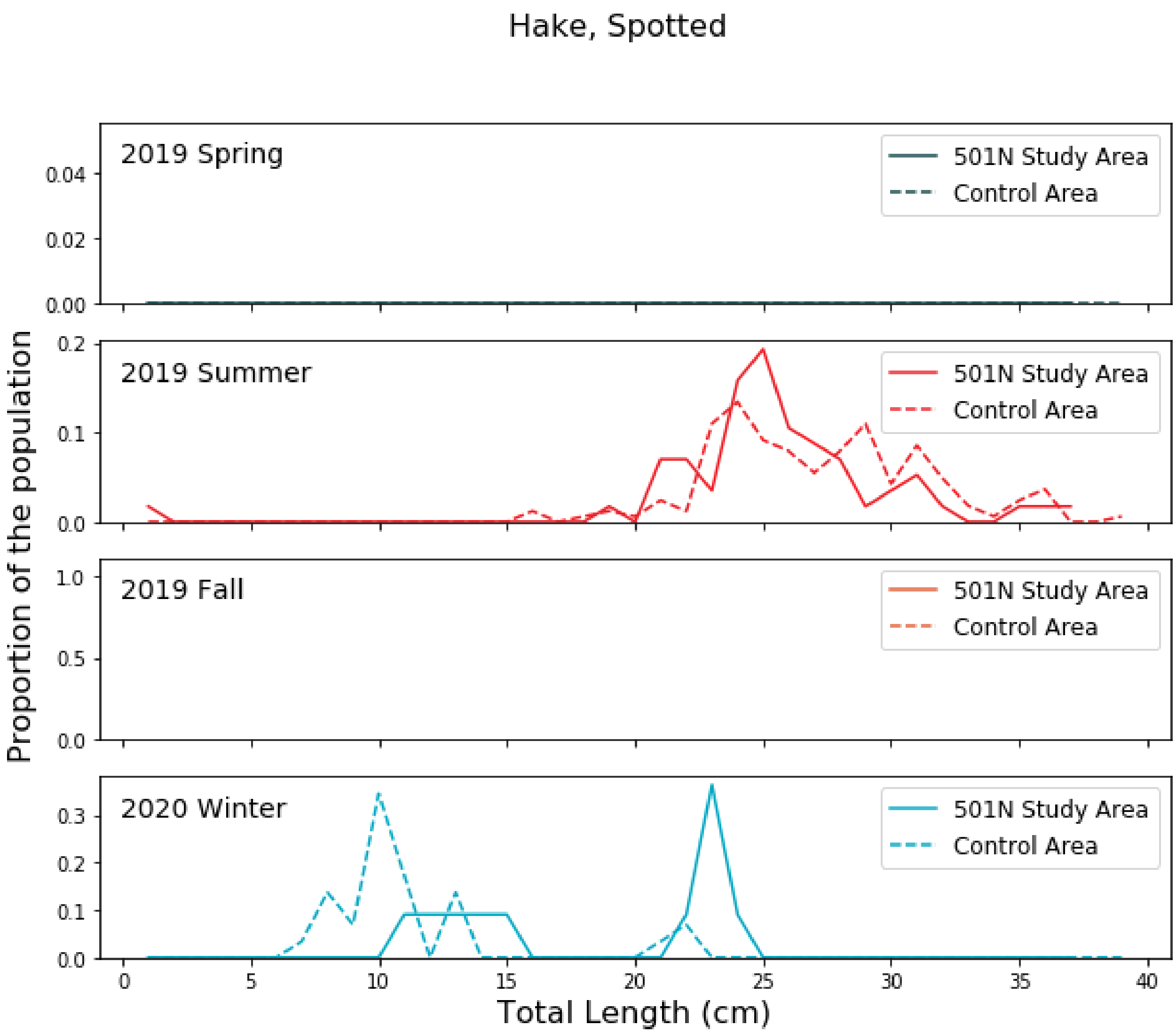


Figure 138: The seasonal length distributions of spotted hake in the 501 North Study Area and Control Area.

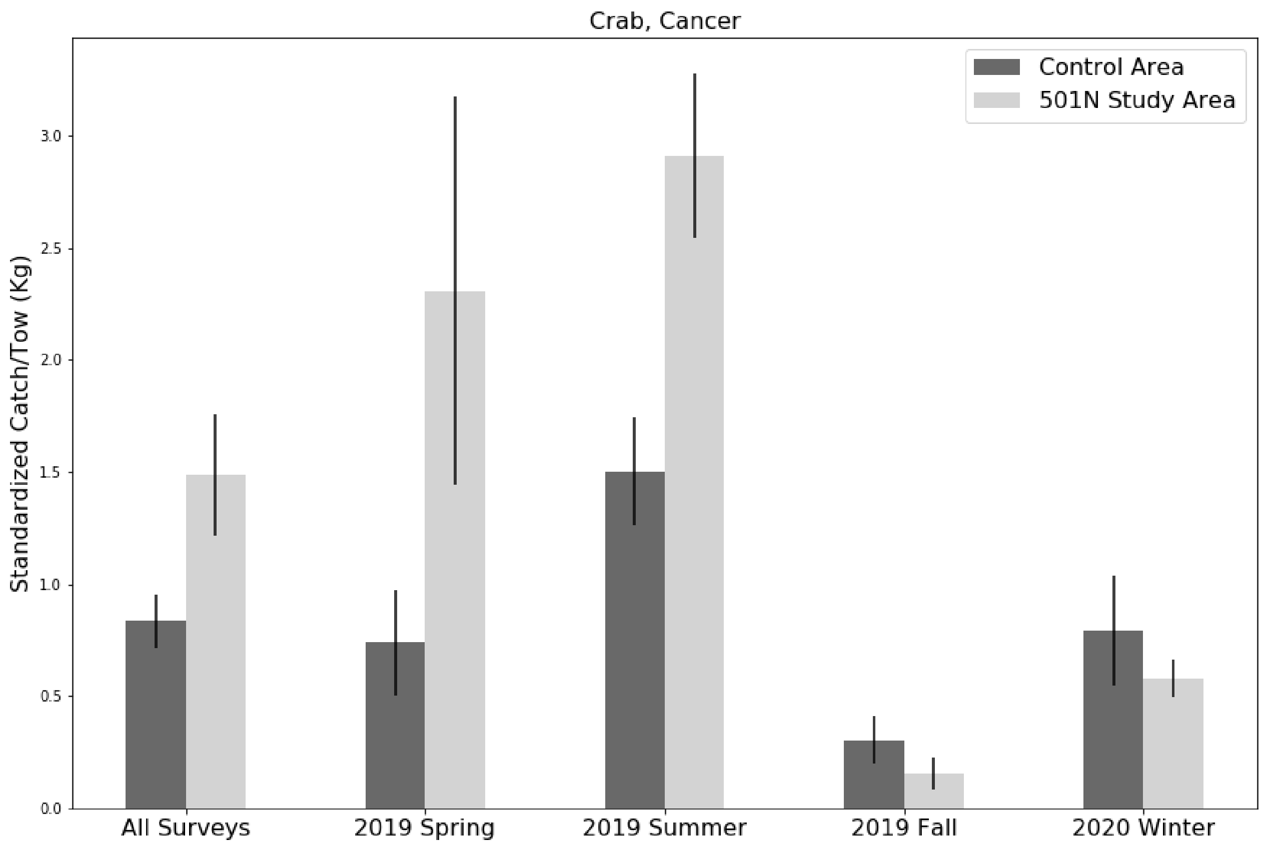


Figure 139: Seasonal catch rates of cancer crab in the 501 North Study Area and Control Area.

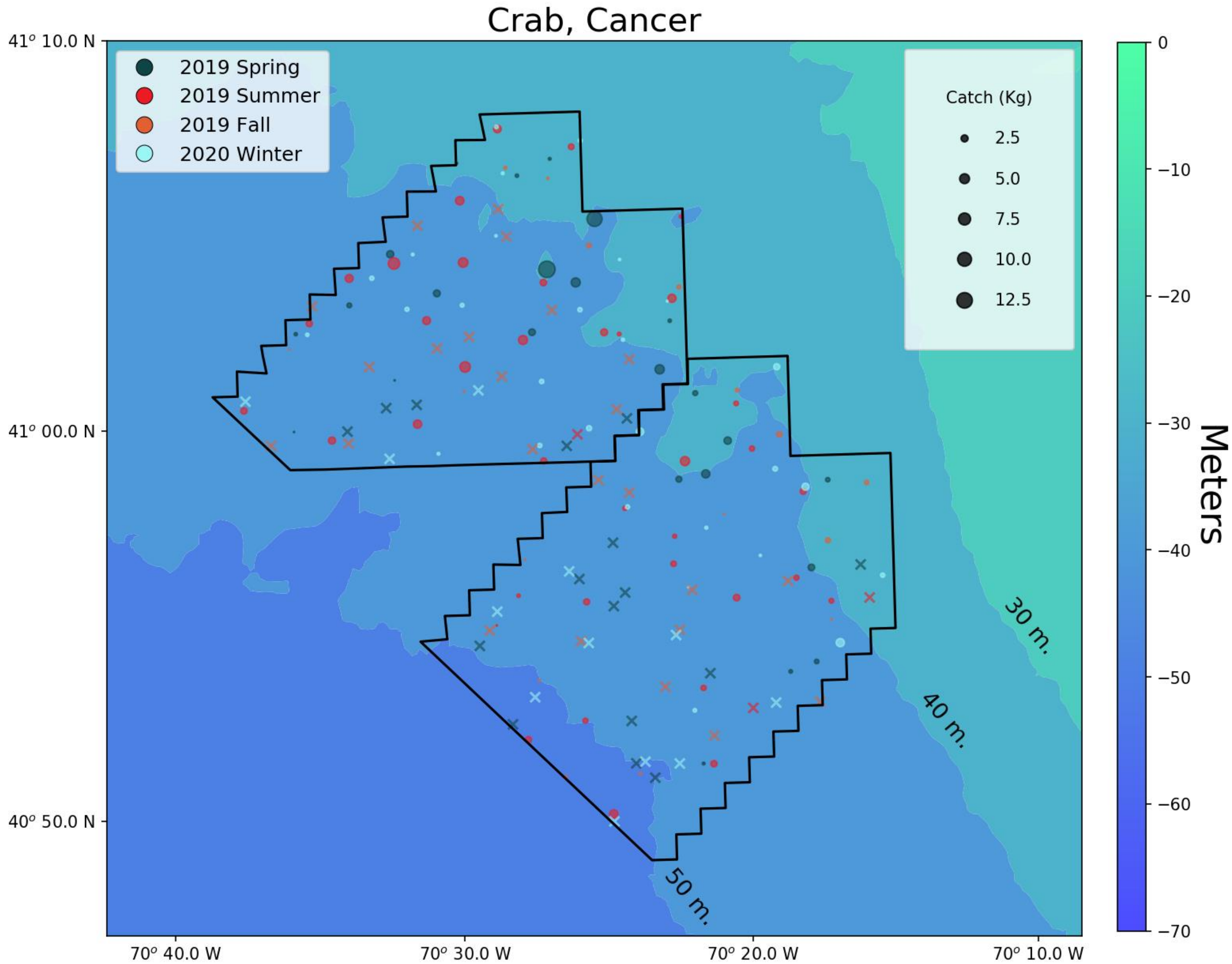


Figure 140: Seasonal distribution of the cancer crab catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.

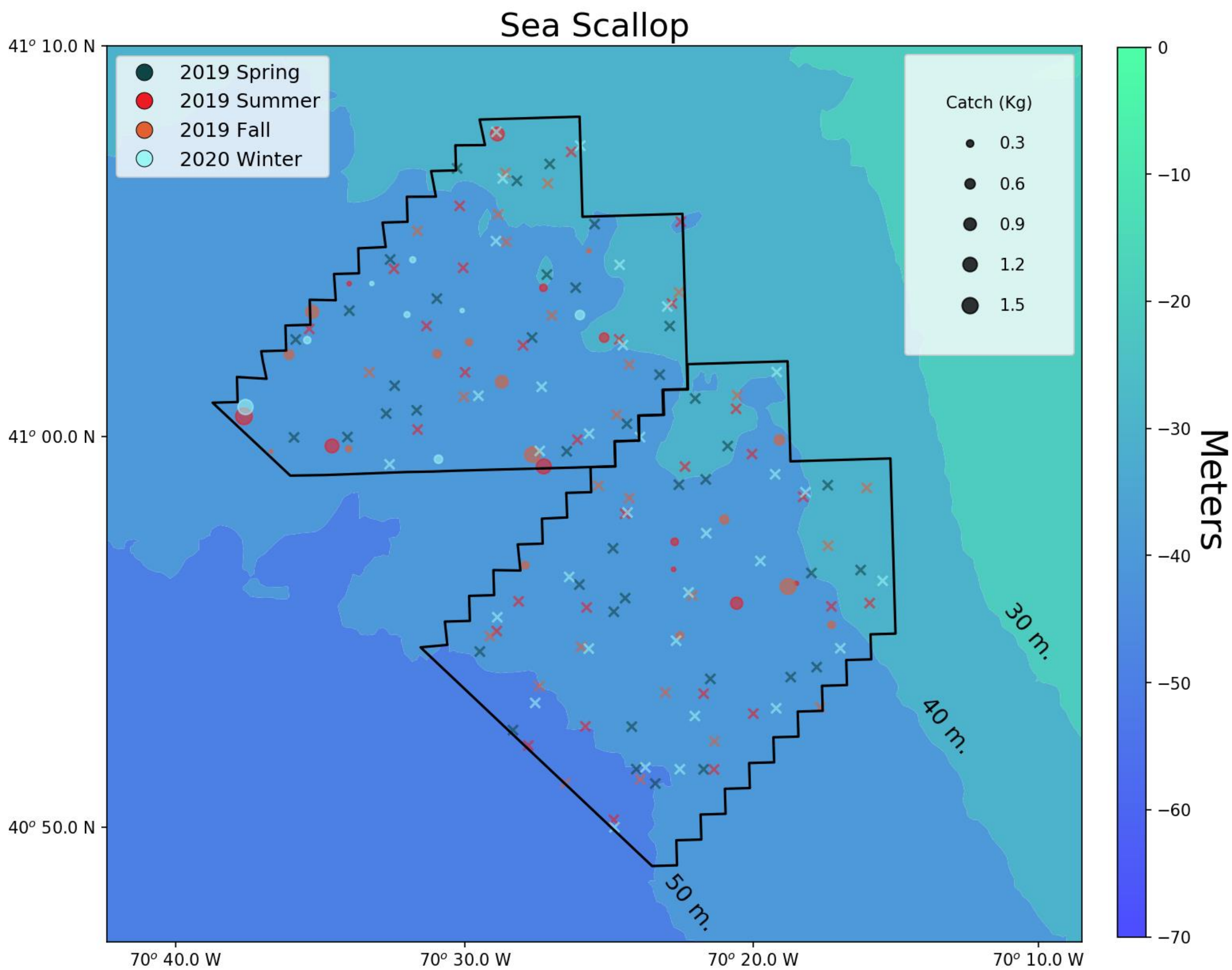
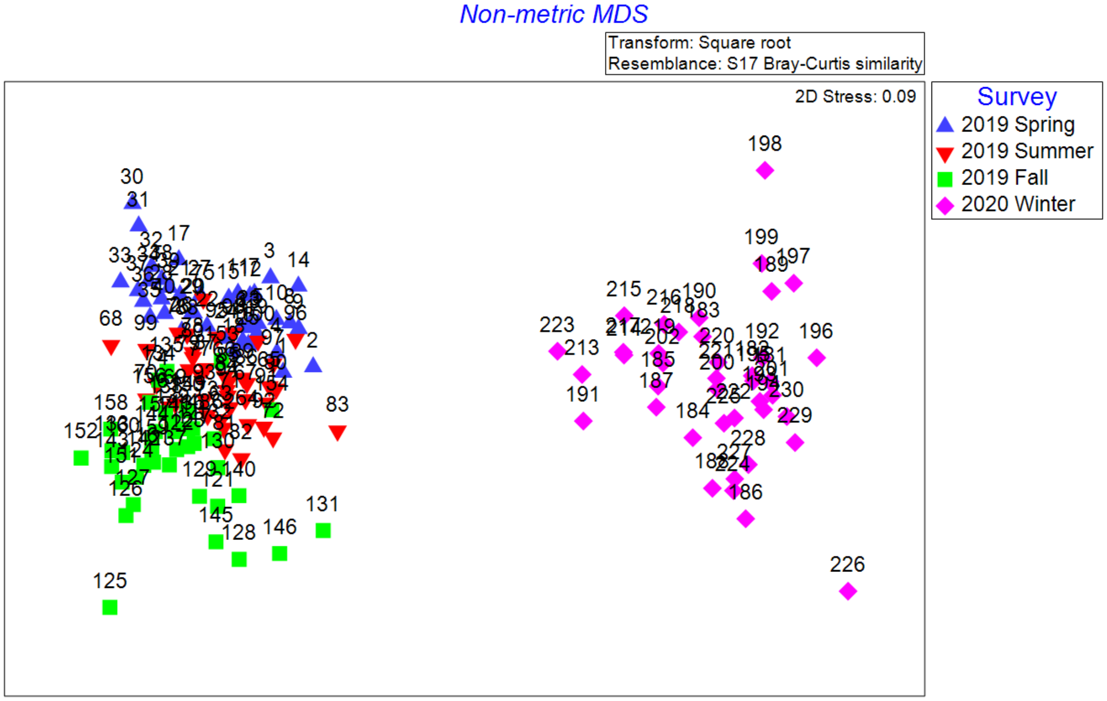


Figure 141: Seasonal distribution of the sea scallop catch in the 501 North Study Area (left) and Control Area (right). Tows with zero catch are denoted with an X.



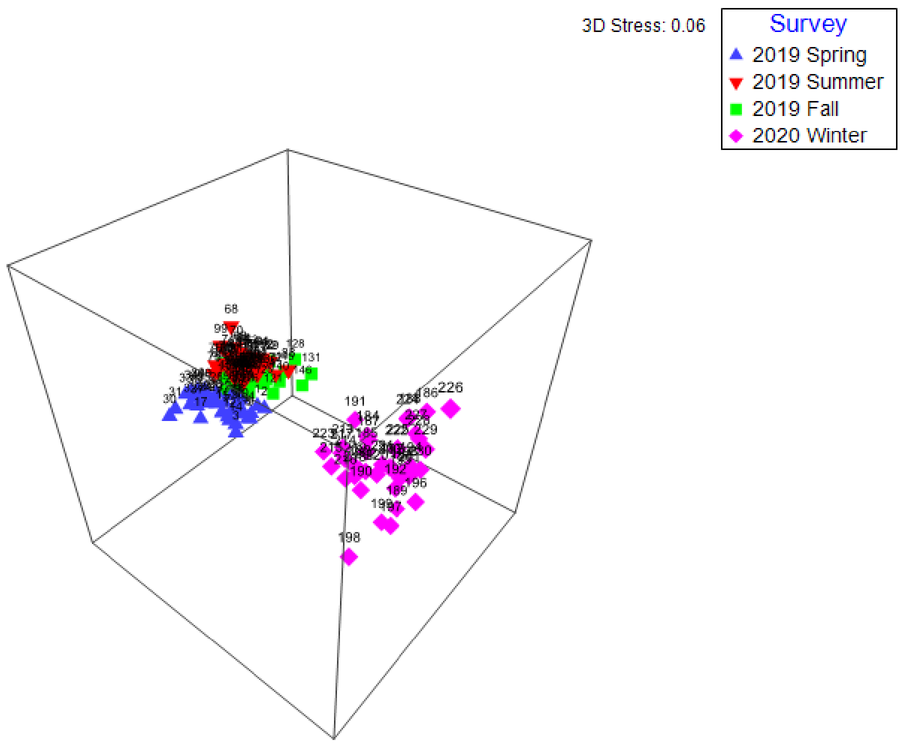


Figure 142: 2D (top) and 3D (bottom) non-metric Multidimensional Scaling (nMDS) plots. Data from all season and survey areas is aggregated with the tow markers colored by season to highlight the seasonal clusters in species similarity.

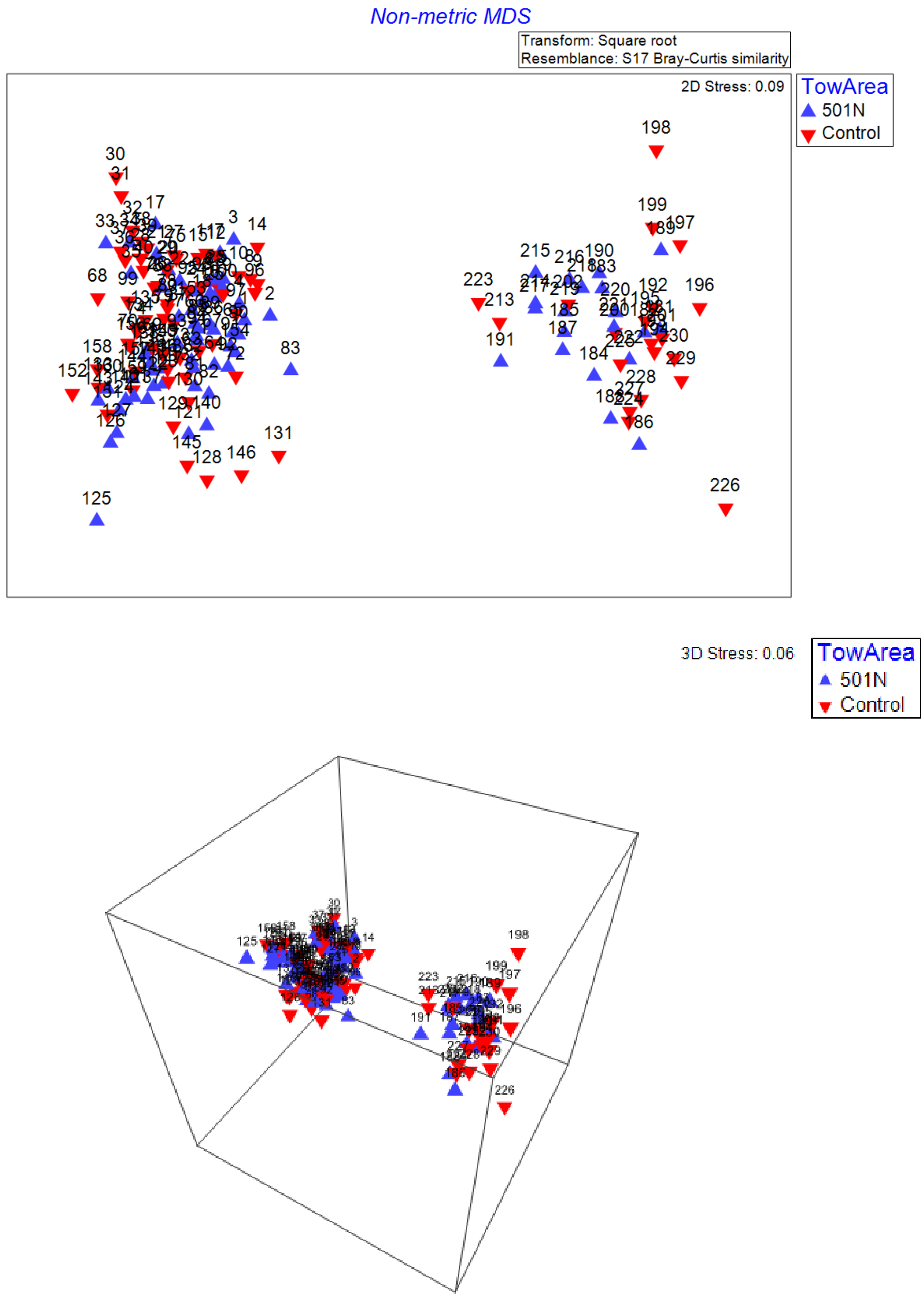


Figure 143: 2D (top) and 3D (bottom) non-metric Multidimensional Scaling (nMDS) plots. Data from all season and survey areas is aggregated with the tow markers colored by survey area to highlight the lack of clustering between survey areas.

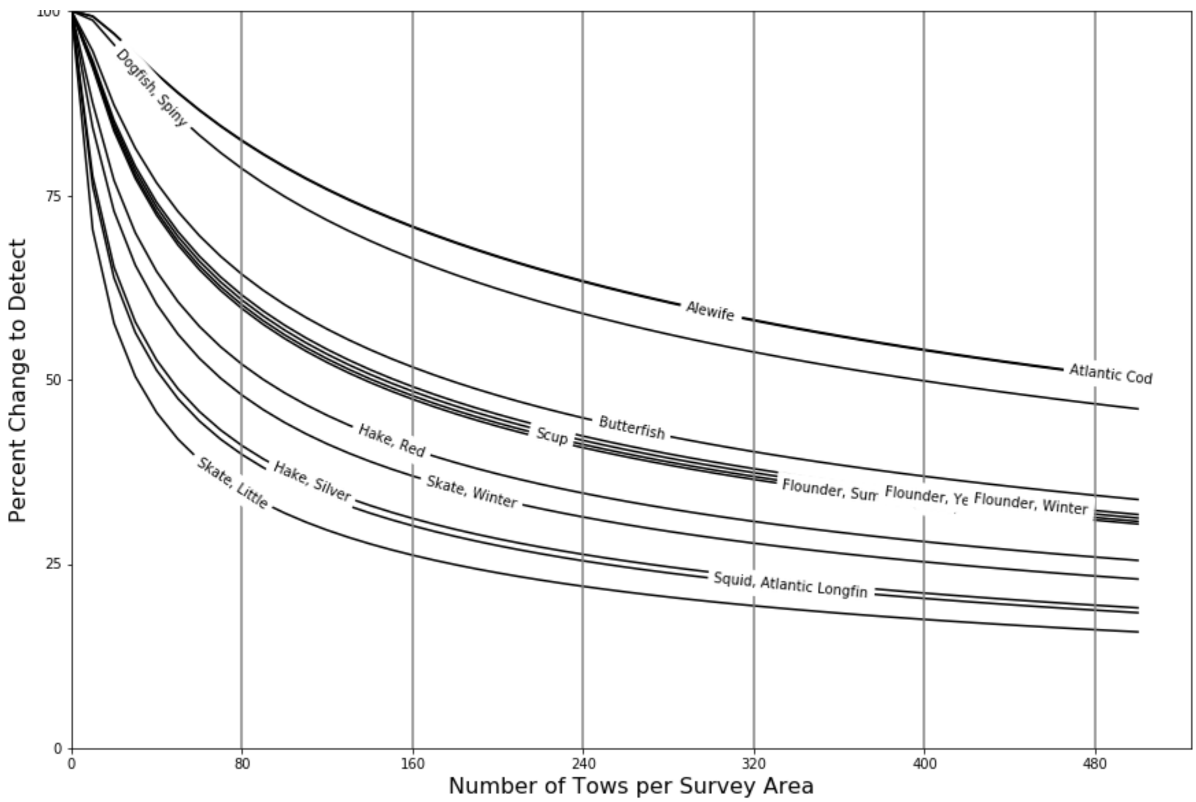


Figure 144: The ability to detect the percent change in a species population size is a function of the variability in the catch and the sample size (i.e. number of tows). The current survey effort samples 80 tows per area per year.

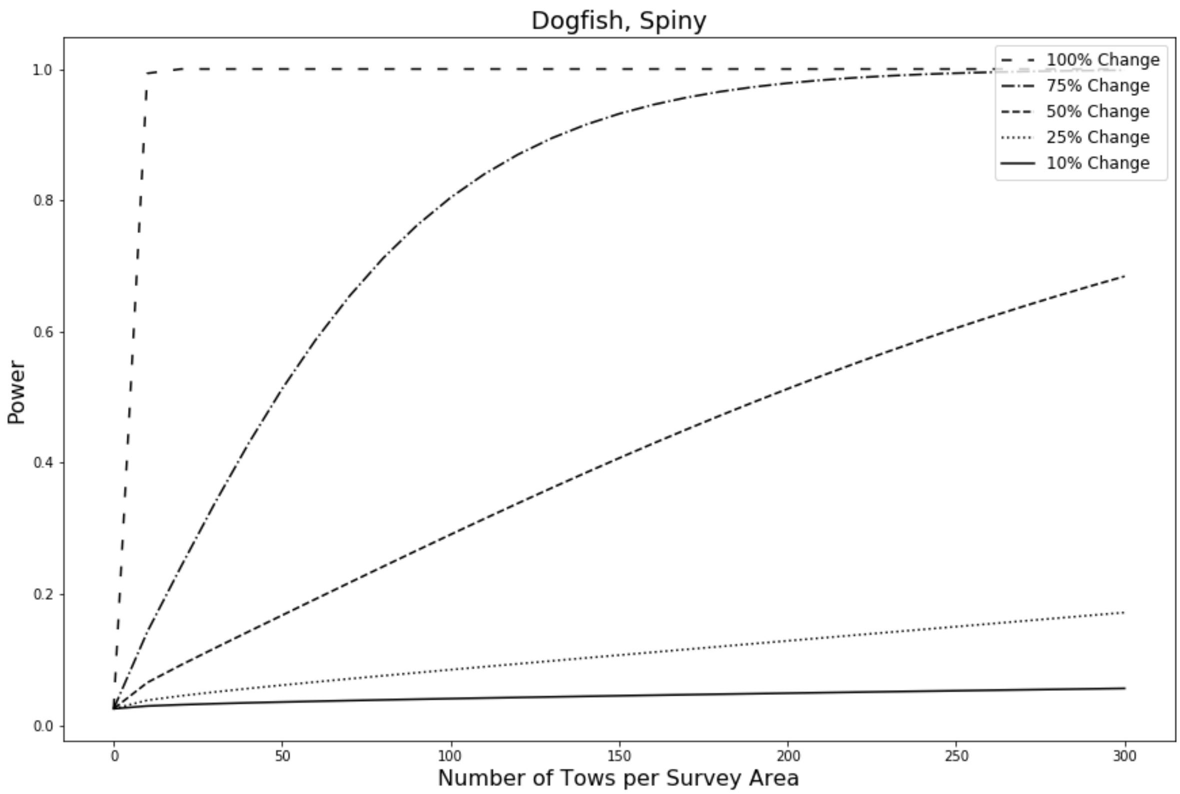


Figure 145: Power analysis relationship between statistical power and sample size in spiny dogfish.

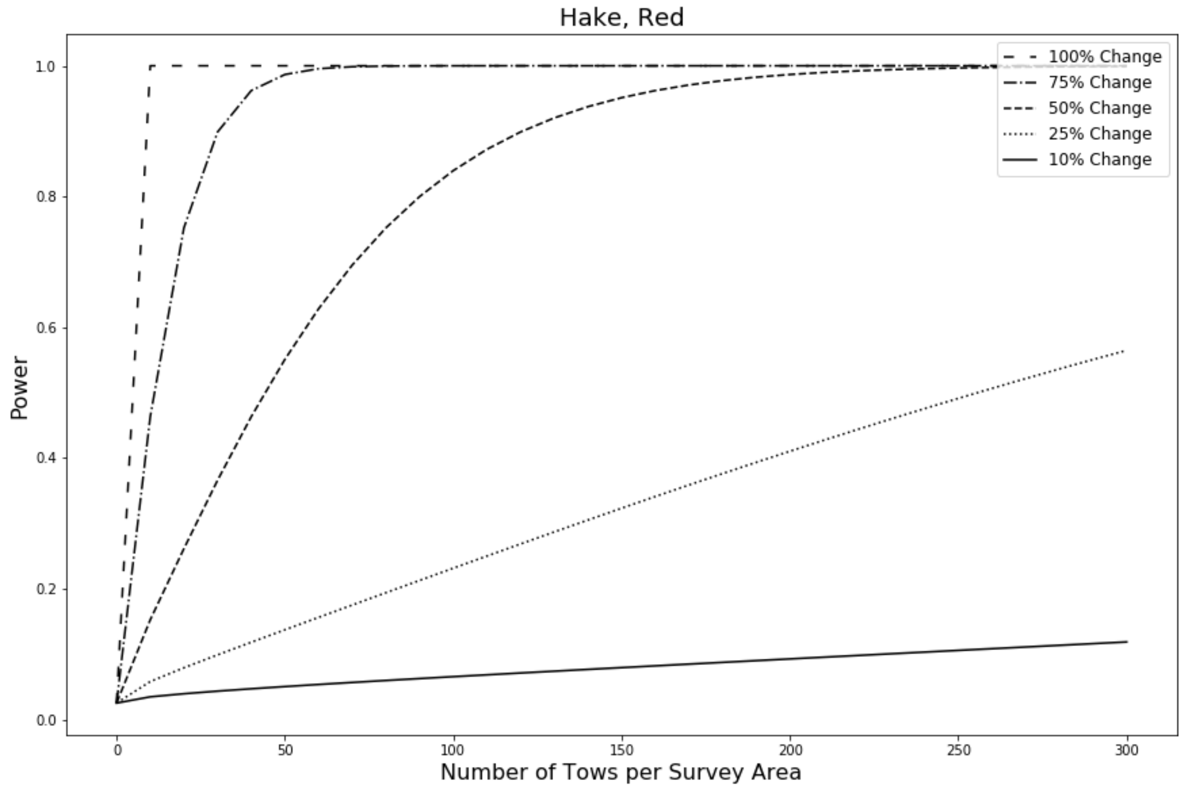


Figure 146: Power analysis relationship between statistical power and sample size in red hake.

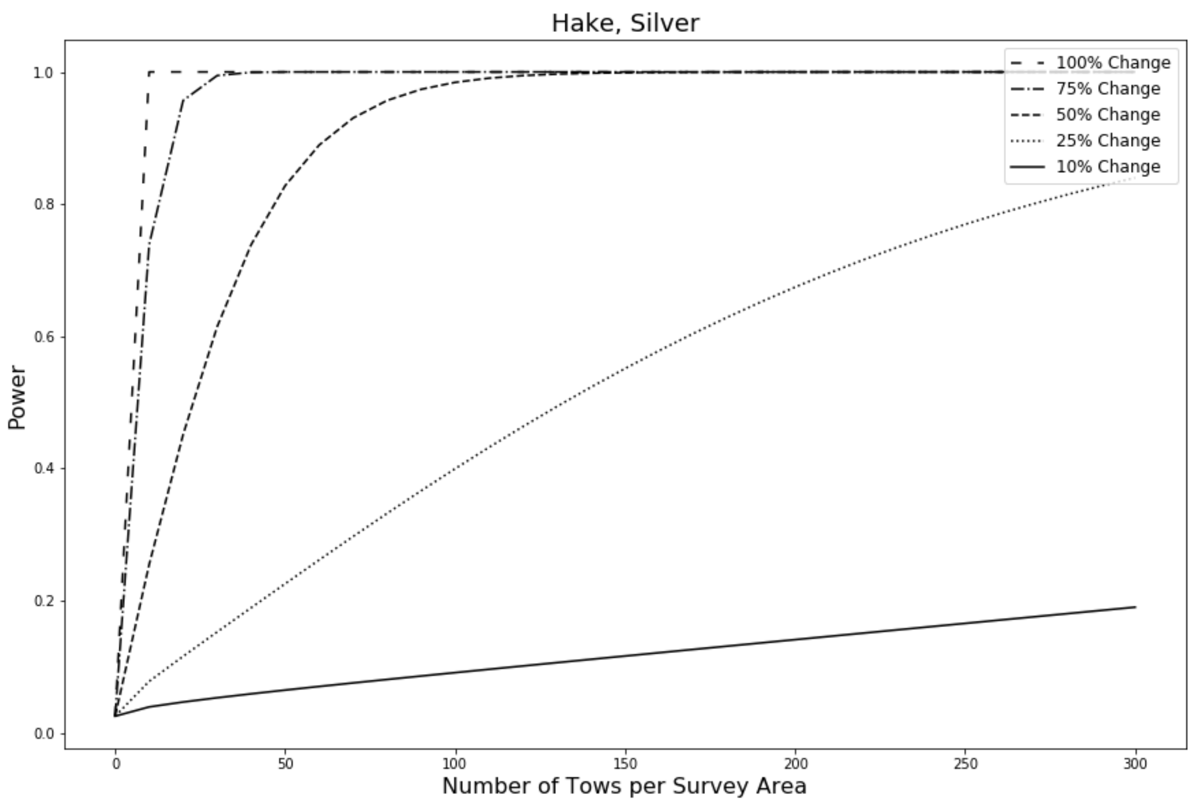


Figure 147: Power analysis relationship between statistical power and sample size in silver hake.

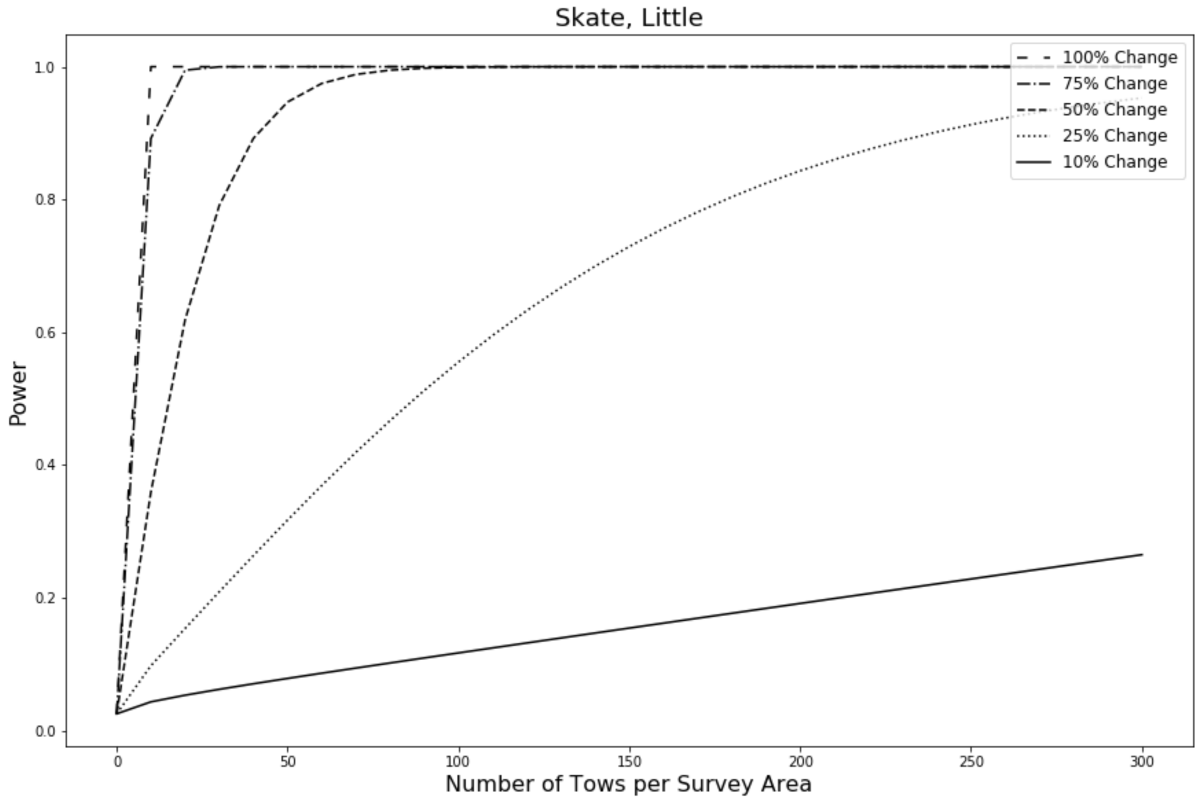


Figure 148: Power analysis relationship between statistical power and sample size in little skate.

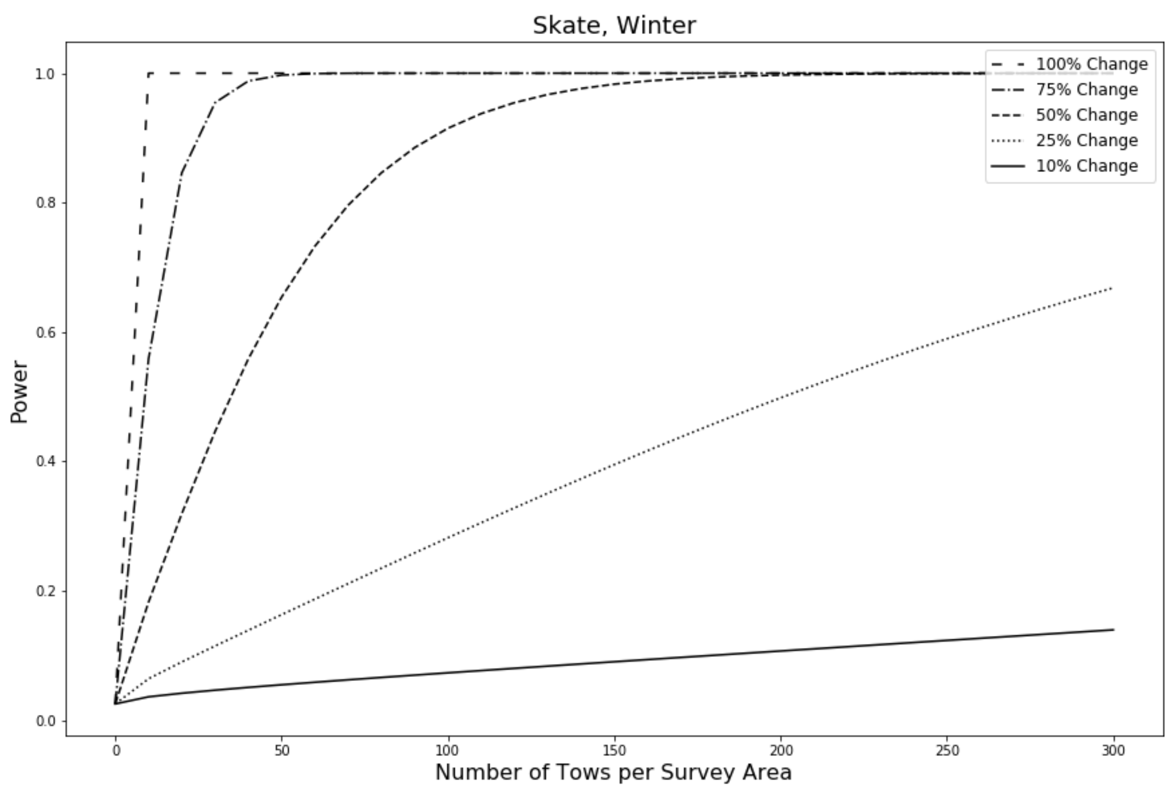


Figure 149: Power analysis relationship between statistical power and sample size in winter skate.

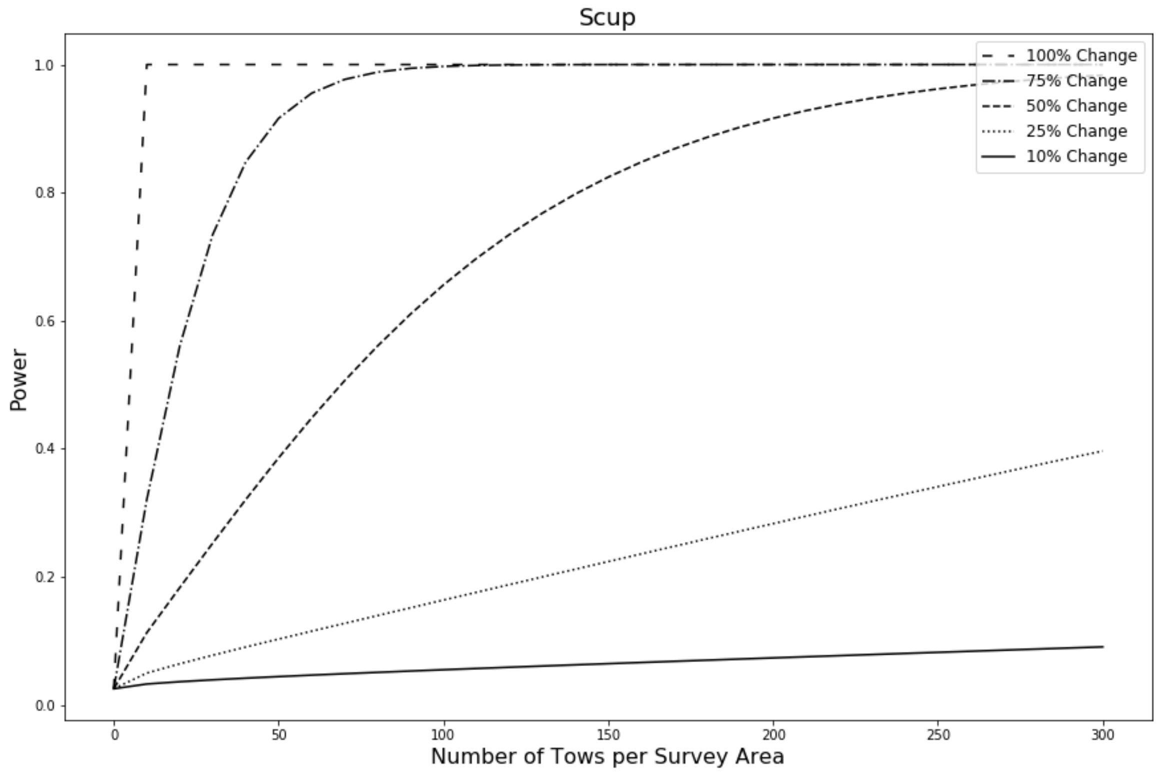


Figure 150: Power analysis relationship between statistical power and sample size in scup.

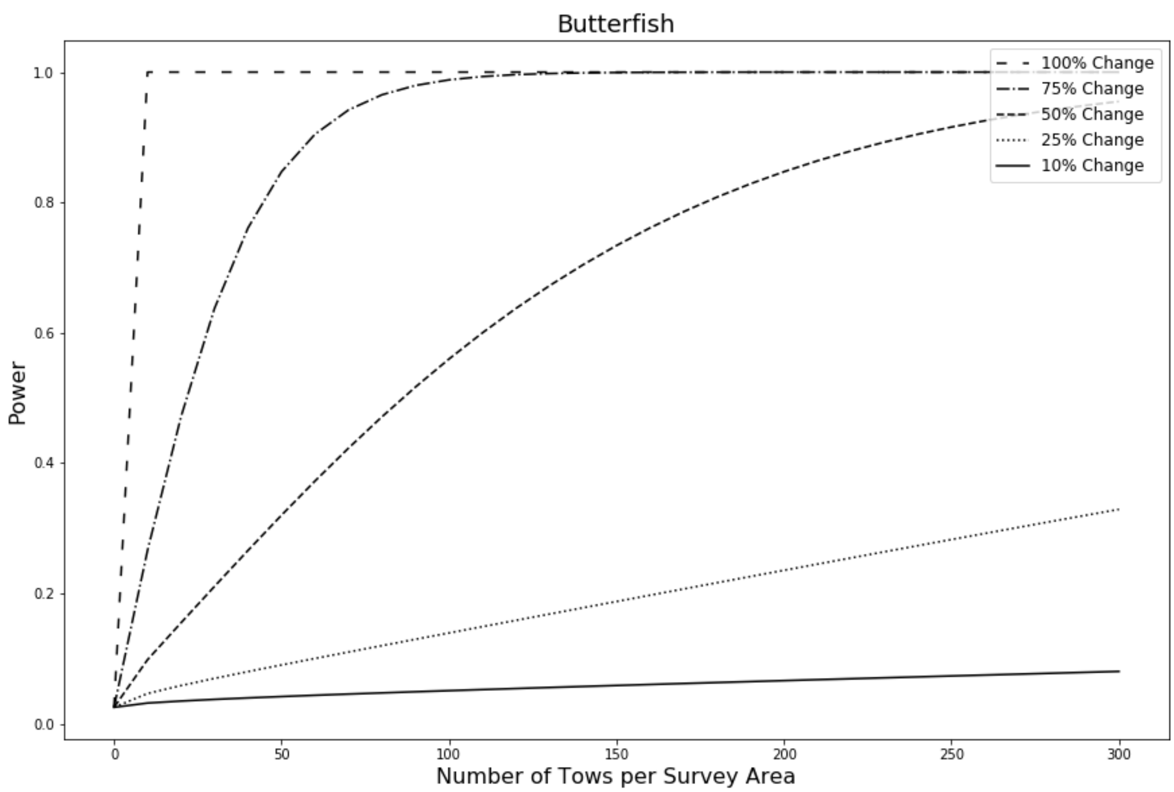


Figure 151: Power analysis relationship between statistical power and sample size in butterfish.

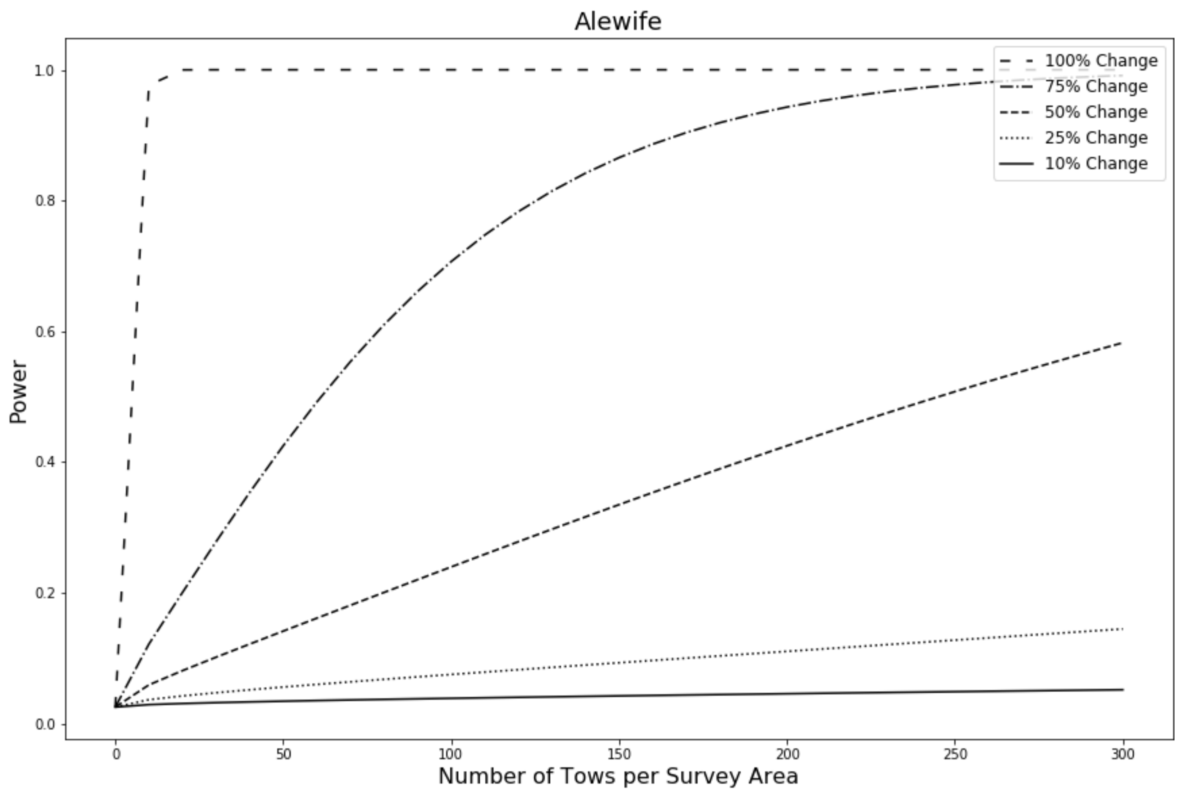


Figure 152: Power analysis relationship between statistical power and sample size in alewife.

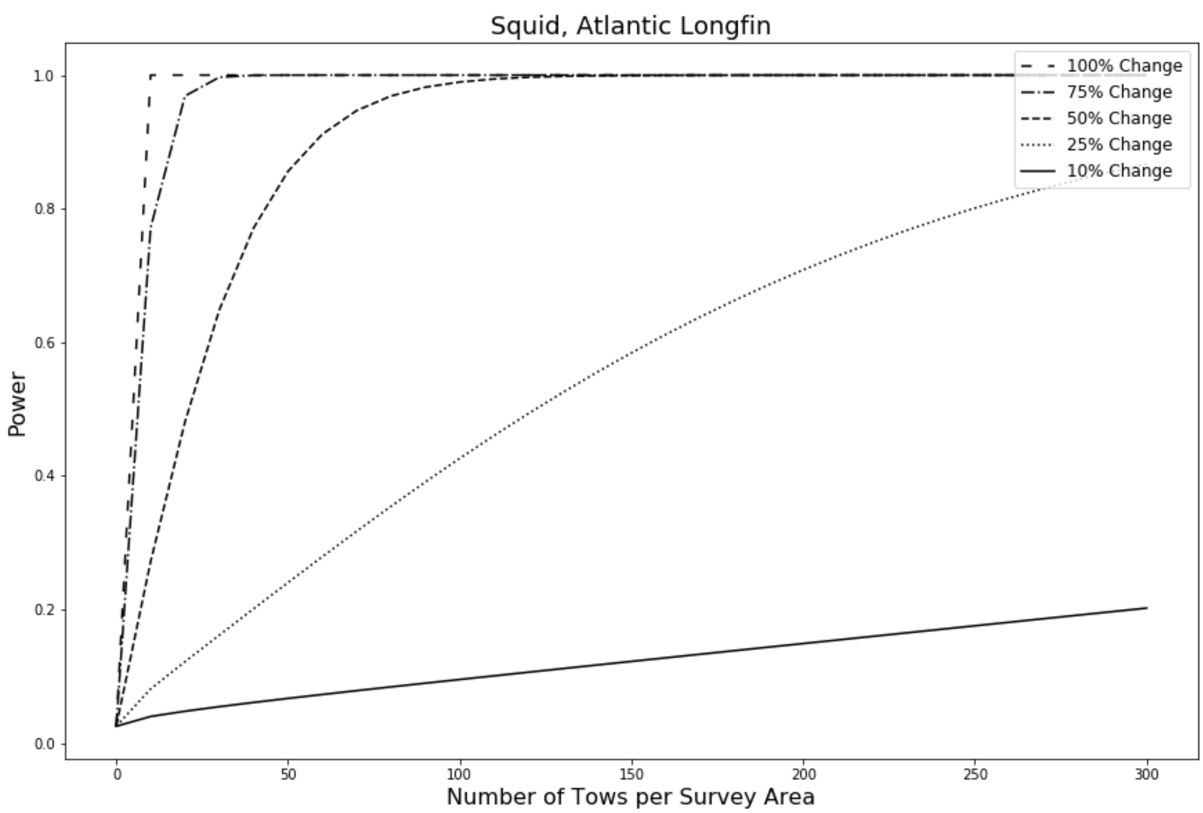


Figure 153: Power analysis relationship between statistical power and sample size in longfin squid.

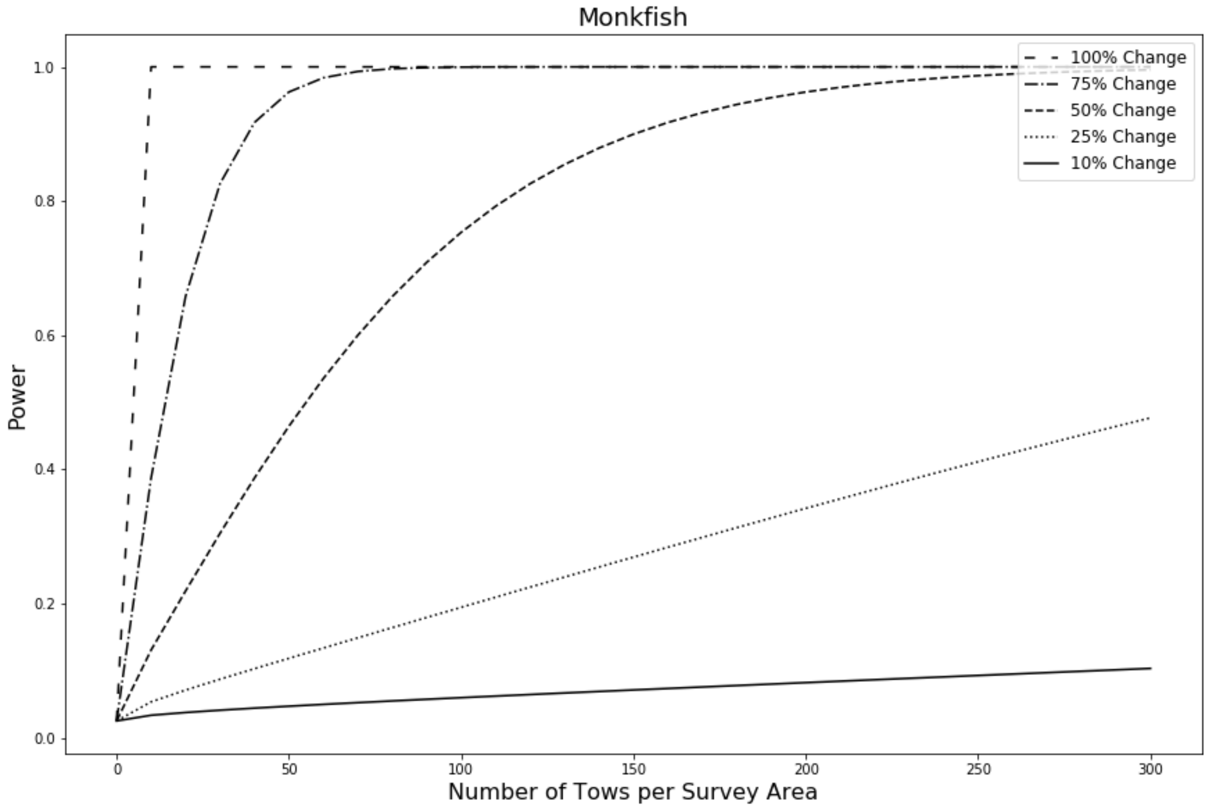


Figure 154: Power analysis relationship between statistical power and sample size in monkfish.