VINEYARD WIND

Vineyard Wind Demersal Trawl Survey

Quarterly Report

Spring 2019 (April - June)

522 Study Area

VINEYARD WIND DEMERSAL TRAWL SURVEY

Spring 2019 Seasonal Report

522 Study Area

February 2020

Prepared for Vineyard Wind, LLC

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School for Marine Science and Technology

Vineyard Wind Demersal Trawl Survey
Spring 2019 Seasonal Report
522 Study Area

<u>Progress Report #1</u>
April 1 – June 30, 2019

Project title:	Vineyard Wind Demersal Trawl Survey Spring 2019 Seasonal Report – 522 Study Area

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Date:	February 27th, 2020

You may cite this report as:
Rillahan, C., He, P. (2019). Vineyard Wind Demersal Trawl Survey Spring 2019 Seasonal Report – 522 Study Area. Progress Report #1. University of Massachusetts Dartmouth - SMAST, New Bedford, MA. SMAST-CE-REP-2020-077. 36 pp.

SMAST-CE-REP-2020-077

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1. Introduction

In 2019, Vineyard Wind LLC leased a 516 km^2 area for renewable energy development on the Outer Continental Shelf, Lease Area OCS-A 0522, located south of Nantucket, Massachusetts. Vineyard Wind is conducting fisheries surveys within Lease Area OCS-A 0522 (the "522 Study Area)," which is the focus of this report. Vineyard Wind is also conducting fisheries studies within the northern portion of Lease Area OCS-A 0501 (the "501 North Study Area") and within the southern portion of Lease Area OCS-A 0501 (the "501 South Study Area"); 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. 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 the 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 fish abundance, distribution, and population structure in and around the Vineyard Wind's 522 Study Area. The data will serve as a baseline to be used in a future analysis under the Before-After-Control-Impact (BACI) framework. This progress report documents survey methodology, survey effort, and data collected during Spring 2019. This is the first season of the study.

2. 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 522 Study Area using a commercial fishing vessel (Bonzek et al., 2008). The current NEAMAP protocol samples at a resolution of 30 sq. nautical miles, which is inadequate to provide scientific information related to potential changes on a smaller scale. Adapting existing methods with increased resolution will enable the survey to fulfill the primary goal of evaluating the impact of windfarm development while improving the consistency between survey platforms, which 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.

2.1 Survey Design

The current survey is designed to provide baseline data on catch rates, population structure, and community structure for a future environmental assessment. Data collected during this survey will be used to understand the population dynamics of the area while providing data related to the spatial and temporal variability of local fish communities. A power analysis of this data will ensure that an adequate sampling resolution is used when conducting a future environmental assessment using the BACI framework as recommended by BOEM (BOEM, 2013).

Tow locations within the Vineyard Wind 522 Study Area were selected using a systematic random sampling design. The 522 Study Area (536 km^2) was sub-divided into 10 sub-areas (~53.6 km^2), and one trawl tow was made in each of the 10 sub-areas. This was designed to ensure adequate spatial coverage throughout the survey area. The starting locations within each area were randomly selected (Figure 2).

2.2 Trawl Net

To ensure standardization and compatibility between these surveys and ongoing regional surveys and to take advantage of the well-established survey protocol, the otter trawl 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., 16.5 ft.) 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 disk 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 Bonsek et al. (2008).

2.3 Trawl geometry and acoustic monitoring equipment

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

The Simrad PX net mensuration system (Kongsberg Group, Kongsberg, Norway) 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. The headline sensor also measured bottom temperature. To ensure the net was on the bottom a sensor was placed behind the footrope in the belly of the net. That sensor was equipped with a tilt sensor which reported the angle of the net belly. An angle around 0^{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).

2.4 Survey Operations

The survey was conducted on F/V *Guardian*, an 80' stern trawler operating out of Boston, MA. F/V *Guardian* is a commercial groundfish vessel currently operating in the industry. All planned tows were completed during one seven-day trips to the survey area (June 22 – 28, 2019).

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. Trawl warp was set at a ~5:1 wire to depth ratio in 25 fathom increments. In addition to monitoring the net geometry to ensure acceptable performance (as described in Section 2.3 above), the following environmental and operational data were collected:

- Cloud cover (i.e. clear, partly cloudy, overcast, fog, etc.)
- Wind speed (Beaufort scale)
- Wind direction
- Sea state (Douglas Sea Scale)
- Start and end position (Latitude and Longitude)
- Start and end depth
- Tow speed
- Bottom temperature

Tow paths and tow speed were continuously logged using the OpenCPN charting software (opencpn.org) running on a computer with a USB GPS unit (GlobalSat BU-353-S4).

2.5 Catch Processing

The catch from each tow was sorted by species. Aggregated weight from each species was weighed on a motion-compensated scale (M1100, Marel Corp., Gardabaer, Iceland). Individual fish length (to the nearest centimeter [cm]) 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. One of two sub-sampling strategies was employed during a tow: straight subsampling by weight, or mixed subsampling by weight.

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 made for individual length and weight measurements. The ratio of the sub-sample weight to the total species weight was then used to extrapolate the length-frequency estimates. This was the predominate sub-sampling strategy employed during this survey.

Mixed subsampling by weight: When catch diversity was high (10+ species) a mixed-subsampling strategy was used. With this strategy the catch of some large animals/species was "pre-sorted" to isolate these species and these individual species were measured separately. Subsequently, the unsorted catch, which usually contained smaller species, was placed into baskets and an aggregated tow weight was measured. A sub-sample from these baskets was sorted, and the relative proportions of each constituent species was used to extrapolate the total species weight from the unsorted catch. Individual lengths and weights of species were then collected. This sub-sampling strategy was used during several tows when the catch of silver hake, red hake, squid, and butterfish was high.

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 dogfish, skates, crabs, lobsters, and some non-commercial species. For these species, aggregated weight and counts were collected. Collection of squid eggs were documented. All data was manually recorded and entered into a Microsoft Access database.

3. Results

3.1 Operational Data, Environmental Data and Trawl Performance

Ten tows were successfully completed in the 522 Study Area (Figure 2, Table 1). Operational parameters can be found in Table 2. Tow durations averaged 21.6 ± 3.3 minutes (mean ± one standard deviation) in the Study Area. Tow distances averaged 1.0 ± 0.2 nautical miles giving an average tow speed of 2.8 ± 0.1 knots.

The seafloor in the study area follows a northeast to southwest depth gradient with the shallowest tow along the northeast edge (~40 meters). Depth increased to a maximum of 60 meters along the southwest boundary. Bottom water temperature followed a similar gradient with warmer water observed during shallow tows (9.9^{o} C at 40 m) and colder water during deeper tows (7.7^{o} C at 60 m). Due to the changes in depth, trawl warp length was adjusted accordingly to keep the trawl from lifting off the bottom and maintain the tow geometry Trawl warp was set to 100 fathoms (183 m.) for tows in 20 to 24 fathoms (36 to 44 m), and 125 fathoms (229 m) in depths between 25 and 27 fathoms (45 to 50 m).

The Simrad PX trawl monitoring system was used during this survey to measure trawl geometry (Figure 7). This system was a significant improvement from the previous system (Notus Trawl Master). The data indicated that the trawl took about 2 to 3 minutes to open and stabilize. Once open, readings were stable through the duration of the tow. The following net geometry metrics were recorded:

- Door spread averaged 40.3 ± 2.2 m for tows in the 522 Study Area. Door spread was collected in 8 of the 10 tows due to issues with hydrophone placement. The hydrophone for the system was placed over the starboard side of the vessel. When towing across the tide, the system had trouble receiving a signal from the port door. It is believed that this was due to interference from the ship's hull. Adding extra weight to the hydrophone allowed it to sink deeper into the water column and the signal was restored.

  Door spread measurements were slightly higher than the allowable tolerance limits. This was due to the idle wires that were used to connect the trawl doors to the net. To expedite the deployment of the survey, trawl doors and idle wires were borrowed from the vessel. The available idle wires were longer than the NEAMAP wires. Since then a new set of doors with the appropriate idle wires have been acquired. While the door spread measurements are higher than the acceptable tolerance limits, we do not believe this affected the catch because the wingspread measurements are within the appropriate range.

- Wing spread averaged 14.3 ± 0.4 m for tows in the 522 area (range: 13.7 – 15.1 m). Wing spread was targeted between 13.0 and 14.0 meters (acceptable range: 11.7 – 15.4 m). All tows were within the acceptable range.

- Headline height averaged 4.1 ± 0.2 m (range: 3.6 – 4.4 m). Headline height was targeted between 5.0 and 5.5 m (acceptable range: 4.5 – 6.1 m). While wing spread data indicated the net was within acceptable tolerances, the headline height is lower than expected. 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, this survey caught a significant volume of haddock, herring and other pelagic species which traditionally require a high vertical opening of the net. As a result, we believe that the survey results are representative of the fish community in the area, however additional testing is being conducted to increase the headline height to within the acceptable range.

3.2 Catch Data

In the 522 Study Area, a total of 28 species were caught over the duration of the survey (Table 3). Catch volume ranged from 199.1 kg/tow to 1075.1 kg/tow, with an average of 539.7 kg/tow. The five most abundant species (spiny dogfish, red hake, alewife, barndoor skate and little skate) accounted for 76% of the total catch weight. Including the next five most abundant species (winter skate, silver hake, monkfish, butterfish and shortfin squid) would encompass 95% of the total catch weight. Data collected from this area included the catch of both adults and juveniles of most species observed.

Spiny dogfish was the predominate species observed in the 522 area. Observed on every tow, catches averaged 140.9 ± 39.6 kg/tow (range: 10.5 - 331.3 kg/tow). Higher catches were observed in the northern area between 40 and 50 meters (Figure 8).

Red hake was the second most abundant species. Caught in every tow, the average catch was 102.6 ± 31.3 kg/tow (range: 38.2 – 353.0 kg/tow). Individuals ranged from 14 to 38 cm with a bimodal size distribution (Figure 9). The catch of red hake was widely dispersed in the 522 Study Area (Figure 10).

Alewife had the largest single catch in a tow (460.5 kg). Alewife were observed in 8 of the 10 tows with an average catch of 67.4 ± 44.2 kg/tow. All individuals observed in the 522 Study Area were larger adults between 20 and 28 cm (Figure 11). While the catch was dispersed around the 522 Study Area the highest catch was in the southwestern corner (Figure 12).

Elasmobranchs, including barndoor skate, little skate and winter skate were the fourth, fifth and sixth most abundant species, respectively. Barndoor skates were observed in all 10 of the tows, with catches ranging from 2.2 to 186.4 kg/tow (average: 58.0 ± 19.2 kg/tow). Little skates were caught in 9 out of the 10 tows with an average catch of 42.9 ± 9.8 kg/tow (range: 0 – 95.4 kg/tow). Finally, winter skates were caught in 9 of the 10 tows with an average catch of 32.6 ± 9.4 kg/tow (range: 0 – 81.6 kg/tow). Barndoor, little and winter skates were caught throughout the 522 Study Area without a discernable pattern to the distribution (Figure 13, 14 and 15).

Additional common commercial species included silver hake, monkfish, butterfish, shortfin and longfin squid. All these species were observed in every tow, except for shortfin squid which was observed in 9 out of the 10 tows. The average catch of silver hake was 26.5 ± 4.0 kg/tow (range: 8.5 – 55.2 kg/tow). Silver hake ranged in length from 12 – 42 cm however the catch was dominated by juveniles (14 – 20 cm, Figure 16). Monkfish catches averaged 18.3 kg/tow (range: 3.9 – 48.3 kg/tow) with a wide size distribution (24 – 71 cm, Figure 18). The average butterfish catch was 14.5 ± 3.1 kg/tow (range: 2.2 - 36.6 kg/tow) primarily consisting of small fish (Figure 20). Shortfin squid had higher catches (average: 10.9 ± 8.5 kg/tow; range: 0 – 86.5 kg/tow) and were larger (mantle length: 12 – 18 cm; Figure 22) then longfin squid in the area. Longfin squid had a mantle length of 5 – 13 cm (Figure 24) with catches averaging 8.9 ± 1.6 kg/tow (range: 2.9 – 18.0 kg/tow). All five species were observed throughout the Study Area (Figure 17, 19, 21, 23, 25).

Other commercially important species observed included haddock, yellowtail flounder, Atlantic halibut, American lobster, witch flounder (grey sole), American plaice and the Atlantic sea scallop. Of these, only single individuals were observed except for haddock and yellowtail flounder, in which 6 and 7 individuals were observed, respectively.

4. Acknowledgements

We would like to thank the owner (Mike Walsh), captain (William Walsh) and crew (Adam Walsh, Kirk Walters, Raphael Felix, and Bob Felix) of F/V *Guardian* for their help sorting, processing and measuring the catch. Additionally, we would like to thank Rob Bland (A.I.S.), Nick Calabrese, Janne Haugen, and Alex Hansell (SMAST) for their help with data collection at sea.

5. References

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Table 1: Operational and environmental conditions for the survey.

Tow Number	TowArea	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)	Tow Warp (fm)
1	522	6/26/2019	Obscured	7-10	S	0.5-1.25	6:26	N 40° 36.750	W 70° 27.792	32	6:46	N 40° 36.339	W 70° 26.588	32	150
2	522	6/26/2019	Obscured	7-10	S	0.5-1.25	8:56	N 40° 37.972	W 70° 22.159	30	9:16	N 40° 38.787	W 70° 21.640	30	125
3	522	6/26/2019	Overcast	7-10	S	0.5-1.25	10:27	N 40° 37.997	W 70° 16.415	28	10:47	N 40° 38.016	W 70° 15.140	28	125
4	522	6/26/2019	Mostly Cloudy	7-10	S	0.5-1.25	12:12	N 40° 38.497	W 70° 09.445	26	12:32	N 40° 39.198	W 70° 08.527	25	125
5	522	6/26/2019	Obscured	11-15	S	0.5-1.25	14:23	N 40° 39.583	W 70° 02.262	25	14:43	N 40° 40.508	W 70° 02.391	25	125
6	522	6/26/2019	Clear	3-6	S	0.5-1.25	16:02	N 40° 42.611	W 70° 04.892	22	16:22	N 40° 43.329	W 70° 05.679	22	100
7	522	6/27/2019	Overcast	3-6	S	0.1-0.5	6:40	N 40° 39.815	W 70° 39.818	25	7:00	N 40° 40.615	W 70° 12.163	24	100
8	522	6/27/2019	Mostly Cloudy	3-6	S	0.1-0.5	9:08	N 40° 41.037	W 70° 10.591	24	9:38	N 40° 42.130	W 70° 11.804	24	100
9	522	6/27/2019	Mostly Cloudy	1-2	S	0.1-0.5	11:53	N 40° 44.158	W 70° 16.469	25	12:13	N 40° 44.670	W 70° 15.484	24	100
10	522	6/27/2019	Obscured	7-10	E	0.5-1.25	14:03	N 40° 45.982	W 70° 12.539	22	14:22	N 40° 45.244	W 70° 11.989	22	100

Table 2: Tow parameters for survey tows.

Tow Number	Tow Area	Tow Duration (min.)	Tow Speed (Knots)	Tow Distance (nautical miles)	Bottom Temp. (°C)	Headrope Height (m)	Wing spread (m)	Door Spread (m)
1	522	21.1	2.9	1.0	7.7	3.6	15.1	
2	522	23.9	2.7	1.1	7.9	4.1	14.2	
3	522	21.3	2.7	1.0	8.2	4.0	14.4	43.7
4	522	20.5	2.9	1.0	8.6	3.9	14.5	41.7
5	522	19.7	2.9	0.9	8.8	4.4	14.7	43.2
6	522	19.7	2.8	0.9	9.5	4.4	13.9	39.2
7	522	21.1	2.9	1.0	8.6	4.1	14.1	39.0
8	522	30.0	2.9	1.4	9.0	4.3	13.7	38.1
9	522	20.0	2.8	0.9	9.0	4.2	14.0	38.4
10	522	18.8	2.7	0.9	9.9	4.0	14.0	39.4
Summary Statistics								
	Minimum	18.8	2.7	0.9	7.7	3.6	13.7	38.1
	Maximum	30.0	2.9	1.4	9.9	4.4	15.1	43.7
	Average	21.6	2.8	1.0	8.7	4.1	14.3	40.3
	St. Dev.	3.3	0.1	0.2	0.7	0.2	0.4	2.2

Table 3: Total and average catch weighs observed within the 522 Study Area.

Species Name	Scientific Name	Total Weight (Kg)	Catch/Tow (Kg)		% of Total Catch	Tows with Species Present
			Mean	SEM		
Dogfish, Spiny	*Squalus acanthias*	1409.0	140.9	39.6	26.1	10
Hake, Red	*Urophycis chuss*	1025.8	102.6	31.3	19.0	10
Alewife	*Alosa pseudoharengus*	674.4	67.4	44.2	12.5	8
Skate, Barndoor	*Dipturus laevis*	579.6	58.0	19.2	10.7	10
Skate, Little	*Leucoraja erinacea*	428.7	42.9	9.8	7.9	9
Skate, Winter	*Leucoraja ocellata*	325.5	32.6	9.4	6.0	9
Hake, Silver	*Merluccius bilinearis*	265.0	26.5	4.0	4.9	10
Monkfish	*Lophius americanus*	182.6	18.3	4.2	3.4	10
Butterfish	*Peprilus triacanthus*	145.0	14.5	3.1	2.7	10
Squid, Shortfin	*Illex illecebrosus*	109.2	10.9	8.5	2.0	9
Squid, Atlantic Longfin	*Doryteuthis pealeii*	89.2	8.9	1.6	1.7	10
Shad, American	*Alosa sapidissima*	65.0	6.5	6.3	1.2	4
Flounder, Fourspot	*Hippoglossina oblonga*	33.1	3.3	1.4	0.6	8
Ocean Pout	*Zoarces americanus*	18.0	1.8	0.6	0.3	7
Flounder, Gulfstream	*Citharichthys arctifrons*	16.0	1.6	0.4	0.3	10
Haddock	*Melanogrammus aeglefinus*	9.7	1.0	0.8	0.2	2
Mackerel, Atlantic	*Scomber scombrus*	8.6	0.9	0.8	0.2	3
Crab, Rock	*Cancer sp.*	5.6	0.6	0.2	0.1	6
Flounder, Yellowtail	*Limanda ferruginea*	1.9	0.2	0.1	0.0	3
Atlantic Halibut	*Hippoglossus hippoglossus*	1.4	0.1		0.0	1
Herring, Atlantic	*Clupea harengus*	0.8	0.1	0.1	0.0	2
Lobster, American	*Homarus americanus*	0.8	0.1		0.0	1
Sea Raven	*Hemitripterus americanus*	0.5	0.1	0.0	0.0	2
Northern Sea Robin	*Prionotus carolinus*	0.4	0.0	0.0	0.0	2
Flounder, Witch (Grey sole)	*Glyptocephalus cynoglossus*	0.4	0.0		0.0	1
Flounder, American Plaice	*Hippoglossus platessoides*	0.4	0.0		0.0	1
Sculpin, Longhorn	*Myoxocephalus octodecemspinosus*	0.4	0.0		0.0	1
Sea Scallop	*Placopecten magellanicus*	0.3	0.0		0.0	1
Total		**5397.2**				

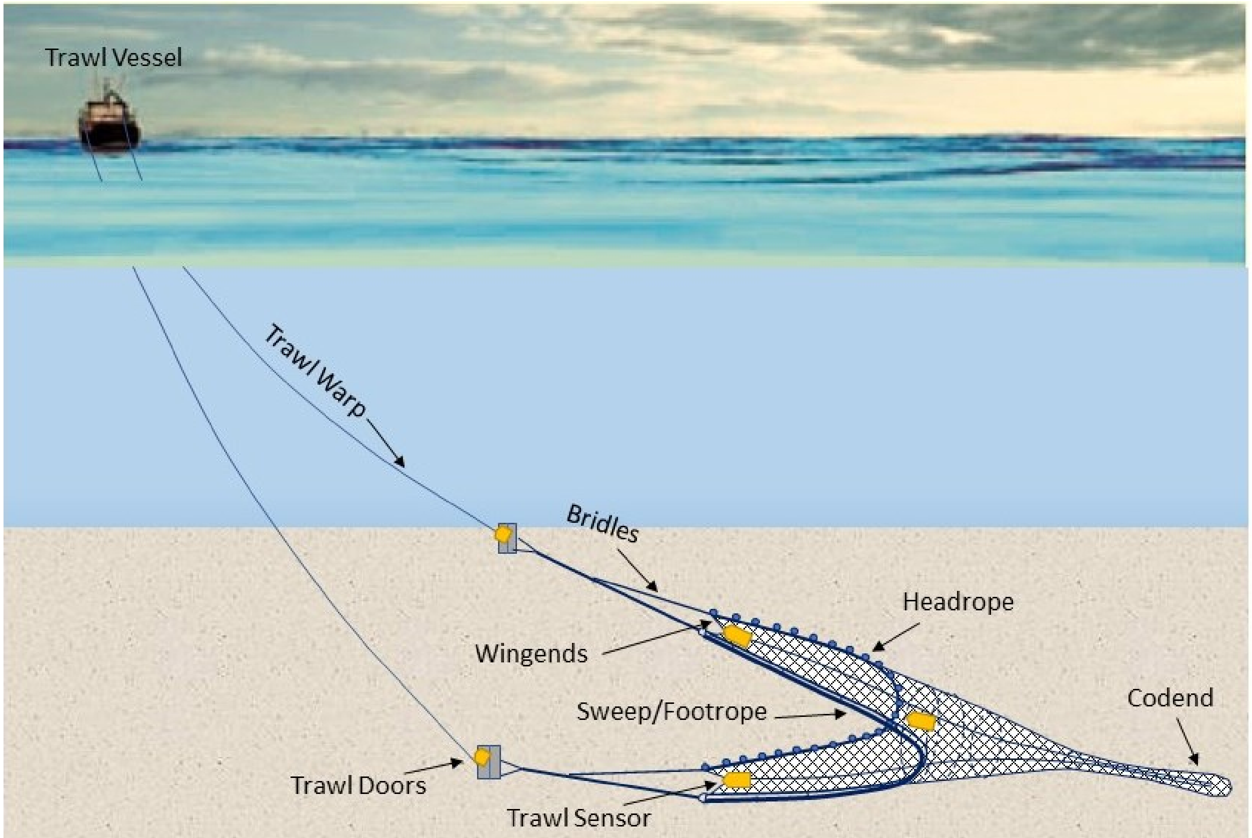


Figure 1: General schematic (not to scale) of a demersal otter trawl. Yellow rectangles indicate geometry sensors.

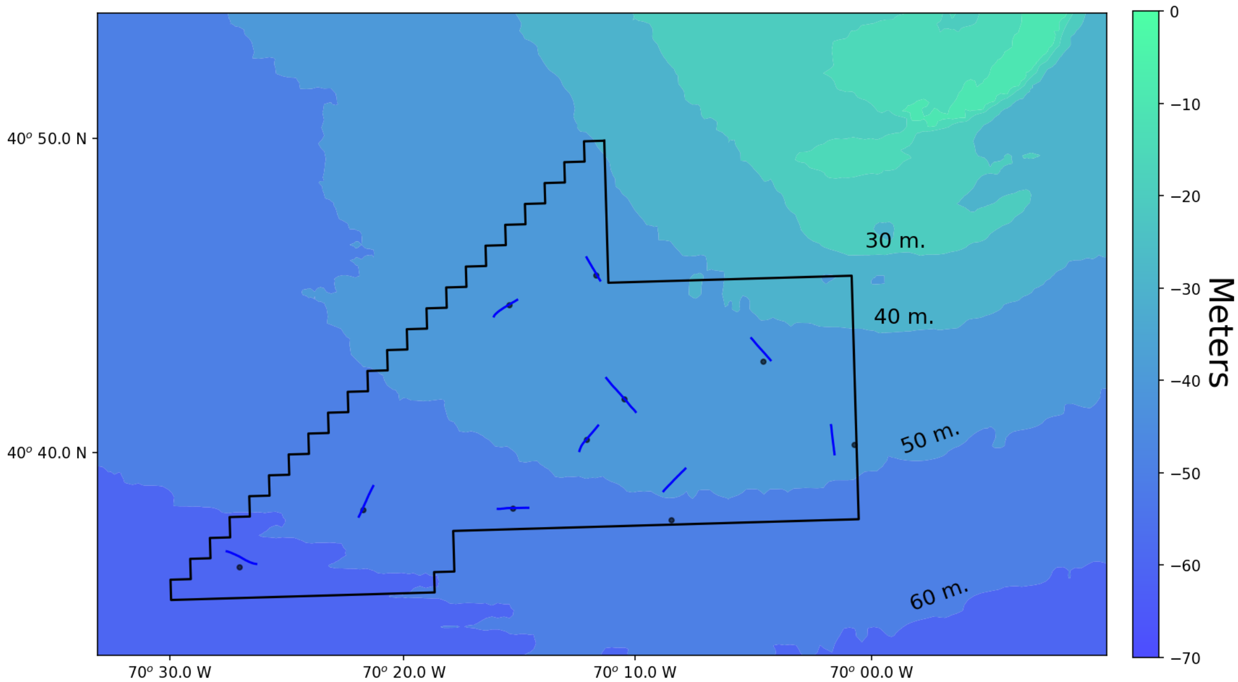


Figure 2: Tow locations (black dots) and trawl tracks (blue lines) from the 522 Study Area.

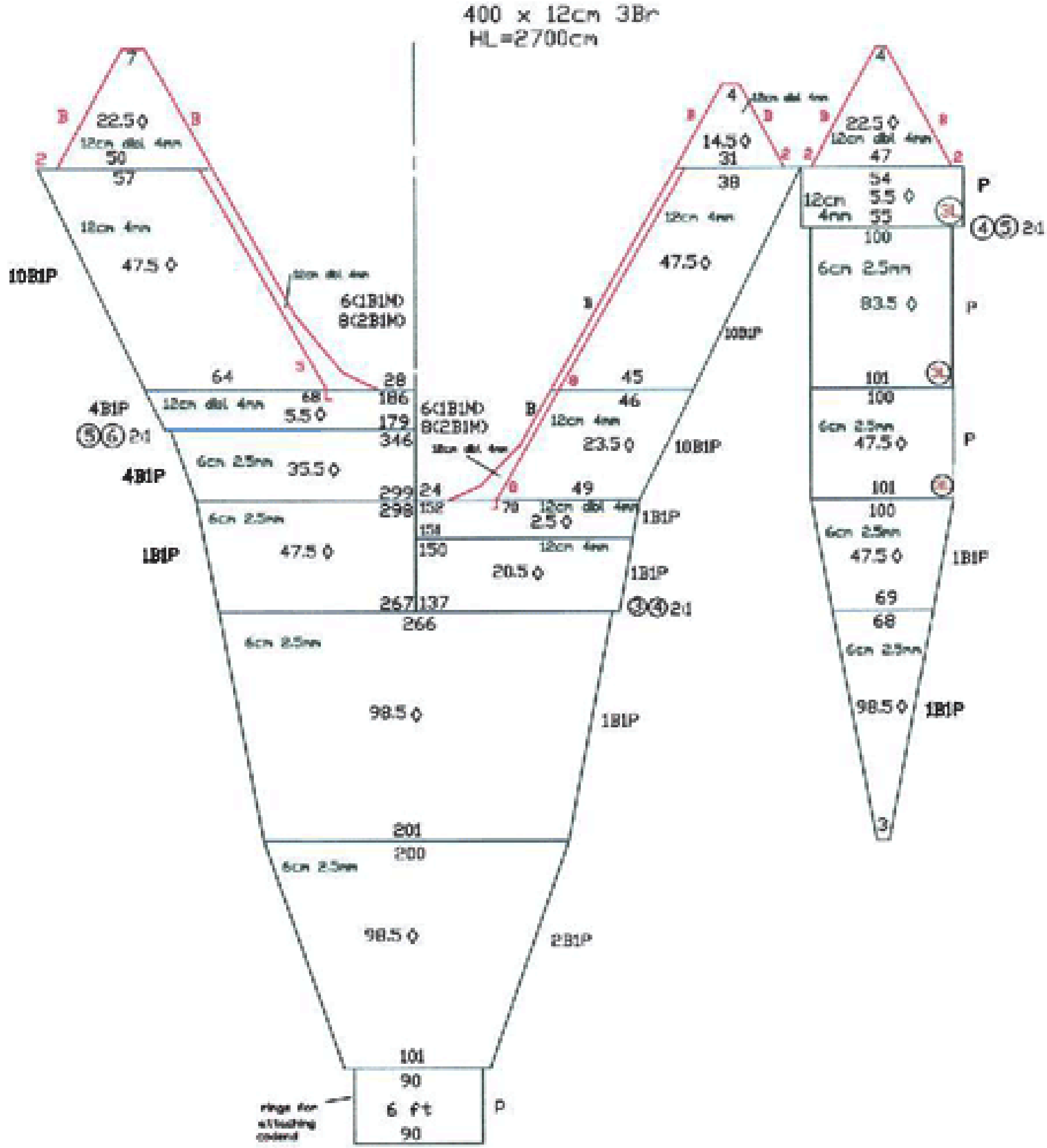


Figure 3: Schematic net plan for the NEAMAP trawl (Bonsek et al. 2008).

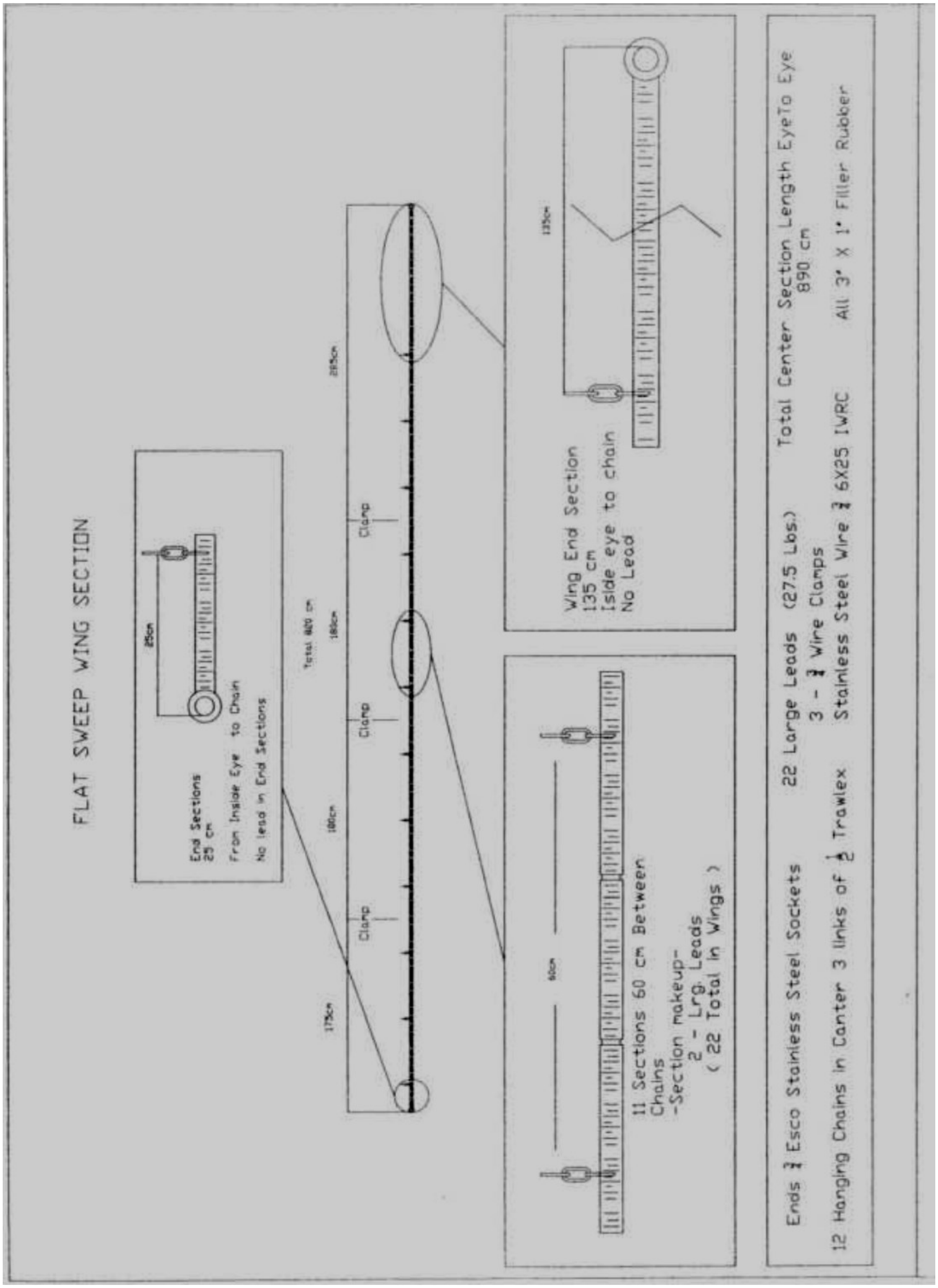


Figure 4: Sweep diagram for the survey trawl (Bonsek et al. 2008)

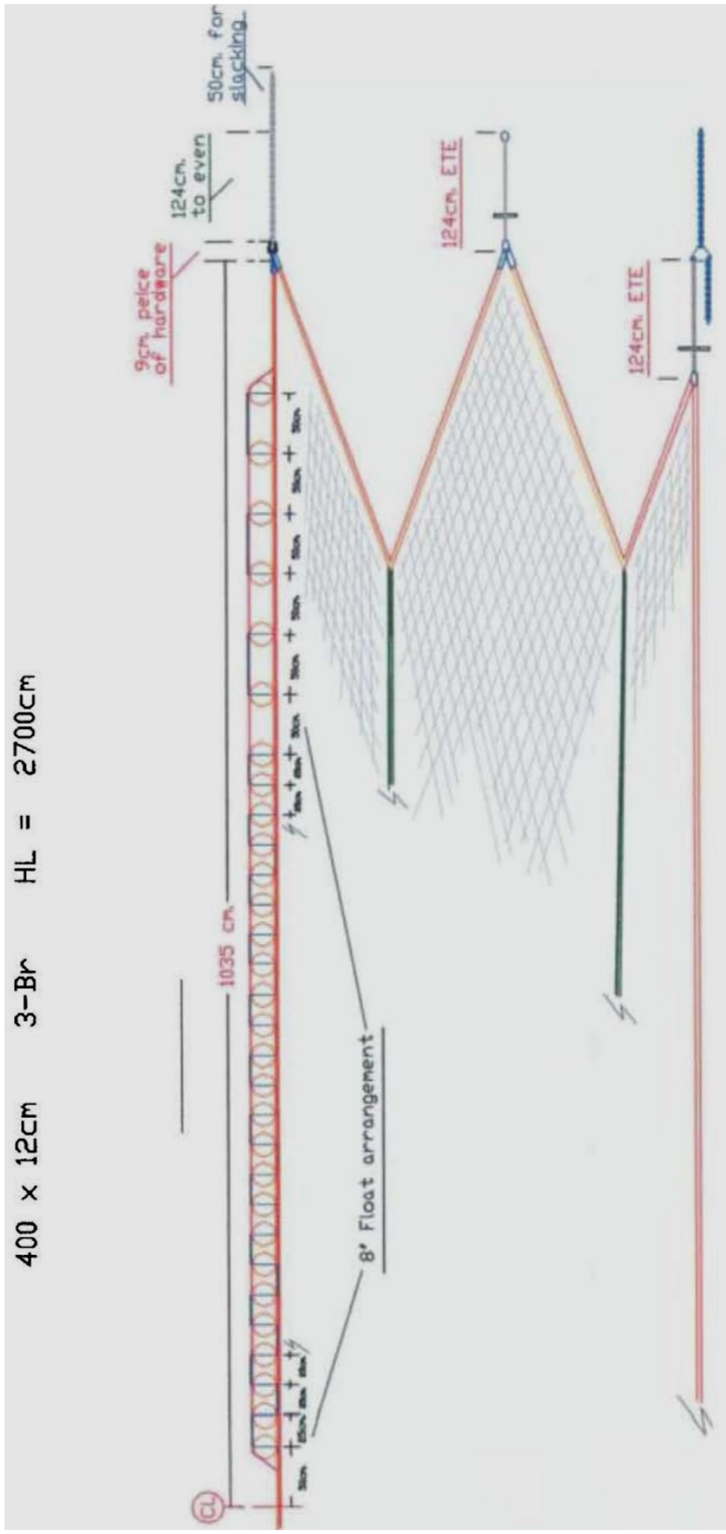


Figure 5: Headrope annd rigging plan for the survey trawl (Bonsek et al. 2008).

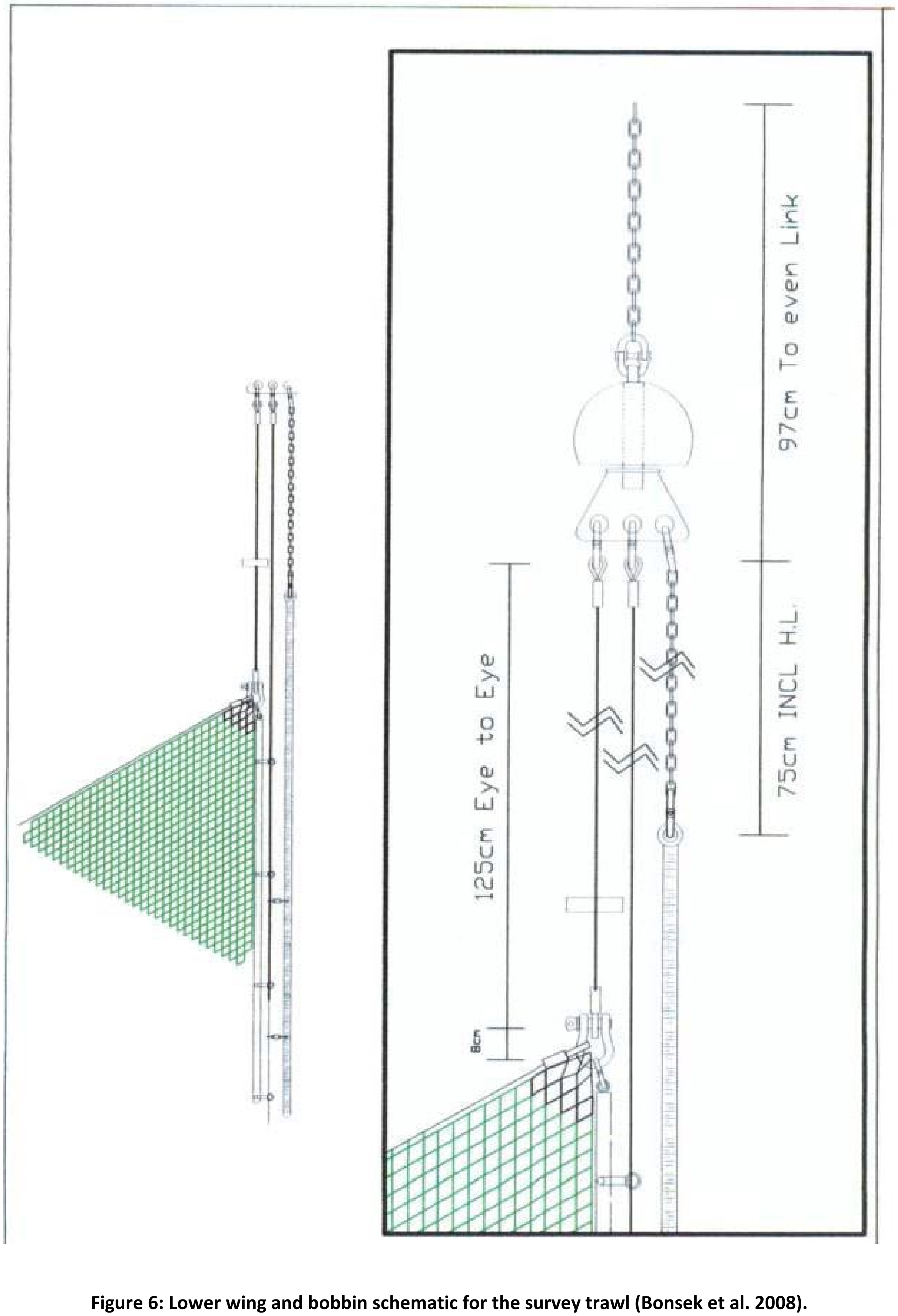


Figure 6: Lower wing and bobbin schematic for the survey trawl (Bonsek et al. 2008).

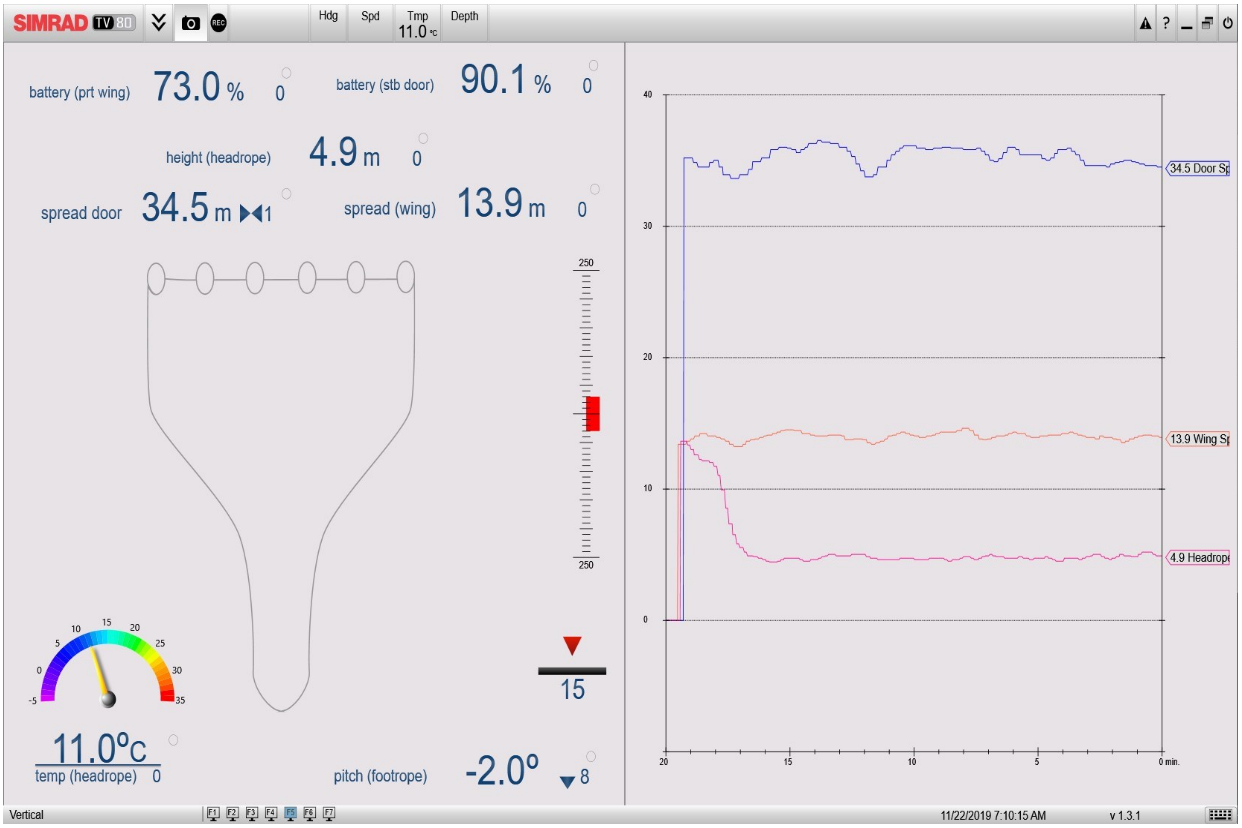


Figure 7: Screenshot of the SIMRAD TV80 software monitoring the trawl parameters.

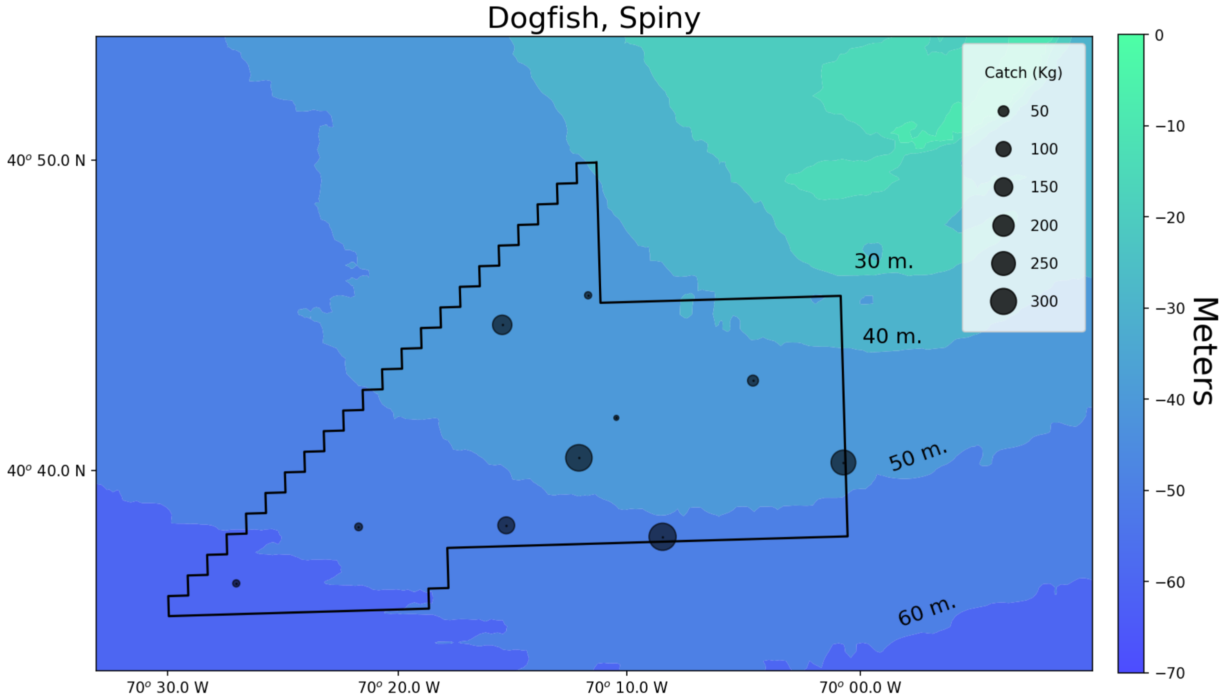
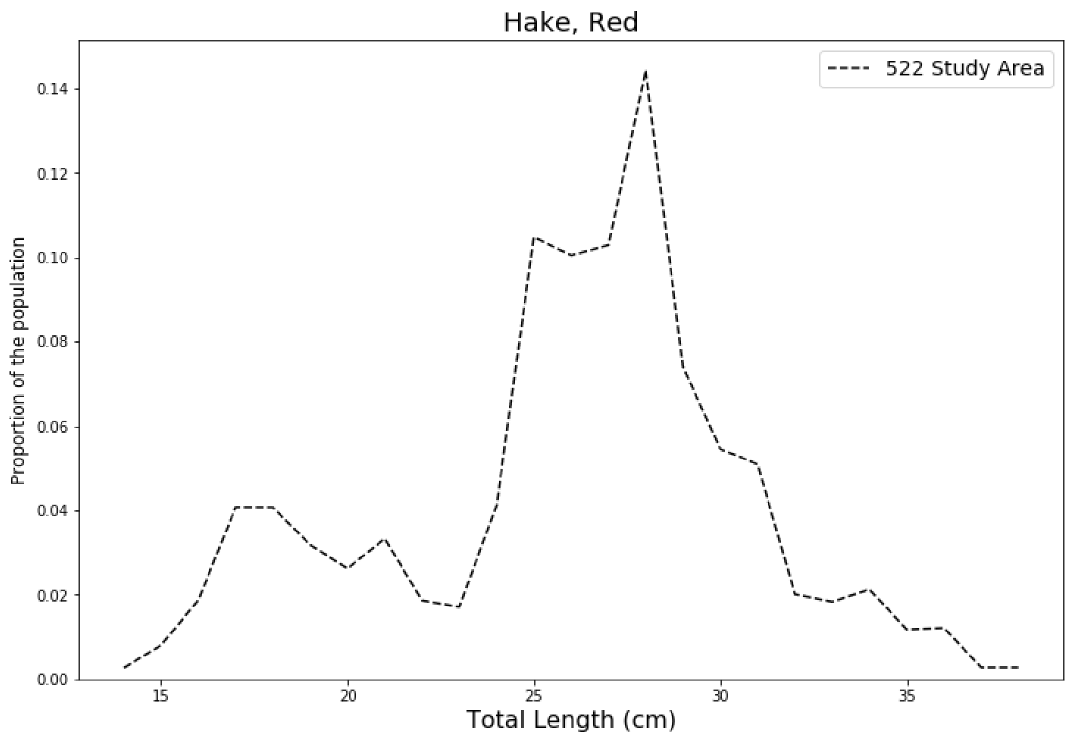


Figure 8: Distribution of the catch of spiny dogfish in the 522 Study Area.



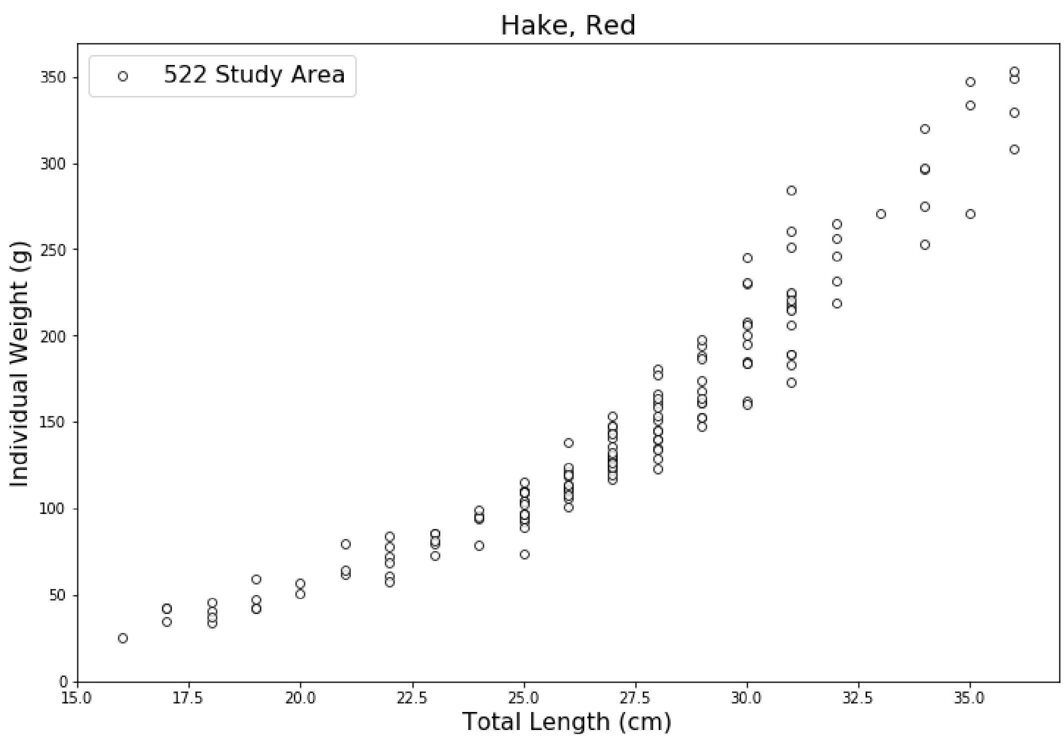


Figure 9: Population structure of red hake in the 522 Study Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

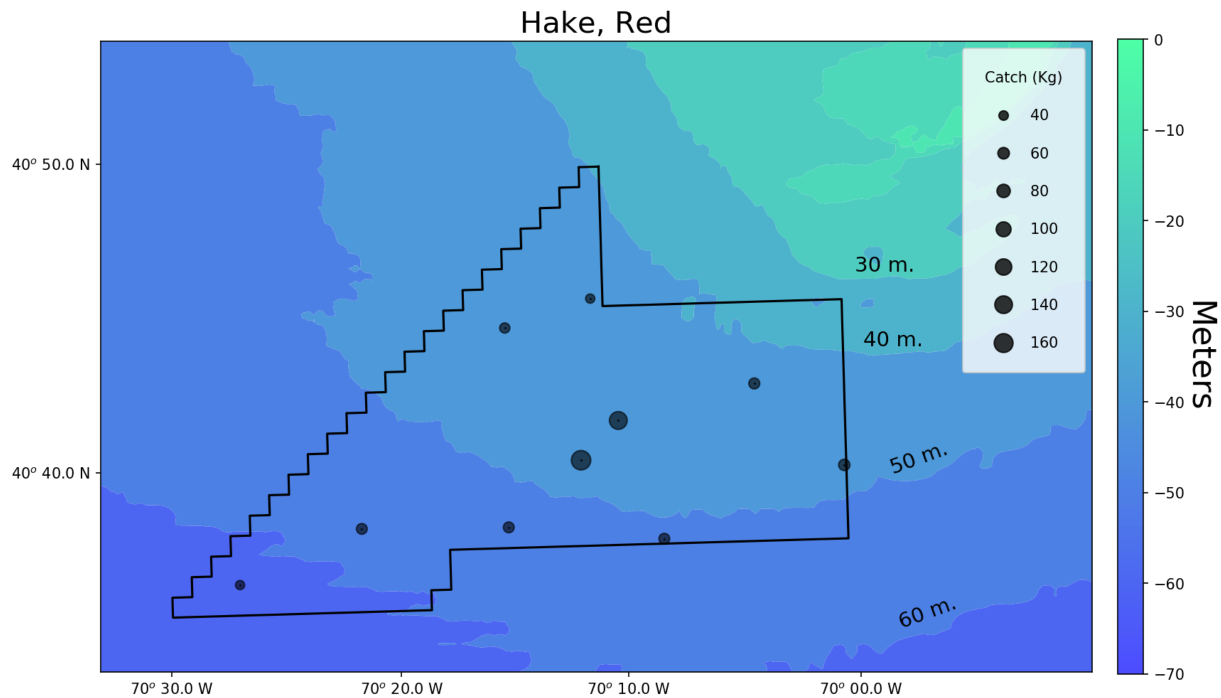
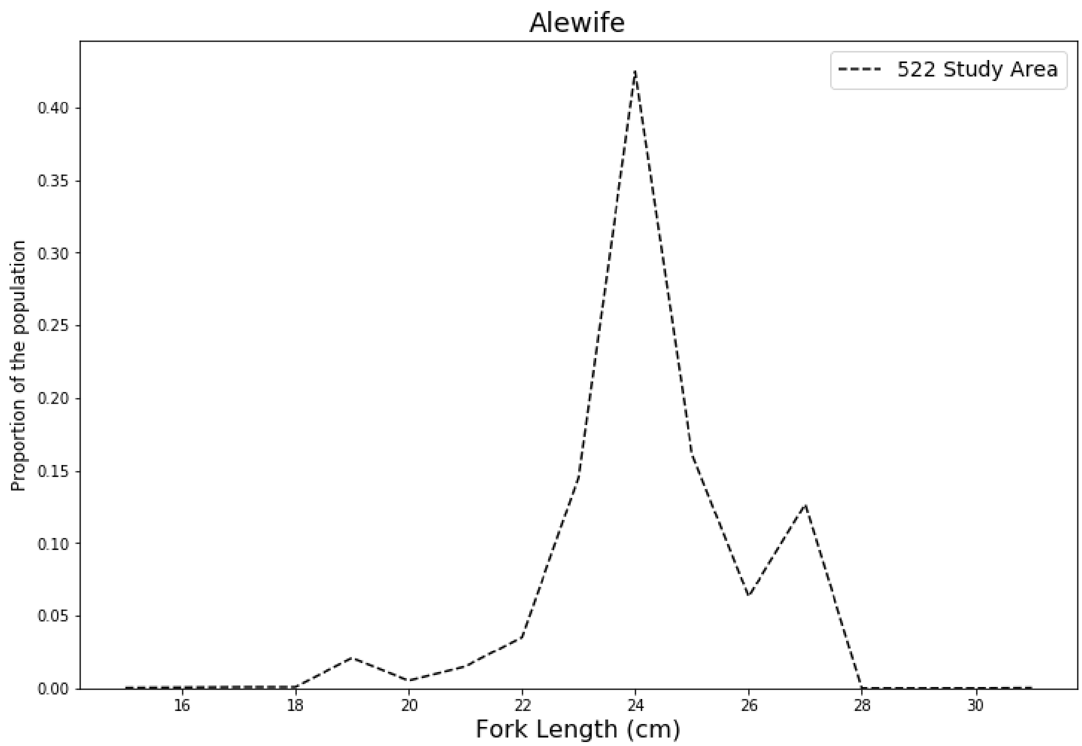


Figure 10: Distribution of the catch of red hake in the 522 Study Area.



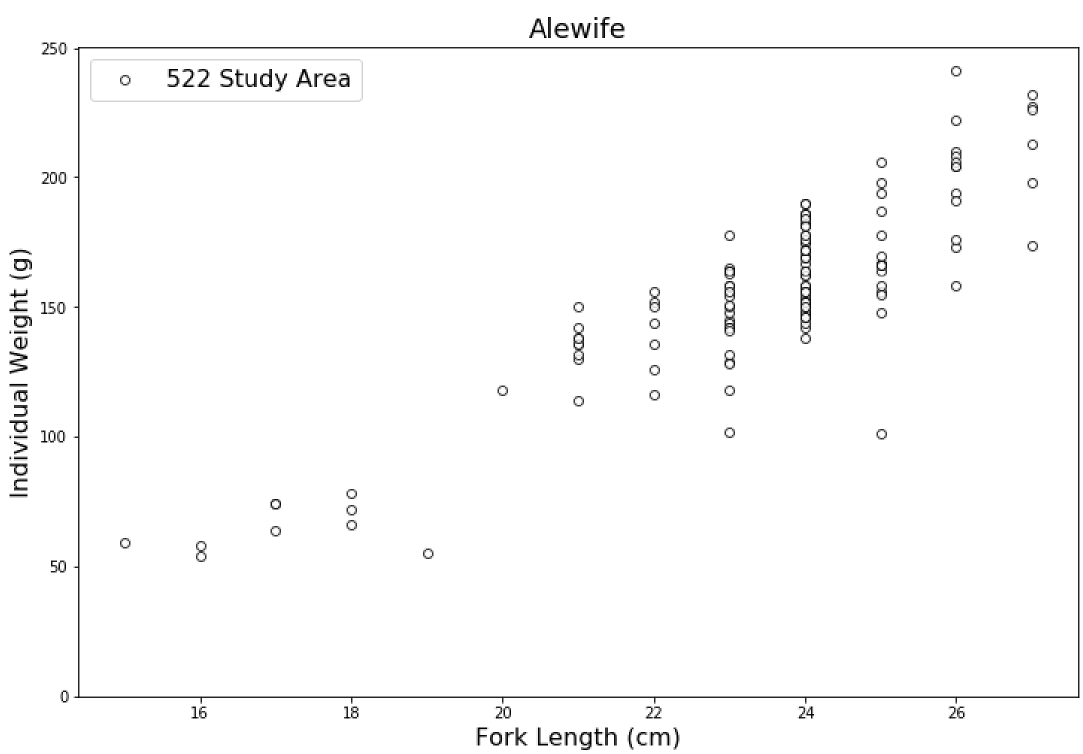


Figure 11:Population structure of alewife in the 522 Study Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

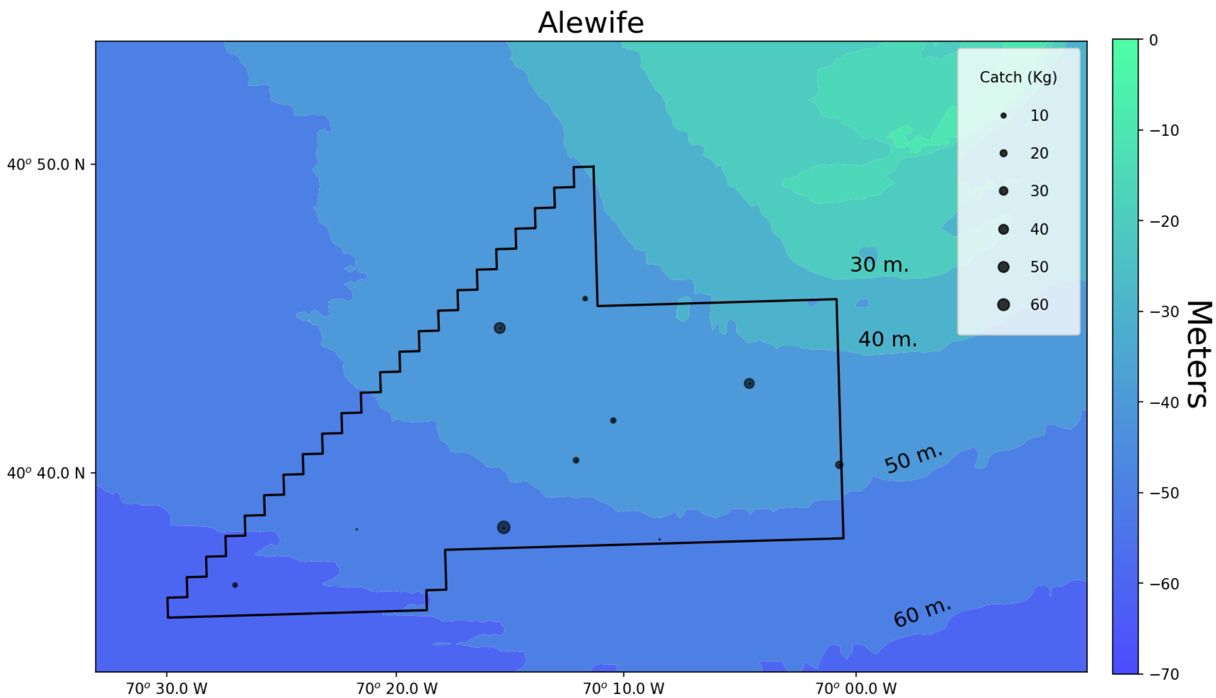


Figure 12: Distribution of the catch of alewife in the 522 Study Area.

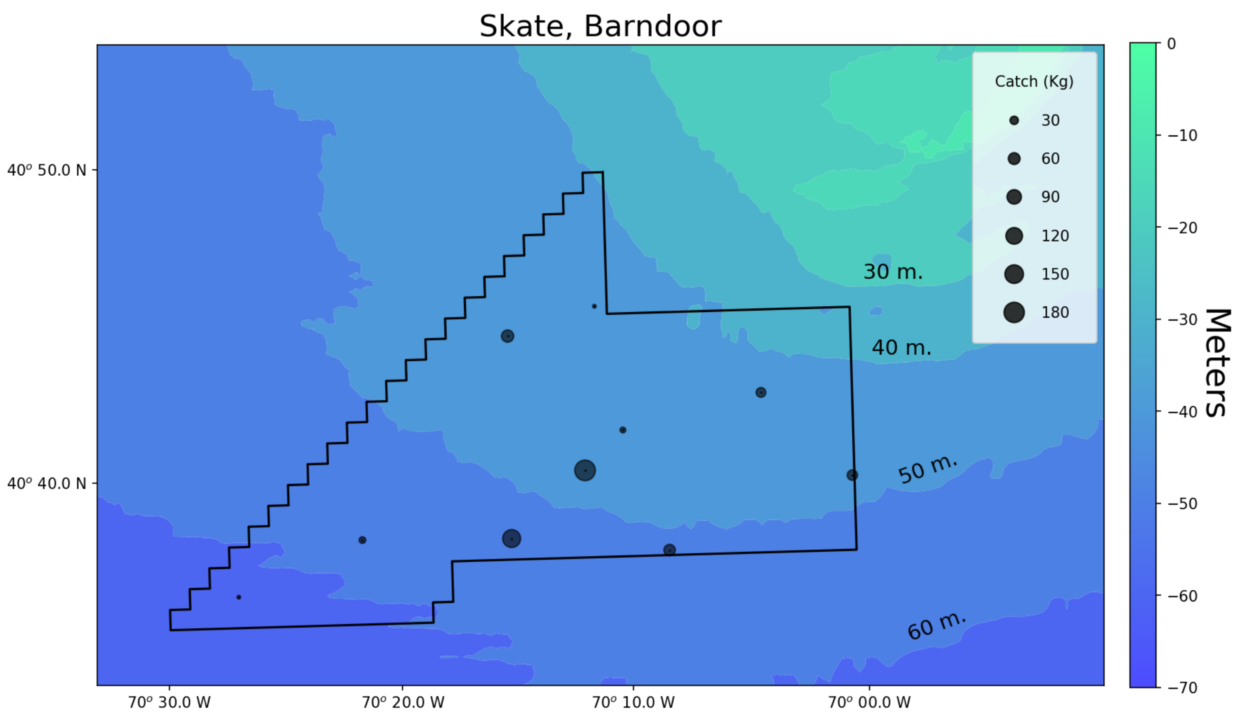


Figure 13: Distribution of the catch of barndoor skate in the 522 Study Area.

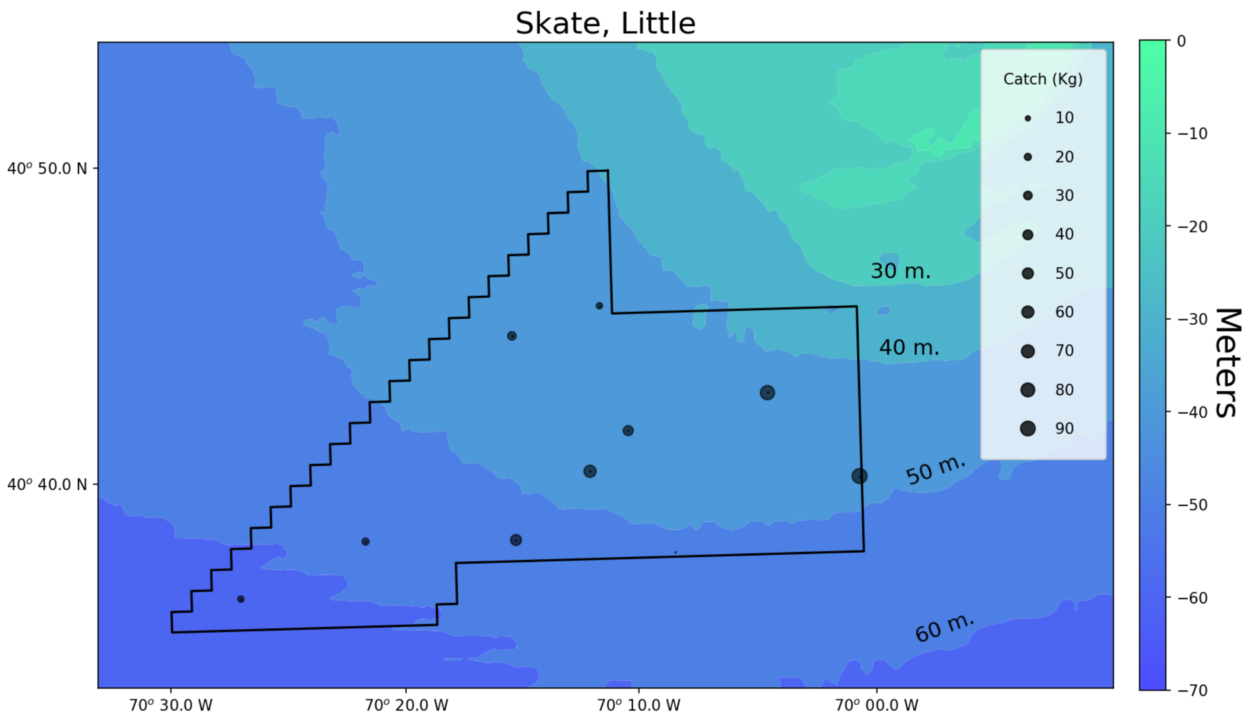


Figure 14: Distribution of the catch of little skate in the 522 Study Area.

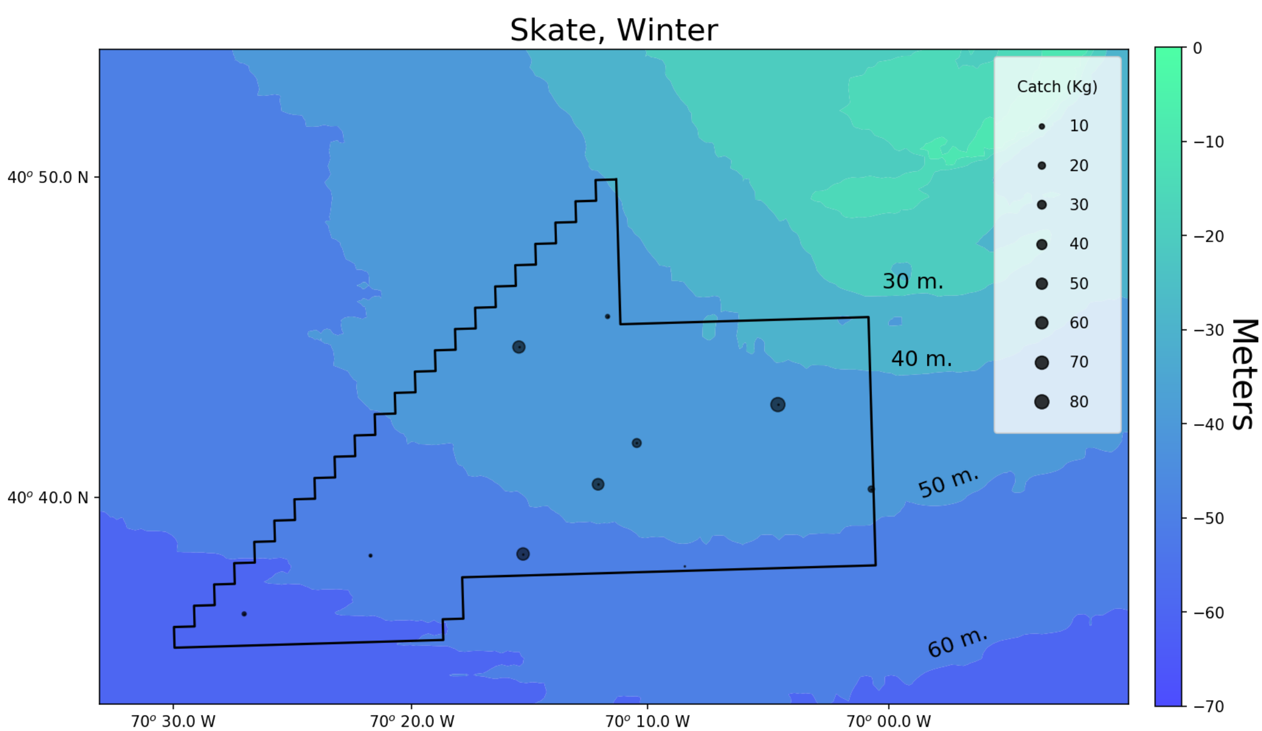
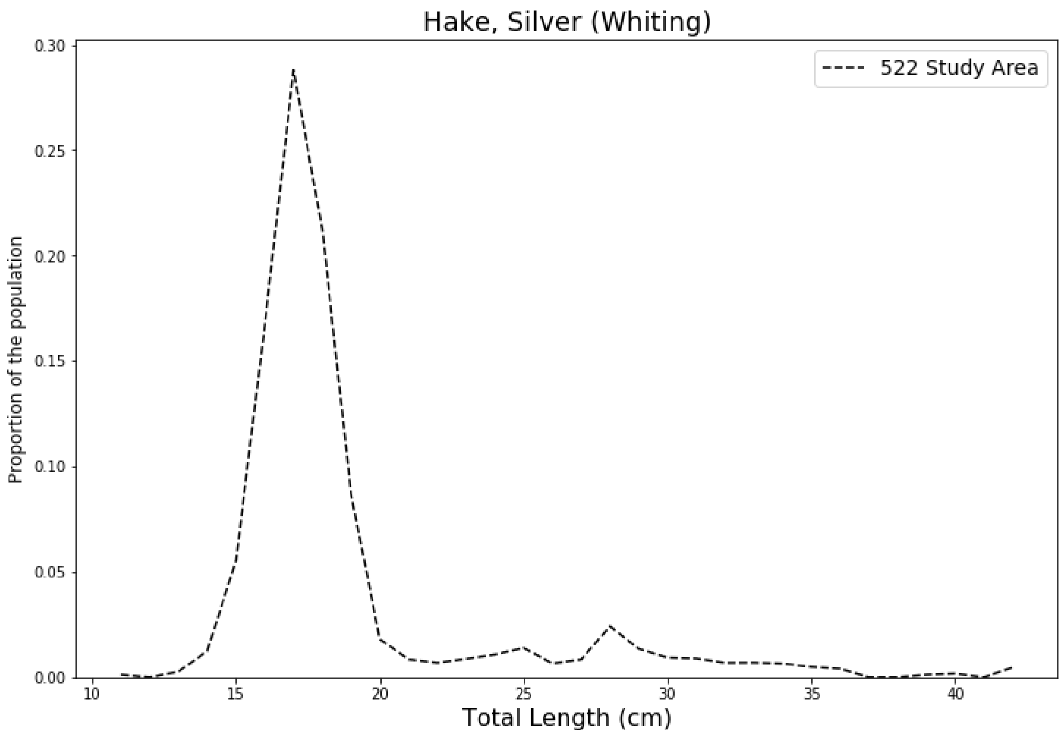


Figure 15: Distribution of the catch of winter skate in the 522 Study Area.



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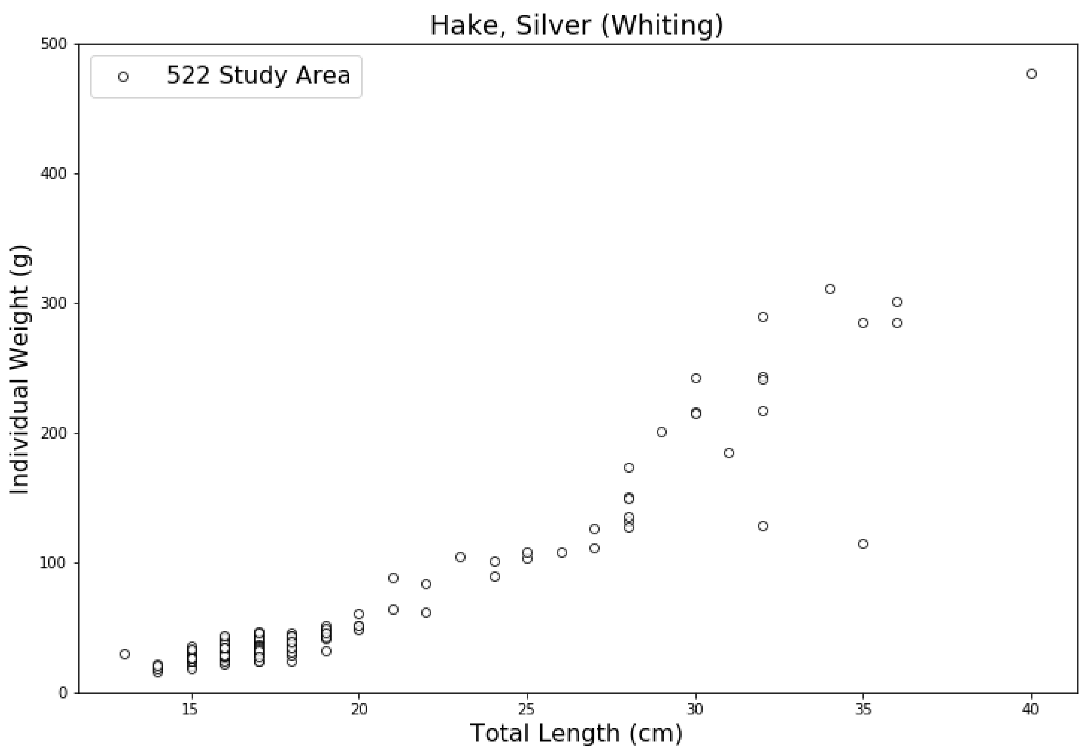


Figure 16: Population structure of silver hake in the 522 Study Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

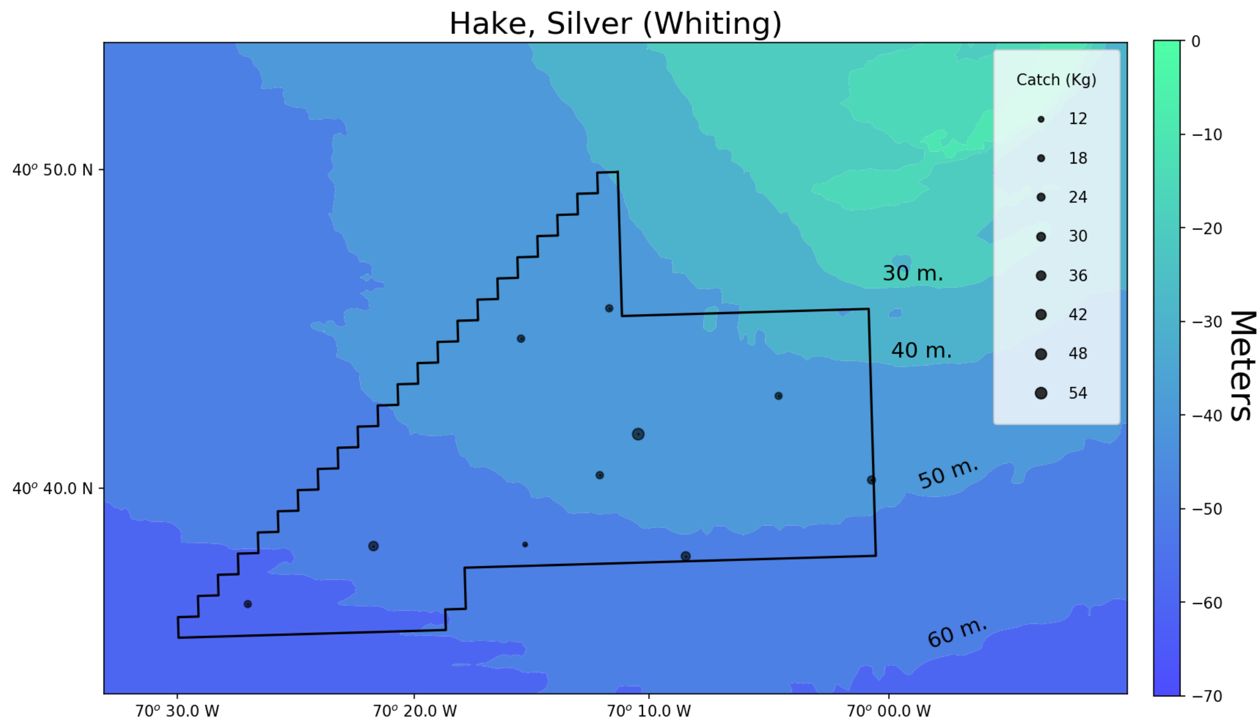
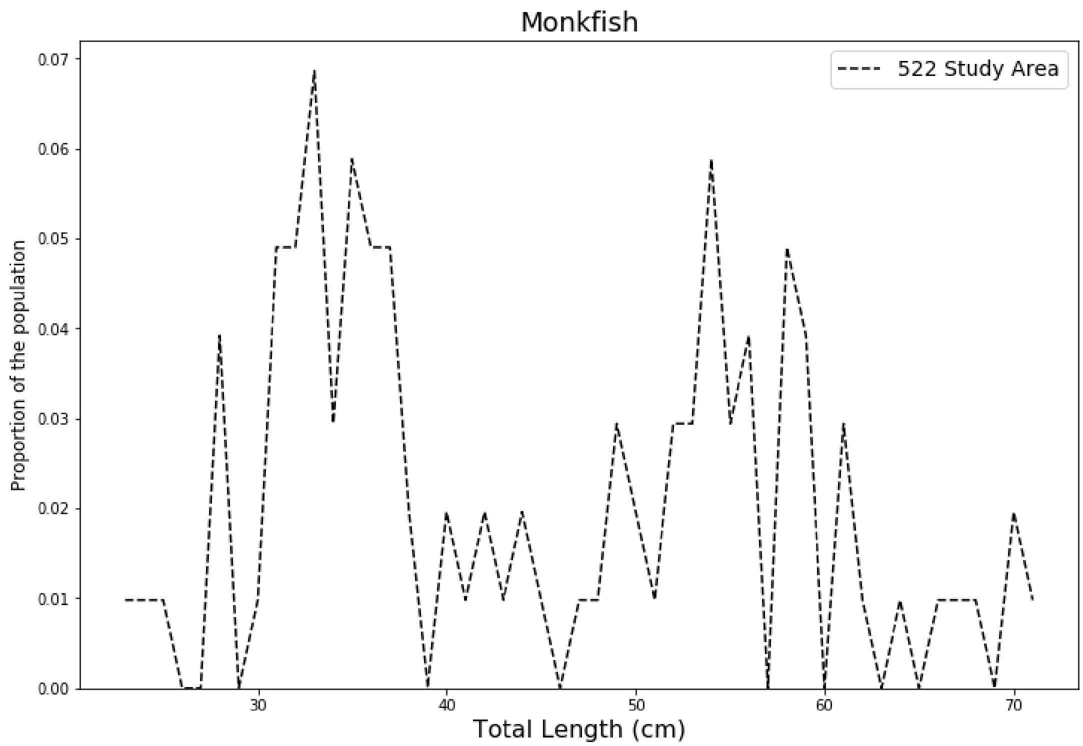


Figure 17: Distribution of the catch of silver hake in the 522 Study Area.



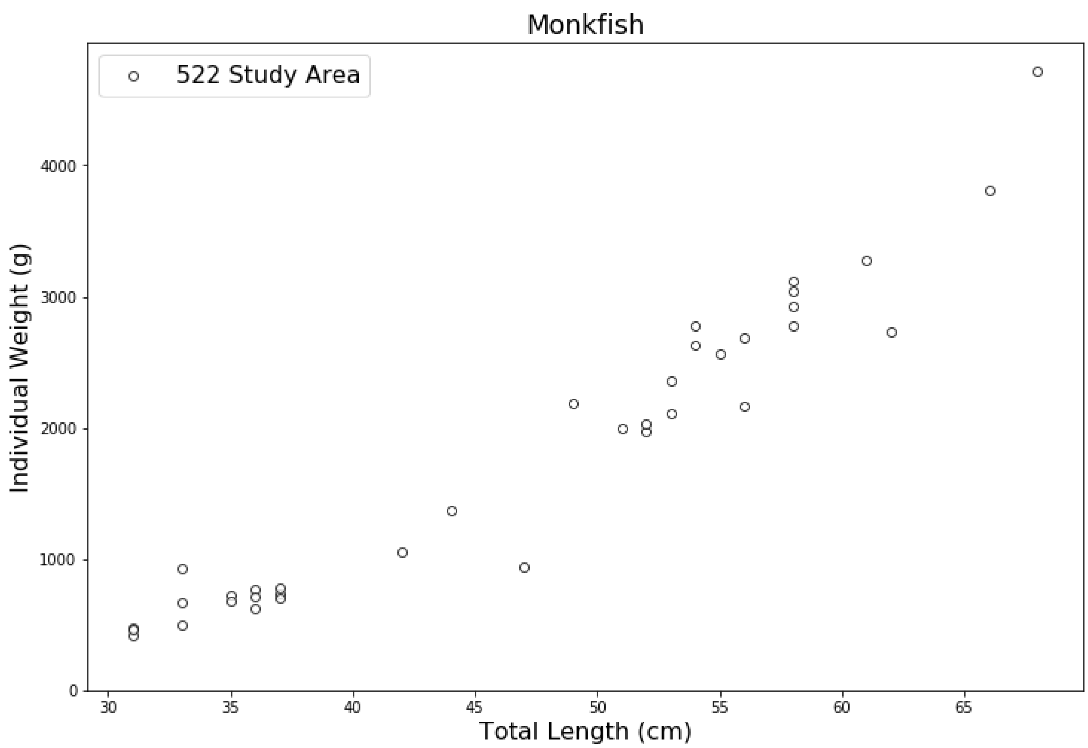


Figure 18: Population structure of monkfish in the 522 Study Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

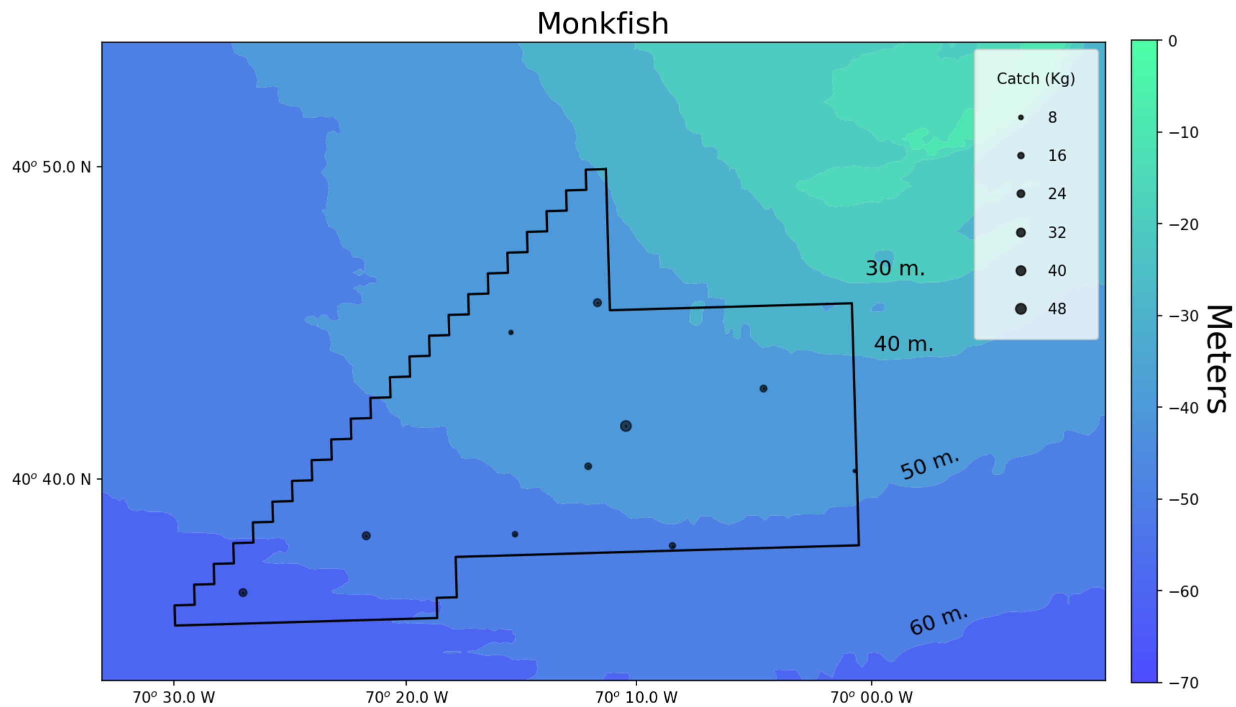
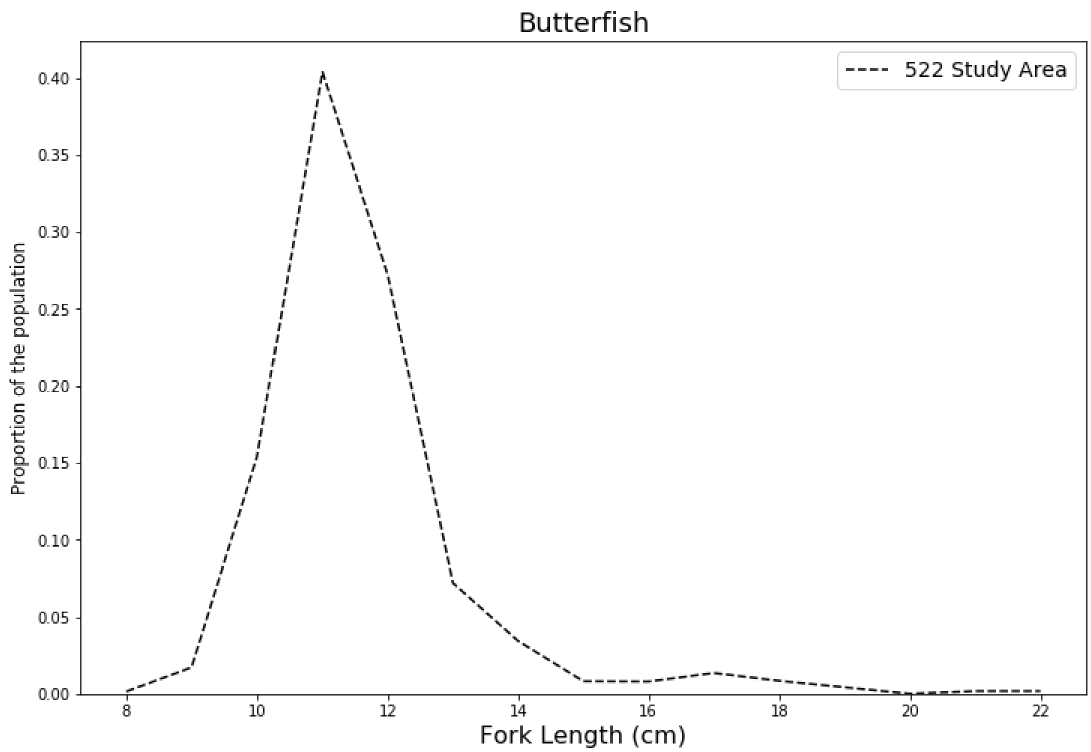


Figure 19: Distribution of the catch of monkfish in the 522 Study Area.



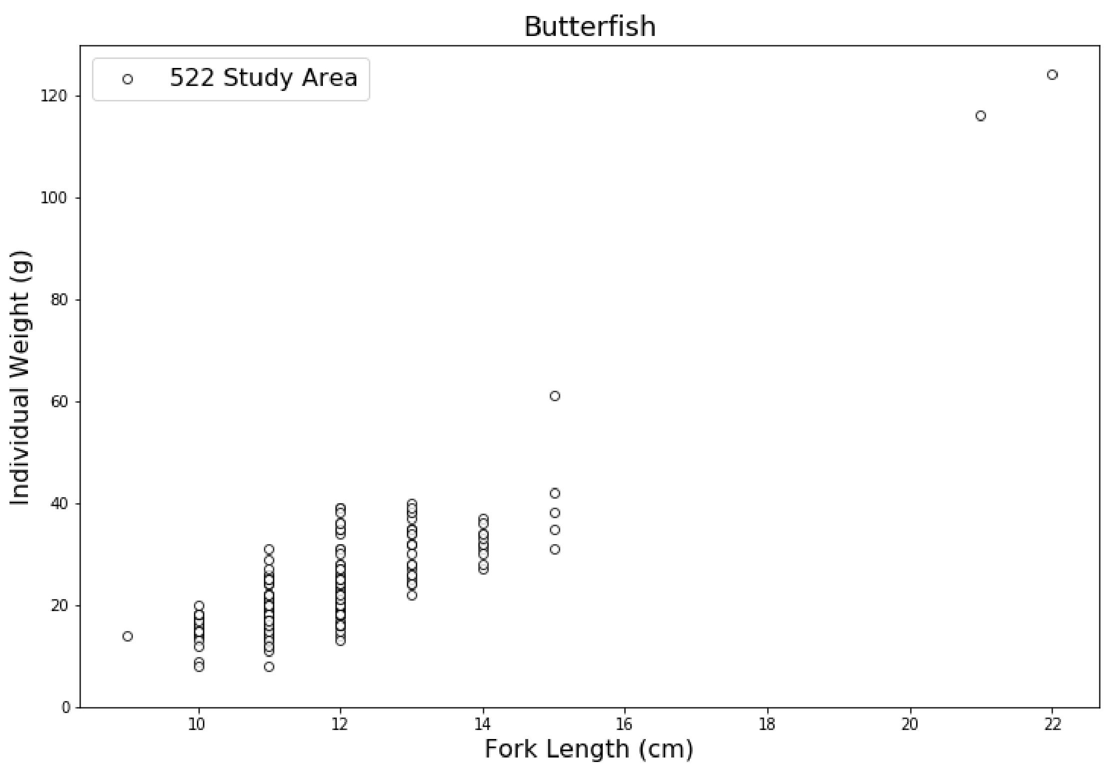


Figure 20: Population structure of butterfish in the 522 Study Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

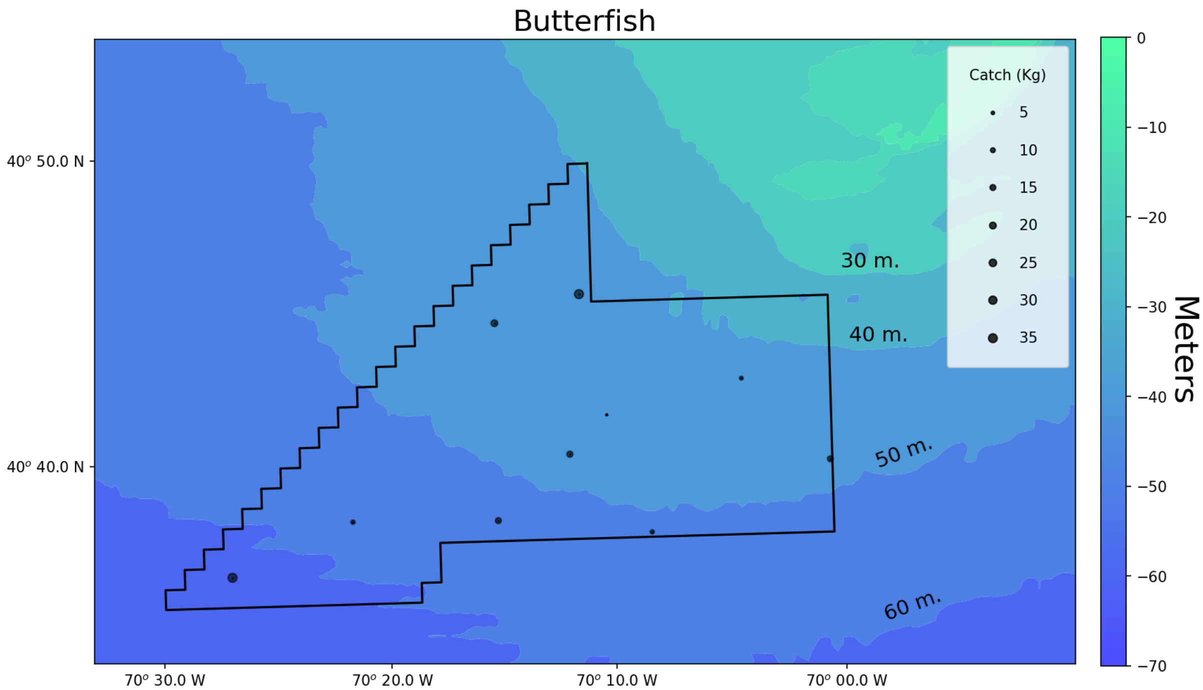
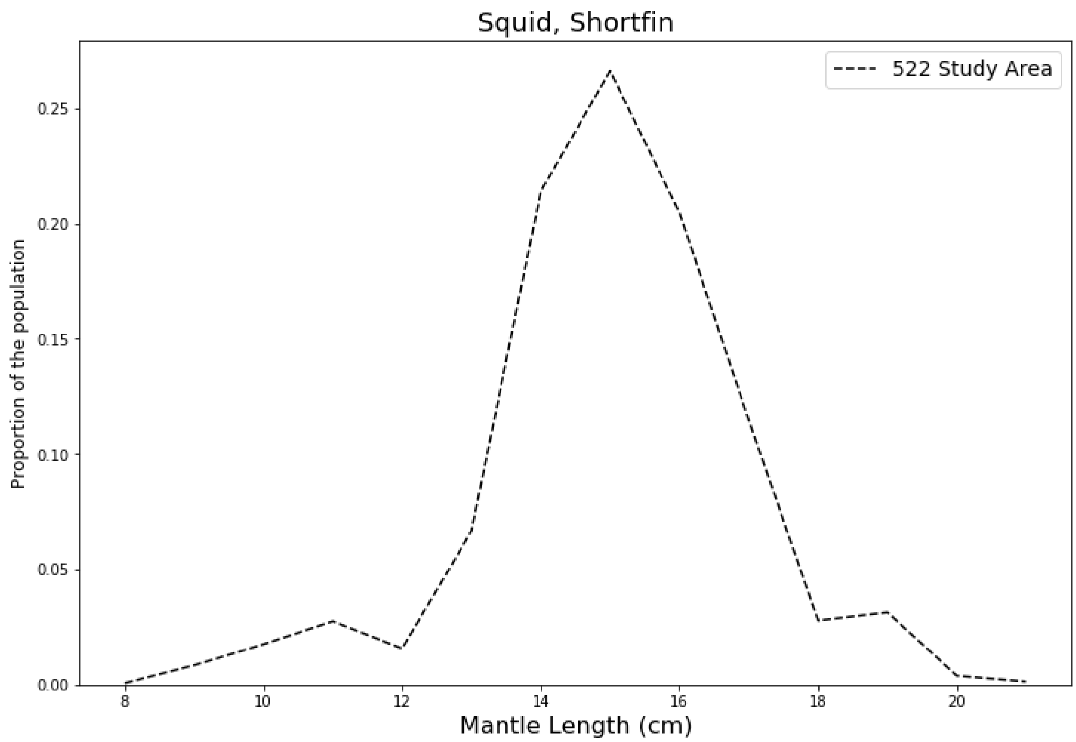


Figure 21: Distribution of the catch of butterfish in the 522 Study Area.



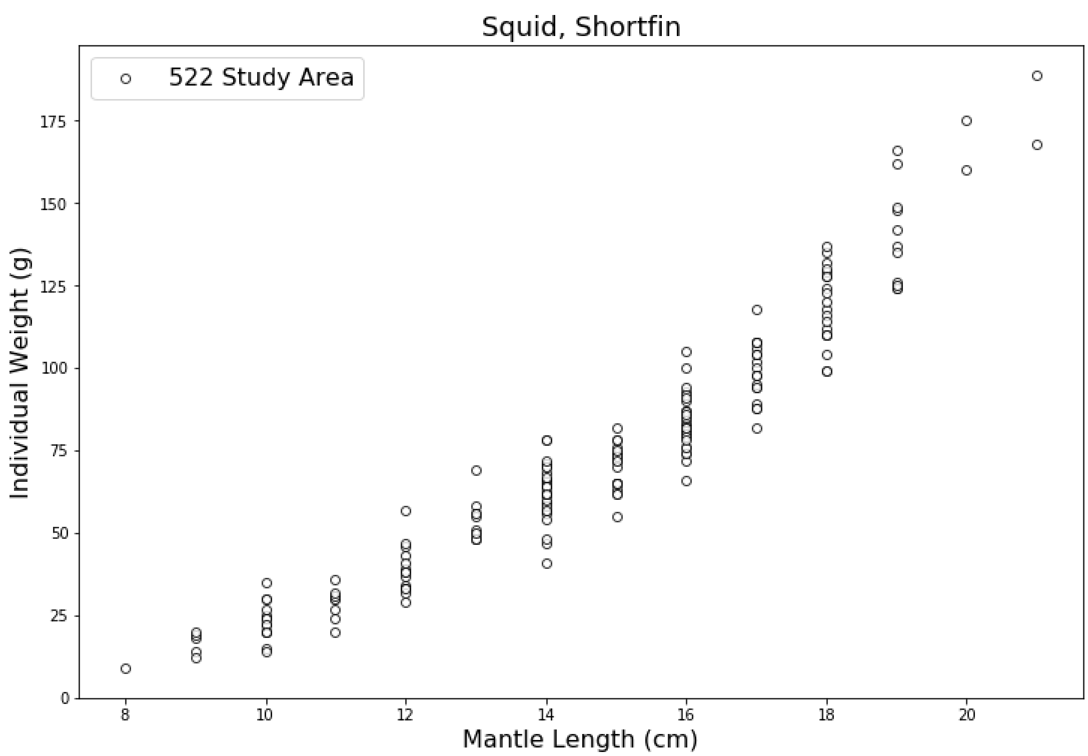


Figure 22: Population structure of shortfin squid in the 522 Study Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

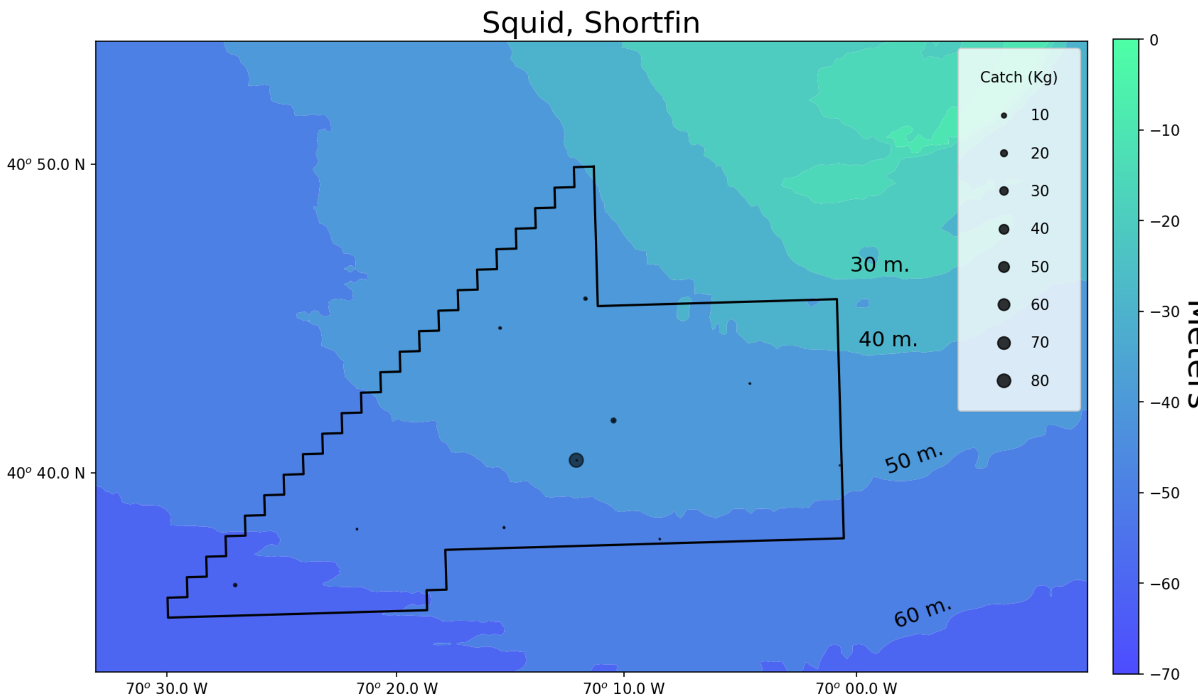
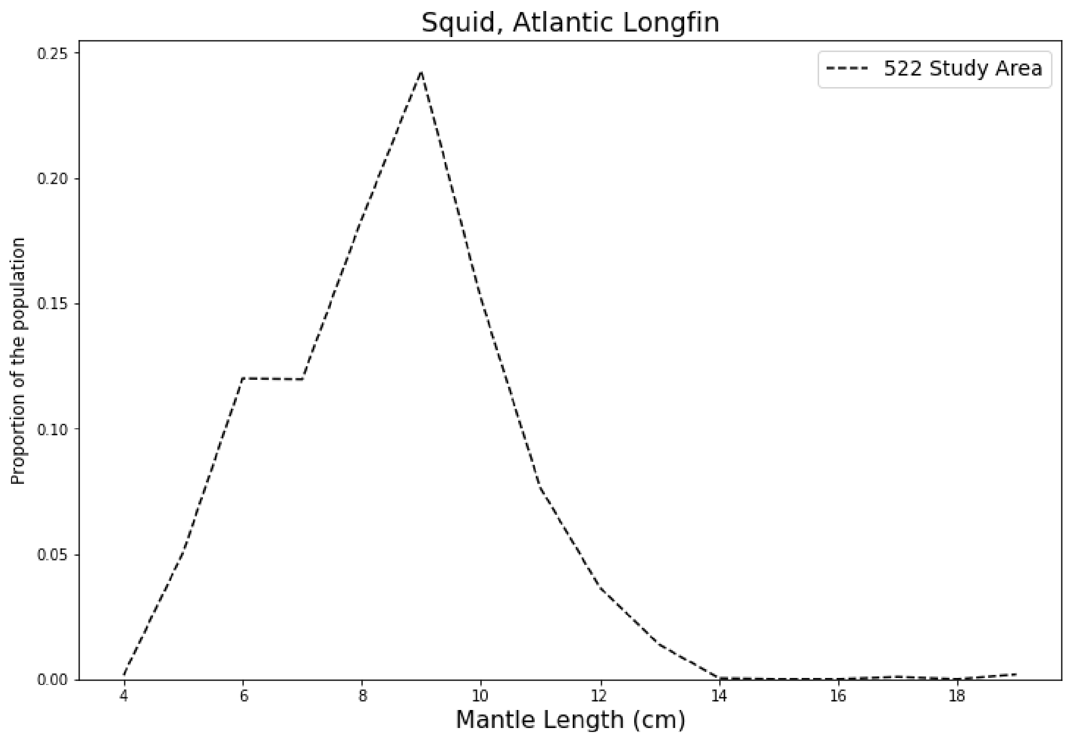


Figure 23: Distribution of the catch of shortfin squid in the 522 Study Area.



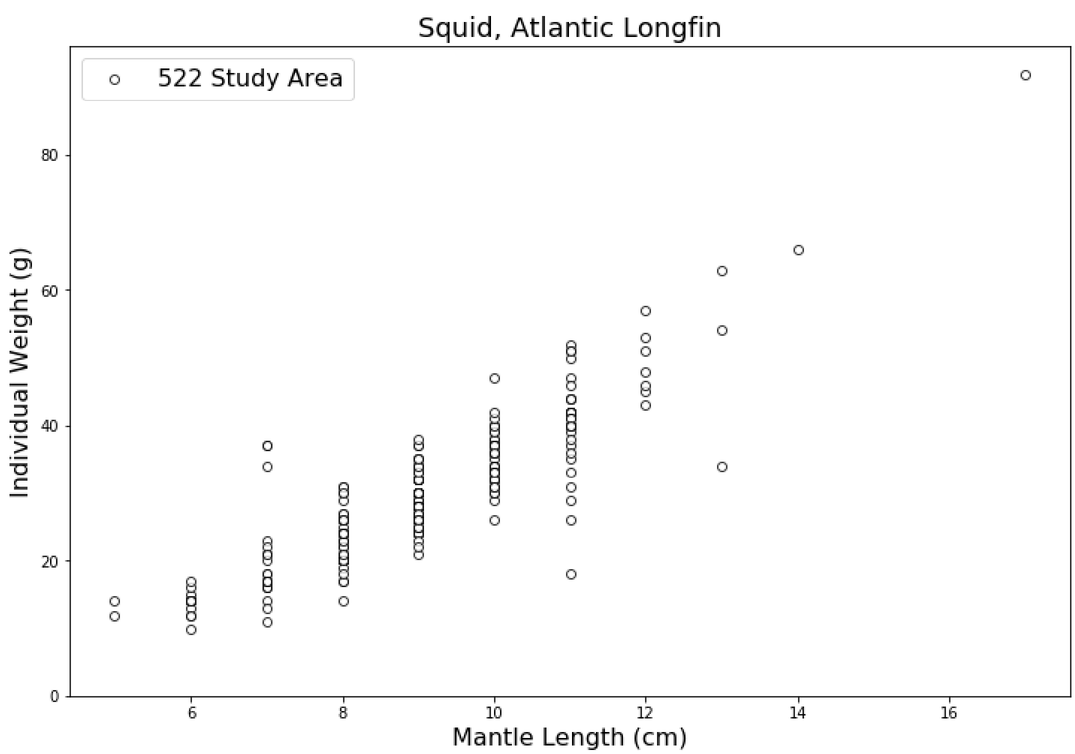


Figure 24: Population structure of longfin squid in the 522 Study Area as determined by the length-frequency data (top) and length-weight relationships (bottom).

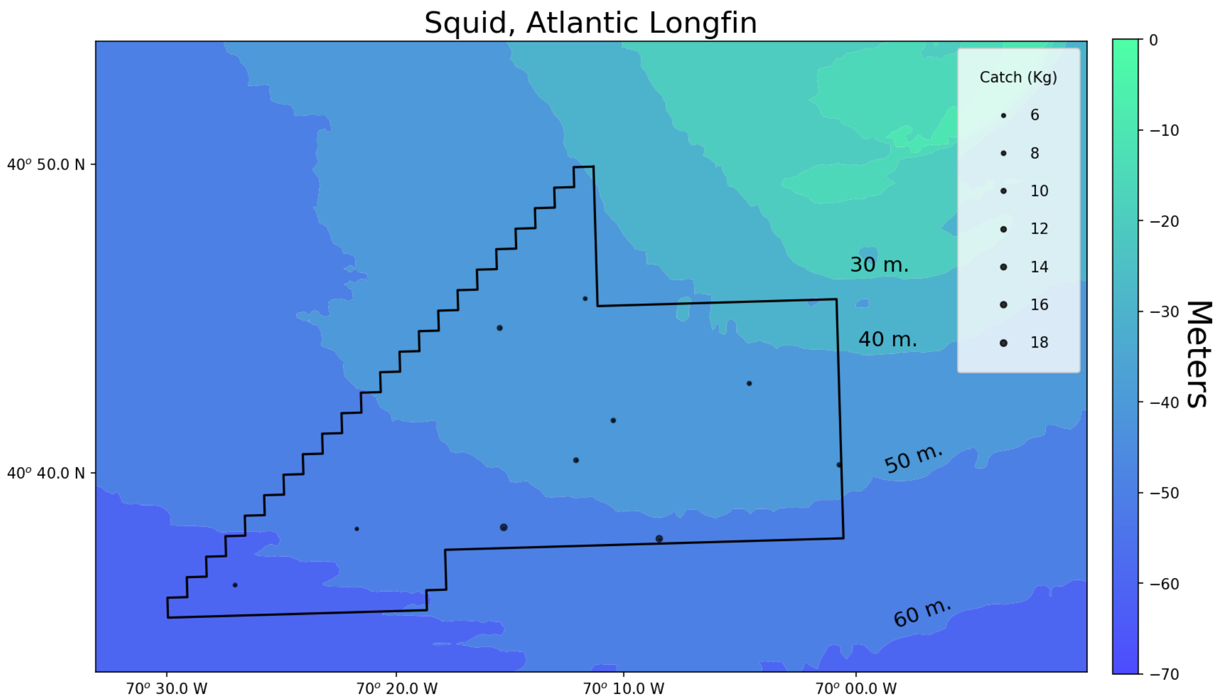


Figure 25: Distribution of the catch of longfin squid in the 522 Study Area.