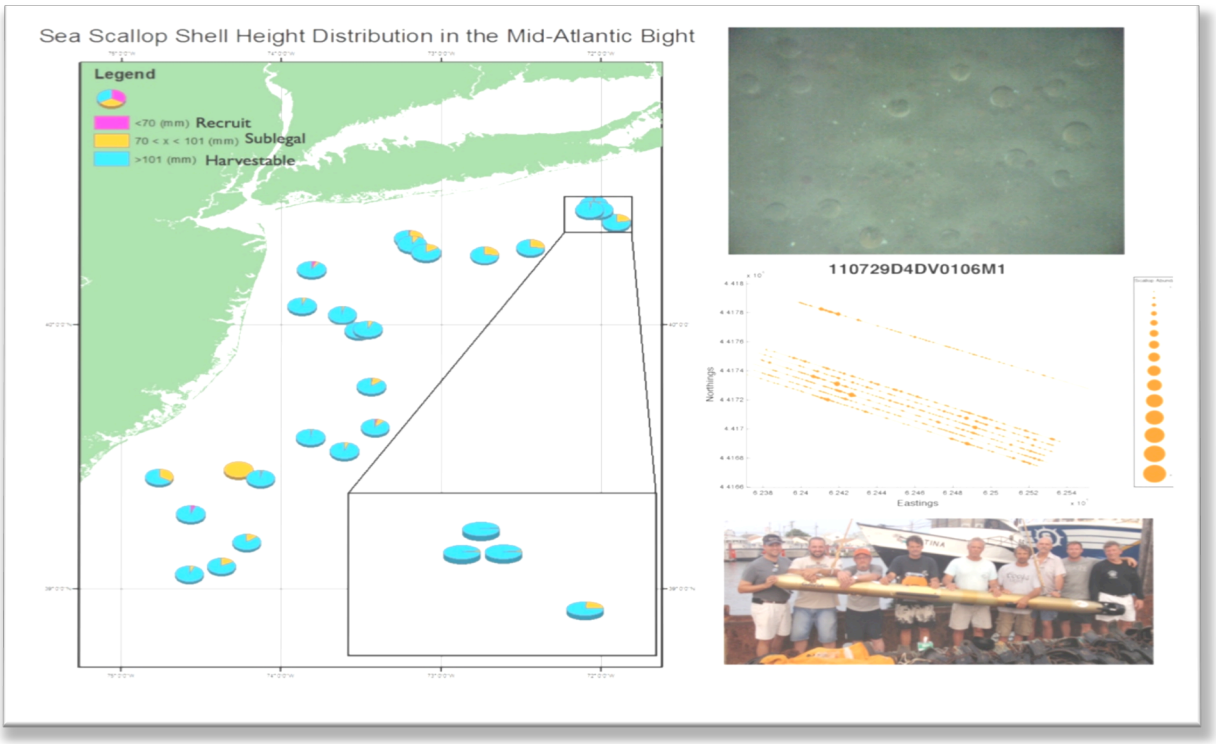
Final Report

A Demonstration Sea Scallop Survey of the Federal Inshore Areas of the New York Bight using a Camera Mounted Autonomous Underwater Vehicle



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Award Number: Award Number: NA11NMF4540011

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Executive Summary

The 2011 RSA project successfully used a rapid-fire digital camera integrated with a Gavia autonomous underwater vehicle (AUV) to collect a continuous record of photographs for mosaicing and subsequent scallop enumeration of abundance and size distribution. The AUV collected altitude and attitude data allowing us to georectify each image into scaled images for size measurements. During our 2011 pilot study survey we collected over 250,000 images of the seabed. All of these images were manually analyzed in the University of Delaware's laboratory for measurements of abundance and size distribution. Approximately half of the missions reoccupied previous NMFS stations. The missions were distributed throughout 8 substrata ranging from the eastern end of Long Island to off the Delaware coast. A typical mission ran along ~14 km of seabed trackline covering approximately 22,400 m^2 of continuous seabed in color camera images and approximately 280,000 m^2 in sonar coverage of the seabed. A typical survey day involved four (4) AUV missions of three hours each resulting in ~90,000 m^2 of continuous seabed color camera imagery. Based on the altitude of the AUV and the calibrated geometry of the camera each image is ~ 1.9 m across with a resolution of 2.4 mm/pixel. Trained team of image analysts using a newly developed web-based software measuring-tool then measured the scallop sizes manually. In addition, a brand new citizen science website portal (SubSeaObservers.com) was developed utilizing the project seabed images allowing public participants to view and learn about scallops while helping to contribute to additional quantitative assessments of the images. This project confirms that AUV seabed imagery is capable of being used for sea scallop survey objectives. Furthermore, the unique abilities of an AUV to maintain close proximity to the seabed and perform precise repeatable missions also demonstrates the suitability of AUVs for more focused projects and experimental studies such as repeated monitoring of site conditions.

Project Background

The sea scallop (*Placopecten magellanicus*) fishery in the US EEZ of the northwest Atlantic Ocean has been, and still is, one of the most valuable fisheries in the United States Historically, the inshore sea scallop fishing grounds in the New York Bight, i.e. Montauk Point, New York to Cape May, New Jersey have provided a substantial amount of scallops. These New York Bight "open access" grounds are especially important, not only for vessels fishing in the

day boat category which are usually smaller vessels with limited range opportunities, but also all the vessels that want to fish in near-shore "open access" areas to save fuel (personal

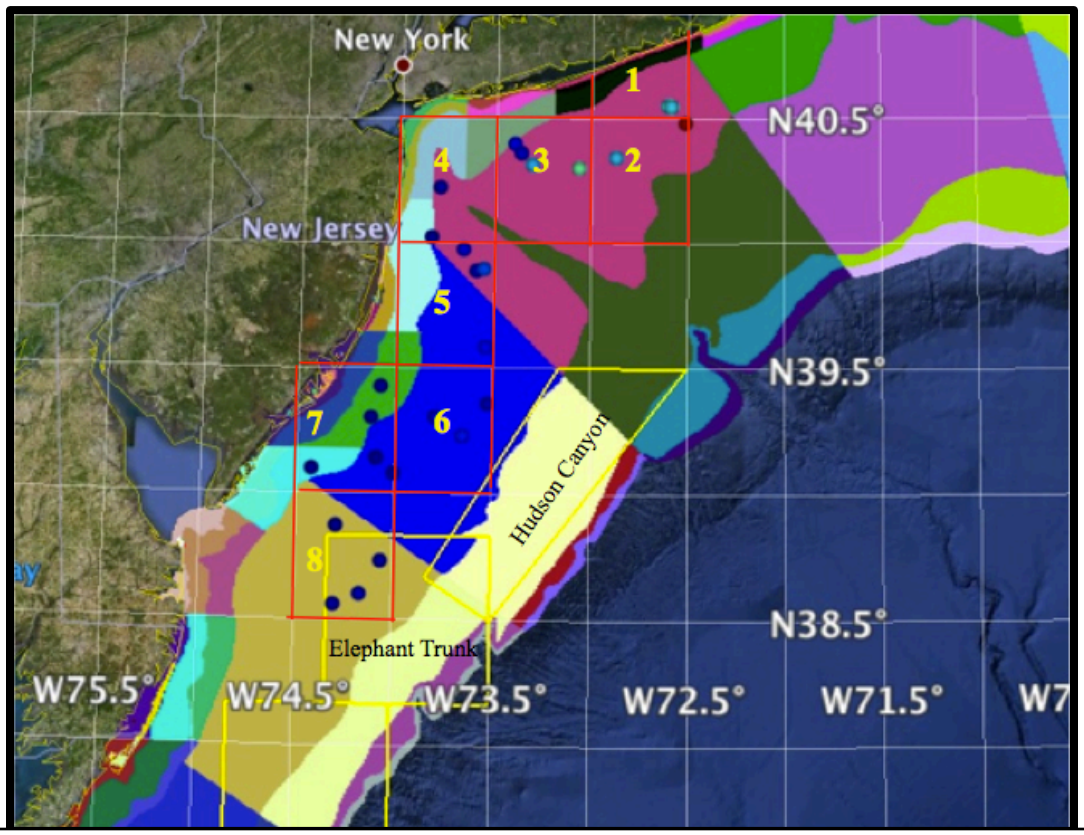


Figure 1. Location of missions from 2011 AUV based scallop survey. Location of all project AUV missions (10 days) within originally planned 8 substrata (0.5 degree x 0.5 degree). NMFS substrata GIS sectors shown by colored underlying shapes.

communication, several limited access and day boat scallopers). These areas can be highly productive but are at times rapidly depleted due to heavy fishing pressure. Time and funding prevent these inshore areas from being thoroughly surveyed by the NMFS during its annual scallop dredge survey.

The 2011 RSA project "A Demonstration Sea Scallop Survey of the Federal Inshore the New York Bight using a Camera Mounted Autonomous Underwater Vehicle" was a proof-of-concept project that successfully used a digital, rapid-fire camera integrated with a Gavia autonomous underwater vehicle (AUV) to collect a continuous record of photographs for mosaicing and subsequent scallop enumeration and size distribution (Figure 1 and Table 1, Appendices). In July 2011, transects were completed in the northwestern waters of the New York Bight at depths of 25-55 m. The AUV continuously photographed the seafloor along each

transect at a constant 2 m above the seafloor. Parallel sets of transects were spaced as close as 4 m, offering unprecedented two-dimensional spatial resolution of the sea scallop distribution. Georeferenced images were manually analyzed for the presence of sea scallops using GPS data logged with each image.

In the 2011 demonstration survey, we divided the Federal inshore scallop grounds from Shinnecock, New York to Cape May, New Jersey into eight blocks or strata (Figure 1). The F/V CHRISTIAN AND ALEXA served as the surface support platform from which a Gavia autonomous underwater vehicle (AUV, Figure 2) was deployed and recovered. The Gavia conducted photographic surveys of the seabed for a continuous duration of ~3 hours during each dive repeated 3-4 times in each stratum occupying each strata for a total of ~10hrs and imaging ~90,000 m^2 in each strata.

The AUV collected altitude (height above the seabed) and attitude (heading, pitch, roll) data allowing us to georectify each image into scaled images for size and counting measurements. During our 2011 pilot study survey season we collected over 250,000 images of the seabed (Table 1 and Appendix I). These images were analyzed in the University of Delaware's laboratory for estimates of abundance and size distribution. The F/V CHRISTIAN AND ALEXA provided surface support and made tows along the AUV transect to ground-truth the presence of scallops and provide calibration for the size distribution. Abundance and sizing estimates were conducted via heads-up manual method and each image includes embedded metadata allowing them to be incorporated into to existing benthic image classification systems (Habcam MIP- http://habcam.whoi.edu/HabCamData/).

During our proof of concept study, in each stratum the F/V CHRISTIAN AND ALEXA made one (1) 15-minute dredge tow along the AUV transect to ground-truth the presence of scallops and other fauna and provide calibration for the size distribution. The vessel was maintained on the dredge track by using DGPS. The tows were made with the starboard 15' wide New Bedford style commercial dredge at the commercial dredge speed of 4.5 – 5.0 knots. Where dredging was accomplished the catch was sorted, identified, and weighed. Length-frequency data were obtained for the scallops. This information was recorded onto data logs and then entered into a laptop computer database aboard ship for comparison to the camera image estimates.

The mobile platform of the AUV provided a more expansive and continuous coverage of the seabed than traditional fixed drop camera systems or towed camera systems. In a given day, our AUV surveys covered ~90,000 m^2 of seabed from an altitude of 2m above the bed simultaneously producing broad sonar swath coverage (Appendix IX) and measuring the salinity, temperature, dissolved oxygen, and chlorophyll-a in the water.

The precise positioning and ability to run very tight mission lines allowed us to also compare variability from one parallel line to the next with spacing typically of 10 m but as narrow as 2 m possible. Half of our pilot project surveys were chosen to both reoccupy NMFS stations made on the spring 2011 scallop cruise and also added new inshore areas to survey coverage (Figure 1). Thus we can compare abundance estimates from the AUV to the NMFS surveys and to the concomitant commercial dredge surveys (Appendix VI).

2011 Survey Season Summary

Table 1. AUV Mission Summary Table

Mission Names	Date	Mission Length (Km)	Images	Depth (m)	Lat Start	Lon Start
110708_Scallop_DvoraRun	7/8/11	10.34	8066	43	40.5503	-72.5872
110708_ScallopD2	7/8/11	15.904	12775	41	40.5529	-72.5899
110708_ScallopD2_M4	7/8/11	3.015	2388	41	40.5503	-72.5872
110709_Scallop_D3_M1_Corey	7/9/11	12.28	9993	44	40.3449	-72.8817
110708_SM2	7/8/11	3.199	2688	41	40.5502	-72.625
110709_ScallopDay3_DV119	7/9/11	10.773	8339	40	40.3111	-73.0825
110710_DV117	7/10/11	14.211	11330	30	40.3961	-73.3818
110710_DV118	7/10/11	12.271	10164	32	40.3551	-73.3483
110710_M1_ArtiesRun	7/10/11	12.154	9781	33	40.3213	-73.2749
110711_DV115	7/11/11	10.398	9142	33	40.2249	-73.7828
20110726_ScallopD1_M1	7/26/11	12.713	10475	45	38.5600	-74.3177
110726_ScallopD1_DV44_M3	7/26/11	15.913	12036	47	38.7372	-74.0551
110727_D2_R2_M2	7/27/11	11.791	9171	20	39.0907	-74.447
110727_D2_R3_M3	7/27/11	13.499	10392	36	39.1432	-74.0397
110727_D2_R4_M4	7/27/11	12.207	7346	37	39.1432	-74.0397
110727_D2_R5_M5	7/27/11	8.292	6286	24	39.4200	-74.0267
110727_ScallopD2_R1_M1	7/27/11	12.127	11098	39	38.9049	-74.3271
110728_D3_DV062_M3	7/28/11	12.196	12069	45	39.2178	-73.6423
110728_D3_DV063_M4	7/28/11	12.149	9528	49	39.3477	-73.5099
110728_D3_R6_M1	7/28/11	13.086	10951	38	39.3536	-73.7925
110728_D3_R7_M2	7/28/11	12.331	9438	40	39.1226	-73.984
110728_D3_R8_M5	7/28/11	11.691	9545	39	39.6209	-73.5386
110729_D4_DV0105_M2	7/29/11	12.181	9075	31	39.8959	-73.6105
110729_D4_DV0106_M1	7/29/11	11.752	9426	35	39.8963	-73.5318
110729_D4_DV0112_M3	7/29/11	12.133	9282	36	39.9783	-73.6383
110729_D4_DV0113_M4	7/29/11	12.511	9524	26	40.0173	-73.8078
110726_ScallopD1_DV2_M2	7/26/11	11.699	9256	52	38.6021	-74.1828
Summary		**312.81**	**249564**			

Our initial proof of concept project in 2011 allowed us to develop experience and protocols in operating the AUV from a commercial scallop vessel (the F/V CHRISTIAN & ALEXA) (Figures 1 and 2) and all of the ~250,000 obtained images were manually analyzed for abundance and size distribution of scallops (Figures 3 & 4 and Table 1).

Our round-the-clock survey operations during the 2011 proof of concept missions resulted in coverage of approximately 70-90,000 m^2 in each stratum. After a series of initial dive tests we determined that the optimal height for setting the AUV to swim above the seabed was a constant elevation of 2 m as this provided the best compromise between image resolution and coverage area (Figures 5, 6, and 7).

Table 2. Species List- List of Major Taxa Observed during AUV Field Survey 2011.

Common Name	**Species Name**
Common Sea Star	*Asterias forbesi*
Sand Star	*Astropecten americanus*
Monkfish	*Lophius sp.*
Rock Crab	*Cancer irroratus*
Skate	Family: Rajidae
Barndoor Skate	*Dipturus laevis*
Clearnose Skate	*Raja eglantera*
Little Skate	*Leucoraja erinacea*
Rosette Skate	*Leucoraja garmani*
Smooth Skate	*Malacoraja senta*
Thorny Skate	*Amblyraja radiate*
Winter Skate	*Leucoraja ocellata*
Summer Flounder	*Paralichthys dentatus*
Yellowtail Flounder	*Limanda ferruginea*
Sea Scallop	*Placopecten magellanicus*
Sulfur Sponge	*Cliona celata*

Study Area

The Mid-Atlantic Bight is the shallow portion of the continental shelf that extends from Cape Hatteras, NC to Cape Cod, MA. The area was chosen by the needs of the Mid-Atlantic Council's Research Set-Aside (RSA) program to survey inshore heavily fished grounds. Mission sites were subsampled from pre-existing NMFS scallop stock assessment sites (half of the missions), and were all within 70 km of the coast of Delaware, New Jersey, or New York. The water depths sampled ranged from 20-55 m, which are often cited as the normal habitable zone for the sea scallop. The sites that were surveyed in the summer of 2011 are shown in Figure 1.

Field Survey Equipment

The University of Delaware AUV, *DORA*, (Figure 2) was used to collect continuous images of the benthos and simultaneously map the texture and topography of the seabed. Sensor systems associated with this vehicle include: phase measuring bathymetric sonar (500 kHz GeoAcoustics GeoSwath Plus); dual-frequency high-resolution side-scan sonar (900/1800 kHz Marine Sonic); acoustic Doppler current profiler (DVL/ADCP, RD Instruments); Inertial Navigation System (Kearfott T-24); Combination Fluorometer/Turbidity sensor (Ecopuck FLNTU); Point Grey Scorpion model 20S0 digital camera and strobe; Dissolved Oxygen (Aanderaa Optode); temperature and density sensor; and, altimeter. Each sensor records

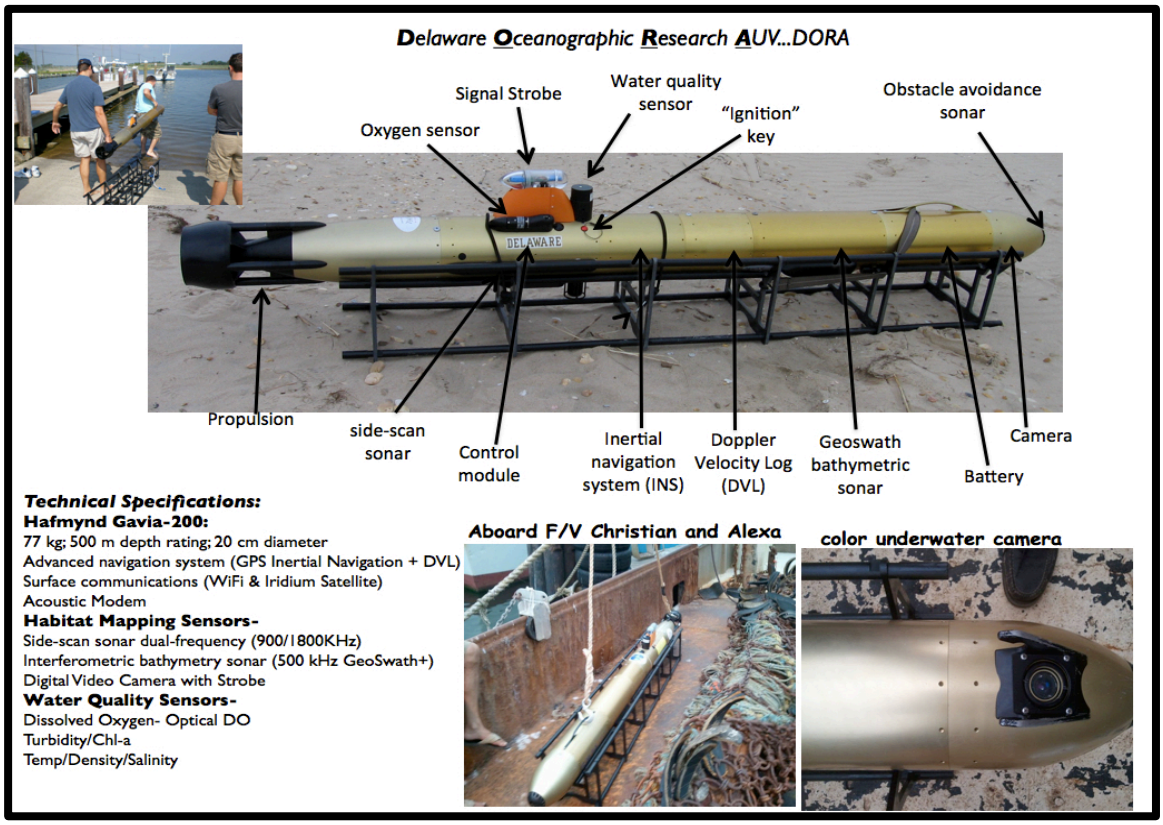


Figure 2. University of Delaware Gavia AUV as configured for the scallop survey project.

separately time and spatially stamped data with frequency and spacing listed in Table 3. The AUV is capable of very precise dynamic positioning adjusting to the variable topography of the seabed while maintaining a constant commanded altitude offset as shown in Figure 3.

Table 3.Sample rate and spatial distribution of AUV sensor systems used in this project.

Sensor	Sampling Frequency (Hz)	Spacing (cm) @ survey speed (1.5 m/s)
camera	4	37.5 cm
Temperature	1	145 cm
Salinity	1	145 cm
Dissolved Oxygen	1	145 cm
Side-scan	15	9.7 cm
swath bathymetry	15	9.7 cm

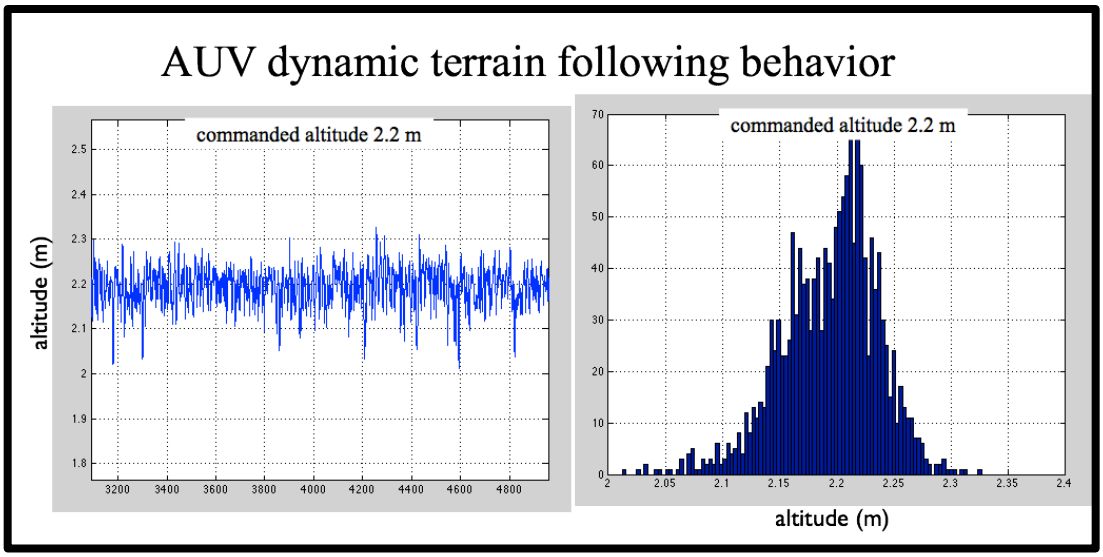


Figure 3. AUV mission data plots illustrating precise terrain following behavior over the vehicle adjusting to the seabed while maintaining a commanded altitude offset. Standard deviation 16 cm.

Survey Missions Experimental Design

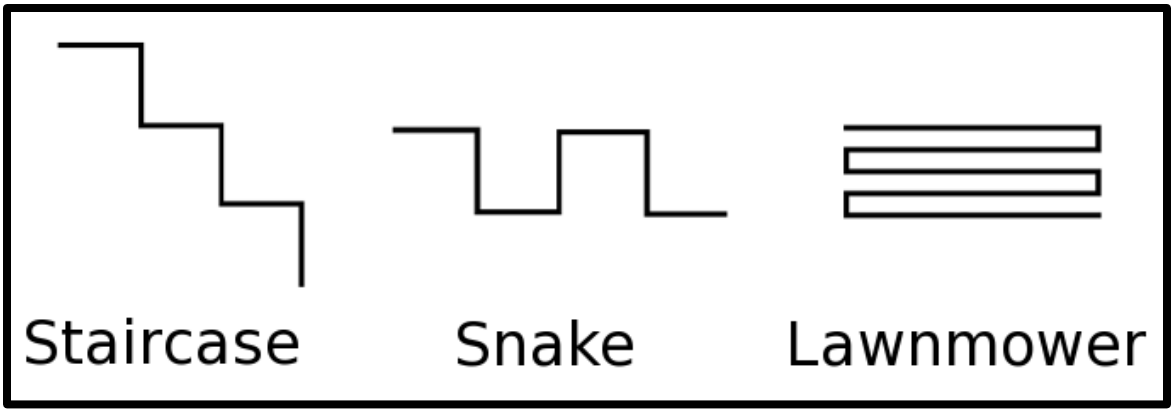


Figure 4 - AUV survey mission designs design types tested in this project.

Given the pilot study nature of this project, variable sampling designs were chosen to assess optimal image sampling utilizing an AUV. The goal of the study was to photograph 90,000 m^2 of seafloor in the eight boxed inshore NMFS sea scallop survey strata (Figure 1). An AUV image of the seafloor is typically about 2 m wide, meaning that the AUV had to complete approximately 45 km of transects in each strata to get the desired coverage. A minimum of two missions were run in each strata to increase the number of sampling sites. A mission is defined as the AUV sampling path completed in a single dive and surfacing deployment.

The staircase (Figure 1) sampling design consists of the AUV completing orthogonal transects of equal length that mimics the profile view of a staircase. Of the 27 missions, two utilized this sampling design. The advantage of this design over the other designs chosen is that it samples from the largest area given the same battery usage, while maintaining two distinct spatial dimensions of sampling. This sampling design would be recommended for generally quantifying a large area in a single mission.

The snake (Figure 1) sampling design is similar to the staircase (equidistant orthogonal transects), except that it propagates along only one of the transect axes. We utilized this sampling design for 6 missions. This sampling design is recommended for generally sampling a large area in which the scallops form an elongated bed.

The lawnmower (Figure 5) pattern consists of running parallel transects, typically at a small spacings (4 – 40 m). This survey method was most preferred for this project (56% of the missions) as it precisely samples a small area, while utilizing the high accuracy navigation and maneuverability of the AUV. A lawnmower pattern can achieve up to 100% photographic

coverage of a 30,000 m^2 rectangular survey area in a single mission. This sampling design can also perform accurate structured grids, which are preferred in many biological statistical analyses.

The fourth sampling design category consists of non-regular designs that are uniquely designed to the special needs of a mission. Reasons for using a non-regular design include experimentation, terrain limitation, or surveying a specific topographical feature, such as a submarine canyon.

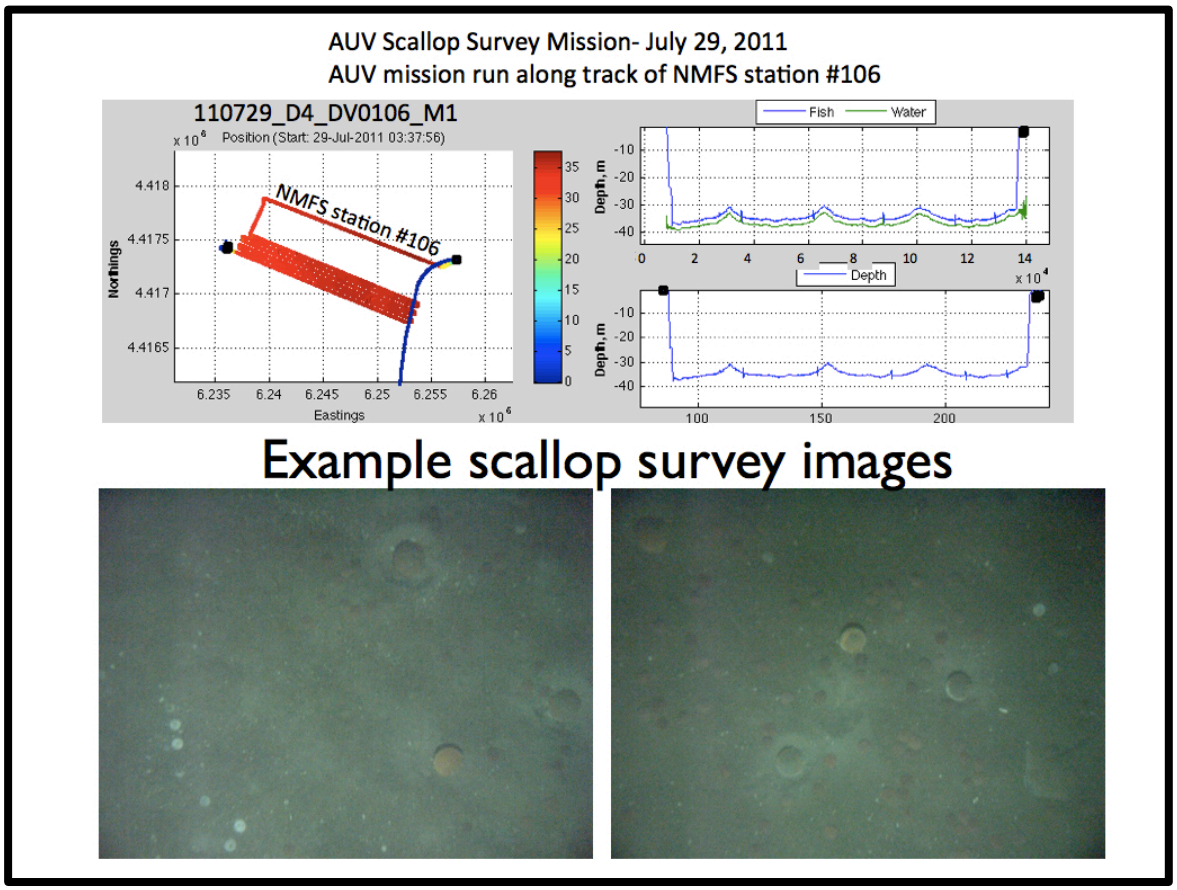


Figure 5. Showing the AUV trackline for a single mission. This mission reoccupied a previous NMFS station (#106). This mission ran along ~14 km of seabed trackline covering approximately 22,400 m^2 of continuous seabed in color camera images and approximately 280,000 m^2 in sonar coverage of the seabed. A typical survey day involves 4 AUV surveys of 3 hours each resulting in ~90,000 m^2 of continuous seabed color camera imagery.

Image Analysis

The data was collected over two separate five-day cruises in July 2011. In total, 27 missions were run using the autonomous underwater vehicle (AUV) to photograph the seafloor. Mission lengths were constrained by the 2.5 to 3.5 hour battery life of the AUV. During each mission, the AUV was instructed to follow a constant height of 2m above the seafloor. In addition to the 255,000 images that were collected, the AUV also gathered data about water temperature, salinity, dissolved oxygen, Geoswath bathymetry, and side-scan sonar of the seafloor.

The camera on the AUV is a Point Grey Scorpion model 20S0. It is mounted within the nose module of the AUV. The camera is focused to take images at a distance of 2m. The camera takes images at a resolution of 800 x 600 and has a horizontal viewing angle of 49.92 degrees. Given the viewing angle and distance to the object being photographed, it was calculated that each image covered 1.86 m x 1.40 m of seafloor (Figure 6). Each image was

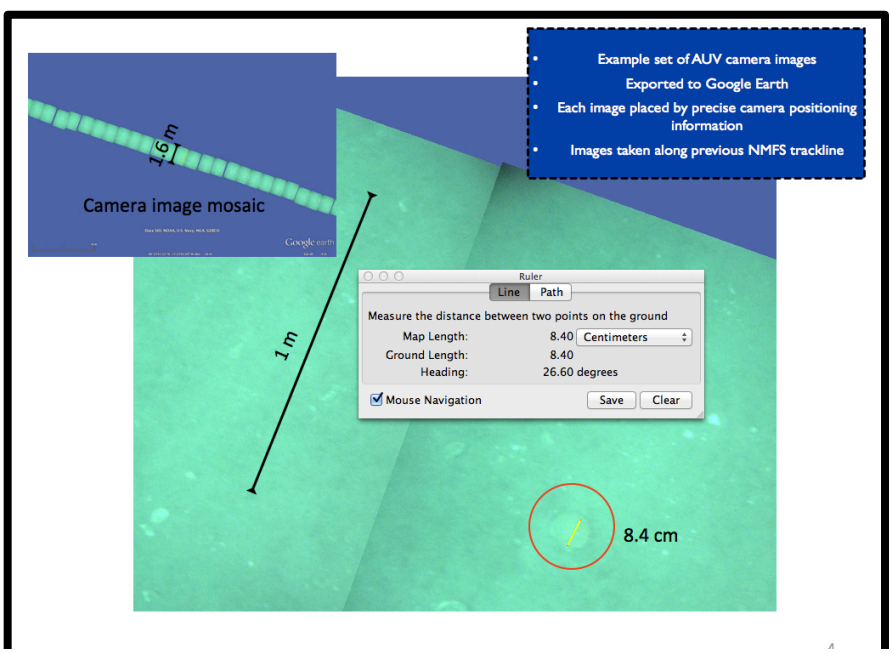


Figure 6. A camera strip mosaic in Google Earth (upper left). Based on the altitude of the AUV and the geometry of the camera each image is ~ 1.6-1.8 m across with a resolution of 2 mm/pixel. Lower right is a close up of two images showing the location of a scallop, which can be measured using the measuring tool.

saved with metadata that included GPS information and the near seafloor environmental conditions analyzed in this study. Each image is collected in JPEG format with metadata (including latitude, longitude, depth, altitude, pitch, heading, roll) embedded in the header file making the images readily comparable and able to be incorporated into existing RSA image databases (i.e. Habcam database).

Each photograph taken along a transect was counted as one data point (Figure 7). Each data point was georeferenced with a latitude and longitude and a scallop abundance. This resulted in each transect having 100% coverage in the direction of travel of the AUV. The scallop abundance of each data point was calculated by manual analysis of the number of scallops in each image. Scallops counted were articulated shells in a life position (left valve up).

Traditionally, scallop populations in the Mid-Atlantic waters are estimated by dredging the seafloor with either a commercial scallop dredge or a research scallop dredge (Rudders & DuPaul, 2010). Within the last decade however, different image capture techniques are being employed to photograph the seafloor so that scallops can be more accurately, efficiently, and less invasively estimated (Stokesbury, Harris, Marino,Michael C.,II & Nogueira, 2004; Rosenkranz, Gallager, Shepard, & Blakeslee, 2008).

Dredging data were collected and utilized in two independent ways for this project. The first instance of dredging has been previously done and completed by Dr. Hart for NMFS during the spring of 2011 (NEFSC internal document). The sampling was done in the Mid-Atlantic region utilizing an 8-foot wide standard survey dredge. Additionally, the dredge has a 1.5-inch liner and a 3.5-inch twine top diamond mesh (DuPaul & Rudders, 2008). The second instance of dredging took place during summer 2011 data collection by this project team. The F/V CHRISTIAN ALEXA ran a single dredge during sampling missions that reran the same tow done by Hart previously in the year. The tows were ran from the start and end latitude and longitudinal coordinates provided by Dr. D. Hart (NMFS). The F/V CHRISTIAN ALEXA dredge is 15-feet wide and has rings that are 4 inches in diameter. The ring sizes of the commercial dredges are larger than that of survey dredges so that smaller, juvenile scallops will be preferentially left on the seafloor. The difference in the sieve size of the dredges, and in their respective widths must be normalized so that the data from the two can be accurately compared (Appendix VI). The way that this will be done requires the use of the seafloor images, so it will be discussed later.

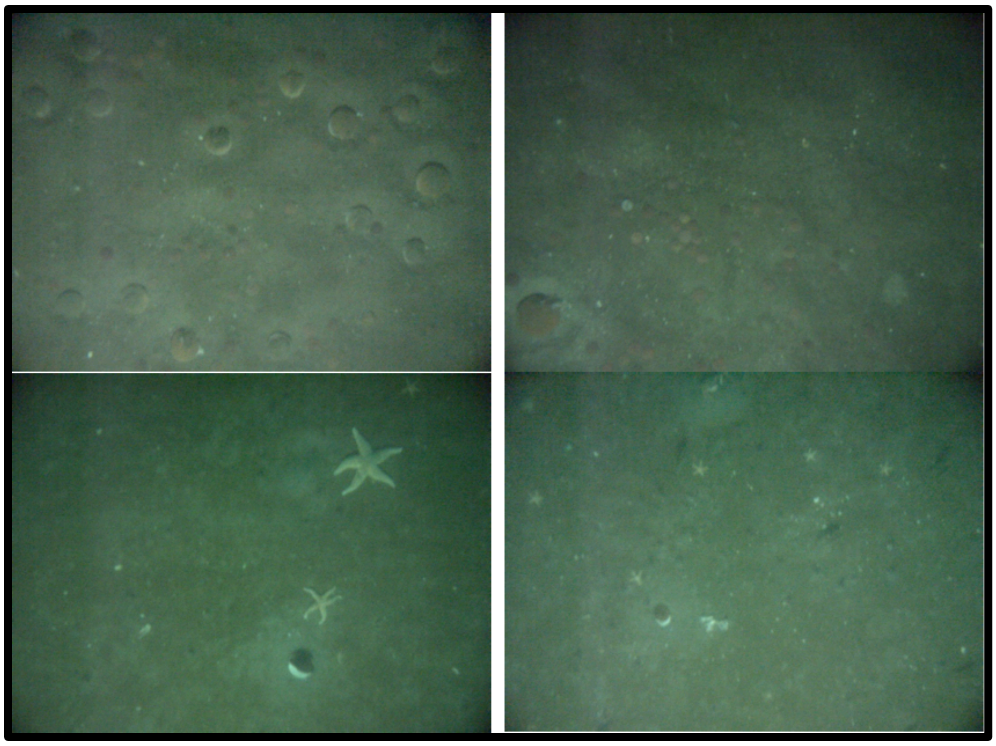


Figure 7. Scallop images taken at night within the New York Bight from the AUV.

Knowing the viewing angle and distance to the object being photographed, it can be calculated that each image covers 1.86 m x 1.40 m of seafloor. This yields a pixel width and height within in each image of 2.3 mm. The general formula used for calculating image dimensions is:

$$Image\ Width(m) = 2 * (Altitude(m) - 1.3 * \tan(-Pitch)) * \tan\left(\frac{49.92°}{2}\right)$$

$$Image\ Height(m) = 0.75 * ImageWidth$$

Altitude refers to height (meters) of the AUV above the seafloor. *Pitch* is the pitch (in degrees) of the AUV. The coefficient of 1.3 is the arm distance (meters) from the camera to the location of the DVL (Doppler velocity log). These equations allow scallops to be precisely sized given the varying altitude of each image. Figure 7 shows a standard sample of nighttime images of the seafloor taken by the AUV camera with the upper left panel showing 15 scallops in a 2.6m^2 area.

In order to estimate the scallop populations within the region, manual counts of the scallop population within the surveyed areas have been done from all of the images. The scallops were counted, sized, and logged as follows:

1. All images for a mission that were taken at a height above the seafloor between 1.5 m and 2.5 m were counted.
2. Each scallop in an image was counted individually, unless a scallop had already been counted from an image that overlapped the same section of seafloor. Analysts were trained to recognize when images overlap, so that scallops were not counted more than once.
3. Each scallop was sized based on the distance from the hinge to the end of the shell bisecting the scallop using a web-based pixel-measuring tool (where each pixel equals ~2mm) (Figure 9).
4. The scallop size was **not** recorded if more than half the entire scallop was not contained within the frame (Figure 8).
5. The final count for a mission was the number of scallops that could be sized.

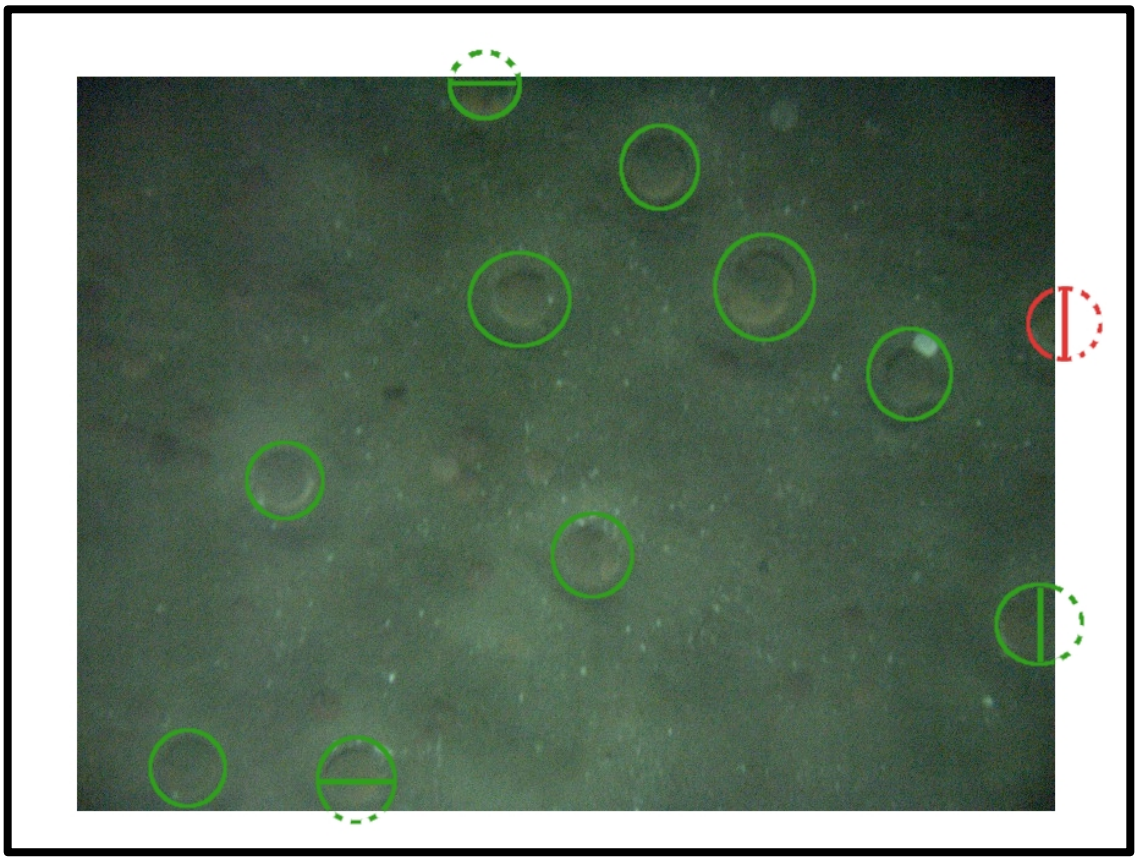


Figure 8. Image analysis approach showing cut-off selection between scallops counted (green circles) and those left out (red circle). Any scallop with less than half of the scallop in the image was left out of the count and sizing analysis.

The data was logged on Excel sheets (see Appendices) that are divided by mission and archived onto our secure data server. A team of trained image analysts comprised of M.S. student Justin Walker and undergraduate and graduate interns completed scallop counts in January 2012. Each analyst received training of 3-5 hours of one-on-one instructions together with example image worksheets on how to identify a scallop from an image, and how to size it. After being trained, each analyst was given a standardized packet of 100 images to analyze. Each analyst correctly identified at least 95% of the scallops in the test packet. Quality assurance was also completed through internal checks by randomly crosschecking data points recorded by the individuals (Figure 10).

In order to aid the process of scallop counting and to further standardize the process for volunteers, a web-based program has been developed by IT consultants for CSHEL (Figure 9).

The software offers a user-friendly environment that is completely mouse-click driven. The next development phase of the software was to published out onto the web (http://cshel.geology.udel.edu:8080/Scallops/Home.jsp) , where team users and public volunteers were be able to remotely login to complete a count. Data such as the number of scallops, the size of the scallops, the seabed type, and image quality were manually inputted by the user and automatically recorded into our database. Shown in Figure 9 is what the current user interface looks like.

Development of Web-based Image Analysis Systems for both Expert teams and Public Outreach

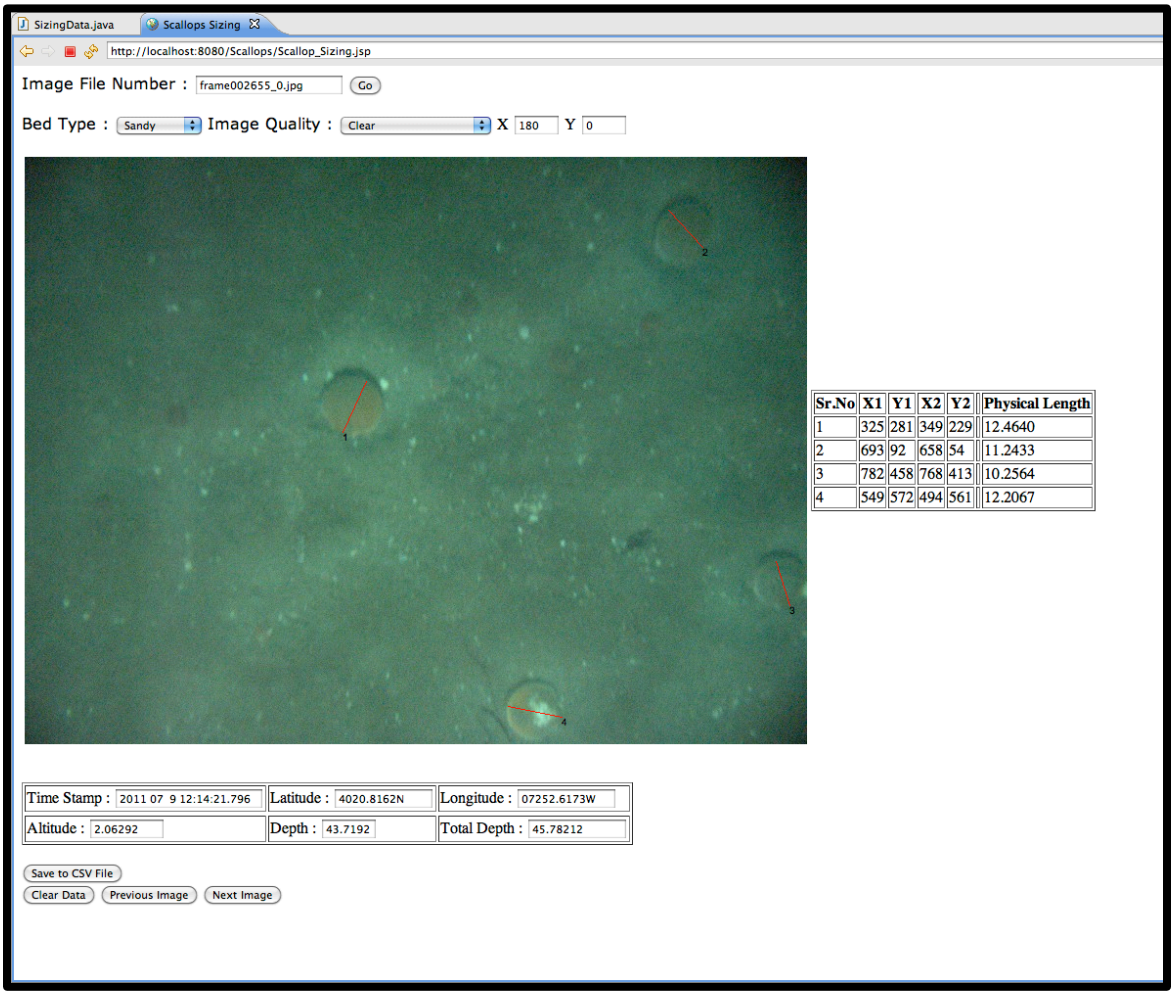


Figure 9 – Graphical User Interface to the UDel web-based scallop counting/sizing program.

The UDel expert team scallop count data for each mission was used to produce scallop densities for each surveyed area. *An important point to note is that only the expert team counted data was used for the analyses in this report*. Calculating the total area of seafloor that was surveyed within the images for a mission allowed the calculation of the mission's total density. The total area was calculated by dividing each mission up by its individual lines. This calculation was done on a line-by-line basis so that a representative average image width (based on altitude) for the line was calculated. The line length was then multiplied by the average image width to the total area surveyed for that line. The line areas were summed to yield a total mission area surveyed. The scallop density for a mission was then calculated for a mission by

taking the total scallop count for the mission and dividing it by the image surveyed area for the mission. This density can also be compared to the densities calculated by the survey and commercial dredges where all 3 sampling methods surveyed the same track line (Table 5). From this, efficiencies can be calculated for the survey and commercial dredge (Table 4).

In addition to a general scallop density for a mission, a harvestable population density was also calculated (Appendix I). The data used for this estimate was the size data that was calculated for each scallop within the software. Scallops that have shell heights that exceed 10.15 cm are harvestable (Kelly, 2007). The scallop densities for each mission were corrected to only include scallops that are greater than 10.15 cm in shell height. Conversely, the immature scallop densities were calculated from the difference of harvestable density and total scallop density.

The expert team scallop densities from each mission were used to estimate the total scallop population within the region (Appendix I, Figures 15 and 16). Lastly, size distributions were calculated for each mission from the measured shell heights of each counted scallop (Figures 15 and 16).

Data Quality Control Efforts

Each and every AUV image is stamped with the precise position, altitude, depth, pitch, heading, and roll of the camera. The camera is fixed mounted and has been calibrated in the

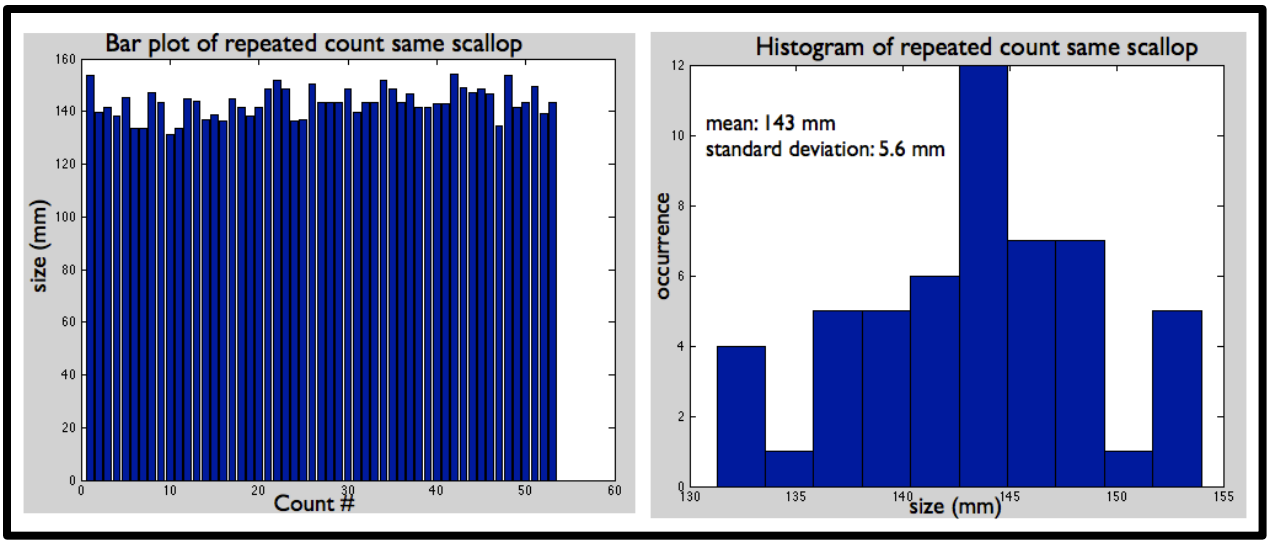
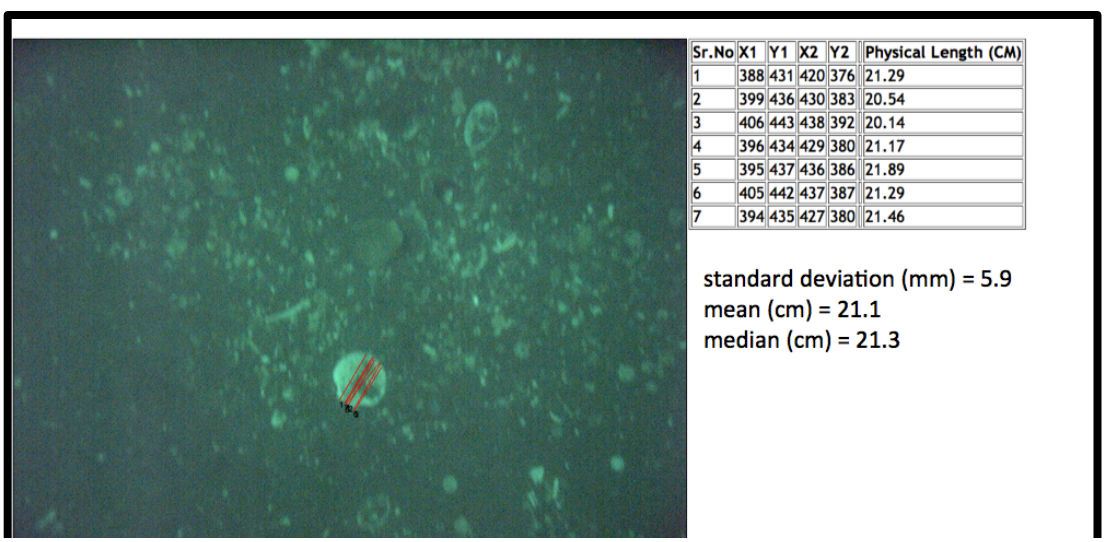


Figure 10. Results of manually sizing the same scallop image (left panel) multiple [N=54 times] by the same image analyst in order to determine the spread and standard deviation (right panel) of operator measurements.

water in order to obtain the field of view measurements (~50 degrees horizontal field of view). A simple geometric calculation allows us to convert the pixel dimensions of the image into real



Sr.No	X1	Y1	X2	Y2	Physical Length (CM)
1	388	431	420	376	21.29
2	399	436	430	383	20.54
3	406	443	438	392	20.14
4	396	434	429	380	21.17
5	395	437	436	386	21.89
6	405	442	437	387	21.29
7	394	435	427	380	21.46

standard deviation (mm) = 5.9
mean (cm) = 21.1
median (cm) = 21.3

Figure 11. Example of repeated sizing estimate of the same scallop using the UDel web-base scallop sizing program. [http://cshel.geology.udel.edu:8080/Scallops/Scallop_Sizing.jsp]

world distances based on the altitude/attitude and field of view (Figure 9). The camera information also allows us to create a strip mosaic of images along the trackline (Figure 6) of the vehicle providing a more continuous coverage of the seabed than is attainable from a fixed drop-camera system.

The AUV derived scallop density estimate is closer to the true density compared to dredge based counts as photographic sampling methods for scallops have been shown to have an

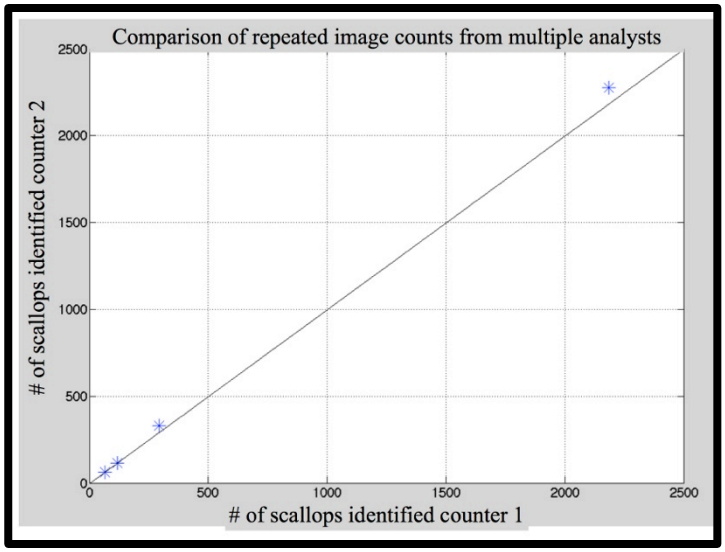


Figure 12. Comparison of image counts repeated by multiple image analysts using the same set of images.

efficiency close to 1. Dredge calibration has previously been done using photographs of the sampled area to calculate the dredge efficiency. Previous studies have found dredges to have efficiencies between 0.33 and 0.46. Our own preliminary dredge efficiency calculations (see Table 4) for the 8' and 15' dredge fall within those ranges. The data can be correlated as the AUV data was taken immediately before the commercial 15' dredge dredged the same track. The NMFS dredge data was from the same track line, but 2 months earlier (May, 2011).

<u>Efficiency comparison between images and dredge surveys</u>

Based on the AUV image analysis it was possible to compare the abundance and size estimates between the camera images and the dredge material.

Table 4. Abundance and efficiency comparison between the 2 dredge surveys (NMFS and commercial dredge) to the seabed image analysis results.

Efficiency Comparison	NMFS Dredge	Commercial Dredge	AUV Images
Count	207	465	340
Dredge/Image Width (m)	2.4	4.6	1.8
Line Length (m)	1740	1960	1960
Scallop Density (scallops/m^2)	0.0488	0.0519	0.1084
Estimated Efficiency (relative to image count)	0.45	0.48	

Table 5. Comparison of mission average scallop size between AUV image-based measurement and commercial scallop dredge.

Mission Name	Image Measurement Size (+/- 2mm)	Dredge Measurement (+/- 5 mm)
20110726_ScallopD1_M1	140	133
110726_ScallopD1_DV44_M3	136	144
110728_D3_DV062_M3	136	124
110728_D3_DV063_M4	136	126
110729_D4_DV0105_M2	147	135
110729_D4_DV0106_M1	132	122
110729_D4_DV0112_M3	135	127
110726_ScallopD1_DV2_M2	125	129

A comparison is shown below in Table 4 for NMFS station 119 sampled 2011 to both the commercial dredge and the AUV images.

Next, in Table 5, we compare the average shell height for each available station from the commercial dredge to the AUV image result from the coeval survey.

Monte Carlo Simulation of Abundance Results

In our study we manually examined and analyzed 100% of the available seabed images. We were able to do this because of the efficient user interface data processing systems (Figure 9) that we built for this study and because of the careful training taken to instruct a select team of image

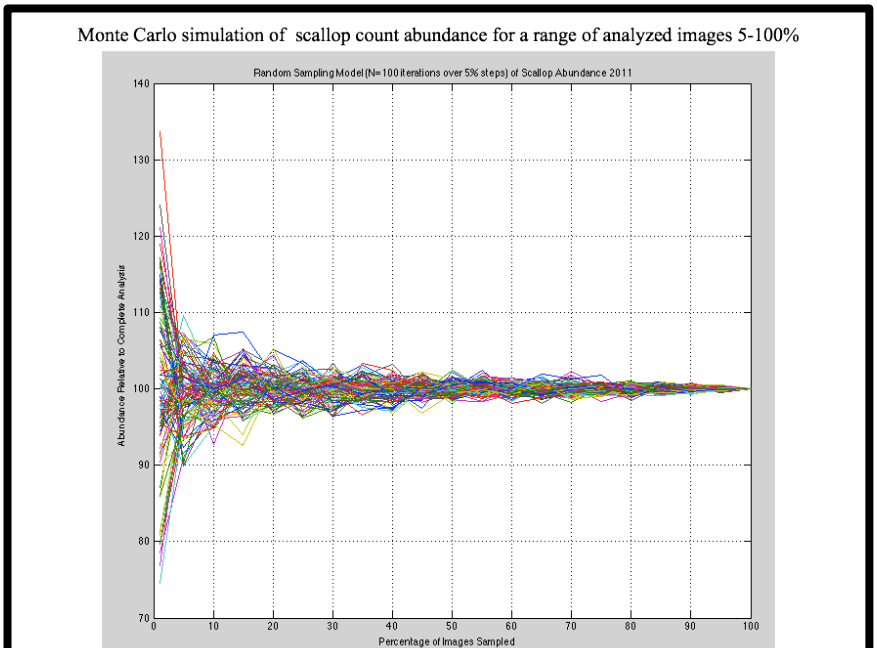


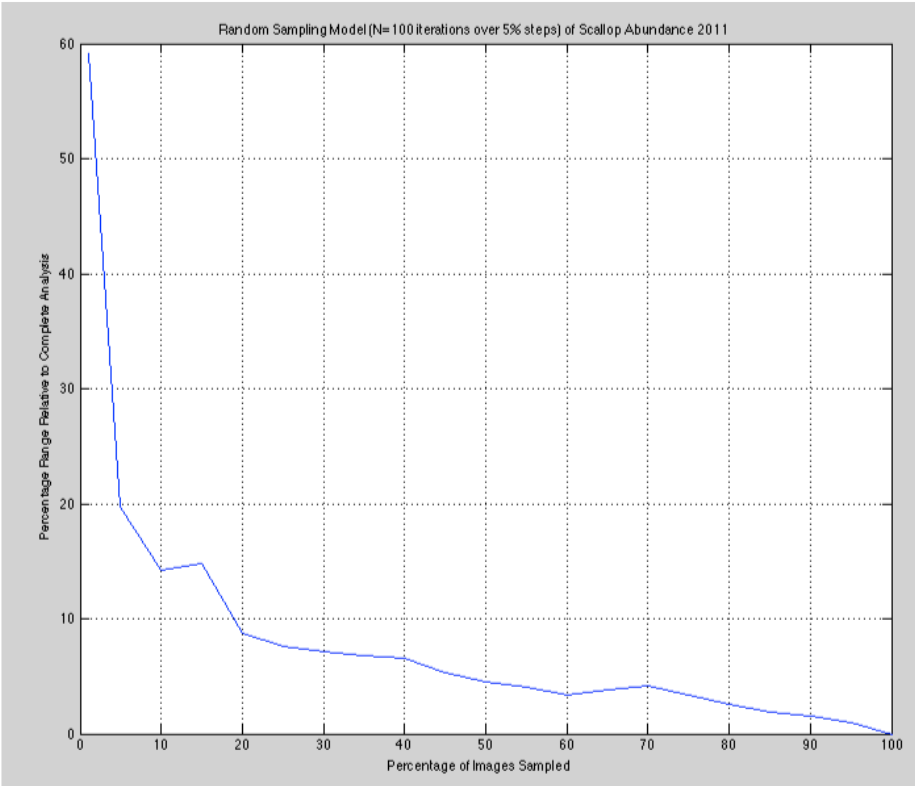
Figure 13. The response of abundance estimate to the portion of the available images that are analyzed.

analysts. Previously, studies typically only looked at small random fractional subsets of the entire image database. We wanted to further examine the effect of looking at various random fractions of the complete image database on the overall abundance estimate. We conducted a Monte Carlo simulation by repeatedly drawing (N=100 times) a random set of images from the entire database spanning the range from 1% up to 100% in 5 percentage increments (i.e. 1, 5, 10, 15, etc.) and calculating the normalized abundance relative to the value obtained from our expert team analysis of all 100% of the images. The results are displayed in Figure 13, and illustrate the wide spread of estimates for analysis of small portions of the total database (portions below 15-

20%) and the convergence that occurs as greater and greater portions of the full record are analyzed. This type of simulation is useful in helping to assess the potential uncertainty of analyzing only a subset of the images.

Furthermore, this simulation allows us to assess the trade offs between the speed of analyzing a portion of the images versus analyzing every available image in terms of accuracy thresholds. By reconfigured the simulation as shown in Figure 14, one can establish the minimum percentage of images that need to be analyzed for a given uncertainty tolerance. For example, a tolerance requirement of achieving results within 9 percent of the complete value can reasonably be expected from an analysis of 20% of the images, whereas achieving results within 5% requires analyzing 50% of the images.

Scallop count uncertainty as a function of % of the total images analyzed



% photos examined	% proximity to complete value
1	59.2
5	19.7
10	14.3
15	14.8
20	8.8
25	7.6
30	7.1
35	6.8
40	6.6
45	5.3
50	4.6
55	4.1
60	3.4
65	3.9
70	4.1
75	3.4
80	2.6
85	1.8
90	1.6
95	1.0
100	0.0

Figure 14. Plot of relative accuracy of abundance estimate for a range of analyzed images.

Outreach

General Public Events and Invited Seminars

We have already presented a summary poster of our survey work at the 2011 Coast Day event in Lewes Delaware and had several hundred members of the general public and scientific community come up to our display and inquire about the study.

Public Forum Presentations

1. Coast Day Poster Presentation- "The Sea Scallop" October 2, 2011 (copy attached in Appendix VIII)
2. New sensors and recent findings from the CSHEL AUV program. BEST of the Chester Observing System Workshop. April 19th, 2012.
3. From scallops to barrel sponges-recent findings and developments in benthic habitat mapping using geoacoustic and photographic techniques. SMSP Invitational Seminar Series. March 6, 2012

In the course of this project we have developed several new website resources including both an internal UDel scallop counting website and a new citizen scientist website.
SubseaObservers.com Website- http://subseaobservers.com/
UD Scallop counting website- http://cshel.geology.udel.edu:8080/Scallops/Home.jsp

Professional Conferences and Fisheries Management Meetings

1. PDT Meeting, January 5, 2012. Trembanis, A.C. and J. Walker. Utilizing Image Analysis of Benthic Photographs to Quantify the Abundance and Size of the Sea Scallop Population within the Mid-Atlantic Bight. Warwick, RI.

2. GeoHab Conference May 2012 (full reference below, copy attached in Appendices)
Trembanis, A.C., J. Walker, D. Miller, B. Phoel, 2012. A High-Density Image Analysis of Sea Scallop Habitat in the Mid-Atlantic Bight. GeoHab 2012 Conference, May 1-4, 2012. Orcas Island, WA.

3. Citizen Scientist Conference 2012 (full reference below, copy attached in Appendices)
Wilkinson, N., Lim, D.S.S., Trembanis, A.C. From the oceans to Mars: Opportunities and results from two online citizen science activities. Conference on Public Participation in Scientific Research, 2012.

Student Involvement

This project has involved a dedicated full-time graduate student research assistant, Justin Walker, who is working on the project for his Masters thesis and who is conducting comparison counts between NMFS survey sites from 2011 and our AUV transects. Furthermore, we involved the participation of 8 different students who contributed directly to the image counting process including 4 undergrads and 4 graduate students.

Project Related Web Products

UDel Scallop counting website

http://cshel.geology.udel.edu:8080/Scallops/Home.jsp

SubseaObservers Interactive Public Participation Science Website

http://subseaobservers.com/

AUV trackline data in Google Earth format showing depth, salinity, and temperature along mission path organized by separate cruise

http://cshel.geology.udel.edu/kml_files/Scallop/CruiseData/

Side-scan sonar Mosaics @ 0.5 m/pixel resolution for each AUV mission

http://cshel.geology.udel.edu/kml_files/Scallop/Sidescan%20Sonar%20KMZ/

Results: Key overall project summary results are presented below. Individual mission specific results are presented in the report Appendices.

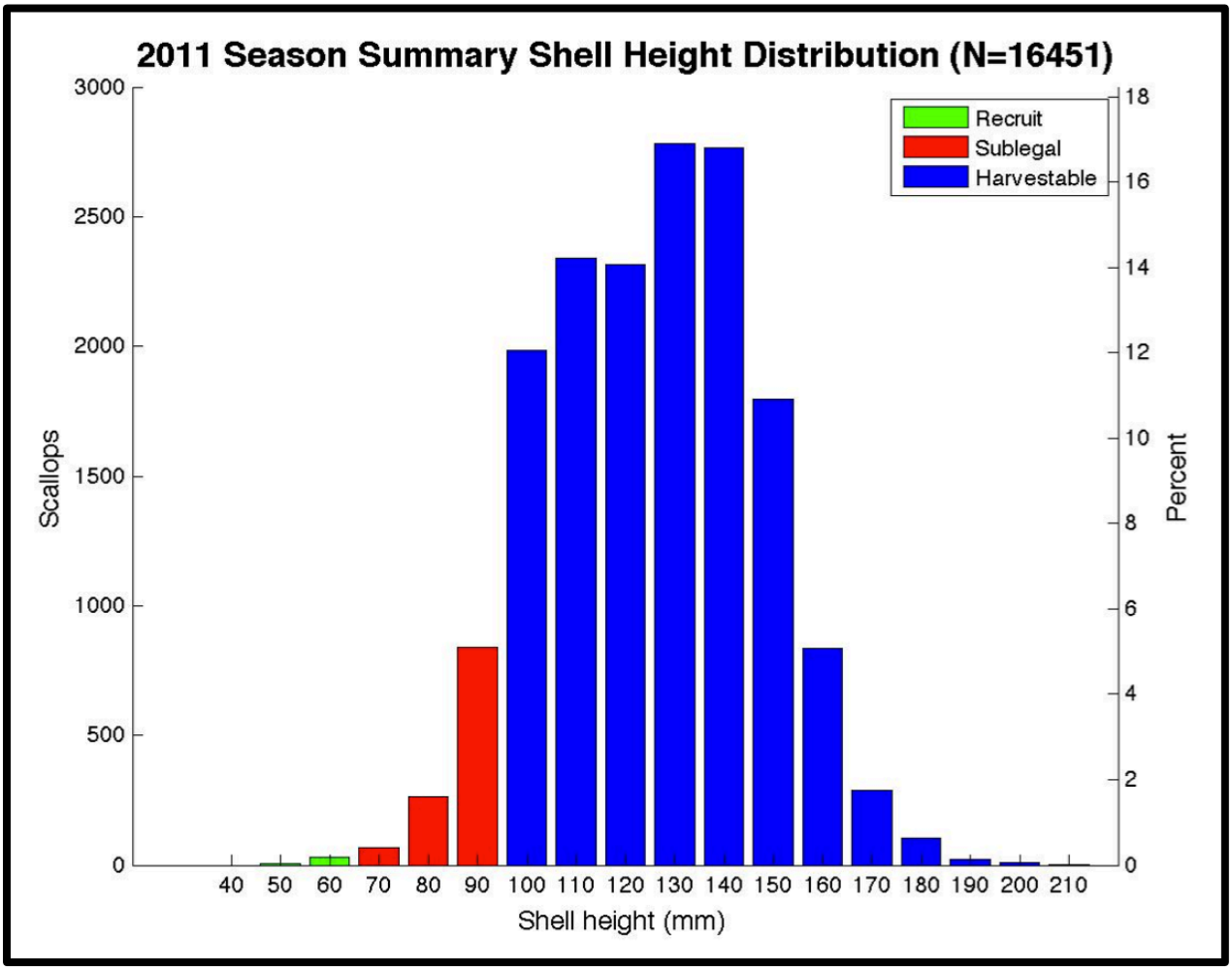


Figure 15. Histogram plot summary of shell height distribution for the entire project survey database.

Figure 15 presents the overall project survey shell height distribution based on the direct manual image measurement of 16,451 scallops. This illustrations the size distribution for the surveyed scallop population and is further organized into distinct size classes (i.e. harvestable, sublegal, and recruit).

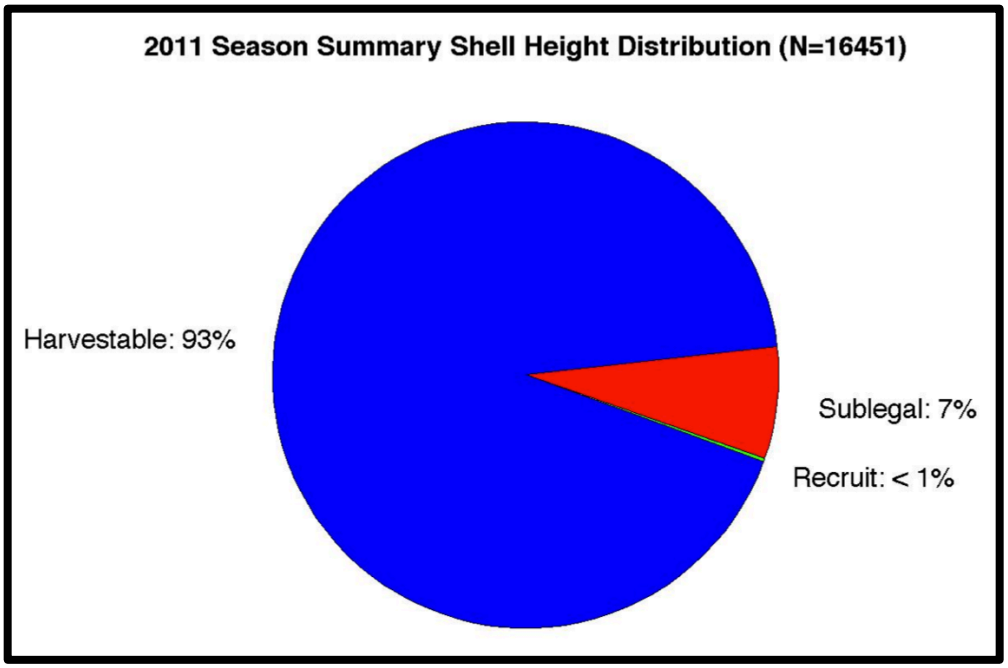


Figure 16. Season summary pie chart distribution of shell height (N=16,451).

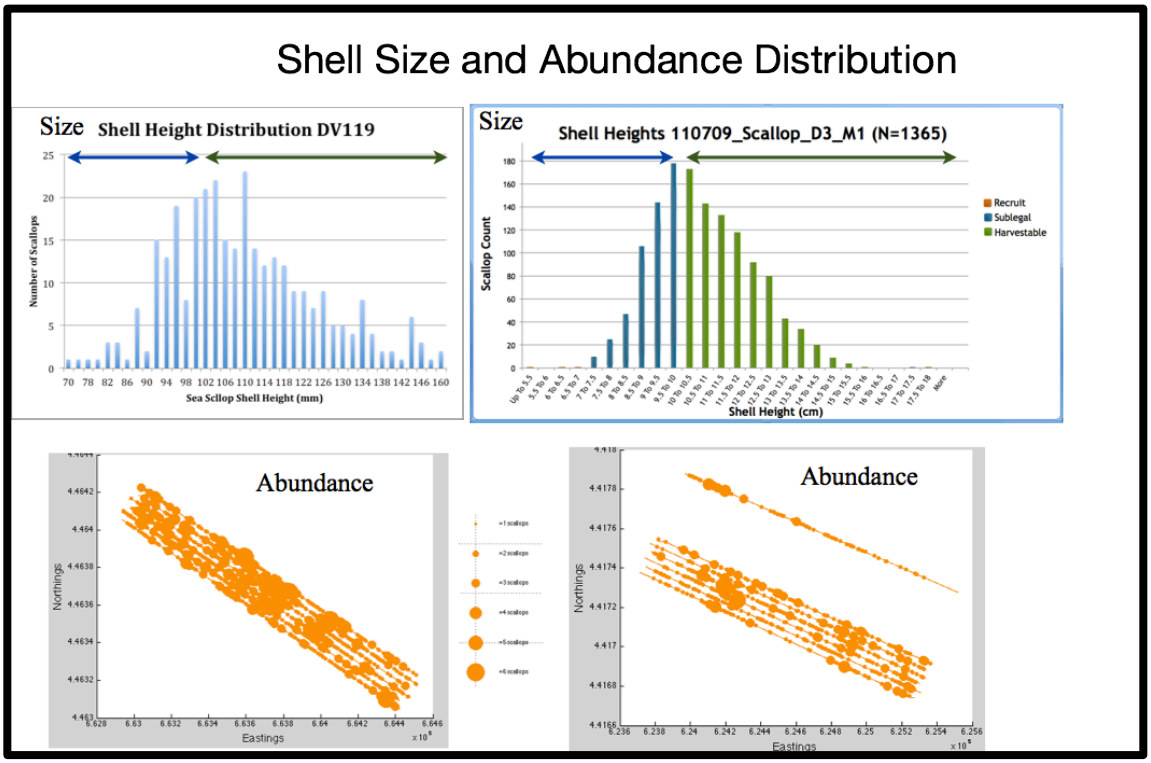


Figure 17. Example mission result plots illustrating shell height distribution (upper panels) and spatial abundance bubble plots (lower panels) for two missions. All other mission data plots have a similar layout and are included in the Appendices.

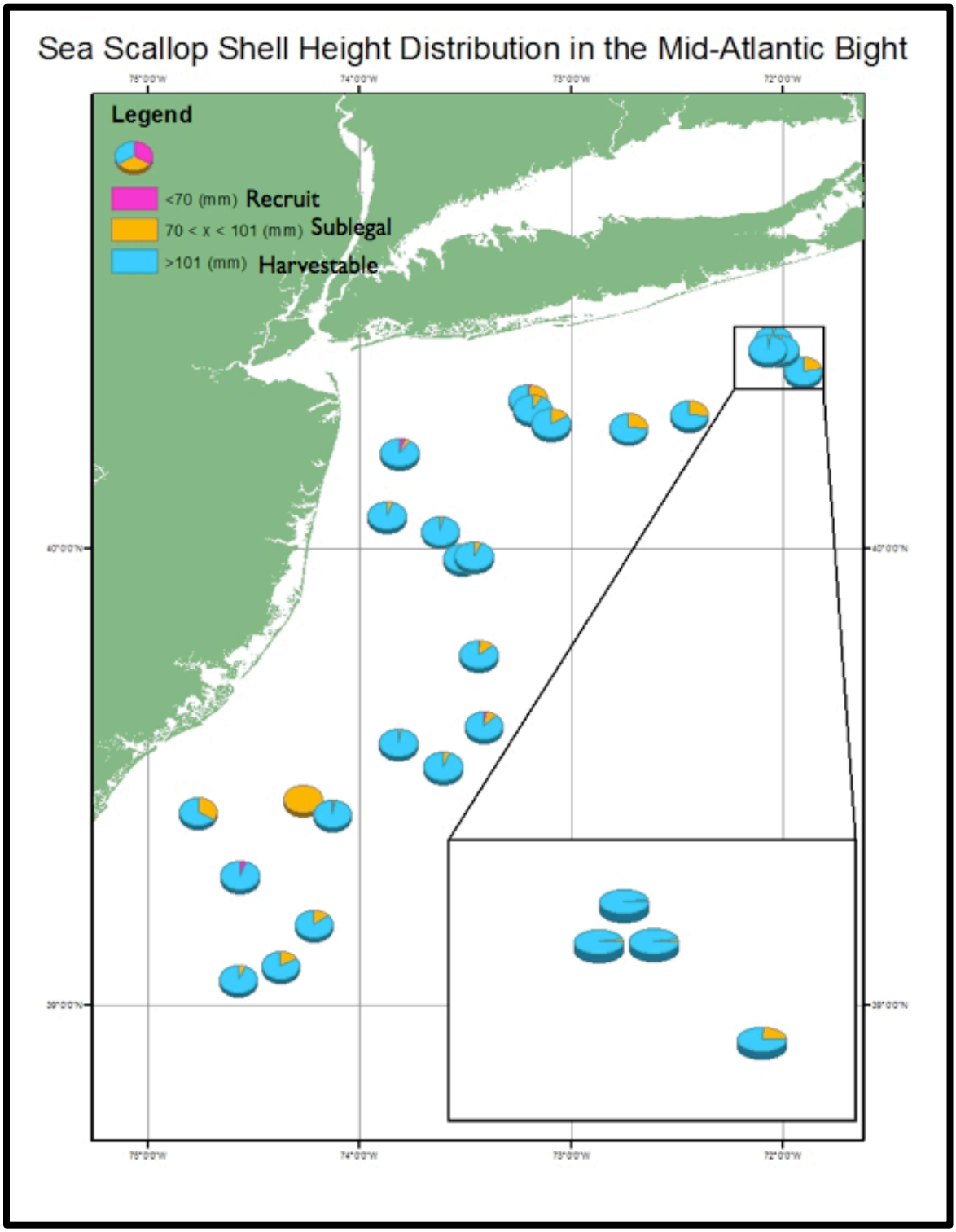


Figure 18. Pie chart distribution of scallop shell height shown for each AUV survey station from the 2011 pilot study project.

Discussion/Conclusions

The importance of this work is to show that the higher efficiency and reliability of utilizing images to survey scallop populations can be used in the inshore fishing grounds of the Mid-Atlantic Bight. To date, an AUV has not been used as a mobile platform to gather the images of the seafloor for a sea scallop survey as was done in this pilot study. The NMFS has shown a desire for the use of AUVs and image survey methods in the assistance and completion of sea scallop surveys (NMFS, 2010). This study shows that both the AUV can non-invasively survey a larger area in a shorter amount of time than many of the current methods and that the images can give the accuracy of sea scallop count and size data obtained by dredging surveys.

The size distribution mapping of the scallops offer an unprecedented look at the small and large-scale distance and patchiness of the scallop beds. This information will be invaluable to the design of future stock assessment efforts and will also have also be applicable to commercial fishing operations. This project confirms that AUV seabed imagery is capable of being used for sea scallop survey objectives. Furthermore, the unique abilities of an AUV to maintain close proximity to the seabed and perform precise repeatable missions also demonstrates the suitability of AUVs for more focused projects and experimental studies such as repeated monitoring of site conditions.

List of entities performing the work and how the work was accomplished

William C. Phoel, Ph.D., of Phoel Associates, Inc., was until his passing, the project manager and a PI for this project. Phoel Associates, Inc. coordinates the project and is responsible for the biological sampling at sea. It also provides local communications and scientific equipment.

Art Trembanis, Ph.D., College of Earth, Ocean, and Environment, University of Delaware, PI responsible for all the AUV work and data processing. Dr. Trembanis presented the work at several meetings (including the GeoHab 2012 conference) and is the thesis advisor for Justin Walker who is conducting his M.S. thesis from this project. Dr. Trembanis also assumed head PI responsibilities after Dr. Phoel's passing and lead the preparation of this final project report.

Arthur Ochse, Co-Owner and Co-Captain, and Kenneth Ochse, Co-Owner and Co-Captain, of the F/V CHRISTIAN & ALEXA, both PIs, provided the scalloper as the support vessel for the

AUV operations and conducted dredge hauls for ground-truthing the AUV photographs. The vessel also participated as a compensation vessel.

Compensation Vessels:

Vessel Name	Hull Number	Federal Permit Number
F/V CHRISTIAN AND ALEXA	937930	330683
F/V WILLIAM AND LAUREN	615155	330394
F/V SUSAN L	610983	410232
F/V KATHY MARIE	941590	410496

Acknowledgements

We would like to thank the vessel owners, captains and crews of the F/V *Christian and Alexa* and all of the participating vessels that contributed to the RSA catch that supported this project. We would like to thank Scott Gallager and Amber York both of the WHOI Habcam program for fruitful and informative discussions of approaches to dealing with massive seabed image datasets. We are thankful to the field survey team including Justin Walker, Carter DuVal, Jonathan Gutsche, Bryan Keller, Mike Carrington, and Corey Wells who all contributed to the safe and effective operation of the AUV. We are also grateful to Val Schmidt, Vinar Amrutia, and Nick Wilkinson for technical support and development of our webpage counting/sizing system and for the new SubSeaObservers citizen science website. We would also like to thank Dr. Dvora Hart and Dr. Doug Miller for many useful discussions and advice with respect to statistical treatments and data analysis suggestions.

References

Adams, C. F., Harris, B. P., Marino, M. C., & Stokesbury, K. D. (2010). Quantifying sea scallop bed diameter on Georges Bank with geostatistics. *Fisheries Research*, *106*(3), 460-467. doi:10.1016/j.fishres.2010.09.02

Brand, A. R. (2006). Scallop ecology: Distribution and behavior. In *Developments in Aquaculture and Fisheries Science: Scallops: Biology, ecology, and aquaculture* (2 ed.) (pp. 651-744). Elsevier B. V.

Bulit, C., Díaz-Ávalos, C., & Montagnes, D. J. S. (2004). Assessing spatial and temporal patchiness of the autotrophic ciliate myrionecta rubra: A case study in a coastal lagoon. *Marine Ecology Progress Series*, *268*, 55-67.

Bulit, C., Díaz-Avalos, C., Signoret, M., & Montagnes, D. J. S. (2003). Spatial structure of planktonic ciliate patches in a tropical coastal lagoon: An application of geostatistical methods. *Aquatic Microbial Ecology*, *30*(2), 185-196.

Currie, D. R., & Parry, G. D. (1999). Impacts and efficiency of scallop dredging on different soft substrates. *Canadian Journal of Fisheries and Aquatic Sciences*, *56*(4), 539-550.

DuPaul, W. D., & Rudders, D. B. (2008). An assessment of sea scallop abundance and distribution in selected closed areas: Georges bank area I and II, nantucket lightship and elephant trunk.

A.L. Forrest, A.C. Trembanis, and W. L. Todd. Ocean floor mapping as a precursor for space exploration. Journal of Ocean Technology. 2012. Vol. 7, No. 2 pp 71-87.

Forrest, L., Wittmann, E., Schmidt, V., Raineault, A., Hamilton, A., Pike, W., Trembanis, C. (2012). Quantitative assessment of invasive species in lacustrine environments through benthic imagery analysis. *Limnology and Oceanography: Methods*, *10*, 65-74. doi:10.4319/lom.2012.10.65

Hart, D. R., & Chute, A. S. (2004). *Essential fish habitat source document. Sea scallop, placopecten magellanicus, life history and habitat characteristics*. DIANE Publishing.
Kelly, K. H. (2007). Results from the 2006 Maine sea scallop survey. *Maine Department of Marine Resources*

NMFS (National Marine Fisheries Service Northeast Fisheries Science Center), 2010. Atlantic sea scallop stock assessment for 2010. 50th northeast regional stock assessment workshop (50th SAW) assessment report. Ref Doc 10-17, US Dept Commerce, Northeast Fisheries Science Center, Woods Hole, MA, p 844

Raineault, N. A., Trembanis, A. C., & Miller, D. C. (2011). Mapping benthic habitats in delaware bay and the coastal atlantic: Acoustic techniques provide greater coverage and high resolution in complex, shallow-water environments. *Estuaries and Coasts.* doi:10.1007/s12237-011-9457-

Rosenkranz, G. E., Gallager, S. M., Shepard, R. W., & Blakeslee, M. (2008). Development of a high-speed, megapixel benthic imaging system for coastal fisheries research in alaska. *Fisheries Research*, *92*(2-3), 340-344. doi:10.1016/j.fishres.2008.03.014

Rudders, D. B., & DuPaul, W. D. (2010). An assessment of sea scallop abundance and distribution in selected closed areas: Nantucket lightship closed area.

Stokesbury, K. D. E. (2002). Estimation of sea scallop abundance in closed areas of georges bank, USA. *Transactions of the American Fisheries Society*, *131*(6), 1081-1092.

Stokesbury, K. D. E., Harris, B. P., Marino II, M. C., & Nogueira, J. I. (2004). Estimation of sea scallop abundance using a video survey in off-shore US waters. *Journal of Shellfish Research*, *23*(1), 33-40.

List of Appendices

I. Project Summary Data Table

II. Size Distribution Histograms

III. Size Distribution Pie Charts

IV. Spatial Abundance Bubble Plots

V. Image measured Shell Height compared to Dredge sample measured Shell Height

VI. Dredge Efficiency Estimate Table for both NMFS and Commercial Dredge compared to image analysis results

VII. Overview and Interface Details of the newly developed SubSeaObservers Citizen Science Participation Website

VIII. Conference Proceedings, Press Articles, and Poster Presentations of Project Results.

IX. Side-scan sonar target reports for each AUV mission site

Appendix I. Project Summary Data Table

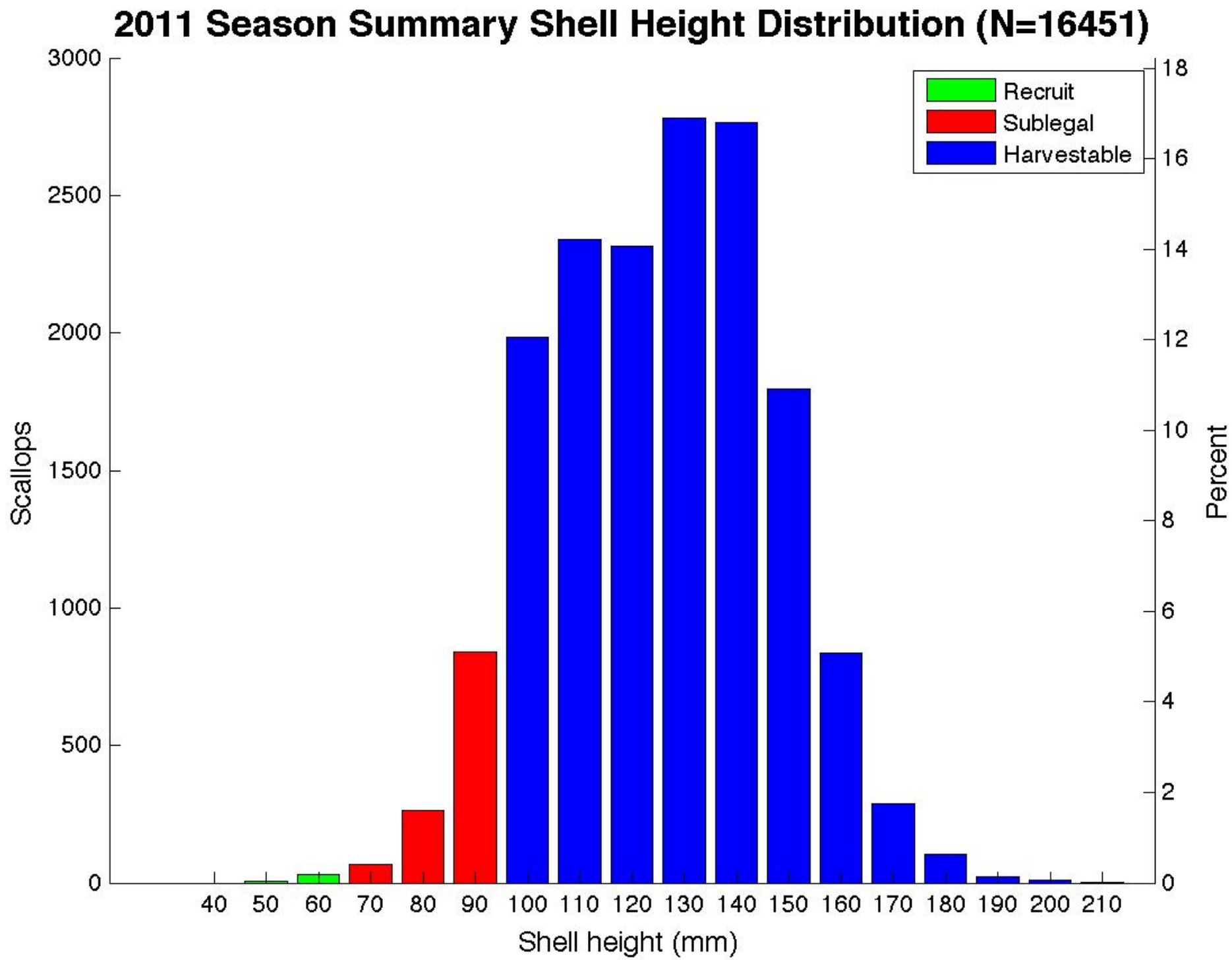
Season Summary		
Season Total Missions:	27	
Season Total Mission Lines:	189	
Season Total Mission Images:	249564	
Season Total Line Length (m):	312814	
Season Total Sea Scallop Abundance:	164511	uncertainty 5%
Season Total Area Surveyed (m^2):	607680	
Season Total Density (Scallops/m^2):	0.027	uncertainty 0.001
Season Total Avg Shell Height (mm):	125.2	stdev = 6mm
Season Total Scallop Biomass (g):	708552.6	

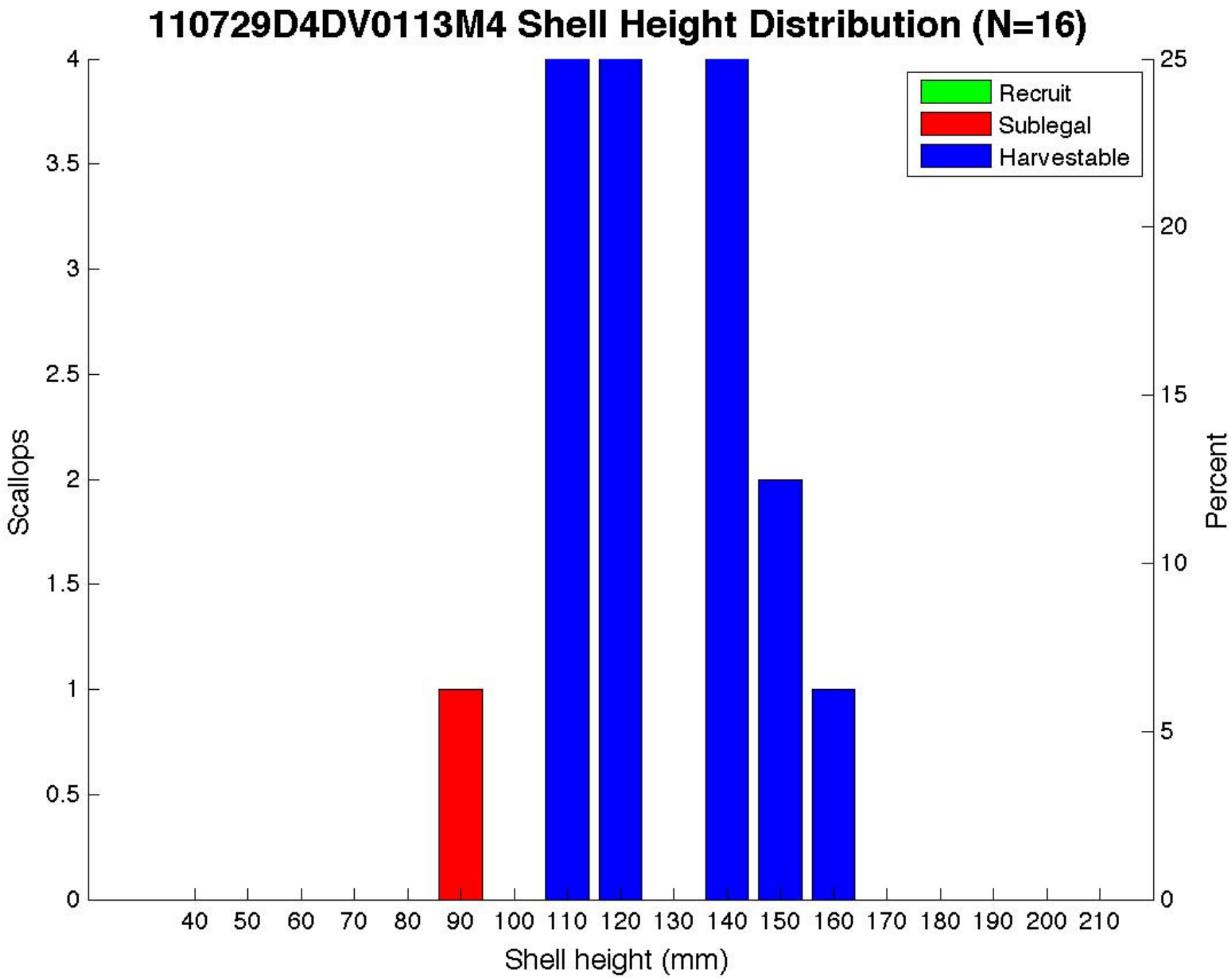
Mission	Line #	Line Length (m)	Image Num Start	Image Num End	Mean Altitude (m)	Mean Pitch (deg)	Mean Image Width (m)	Area Surveyed (m^2)	Scallops Counted	Scallop Density (scallop/m^2)	Mean Shell Height (mm)	<70mm (%)	70 ≤ h < 101.6mm (%)	≥ 101.6mm (%)	Mission Total Scallop Biomass (g)	Latitude Start	Longitude Start	Latitude End	Longitude End
110708_Scallop_DvoraRun	1	3015	0	2387	2.18	-2.74	1.99	5985	847	0.142						40.5503	-72.5872	40.5503	-72.6228
	2	1771	2388	3771	2.20	-2.79	2.00	3540	217	0.061						40.4709	-72.4986	40.4836	-72.5113
	3	1943	3772	5271	2.19	-2.85	1.99	3871	650	0.168						40.4828	-72.5123	40.4707	-72.5288
	4	1744	5272	6655	2.18	-2.84	1.98	3457	784	0.227						40.4707	-72.5305	40.4834	-72.5426
	5	1864	6656	8065	2.18	-2.83	1.99	3704	1208	0.326						40.4832	-72.5438	40.4713	-72.5593
Mission Total:		10337						20556	3706	0.180	116.8	0.3	23.4	76.3	124244				
110708_ScallopD2	1	2777	1967	4227	**2.10**	-2.75	1.91	5305	424	0.080						40.5529	-72.5899	40.5779	-72.5901
	2	2731	4228	6336	2.10	-2.27	1.92	5241	373	0.071						40.5777	-72.5960	40.5532	-72.5967
	3	2732	6337	8623	2.10	-2.32	1.91	5226	458	0.088						40.5535	-72.6025	40.5781	-72.6020
	4	2730	8624	10757	2.08	-2.30	1.90	5180	394	0.076						40.5779	-72.6078	40.5533	-72.6085
	5	2732	10758	13027	2.10	-2.33	1.92	5234	266	0.051						40.5537	-72.6143	40.5782	-72.6138
	6	2200	13028	14742	2.11	-2.29	1.92	4230	257	0.061						40.5781	-72.6196	40.5583	-72.6202
Mission Total:		15904						30416	2172	0.071	136.4	0.0	1.9	98.1	114306				
110708_ScallopD2_M4	1	3015	0	2387	5.03	-2.72	4.64	13990	894	0.064						40.5503	-72.5872	40.5503	-72.6228
Mission Total:		3015						13990	894	0.064	138.6	0.0	2.5	97.5	48429				
110709_Scallop_D3_M1_Corey	1	1540	0	1294	2.20	-2.97	2.00	3083	174	0.056						40.3449	-72.8817	40.3588	-72.8817
	2	1531	1295	2464	2.20	-2.94	2.00	3056	96	0.031						40.3585	-72.8794	40.3447	-72.8793
	3	1533	2465	3743	2.20	-2.88	2.00	3073	188	0.061						40.3450	-72.8770	40.3588	-72.8770
	4	1530	3744	4934	2.20	-2.95	2.00	3063	151	0.049						40.3585	-72.8747	40.3447	-72.8746
	5	1533	4935	6222	2.20	-2.98	2.00	3066	211	0.069						40.3450	-72.8723	40.3588	-72.8722
	6	1531	6223	7438	2.20	-2.99	2.00	3061	201	0.066						40.3585	-72.8700	40.3447	-72.8699
	7	1533	7439	8750	2.21	-3.06	2.00	3072	179	0.058						40.3450	-72.8676	40.3588	-72.8675
	8	1530	8751	9967	2.20	-3.00	2.00	3066	165	0.054						40.3585	-72.8653	40.3447	-72.8652
	9	20	9968	9992	2.41	-2.94	2.19	44	0	0.000						40.3450	-72.8629	40.3451	-72.8628
Mission Total:		12280						24584	1365	0.056	114.1	0.2	25.7	74.1	42048				
110708_SM2	1	3189	345	3020	2.08	-1.99	1.90	6064	707	0.117						40.5502	-72.6250	40.5504	-72.5873
	2	10	3021	3031	2.85	13.24	2.87	30	0	0.000						40.5503	-72.5872	40.5503	-72.5871
Mission Total:		3199						6094	707	0.116	137.6	0.0	3.0	97.0	37722				
110709_ScallopDay3_DV119	1	1797	0	1481	2.30	-3.28	2.09	3757	234	0.062						40.3111	-73.0825	40.3018	-73.0653
	2	1796	1482	2799	2.18	-2.68	1.99	3573	304	0.085						40.3021	-73.0653	40.3116	-73.0825
	3	1795	2800	4294	2.20	-2.93	2.00	3589	372	0.104						40.3117	-73.0820	40.3023	-73.0647
	4	1793	4295	5573	2.18	-2.56	1.99	3566	232	0.065						40.3027	-73.0647	40.3121	-73.0819
	5	1796	5574	7059	2.20	-2.87	2.00	3587	383	0.107						40.3123	-73.0814	40.3029	-73.0642
	6	1795	7060	8338	2.18	-2.61	1.98	3561	325	0.091						40.3033	-73.0642	40.3127	-73.0814
Mission Total:		10773						21633	1850	0.086	114.1	0.2	25.7	74.1	61863				
110710_DV117	1	1774	0	1458	2.05	-1.95	1.88	3333	74	0.022						40.3961	-73.3818	40.4009	-73.4017
	2	1777	1459	2849	2.04	-1.89	1.87	3315	71	0.021						40.4008	-73.4015	40.3959	-73.3815
	3	1776	2850	4342	2.06	-1.76	1.89	3348	59	0.018						40.3959	-73.3818	40.4009	-73.4017
	4	1778	4343	5688	2.04	-1.83	1.87	3320	39	0.012						40.4007	-73.4015	40.3959	-73.3815
	5	1776	5689	7206	2.06	-1.78	1.89	3351	55	0.016						40.3959	-73.3818	40.4009	-73.4017
	6	1778	7207	8514	2.04	-1.83	1.87	3327	46	0.014						40.4007	-73.4015	40.3959	-73.3815
	7	1775	8515	10047	2.02	-1.87	1.85	3278	38	0.012						40.3959	-73.3818	40.4008	-73.4017
	8	1777	10048	11329	2.05	-1.82	1.88	3334	40	0.012						40.4006	-73.4015	40.3958	-73.3816
Mission Total:		14211						26606	422	0.016	112.8	2.6	28.2	69.2	15216				
110710_DV118	1	1763	0	1349	2.16	-2.24	1.97	3480	18	0.005						40.3551	-73.3483	40.3653	-73.3642
	2	1740	1350	2885	2.05	-1.90	1.88	3265	34	0.010						40.3639	-73.3660	40.3538	-73.3504
	3	1748	2886	4256	2.06	-1.95	1.88	3289	32	0.010						40.3537	-73.3508	40.3637	-73.3667
	4	1750	4257	5842	2.01	-2.06	1.84	3222	42	0.013						40.3633	-73.3668	40.3532	-73.3510
	5	1770	5843	7249	2.04	-2.02	1.87	3312	38	0.011						40.3531	-73.3511	40.3632	-73.3673
	6	1751	7250	8758	2.03	-1.87	1.85	3248	33	0.010						40.3628	-73.3674	40.3527	-73.3516
	7	1748	8759	10163	2.06	-1.97	1.88	3290	30	0.009						40.3526	-73.3521	40.3626	-73.3679
Mission Total:		12271						23105	227	0.010	126.9	0.0	9.3	90.7	10816				
110710_M1_ArtiesRun	1	2936	0	2283	2.18	-2.72	1.99	5836	448	0.077						40.3213	-73.2749	40.3199	-73.3094
	2	1532	2284	3506	2.18	-2.65	1.98	3040	243	0.080						40.3177	-73.3088	40.3182	-73.2908
	3	1537	3507	4681	2.17	-2.63	1.98	3043	179	0.059						40.3179	-73.2910	40.3172	-73.3091
	4	1537	4682	5967	2.18	-2.73	1.99	3053	164	0.054						40.3169	-73.3088	40.3175	-73.2907
	5	1536	5968	7172	2.18	-2.80	1.98	3047	123	0.040						40.3172	-73.2910	40.3165	-73.3091
	6	1540	7173	8571	2.20	-2.96	2.00	3080	118	0.038						40.3162	-73.3088	40.3168	-73.2907
	7	1536	8572	9780	2.20	-2.89	2.00	3075	128	0.042						40.3165	-73.2910	40.3158	-73.3090
Mission Total:		12154						24175	1403	0.058	117.4	0.9	17.5	81.6	52799				
110711_DV115	1	1739	0	1448	2.10	-2.14	1.92	3344	39	0.012						40.2249	-73.7828	40.2368	-73.7961
	2	1442	1449	2747	2.12	-2.50	1.94	2791	14	0.005						40.2359	-73.7965	40.2260	-73.7857
	3	1445	2748	3978	2.12	-2.20	1.93	2795	4	0.001						40.2259	-73.7861	40.2359	-73.7971
	4	1443	3979	5330	2.11	-2.52	1.92	2777	5	0.002						40.2355	-73.7972	40.2255	-73.7864
	5	1443	5331	6547	2.11	-2.18	1.93	2786	5	0.002						40.2255	-73.7869	40.2354	-73.7978
	6	1442	6548	7906	2.10	-2.51	1.92	2764	11	0.004						40.2350	-73.7980	40.2251	-73.7871
	7	1444	7907	9141	2.11	-2.28	1.93	2787	4	0.001						40.2250	-73.7876	40.2349	-73.7986
Mission Total:		10398						20044	82	0.004	120.0	6.1	4.9	89.0	3313				
20110726_ScallopD1_M1	1	1934	0	1529	2.20	-2.75	2.00	3874	16	0.004						38.5600	-74.3177	38.5635	-74.2959
	2	1793	1530	3027	2.20	-2.66	2.00	3588	16	0.004						38.5625	-74.2959	38.5591	-74.3161
	3	1797	3028	4480	2.20	-2.67	2.01	3606	19	0.005						38.5589	-74.3157	38.5621	-74.2955
	4	1799	4481	6012	2.20	-2.75	2.00	3598	24	0.007						38.5618	-74.2957	38.5584	-74.3159
	5	1796	6013	7516	2.20	-2.74	2.01	3605	17	0.005						38.5582	-74.3155	38.5614	-74.2953
	6	1797	7517	9003	2.20	-2.72	2.00	3592	26	0.007						38.5611	-74.2955	38.5577	-74.3157
	7	1797	9004	10474	2.19	-2.55	2.00	3591	14	0.004						38.5574	-74.3153	38.5607	-74.2951
Mission Total:		12713						25453	132	0.005	140.2	0.0	6.8	93.2	7543				
110726_ScallopD1_DV44_M3	1	1742	0	1283	2.15	-2.10	1.96	3422	11	0.003						38.7372	-74.0551	38.7253	-74.0420
	2	1768	1284	2685	2.14	-2.04	1.96	3470	24	0.007						38.7241	-74.0443	38.7362	-74.0575
	3	1770	2686	3971	2.10	-2.10	1.93	3408	10	0.003						38.7358	-74.0576	38.7237	-74.0445
	4	1772	3972	5394	2.14	-2.00	1.96	3474	15	0.004						38.7236	-74.0450	38.7357	-74.0582
	5	1772	5395	6666	2.13	-2.08	1.95	3458	16	0.005						38.7354	-74.0583	38.7232	-74.0452
	6	1772	6667	8089	2.13	-1.97	1.95	3458	12	0.003						38.7232	-74.0457	38.7353	-74.0589
	7	1772	8090	9354	2.15	-2.08	1.97	3483	8	0.002						38.7349	-74.0591	38.7227	-74.0459
	8	1773	9355	10774	2.14	-1.98	1.96	3472	9	0.003						38.7227	-74.0464	38.7348	-74.0596
	9	1772	10775	12035	2.13	-2.04	1.95	3457	8	0.002						38.7344	-74.0598	38.7223	-74.0466
Mission Total:		15913						31101	113	0.004	136.2	0.9	15.9	83.2	6163				
110727_D2_R2_M2	1	1040	0	774	2.06	-1.87	1.89	1967	2	0.001						39.0907	-74.4470	39.1000	-74.4470
	2	986	775	1505	2.09	-1.95	1.92	1891	1	0.001						39.1002	-74.4469	39.1000	-74.4355
	3	1075	1506	2334	2.06	-1.94	1.89	2027	0	0.000						39.1000	-74.4353	39.0904	-74.4352
	4	1024	2335	3150	2.04	-1.85	1.87	1914	0	0.000						39.0903	-74.4352	39.0902	-74.4233
	5	1107	3151	4036	2.13	-2.01	1.95	2161	0	0.000						39.0902	-74.4232	39.1002	-74.4231
	6	1101	4037	4881	2.05	-2.05	1.88	2066	0	0.000						39.1003	-74.4229	39.1001	-74.4101
	7	1070	4882	5713	2.05	-1.97	1.87	2006	0	0.000						39.1000	-74.4098	39.0904	-74.4098
	8	1093	5714	6552	2.08	-2.21	1.90	2075	0	0.000						39.0903	-74.4095	39.0903	-74.3968
	9	1081	6553	7422	2.10	-1.98	1.92	2076	0	0.000						39.0904	-74.3966	39.1001	-74.3969
	10	1136	7423	8306	2.07	-2.04	1.90	2157	0	0.000						39.1003	-74.3969	39.1002	-74.3837
	11	1076	8307	9170	2.07	-2.09	1.89	2035	0	0.000						39.1004	-74.3835	39.0907	-74.3838
Mission Total:		11791						22375	3	0.000	104.5	0.0	33.3	66.7	101				
110727_D2_R3_M3	1	2911	0	2279	2.17	-2.65	1.97	5749	0	0.000						39.1432	-74.0397	39.1431	-74.0735
	2	1538	2280	3477	2.17	-2.73	1.97	3036	0	0.000						39.1425	-74.0734	39.1287	-74.0735
	3	1493	3478	4659	2.18	-2.65	1.98	2960	1	0.000						39.1282	-74.0735	39.1284	-74.0908
	4	1540	4660	5885	2.17	-2.63	1.98	3047	0	0.000						39.1290	-74.0923	39.1427	-74.0908
	5	1495	5886	7050	2.18	-2.57	1.99	2974	0	0.000						39.1434	-74.0909	39.1434	-74.1082
	6	1512	7051	8137	2.17	-2.85	1.98	2987	0	0.000						39.1429	-74.1082	39.1293	-74.1082
	7	1499	8138	9236	2.16	-2.32	1.97	2957	0	0.000						39.1288	-74.1082	39.1288	-74.1256
	8	1510	9237	10391	2.17	-2.43	1.98	2993	0	0.000						39.1293	-74.1255	39.1428	-74.1254
Mission Total:		13499						26703	1	0.000	97.2	0.0	100.0	0.0	19				
110727_D2_R4_M4	1	2911	0	2279	2.17	-2.65	1.97	5749	0	0.000						39.1432	-74.0397	39.1431	-74.0735
	2	2999	2280	2305	2.17	-2.64	1.97	5919	0	0.000						39.2956	-74.1666	39.2956	-74.1318
	3	1031	2306	3156	2.07	-1.80	1.90	1955	0	0.000						39.2956	-74.1315	39.3048	-74.1314
	4	1029	3157	3943	2.05	-1.71	1.88	1934	0	0.000						39.3046	-74.1199	39.2953	-74.1198
	5	1032	3944	4848	2.04	-1.63	1.87	1930	0	0.000						39.2956	-74.1083	39.3049	-74.1082
	6	1030	4849	5637	2.06	-1.81	1.88	1940	0	0.000						39.3046	-74.0967	39.2953	-74.0966
	7	2176	5638	7345	2.02	-1.83	1.85	4036	0	0.000						39.2951	-74.0964	39.2956	-74.0712
Mission Total:		12207						23463	0	0.000					0				

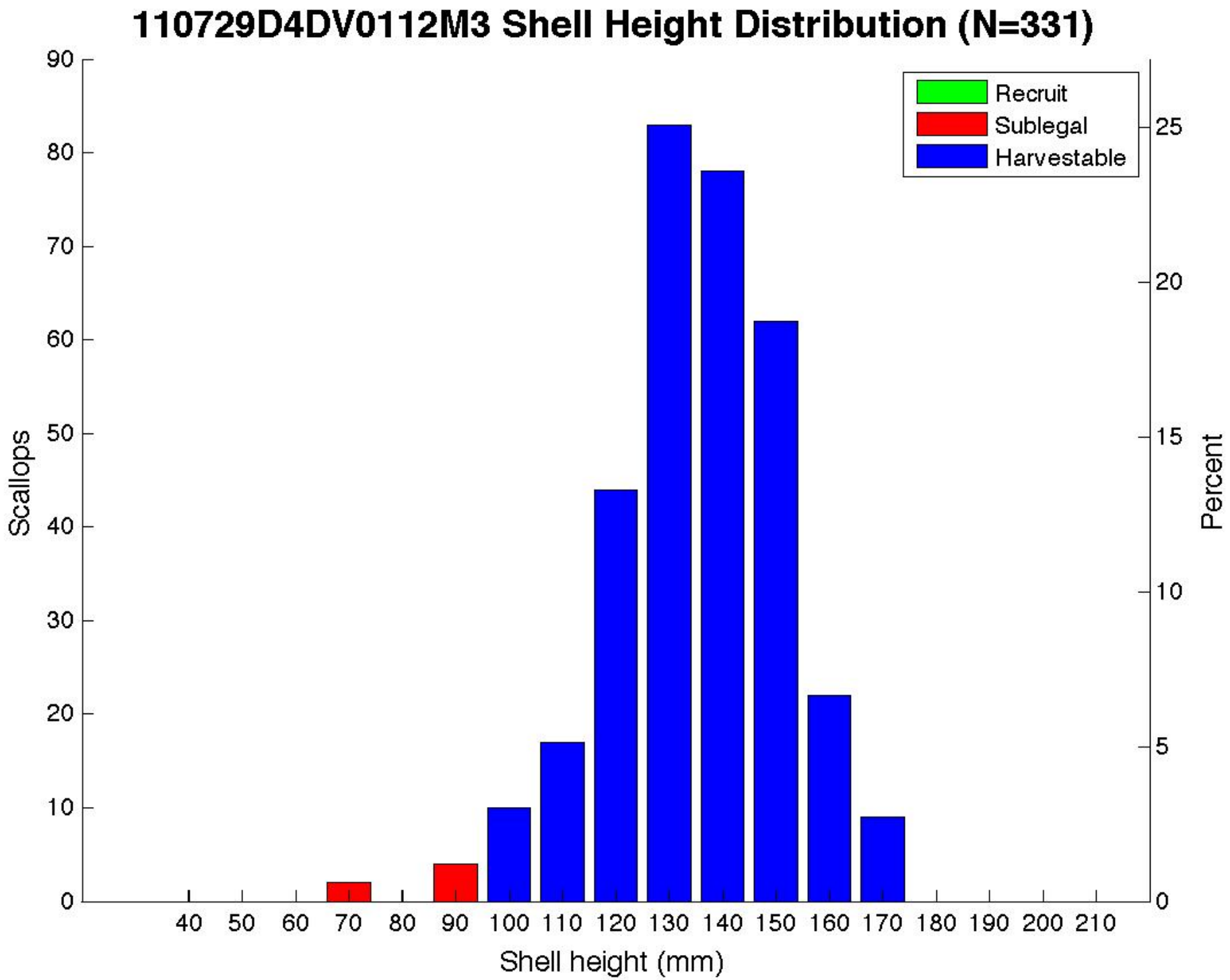
110727_D2_R5_M5	1	3017	0	2199	2.00	-1.56	1.84	5537	0	0.000						39.4200	-74.0267	39.4200	-74.0618
	2	1037	2200	2988	1.96	-1.56	1.80	1868	0	0.000						39.4200	-74.0620	39.4294	-74.0621
	3	1005	2989	3772	2.00	-1.51	1.84	1846	0	0.000						39.4297	-74.0620	39.4295	-74.0737
	4	1037	3773	4524	1.95	-1.66	1.79	1854	0	0.000						39.4292	-74.0738	39.4198	-74.0737
	5	999	4525	5321	1.99	-1.57	1.83	1828	0	0.000						39.4196	-74.0737	39.4197	-74.0853
	6	1038	5322	6123	1.97	-1.64	1.81	1878	0	0.000						39.4200	-74.0853	39.4294	-74.0853
	7	160	6124	6285	3.36	-6.26	3.03	484	0	0.000						39.4296	-74.0854	39.4296	-74.0873
Mission Total:		8292						15295	0	0.000					0				
110727_ScallopD2_R1_M1	1	1539	0	1247	2.16	-2.27	1.97	3037	0	0.000						38.9049	-74.3271	38.9047	-74.3094
	2	1502	1248	2435	2.15	-2.16	1.97	2961	0	0.000						38.9038	-74.3094	38.8903	-74.3096
	3	1533	2436	3730	2.15	-2.30	1.97	3015	6	0.002						38.8894	-74.3095	38.8894	-74.2918
	4	1533	3731	4981	2.14	-2.26	1.96	3003	1	0.000						38.8887	-74.2915	38.8749	-74.2917
	5	1499	4982	6252	2.15	-2.47	1.96	2935	6	0.002						38.8743	-74.2907	38.8742	-74.2734
	6	1519	6253	7551	2.15	-2.39	1.96	2981	5	0.002						38.8733	-74.2730	38.8596	-74.2731
	7	1500	7552	9252	**2.15**	-6.15	1.90	2851	0	0.000						38.8594	-74.2723	38.8594	-74.2550
	8	1502	9253	11097	**2.15**	-7.16	1.88	2830	0	0.000						38.8586	-74.2547	38.8451	-74.2549
Mission Total:		12127						23612	18	0.001	141.4	5.6	0.0	94.4	1126				
110728_D3_DV062_M3	1	1738	0	1535	2.05	-2.44	1.87	3249	61	0.019						39.2178	-73.6423	39.2332	-73.6457
	2	1729	1536	3038	1.97	-2.90	1.78	3083	56	0.018						39.2328	-73.6485	39.2174	-73.6455
	3	1750	3039	4802	1.47	-3.15	1.31	2300	45	0.020						39.2174	-73.6460	39.2330	-73.6491
	4	1749	4303	6520	1.67	-3.19	1.51	2636	126	0.048						39.2328	-73.6496	39.2173	-73.6464
	5	1740	6521	8351	1.86	-3.47	1.68	2915	71	0.024						39.2174	-73.6469	39.2329	-73.6500
	6	1753	8352	10195	1.97	-3.42	1.78	3112	88	0.028						39.2327	-73.6505	39.2172	-73.6473
	7	1737	10196	12068	2.15	-3.85	1.94	3367	59	0.018						39.2173	-73.6478	39.2327	-73.6509
Mission Total:		12196						20662	506	0.025	135.9	0.6	5.9	93.5	25580				
110728_D3_DV063_M4	1	1728	0	1318	2.03	-2.00	1.85	3203	29	0.009						39.3477	-73.5099	39.3621	-73.5173
	2	1731	1319	2663	2.06	-2.06	1.89	3266	17	0.005						39.3613	-73.5214	39.3467	-73.5145
	3	1739	2664	4020	2.03	-1.99	1.86	3226	23	0.007						39.3468	-73.5150	39.3614	-73.5220
	4	1738	4021	5358	2.05	-2.11	1.88	3259	20	0.006						39.3611	-73.5223	39.3465	-73.5154
	5	1737	5359	6756	2.05	-2.08	1.87	3252	19	0.006						39.3466	-73.5159	39.3612	-73.5229
	6	1736	6757	8087	2.04	-2.14	1.87	3240	15	0.005						39.3609	-73.5232	39.3462	-73.5163
	7	1740	8088	9527	2.03	-2.13	1.86	3231	17	0.005						39.3463	-73.5167	39.3609	-73.5238
Total mission length:		12149						22676	140	0.006	136.0	3.6	10.0	86.4	7405				
110728_D3_R6_M1	1	3009	0	2448	2.05	-2.15	1.87	5639	62	0.011						39.3536	-73.7925	39.3266	-73.7910
	2	1014	2449	3220	2.08	-2.17	1.90	1925	1	0.001						39.3263	-73.7910	39.3245	-73.8026
	3	1004	3221	4078	2.03	-2.12	1.86	1866	7	0.004						39.3260	-73.8028	39.3170	-73.8027
	4	1007	4079	4930	2.03	-2.24	1.86	1870	6	0.003						39.3167	-73.8027	39.3167	-73.7910
	5	1024	4931	5824	2.06	-2.38	1.88	1921	19	0.010						39.3164	-73.7910	39.3072	-73.7911
	6	1002	5825	6620	2.07	-2.25	1.89	1894	40	0.021						39.3069	-73.7911	39.3069	-73.8027
	7	1008	6621	7494	2.08	-2.29	1.90	1917	21	0.011						39.3066	-73.8028	39.2975	-73.8028
	8	1001	7495	8343	2.09	-2.48	1.91	1910	177	0.093						39.2972	-73.8028	39.2972	-73.7912
	9	1005	8344	9220	2.04	-2.40	1.86	1868	89	0.048						39.2968	-73.7911	39.2878	-73.7912
	10	1003	9221	10047	2.08	-2.31	1.90	1905	51	0.027						39.2875	-73.7912	39.2875	-73.8028
	11	1009	10048	10950	2.05	-2.42	1.87	1887	50	0.026						39.2874	-73.8031	39.2783	-73.8029
Mission Total:		13086						24602	523	0.021	145.2	0.0	2.9	97.1	33988				
110728_D3_R7_M2	1	3075	0	2353	2.15	-2.54	1.96	6027	53	0.009						39.1226	-73.9840	39.0950	-73.9840
	2	1291	2354	3415	2.17	-2.73	1.98	2556	12	0.005						39.0952	-73.9853	39.0952	-74.0003
	3	1265	3416	4372	2.15	-2.52	1.96	2479	7	0.003						39.0944	-74.0007	39.0831	-74.0008
	4	1418	4373	5409	2.15	-2.52	1.96	2779	2	0.001						39.0832	-74.0000	39.0832	-73.9836
	5	1240	5410	6332	2.15	-2.65	1.96	2427	2	0.001						39.0824	-73.9839	39.0712	-73.9840
	6	1430	6333	7557	2.15	-2.57	1.96	2801	5	0.002						39.0714	-73.9848	39.0715	-74.0014
	7	2612	7558	9437	2.15	-2.76	1.96	5114	9	0.002						39.0710	-74.0017	39.0475	-74.0018
Mission Total:		12331						24182	90	0.004	142.7	1.1	2.2	96.6	5569				
110728_D3_R8_M5	1	2966	0	2163	2.05	-2.34	1.87	5534	167	0.030						39.6209	-73.5386	39.5942	-73.5382
	2	1346	2164	3242	2.06	-2.16	1.88	2528	95	0.038						39.5932	-73.5381	39.5935	-73.5224
	3	1443	3243	4444	2.05	-2.66	1.86	2689	125	0.046						39.5932	-73.5220	39.5878	-73.5373
	4	1336	4445	5513	2.07	-2.33	1.89	2521	23	0.009						39.5871	-73.5373	39.5846	-73.5221
	5	1399	5514	6756	2.05	-2.58	1.87	2613	11	0.004						39.5840	-73.5218	39.5837	-73.5381
	6	1368	6757	7853	1.89	-2.55	1.72	2357	16	0.007						39.5830	-73.5379	39.5707	-73.5378
	7	1833	7854	9544	2.03	-2.86	1.85	3384	71	0.021						39.5707	-73.5419	39.5872	-73.5423
Total mission length:		11691						21626	508	0.023	131.1	1.2	13.6	85.2	25532				
110729_D4_DV0105_M2	1	1673	405	1676	2.00	-1.98	1.83	3065	49	0.016						39.8959	-73.6105	39.8873	-73.5943
	2	1679	1677	2992	1.98	-1.72	1.81	3047	40	0.013						39.8902	-73.5915	39.8988	-73.6077
	3	1687	2993	4257	2.01	-2.02	1.84	3096	56	0.018						39.8989	-73.6072	39.8904	-73.5909
	4	1689	4258	5606	2.01	-1.81	1.84	3111	25	0.008						39.8908	-73.5909	39.8994	-73.6072
	5	1685	5607	6849	2.00	-2.05	1.83	3080	12	0.004						39.8995	-73.6067	39.8910	-73.5904
	6	1687	6850	8239	2.01	-1.85	1.84	3101	17	0.005						39.8914	-73.5903	39.9000	-73.6066
	7	1686	8240	9479	2.02	-2.05	1.85	3115	13	0.004						39.9001	-73.6062	39.8916	-73.5898
Total mission length:		12181						21614	212	0.010	146.8	0.5	0.9	98.6	15513				
110729_D4_DV0106_M1	1	1662	0	1285	2.16	-2.80	1.97	3272	100	0.031						39.8963	-73.5318	39.9019	-73.5498
	2	1672	1286	2699	2.18	-3.17	1.98	3303	134	0.041						39.8990	-73.5516	39.8930	-73.5336
	3	1687	2700	3996	2.16	-2.79	1.97	3317	103	0.031						39.8928	-73.5340	39.8988	-73.5521
	4	1685	3997	5423	2.17	-3.14	1.97	3315	127	0.038						39.8984	-73.5521	39.8924	-73.5340
	5	1683	5424	6693	2.18	-2.77	1.98	3334	107	0.032						39.8921	-73.5344	39.8981	-73.5525
	6	1683	6694	8138	2.17	-3.14	1.97	3310	113	0.034						39.8977	-73.5525	39.8917	-73.5344
	7	1680	8139	9425	2.17	-2.81	1.97	3316	117	0.035						39.8915	-73.5348	39.8975	-73.5529
Total mission length:		11752						23169	801	0.035	131.9	0.1	7.7	92.1	41509				
110729_D4_DV0112_M3	1	1711	0	1306	2.05	-1.96	1.87	3207	90	0.028						39.9783	-73.6383	39.9793	-73.6583
	2	1729	1307	2607	2.07	-1.80	1.90	3283	62	0.019						39.9775	-73.6588	39.9763	-73.6386
	3	1739	2608	3939	2.06	-1.93	1.88	3277	40	0.012						39.9760	-73.6389	39.9770	-73.6592
	4	1738	3940	5253	2.05	-1.83	1.88	3274	36	0.011						39.9767	-73.6590	39.9756	-73.6386
	5	1739	5254	6584	2.05	-1.94	1.88	3267	31	0.009						39.9753	-73.6389	39.9763	-73.6593
	6	1739	6585	7939	2.05	-1.91	1.88	3263	41	0.013						39.9760	-73.6590	39.9749	-73.6387
	7	1738	7940	9281	1.98	-1.98	1.81	3140	31	0.010						39.9746	-73.6390	39.9756	-73.6593
Total mission length:		12133						22710	331	0.015	135.0	0.0	3.3	96.7	17782				
110729_D4_DV0113_M4	1	1789	0	1338	2.08	-2.03	1.91	3412	8	0.002						40.0173	-73.8078	40.0279	-73.8236
	2	1782	1339	2750	2.09	-2.02	1.92	3417	8	0.002						40.0256	-73.8262	40.0150	-73.8106
	3	1785	2751	4077	2.08	-2.02	1.91	3404	0	0.000						40.0149	-73.8111	40.0255	-73.8269
	4	1790	4078	5467	2.06	-2.04	1.89	3376	0	0.000						40.0251	-73.8270	40.0145	-73.8112
	5	1789	5468	6796	2.08	-2.00	1.91	3409	0	0.000						40.0144	-73.8117	40.0250	-73.8275
	6	1787	6797	8180	2.05	-2.09	1.88	3357	0	0.000						40.0246	-73.8276	40.0140	-73.8118
	7	1788	8181	9523	2.09	-1.99	1.92	3429	0	0.000						40.0139	-73.8123	40.0244	-73.8281
Total mission length:		12511						23804	16	0.001	126.9	0.0	6.3	93.8	844				
110726_ScallopD1_DV2_M2	1	1670	0	1360	2.20	-2.74	2.00	3344	31	0.009						38.6021	-74.1828	38.6063	-74.1643
	2	1668	1361	2636	2.20	-2.71	2.00	3342	35	0.010						38.6043	-74.1636	38.6002	-74.1820
	3	1672	2637	3988	2.19	-2.58	2.00	3344	37	0.011						38.6000	-74.1816	38.6040	-74.1631
	4	1672	3989	5254	2.20	-2.72	2.01	3353	27	0.008						38.6037	-74.1633	38.5995	-74.1817
	5	1674	5255	6621	2.20	-2.77	2.01	3358	40	0.012						38.5993	-74.1814	38.6033	-74.1629
	6	1671	6622	7895	2.20	-2.77	2.00	3341	29	0.009						38.6030	-74.1630	38.5988	-74.1815
	7	1673	7896	9255	2.20	-2.70	2.00	3346	30	0.009						38.5986	-74.1811	38.6026	-74.1626
Total mission length:		11699						23428	229	0.010	124.7	0.4	17.5	82.1	9072				

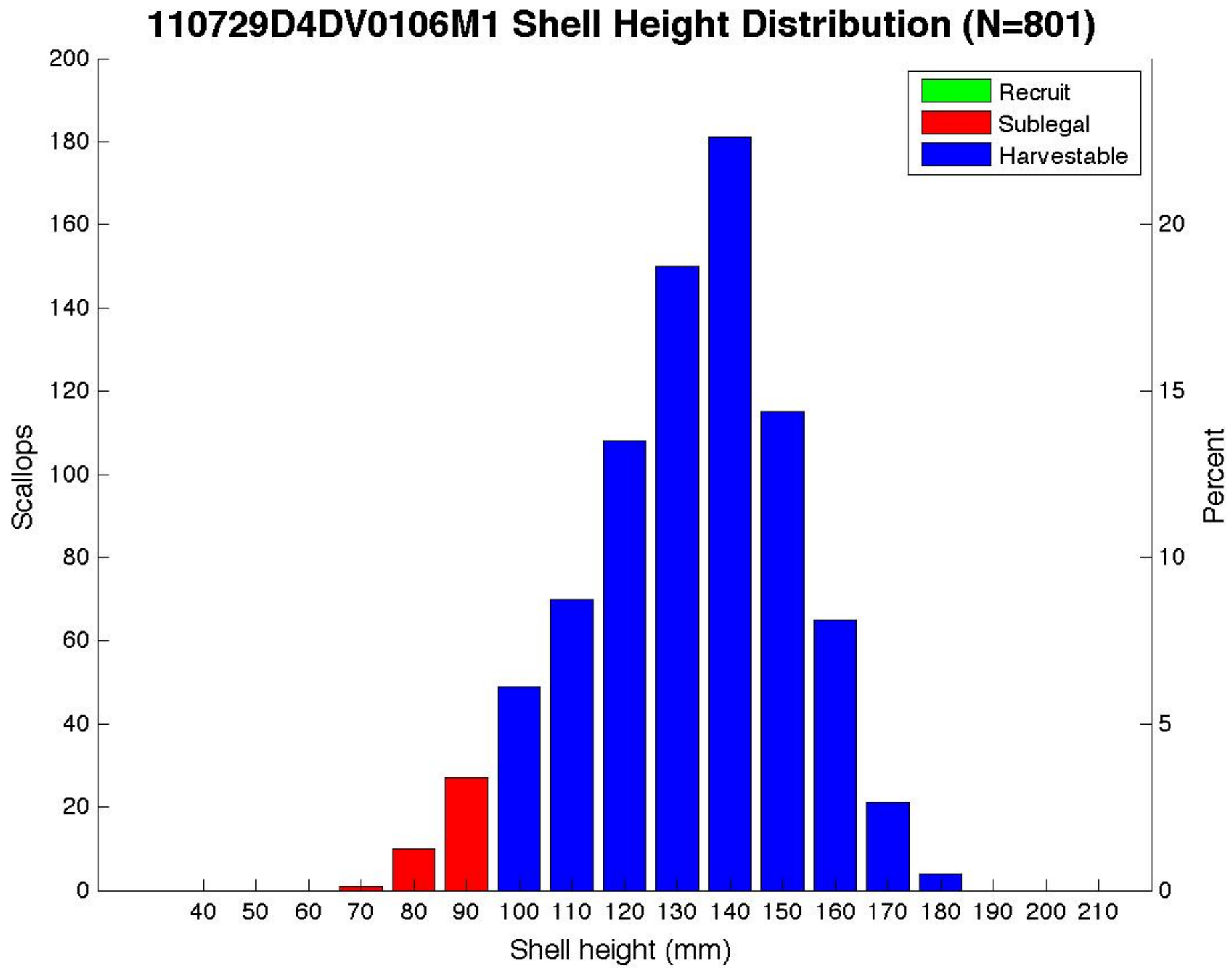
***Bold represents approximate values chosen as a result of instrument error**

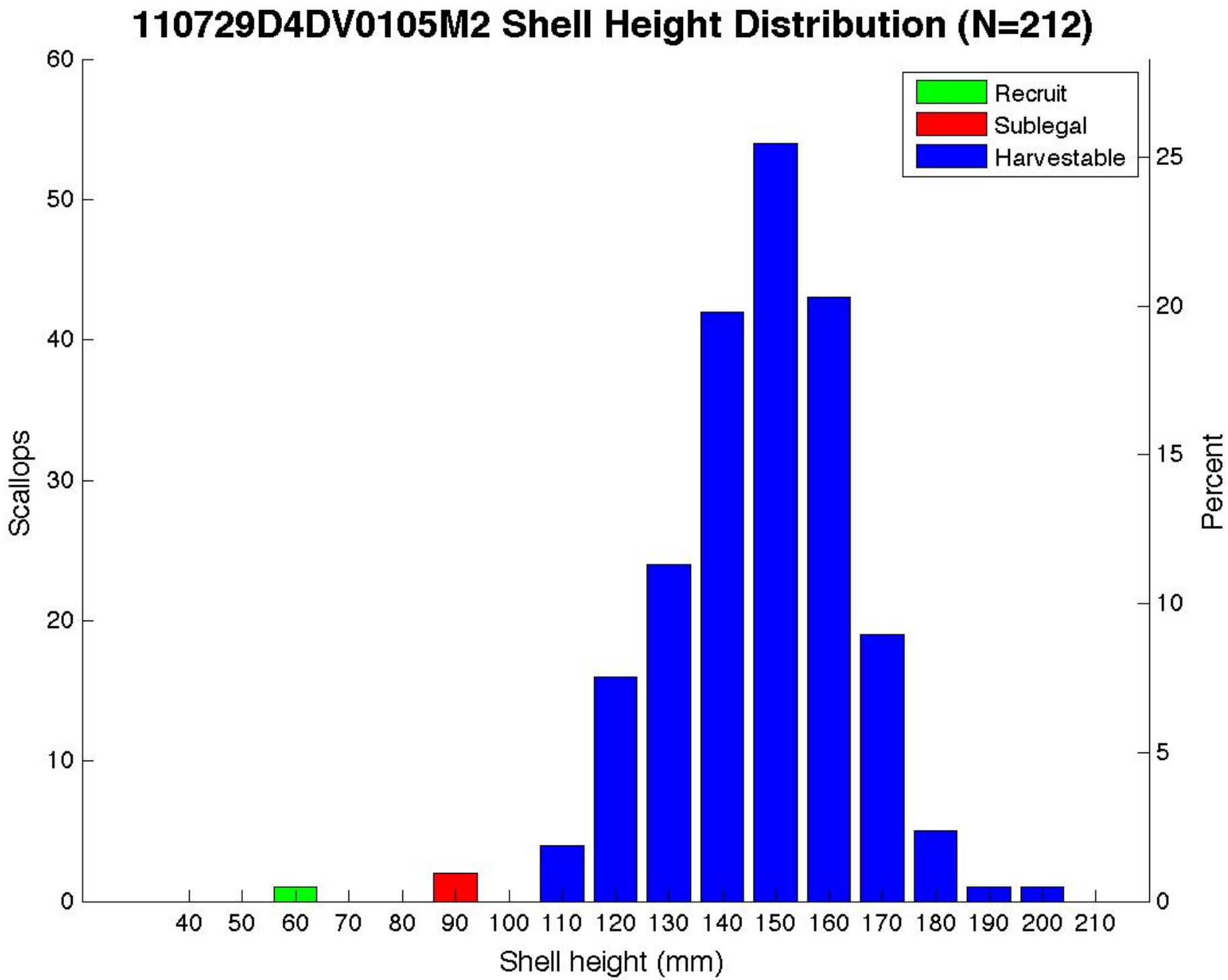
Appendix II. Size Distribution Histograms

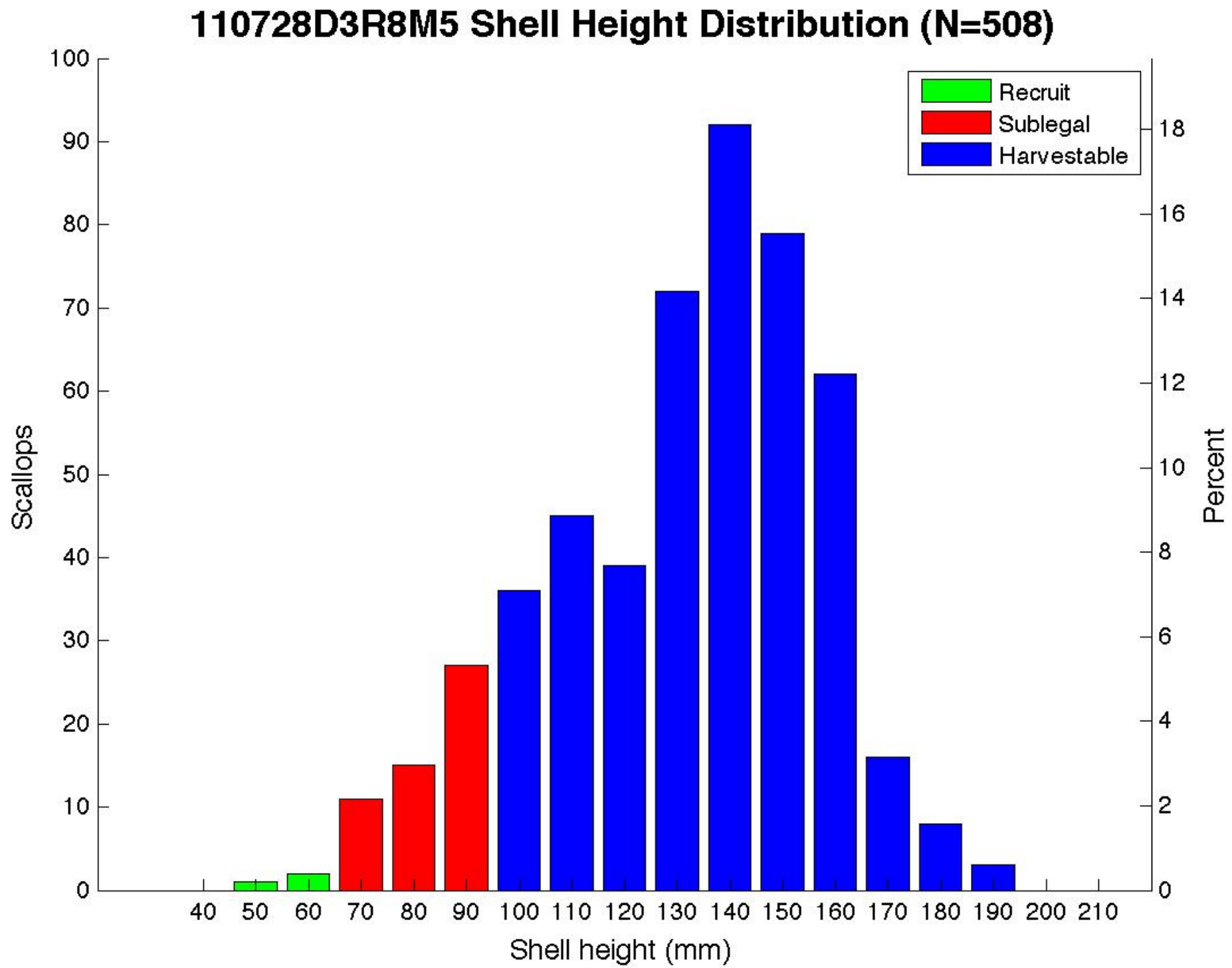

2011 Season Summary Shell Height Distribution (N=16451)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
500
1000
1500
2000
2500
3000
0
2
4
6
8
10
12
14
16
18
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

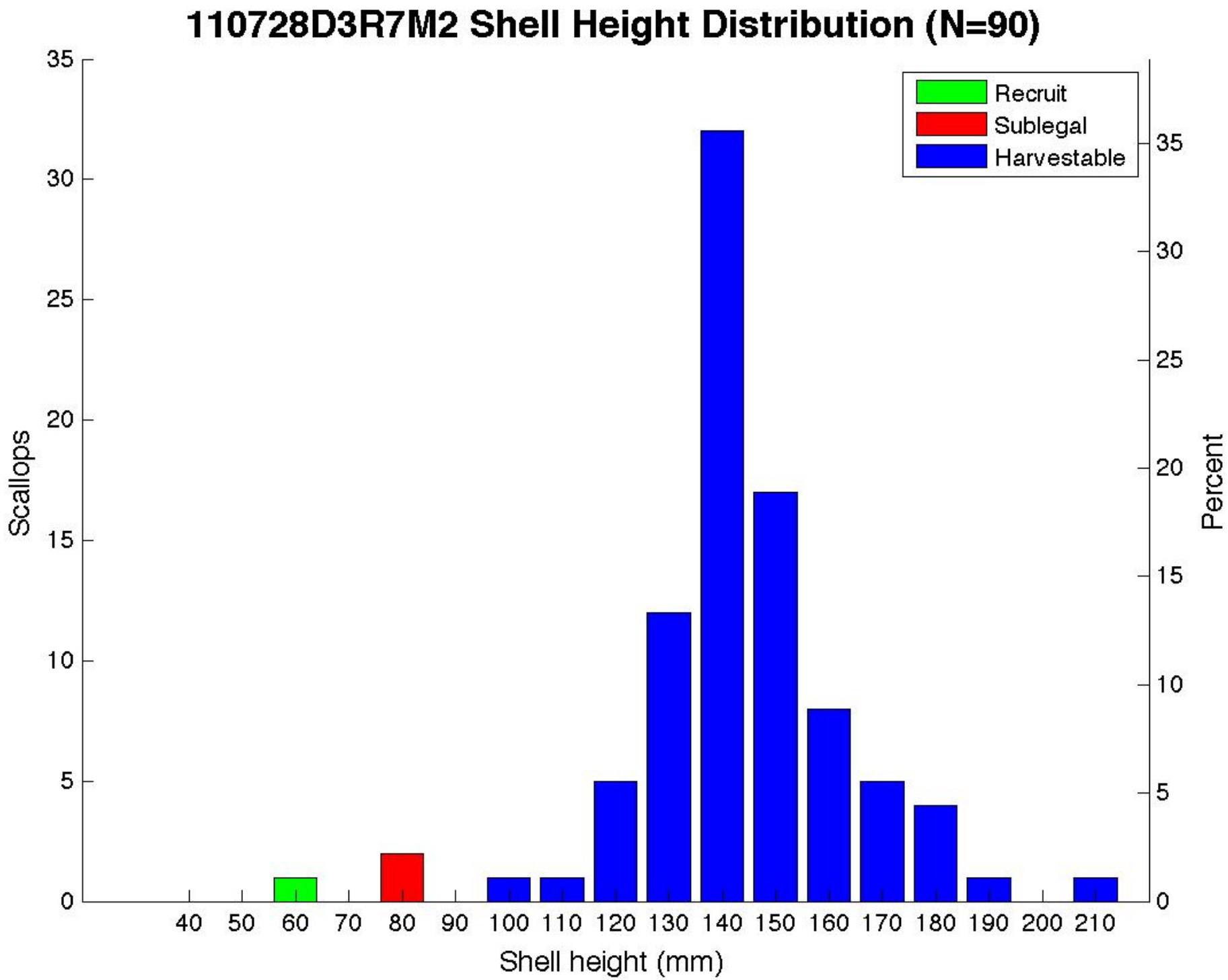

110729D4DV0113M4 Shell Height Distribution (N=16)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
5
10
15
20
25
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

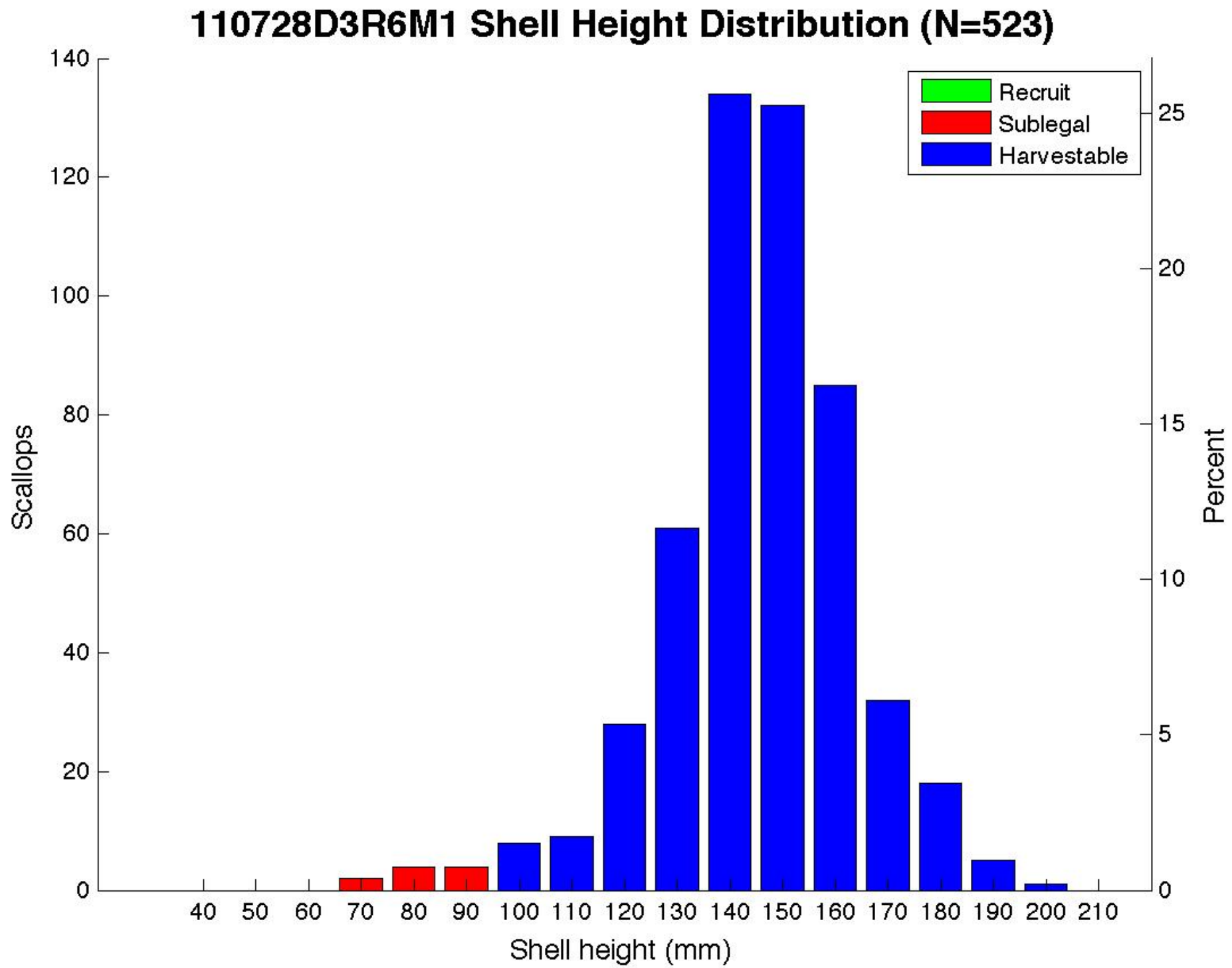

110729D4DV0112M3 Shell Height Distribution (N=331)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
10
20
30
40
50
60
70
80
90
0
5
10
15
20
25
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

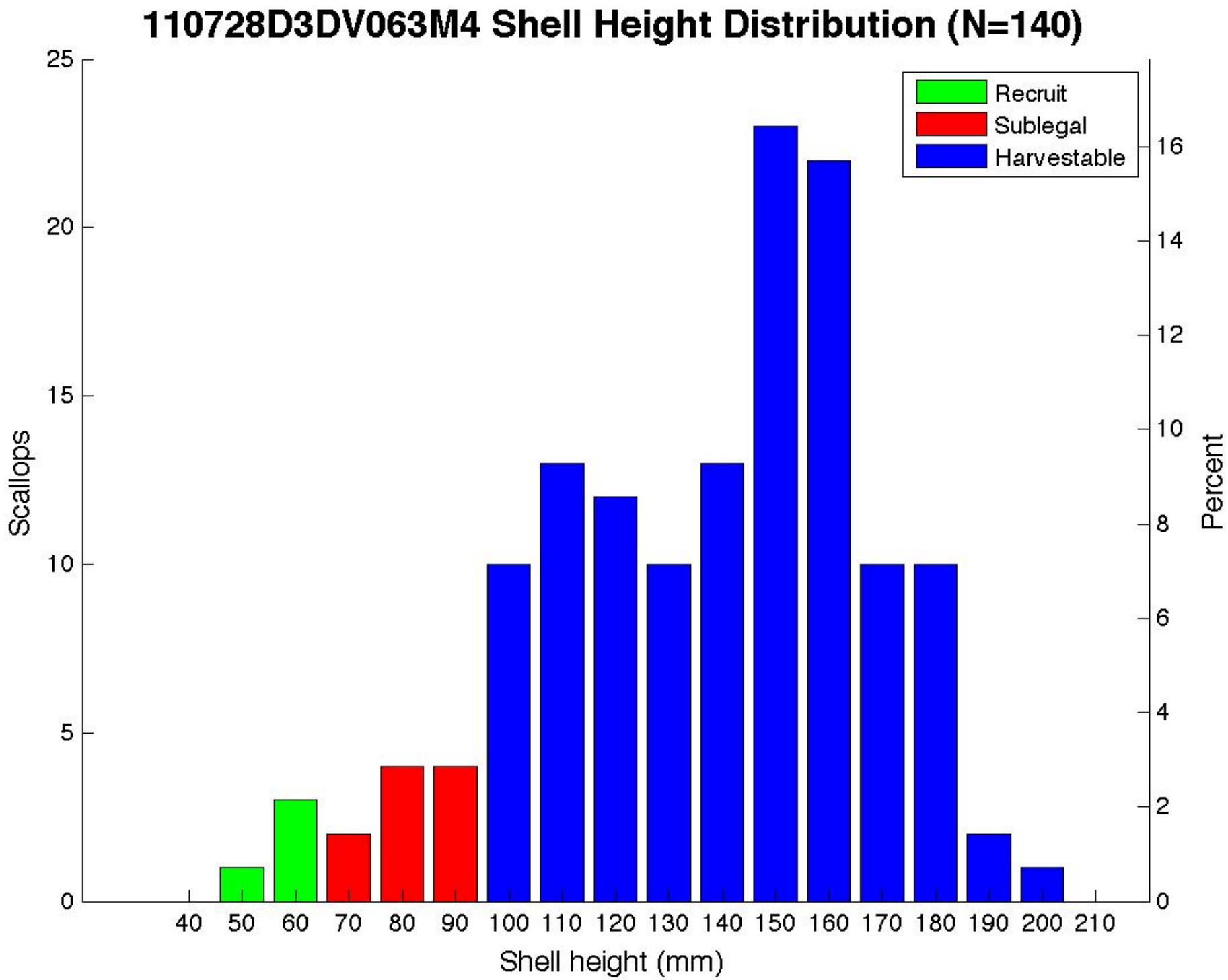

110729D4DV0106M1 Shell Height Distribution (N=801)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
20
40
60
80
100
120
140
160
180
200
0
5
10
15
20
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

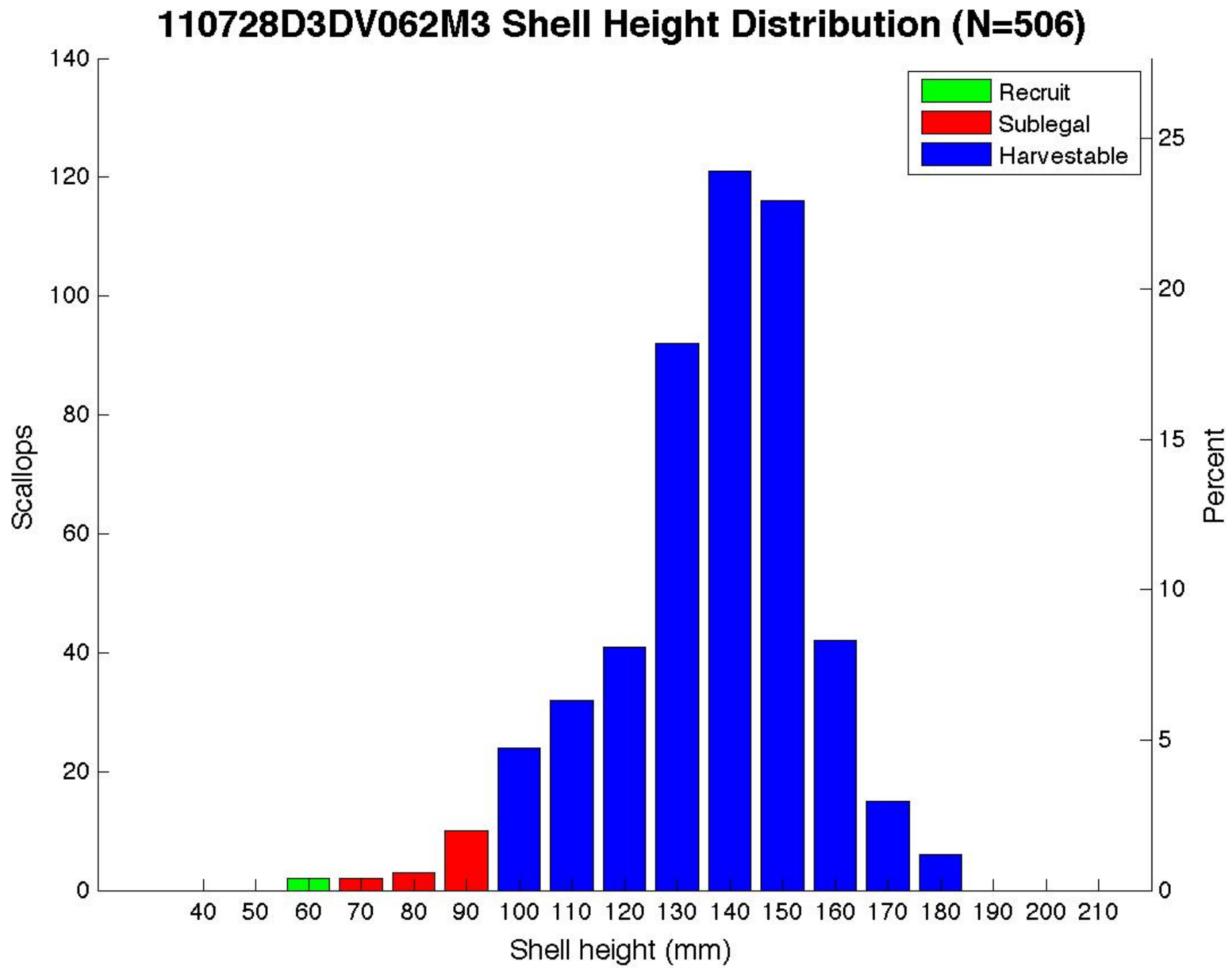

110729D4DV0105M2 Shell Height Distribution (N=212)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
10
20
30
40
50
60
0
5
10
15
20
25
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

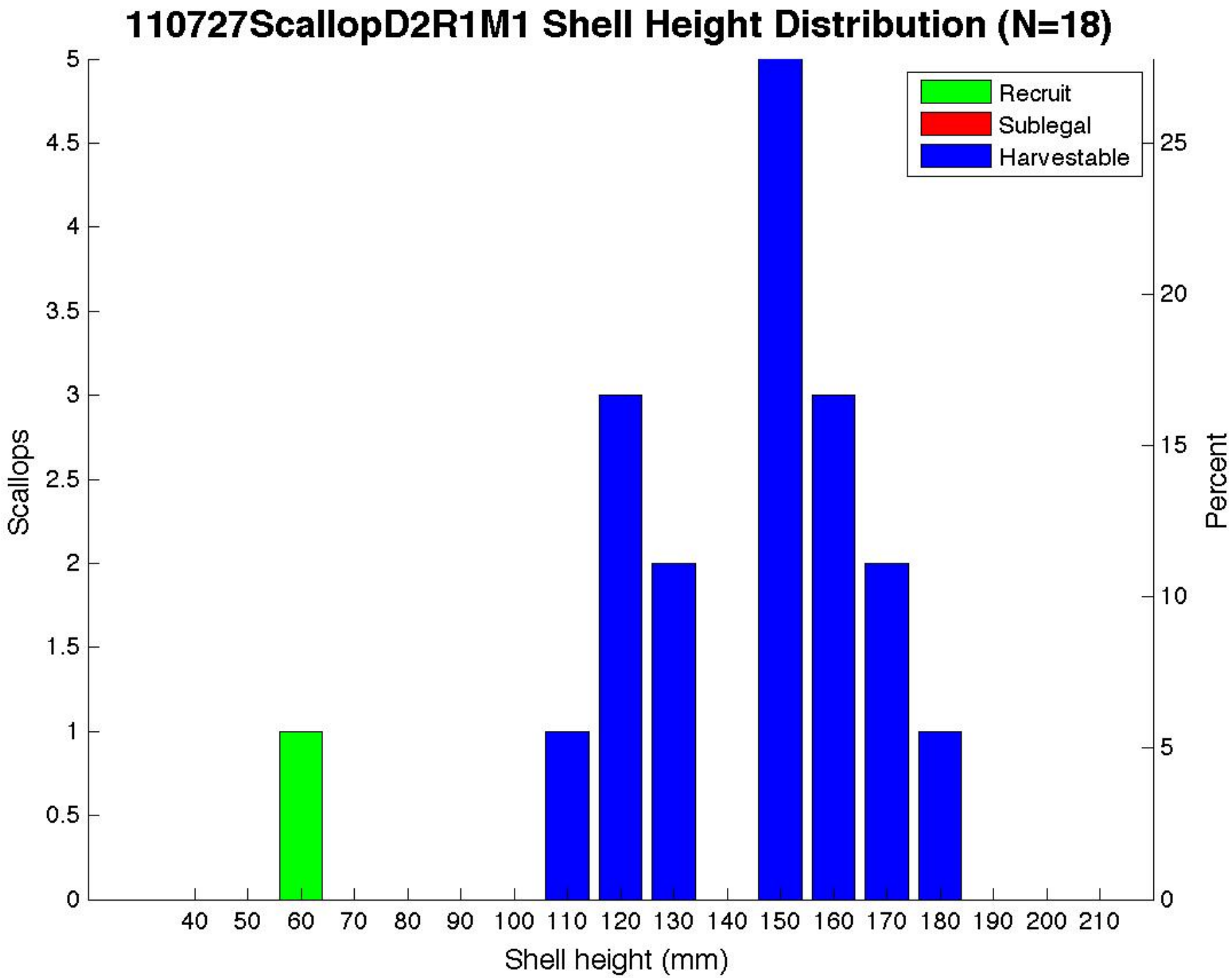

110728D3R8M5 Shell Height Distribution (N=508)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

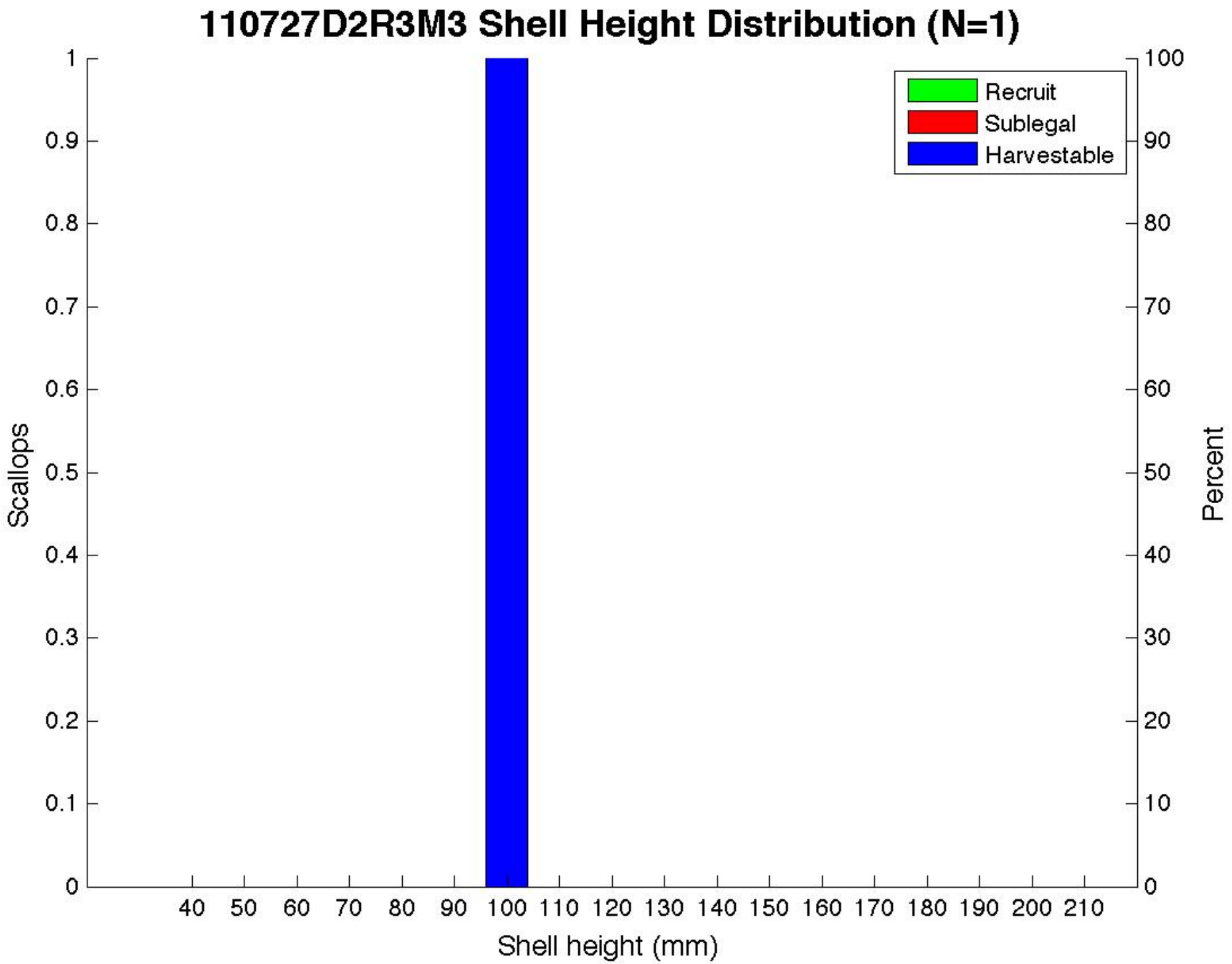

110728D3R7M2 Shell Height Distribution (N=90)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
5
10
15
20
25
30
35
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

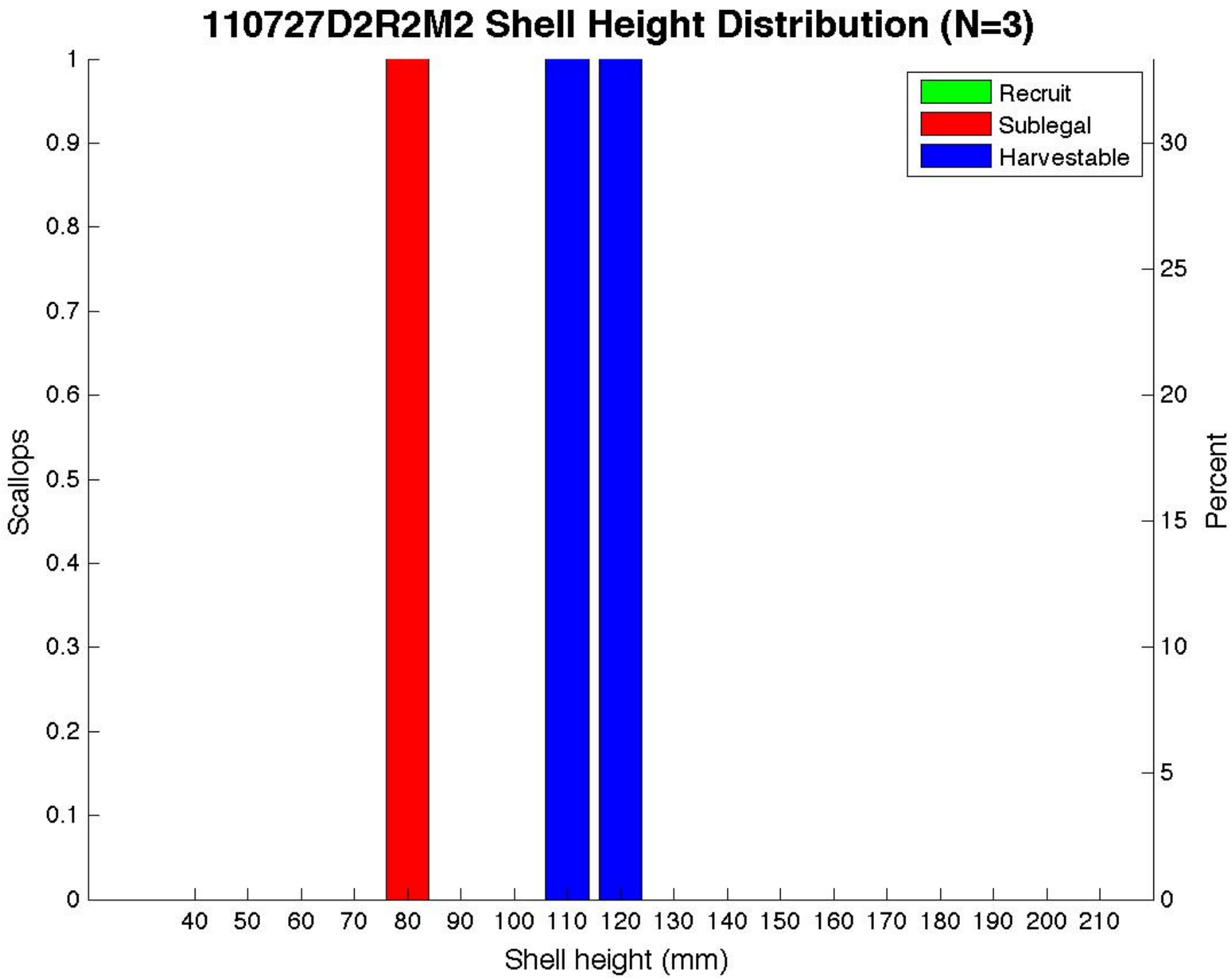

110728D3R6M1 Shell Height Distribution (N=523)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
20
40
60
80
100
120
140
0
5
10
15
20
25
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

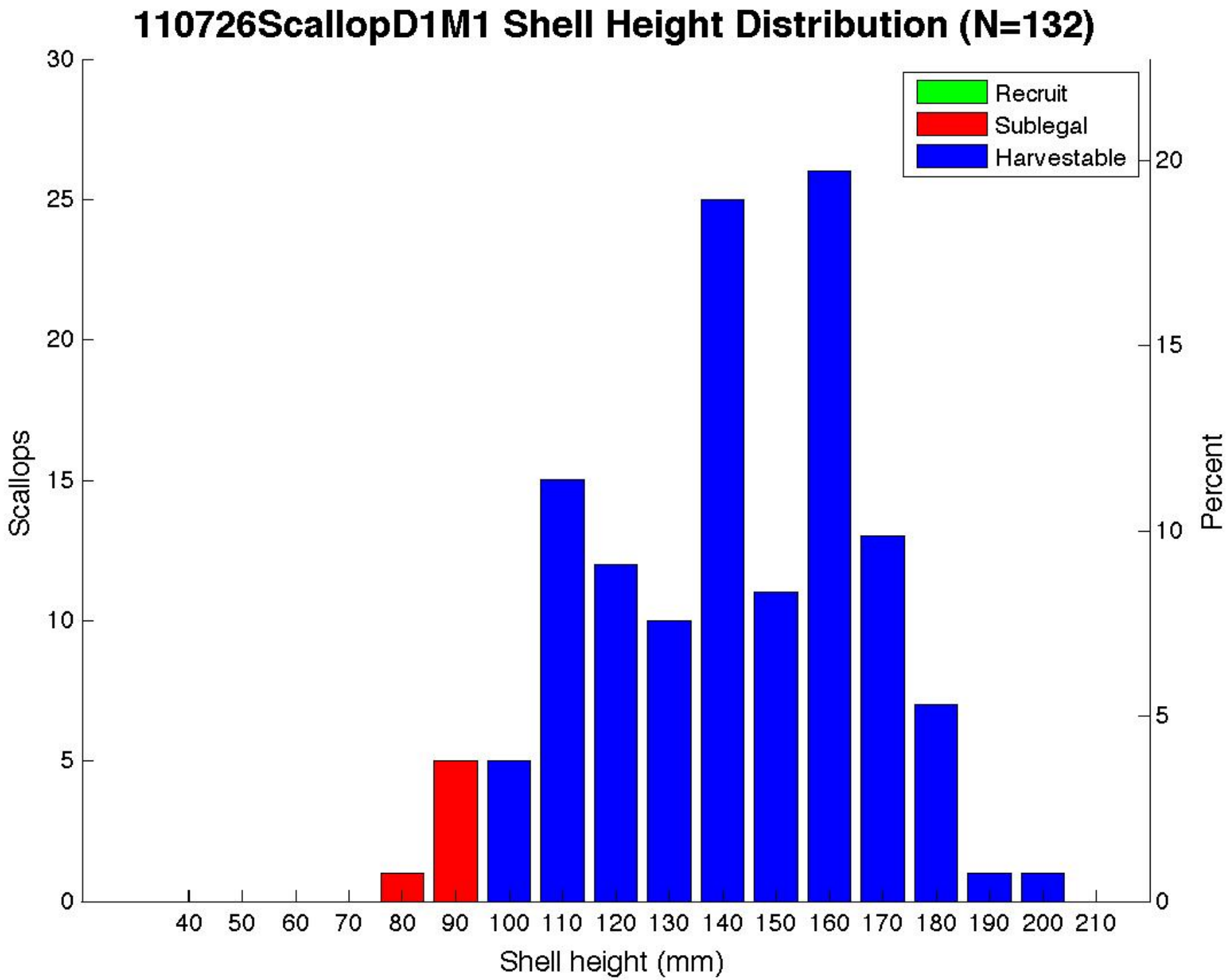

110728D3DV063M4 Shell Height Distribution (N=140)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
5
10
15
20
25
0
2
4
6
8
10
12
14
16
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

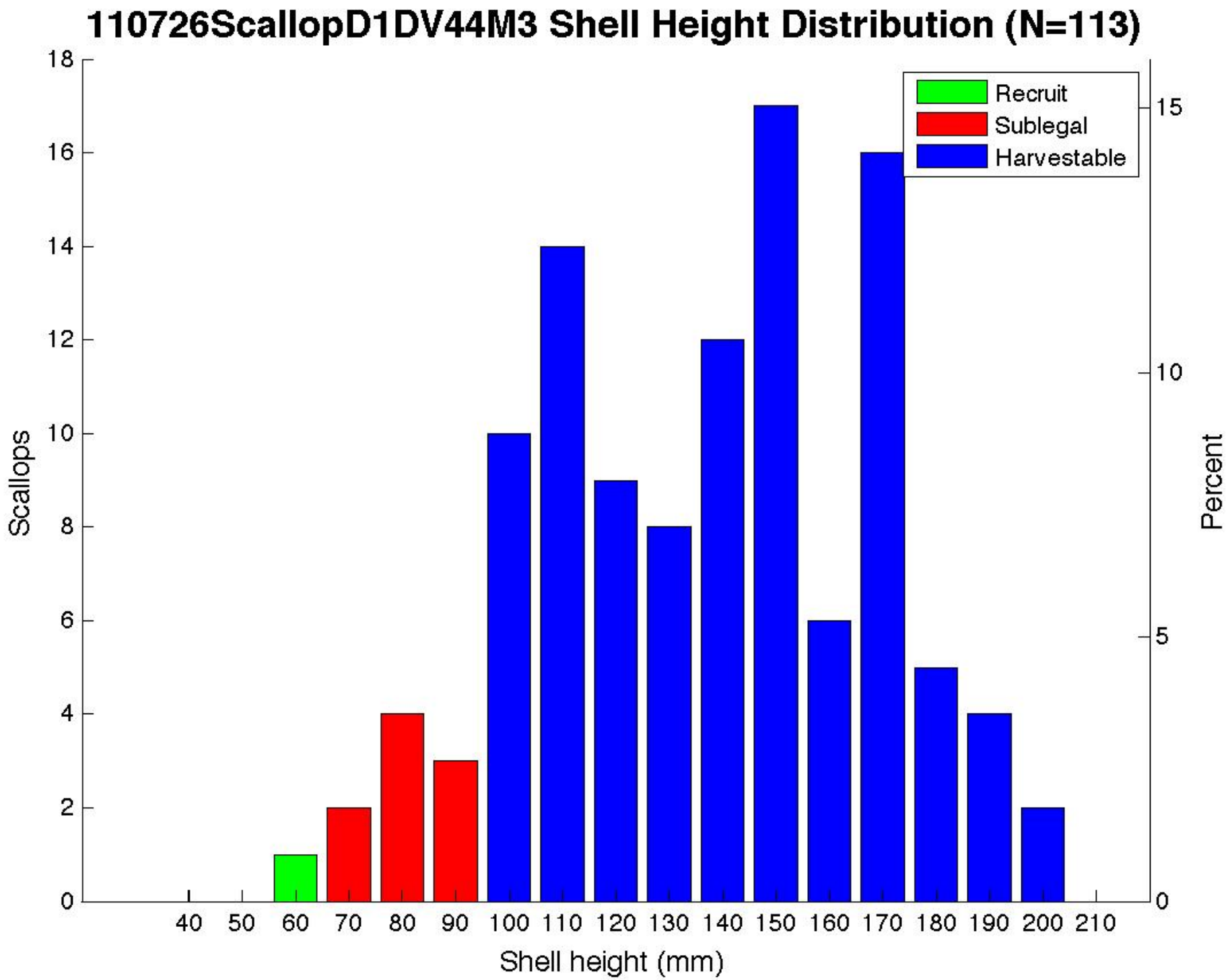

110728D3DV062M3 Shell Height Distribution (N=506)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
20
40
60
80
100
120
140
0
5
10
15
20
25
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

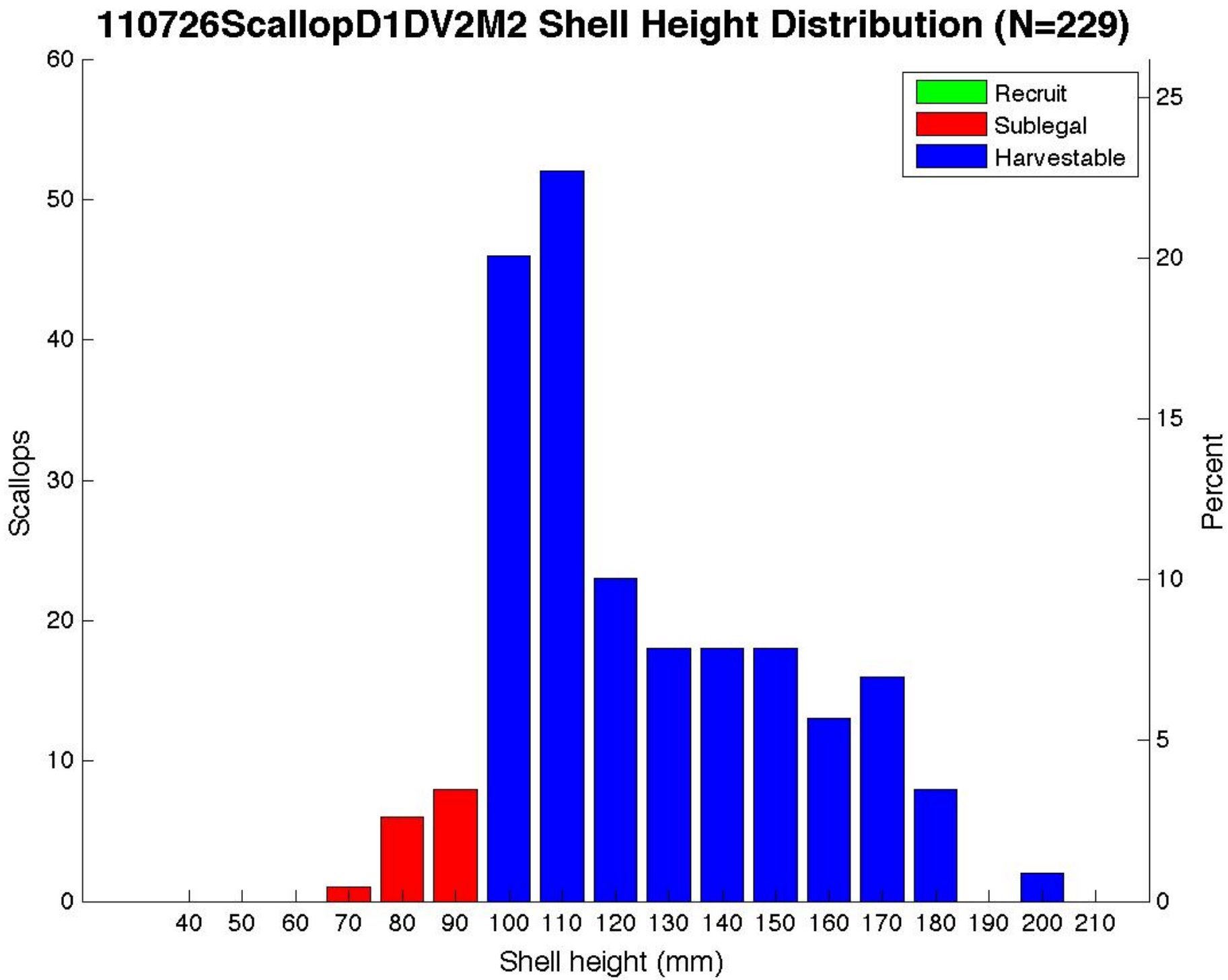

110727ScallopD2R1M1 Shell Height Distribution (N=18)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
5
10
15
20
25
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

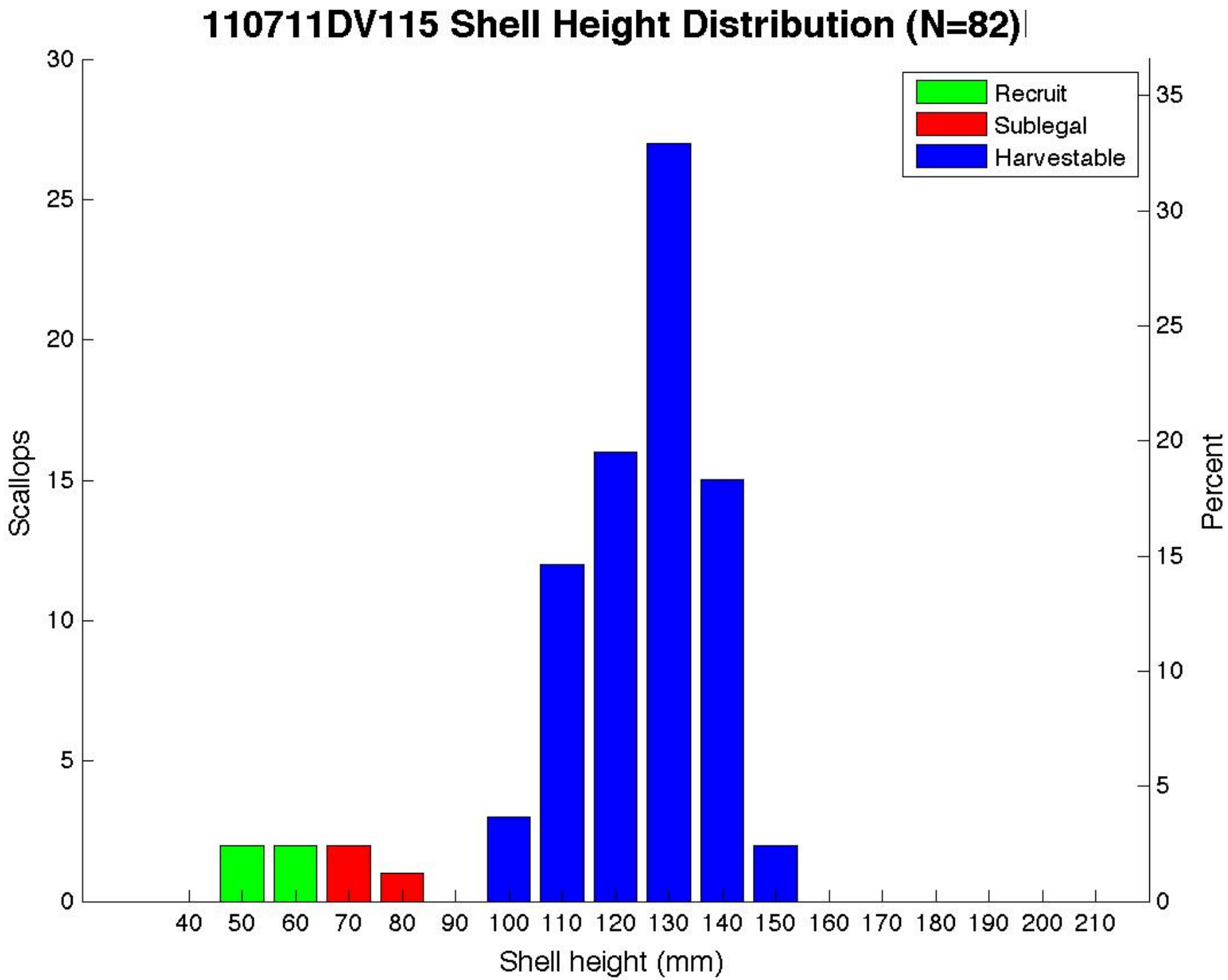

110727D2R3M3 Shell Height Distribution (N=1)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80
90
100
40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210

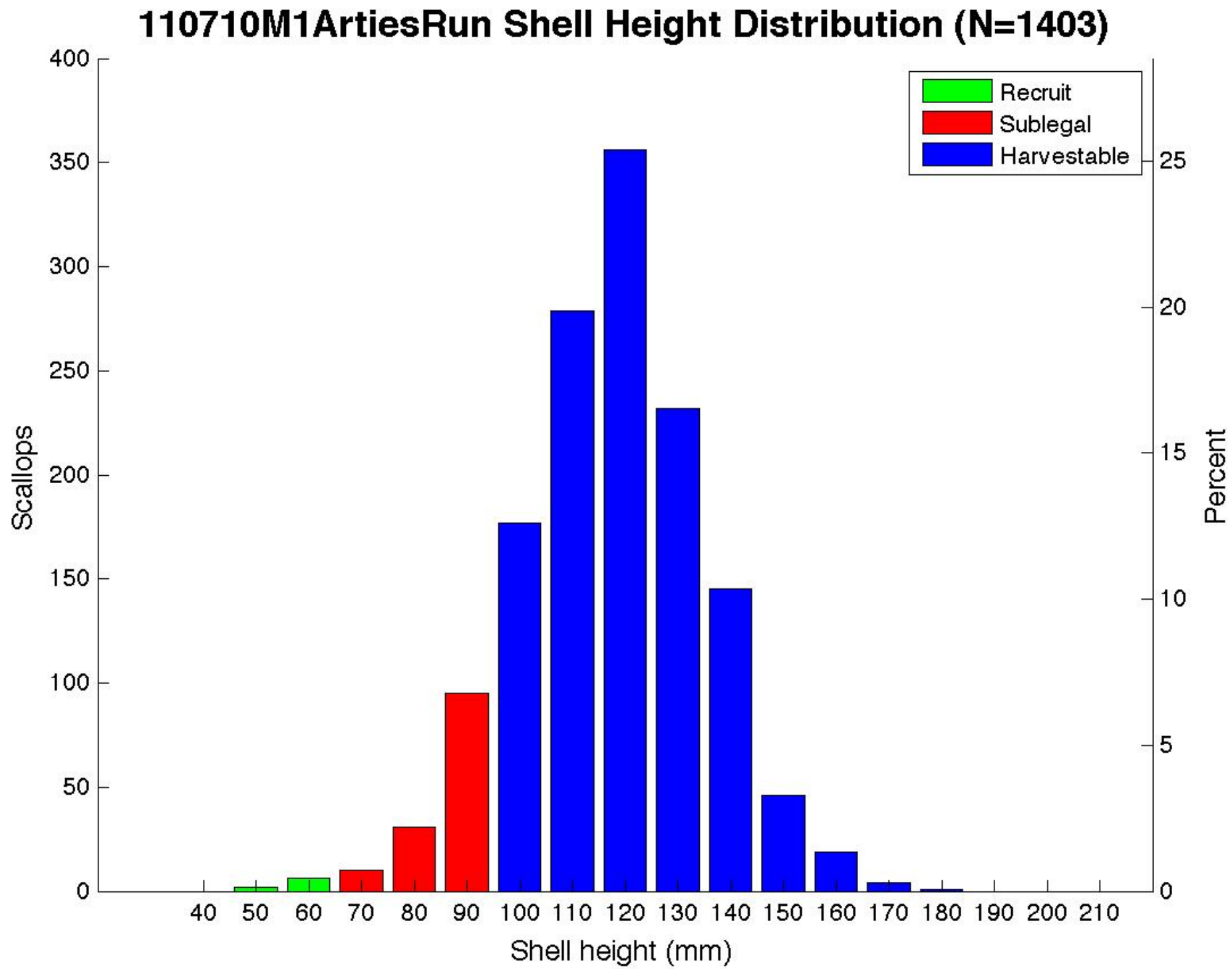

110727D2R2M2 Shell Height Distribution (N=3)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
5
10
15
20
25
30
40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210

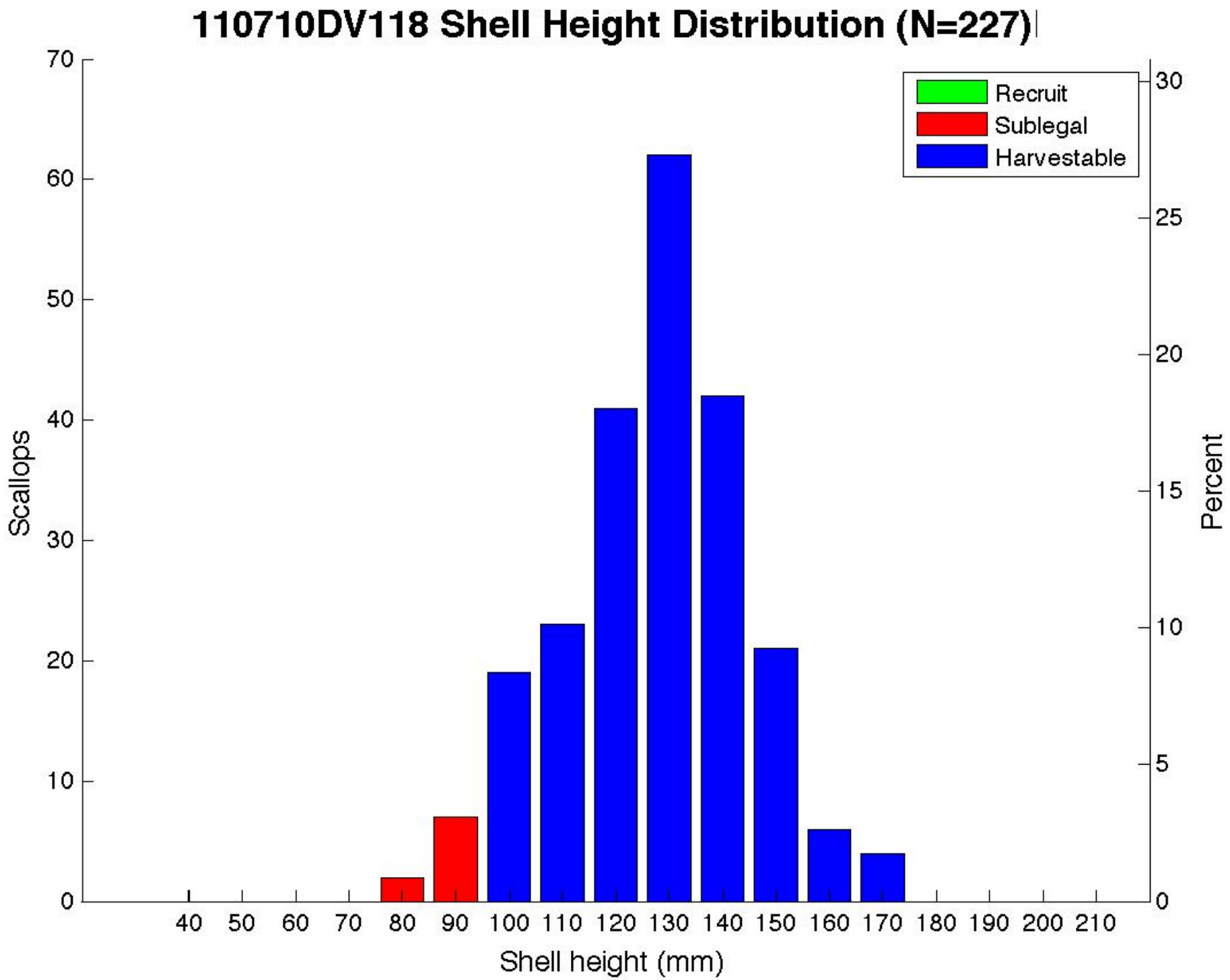

110726ScallopD1M1 Shell Height Distribution (N=132)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
5
10
15
20
25
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

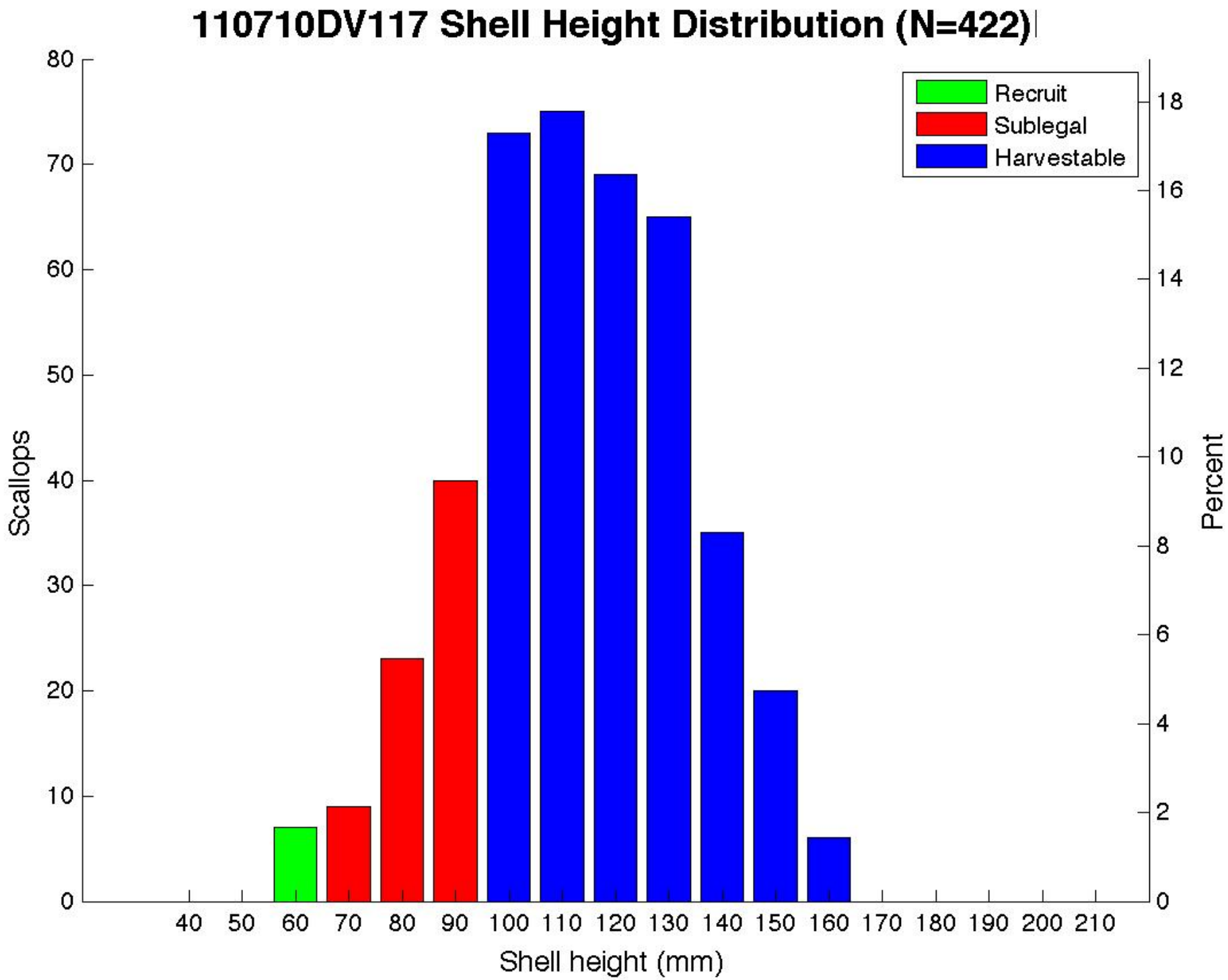

110726ScallopD1DV44M3 Shell Height Distribution (N=113)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
2
4
6
8
10
12
14
16
18
0
5
10
15
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

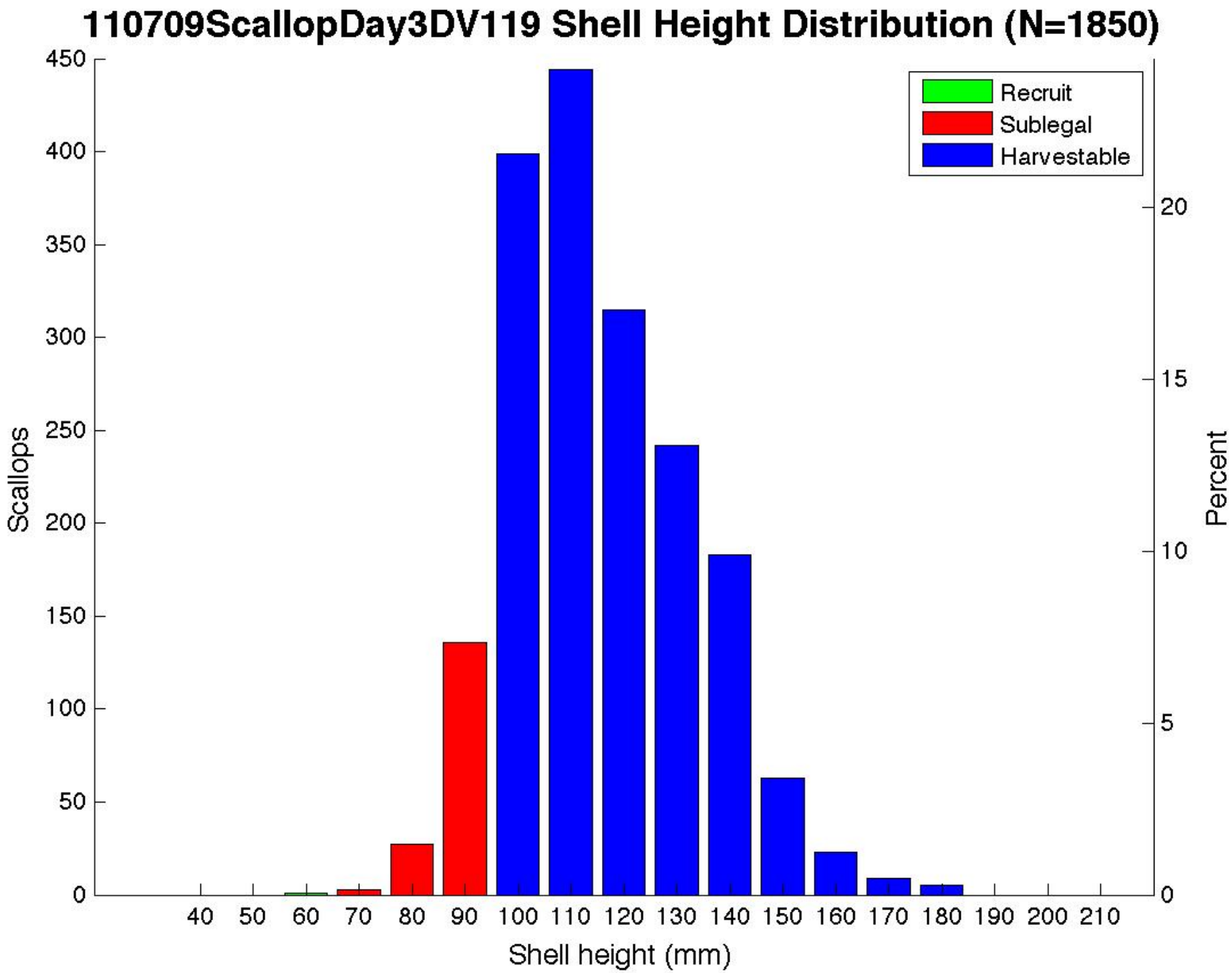

110726ScallopD1DV2M2 Shell Height Distribution (N=229)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
10
20
30
40
50
60
0
5
10
15
20
25
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

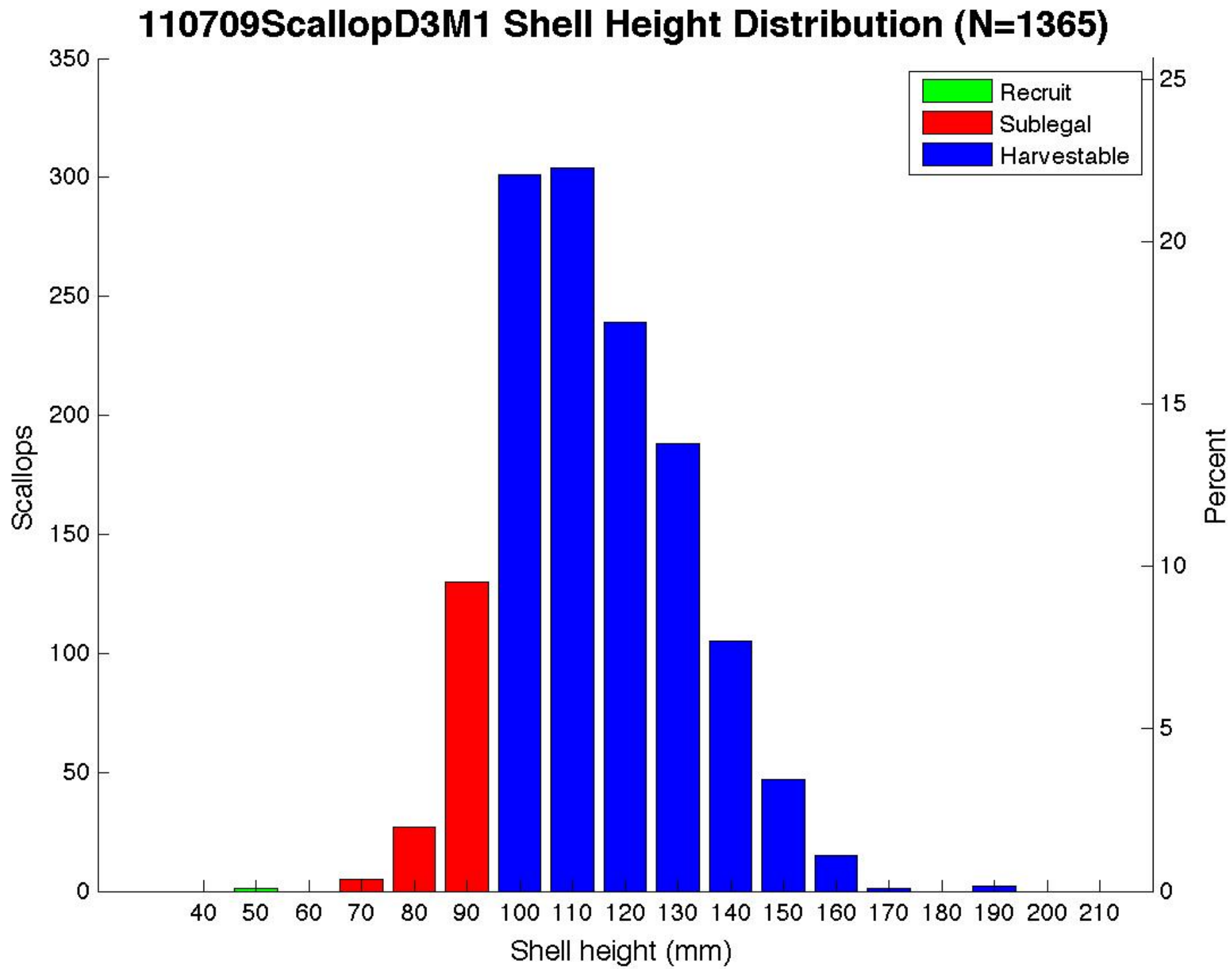

110711DV115 Shell Height Distribution (N=82)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
5
10
15
20
25
30
35
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

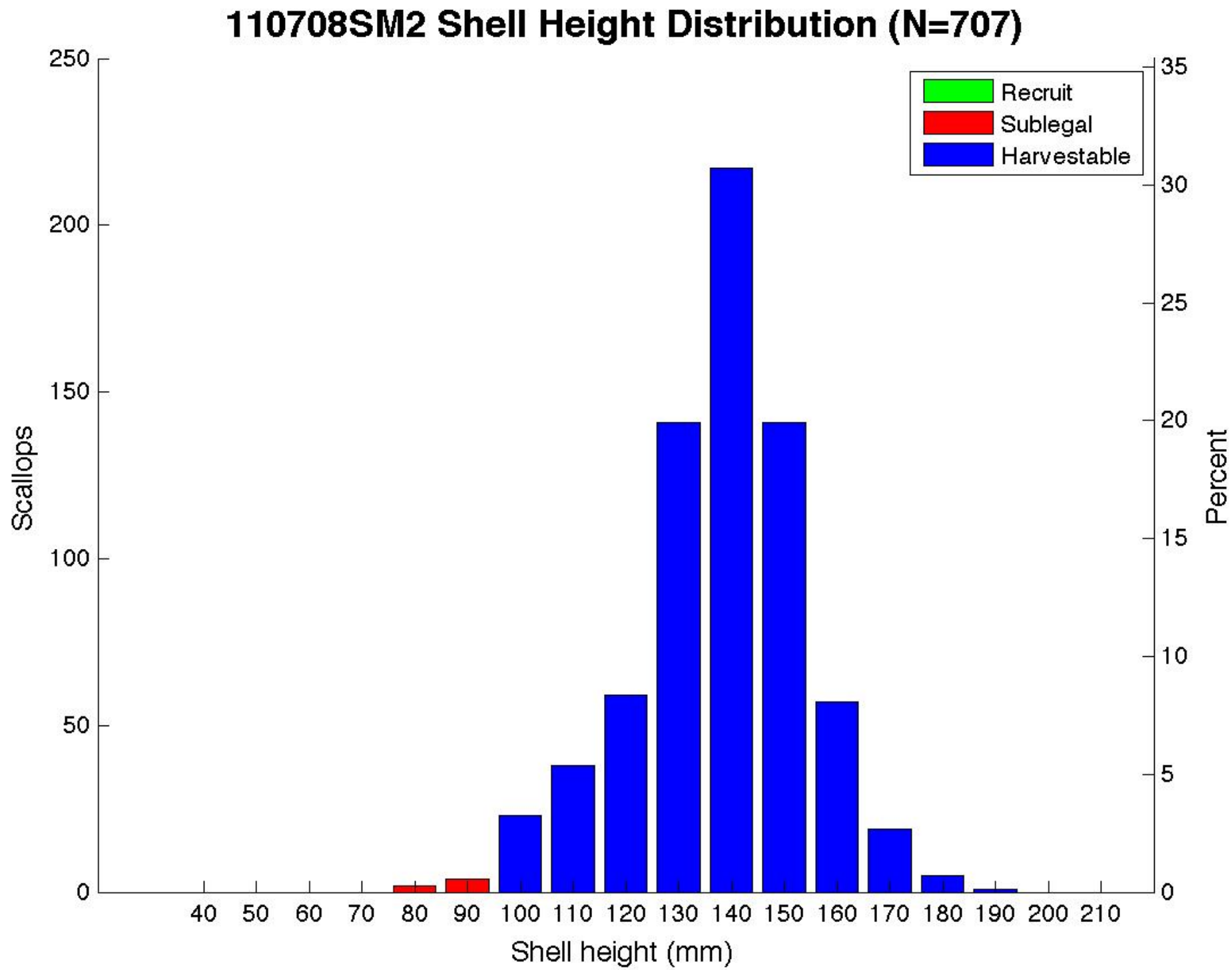

110710M1ArtiesRun Shell Height Distribution (N=1403)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
50
100
150
200
250
300
350
400
0
5
10
15
20
25
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

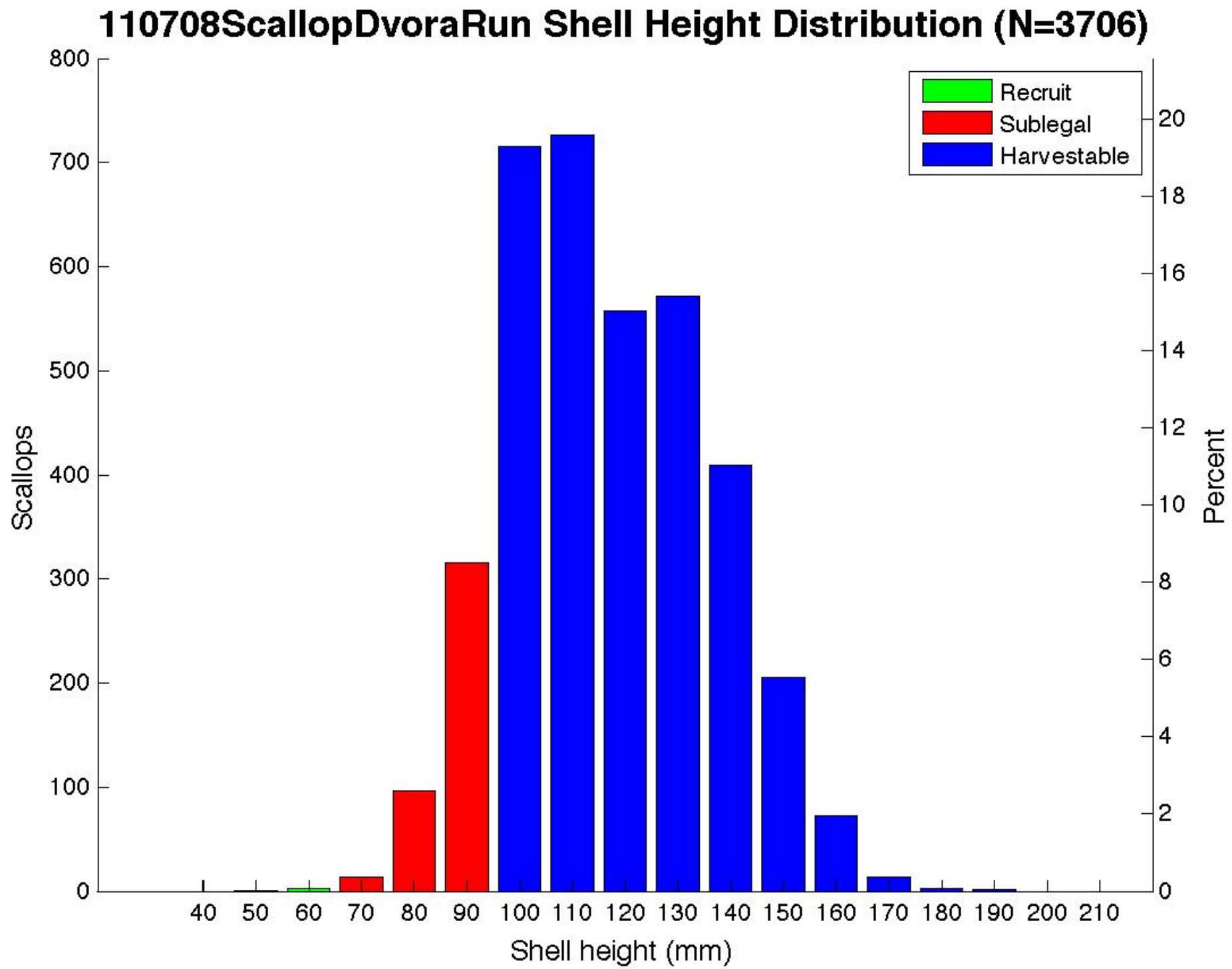

110710DV118 Shell Height Distribution (N=227)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
10
20
30
40
50
60
70
0
5
10
15
20
25
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

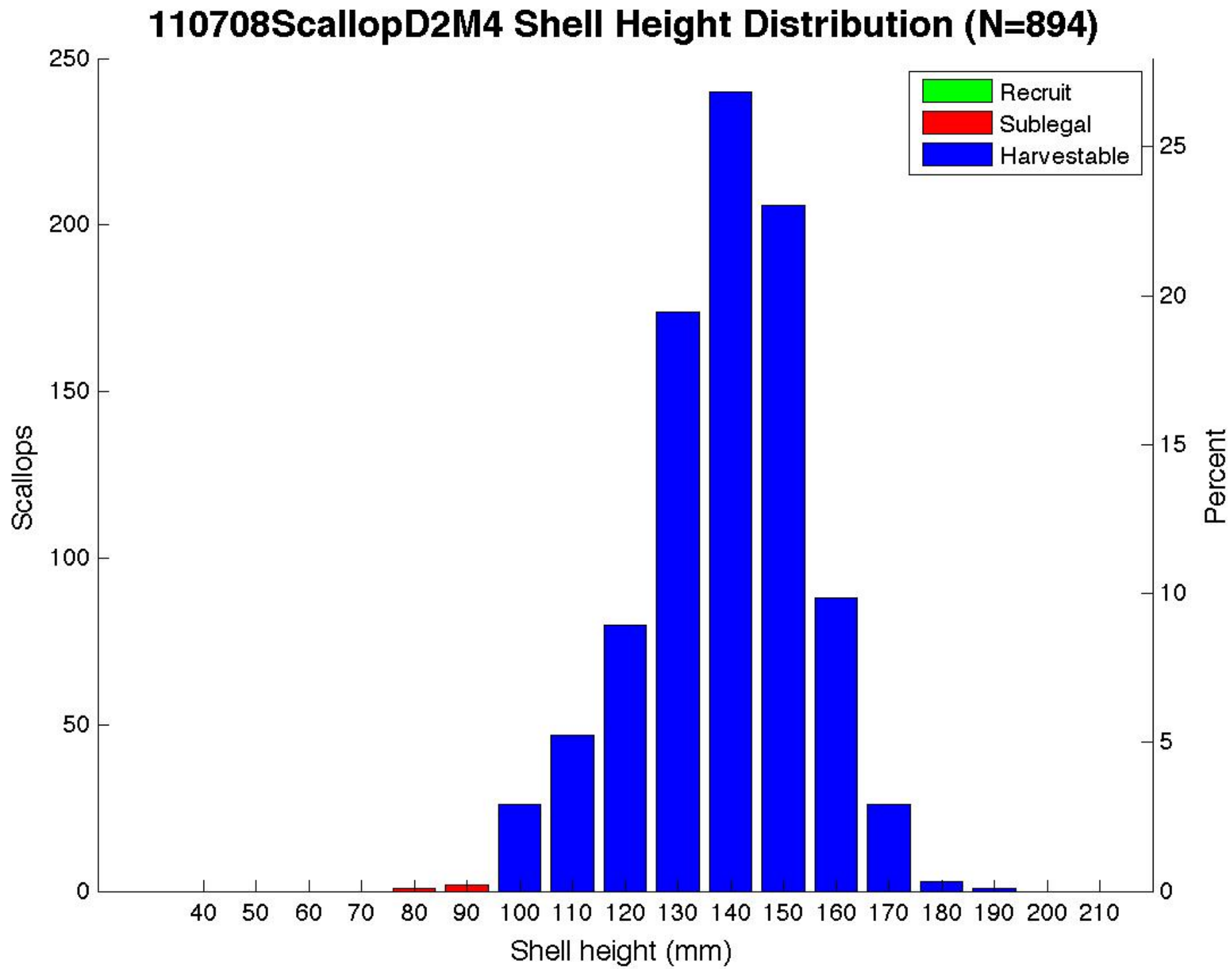

110710DV117 Shell Height Distribution (N=422)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
10
20
30
40
50
60
70
80
0
2
4
6
8
10
12
14
16
18
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

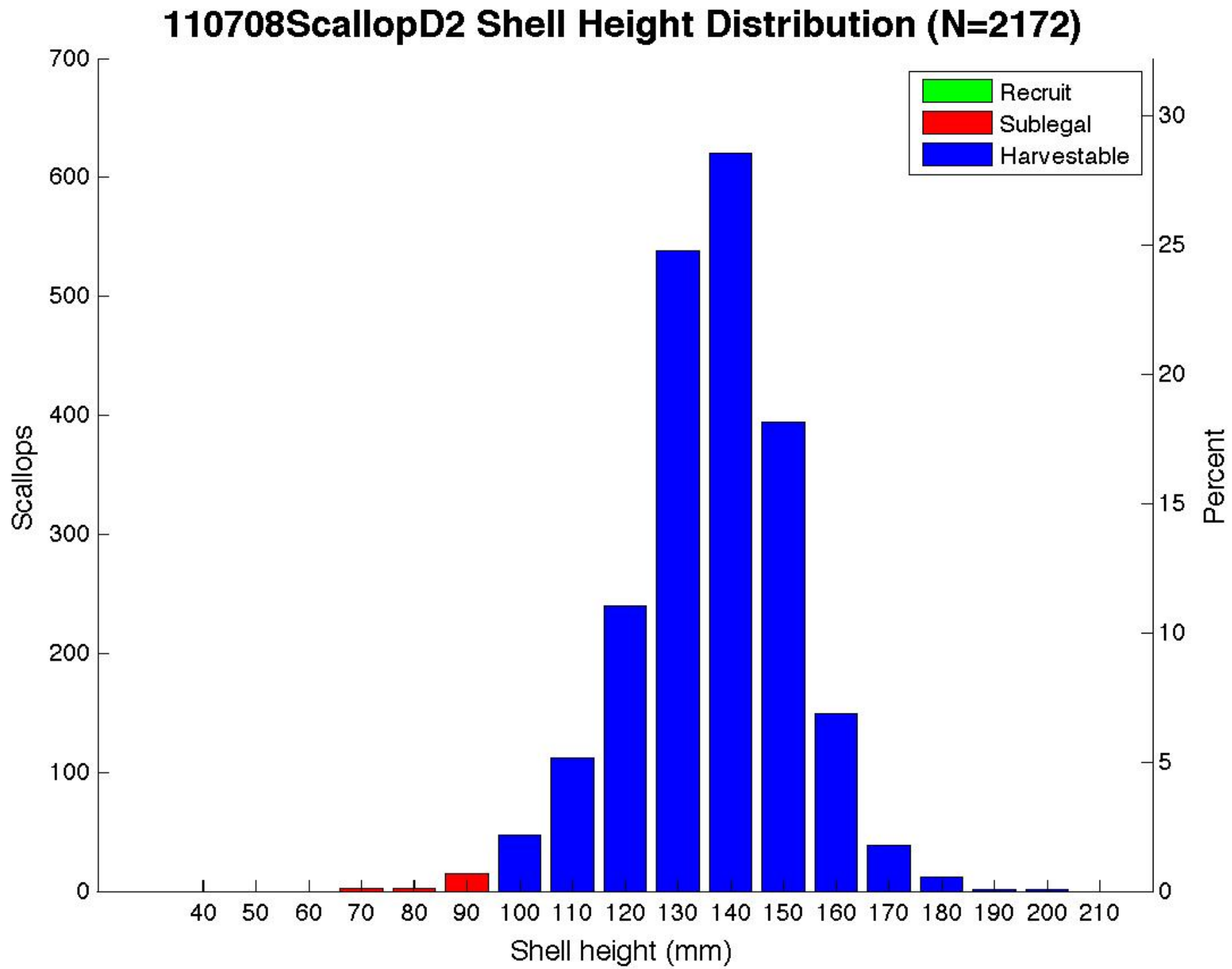

110709ScallopDay3DV119 Shell Height Distribution (N=1850)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
50
100
150
200
250
300
350
400
450
0
5
10
15
20
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210


110709ScallopD3M1 Shell Height Distribution (N=1365)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
50
100
150
200
250
300
350
0
5
10
15
20
25
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210


110708SM2 Shell Height Distribution (N=707)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
50
100
150
200
250
0
5
10
15
20
25
30
35
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

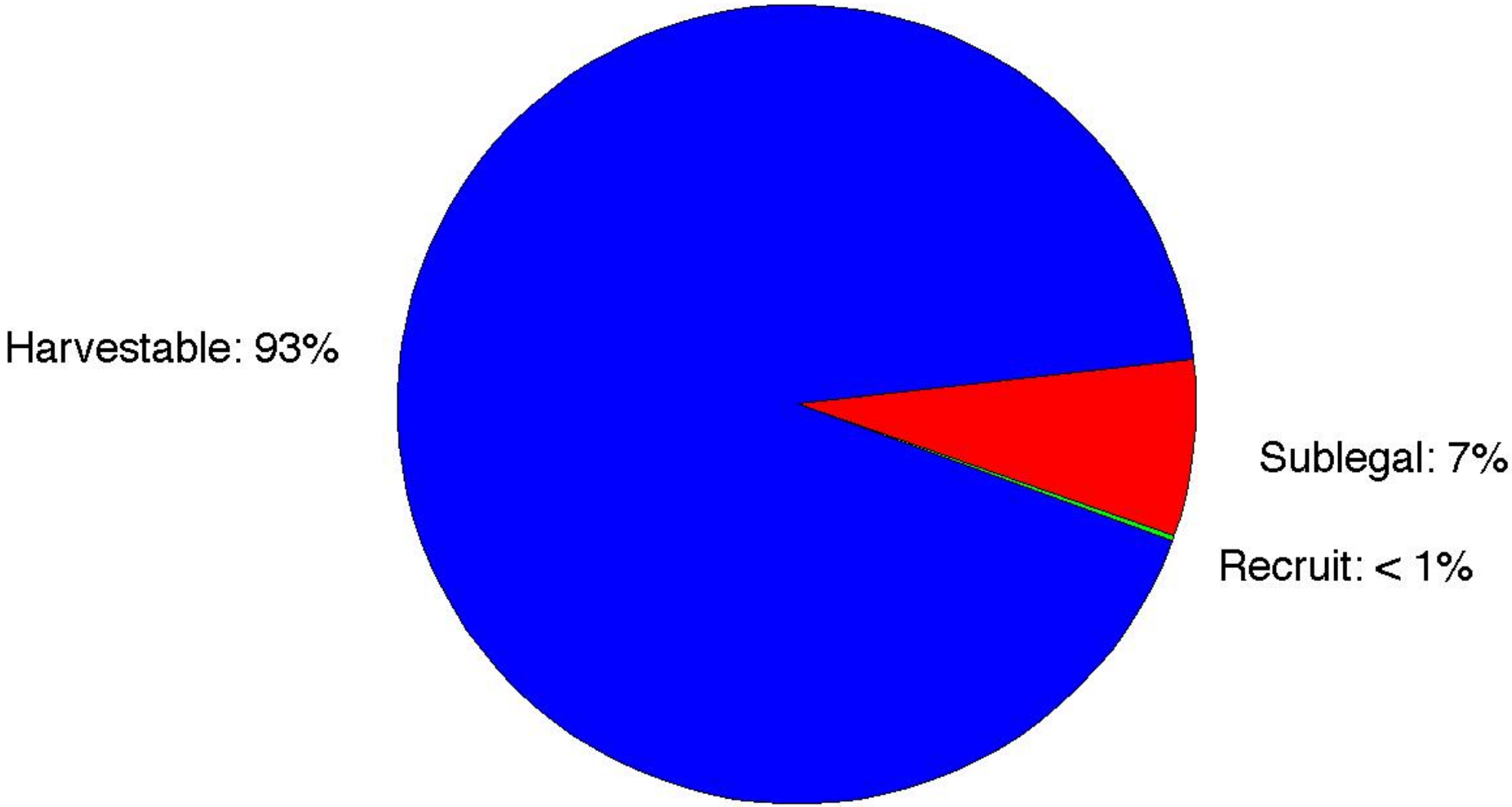

110708ScallopDvoraRun Shell Height Distribution (N=3706)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
100
200
300
400
500
600
700
800
0
2
4
6
8
10
12
14
16
18
20
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210


110708ScallopD2M4 Shell Height Distribution (N=894)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
50
100
150
200
250
0
5
10
15
20
25
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

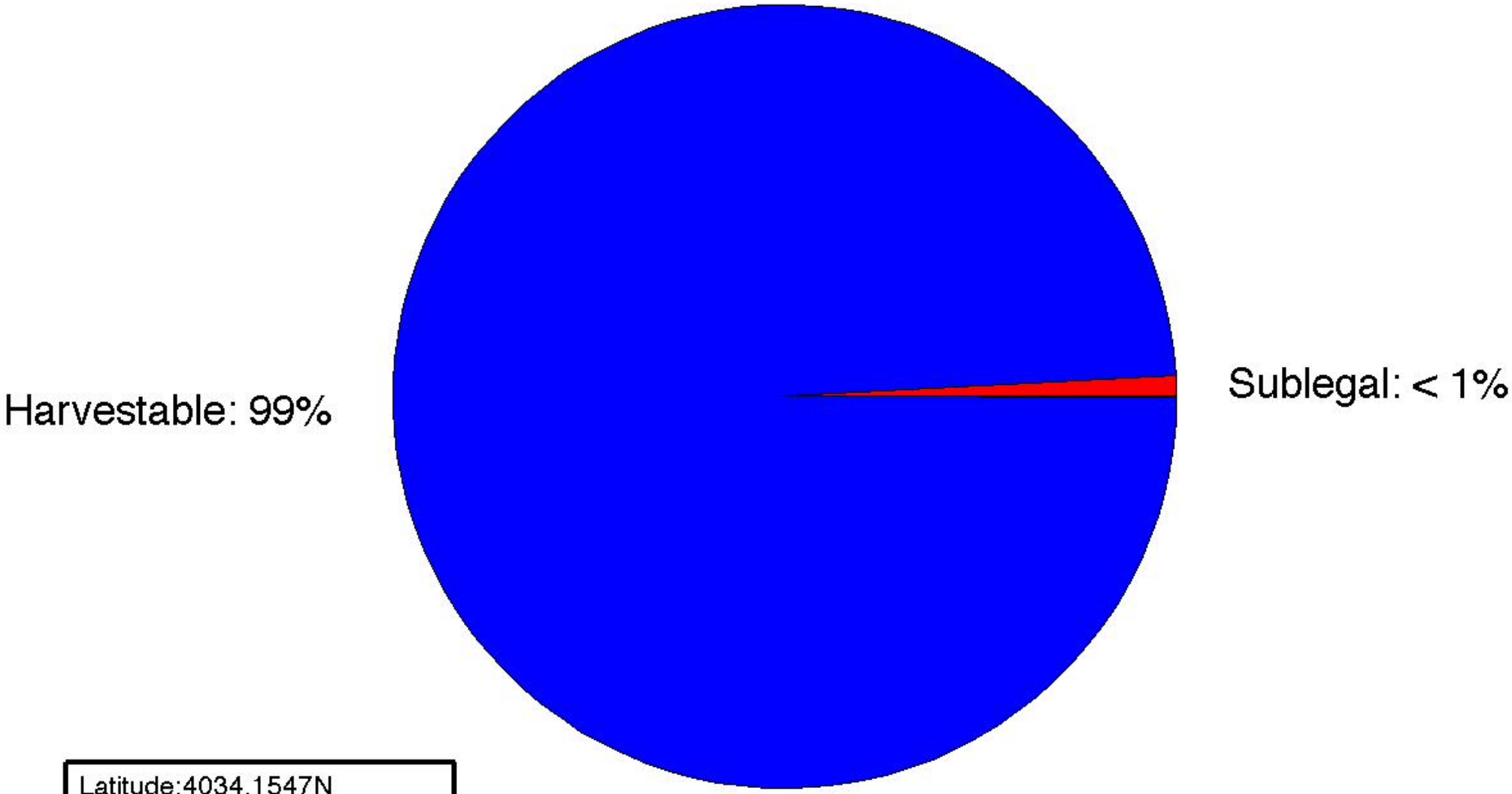

110708ScallopD2 Shell Height Distribution (N=2172)
Recruit
Sublegal
Harvestable
Scallops
Percent
Shell height (mm)
0
100
200
300
400
500
600
700
0
5
10
15
20
25
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

Appendix III. Size Distribution Pie Charts

2011 Season Summary Shell Height Distribution (N=16451)

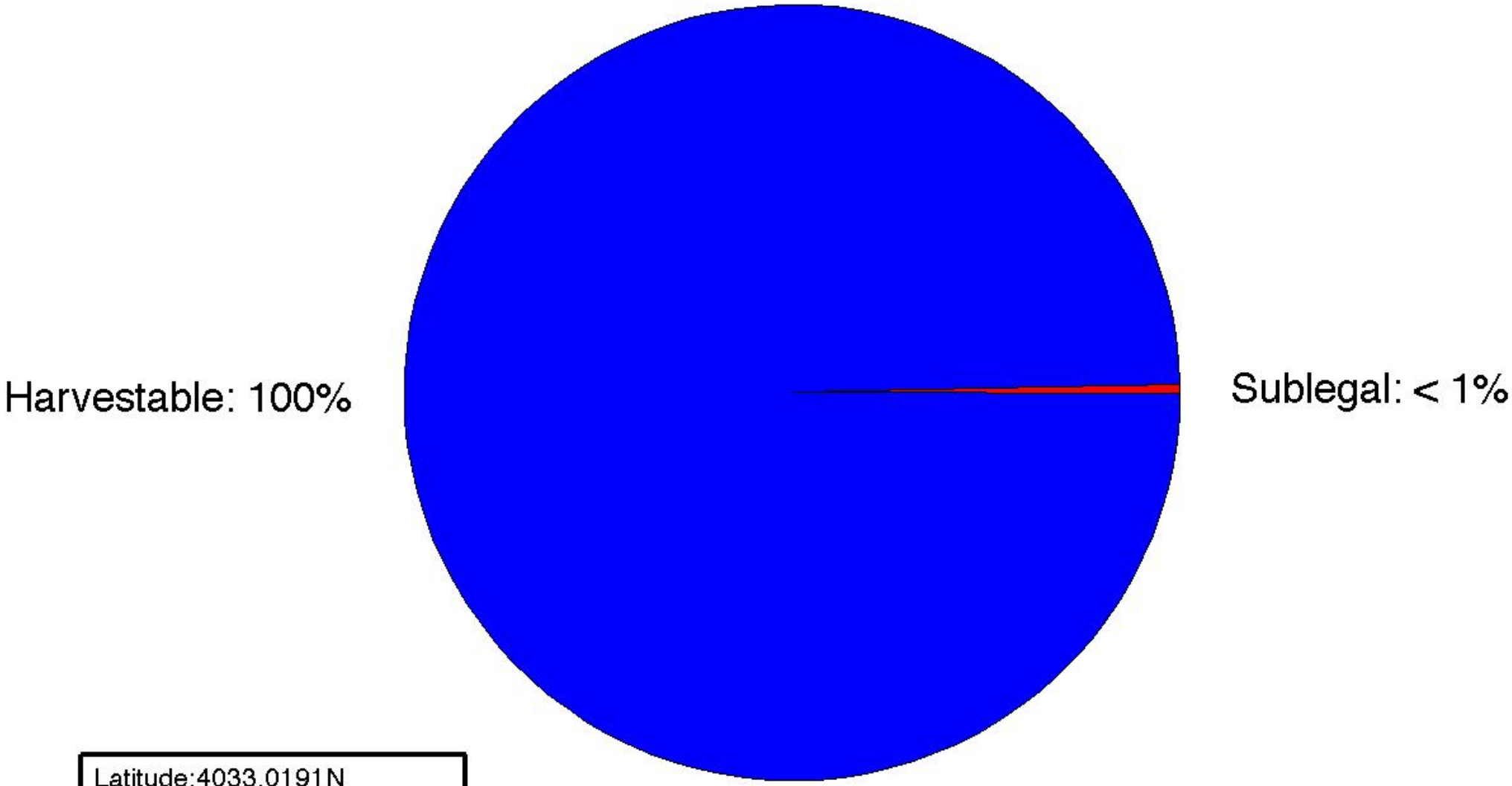


110708ScallopD2 Shell Height Distribution (N=2172)



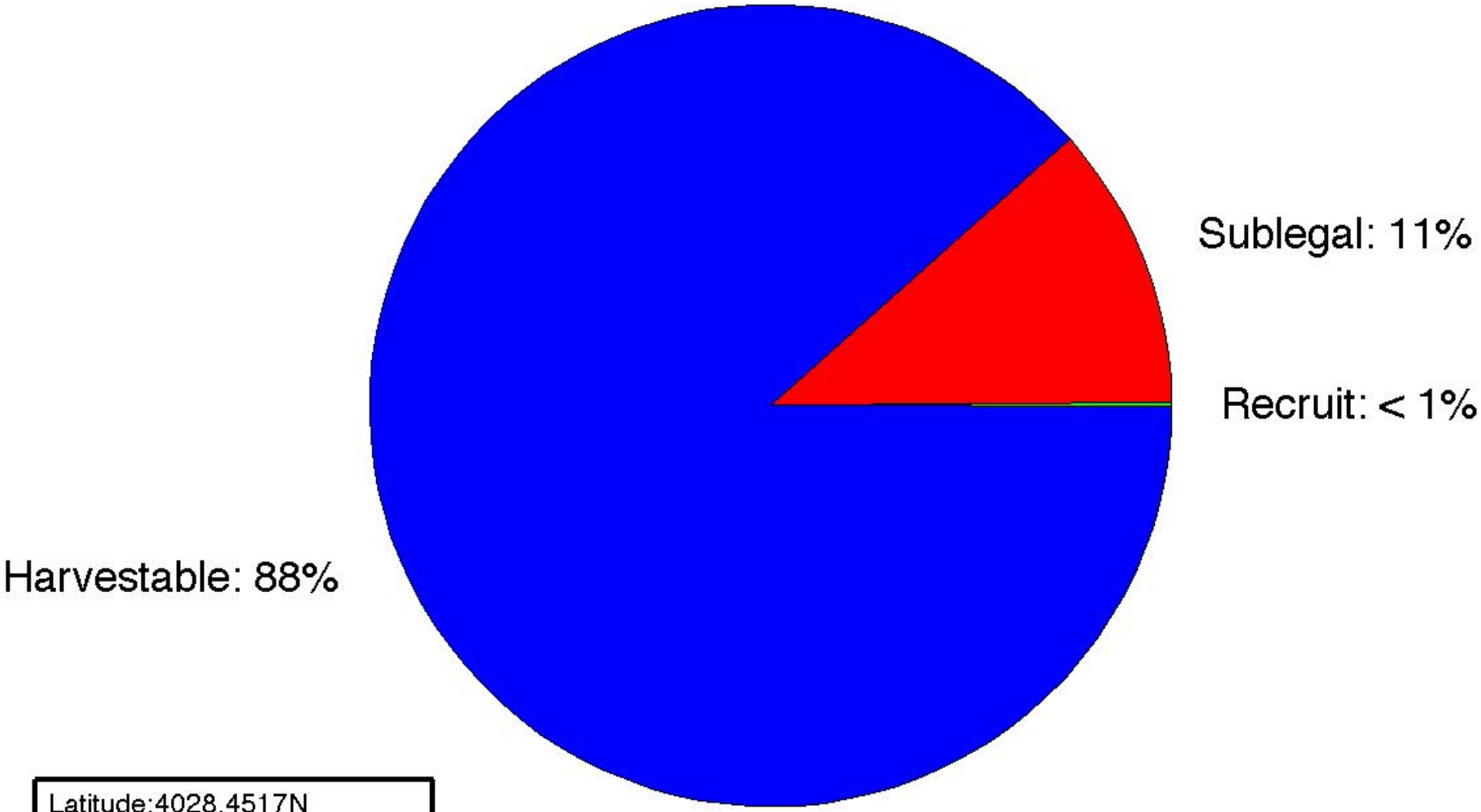
Latitude:4034.1547N
Longitude:07236.1314W
Depth:40m

110708ScallopD2M4Sizing Shell Height Distribution (N=894)



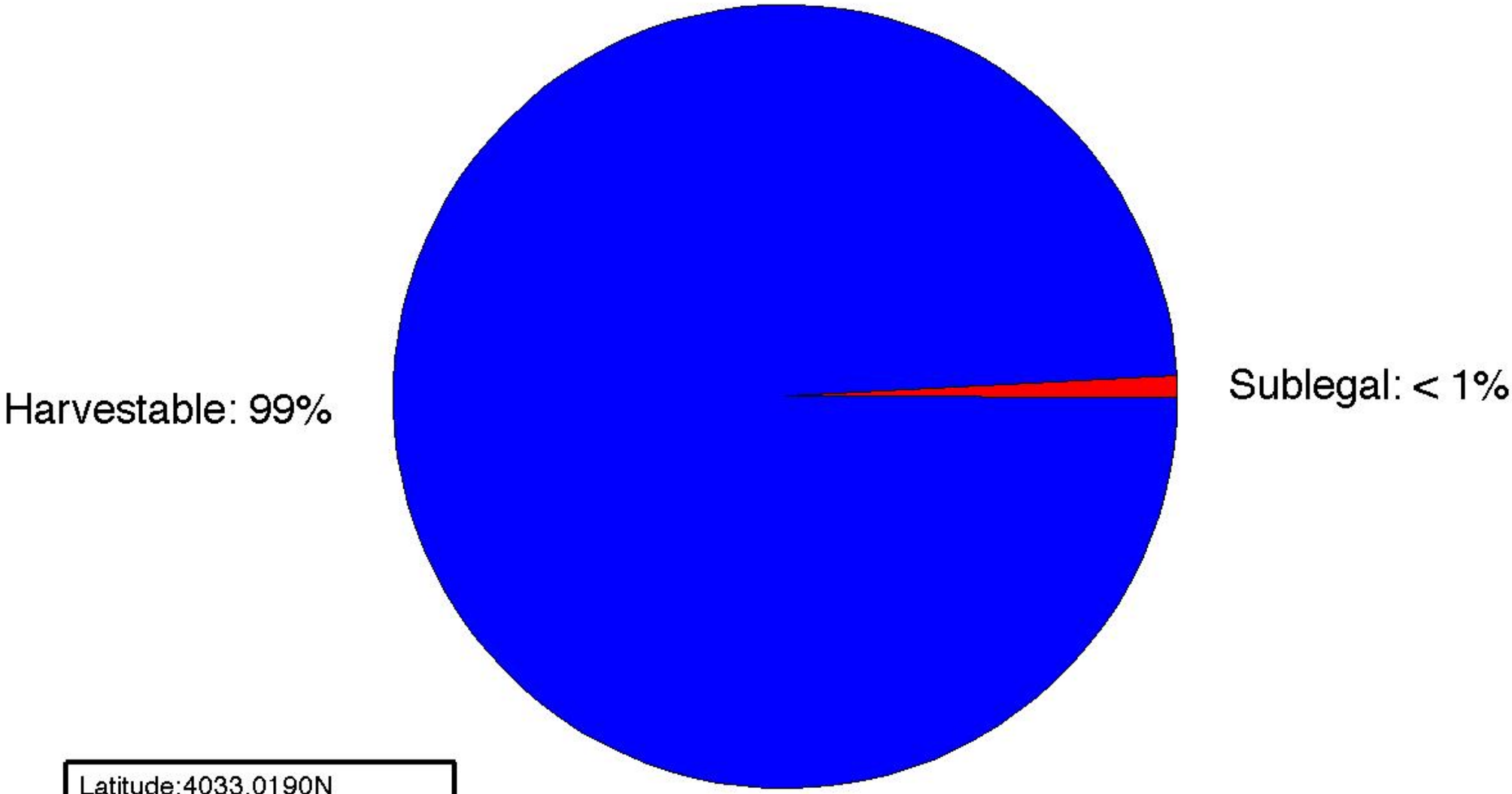
Latitude:4033.0191N
Longitude:07236.5143W
Depth:41m

110708ScallopDvoraRun Shell Height Distribution (N=3706)



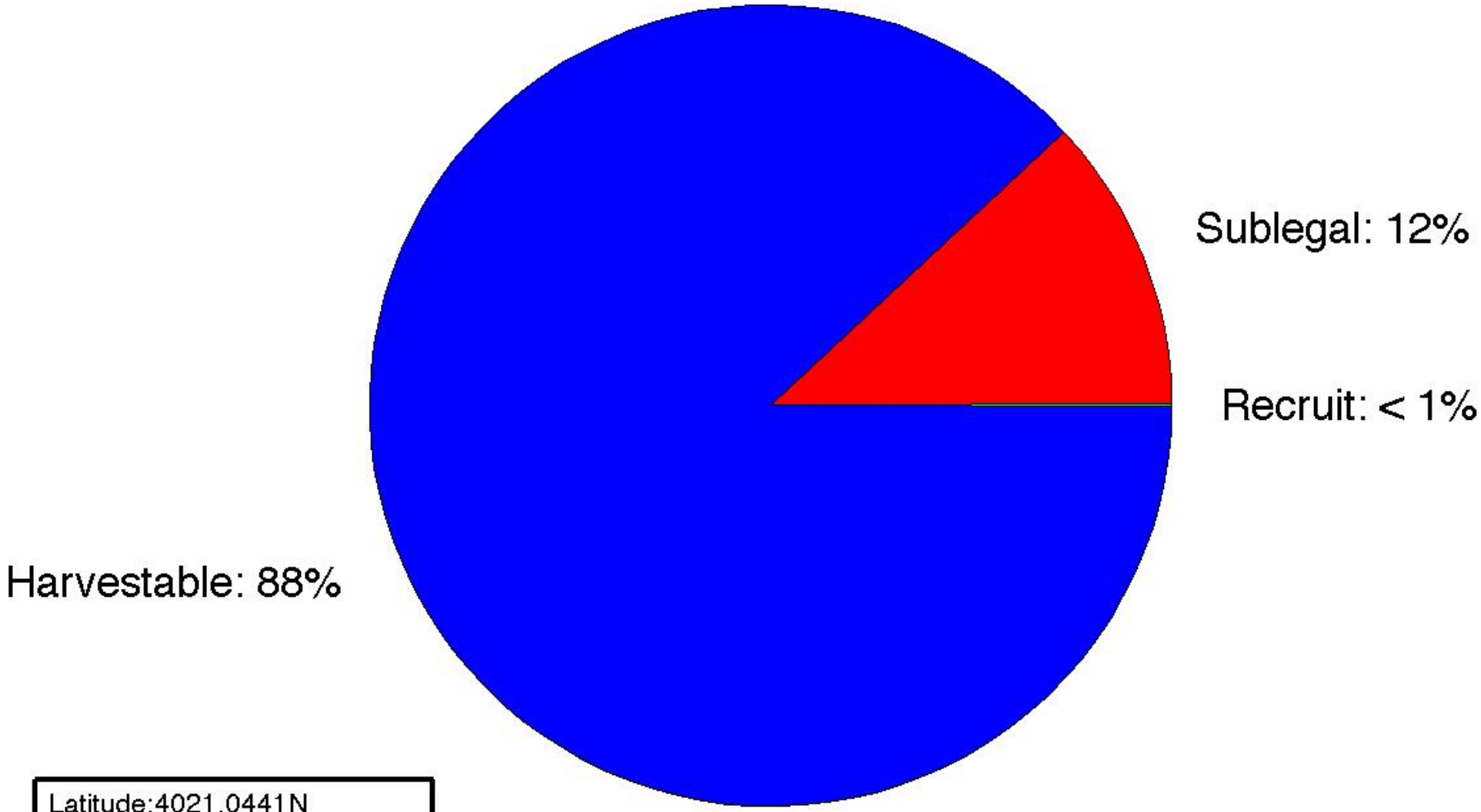
Latitude:4028.4517N
Longitude:07232.0362W
Depth:43m

110708SM2 Shell Height Distribution (N=707)



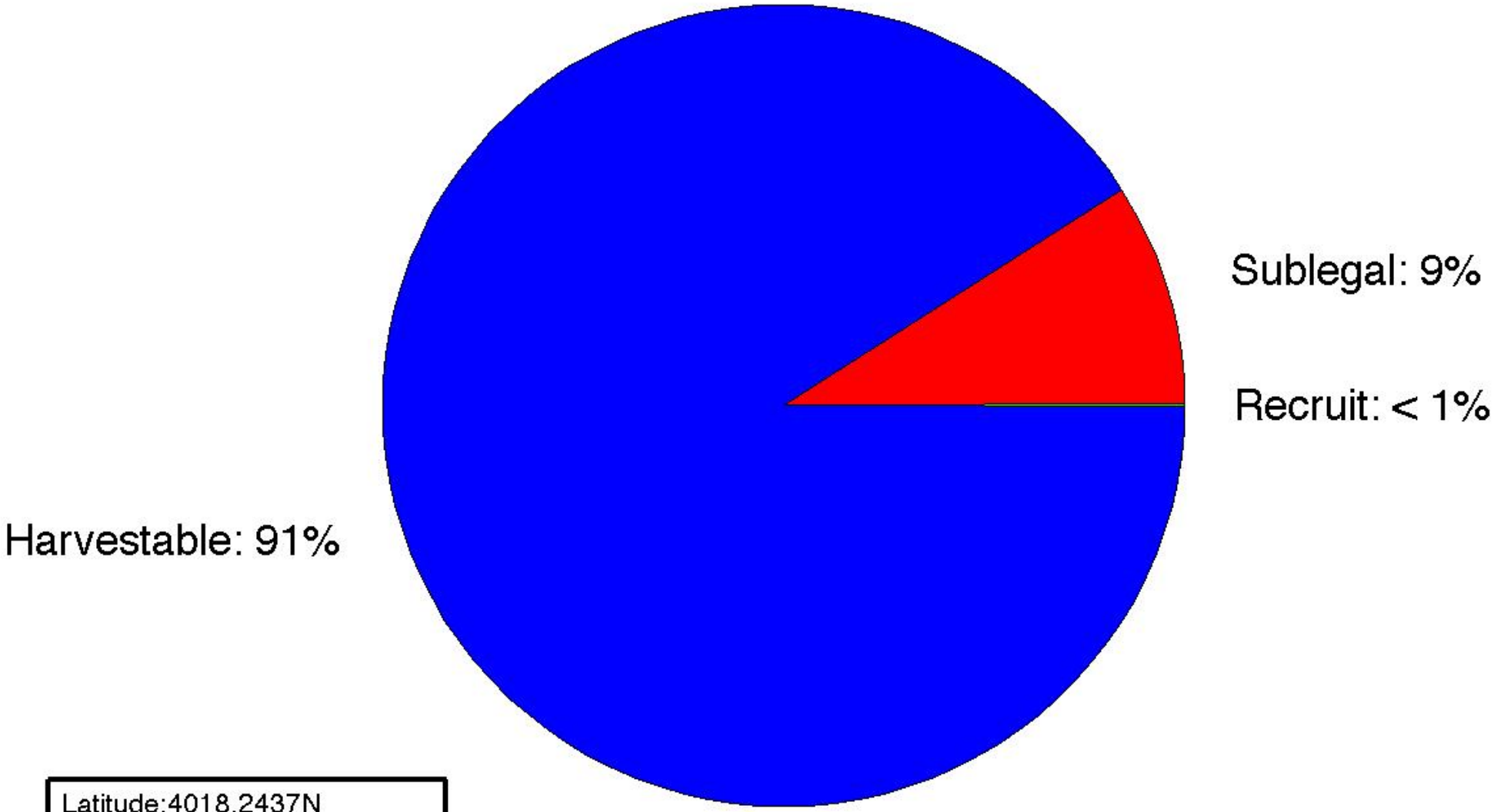
Latitude:4033.0190N
Longitude:07236.6018W
Depth:41m

110709ScallopD3M1 Shell Height Distribution (N=1365)



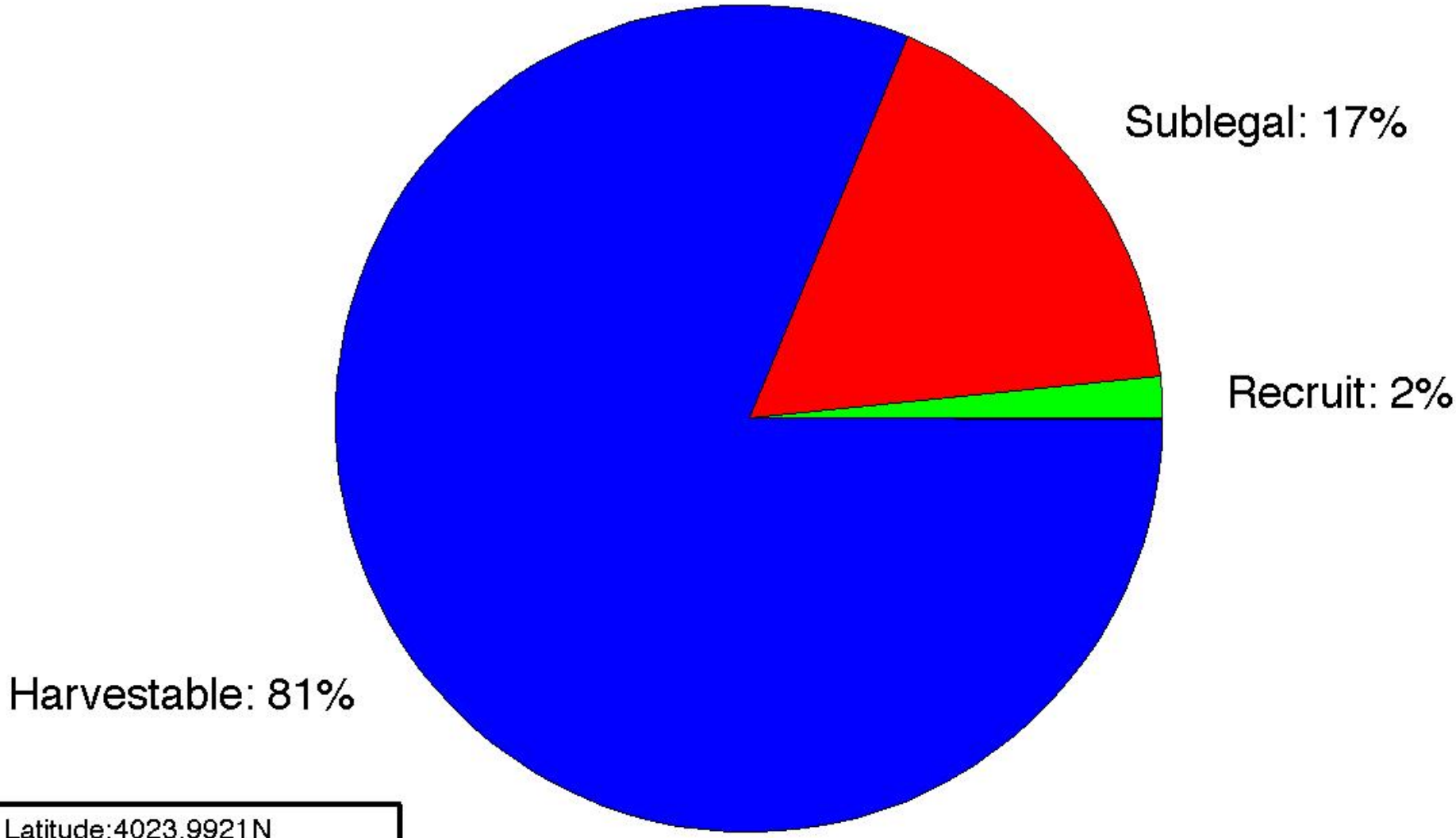
Latitude:4021.0441N
Longitude:07252.3345W
Depth:44m

110709ScallopDay3DV119 Shell Height Distribution (N=1850)



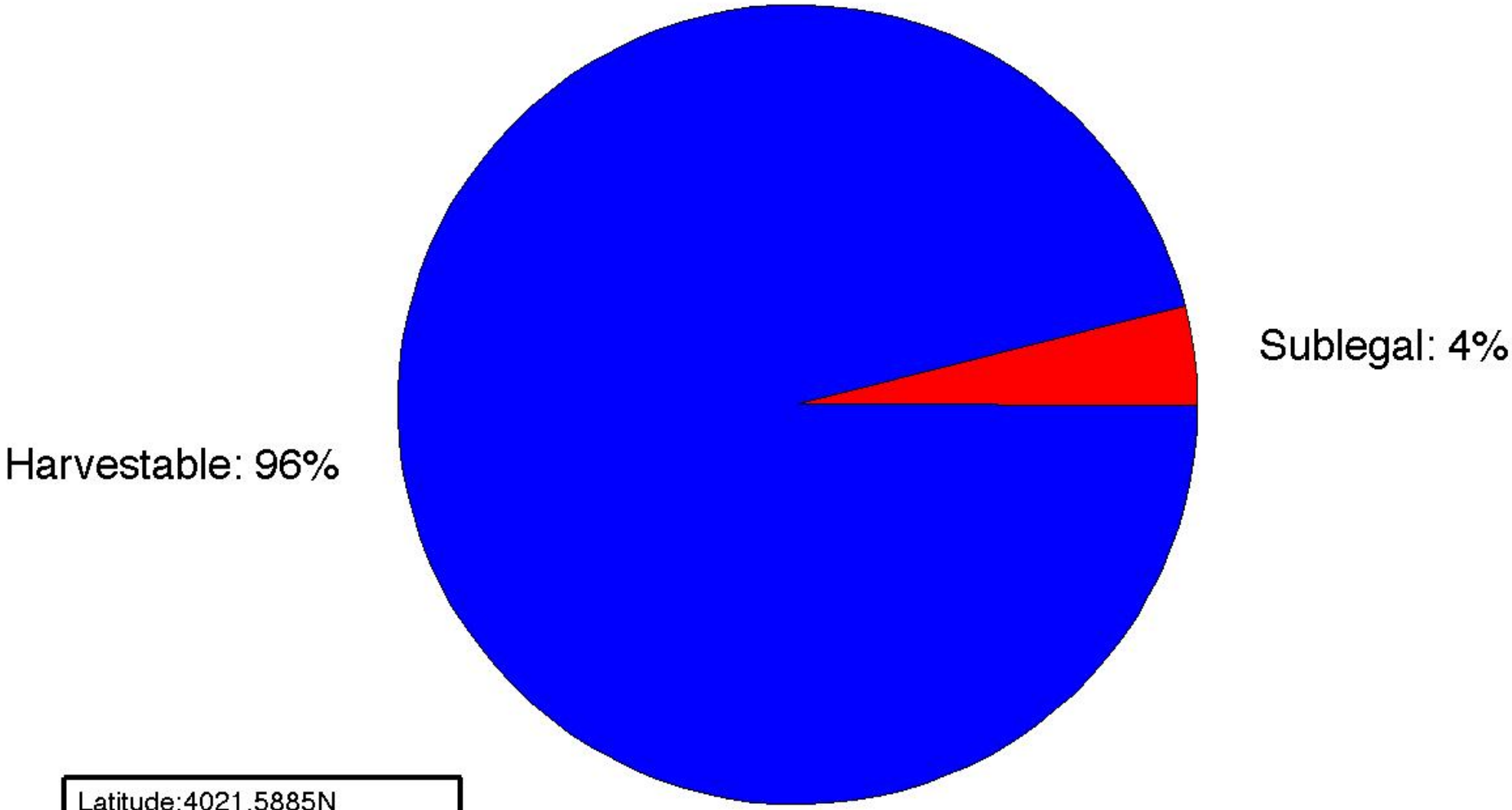
Latitude:4018.2437N
Longitude:07304.0246W
Depth:40m

110710DV117 Shell Height Distribution (N=422).



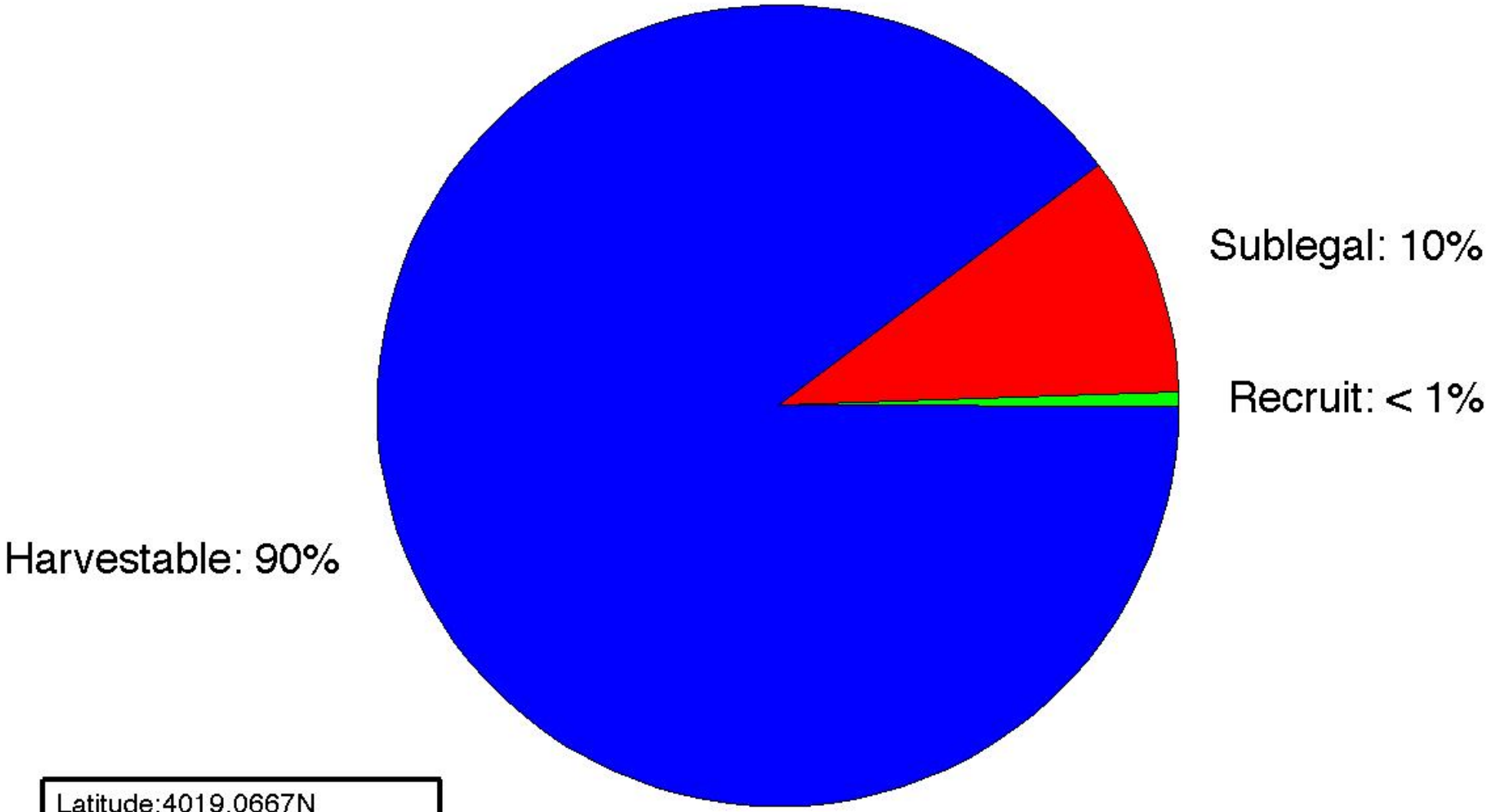
Latitude:4023.9921N
Longitude:07323.8567W
Depth:30m

110710DV118 Shell Height Distribution (N=227).



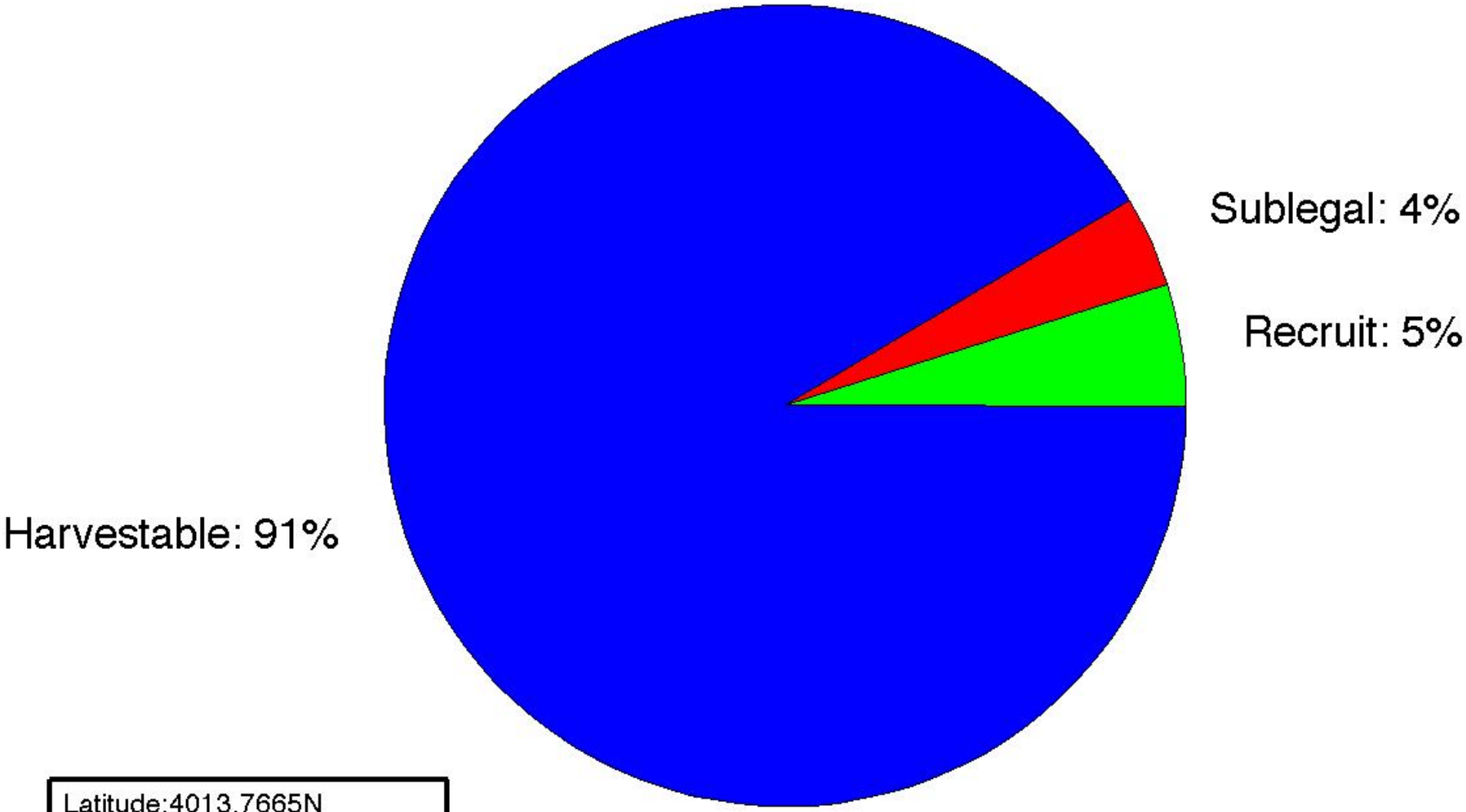
Latitude:4021.5885N
Longitude:07321.6772W
Depth:32m

110710M1ArtiesRun Shell Height Distribution (N=1403)



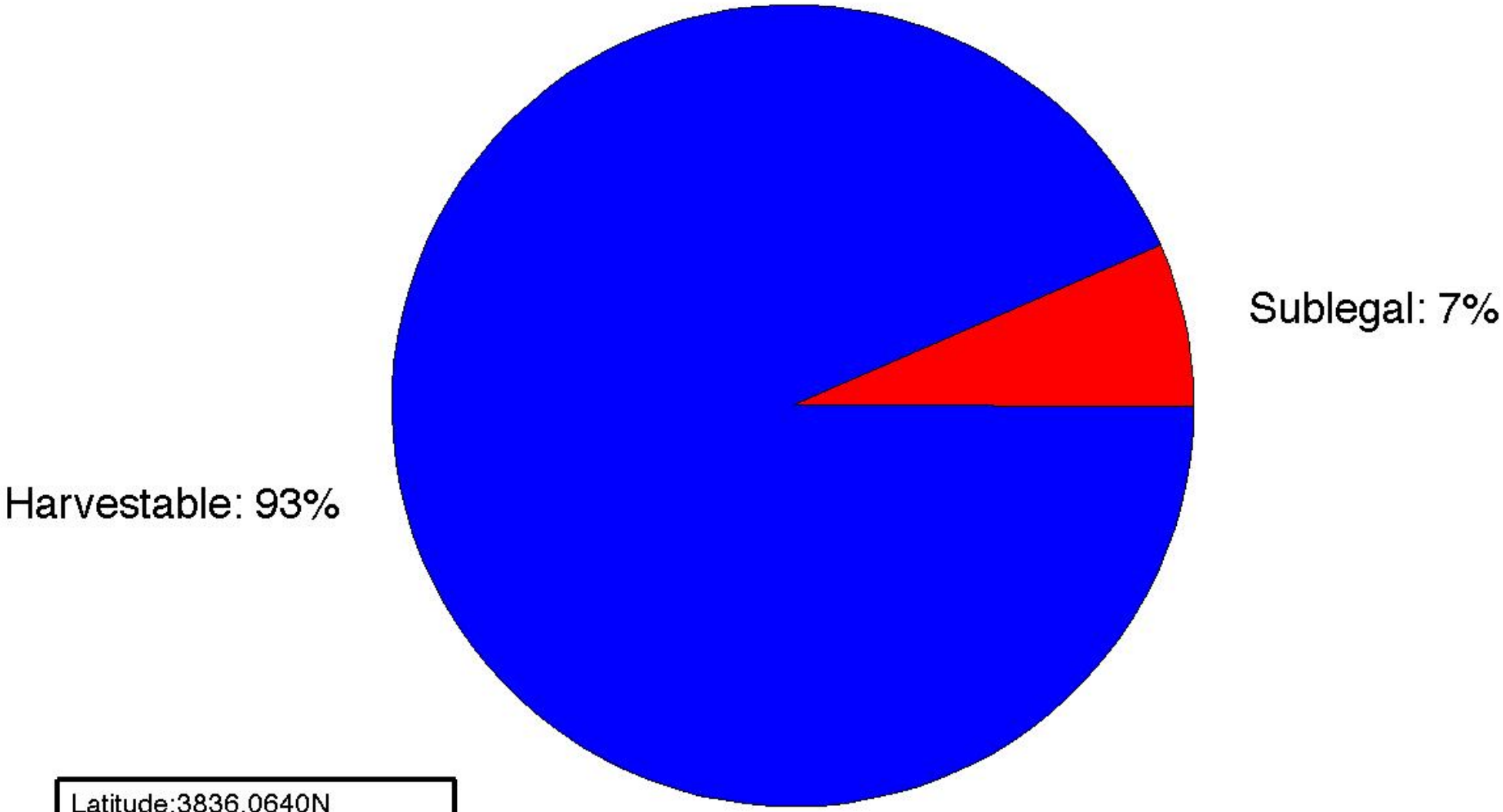
Latitude:4019.0667N
Longitude:07317.6349W
Depth:33m

110711DV115 Shell Height Distribution (N=82).



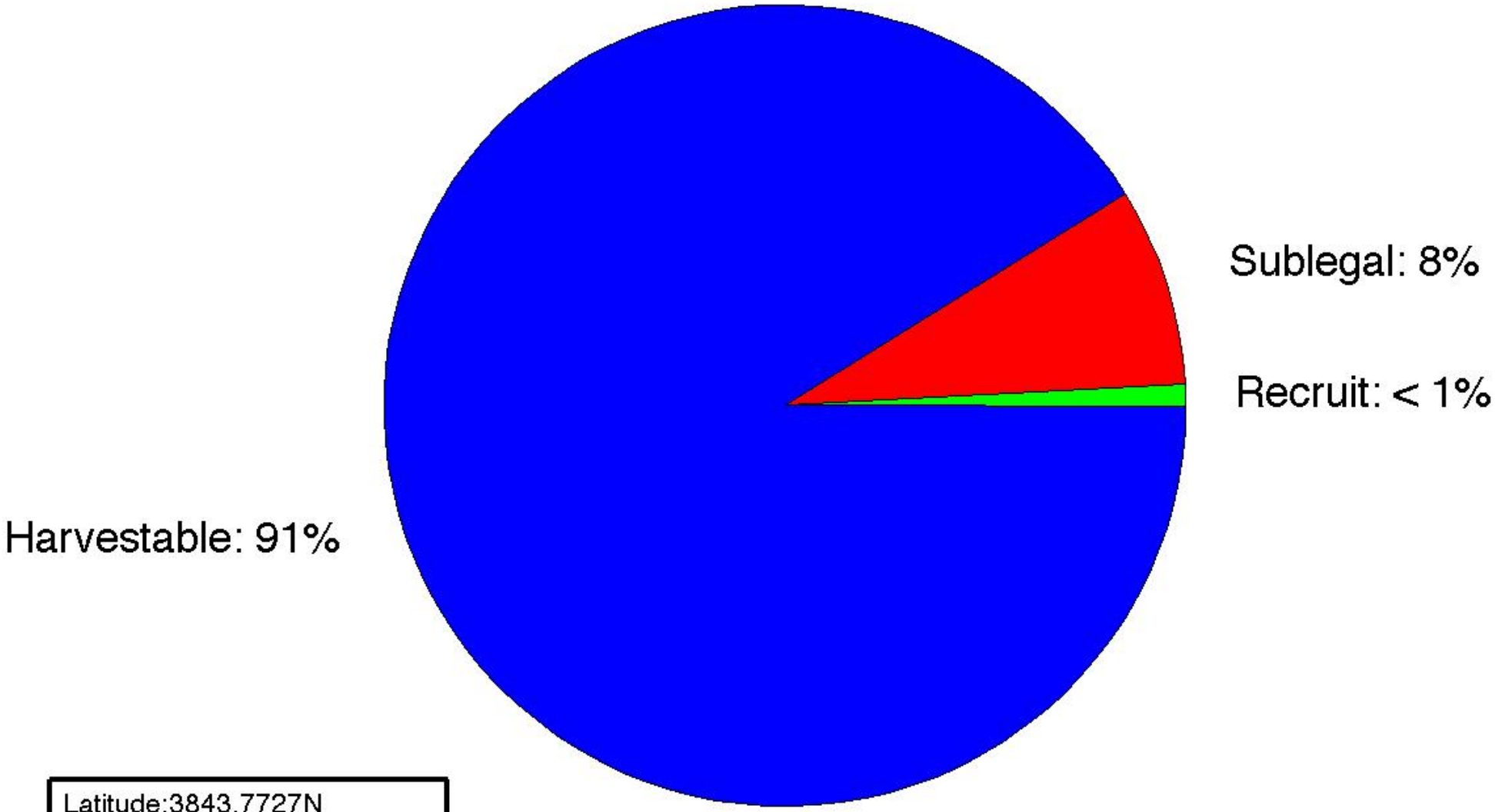
Latitude:4013.7665N
Longitude:07347.3676W
Depth:33m

110726ScallopD1DV2M2 Shell Height Distribution (N=229)



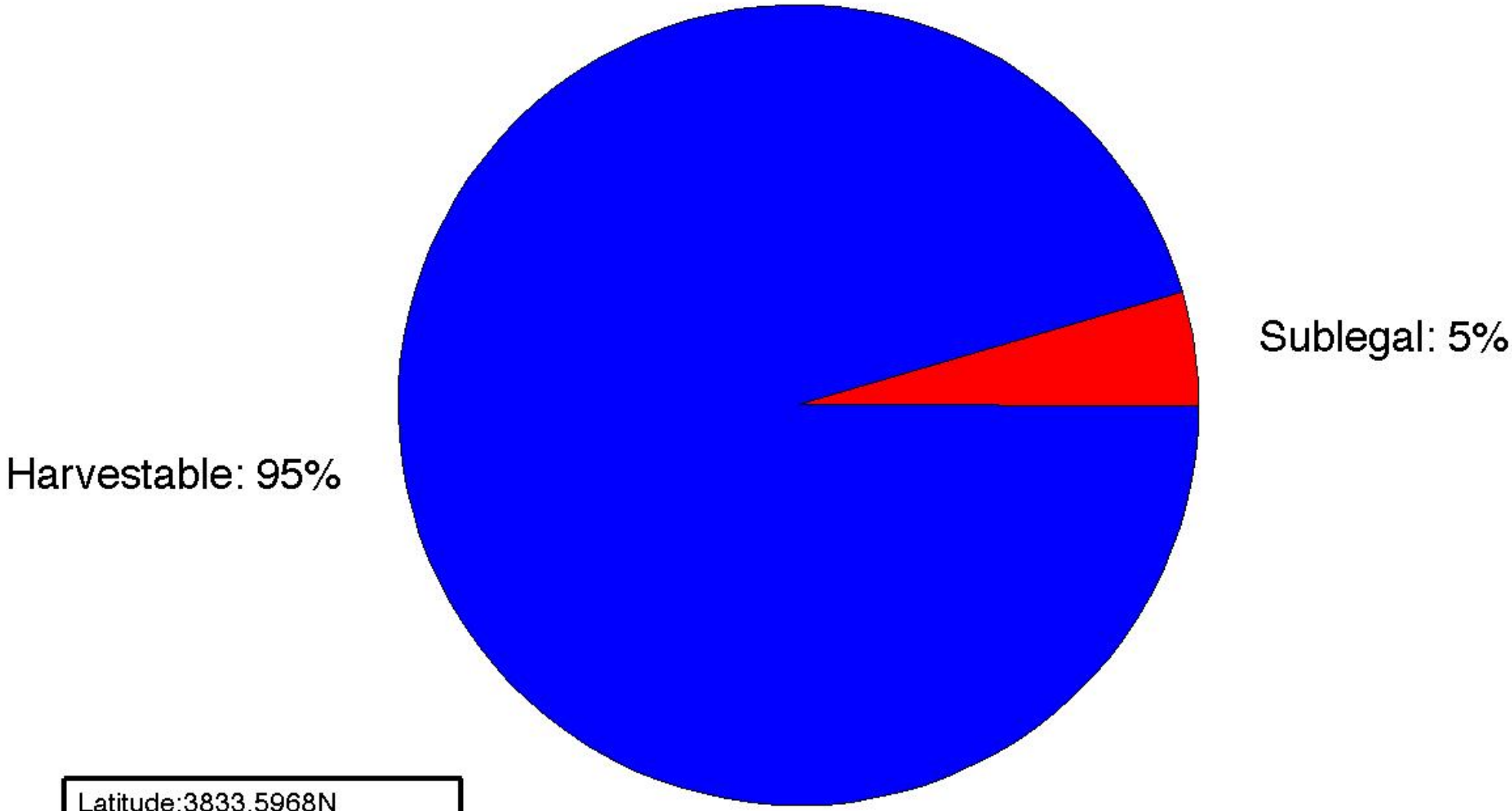
Latitude:3836.0640N
Longitude:07410.4852W
Depth:52m

110726ScallopD1DV44M3 Shell Height Distribution (N=113)



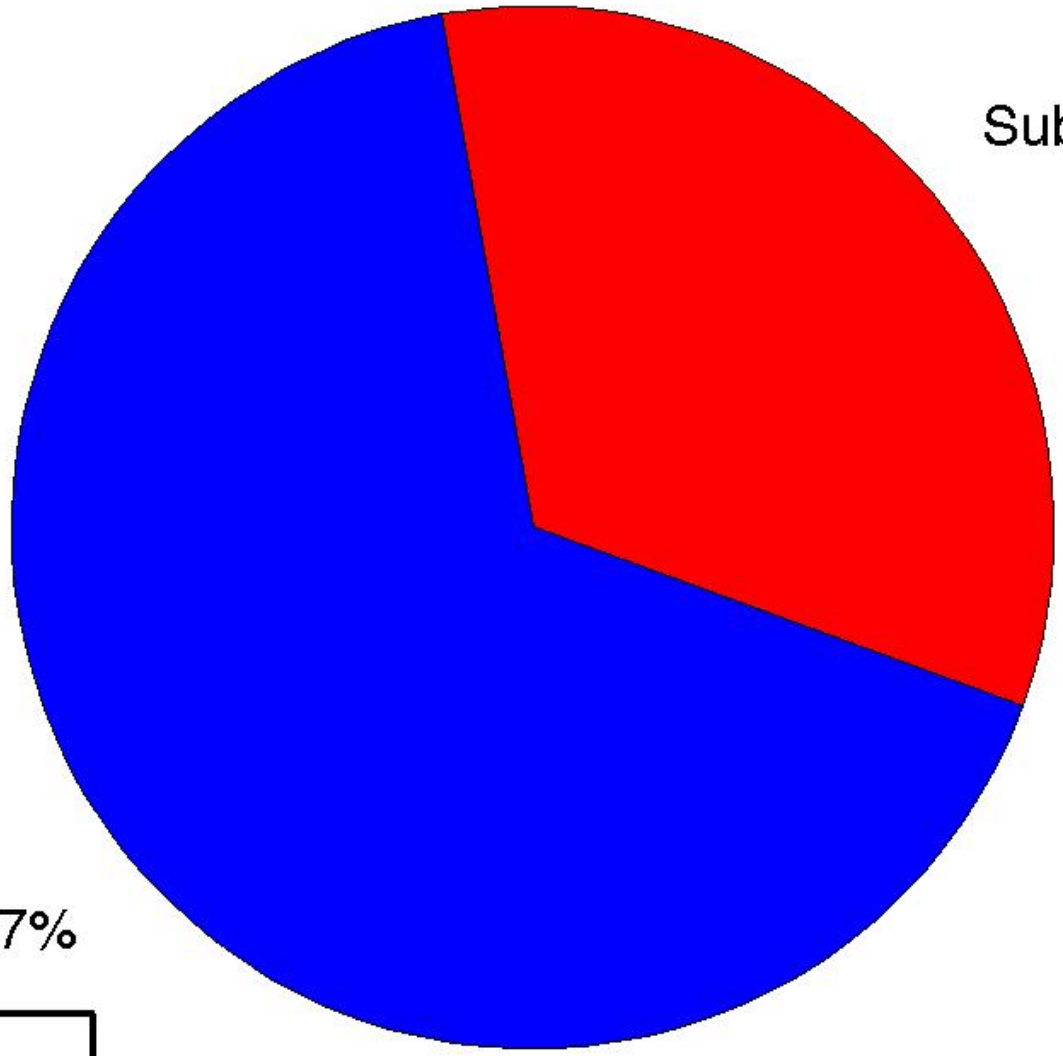
Latitude:3843.7727N
Longitude:07403.0895W
Depth:47m

110726ScallopD1M1 Shell Height Distribution (N=132)



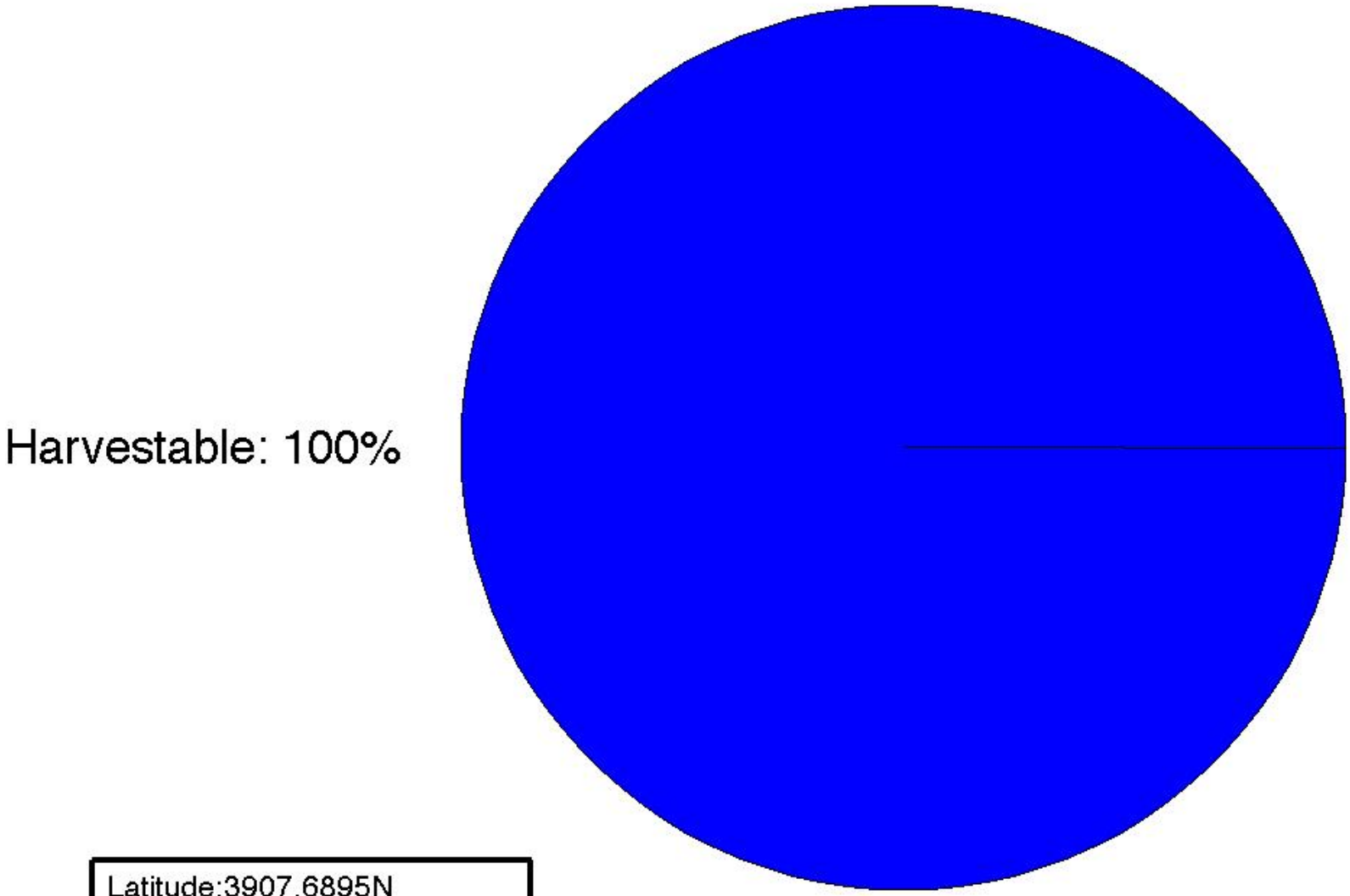
Latitude:3833.5968N
Longitude:07418.3964W
Depth:45m

110727D2R2M2 Shell Height Distribution (N=3)



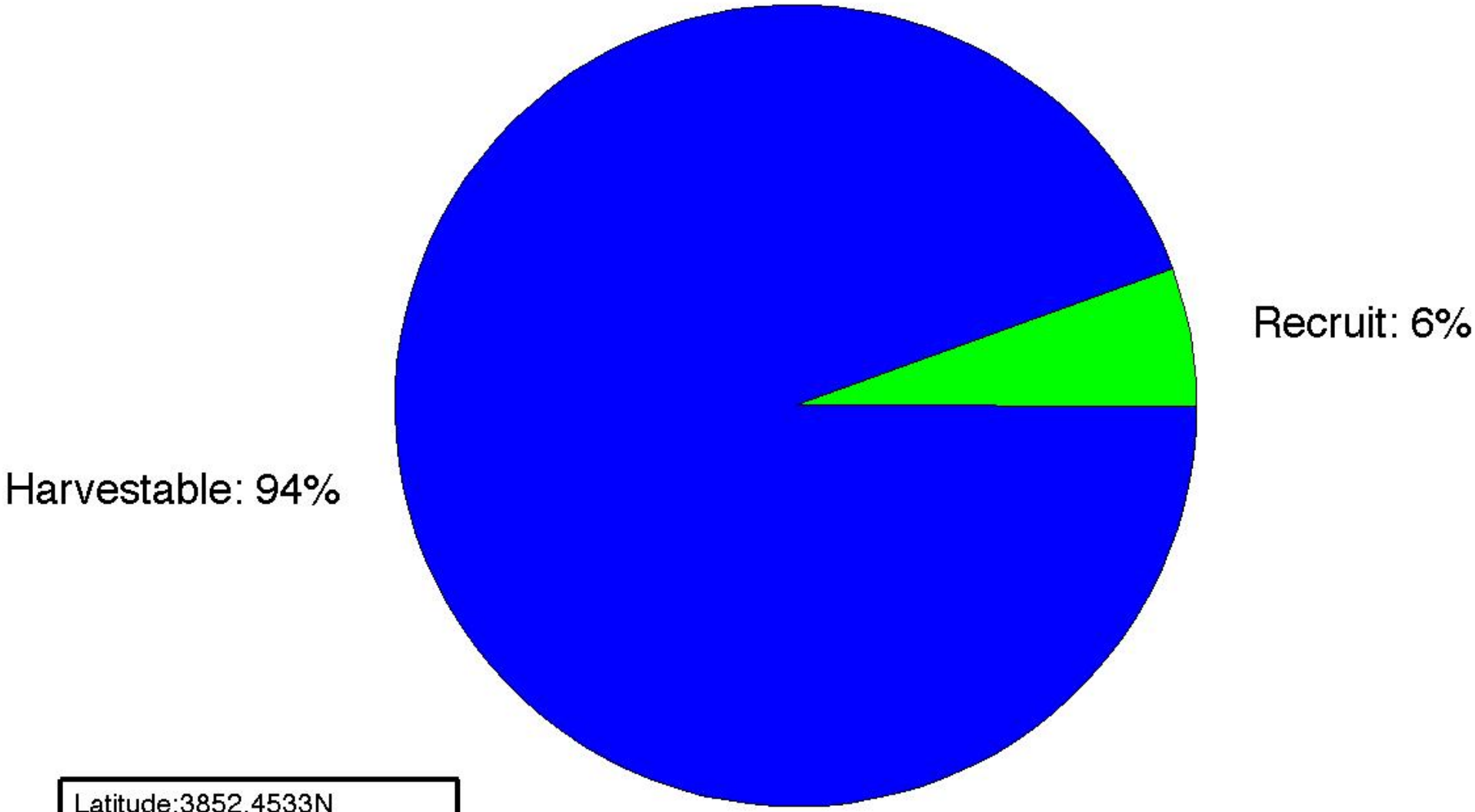
Latitude:3905.4919N
Longitude:07426.8228W
Depth:20m

110727D2R3M3 Shell Height Distribution (N=1)



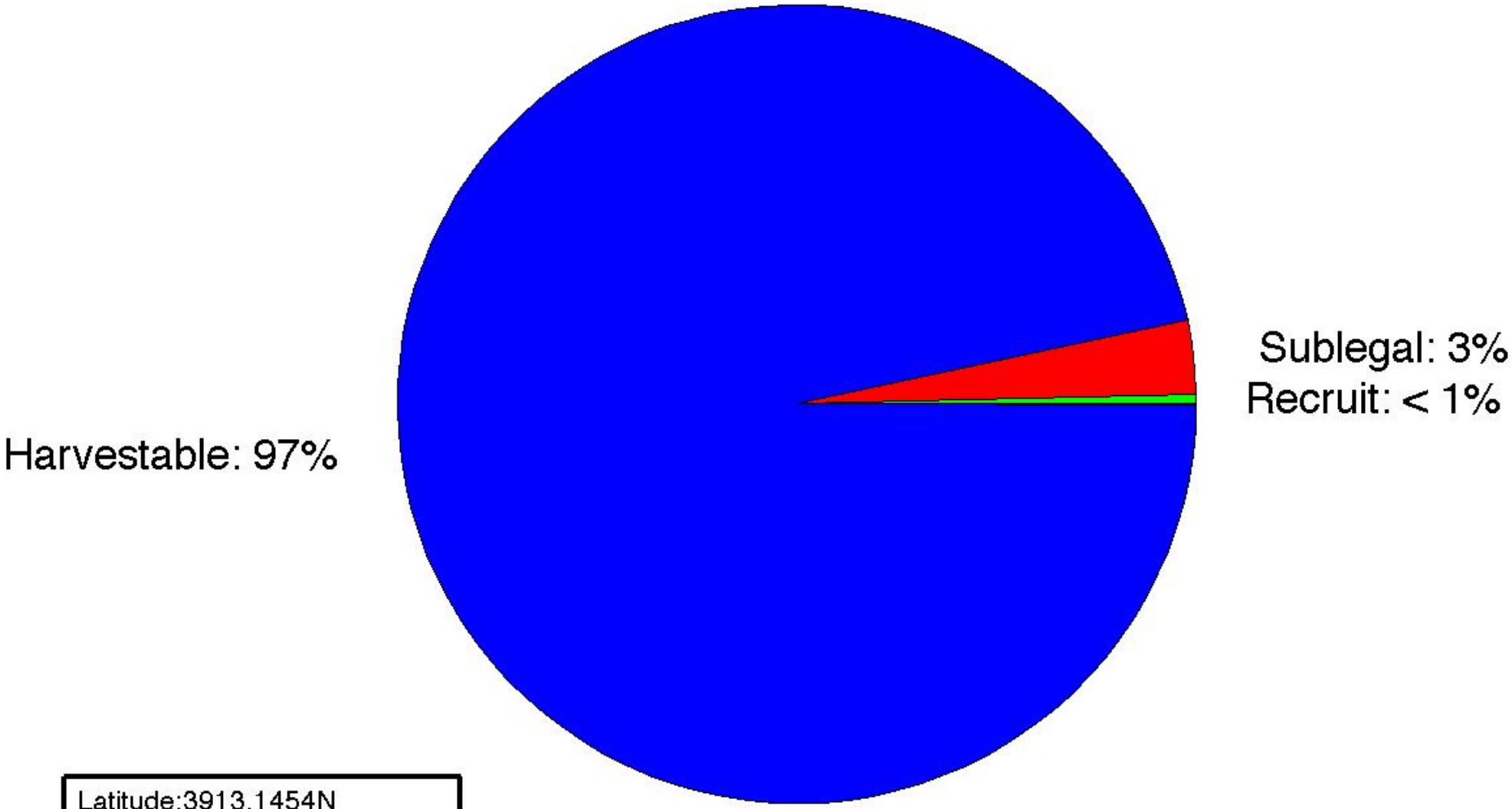
Latitude:3907.6895N
Longitude:07404.5050W
Depth:36m

110727ScallopD2R1M1 Shell Height Distribution (N=18)



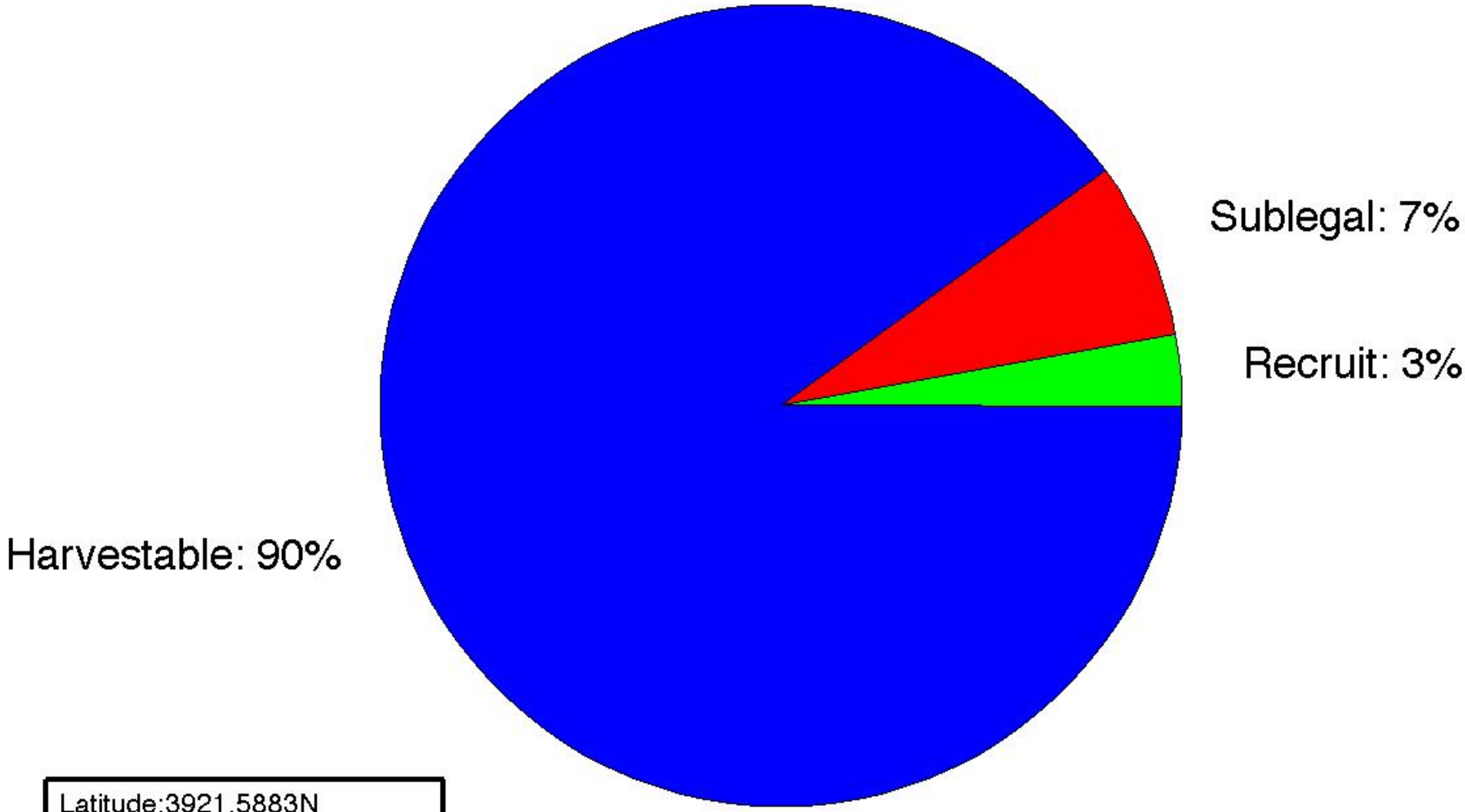
Latitude:3852.4533N
Longitude:07417.0881W
Depth:39m

110728D3DV062M3 Shell Height Distribution (N=506)



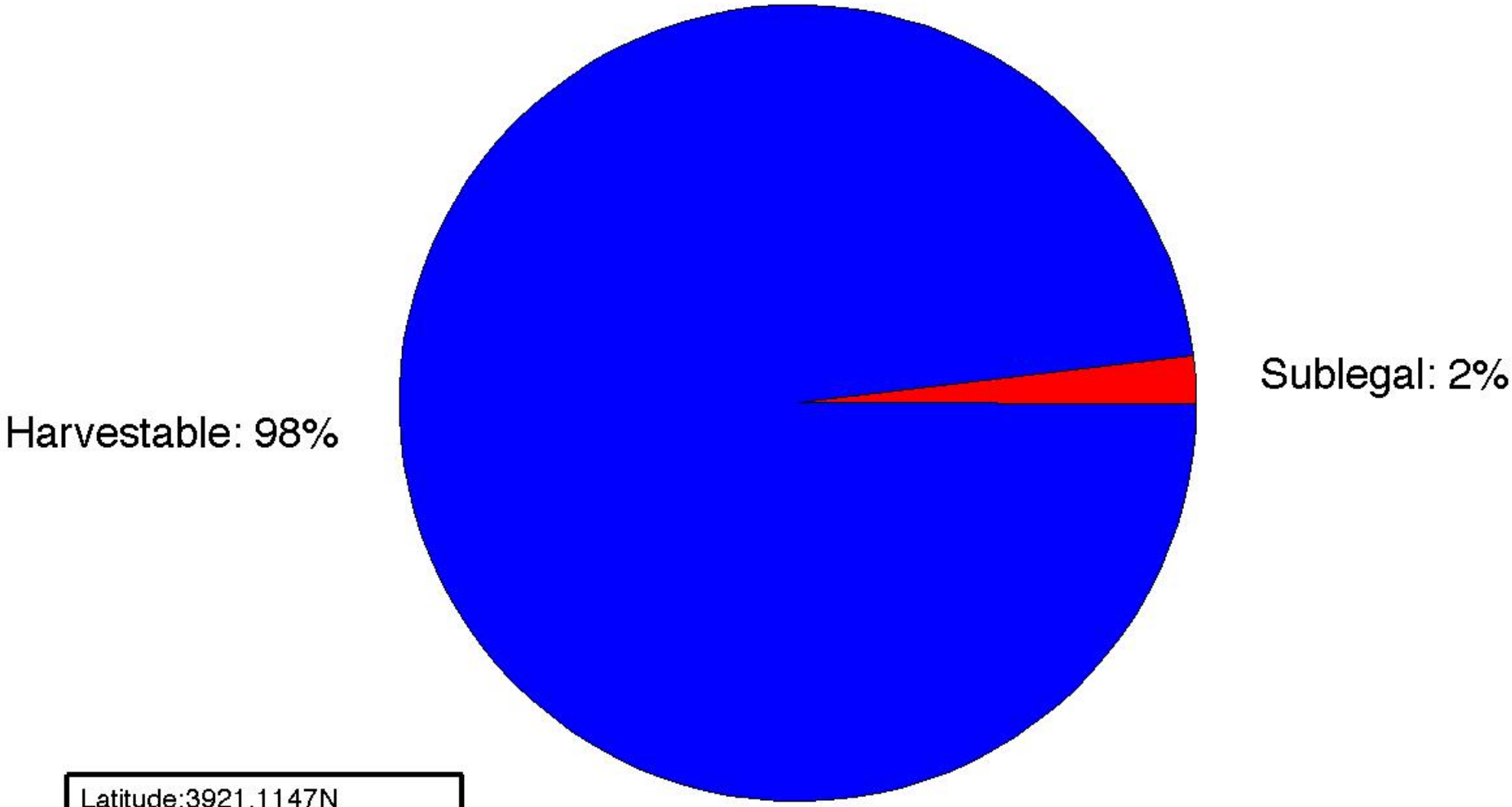
Latitude:3913.1454N
Longitude:07338.8069W
Depth:45m

110728D3DV063M4 Shell Height Distribution (N=140)



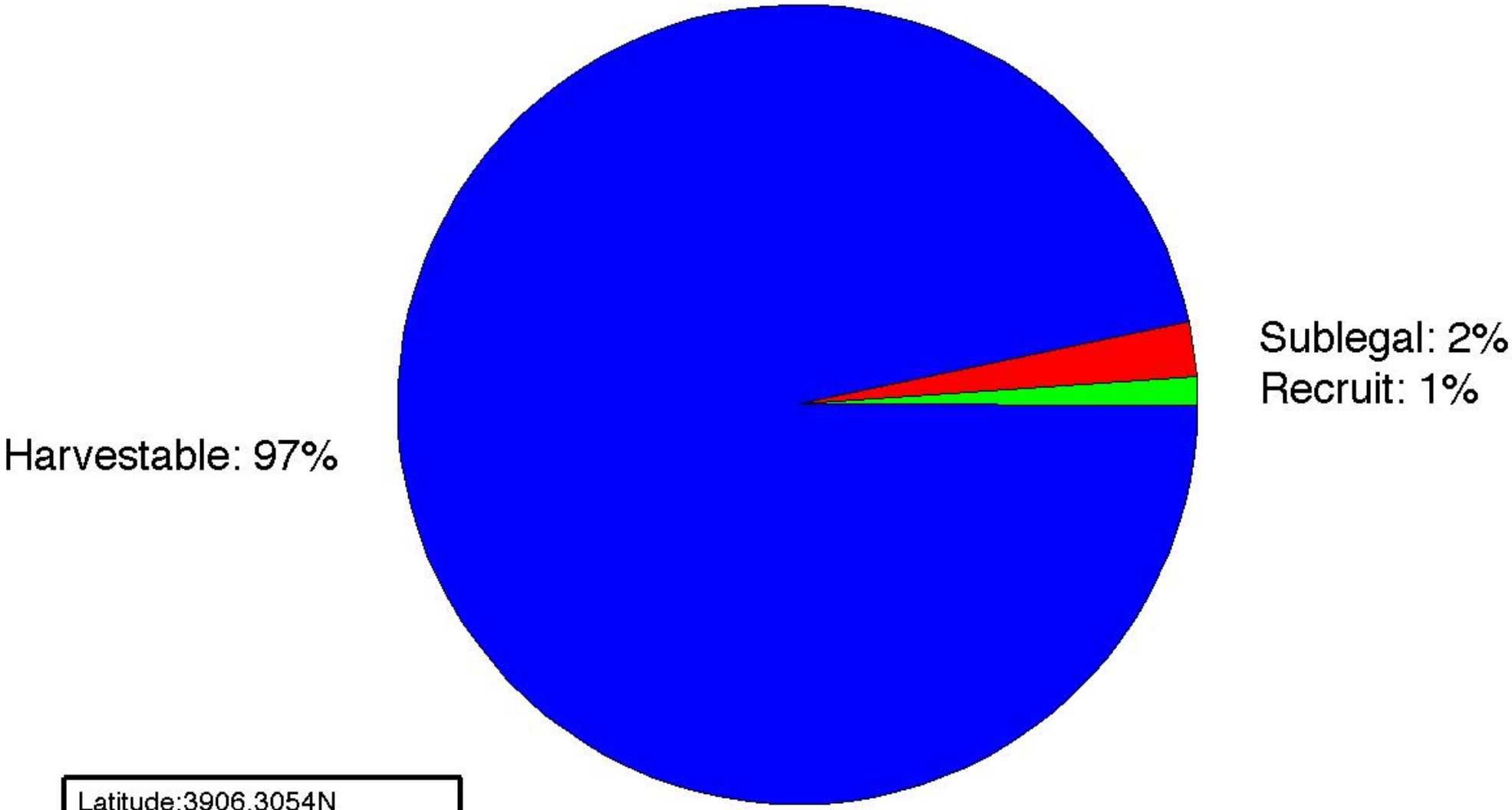
Latitude:3921.5883N
Longitude:07331.3033W
Depth:49m

110728D3R6M1 Shell Height Distribution (N=523)



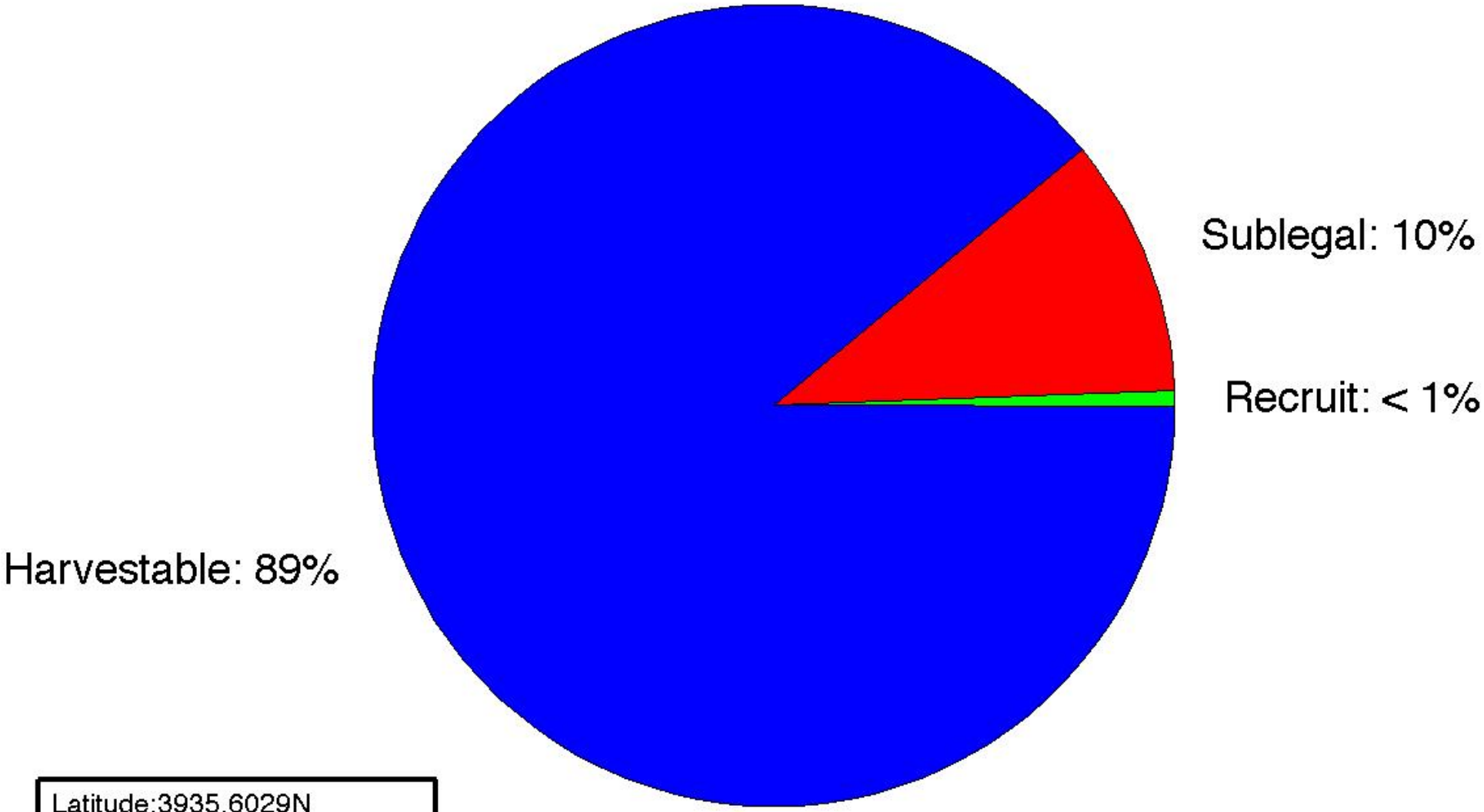
Latitude:3921.1147N
Longitude:07347.4586W
Depth:38m

110728D3R7M2 Shell Height Distribution (N=90)



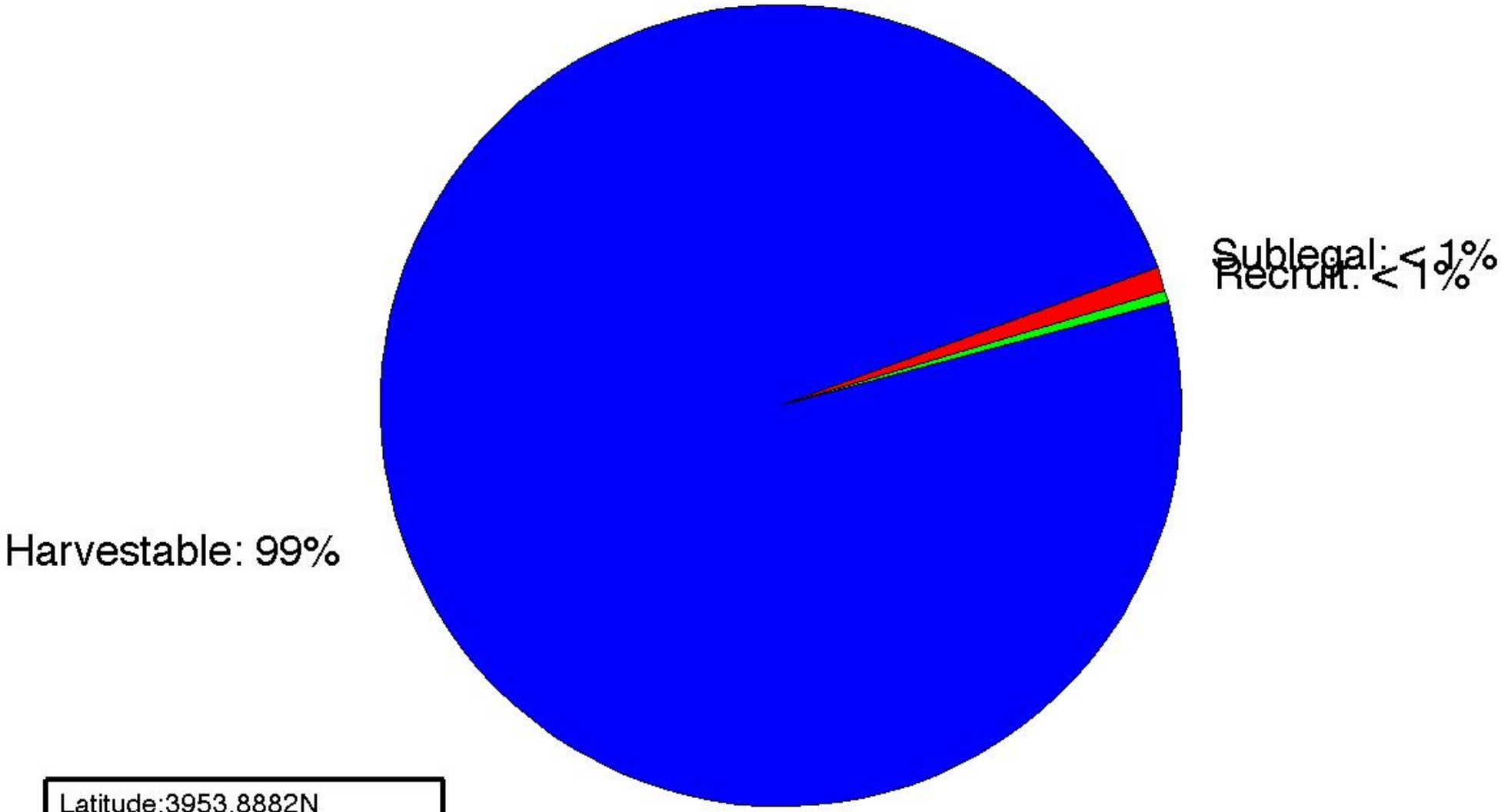
Latitude:3906.3054N
Longitude:07359.0386W
Depth:40m

110728D3R8M5 Shell Height Distribution (N=508)



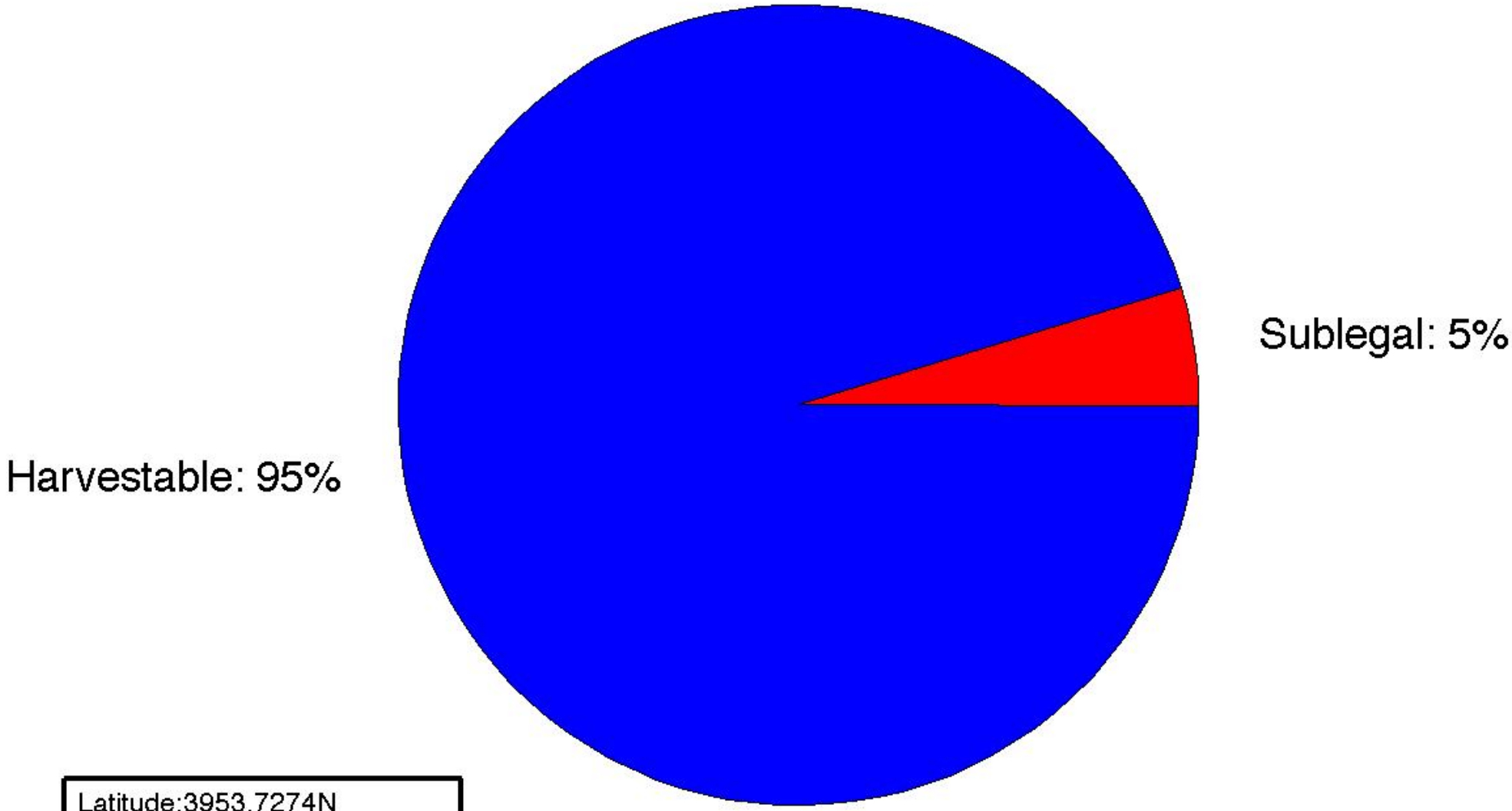
Latitude:3935.6029N
Longitude:07331.7419W
Depth:39m

110729D4DV0105M2 Shell Height Distribution (N=212)



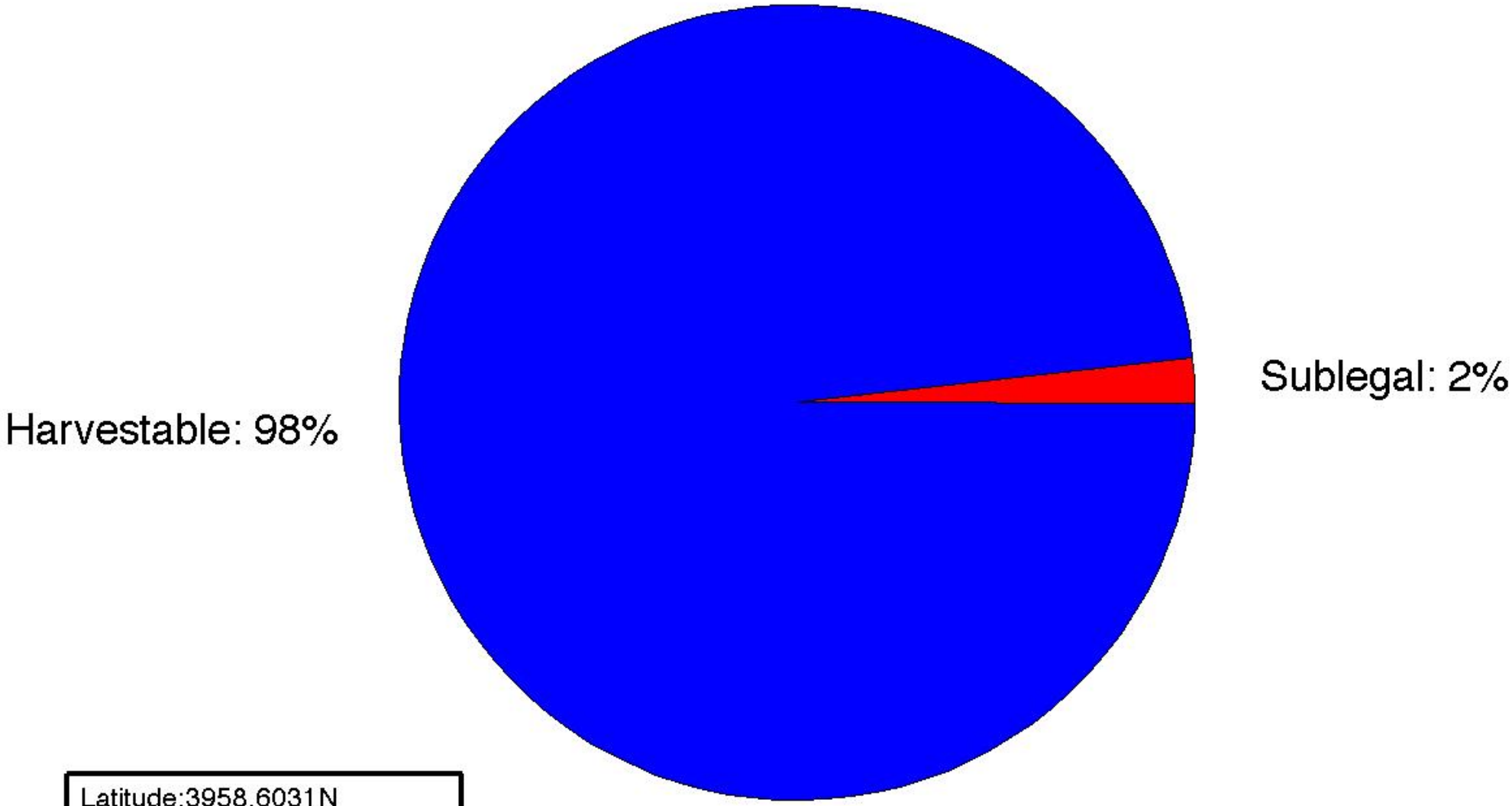
Latitude:3953.8882N
Longitude:07336.3378W
Depth:31m

110729D4DV0106M1 Shell Height Distribution (N=801)



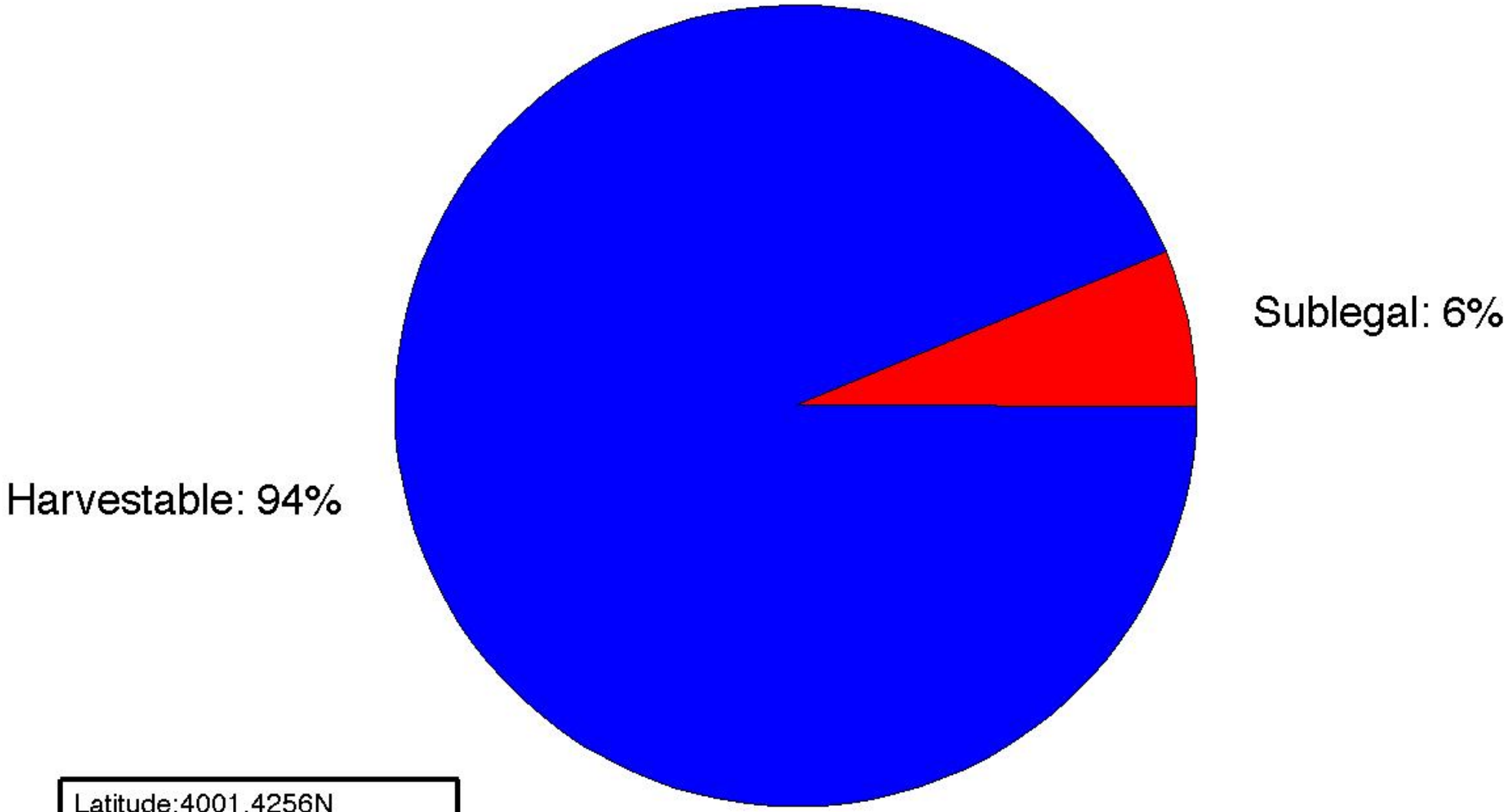
Latitude:3953.7274N
Longitude:07332.5991W
Depth:35m

110729D4DV0112M3 Shell Height Distribution (N=331)



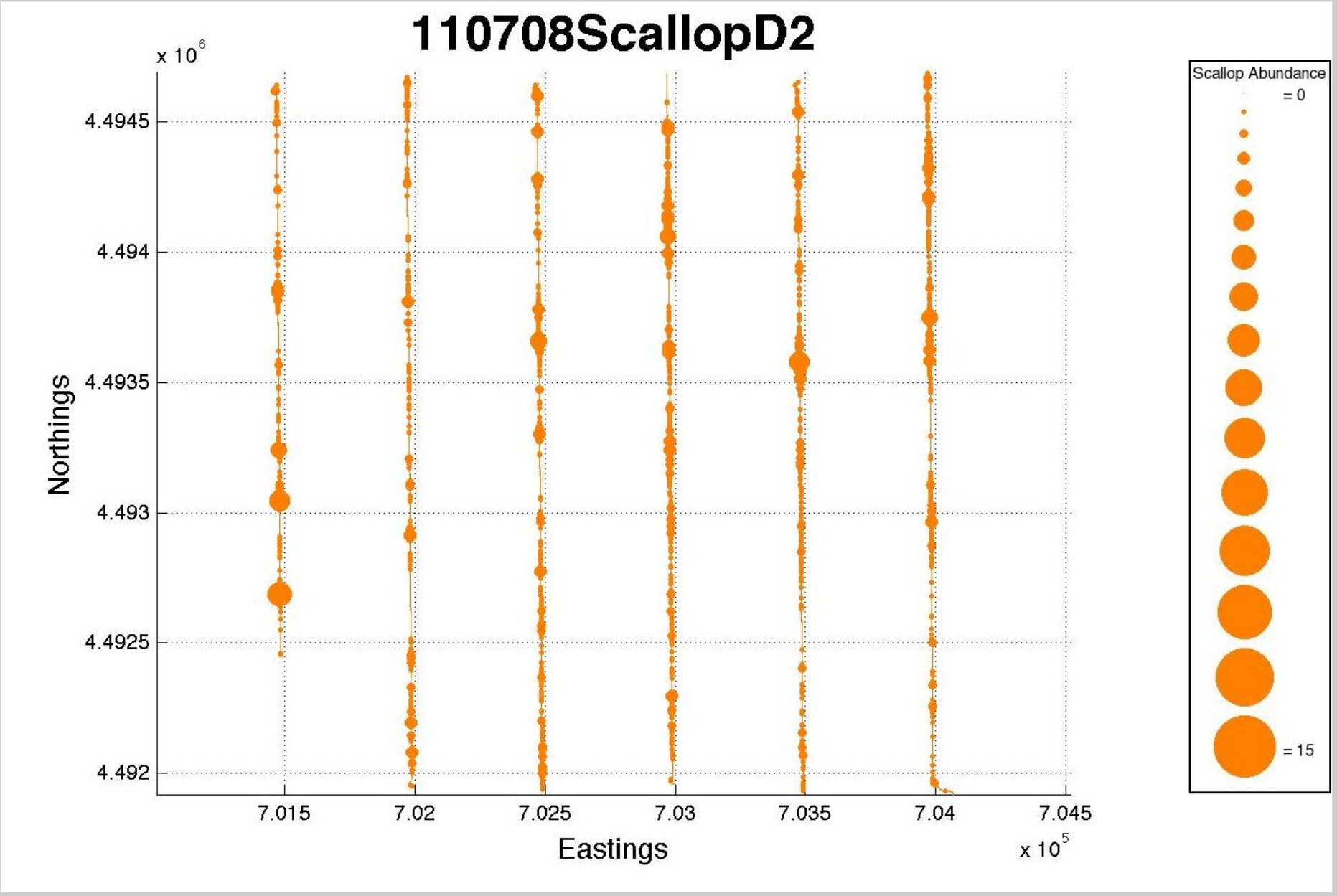
Latitude:3958.6031N
Longitude:07339.1653W
Depth:36m

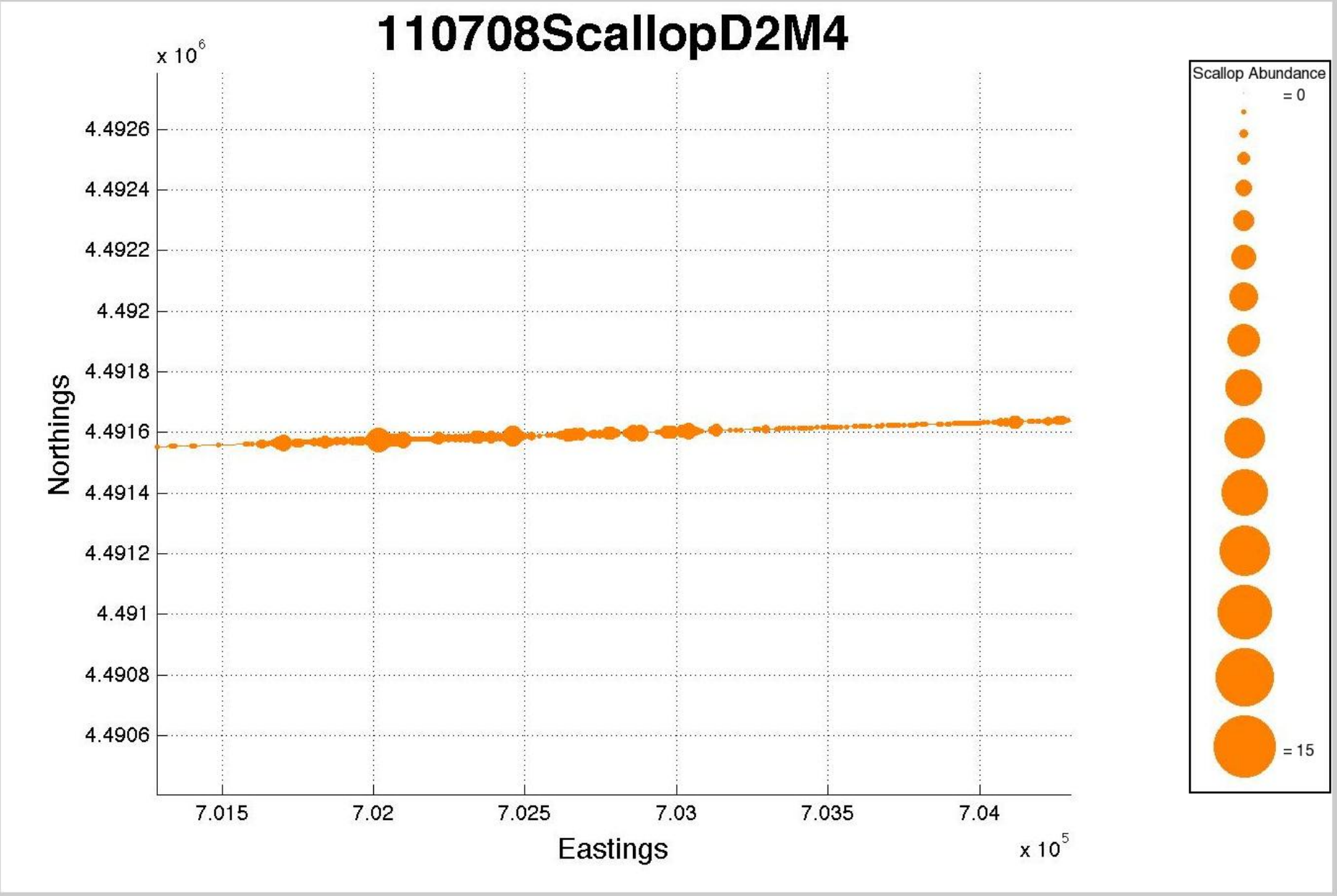
110729D4DV0113M4 Shell Height Distribution (N=16)

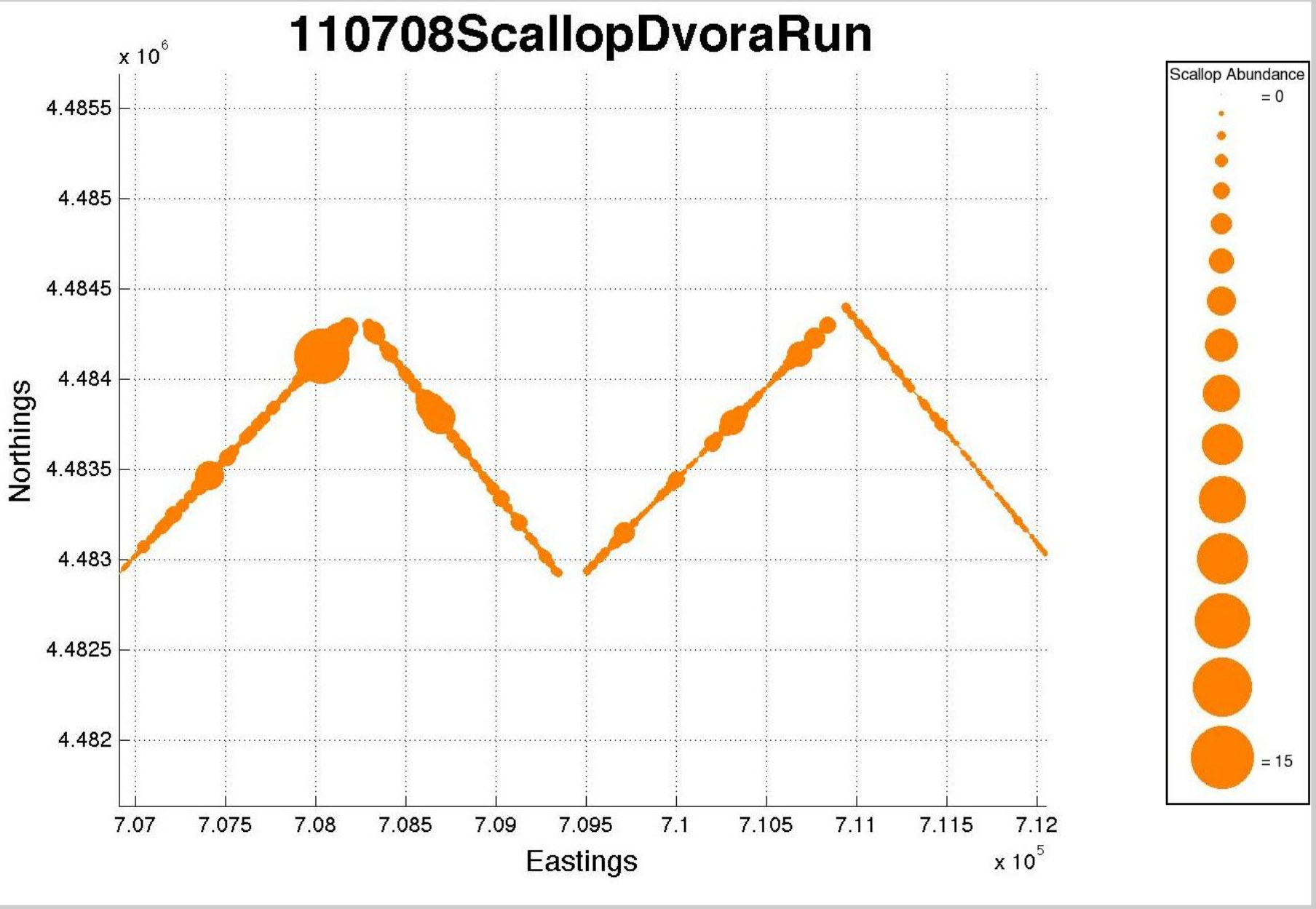


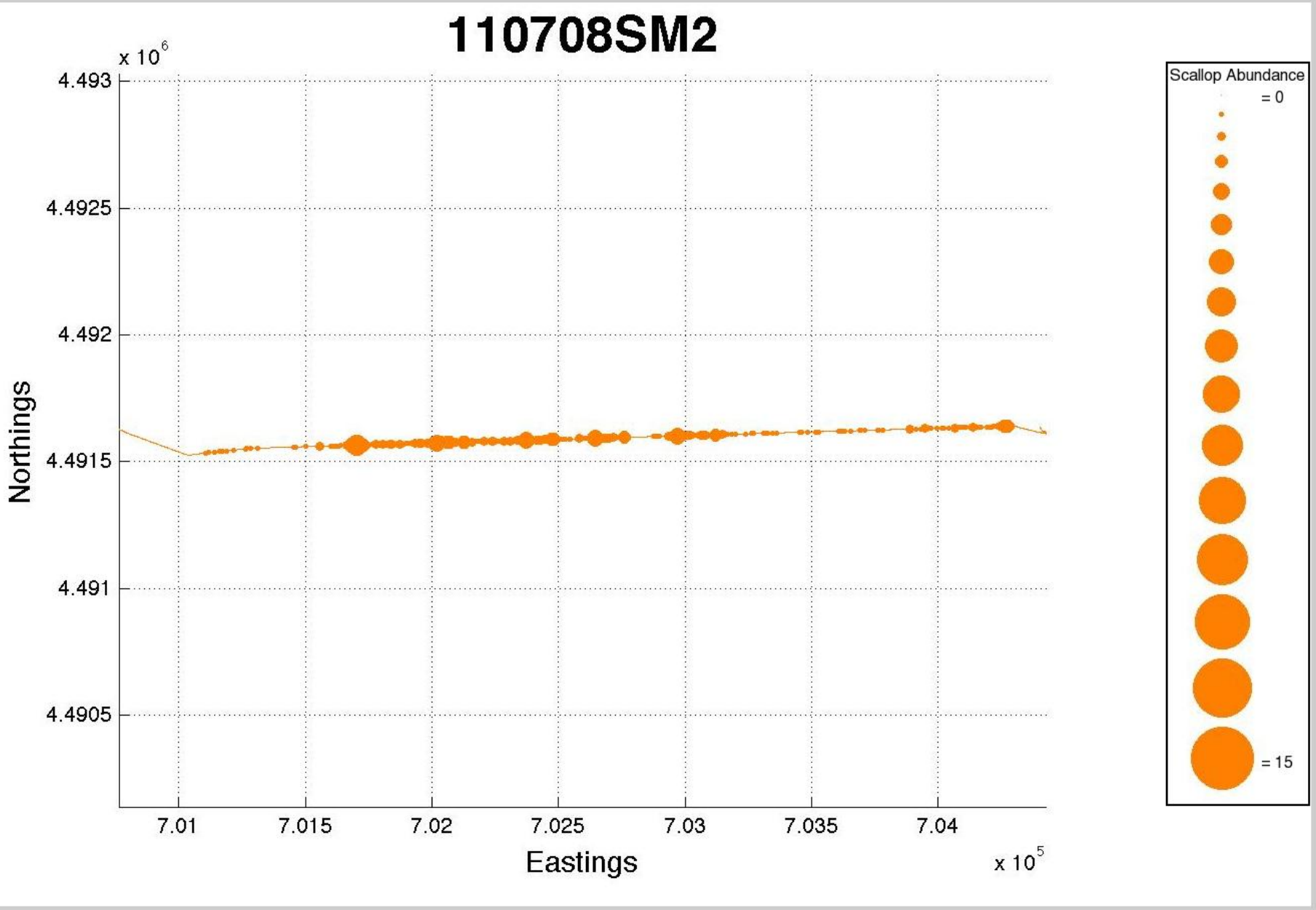
Latitude:4001.4256N
Longitude:07349.0415W
Depth:26m

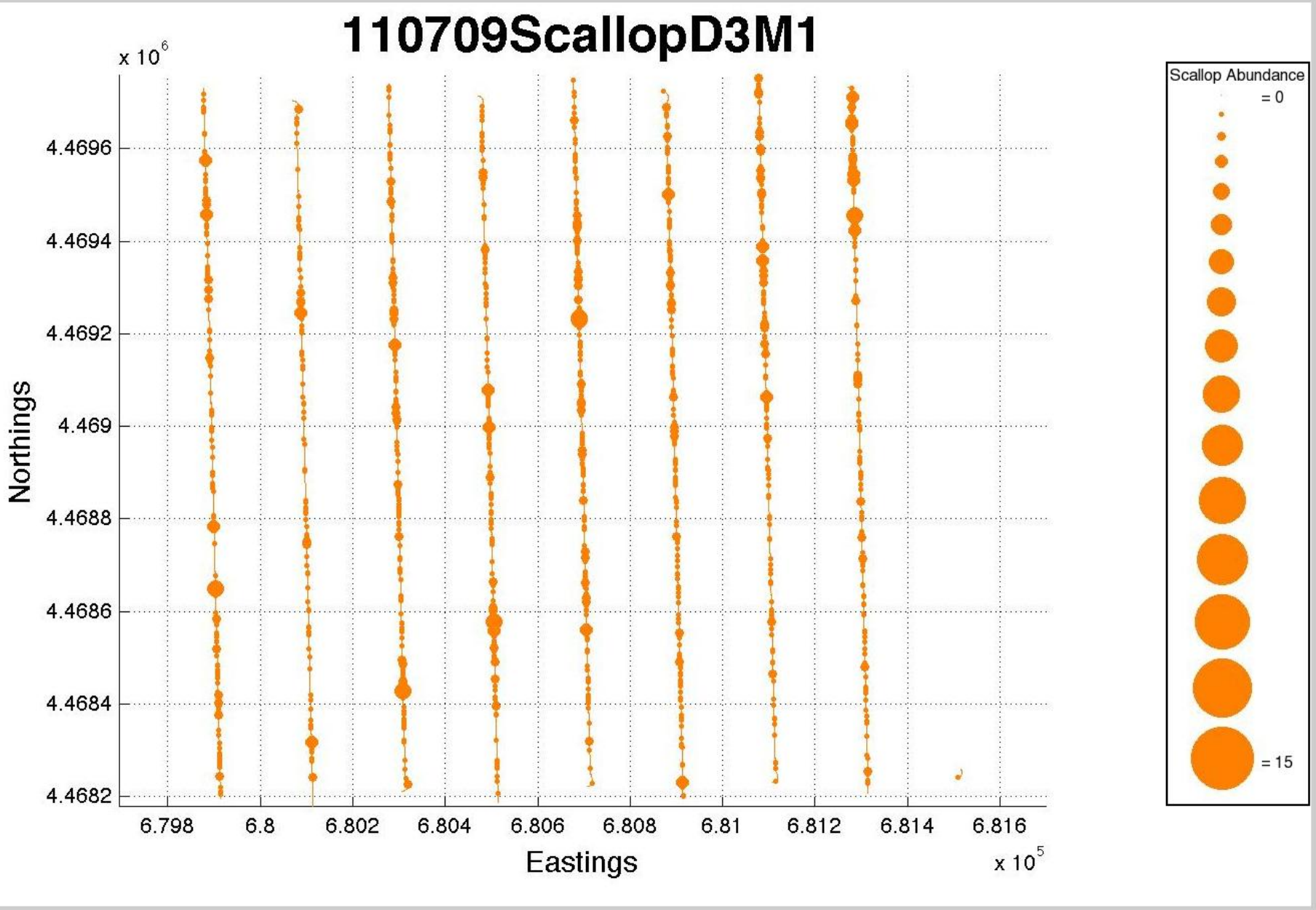
Appendix IV. Spatial Abundance Bubble Plots

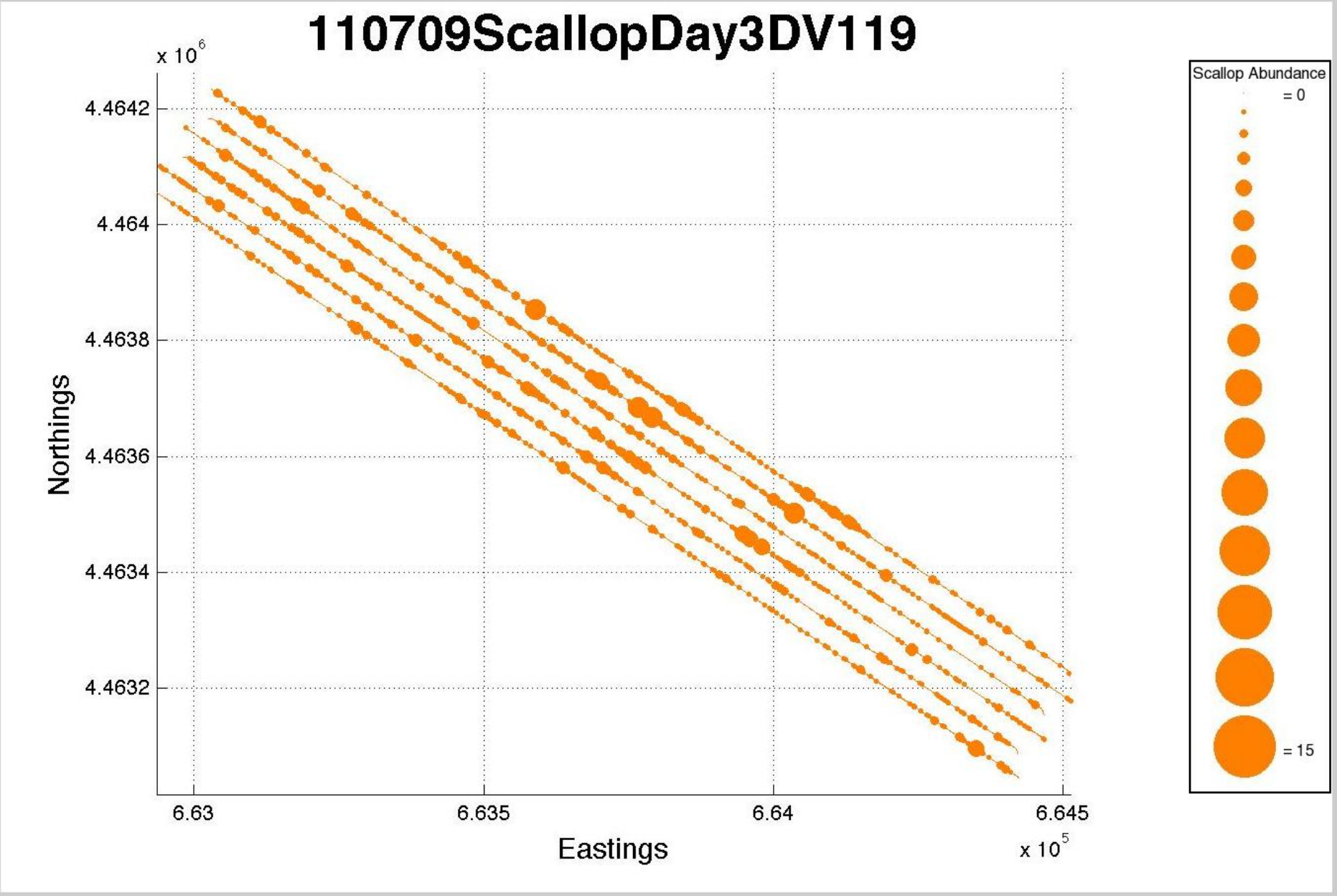

110708ScallopD2
x 10^6
4.4945
4.494
4.4935
4.493
4.4925
4.492
Northings
7.015
7.02
7.025
7.03
7.035
7.04
7.045
Eastings
x 10^5
Scallop Abundance
= 0
= 15

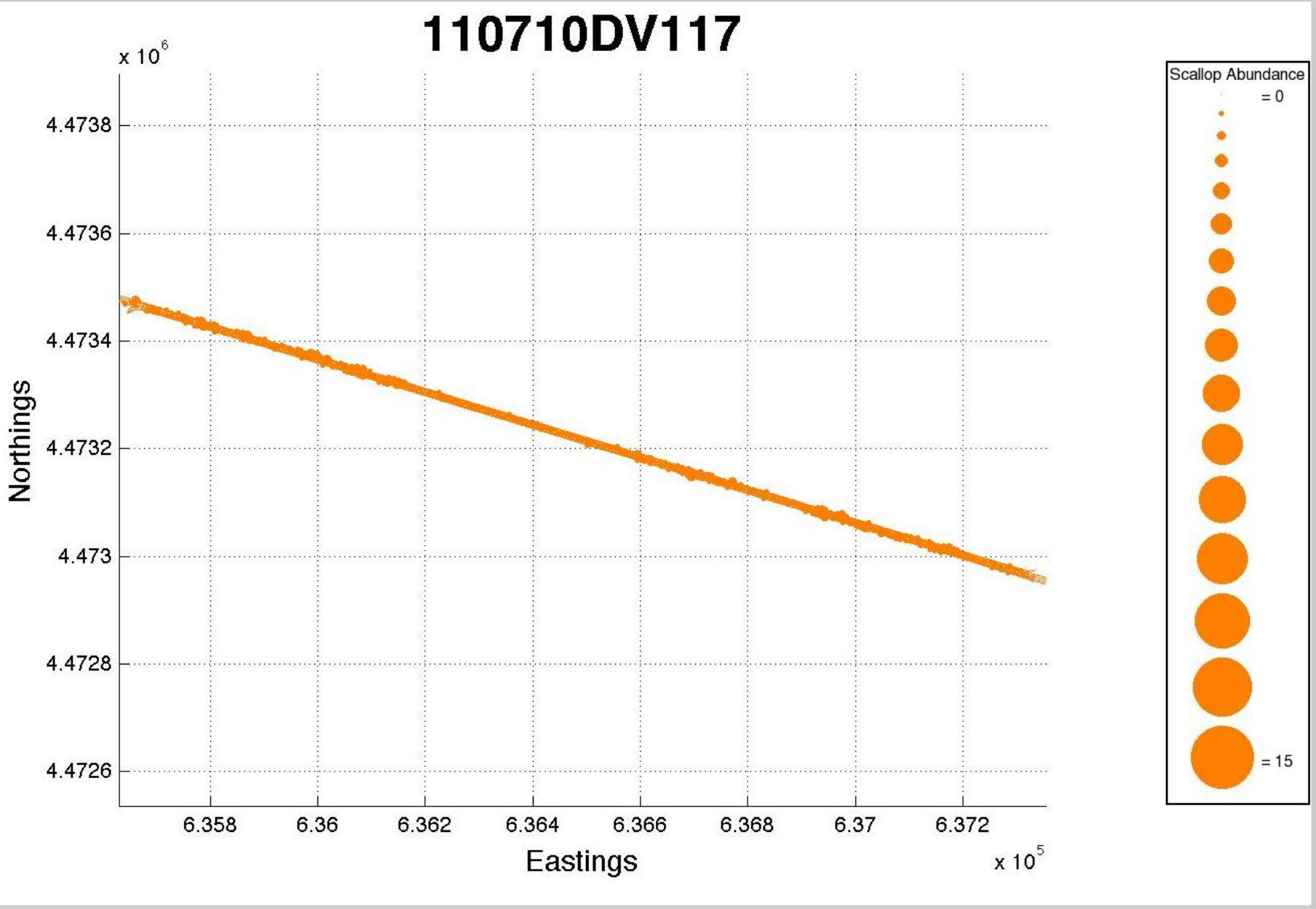

110708ScallopD2M4
x 10^6
4.4926
4.4924
4.4922
4.492
4.4918
4.4916
4.4914
4.4912
4.491
4.4908
4.4906
Northings
7.015
7.02
7.025
7.03
7.035
7.04
Eastings
x 10^5
Scallop Abundance
= 0
= 15

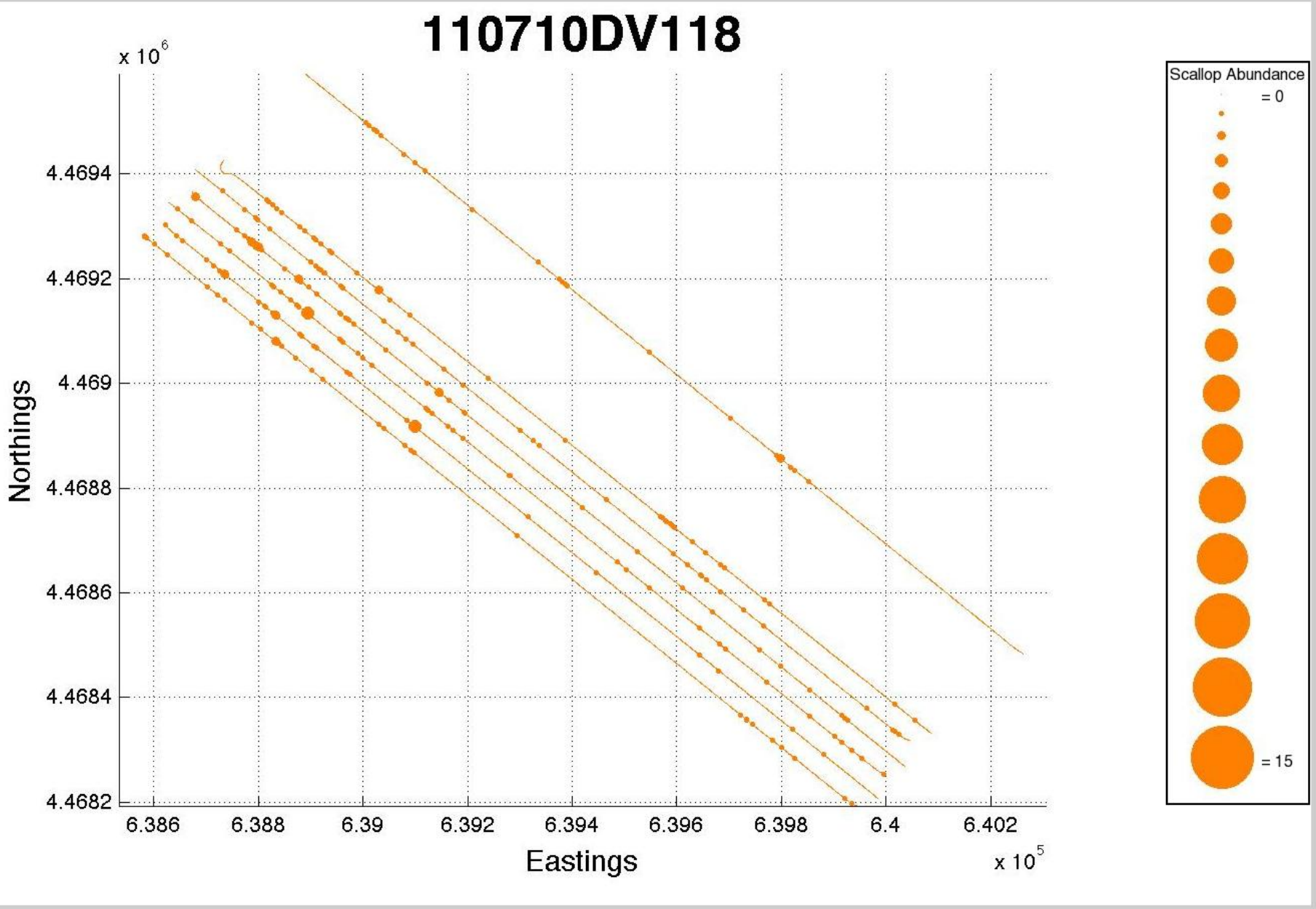

110708ScallopDvoraRun
x 10^6
4.4855
4.485
4.4845
4.484
4.4835
4.483
4.4825
4.482
Northings
7.07
7.075
7.08
7.085
7.09
7.095
7.1
7.105
7.11
7.115
7.12
Eastings
x 10^5
Scallop Abundance
= 0
= 15

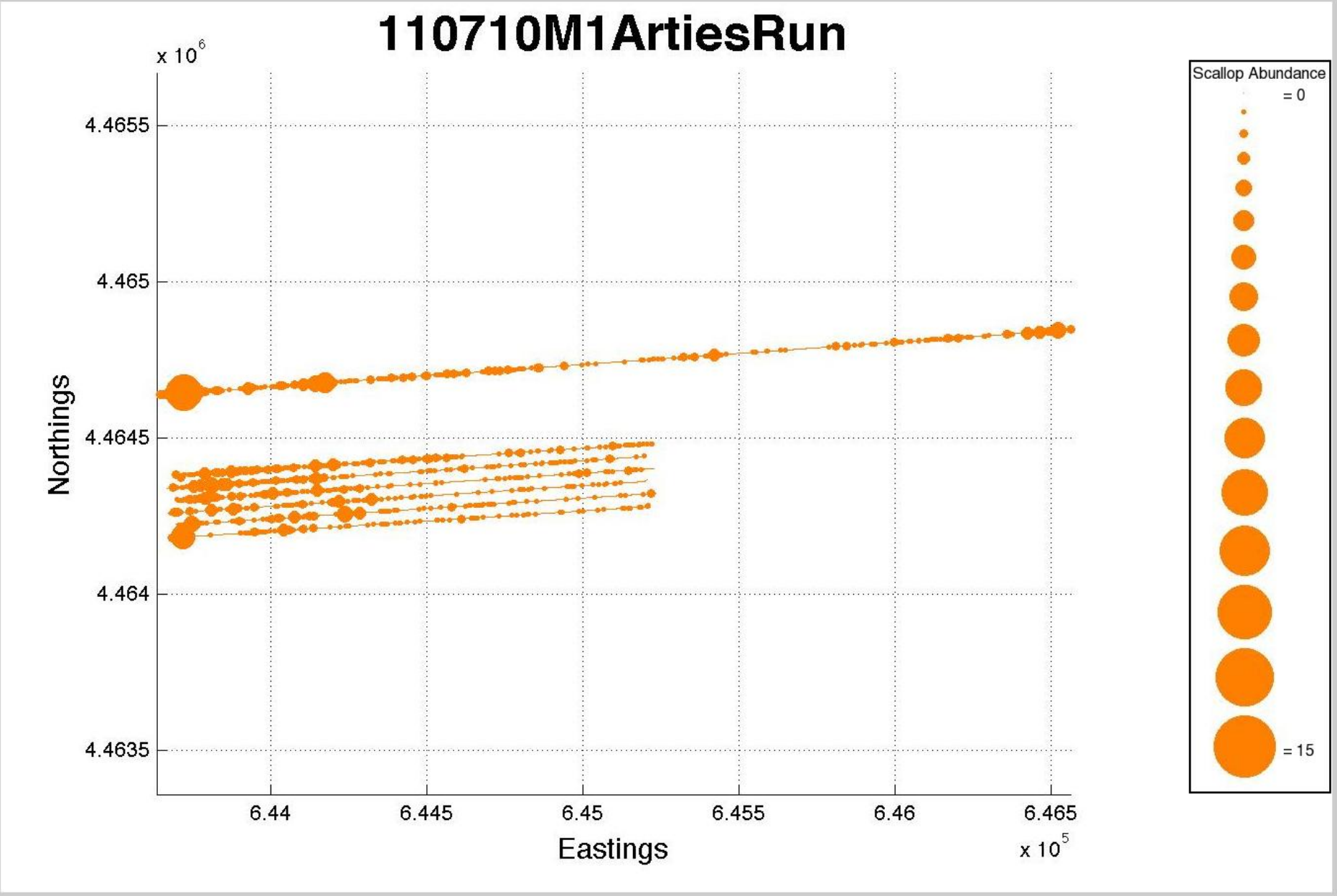

110708SM2
x 10^6
4.493
4.4925
4.492
4.4915
4.491
4.4905
Northings
7.01
7.015
7.02
7.025
7.03
7.035
7.04
Eastings
x 10^5
Scallop Abundance
= 0
= 15

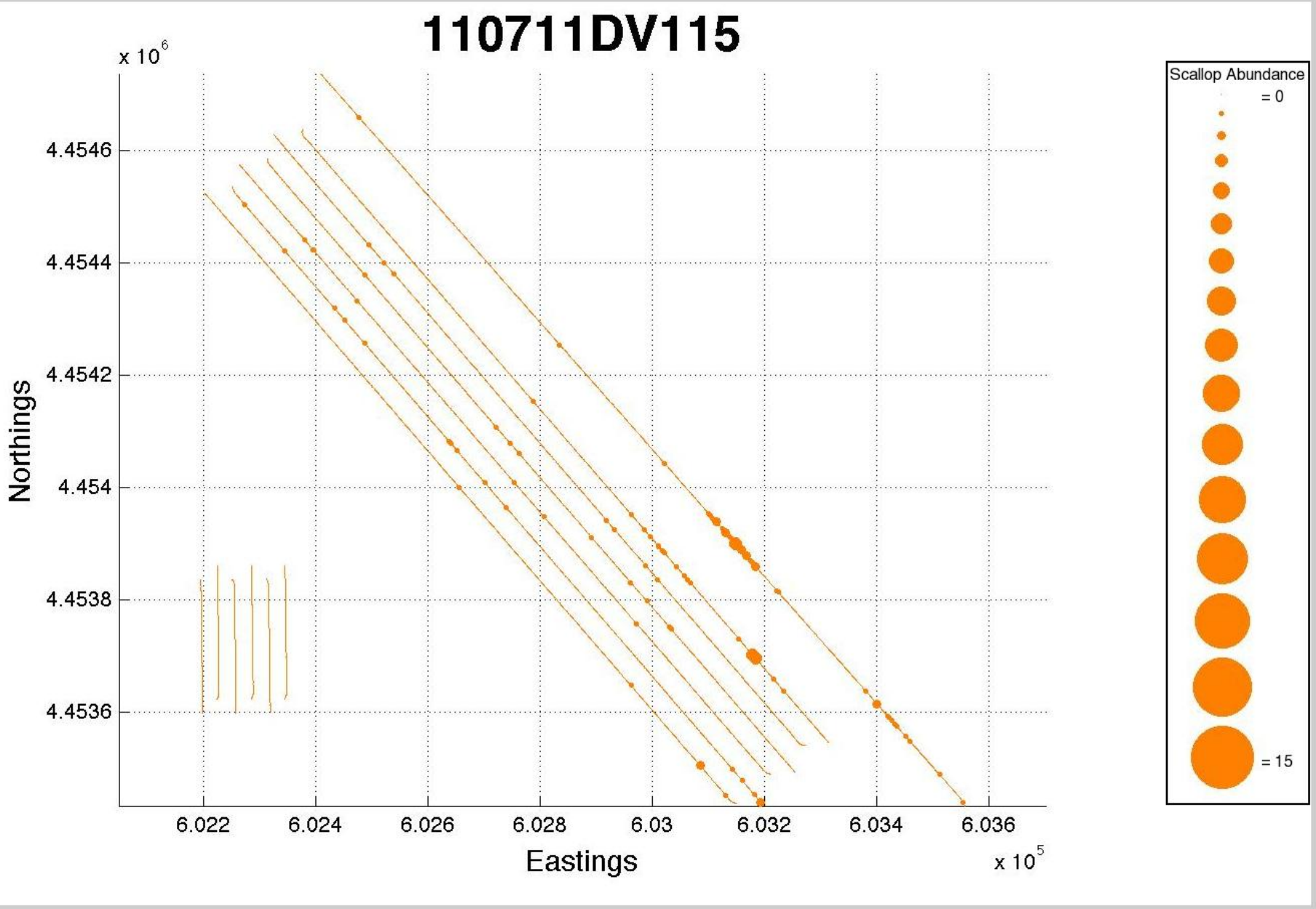

110709ScallopD3M1
x 10^6
4.4696
4.4694
4.4692
4.469
4.4688
4.4686
4.4684
4.4682
Northings
6.798
6.8
6.802
6.804
6.806
6.808
6.81
6.812
6.814
6.816
Eastings
x 10^5
Scallop Abundance
= 0
= 15

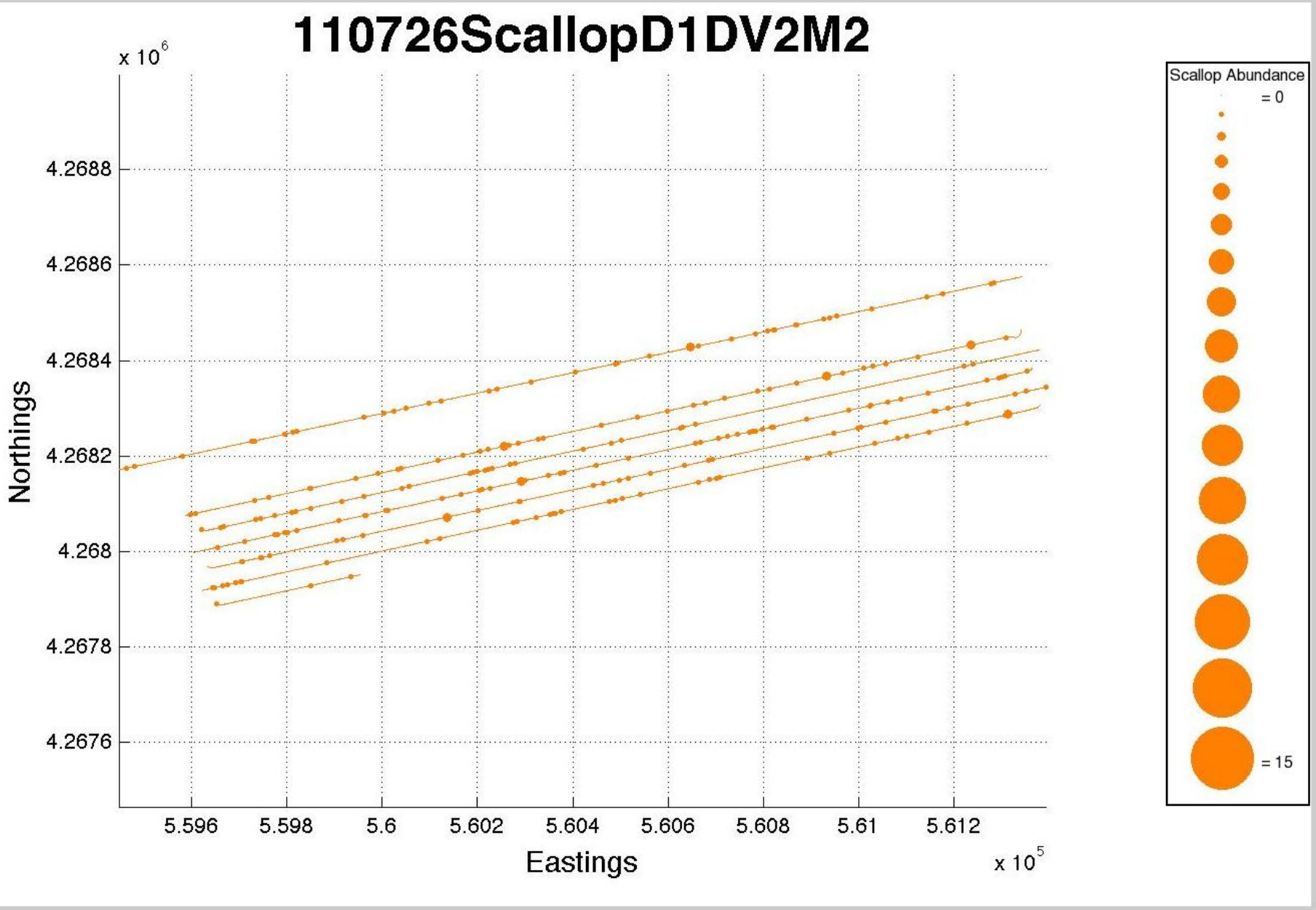

110709ScallopDay3DV119
x 10^6
4.4642
4.464
4.4638
4.4636
4.4634
4.4632
Northings
6.63
6.635
6.64
6.645
Eastings
x 10^5
Scallop Abundance
= 0
= 15

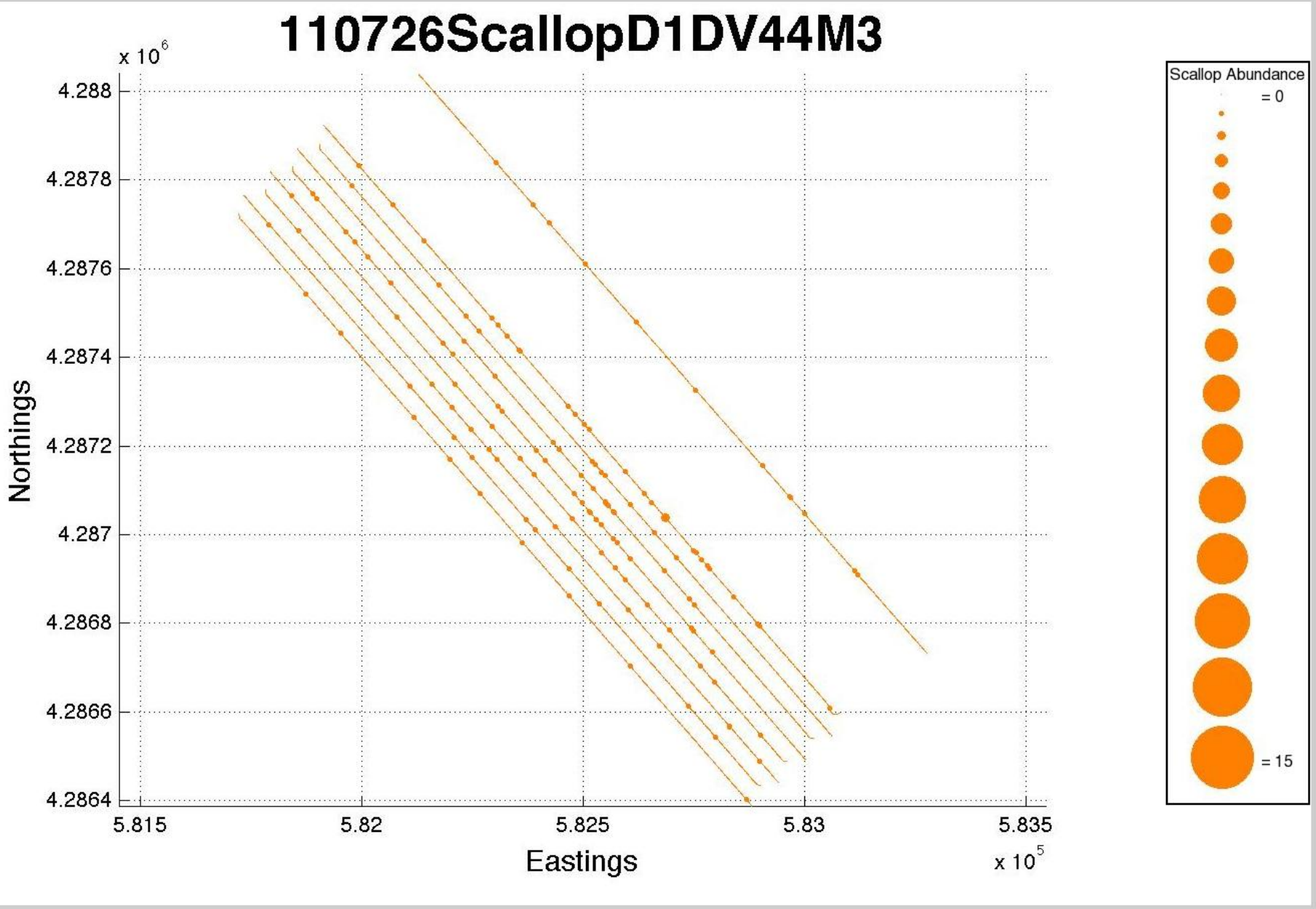

110710DV117
x 10^6
4.4738
4.4736
4.4734
4.4732
4.473
4.4728
4.4726
Northings
6.358
6.36
6.362
6.364
6.366
6.368
6.37
6.372
Eastings
x 10^5
Scallop Abundance
= 0
= 15


110710DV118
x 10^6
4.4694
4.4692
4.469
4.4688
4.4686
4.4684
4.4682
Northings
6.386
6.388
6.39
6.392
6.394
6.396
6.398
6.4
6.402
Eastings
x 10^5
Scallop Abundance
= 0
= 15


110710M1ArtiesRun
x 10^6
4.4655
4.465
4.4645
4.464
4.4635
Northings
6.44
6.445
6.45
6.455
6.46
6.465
Eastings
x 10^5
Scallop Abundance
= 0
= 15


110711DV115
x 10^6
4.4546
4.4544
4.4542
4.454
4.4538
4.4536
Northings
6.022
6.024
6.026
6.028
6.03
6.032
6.034
6.036
Eastings
x 10^5
Scallop Abundance
= 0
= 15


110726ScallopD1DV2M2
x 10^6
4.2688
4.2686
4.2684
4.2682
4.268
4.2678
4.2676
Northings
5.596
5.598
5.6
5.602
5.604
5.606
5.608
5.61
5.612
Eastings
x 10^5
Scallop Abundance
= 0
= 15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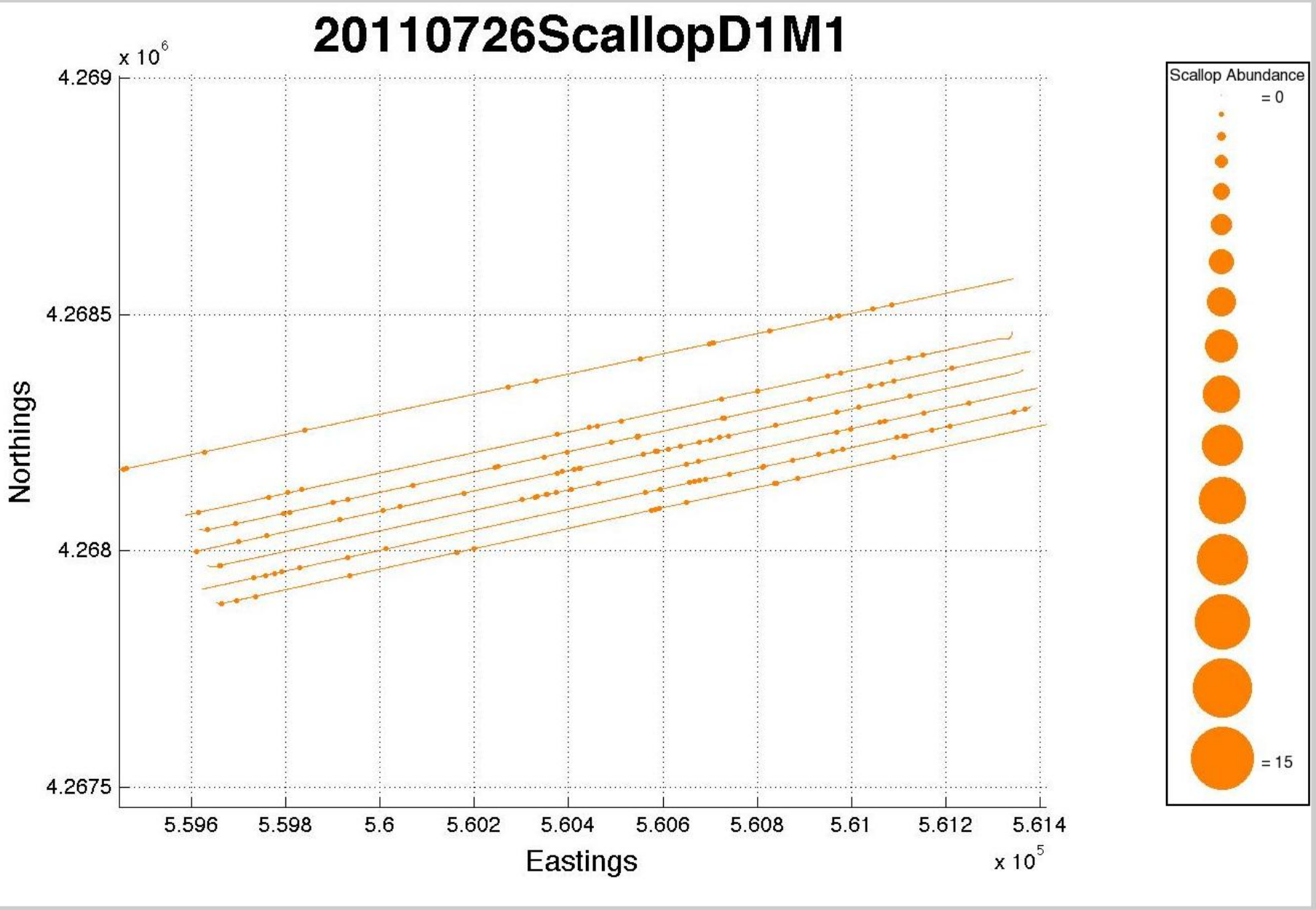
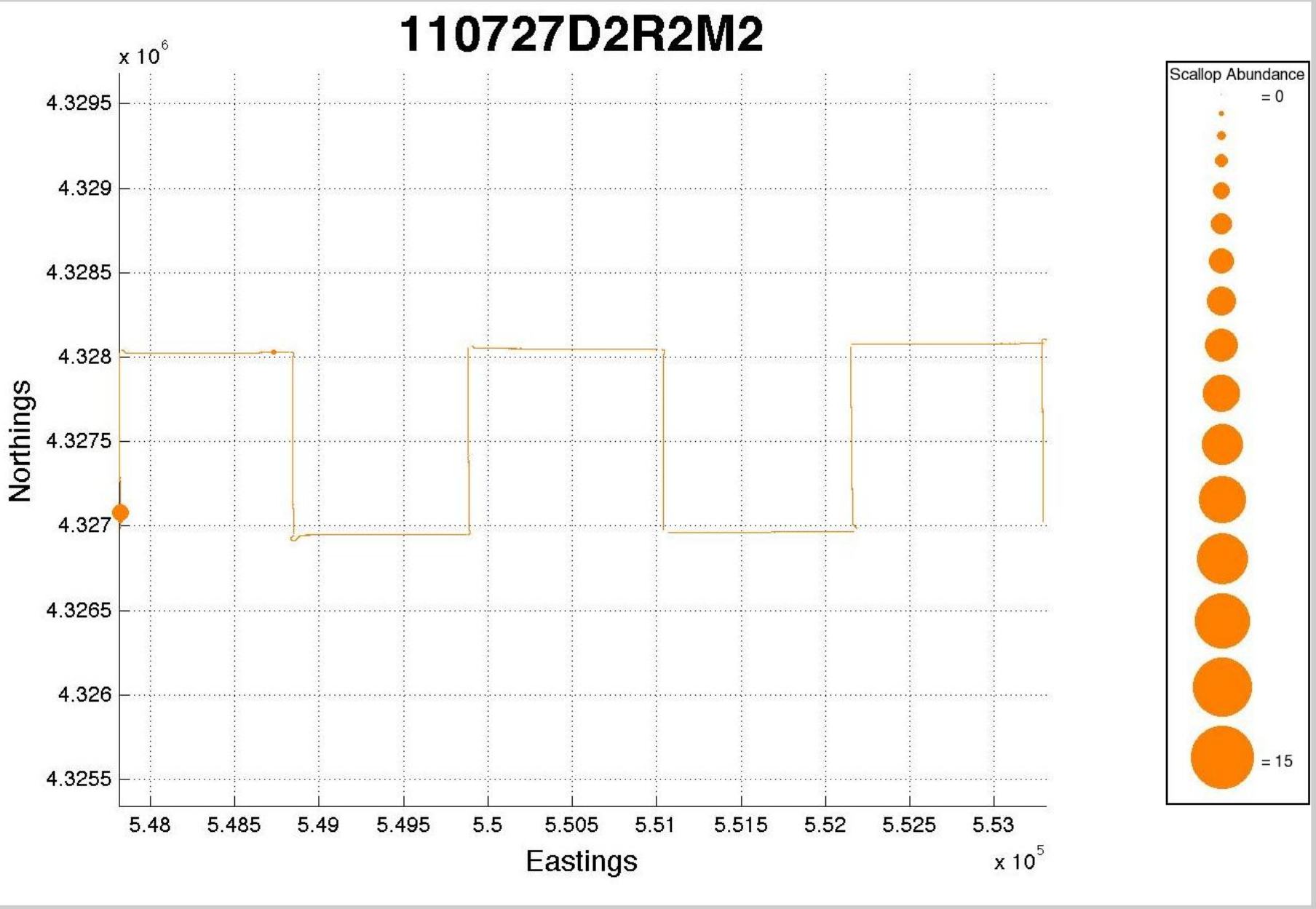
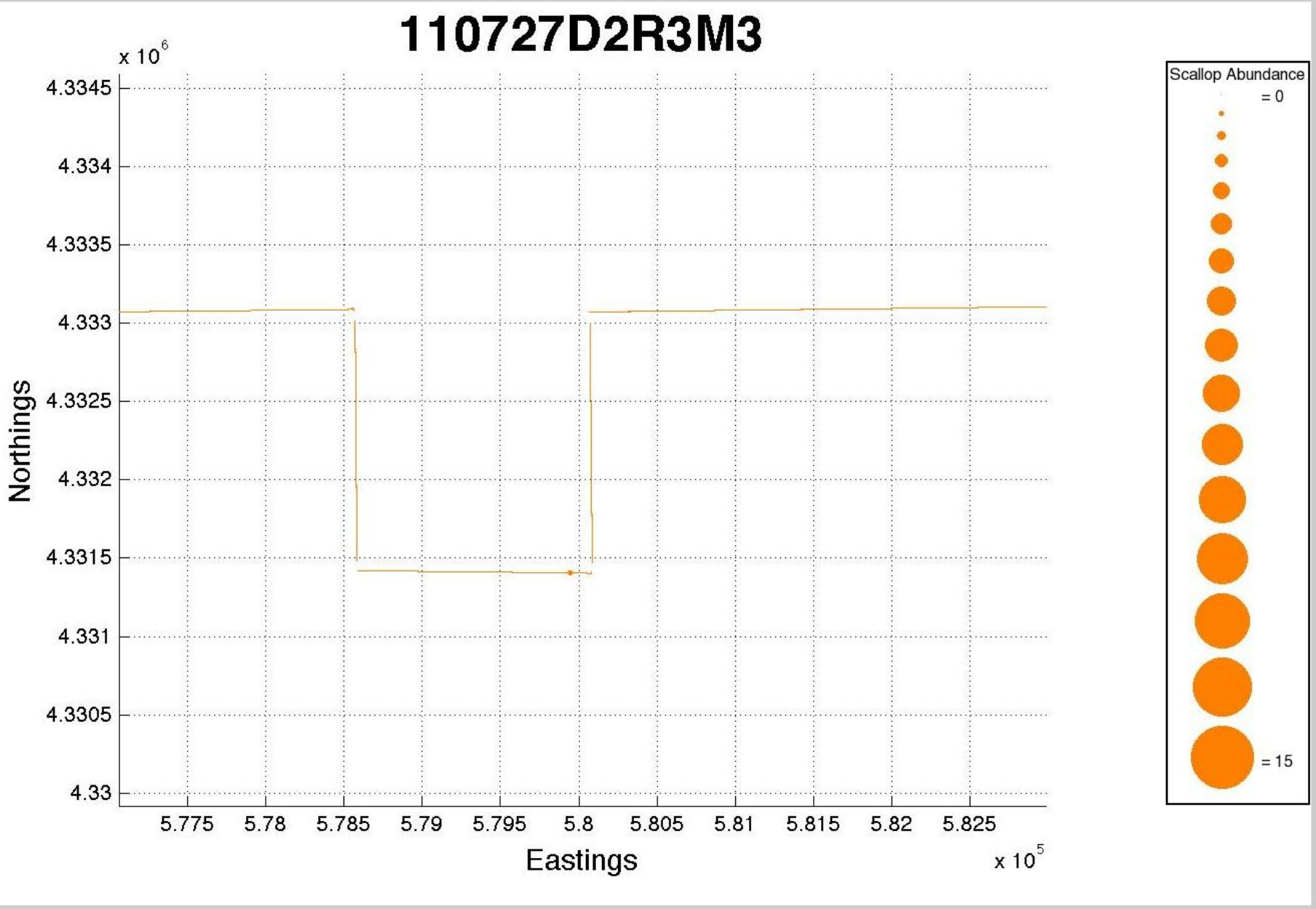
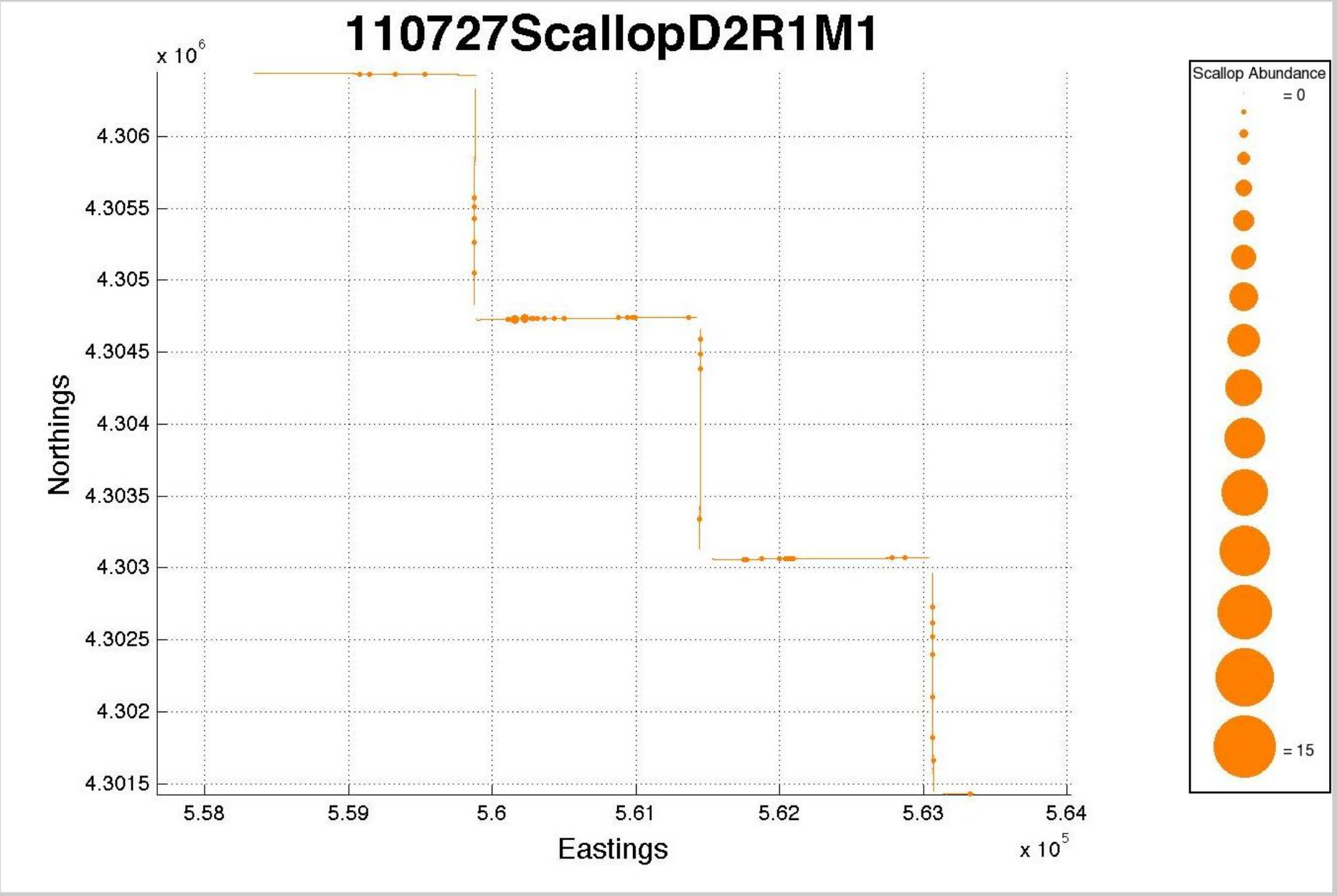
x 10^6
4.288
4.2878
4.2876
4.2874
4.2872
4.287
4.2868
4.2866
4.2864
Northings
5.815
5.82
5.825
5.83
5.835
Eastings
x 10^5
Scallop Abundance
= 0
= 15


20110726ScallopD1M1
x 10^6
4.269
4.2685
4.268
4.2675
Northings
5.596
5.598
5.6
5.602
5.604
5.606
5.608
5.61
5.612
5.614
Eastings
x 10^5
Scallop Abundance
= 0
= 15


110727D2R2M2
x 10^6
4.3295
4.329
4.3285
4.328
4.3275
4.327
4.3265
4.326
4.3255
Northings
5.48
5.485
5.49
5.495
5.5
5.505
5.51
5.515
5.52
5.525
5.53
Eastings
x 10^5
Scallop Abundance
= 0
= 15


110727D2R3M3
x 10^6
4.3345
4.334
4.3335
4.333
4.3325
4.332
4.3315
4.331
4.3305
4.33
Northings
5.775
5.78
5.785
5.79
5.795
5.8
5.805
5.81
5.815
5.82
5.825
Eastings
x 10^5
Scallop Abundance
= 0
= 15


110727ScallopD2R1M1
x 10^6
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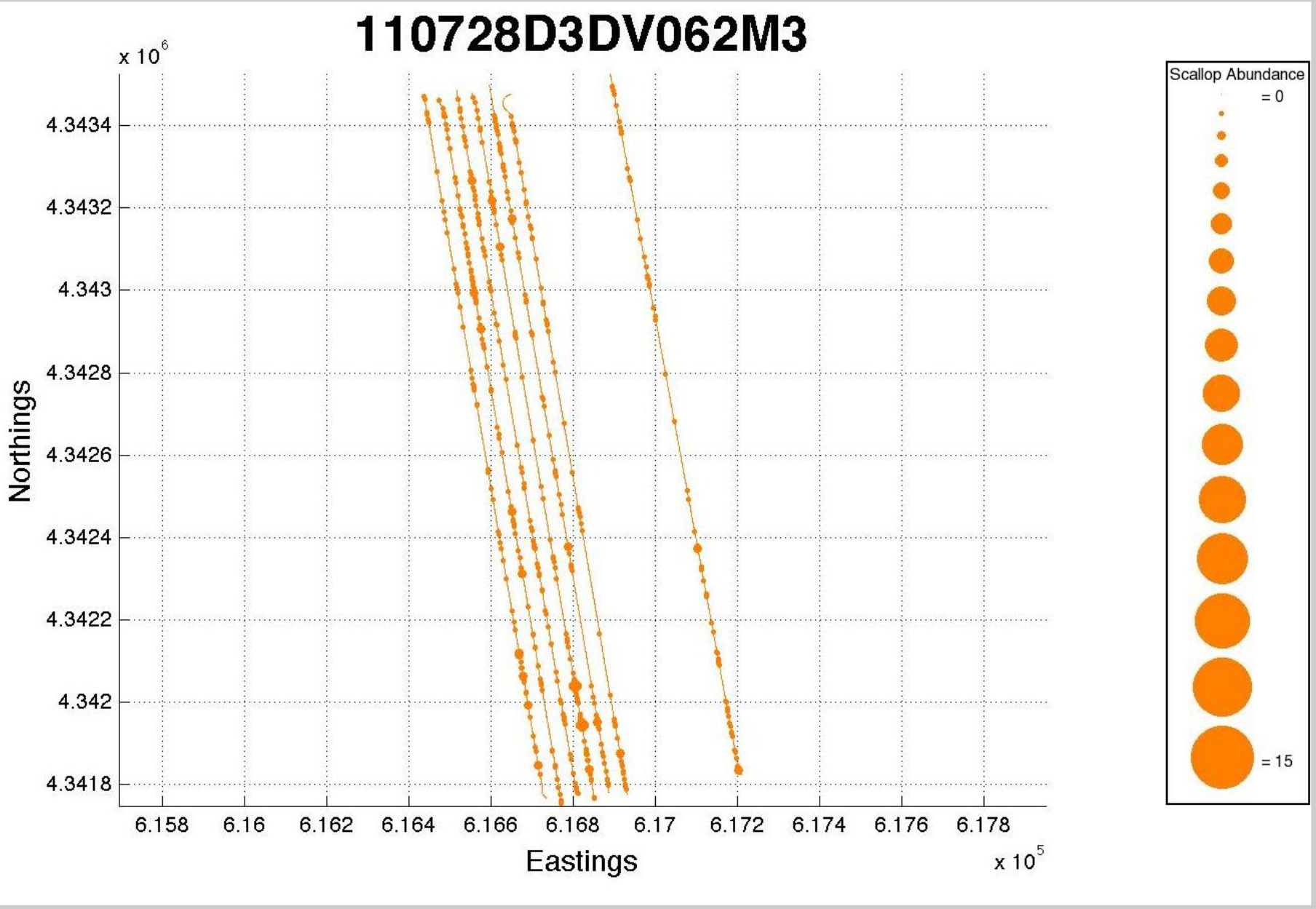
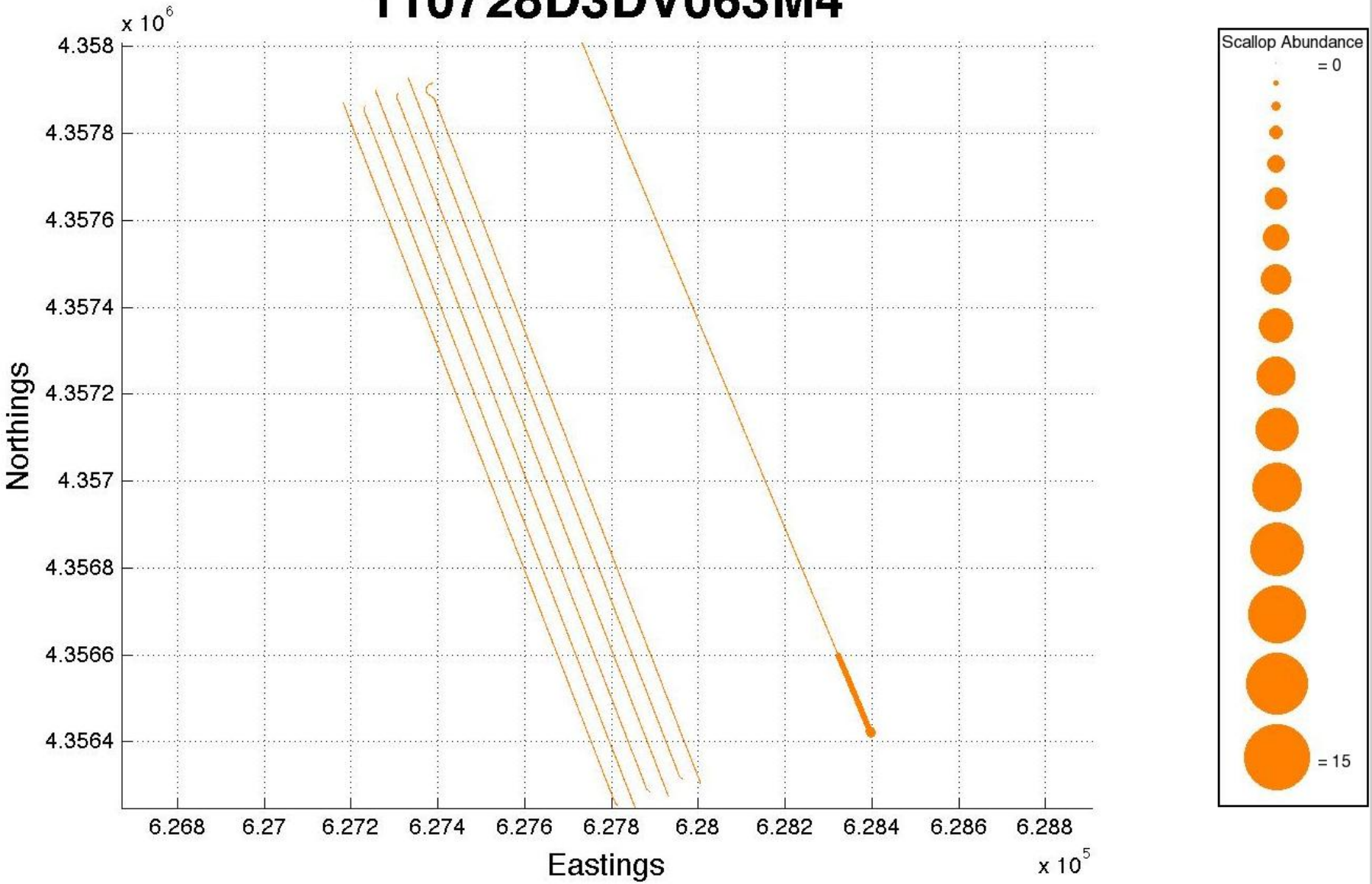
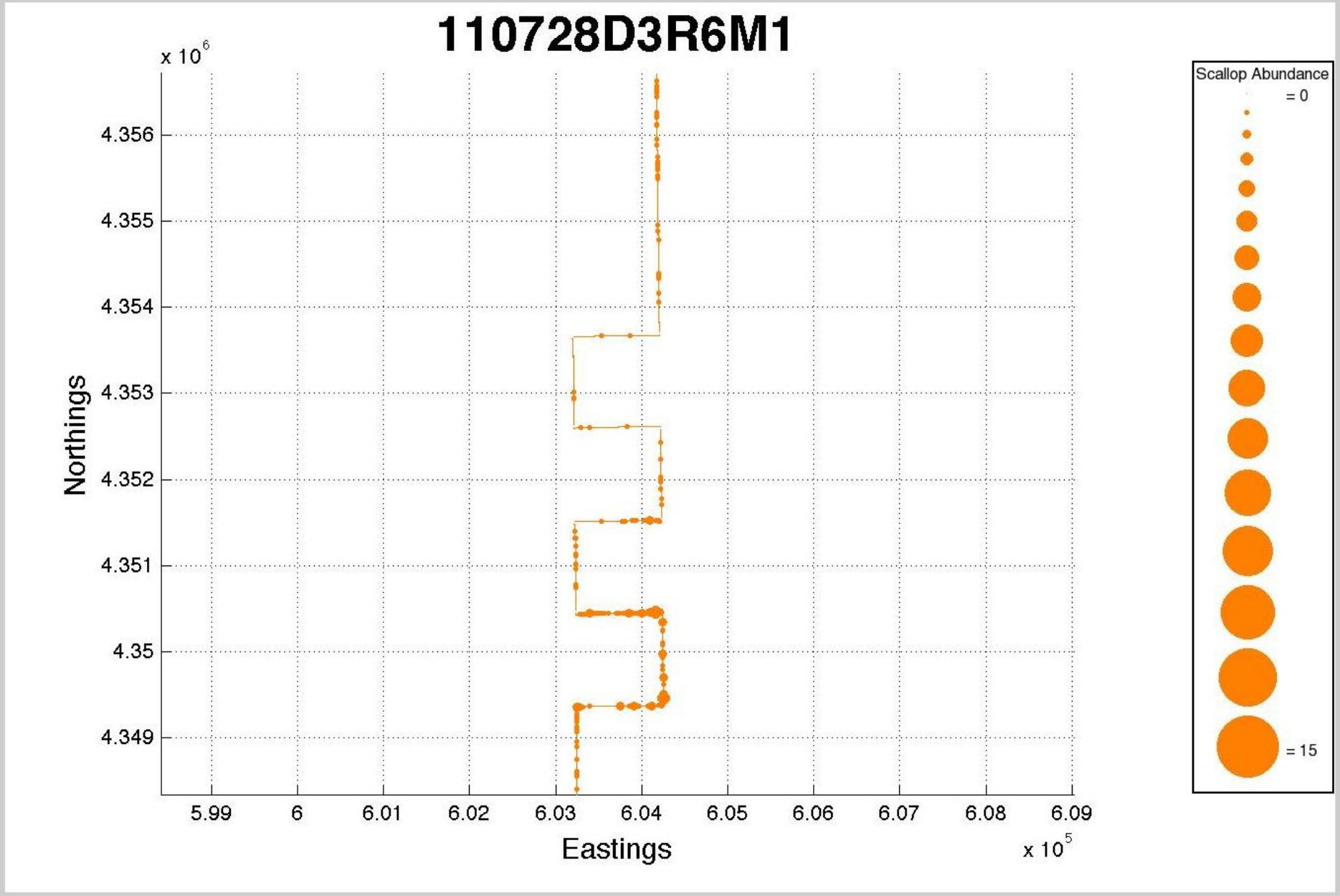
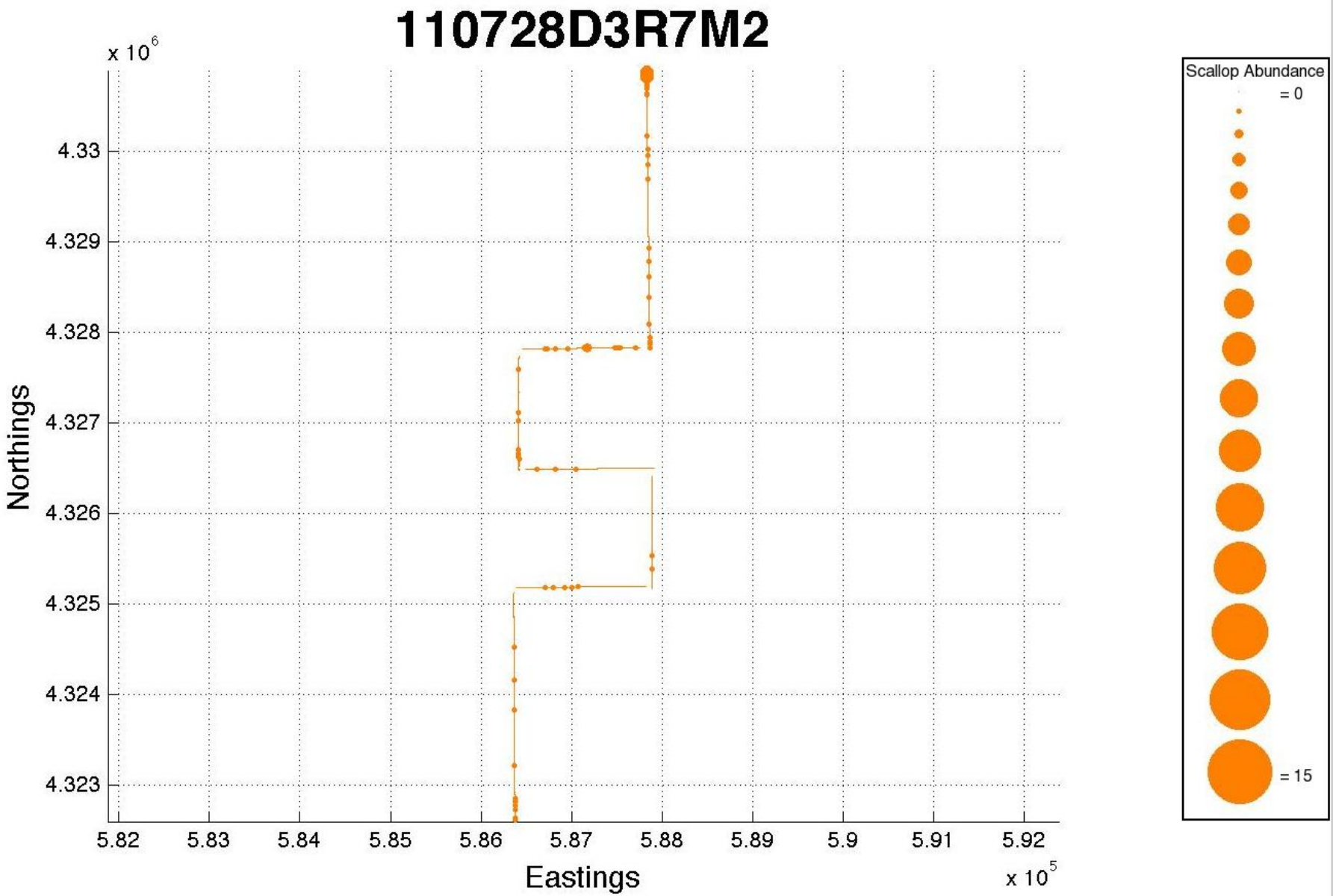
4.3055
4.305
4.3045
4.304
4.3035
4.303
4.3025
4.302
4.3015
Northings
5.58
5.59
5.6
5.61
5.62
5.63
5.64
Eastings
x 10^5
Scallop Abundance
= 0
= 15

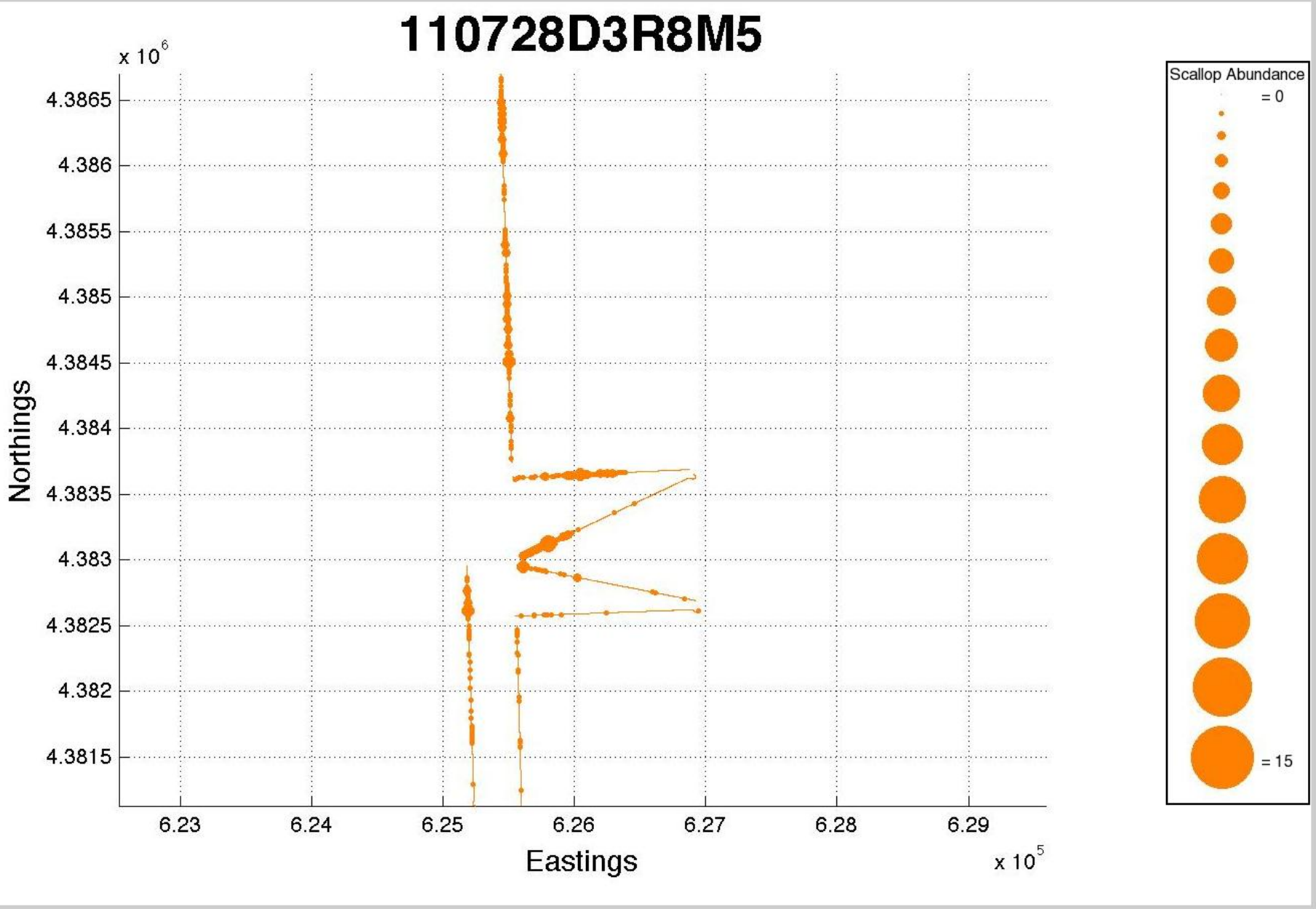

110728D3DV062M3
x 10^6
4.3434
4.3432
4.343
4.3428
4.3426
4.3424
4.3422
4.342
4.3418
Northings
6.158
6.16
6.162
6.164
6.166
6.168
6.17
6.172
6.174
6.176
6.178
Eastings
x 10^5
Scallop Abundance
= 0
= 15

110728D3DV063M4

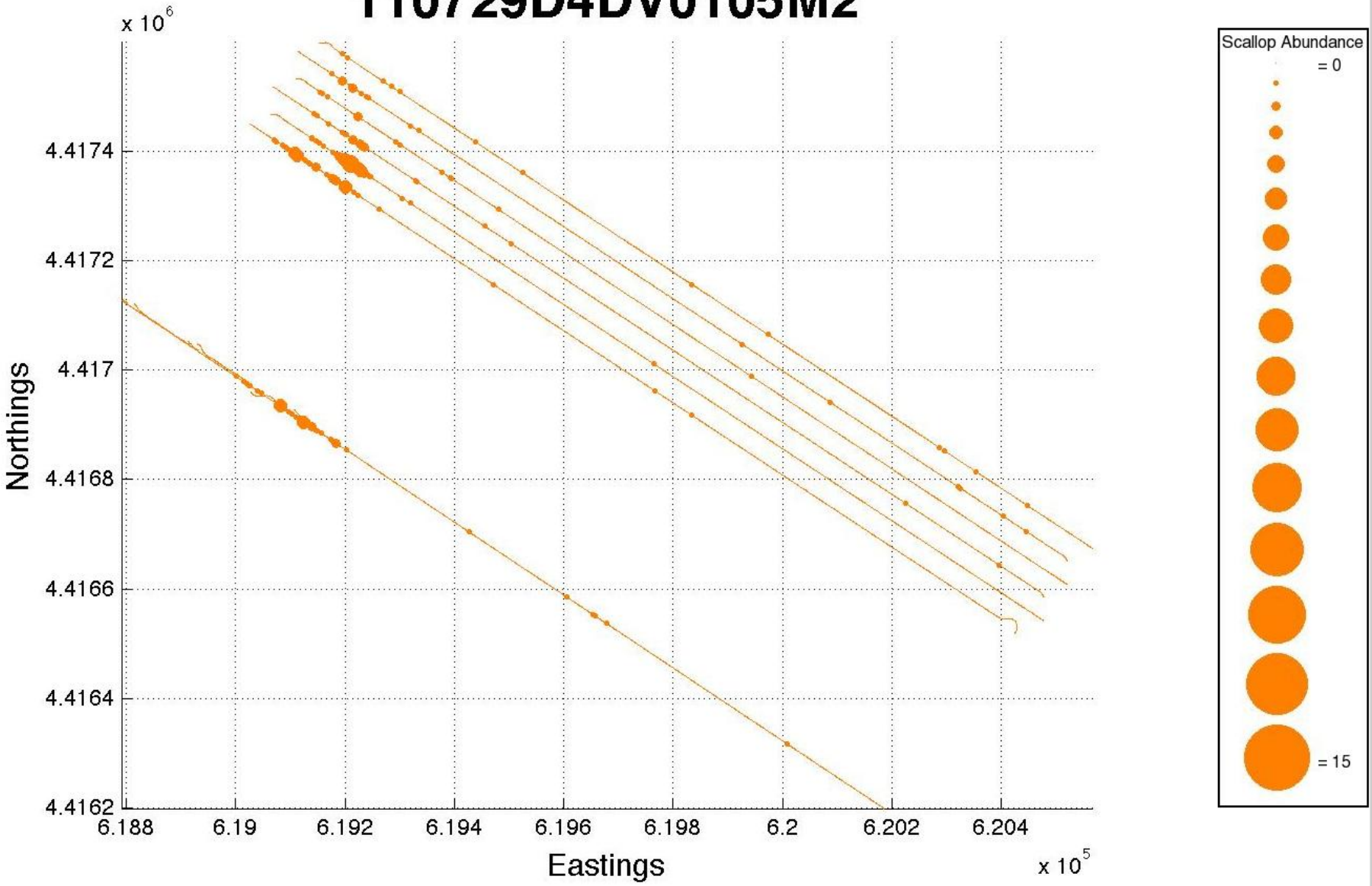


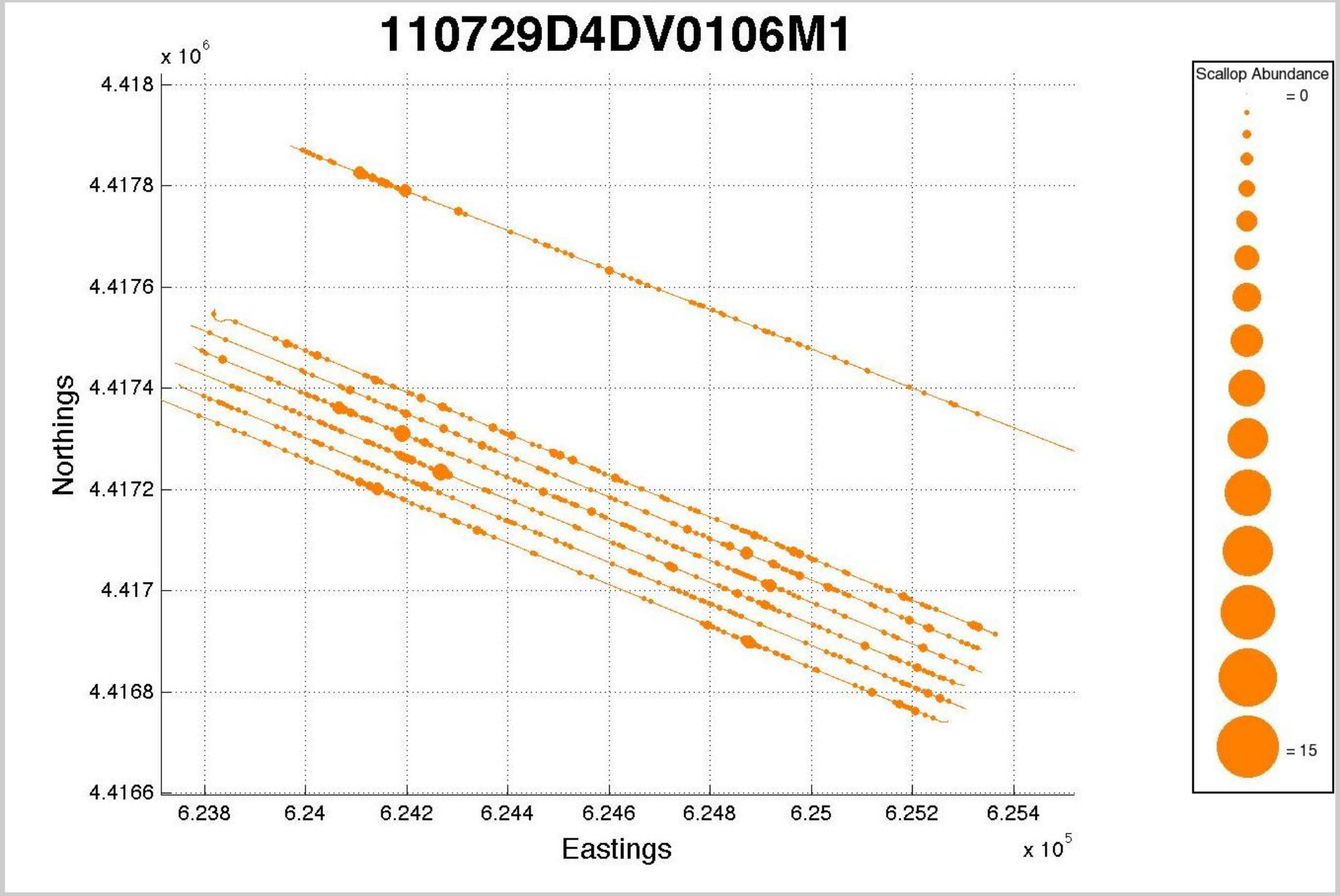

110728D3R6M1
x 10^6
4.356
4.355
4.354
4.353
4.352
4.351
4.35
4.349
Northings
5.99
6
6.01
6.02
6.03
6.04
6.05
6.06
6.07
6.08
6.09
Eastings
x 10^5
Scallop Abundance
= 0
= 15

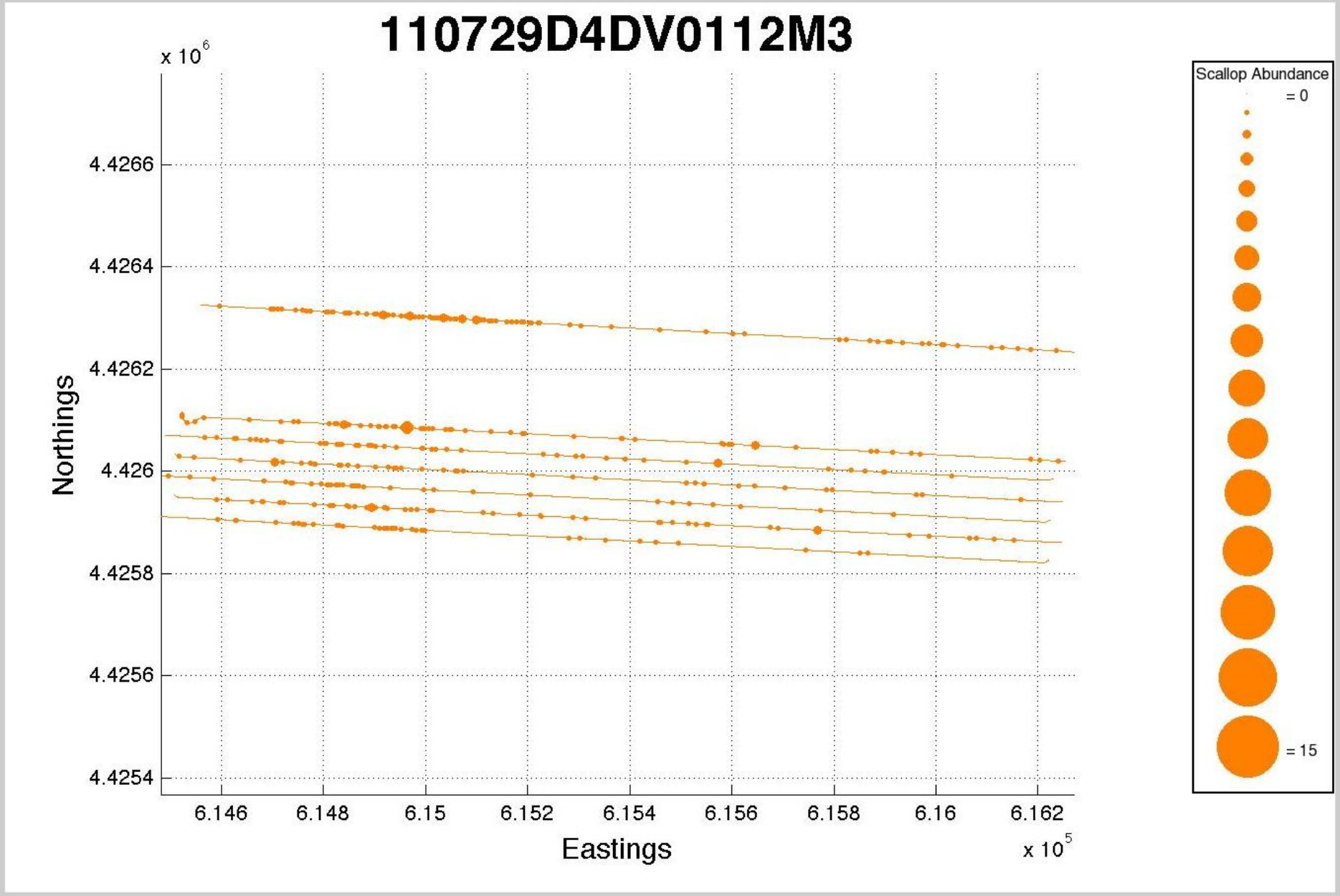

110728D3R7M2
x 10^6
4.33
4.329
4.328
4.327
4.326
4.325
4.324
4.323
Northings
5.82
5.83
5.84
5.85
5.86
5.87
5.88
5.89
5.9
5.91
5.92
Eastings
x 10^5
Scallop Abundance
= 0
= 15


110728D3R8M5
x 10^6
4.3865
4.386
4.3855
4.385
4.3845
4.384
4.3835
4.383
4.3825
4.382
4.3815
Northings
6.23
6.24
6.25
6.26
6.27
6.28
6.29
Eastings
x 10^5
Scallop Abundance
= 0
= 15

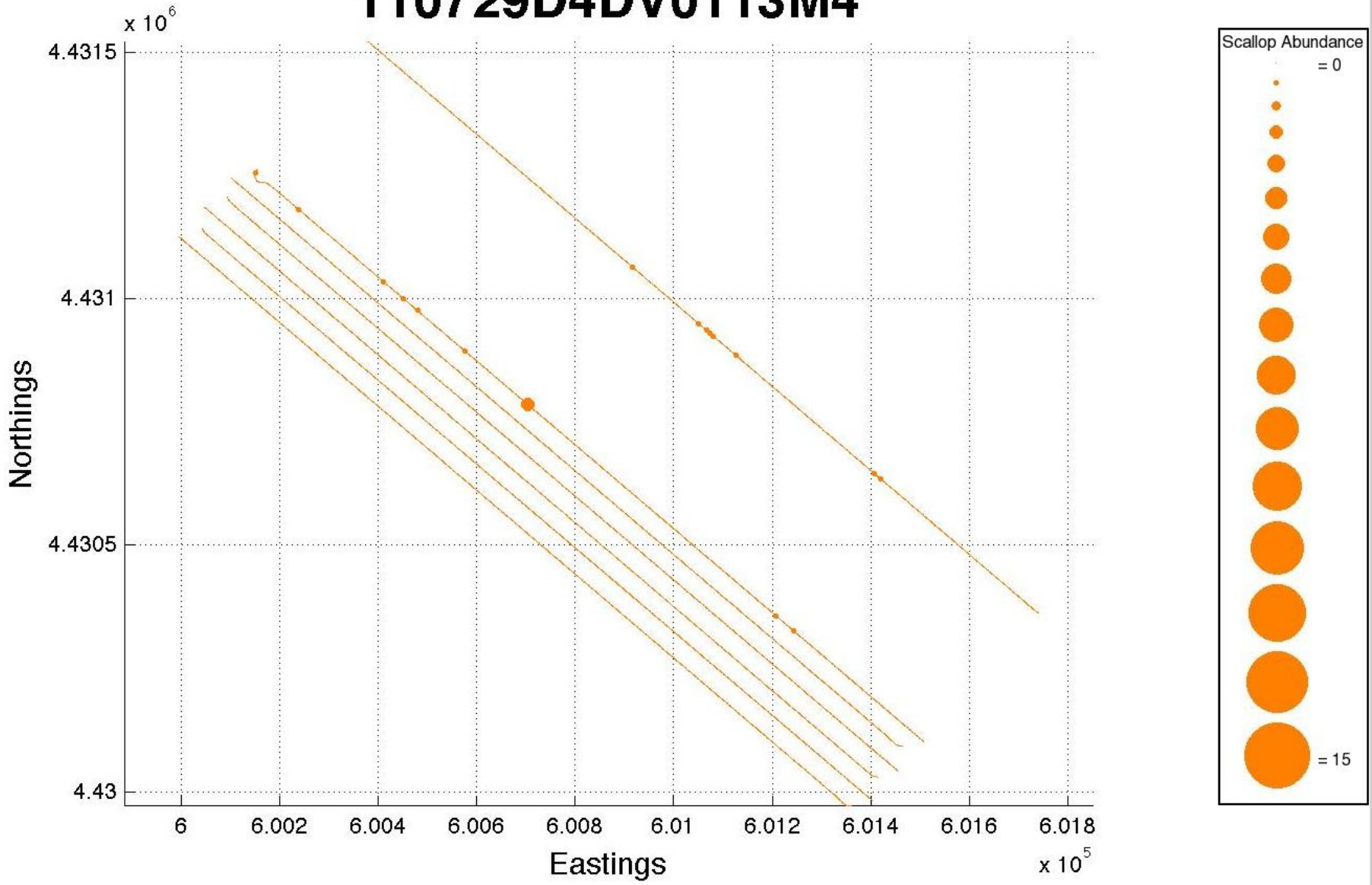
110729D4DV0105M2



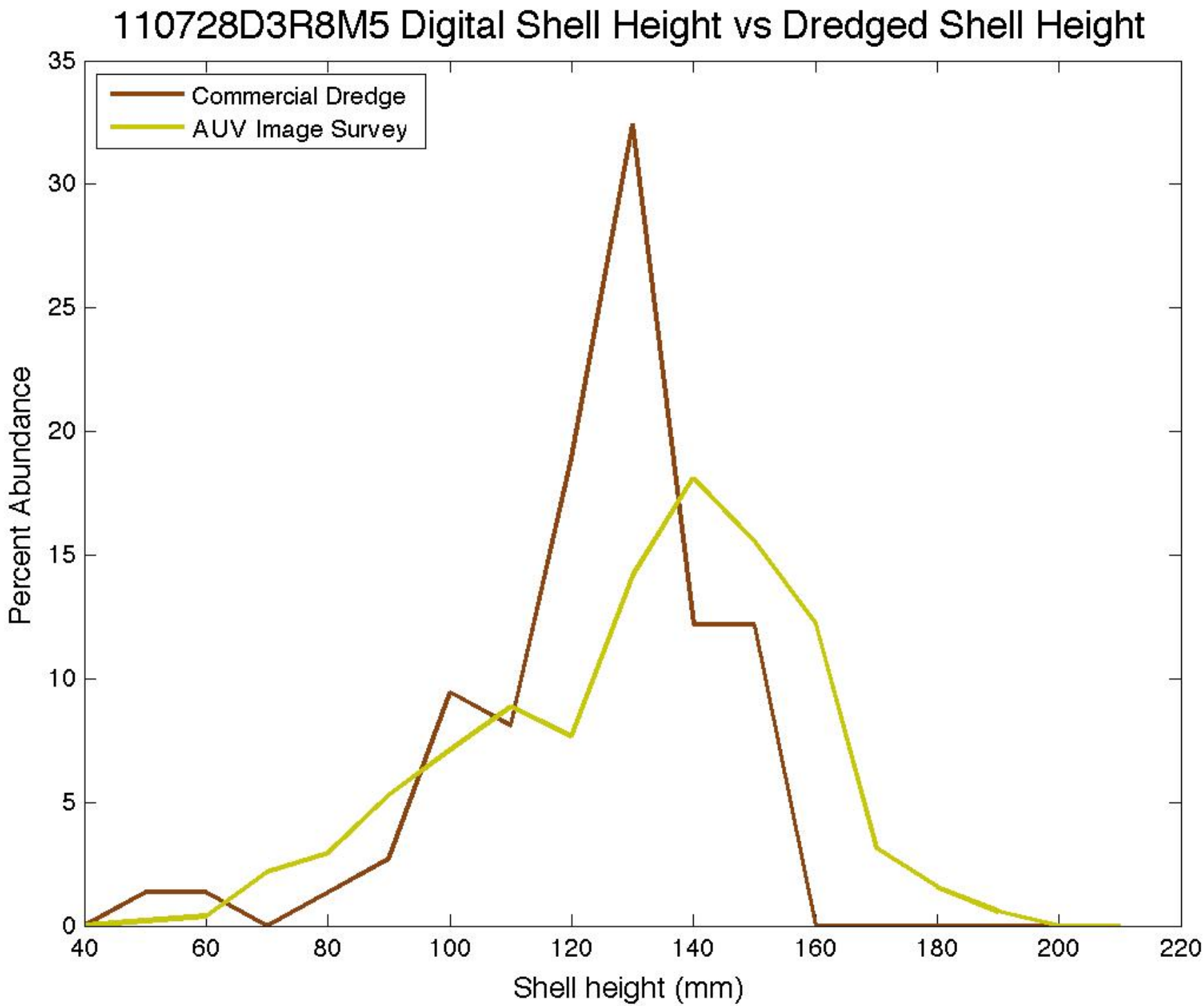

110729D4DV0106M1
x 10^6
4.418
4.4178
4.4176
4.4174
4.4172
4.417
4.4168
4.4166
Northings
6.238
6.24
6.242
6.244
6.246
6.248
6.25
6.252
6.254
Eastings
x 10^5
Scallop Abundance
= 0
= 15

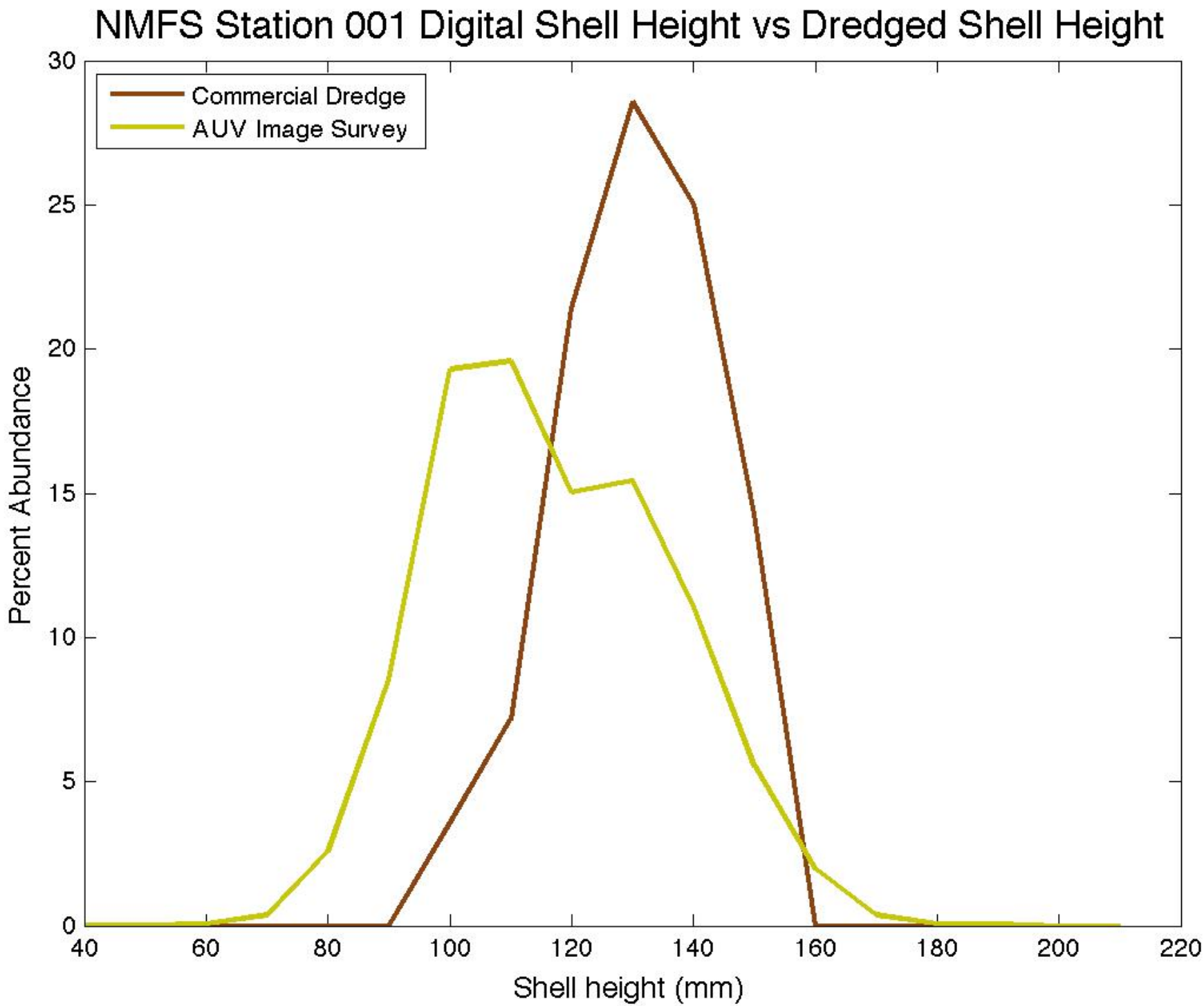

110729D4DV0112M3
x 10^6
4.4266
4.4264
4.4262
4.426
4.4258
4.4256
4.4254
Northings
6.146
6.148
6.15
6.152
6.154
6.156
6.158
6.16
6.162
Eastings
x 10^5
Scallop Abundance
= 0
= 15

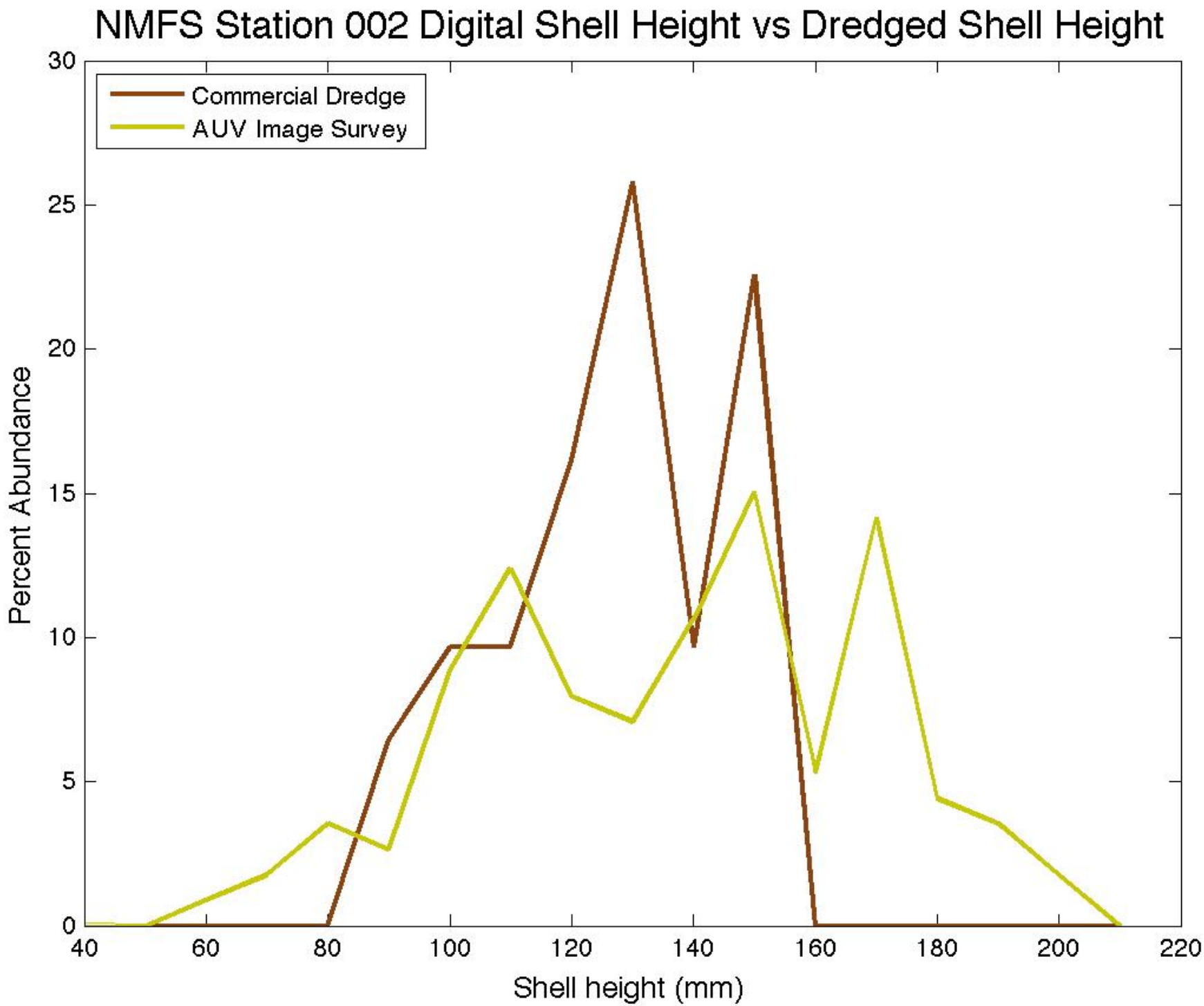
110729D4DV0113M4



Appendix V. Image measured Shell Height compared to Dredge sample measured Shell Height


110728D3R8M5 Digital Shell Height vs Dredged Shell Height
Commercial Dredge
AUV Image Survey
Percent Abundance
Shell height (mm)
0
5
10
15
20
25
30
35
40
60
80
100
120
140
160
180
200
220


NMFS Station 001 Digital Shell Height vs Dredged Shell Height
Commercial Dredge
AUV Image Survey
Percent Abundance
Shell height (mm)
0
5
10
15
20
25
30
40
60
80
100
120
140
160
180
200
220


NMFS Station 002 Digital Shell Height vs Dredged Shell Height
Commercial Dredge
AUV Image Survey
Percent Abundance
Shell height (mm)
0
5
10
15
20
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30
40
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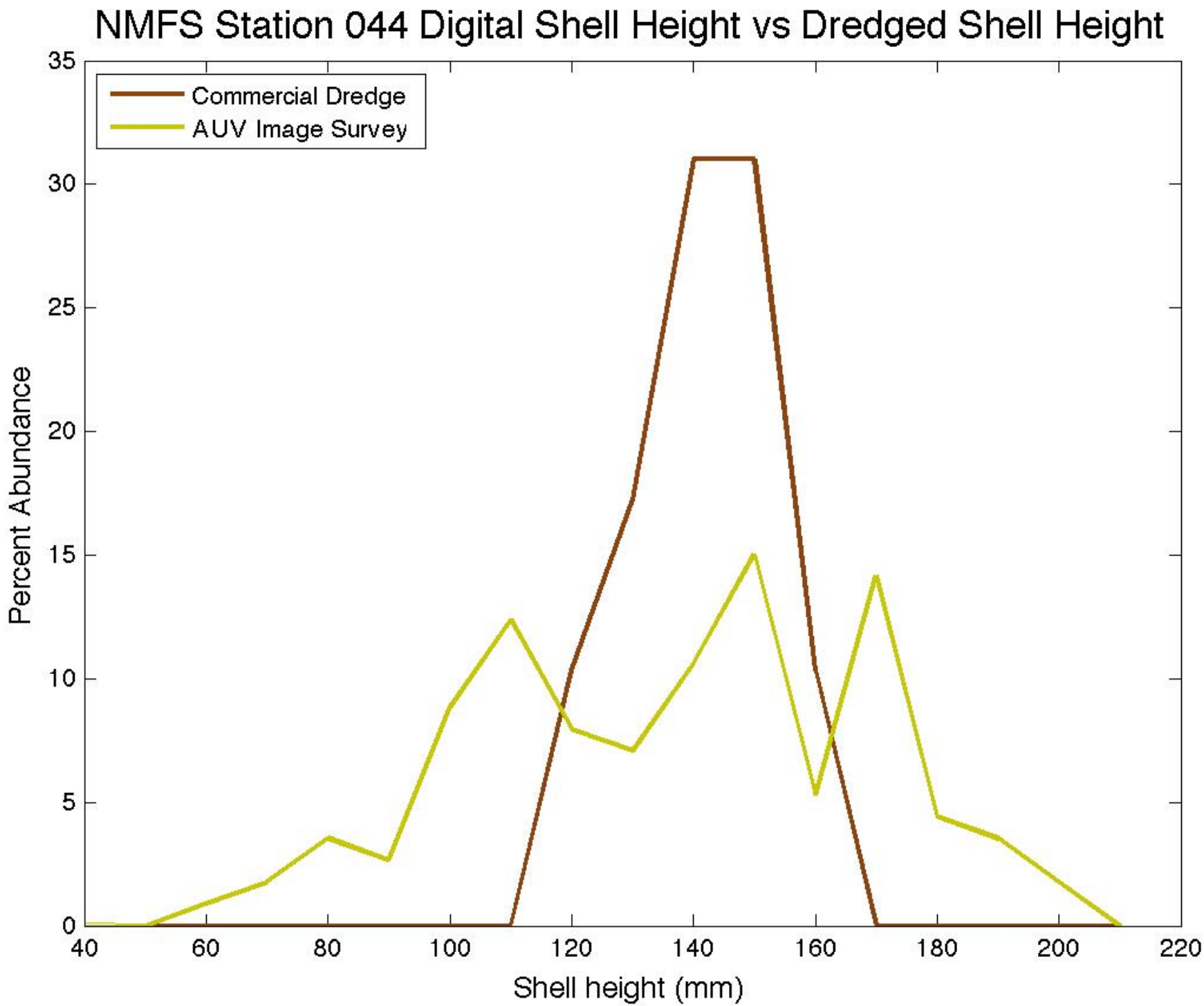
80
100
120
140
160
180
200
220


NMFS Station 044 Digital Shell Height vs Dredged Shell Height
Commercial Dredge
AUV Image Survey
Percent Abundance
Shell height (mm)
0
5
10
15
20
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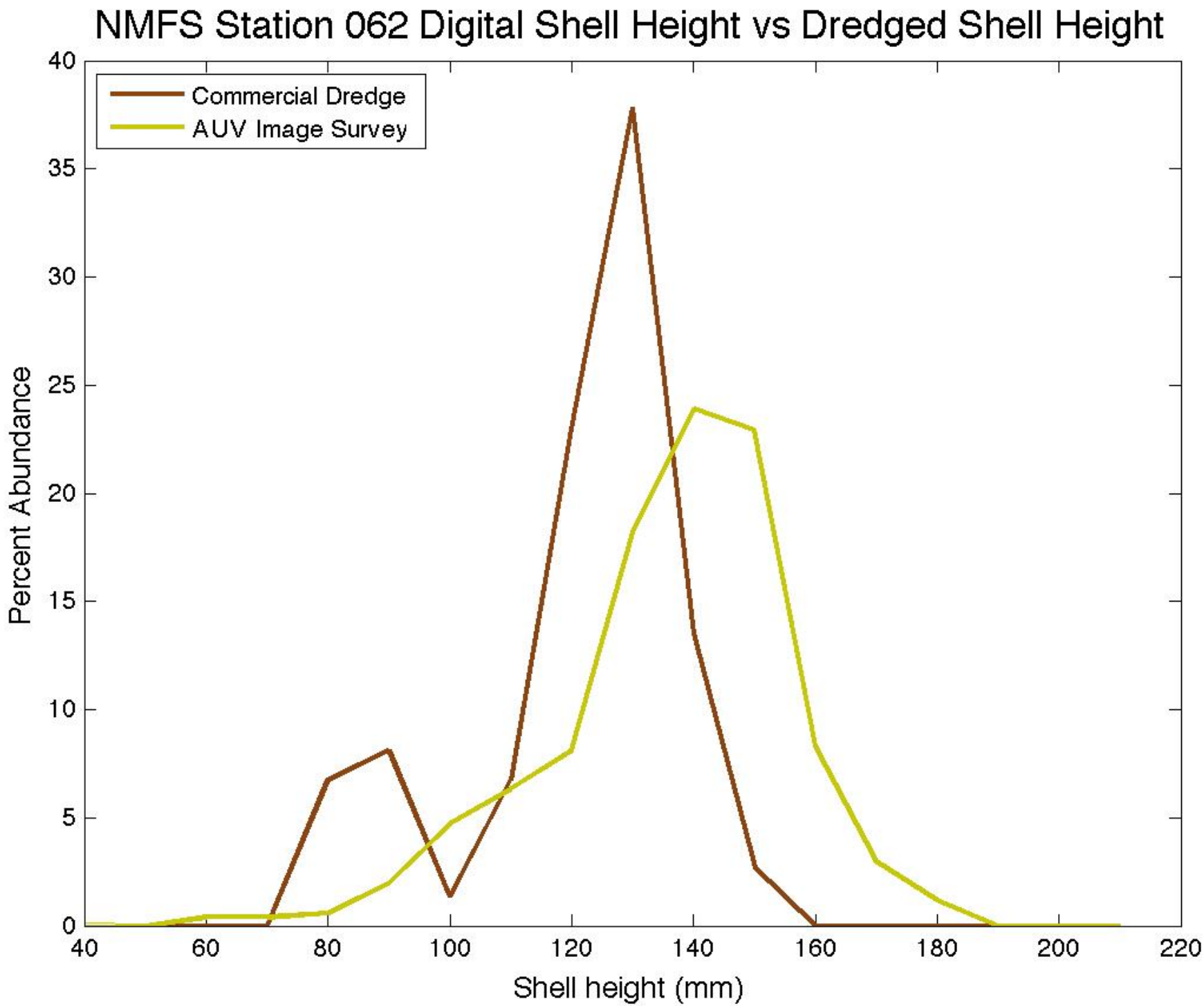
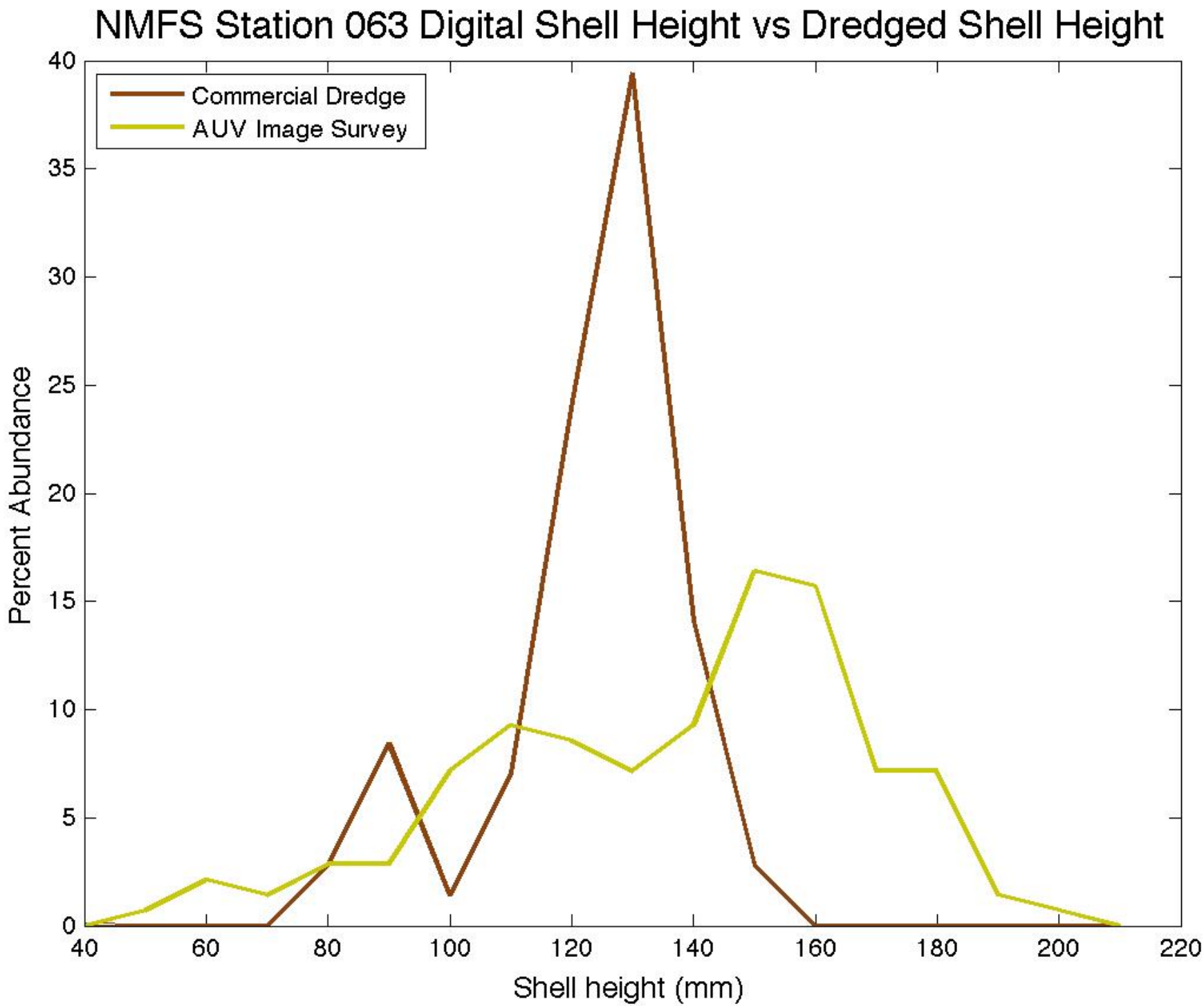
30
35
40
60
80
100
120
140
160
180
200
220


NMFS Station 062 Digital Shell Height vs Dredged Shell Height
Commercial Dredge
AUV Image Survey
Percent Abundance
Shell height (mm)
0
5
10
15
20
25
30
35
40
40
60
80
100
120
140
160
180
200
220


NMFS Station 063 Digital Shell Height vs Dredged Shell Height
Commercial Dredge
AUV Image Survey
Percent Abundance
Shell height (mm)
0
5
10
15
20
25
30
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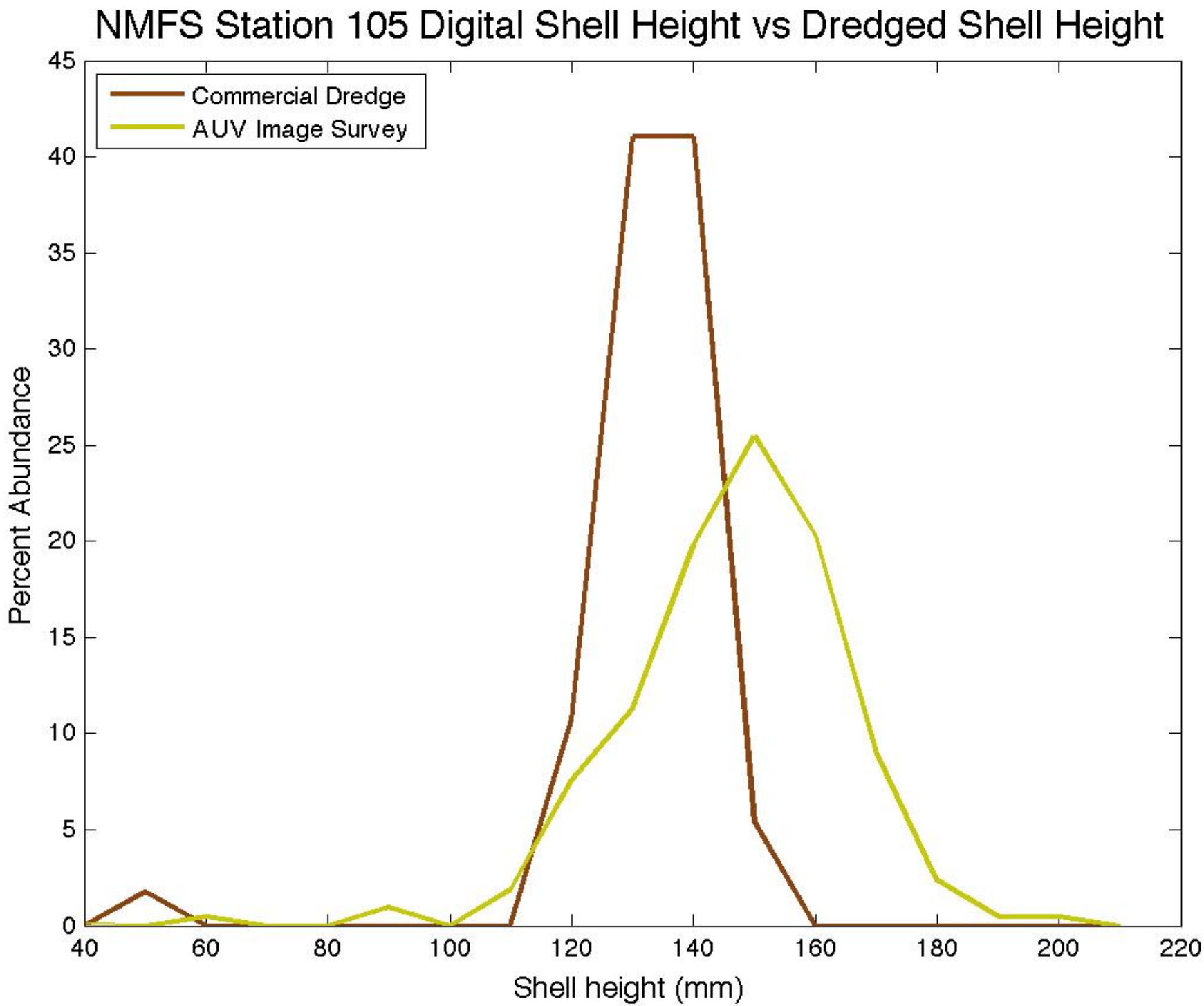
40
40
60
80
100
120
140
160
180
200
220


NMFS Station 105 Digital Shell Height vs Dredged Shell Height
Commercial Dredge
AUV Image Survey
Percent Abundance
Shell height (mm)
0
5
10
15
20
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30
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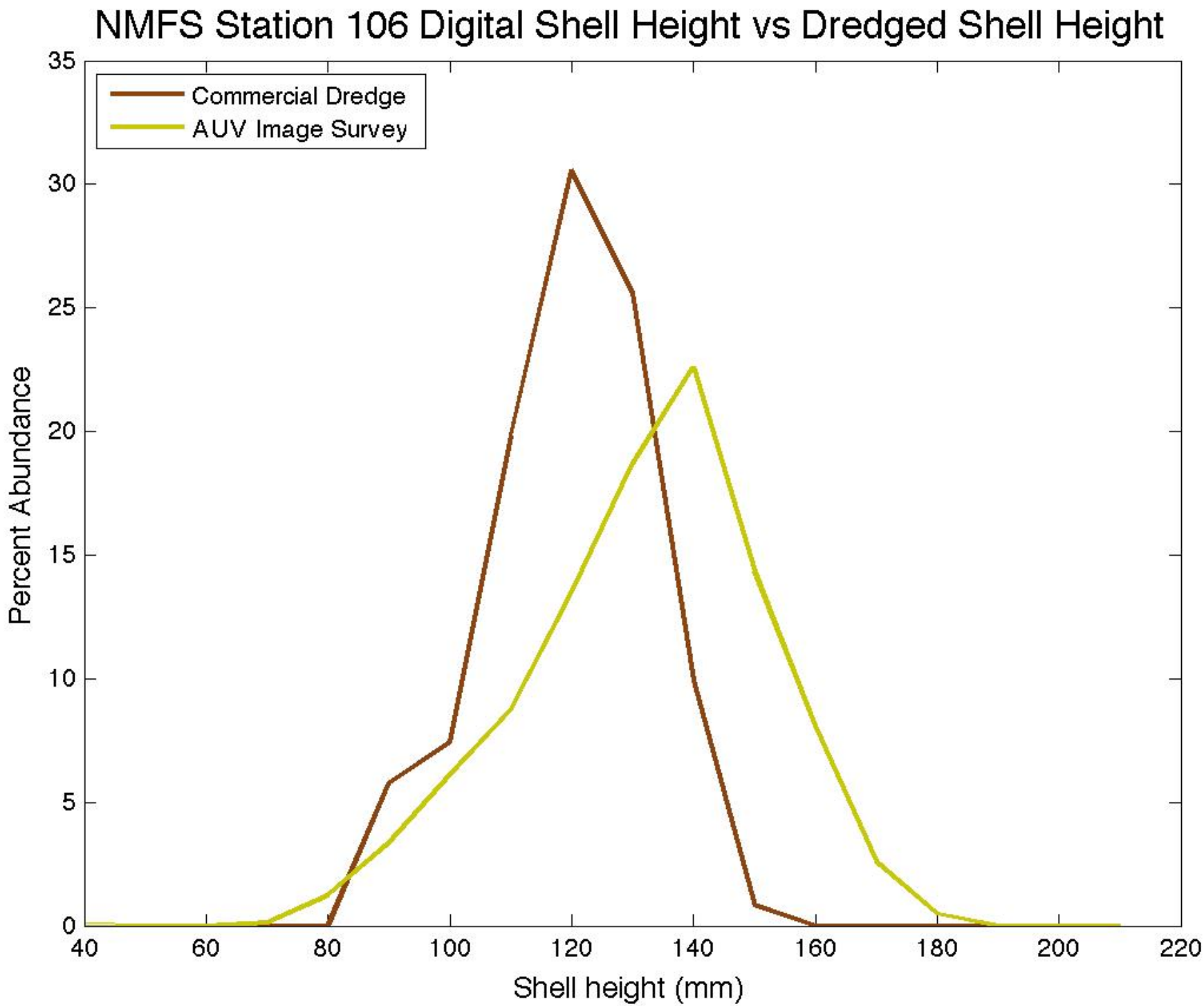
45
40
60
80
100
120
140
160
180
200
220


NMFS Station 106 Digital Shell Height vs Dredged Shell Height
Commercial Dredge
AUV Image Survey
Percent Abundance
Shell height (mm)
0
5
10
15
20
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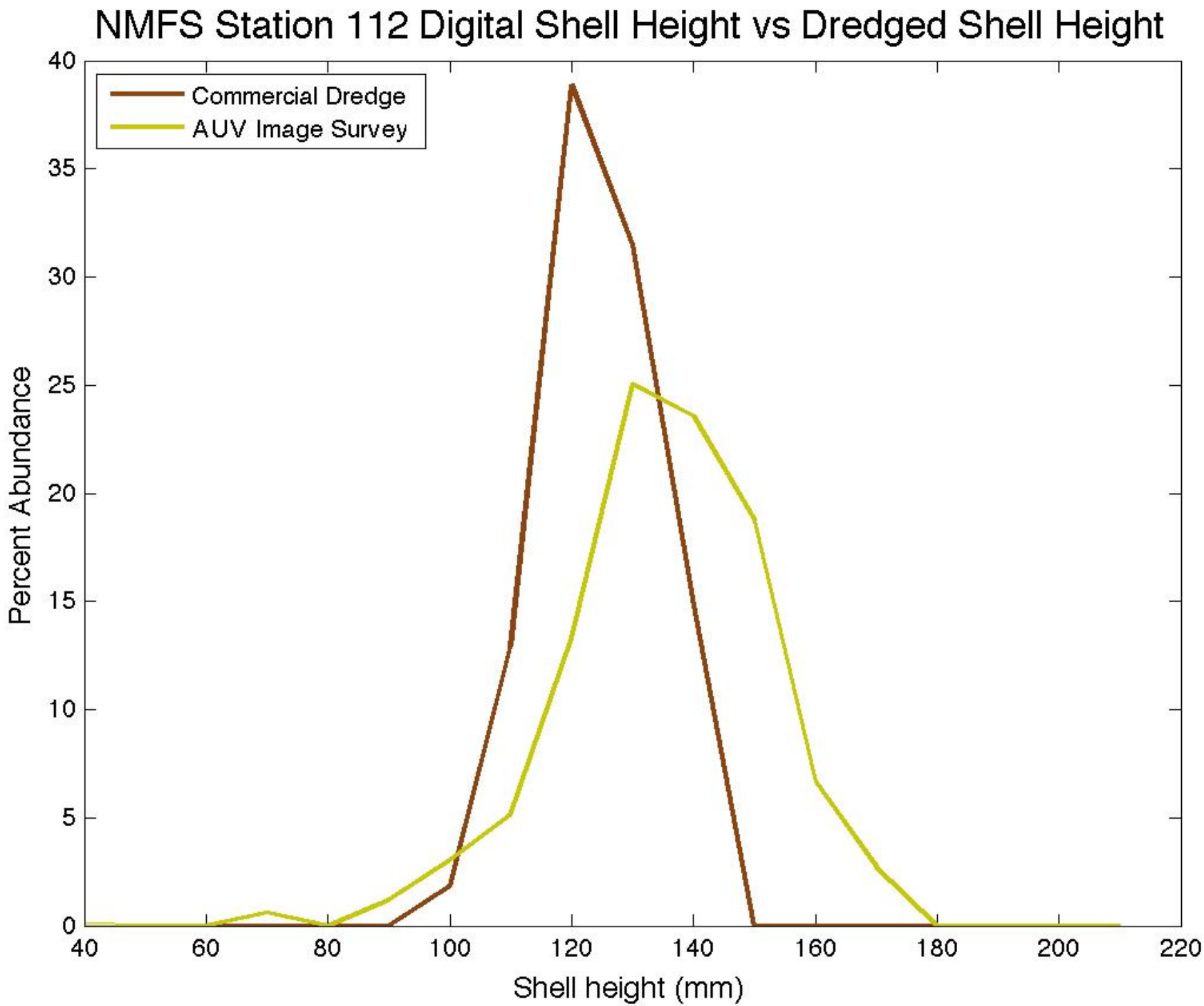
30
35
40
60
80
100
120
140
160
180
200
220


NMFS Station 112 Digital Shell Height vs Dredged Shell Height
Commercial Dredge
AUV Image Survey
Percent Abundance
Shell height (mm)
0
5
10
15
20
25
30
35
40
40
60
80
100
120
140
160
180
200
220

Appendix VI. Dredge Efficiency Estimate Table for both NMFS and Commercial Dredge compared to image analysis results

Summary	
NMFS Dredge	80.2%
Commercial Dredge	55.4%

	Total Scallops	Total Distance (m)	Survey Width (m)	Density (scallops/m2)	Efficiency
DV002(NMFS)	28	943	2.4384	0.012177	116.2%
DV002(F/V)	31	1670	4.572	0.004060	38.7%
DV002(UD)	35	1670	2	0.010479	
DV044(NMFS)	6	1729	2.4384	0.001423	40.5%
DV044(F/V)	29	1742	4.572	0.003641	103.6%
DV044(UD)	12	1742	1.96	0.003515	
DV062(NMFS)	11	1725	2.4384	0.002615	12.3%
DV062(F/V)	74	1738	4.572	0.009313	43.9%
DV062(UD)	69	1738	1.87	0.021230	
DV063(NMFS)	18	1782	2.4384	0.004142	38.9%
DV063(F/V)	71	1728	4.572	0.008987	84.5%
DV063(UD)	34	1728	1.85	0.010636	
DV105(NMFS)	31	1654	2.4384	0.007686	43.6%
DV105(F/V)	56	1673	4.572	0.007321	41.5%
DV105(UD)	54	1673	1.83	0.017638	
DV106(NMFS)	104	1731	2.4384	0.024639	81.5%
DV106(F/V)	121	1662	4.572	0.015924	52.7%
DV106(UD)	99	1662	1.97	0.030237	
DV112(NMFS)	50	1706	2.4384	0.012019	40.1%
DV112(F/V)	54	1711	4.572	0.006903	23.0%
DV112(UD)	96	1711	1.87	0.030004	
DV113(NMFS)	13	1779	2.4384	0.002997	128.0%
DV113(F/V)	-	-	-	-	
DV113(UD)	8	1789	1.91	0.002341	
DV115(NMFS)	163	1735	2.4384	0.038529	262.5%
DV115(F/V)	-	-	-	-	
DV115(UD)	49	1739	1.92	0.014676	
DV117(NMFS)	97	1739	2.4384	0.022875	57.4%
DV117(F/V)	-	-	-	-	
DV117(UD)	119	1589	1.88	0.039835	
DV118(NMFS)	21	1670	2.4384	0.005157	58.5%
DV118(F/V)	-	-	-	-	
DV118(UD)	29	1670	1.97	0.008815	
DV119	207	1740	2.4384	0.048788	83.3%
DV119(F/V)	465	1960	4.572	0.051891	88.6%
DV119(UD)	240	1960	2.09	0.058588	

Appendix VII. Overview and Interface Details of the newly developed SubSeaObservers Citizen Science Participation Website

SubseaObservers - Enabling citizen scientists to help assess the health and abundance of the East coast scallop fishery

Overview

The following is an overview of SubseaObservers, a modular and expandable citizen science web application currently under development for assessing scallop stocks. The goal of this project is to integrate educational material with an opportunity for the general public to participate directly in the assessment process.

The sea floor imagery generated by the University of Delaware's CSHEL group represents an exciting opportunity to engage the public. By making the massive image datasets generated by CSHEL's AUV activities available through a user-friendly, engaging and managed online experience, the general public will have an opportunity to 'learn by doing' and assist research teams with analyzing the imagery. In the process, a tremendous amount of well-structured data and metadata will be collected through user submissions that feed directly into ongoing scallop stock assessments, marine life identification research and other related programs.

To reduce costs and development time, SubseaObservers is being developed by leveraging the existing code base and infrastructure used to run MAPPER (www.getmapper.com), a citizen science image classification system used by the NASA Pavilion Lake Research Project. Since September 2011, MAPPER has been used by 4,500+ volunteers to classify over 1,045,000 images of the bottom of Pavilion and Kelly Lake in British Columbia, Canada. MAPPER has also opened a new channel of discussion with the general public by enabling direct participation in the research behind the project, and serves as a resource to help increase scientific literacy regarding life in extreme environments on Earth and how that relates to space.

Activity Workflow & Interface

SubseaObservers provides a custom-tailored interface for exploring and contributing to AUV-based scallop stock assessments using a video game-like approach. After users create an account and successfully complete a tutorial and quiz to orient themselves with the interface and analysis tasks, participants will be invited to analyze images of the sea floor by deploying their own customizable, virtual AUV (Figure 1). Participants are presented with a map of available datasets where they can chose to deploy their virtual sub and participate in classification activities (Figure 2).

During these activities, users are presented with a short series of images to analyze. The interface provides user-friendly tools for completing specific tasks such as counting the number of scallops in an image, measuring their size, etc (Figure 3). Users can also include text annotations to highlight interesting features or to provide in-depth comments about what they see. New task-specific tools will be added to SubseaObservers as required to accommodate new datasets as the system expands. As users submit their observations, the results are stored in a database for subsequent analysis.

Educational content will also be featured in SubseaObservers, and will provides background information about marine habitat research programs, technologies and personnel (Figure 4).

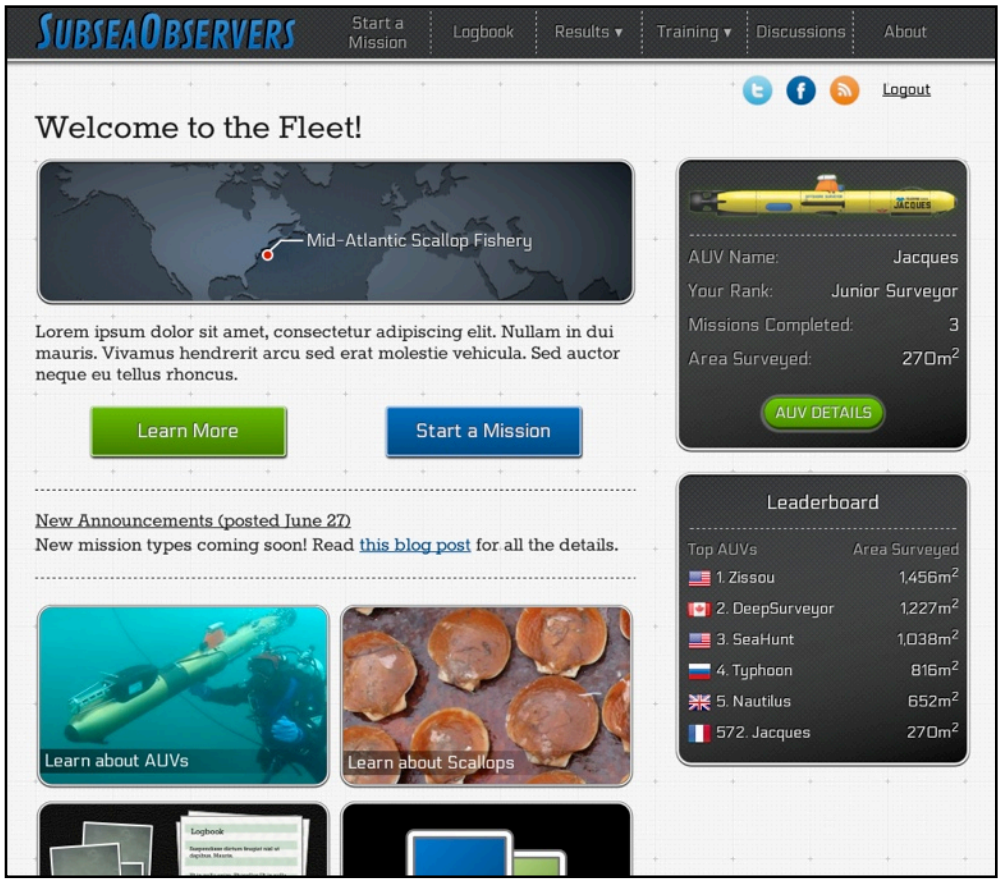


Figure 1: SubseaObservers Welcome screen

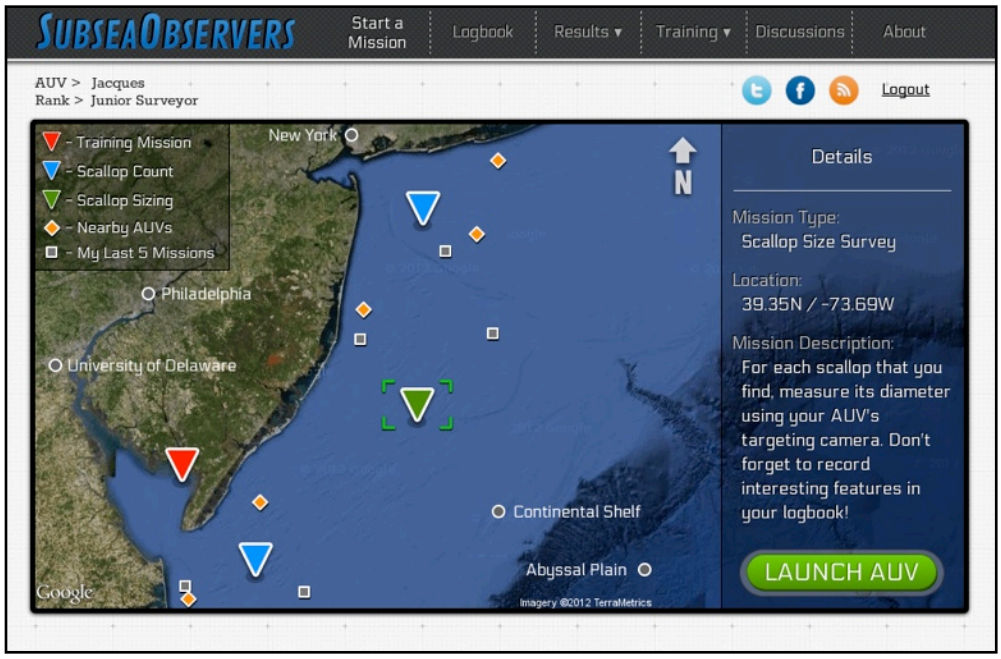


Figure 2: Mission Selection screen

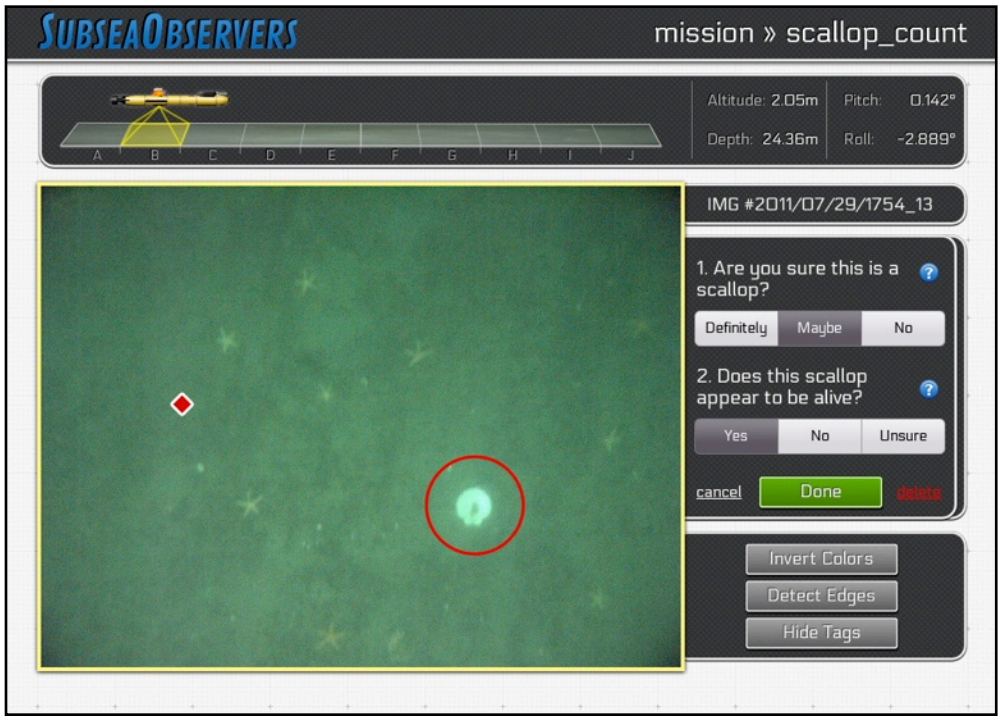


Figure 3: Scallop Counting task

Figure 4: Educational content

Participants increase their rank, earn achievements, unlock vehicle sensor upgrades and climb the leaderboard as they complete tasks. Sensor upgrades allow users to participate in new activities: e.g. after completing a given number of scallop counts, users can earn a 'targeting camera' for their vehicle that allows them to conduct scallop measurement activities.

Offering new types of activities and a variety of datasets to explore keeps the experience fresh and interesting for users as they contribute their observations, and helps to promote friendly competition and a feeling of accomplishment. Enabling users to customize and upgrade their vehicles, in addition to offering a choice of where to deploy their subs, reenforces a sense of self-determination and control over how they contribute to the project.

A notional overview map of the entire SubseaObservers application is provided in Figure 5.

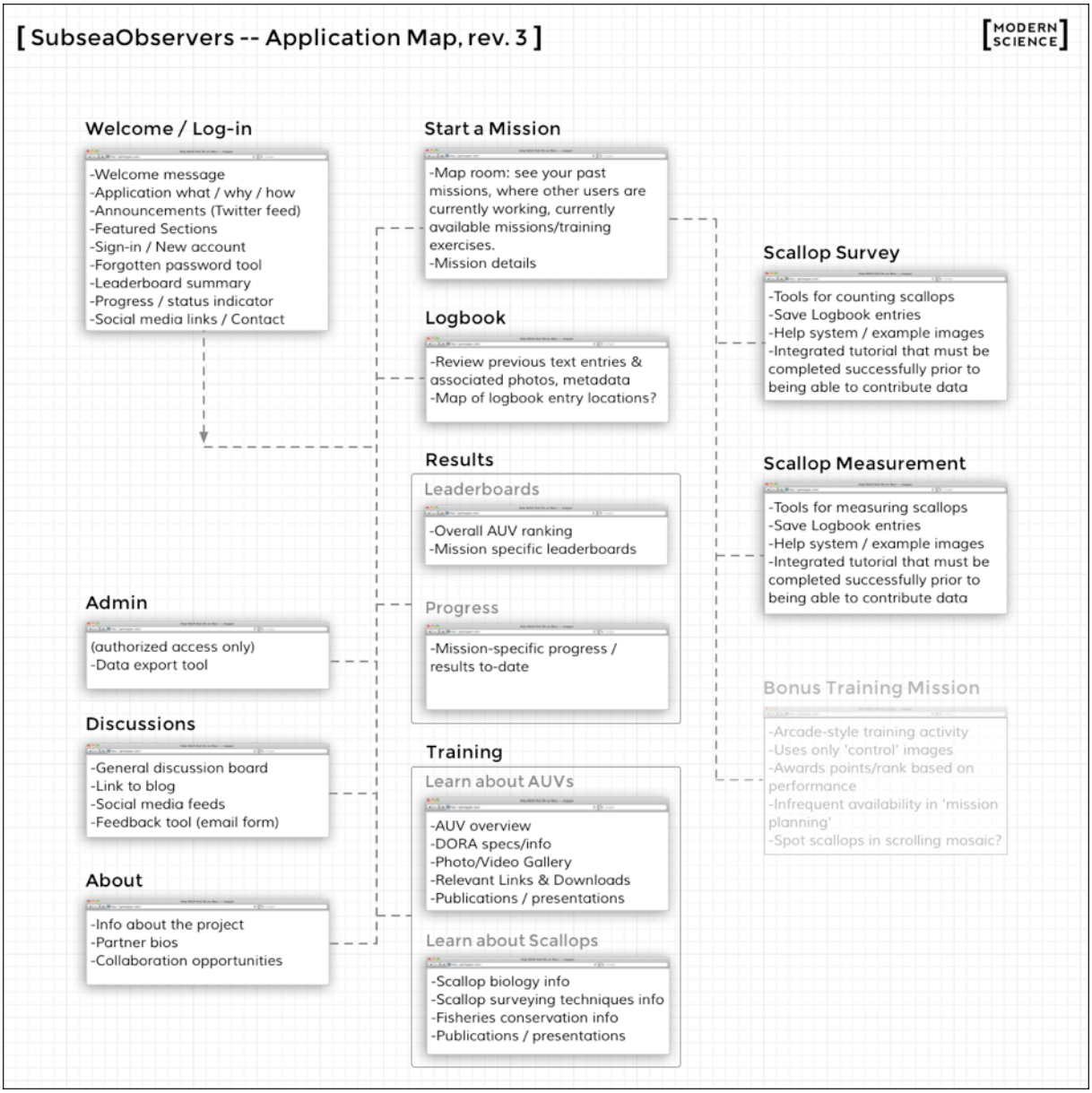


Figure 5: SubseaObservers Application Map

Data Quality

The existing MAPPER infrastructure includes several interrelated mechanisms to ensure that the data submitted by citizen scientists is high quality. These mechanisms include a combination of workflow design, project content and automated back-end software systems, all of which are being integrated into SubseaObservers:

- Tutorials and quizzes: Tutorials familiarize users with the overall goals of a project and the task at hand while introducing different types of imagery that will be encountered while exploring datasets. Quizzes ensure that users understand the interface and provide an opportunity to test proficiency with a given task before allowing users to submit classifications.
- Help system: A robust help system will be available to assist users as they progress through each task. The system could include example imagery with descriptions, videos of scientists explaining how to handle certain classification scenarios, and any other educational material required to assist users with making well-informed observations.
- Educational content: When users have a thorough understanding of what they're being asked to do, how their contributions fit into the big picture, and the nature of the overarching scientific problem that's being addressed, the more time and thought they'll put into each classification that they submit.
- Classification weighting: During survey mission activities, a mix of control images (i.e. photos that have a classification that's accepted by the science team) and unclassified images are presented to the user. The user will not be made aware of which images are the controls, therefore a 'confidence score' can be assigned to each set of submitted classifications based on how well the controls are classified by that user. Contributions from users who perform better on the control images would be weighted more heavily. Contributions from poor performers could be segregated from the rest of the dataset to prevent skewing of the overall results. Those users could also be locked out from submitting additional classifications until they re-demonstrate proficiency in the tutorials and quizzes.
- Participant consensus: One of the goals of this project is to get as many qualified people as possible to review the datasets. More classifications per image leads to a stronger consensus regarding the 'correct' observation for each photo. In conjunction with the classification weighting system described above, this will minimize the effect of outliers and bias in the submitted data.
- Achievement check-points: Certain activities can be set up such that they can only become available to users upon a successful review of their submissions by the science team. This approach serves as a check-point to ensure that only those users who are performing satisfactorily can proceed with new activities.
- Data spot-checks: Science teams can use the spot-check tool available in SubseaObservers' password-protected Admin section to review submitted data and flag inaccurate submissions.
- Automatic identification of suspect users: The system is capable of automatically detecting potential cheaters based on their submitted results. For instance, if it appears as though users are clicking though the interface to advance through the 'game' a quickly as possible without regard for data quality, the software can detect this behavior and flag them for subsequent review by the science team. If it's determined that the user was cheating, their submitted results can be extracted from the database and their account can be suspended.

Technologies

The project would be implemented by leveraging the existing MAPPER code base and infrastructure to reduce costs and shorten development time. MAPPER makes use of standard, well-established and future-proof Web technologies such as HTML5, CSS, and Javascript on the front-end to ensure that the application can run on a wide variety of devices, including tablets. MAPPER's back-end is implemented using PHP and MySQL running on an Apache/nginx webserver framework tuned for responsiveness, large datasets and scalability. A global Content Delivery Network ensures that static resources (such as interface elements, css and js files, etc) are dispatched to users as quickly as possible regardless of their geographic location. Image libraries are being formatted to optimize the balance between application responsiveness and image quality, and will be served from Amazon's S3 storage service to minimize hosting and bandwidth costs while maximizing availability. An overview of SubseaObservers' infrastructure is illustrated in Figure 6.

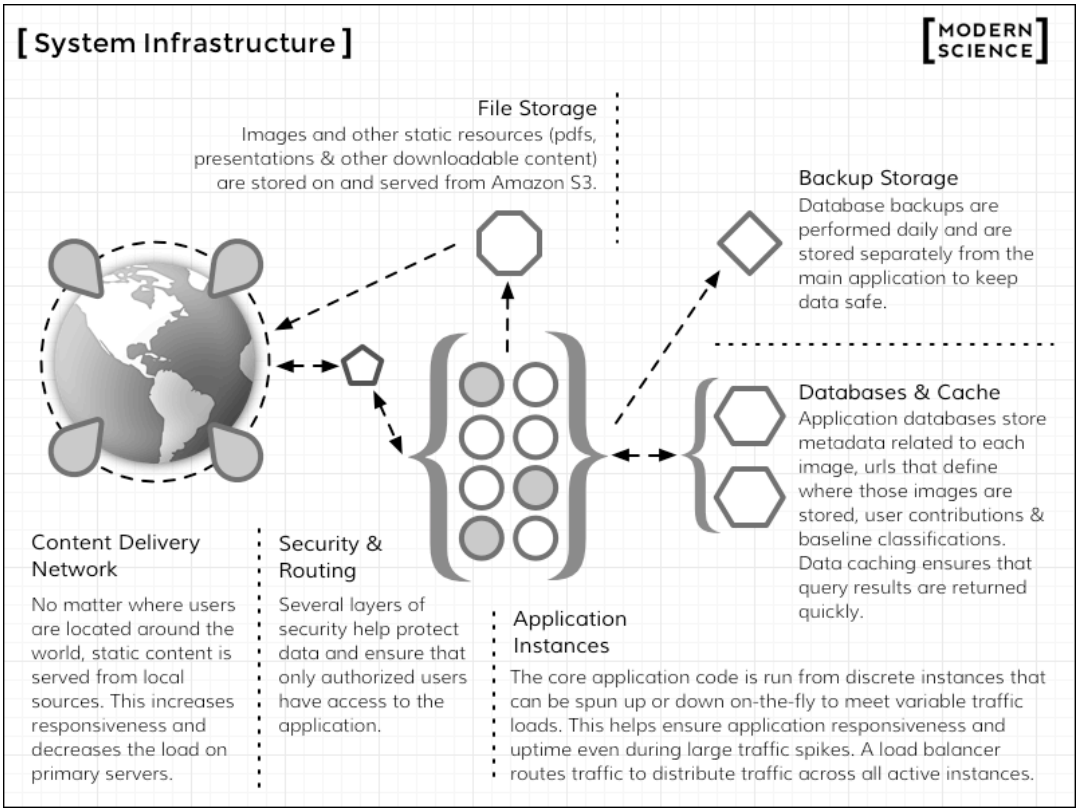


Figure 6: System Infrastructure

System Administration

Project team members will have access to SubseaObservers' password-protected Administration tools to review submitted data, flag suspect / poor quality users, check system usage and traffic analytics, track each activity's progress, manage performance check-points, and export user-submitted data for their particular dataset. The data export tool enables project admins to export the entire submitted dataset for their project, or just a portion of it depending on user-defined parameters (e.g. export data: between two dates, from certain users, pertaining to specific activities, etc). Data exports could be provided in a number of different formats, such

as plain-text .csv files for easy analysis in Excel and MatLab, or SQL dumps for archival purposes and in-depth querying in SQL-based database systems.

Promotion & Communications

Each of MAPPER's 4,500+ volunteers will be invited to contribute to SubseaObservers. To simplify the sign-up process for these existing volunteers, their MAPPER log-in details will be transferrable to SubseaObservers so they can get started right away. Moreover MAPPER has been featured on a number of high-profile websites such as Gizmodo, MSNBC, PC Gamer, Reddit, many other technology and science-related blogs, and has also been added to several online directories of citizen science activities. This established network of sites and directories will be leveraged to solicit new volunteers who are interested in contributing to SubseaObservers. Twitter, Facebook and blog accounts will be set up to facilitate communication between the project team and the SubseaObserver community of volunteers.

Expandability

SubseaObservers is being developed with expansion in mind. New datasets and analysis activities can be added to the application as discrete modules, and code can be reused for different datasets that require similar types of analysis tasks, where appropriate. For instance, the code that powers the scallop counting tool could be reused within SubseaObservers for counting tasks associated with other datasets. The extensive re-use of code and the integration of new datasets and research projects as discrete modules will reduce development time and costs significantly, while increasing the platform's flexibility.

Appendix VIII. Conference Proceedings, Press Articles, and Poster Presentations of Project Results.

A High-Density Image Analysis of Sea Scallop Habitat in the Mid-Atlantic Bight

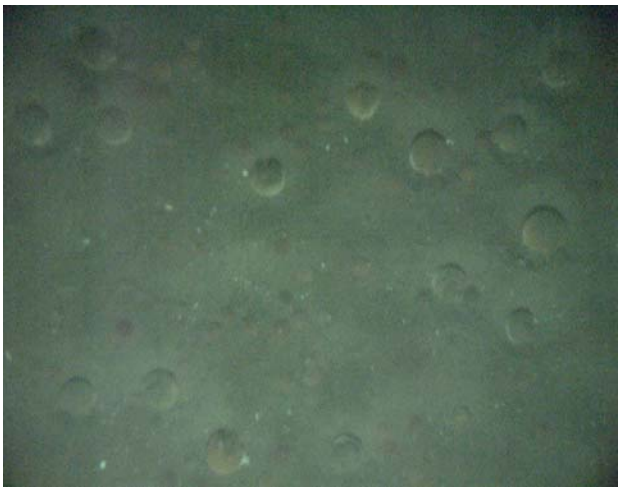
Arthur Trembanis[1], Justin Walker[1], Doug Miller[1], and Bill Phoel*[2]

[1]109 Penny Hall, College of Earth, Ocean, and Environment, University of Delaware, Newark DE, 19716 USA, art@udel.edu

[2]Phoel Associates, Inc.□35 Freeman Court□Toms River, NJ 08753-2613 *posthumous

The sea scallop (*Placopecten magellanicus*) fishery in the US EEZ of the northwest Atlantic Ocean has been, and still is, one of the most valuable fisheries in the United States Historically, the inshore sea scallop fishing grounds in the New York Bight, i.e. Montauk Point, New York to Cape May, New Jersey have provided a substantial amount of scallops. These areas can be highly productive but are at times rapidly depleted due to heavy fishing pressure. In our project we used a digital, rapid-fire camera integrated with a Gavia autonomous underwater vehicle (AUV) to collect a continuous record of photographs for mosaicing and subsequent scallop enumeration and size distribution. During our 2011 pilot study survey we collected over 255,000 images of the seabed. The entire image catalog was manually analyzed in the laboratory for estimates of abundance and size distribution. The AUV collected altitude and attitude data allowing us to georectify each image into scaled images for size measurements and enumeration. Thirteen mission sites reoccupied previous NMFS (National Marine Fisheries Service) monitoring stations. A typical AUV mission ran along ~14 km of seabed trackline covering approximately 22,400 m^2 of continuous seabed in color camera images and approximately 280,000 m^2 in sonar coverage of the seabed. A typical survey day involved four AUV missions of three hours each resulting in ~90,000 m^2 of continuous seabed color camera imagery. Based on the altitude of the AUV and the geometry of the camera each image is ~ 2.0 m across with a resolution of 2 mm/pixel. The scallop sizes can were manual measured using a heads-up digitizing computer software-measuring tool.

AUV camera image counts and sizes were compared to NMFS dredge survey measurements and coeval commercial dredge tows conducted during the AUV missions. A comparison of the imagery-based results to dredge tows confirms dredge efficiency values as have been previously reported. The camera surveys provided a non-extractive remote sensing approach for obtaining distributions over length-scales from meters to 10s of kilometers. Summary plots of AUV vehicle tracks and water column parameters (e.g. salinity and temperature) can be accessed publically at the URL links below.



Benthic Image of Scallop (*Placopecten magellanicus)* Beds from AUV survey- Mid-Atlantic Bight

http://cshel.geology.udel.edu/kml_files/Scallop/CruiseData/
http://cshel.geology.udel.edu/GoogleEarth/

UNIVERSITY of DELAWARE

UDaily

Art Trembanis, associate professor of geological sciences, used an autonomous underwater vehicle (AUV) to collect thousands of photos of the ocean floor and seeks volunteers to help count the number of scallops in each image as part of his research.

'Crowdsourcing'

Volunteers to help scientists analyze images on sea floor

9:01 a.m., March 5, 2012--Digital cameras make it easy to take a lot of photos – so many, in fact, that they can be difficult to sort through.

Try having more than 250,000. That is how many images researchers took of the ocean floor last summer as part of a new approach to estimating the mid-Atlantic sea scallop population. Now they are tasked with examining each photo, searching for scallops within the frame and counting exactly how many and what size.

It's a big job, and one in which they hope to enlist the help of science-minded volunteers. Art Trembanis, associate professor of geological sciences in the College of Earth, Ocean, and Environment, is developing a website where citizen scientists can log in, pull up individual photos and click on the small, sandy circles indicating scallops.

"We are excited to have the public assist in this," Trembanis said.

The concept is part of a growing trend to "crowdsource" scientific research that involves processing large quantities of visual data. Zooniverse.org, for example, houses multiple projects that the general public can take part in, from searching for exploding stars to studying the lives of the ancient Greeks. The site has more than a half-million participants.

Last year Trembanis partnered with NASA on one of the first marine Zooniverse applications, exploring the animals and formations around a Florida reef. A total of 485 volunteers examined seabed images 48,000 times to map an area where astronauts train underwater to simulate future missions to asteroids. A scoreboard ranked the top 50 identifiers to encourage friendly competition, much like a video game.

Trembanis hopes for similar success with his sea scallop project. Together with fishermen Kenny and Arthur Ochse, he is assessing the health and abundance of scallops off the mid-Atlantic coast to help regulators set fishing limits for commercial scallopers. Instead of using dredges to scoop scallops of all sizes up off the ocean floor, as traditional surveys do, the team adopted a new photography technique that is less disruptive to the ocean habitat and more accurate.

From the deck of a fishing boat, researchers send a remotely programmed, underwater robot called an autonomous underwater vehicle (AUV) into the ocean to take photos two meters above the sea floor while moving forward at a steady pace. The resulting images can be cobbled together into a mosaic, creating a continuous map using precise location information collected by the mini-submarine. Last summer the instrument documented nearly 200 acres (800,000 square meters) in a back-and-forth pattern and also generated sonar images of the topography that show features such as gouges in the sand where dredging previously occurred.

To date, Trembanis's three students have together looked at each of the 255,000 images – once. Ideally they would like to have every image reviewed at least four times, averaging the scallop counts in each photo to make a more precise estimate. The more volunteers on board, the quicker and more accurate the undertaking would be.

The team plans to conduct another survey this summer and turn the data around more quickly, possibly helping regulators adjust the scallop catch limit mid-season if warranted. They are finishing the beta version of a website for scallop image analysis and collaborating with the National Oceanic Atmospheric Administration's Fisheries Service to further develop the site in a user-friendly way that is appealing to teachers, students and the general public.

In addition to volunteers, Trembanis is also enlisting the help of computers by working with Herbert Tanner, UD assistant professor of mechanical engineering, on an automated shape detection program for scallops. The prototype is helpful in determining whether there are scallops in a photo at all, as is the case in only about five percent of the images. Yet the system still has some kinks, such as difficulty distinguishing between scallops and sand dollars. Simply put, computers are just not as good as people yet.

“We have the best image-processing computer on the planet resting on our shoulders,” Trembanis said.

People interested in volunteering for this project should contact Trembanis at art@udel.edu or 302-831-2498.

Article by Teresa Messmore

Photos by Evan Krape and Art Trembanis

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| |

Dare to be first.
UNIVERSITY OF DELAWARE.

The Sea Scallop

Justin H. Walker and Dr. Art Trembanis

http://cshel.geology.udel.edu/

Sea Scallop Facts

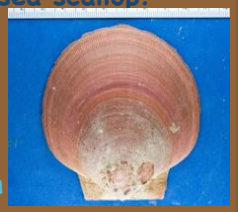
What is the sea scallop named after?

Because the radiating ribs on a scallop shell resemble a Roman comb, it was given the genus name Placopecten, which translates from Latin to mean "appeasing comb".

Can sea scallops see?

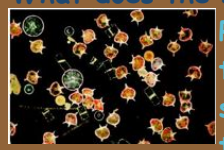
Why yes they can! Each of the black dots on the white mantle of the scallop in the image to the left is an eye. One scallop can have as many as 100 eyes!

How can I tell the age of a sea scallop?



Just like a tree, you can count the major rings on the outside of the scallop shell. Each ring represents about one year. Scallops have been known to live for 20 years!

What does the sea scallop eat?



Phytoplankton and zooplankton that get filtered through the sea scallop's gills where it is trapped in mucus.

What eats the sea scallop?!

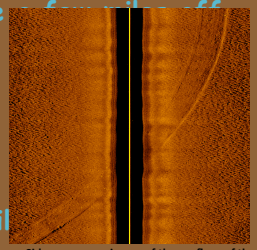
Sea stars, crabs, lobsters, and some fish.

Industry

Why are scallops harvested?

Because they are delicious! The part of the scallop that you eat is the adductor muscle. It is the muscle that the scallop contracts to keep its shell closed.

Each year fishing vessels like the Christian Alexa, set sail off of the North Atlantic coast in order to catch sea scallops. Once they are [illegible] the coast, they drop dredges that they tow along the seafloor, which can catch hundreds of scallops at a time. The contents of the dredges will be emptied onto the deck of the ship where the scallops are sorted and shucked (removing the adductor muscle from the shell). Each year, between 15,000 and 25,000 metric tons of sea scallop meat are fished from Mid-Atlantic waters



Side-scan sonar image of the seafloor of the Atlantic Ocean showing a dredge scar.

UD Research

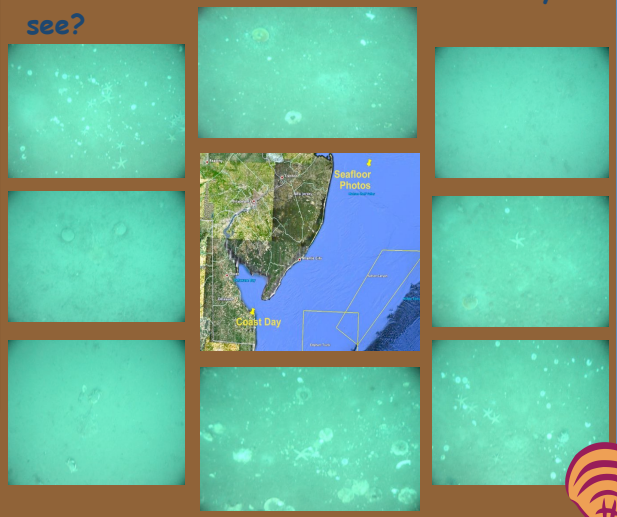
How is the University of Delaware involved with scallop research?

D.O.R.A the seafloor explorer.

D.O.R.A's underwater camera

We have teamed up with Dr. William Phoel and the fishing vessel Christian Alexa (co-captained by Arthur Ochse and Kenneth Ochse) to develop a method of estimating the Mid-Atlantic Bight sea scallop population and to classify their sizes using seafloor photographs, rather than the current method of having to dredge the seafloor for scallop samples.

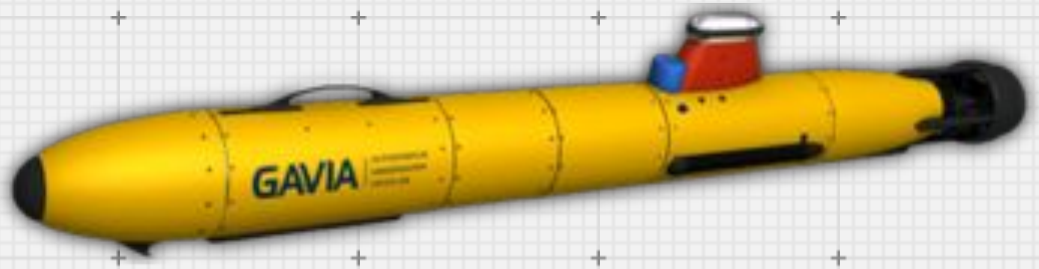
Can you find the scallops in the images below? What other sea creatures do you see?



Acknowledgements: Crew of the Christian Alexa: Co-Captain Arthur Ochse, Co-Captain Kenny Ochse, Mike Newman, Dave Crosson, and Robert Adams; William Phoel; Dvora Hart at NMFS; Mike Carrington and UTEC; Vizzuality; Val Schmidt; Vince Capone; Carter DuVal; and the AUV Team: Jonathan Gutsche and Bryan Keller

SubseaObservers

Welcome to SubseaObservers, where you can help manage the East Coast scallop fishery.

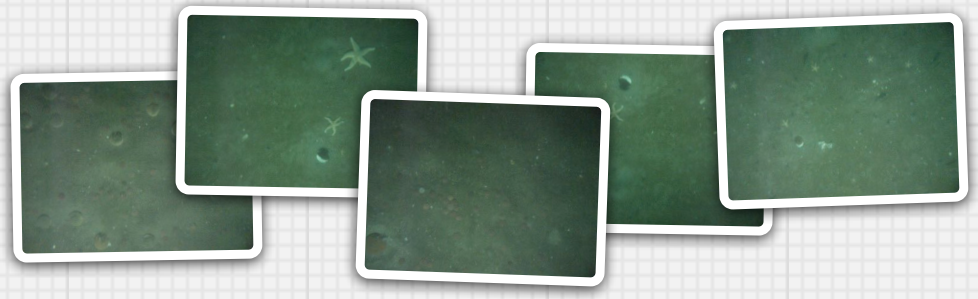


How does it work?

SubseaObservers

Scallop surveys normally use dredges that remove scallops from their natural environment and cause damage to the sea floor.

Researchers at the University of Delaware and their partners have developed a new method for surveying the Mid-Atlantic scallop population using underwater photography.



SubseaObservers

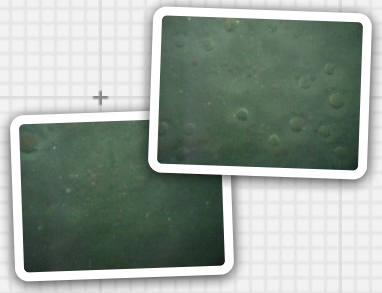
This new method covers more terrain in less time, records information about the sea floor and water quality, and helps researchers observe marine life in its natural habitat.

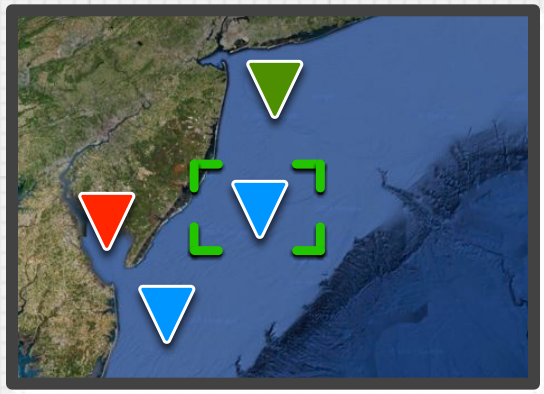
The photos are taken using an Autonomous Underwater Vehicle (AUV) named DORA. AUVs are robots that can explore the ocean without needing to be directly controlled by a person.

In SubseaObservers, you get your own virtual AUV that you can use to find scallops and other ocean critters.

SubseaObservers

After creating an account with SubseaObservers, you'll be able to name and configure your AUV, then choose where to send it in search of scallops.



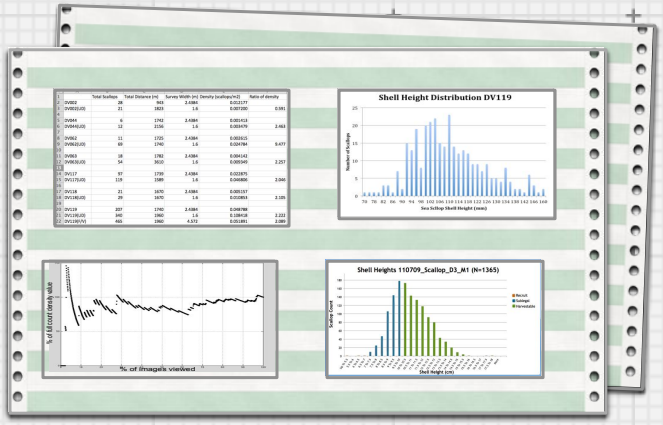


As you complete more missions and climb the Leaderboard, you'll earn AUV upgrades and stickers for your sub.

SubseaObservers

Information about the scallops that you discover is sent to project scientists. They turn your observations into reports about the size and health of the scallop population.

These reports are then used by NOAA and other agencies to manage the scallop fishery to make sure that there's enough scallops to be fished now and in the future.

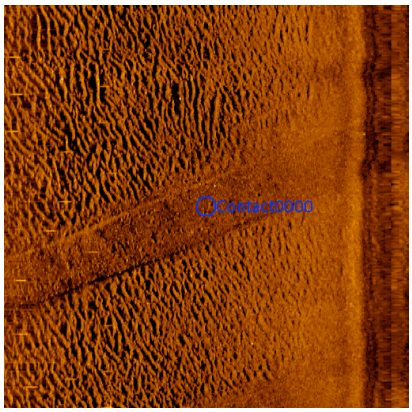


Appendix IX. Side-scan sonar target reports for each AUV mission site

Report 110708_Scallop_DvoraRun

Generated on: 07/23/2012 11:20:40 AM by SonarWiz.MAP targetReportGen2 V3.15.15

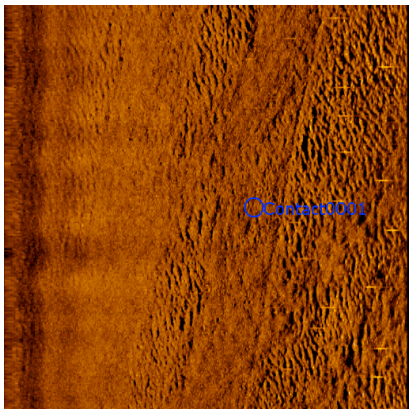
Contact Image | Contact Info | User Entered Info



Contact0000

- Sonar Time at Target: 07/08/2011 23:17:01
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110708_Scallop_DvoraRun\files\ssonar\08JUL218.mst
- Ping Number: 236
- Range to Target: 13.71 Meters
- Fish Height: 2.26 Meters
- Heading: 226.340 degrees
- Event Number: 0
- Water Depth: 46.28
- Line Name: 08JUL218

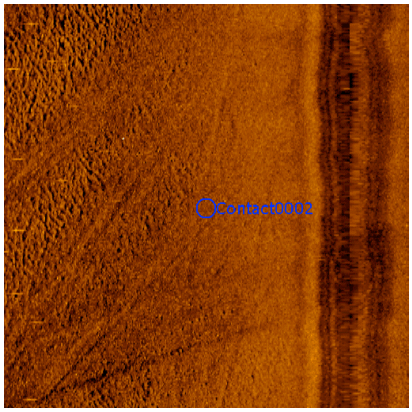
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 4 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Commrecial scallop dredge



Contact0001

- Sonar Time at Target: 07/08/2011 23:17:23
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110708_Scallop_DvoraRun\files\ssonar\08JUL218.mst
- Ping Number: 524
- Range to Target: 18.57 Meters
- Fish Height: 2.43 Meters
- Heading: 226.140 degrees
- Event Number: 0
- Water Depth: 46.23
- Line Name: 08JUL218

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 5 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Commercial scallop dredge



Contact0002

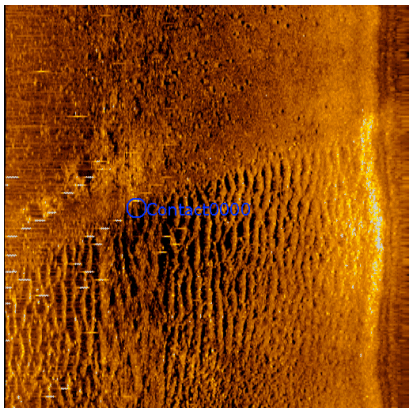
- Sonar Time at Target: 07/08/2011 23:18:25
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110708_Scallop_DvoraRun\files\ssonar\08JUL219.mst
- Ping Number: 347
- Range to Target: 10.66 Meters
- Fish Height: 2.43 Meters
- Heading: 226.930 degrees
- Event Number: 0
- Water Depth: 46.20
- Line Name: 08JUL219

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Intersecting dredge scars

Report 110708_ScallopD2_M4

Generated on: 07/23/2012 11:29:27 AM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image



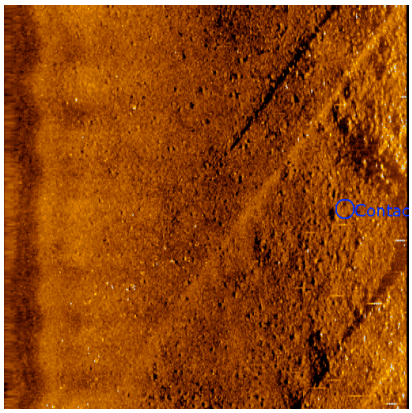
Contact Info

Contact0000

- Sonar Time at Target: 07/08/2011 21:10:52
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110708_ScallopD2_M4\files\ssonar\08JUL167.mst
- Ping Number: 657
- Range to Target: 20.16 Meters
- Fish Height: 1.85 Meters
- Heading: 271.530 degrees
- Event Number: 0
- Water Depth: 43.65
- Line Name: 08JUL167

User Entered Info

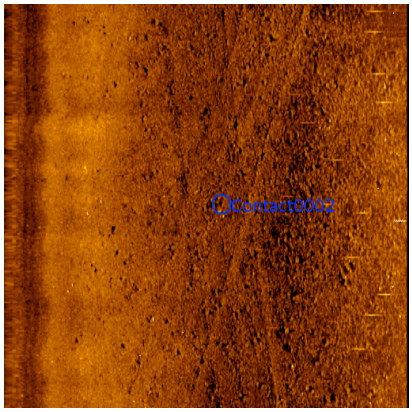
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Ripple Conctact
Classification 2:
Area:
Block:
Description: Ripple contact



Contact0001

- Sonar Time at Target: 07/08/2011 21:21:34
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110708_ScallopD2_M4\files\ssonar\08JUL176.mst
- Ping Number: 195
- Range to Target: 25.31 Meters
- Fish Height: 2.43 Meters
- Heading: 270.980 degrees
- Event Number: 0
- Water Depth: 43.65
- Line Name: 08JUL176

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 4 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Commercial scallop dredge



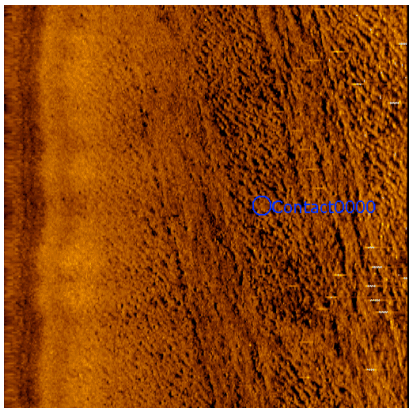
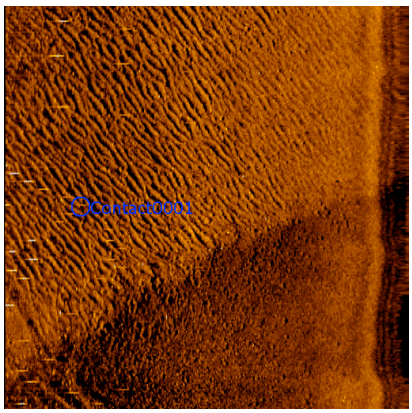
Contact0002

- Sonar Time at Target: 07/08/2011 21:02:53
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110708_ScallopD2_M4\files\ssonar\08JUL161.mst
- Ping Number: 267
- Range to Target: 16.11 Meters
- Fish Height: 2.31 Meters
- Heading: 271.450 degrees
- Event Number: 0
- Water Depth: 43.68
- Line Name: 08JUL161

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Intersecting dredge scars

Report 110708_ScallopD2

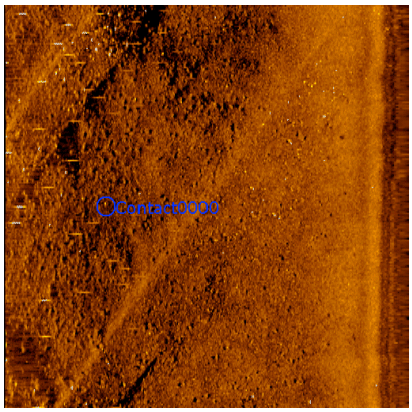
Generated on: 07/23/2012 11:24:09 AM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/08/2011 16:57:00 • Map Proj: UTM84-18N • Acoustic Source File: F:\110708_ScallopD2\files\ssonar\08JUL056.mst • Ping Number: 315 • Range to Target: 19.16 Meters • Fish Height: 2.37 Meters • Heading: 1.850 degrees • Event Number: 0 • Water Depth: 41.14 • Line Name: 08JUL056	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 5 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Commercial Scallop Dredge
	**Contact0001** • Sonar Time at Target: 07/08/2011 17:23:29 • Map Proj: UTM84-18N • Acoustic Source File: F:\110708_ScallopD2\files\ssonar\08JUL076.mst • Ping Number: 552 • Range to Target: 24.26 Meters • Fish Height: 2.02 Meters • Heading: 1.650 degrees • Event Number: 0 • Water Depth: 39.71 • Line Name: 08JUL076	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Ripples Classification 2: Area: Block: Description: Ripples

Report 110708_SM2

Generated on: 07/23/2012 11:34:04 AM by SonarWiz.MAP targetReportGen2 V3.15.15

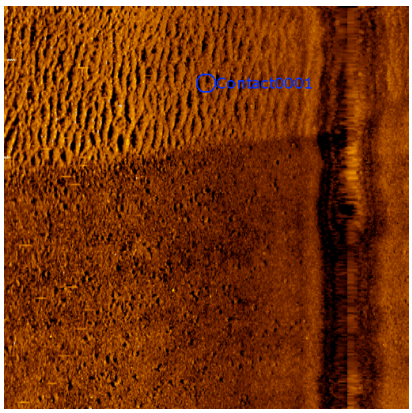
Contact Image | Contact Info | User Entered Info



Contact0000

- Sonar Time at Target: 07/08/2011 13:21:58
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110708_SM2\files\ssonar\08JUL009.mst
- Ping Number: 401
- Range to Target: 22.38 Meters
- Fish Height: 2.37 Meters
- Heading: 89.810 degrees
- Event Number: 0
- Water Depth: 43.45
- Line Name: 08JUL009

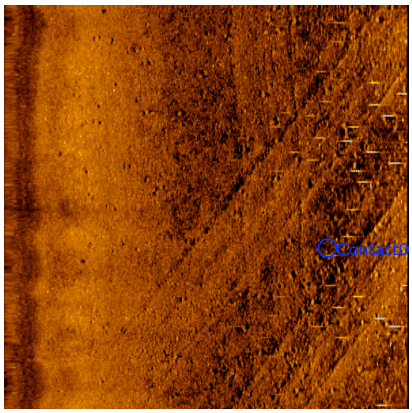
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 4 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Commercial scallop dredge



Contact0001

- Sonar Time at Target: 07/08/2011 13:33:09
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110708_SM2\files\ssonar\08JUL018.mst
- Ping Number: 49
- Range to Target: 10.49 Meters
- Fish Height: 2.43 Meters
- Heading: 89.280 degrees
- Event Number: 0
- Water Depth: 43.40
- Line Name: 08JUL018

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 1 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Ripple Contact
Classification 2:
Area:
Block:
Description: Ripple contact



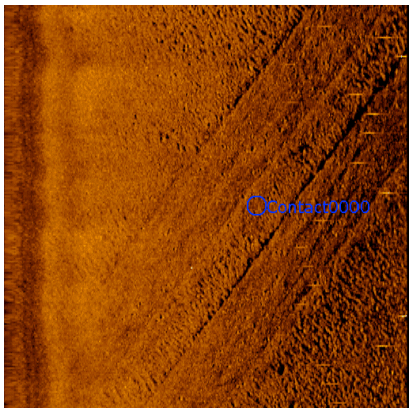
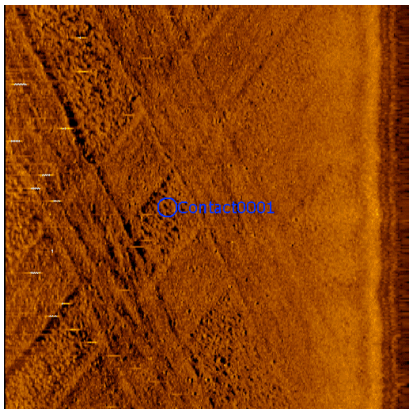
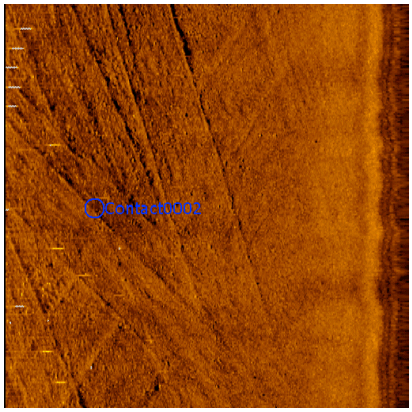
Contact0003

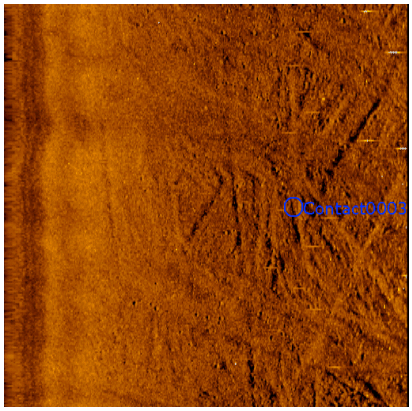
- Sonar Time at Target: 07/08/2011 13:42:11
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110708_SM2\files\ssonar\08JUL024.mst
- Ping Number: 880
- Range to Target: 24.02 Meters
- Fish Height: 2.43 Meters
- Heading: 87.870 degrees
- Event Number: 0
- Water Depth: 42.99
- Line Name: 08JUL024

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Intersecting dredge scars

Report 110709_Scallop_D3_M1_Corey

Generated on: 07/23/2012 11:38:53 AM by SonarWiz.MAP targetReportGen2 V3.15.15

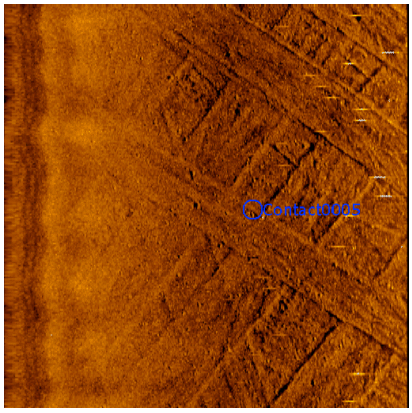
Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/09/2011 11:36:12 • Map Proj: UTM84-18N • Acoustic Source File: F:\110709_Scallop_D3_M1_Corey\files\ssonar\09JUL002.mst • Ping Number: 446 • Range to Target: 18.75 Meters • Fish Height: 2.55 Meters • Heading: 1.610 degrees • Event Number: 0 • Water Depth: 44.69 • Line Name: 09JUL002	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 5 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Commercial scallop dredge
	**Contact0001** • Sonar Time at Target: 07/09/2011 11:55:23 • Map Proj: UTM84-18N • Acoustic Source File: F:\110709_Scallop_D3_M1_Corey\files\ssonar\09JUL015.mst • Ping Number: 572 • Range to Target: 17.81 Meters • Fish Height: 2.31 Meters • Heading: 178.650 degrees • Event Number: 0 • Water Depth: 44.87 • Line Name: 09JUL015	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Intersecting dredge scars
	**Contact0002** • Sonar Time at Target: 07/09/2011 12:17:10 • Map Proj: UTM84-18N • Acoustic Source File: F:\110709_Scallop_D3_M1_Corey\files\ssonar\09JUL031.mst • Ping Number: 579 • Range to Target: 23.20 Meters • Fish Height: 2.37 Meters • Heading: 2.380 degrees • Event Number: 0 • Water Depth: 45.20 • Line Name: 09JUL031	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Intersecting dredge scars



Contact0003

- Sonar Time at Target: 07/09/2011 12:49:16
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110709_Scallop_D3_M1_Corey\files\ssonar\09JUL055.mst
- Ping Number: 806
- Range to Target: 21.50 Meters
- Fish Height: 2.31 Meters
- Heading: 177.400 degrees
- Event Number: 0
- Water Depth: 46.03
- Line Name: 09JUL055

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Intersecting dredge scars



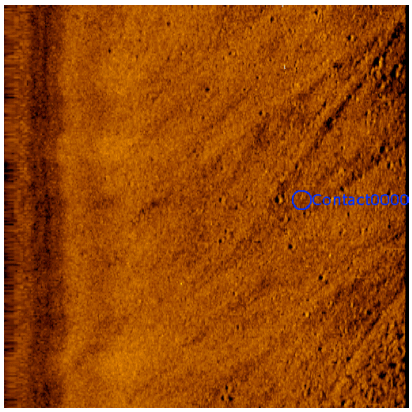
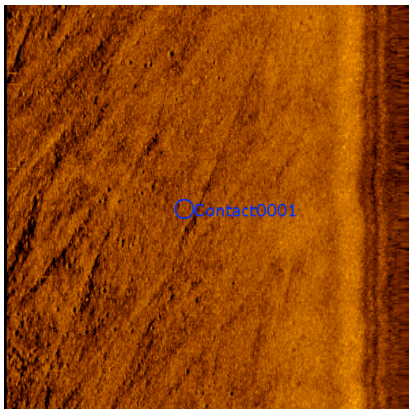
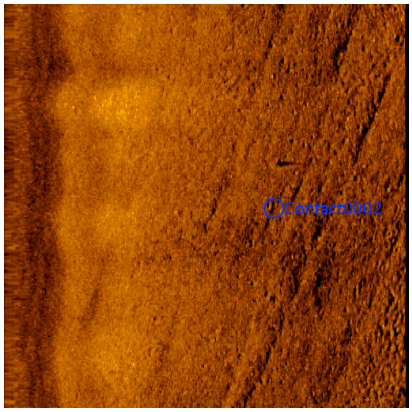
Contact0005

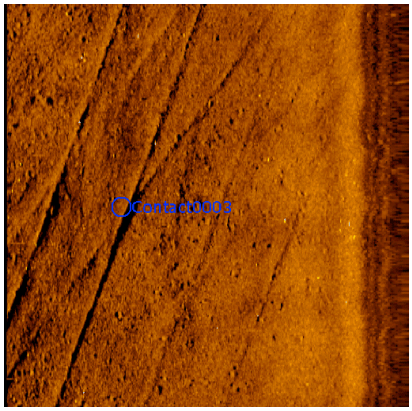
- Sonar Time at Target: 07/09/2011 13:34:57
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110709_Scallop_D3_M1_Corey\files\ssonar\09JUL085.mst
- Ping Number: 852
- Range to Target: 18.46 Meters
- Fish Height: 2.37 Meters
- Heading: 4.190 degrees
- Event Number: 0
- Water Depth: 46.23
- Line Name: 09JUL085

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Intersecting dredge scars

Report 110709_ScallopDay3_DV119

Generated on: 07/20/2012 10:53:17 AM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/10/2011 01:20:12 • Map Proj: UTM84-18N • Acoustic Source File: F:\110709_ScallopDay3_DV119\files\ssonar\10JUL003.mst • Ping Number: 122 • Range to Target: 14.73 Meters • Fish Height: 2.36 Meters • Heading: 123.890 degrees • Event Number: 0 • Water Depth: 40.50 • Line Name: 10JUL003	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Parallel relic scallop dredge scars
	**Contact0001** • Sonar Time at Target: 07/10/2011 01:28:43 • Map Proj: UTM84-18N • Acoustic Source File: F:\110709_ScallopDay3_DV119\files\ssonar\10JUL012.mst • Ping Number: 626 • Range to Target: 11.05 Meters • Fish Height: 2.36 Meters • Heading: 122.930 degrees • Event Number: 0 • Water Depth: 42.13 • Line Name: 10JUL012	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Intersecting scallop dredge scars
	**Contact0002** • Sonar Time at Target: 07/10/2011 02:54:28 • Map Proj: UTM84-18N • Acoustic Source File: F:\110709_ScallopDay3_DV119\files\ssonar\10JUL112.mst • Ping Number: 496 • Range to Target: 13.36 Meters • Fish Height: 2.29 Meters • Heading: 123.330 degrees • Event Number: 0 • Water Depth: 43.06 • Line Name: 10JUL112	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Parallel dredge scars



Contact0003

- Sonar Time at Target: 07/10/2011 01:50:38
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110709_ScallopDay3_DV119\files\ssonar\10JUL038.mst
- Ping Number: 351
- Range to Target: 14.14 Meters
- Fish Height: 2.44 Meters
- Heading: 307.680 degrees
- Event Number: 0
- Water Depth: 42.87
- Line Name: 10JUL038

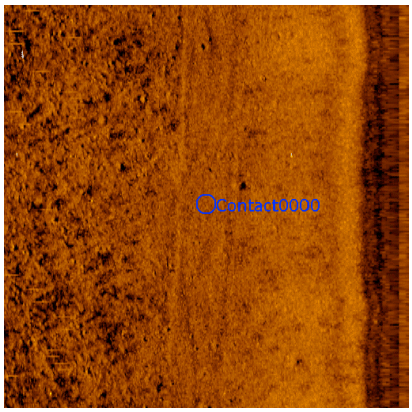
Dimensions

Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Intersecting scallop dredge scars

Report 110710_DV117

Generated on: 08/13/2012 01:28:00 PM by SonarWiz.MAP targetReportGen2 V3.15.15

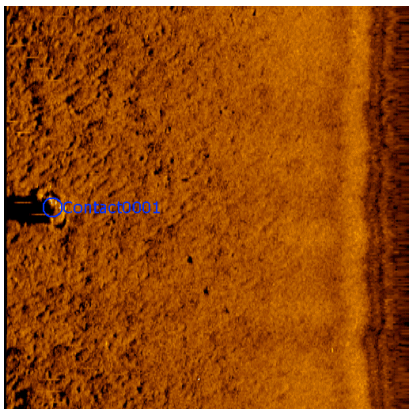
Contact Image | Contact Info | User Entered Info



Contact0000

- Sonar Time at Target: 07/10/2011 15:57:43
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110710_DV117\files\ssonar\10JUL001.mst
- Ping Number: 566
- Range to Target: 9.53 Meters
- Fish Height: 2.52 Meters
- Heading: 314.980 degrees
- Event Number: 0
- Water Depth: 32.03
- Line Name: 10JUL001

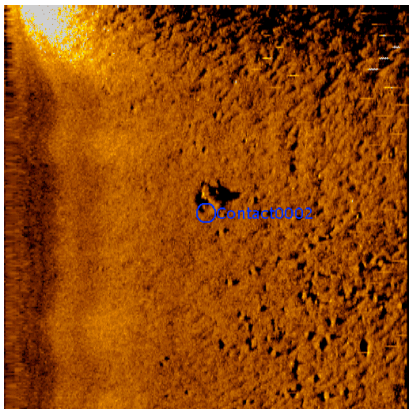
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 3 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: NMFS survey dredge scar



Contact0001

- Sonar Time at Target: 07/10/2011 17:04:53
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110710_DV117\files\ssonar\10JUL076.mst
- Ping Number: 760
- Range to Target: 17.58 Meters
- Fish Height: 2.21 Meters
- Heading: 125.510 degrees
- Event Number: 0
- Water Depth: 34.13
- Line Name: 10JUL076

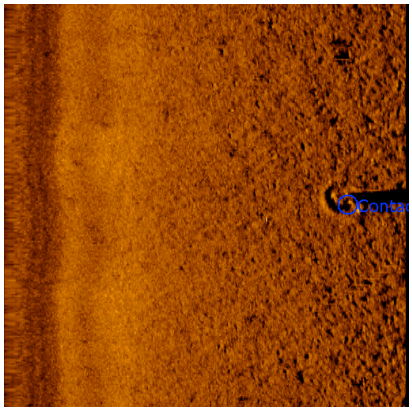
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 2 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Vertical Target
Classification 2:
Area:
Block:
Description:



Contact0002

- Sonar Time at Target: 07/10/2011 17:04:46
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110710_DV117\files\ssonar\10JUL076.mst
- Ping Number: 631
- Range to Target: 9.92 Meters
- Fish Height: 2.29 Meters
- Heading: 125.840 degrees
- Event Number: 0
- Water Depth: 34.18
- Line Name: 10JUL076

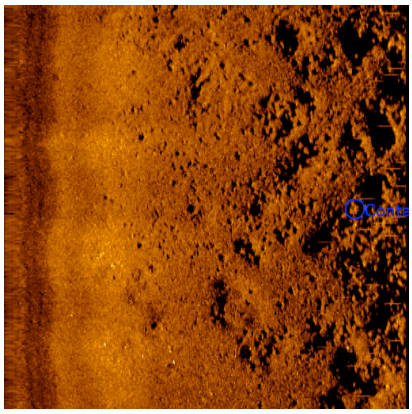
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 2 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Vertical Target
Classification 2:
Area:
Block:
Description:



Contact0003

- Sonar Time at Target: 07/10/2011 17:26:44
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110710_DV117\files\ssonar\10JUL100.mst
- Ping Number: 699
- Range to Target: 16.99 Meters
- Fish Height: 2.21 Meters
- Heading: 313.270 degrees
- Event Number: 0
- Water Depth: 33.11
- Line Name: 10JUL100

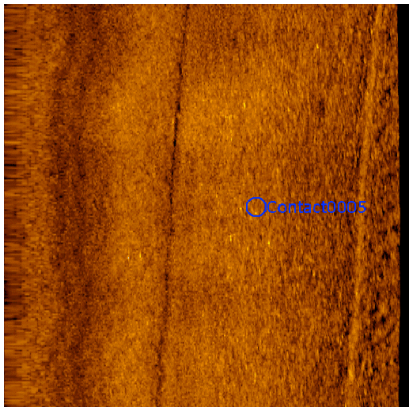
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 2 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Vertical Target
Classification 2:
Area:
Block:
Description:



Contact0004

- Sonar Time at Target: 07/10/2011 17:31:10
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110710_DV117\files\ssonar\10JUL106.mst
- Ping Number: 160
- Range to Target: 17.34 Meters
- Fish Height: 2.05 Meters
- Heading: 313.740 degrees
- Event Number: 0
- Water Depth: 34.32
- Line Name: 10JUL106

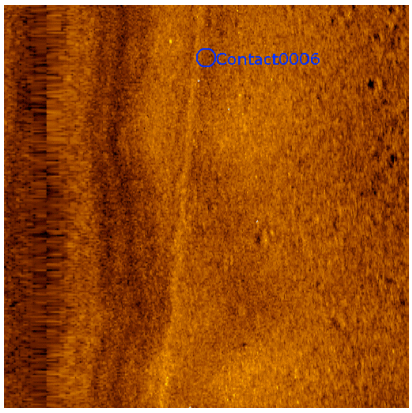
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Mounds
Classification 2:
Area:
Block:
Description: Mounds



Contact0005

- Sonar Time at Target: 07/10/2011 20:11:11
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110710_DV117\files\ssonar\10JUL166.mst
- Ping Number: 610
- Range to Target: 6.23 Meters
- Fish Height: 2.14 Meters
- Heading: 289.730 degrees
- Event Number: 0
- Water Depth: 32.83
- Line Name: 10JUL166

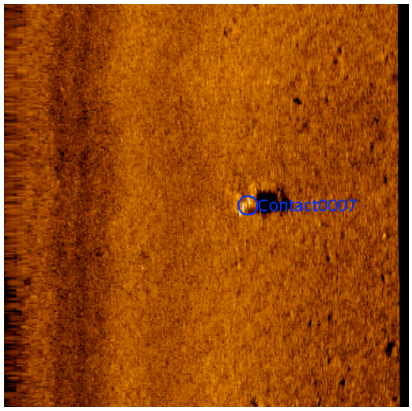
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 5 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Commercial scallop dredge



Contact0006

- Sonar Time at Target: 07/10/2011 20:11:46
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110710_DV117\files\ssonar\10JUL168.mst
- Ping Number: 34
- Range to Target: 3.95 Meters
- Fish Height: 2.04 Meters
- Heading: 289.930 degrees
- Event Number: 0
- Water Depth: 32.53
- Line Name: 10JUL168

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:



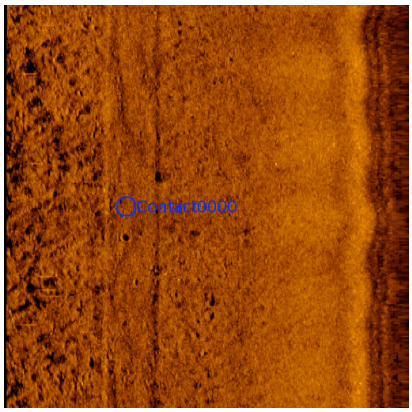
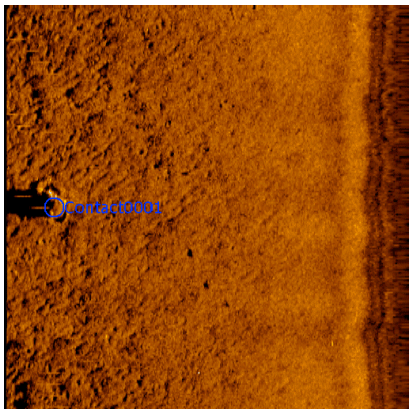
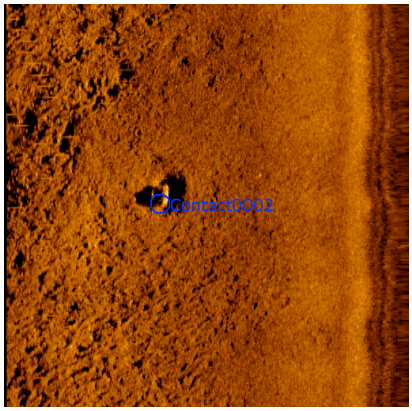
Contact0007

- Sonar Time at Target: 07/10/2011 21:21:00
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110710_DV117\files\ssonar\10JUL328.mst
- Ping Number: 245
- Range to Target: 6.04 Meters
- Fish Height: 2.28 Meters
- Heading: 106.360 degrees
- Event Number: 0
- Water Depth: 32.02
- Line Name: 10JUL328

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 1 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Vertical Anomoly
Classification 2:
Area:
Block:
Description:

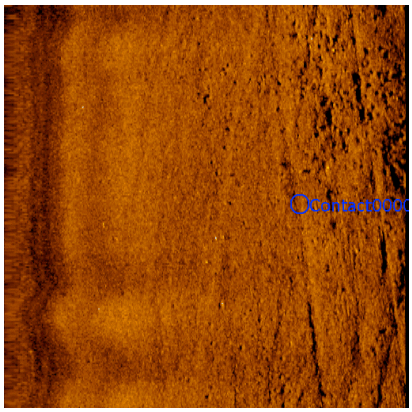
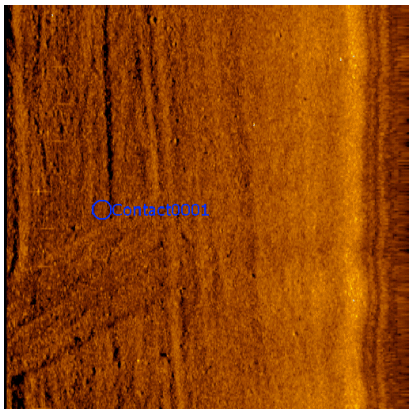
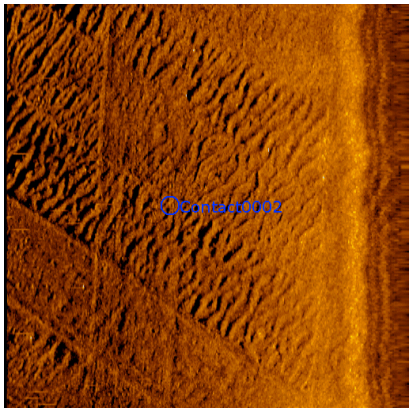
Report 110710_DV118

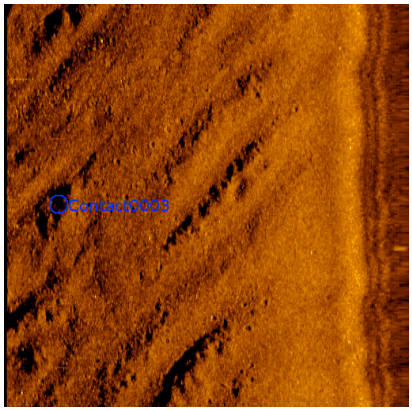
Generated on: 08/13/2012 01:41:57 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/10/2011 15:59:55 • Map Proj: UTM84-18N • Acoustic Source File: H:\110710_DV118\files\ssonar\10JUL004.mst • Ping Number: 429 • Range to Target: 13.91 Meters • Fish Height: 2.32 Meters • Heading: 314.640 degrees • Event Number: 0 • Water Depth: 32.56 • Line Name: 10JUL004	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 2 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: NMFS dredge scar
	**Contact0001** • Sonar Time at Target: 07/10/2011 17:04:53 • Map Proj: UTM84-18N • Acoustic Source File: H:\110710_DV118\files\ssonar\10JUL076.mst • Ping Number: 764 • Range to Target: 17.50 Meters • Fish Height: 2.21 Meters • Heading: 125.510 degrees • Event Number: 0 • Water Depth: 34.13 • Line Name: 10JUL076	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Classification 2: Area: Block: Description:
	**Contact0002** • Sonar Time at Target: 07/10/2011 17:06:33 • Map Proj: UTM84-18N • Acoustic Source File: H:\110710_DV118\files\ssonar\10JUL078.mst • Ping Number: 650 • Range to Target: 12.27 Meters • Fish Height: 2.36 Meters • Heading: 125.570 degrees • Event Number: 0 • Water Depth: 34.24 • Line Name: 10JUL078	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Classification 2: Area: Block: Description:

Report 110710_M1_ArtiesRun

Generated on: 08/13/2012 01:47:25 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/10/2011 12:26:19 • Map Proj: UTM84-18N • Acoustic Source File: F:\110710_M1_ArtiesRun\files\ssonar\10JUL001.mst • Ping Number: 511 • Range to Target: 14.61 Meters • Fish Height: 2.29 Meters • Heading: 268.370 degrees • Event Number: 0 • Water Depth: 37.00 • Line Name: 10JUL001	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Intersecting dredge scars
	**Contact0001** • Sonar Time at Target: 07/10/2011 12:33:02 • Map Proj: UTM84-18N • Acoustic Source File: F:\110710_M1_ArtiesRun\files\ssonar\10JUL009.mst • Ping Number: 705 • Range to Target: 15.12 Meters • Fish Height: 2.40 Meters • Heading: 268.130 degrees • Event Number: 0 • Water Depth: 36.55 • Line Name: 10JUL009	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Intersecting dredge scar
	**Contact0002** • Sonar Time at Target: 07/10/2011 13:32:26 • Map Proj: UTM84-18N • Acoustic Source File: F:\110710_M1_ArtiesRun\files\ssonar\10JUL079.mst • Ping Number: 471 • Range to Target: 11.76 Meters • Fish Height: 2.17 Meters • Heading: 268.740 degrees • Event Number: 0 • Water Depth: 34.98 • Line Name: 10JUL079	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Intersecting dredge scars within rippled bed



Contact0003

- Sonar Time at Target: 07/10/2011 14:01:26
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110710_M1_ArtiesRun\files\ssonar\10JUL113.mst
- Ping Number: 554
- Range to Target: 17.30 Meters
- Fish Height: 2.36 Meters
- Heading: 269.450 degrees
- Event Number: 0
- Water Depth: 34.16
- Line Name: 10JUL113

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 1 Meters
Target Width: 3 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Sand Wave
Classification 2:
Area:
Block:
Description: Parallel sand waves

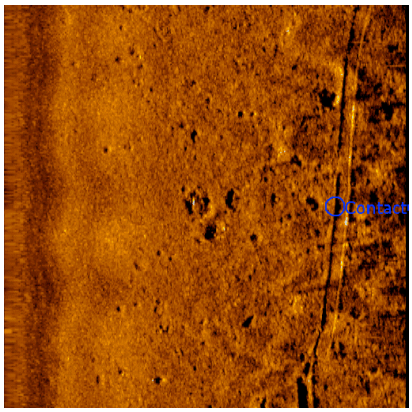
Report 110711_DV115

Generated on: 08/13/2012 01:53:51 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image

Contact Info

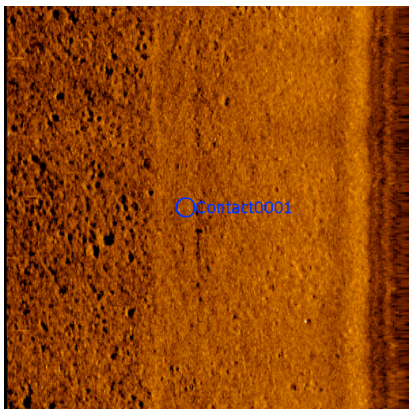
User Entered Info



Contact0000

- Sonar Time at Target: 07/11/2011 15:34:38
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110711_DV115\files\ssonar\11JUL163.mst
- Ping Number: 587
- Range to Target: 16.37 Meters
- Fish Height: 2.32 Meters
- Heading: 322.570 degrees
- Event Number: 0
- Water Depth: 35.37
- Line Name: 11JUL163

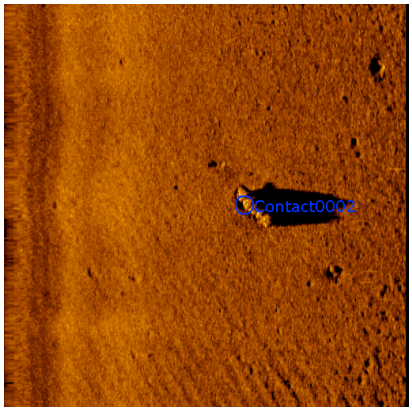
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 1 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Unidentified Track
Classification 2:
Area:
Block:
Description:



Contact0001

- Sonar Time at Target: 07/11/2011 15:39:31
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110711_DV115\files\ssonar\11JUL169.mst
- Ping Number: 359
- Range to Target: 10.98 Meters
- Fish Height: 2.25 Meters
- Heading: 322.810 degrees
- Event Number: 0
- Water Depth: 36.97
- Line Name: 11JUL169

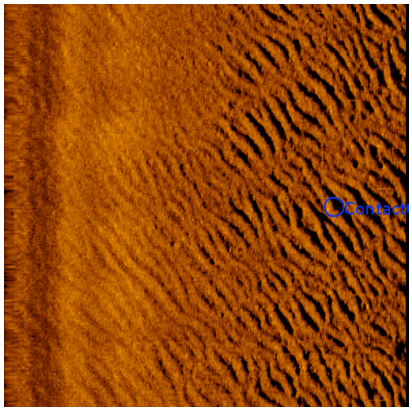
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 2 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: NMFS survey dredge scar



Contact0002

- Sonar Time at Target: 07/11/2011 15:47:39
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110711_DV115\files\ssonar\11JUL178.mst
- Ping Number: 526
- Range to Target: 11.88 Meters
- Fish Height: 2.17 Meters
- Heading: 321.220 degrees
- Event Number: 0
- Water Depth: 33.19
- Line Name: 11JUL178

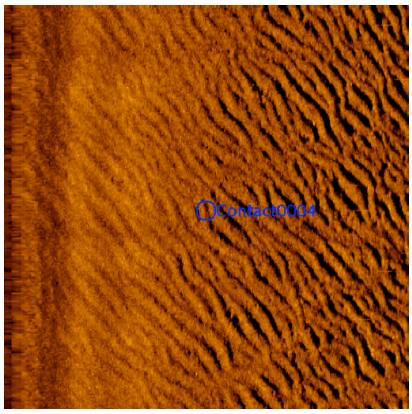
Dimensions
Target Height: = 1 Meters
Target Length: 0 Meters
Target Shadow: 5 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:



Contact0003

- Sonar Time at Target: 07/11/2011 15:51:02
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110711_DV115\files\ssonar\11JUL182.mst
- Ping Number: 397
- Range to Target: 16.33 Meters
- Fish Height: 2.21 Meters
- Heading: 321.490 degrees
- Event Number: 0
- Water Depth: 32.29
- Line Name: 11JUL182

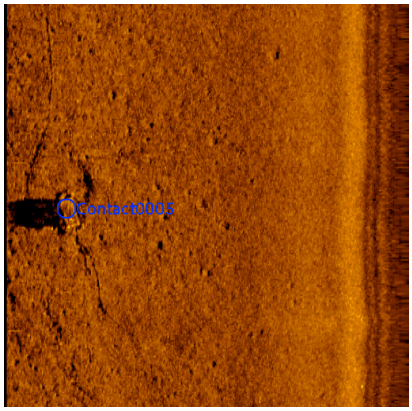
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 1 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Sand Wave
Classification 2:
Area:
Block:
Description:



Contact0004

- Sonar Time at Target: 07/11/2011 15:51:14
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110711_DV115\files\ssonar\11JUL182.mst
- Ping Number: 630
- Range to Target: 9.61 Meters
- Fish Height: 2.29 Meters
- Heading: 321.970 degrees
- Event Number: 0
- Water Depth: 32.15
- Line Name: 11JUL182

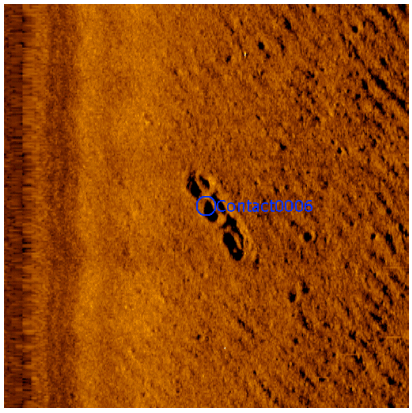
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:



Contact0005

- Sonar Time at Target: 07/11/2011 15:59:48
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110711_DV115\files\ssonar\11JUL190.mst
- Ping Number: 554
- Range to Target: 16.88 Meters
- Fish Height: 2.32 Meters
- Heading: 137.000 degrees
- Event Number: 0
- Water Depth: 33.67
- Line Name: 11JUL190

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Pod
Classification 2:
Area:
Block:
Description:



Contact0006

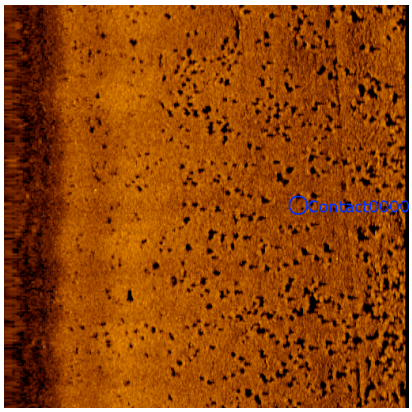
- Sonar Time at Target: 07/11/2011 16:55:01
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110711_DV115\files\ssonar\11JUL247.mst
- Ping Number: 539
- Range to Target: 9.06 Meters
- Fish Height: 2.17 Meters
- Heading: 322.920 degrees
- Event Number: 0
- Water Depth: 35.90
- Line Name: 11JUL247

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1:
Classification 2:
Area:
Block:
Description:

Report 110726_ScallopD1_DV2_M2

Generated on: 08/13/2012 01:56:45 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image



Contact Info

Contact0000

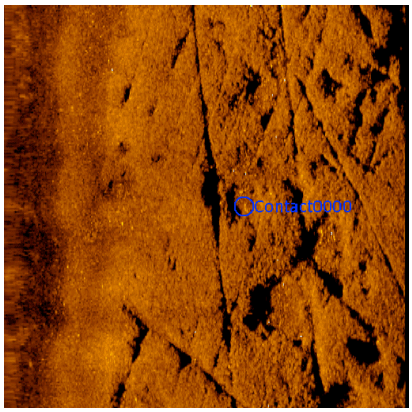
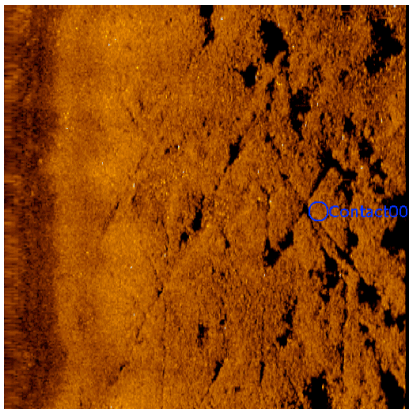
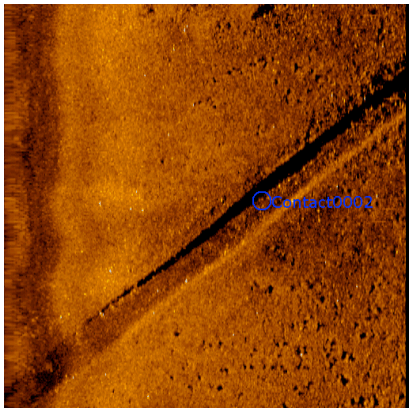
- Sonar Time at Target: 07/26/2011 17:48:52
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110726_ScallopD1_DV2_M2\files\ssonar\26JUL072.mst
- Ping Number: 341
- Range to Target: 14.53 Meters
- Fish Height: 2.68 Meters
- Heading: 254.100 degrees
- Event Number: 0
- Water Depth: 53.98
- Line Name: 26JUL072

User Entered Info

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 4 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Commercial scallop dredge scar

Report 110726_ScallopD1_DV44_M3

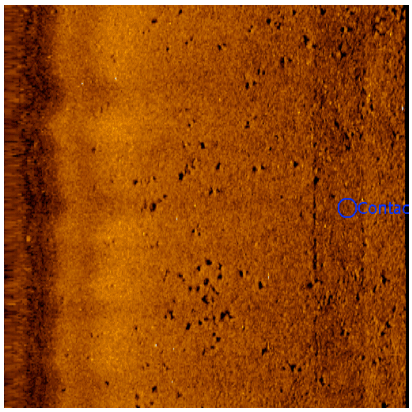
Generated on: 08/13/2012 02:05:33 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/26/2011 21:46:08 • Map Proj: UTM84-18N • Acoustic Source File: F:\110726_ScallopD1_DV44_M3\files\ssonar\26JUL003.mst • Ping Number: 235 • Range to Target: 11.88 Meters • Fish Height: 2.57 Meters • Heading: 138.820 degrees • Event Number: 0 • Water Depth: 47.76 • Line Name: 26JUL003	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Pitted Topography Classification 2: Area: Block: Description:
	**Contact0001** • Sonar Time at Target: 07/26/2011 23:16:46 • Map Proj: UTM84-18N • Acoustic Source File: F:\110726_ScallopD1_DV44_M3\files\ssonar\26JUL110.mst • Ping Number: 584 • Range to Target: 15.55 Meters • Fish Height: 2.52 Meters • Heading: 139.210 degrees • Event Number: 0 • Water Depth: 49.16 • Line Name: 26JUL110	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Pitted Topography Classification 2: Area: Block: Description:
	**Contact0002** • Sonar Time at Target: 07/27/2011 00:36:36 • Map Proj: UTM84-18N • Acoustic Source File: F:\110726_ScallopD1_DV44_M3\files\ssonar\26JUL207.mst • Ping Number: 322 • Range to Target: 12.73 Meters • Fish Height: 2.29 Meters • Heading: 138.110 degrees • Event Number: 0 • Water Depth: 49.15 • Line Name: 26JUL207	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 2 Meters Mag Anomaly: Avoidance Area: Classification 1: Trawl Scar Classification 2: Area: Block: Description:

Report 20110726_ScallopD2_M1

Generated on: 08/13/2012 03:55:45 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image



Contact Info

Contact0000

- Sonar Time at Target: 07/26/2011 12:06:26
- Map Proj: UTM84-18N
- Acoustic Source File: H:\20110726_ScallopD1_M1\files\ssonar\26JUL066.mst
- Ping Number: 373
- Range to Target: 16.99 Meters
- Fish Height: 2.60 Meters
- Heading: 73.840 degrees
- Event Number: 0
- Water Depth: 46.06
- Line Name: 26JUL066

User Entered Info

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 2 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: NMFS scallop survey dredge scar

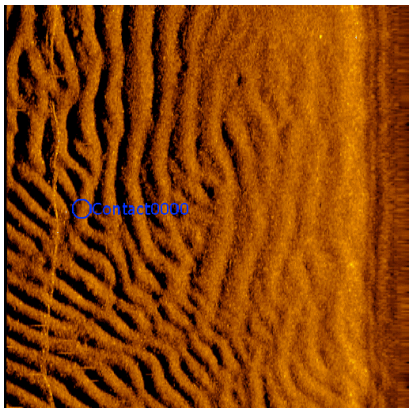
Report 110727_D2_R2_M2

Generated on: 08/13/2012 02:12:43 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image

Contact Info

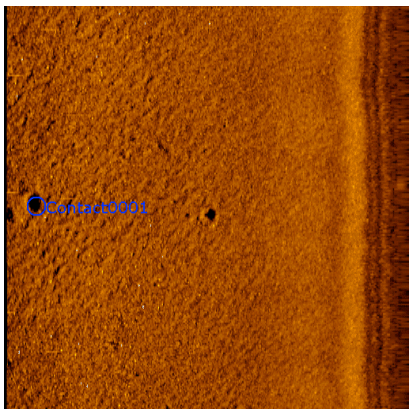
User Entered Info



Contact0000

- Sonar Time at Target: 07/27/2011 10:44:37
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110727_D2_R2_M2\files\ssonar\27JUL169.mst
- Ping Number: 736
- Range to Target: 16.13 Meters
- Fish Height: 2.32 Meters
- Heading: 358.480 degrees
- Event Number: 0
- Water Depth: 20.17
- Line Name: 27JUL169

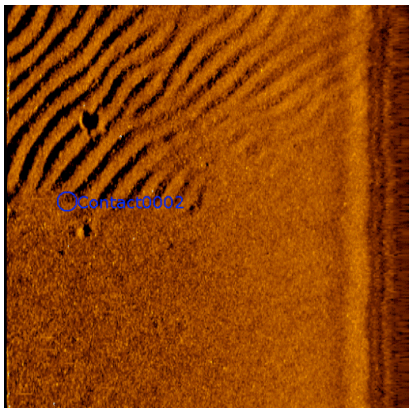
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 1 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Sand Waves
Classification 2:
Area:
Block:
Description: Interweaving sand waves



Contact0001

- Sonar Time at Target: 07/27/2011 11:18:50
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110727_D2_R2_M2\files\ssonar\27JUL213.mst
- Ping Number: 602
- Range to Target: 18.36 Meters
- Fish Height: 2.25 Meters
- Heading: 90.130 degrees
- Event Number: 0
- Water Depth: 23.25
- Line Name: 27JUL213

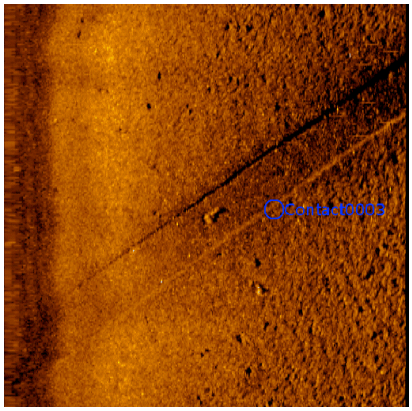
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 1 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dimpled Topography
Classification 2:
Area:
Block:
Description: Pits with raised rims



Contact0002

- Sonar Time at Target: 07/27/2011 11:36:07
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110727_D2_R2_M2\files\ssonar\27JUL235.mst
- Ping Number: 514
- Range to Target: 16.88 Meters
- Fish Height: 2.36 Meters
- Heading: 90.370 degrees
- Event Number: 0
- Water Depth: 22.63
- Line Name: 27JUL235

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Sharp Contact
Classification 2:
Area:
Block:
Description: Sharp contact between sand waves and featureless bed



Contact0003

- Sonar Time at Target: 07/27/2011 12:05:45
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110727_D2_R2_M2\files\ssonar\27JUL273.mst
- Ping Number: 621
- Range to Target: 13.36 Meters
- Fish Height: 2.52 Meters
- Heading: 89.090 degrees
- Event Number: 0
- Water Depth: 25.88
- Line Name: 27JUL273

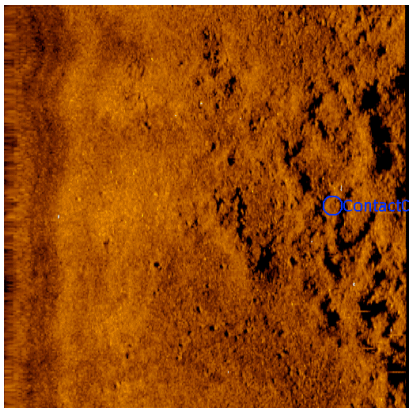
Dimensions

Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 3 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: 7 ft dredge scar

Report 110727_D2_R3_M3

Generated on: 08/13/2012 02:18:20 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image



Contact Info

Contact0000

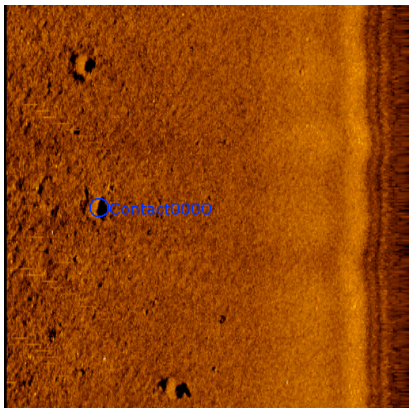
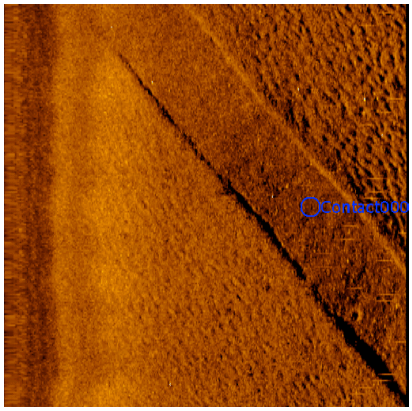
- Sonar Time at Target: 07/27/2011 16:37:17
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110727_D2_R3_M3\files\ssonar\27JUL069.mst
- Ping Number: 482
- Range to Target: 16.25 Meters
- Fish Height: 2.29 Meters
- Heading: 271.510 degrees
- Event Number: 0
- Water Depth: 39.37
- Line Name: 27JUL069

User Entered Info

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 0 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Uneven Topography
Classification 2:
Area:
Block:
Description:

Report 110727_D2_R4_M4

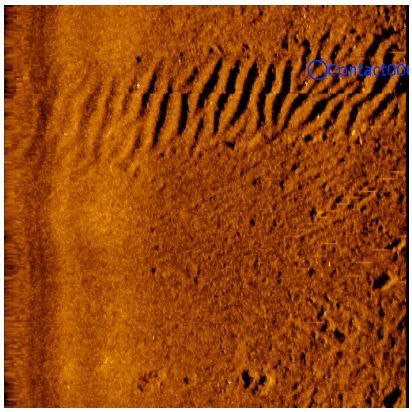
Generated on: 08/13/2012 02:25:00 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/27/2011 20:11:23 • Map Proj: UTM84-18N • Acoustic Source File: F:\110727_D2_R4_M4\files\ssonar\27JUL206.mst • Ping Number: 676 • Range to Target: 15.27 Meters • Fish Height: 2.21 Meters • Heading: 87.360 degrees • Event Number: 0 • Water Depth: 31.40 • Line Name: 27JUL206	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 1 Meters Mag Anomaly: Avoidance Area: Classification 1: Dimpled Topography Classification 2: Area: Block: Description: Pits with raised rims
	**Contact0001** • Sonar Time at Target: 07/27/2011 20:47:52 • Map Proj: UTM84-18N • Acoustic Source File: F:\110727_D2_R4_M4\files\ssonar\27JUL238.mst • Ping Number: 305 • Range to Target: 15.16 Meters • Fish Height: 2.09 Meters • Heading: 180.570 degrees • Event Number: 0 • Water Depth: 28.13 • Line Name: 27JUL238	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 4 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Commercial scallop dredge scar

Report 110727_D2_R5_M5

Generated on: 08/13/2012 02:28:01 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image



Contact Info

Contact0000

- Sonar Time at Target: 07/28/2011 00:25:44
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110727_D2_R5_M5\files\ssonar\27JUL018.mst
- Ping Number: 41
- Range to Target: 15.51 Meters
- Fish Height: 2.09 Meters
- Heading: 273.130 degrees
- Event Number: 0
- Water Depth: 26.41
- Line Name: 27JUL018

User Entered Info

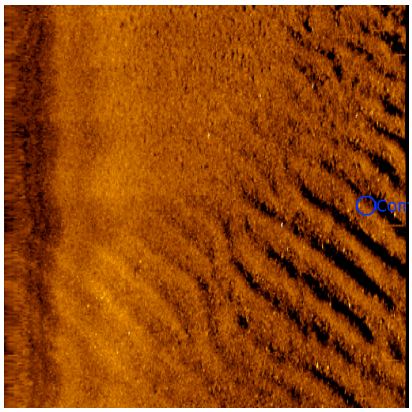
Dimensions

Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 1 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Sand Waves
Classification 2:
Area:
Block:
Description:

Report 110727_ScallopD2_R1_M1

Generated on: 08/13/2012 02:31:14 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image



Contact Info

Contact0000

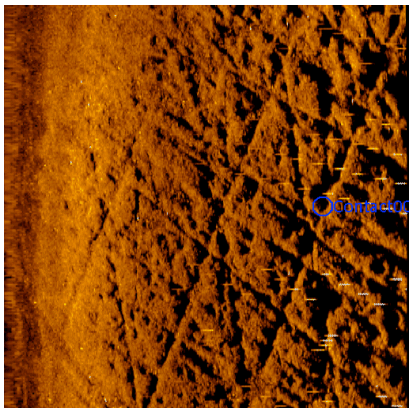
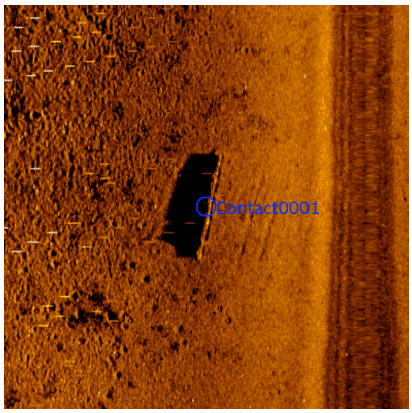
- Sonar Time at Target: 07/27/2011 04:39:36
- Map Proj: UTM84-18N
- Acoustic Source File: F:\110727_ScallopD2_R1_M1\files\ssonar\27JUL030.mst
- Ping Number: 218
- Range to Target: 17.89 Meters
- Fish Height: 2.32 Meters
- Heading: 177.600 degrees
- Event Number: 0
- Water Depth: 36.40
- Line Name: 27JUL030

User Entered Info

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 1 Meters
Target Width: 1 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Sand Waves
Classification 2:
Area:
Block:
Description:

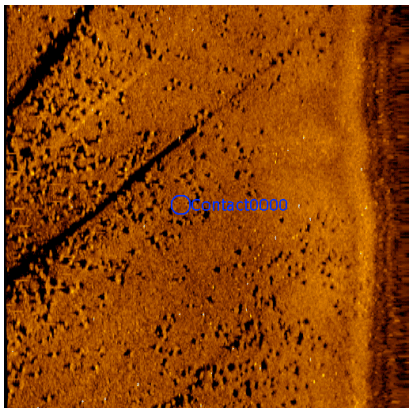
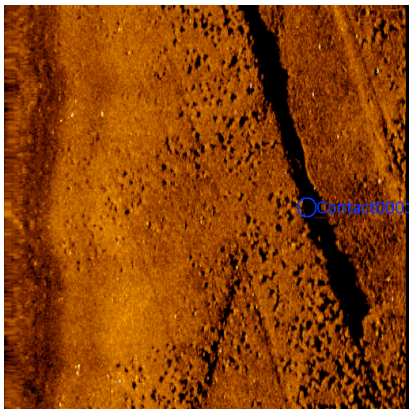
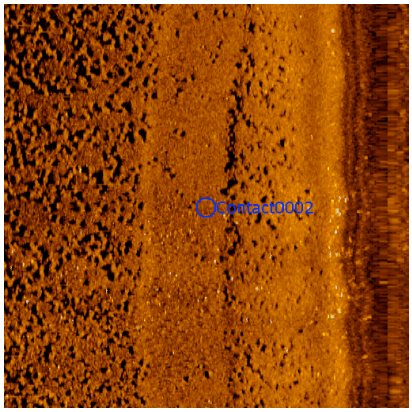
Report 110728_D3_DV062_M3

Generated on: 08/13/2012 02:54:24 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/28/2011 15:30:06 • Map Proj: UTM84-18N • Acoustic Source File: F:\110728_D3_DV062_M3\files\ssonar\28JUL048.mst • Ping Number: 185 • Range to Target: 15.78 Meters • Fish Height: 1.62 Meters • Heading: 354.010 degrees • Event Number: 0 • Water Depth: 46.25 • Line Name: 28JUL048	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Uneven Topography Classification 2: Area: Block: Description:
	**Contact0001** • Sonar Time at Target: 07/28/2011 15:57:08 • Map Proj: UTM84-18N • Acoustic Source File: F:\110728_D3_DV062_M3\files\ssonar\28JUL072.mst • Ping Number: 329 • Range to Target: 7.85 Meters • Fish Height: 1.43 Meters • Heading: 169.320 degrees • Event Number: 0 • Water Depth: 47.01 • Line Name: 28JUL072	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Classification 2: Area: Block: Description:

Report 110728_D3_DV063_M4

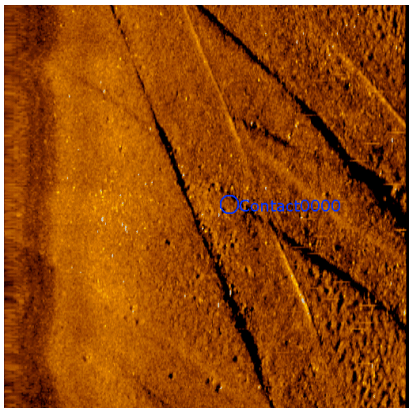
Generated on: 08/13/2012 03:00:27 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/28/2011 19:55:25 • Map Proj: UTM84-18N • Acoustic Source File: F:\110728_D3_DV063_M4\files\ssonar\28JUL001.mst • Ping Number: 334 • Range to Target: 11.21 Meters • Fish Height: 1.93 Meters • Heading: 338.080 degrees • Event Number: 0 • Water Depth: 51.02 • Line Name: 28JUL001	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 3 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Commercial scallop dredge scar
	**Contact0001** • Sonar Time at Target: 07/28/2011 20:59:29 • Map Proj: UTM84-18N • Acoustic Source File: F:\110728_D3_DV063_M4\files\ssonar\28JUL072.mst • Ping Number: 247 • Range to Target: 15.00 Meters • Fish Height: 2.25 Meters • Heading: 159.800 degrees • Event Number: 0 • Water Depth: 50.71 • Line Name: 28JUL072	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 4 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Intersecting scallop dredge scars
	**Contact0002** • Sonar Time at Target: 07/28/2011 21:34:12 • Map Proj: UTM84-18N • Acoustic Source File: F:\110728_D3_DV063_M4\files\ssonar\28JUL112.mst • Ping Number: 413 • Range to Target: 8.95 Meters • Fish Height: 2.17 Meters • Heading: 340.180 degrees • Event Number: 0 • Water Depth: 50.68 • Line Name: 28JUL112	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 4 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Curved commercial scallop dredge scar

Report 110728_D3_R6_M1

Generated on: 08/13/2012 03:17:49 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image



Contact Info

Contact0000

- Sonar Time at Target: 07/28/2011 04:51:21
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110728_D3_R6_M1\files\ssonar\28JUL007.mst
- Ping Number: 684
- Range to Target: 11.13 Meters
- Fish Height: 2.09 Meters
- Heading: 176.370 degrees
- Event Number: 0
- Water Depth: 38.76
- Line Name: 28JUL007

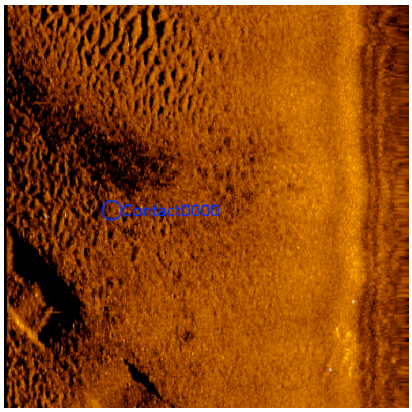
User Entered Info

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 4 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Intersecting commercial scallop dredge scars

Report 110728_D3_R7_M2

Generated on: 08/13/2012 03:25:00 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image



Contact Info

Contact0000

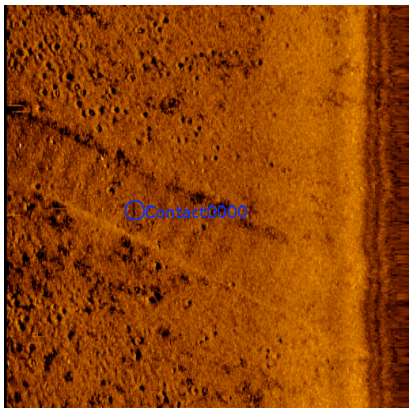
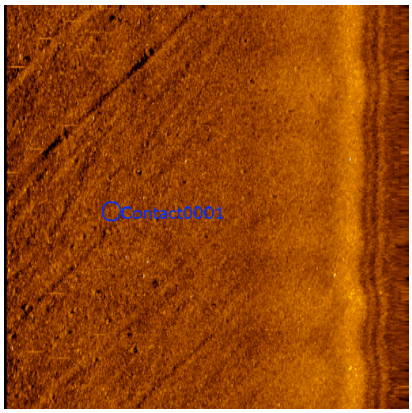
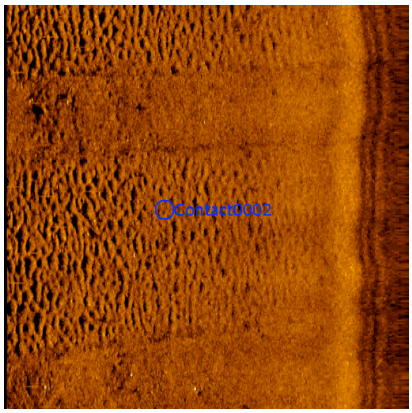
- Sonar Time at Target: 07/28/2011 10:54:04
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110728_D3_R7_M2\files\ssonar\28JUL252.mst
- Ping Number: 569
- Range to Target: 14.65 Meters
- Fish Height: 2.25 Meters
- Heading: 184.520 degrees
- Event Number: 0
- Water Depth: 37.25
- Line Name: 28JUL252

User Entered Info

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 3 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Dredge scar through sandy ripples

Report 110728_D3_R8_M5

Generated on: 08/13/2012 03:29:44 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/29/2011 00:29:14 • Map Proj: UTM84-18N • Acoustic Source File: H:\110728_D3_R8_M5\files\ssonar\28JUL004.mst • Ping Number: 727 • Range to Target: 13.52 Meters • Fish Height: 2.32 Meters • Heading: 183.310 degrees • Event Number: 0 • Water Depth: 40.71 • Line Name: 28JUL004	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 3 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description:
	**Contact0001** • Sonar Time at Target: 07/29/2011 01:05:07 • Map Proj: UTM84-18N • Acoustic Source File: H:\110728_D3_R8_M5\files\ssonar\28JUL048.mst • Ping Number: 181 • Range to Target: 14.65 Meters • Fish Height: 2.29 Meters • Heading: 84.130 degrees • Event Number: 0 • Water Depth: 44.31 • Line Name: 28JUL048	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 3 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Remnant dredge scars
	**Contact0002** • Sonar Time at Target: 07/29/2011 02:30:01 • Map Proj: UTM84-18N • Acoustic Source File: H:\110728_D3_R8_M5\files\ssonar\28JUL135.mst • Ping Number: 567 • Range to Target: 12.03 Meters • Fish Height: 2.25 Meters • Heading: 359.090 degrees • Event Number: 0 • Water Depth: 38.79 • Line Name: 28JUL135	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 4 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Parallel dredge scars

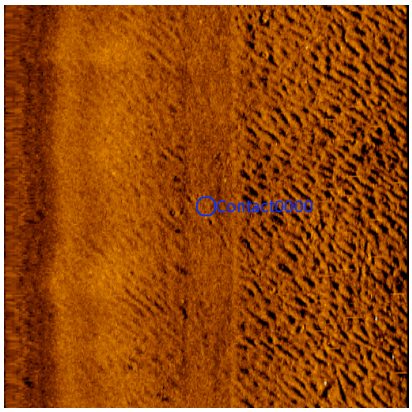
Report 110729_D4_DV0105_M2

Generated on: 08/13/2012 03:35:30 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image

Contact Info

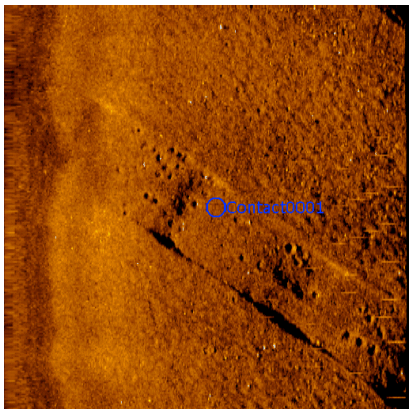
User Entered Info



Contact0000

- Sonar Time at Target: 07/29/2011 09:57:39
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110729_D4_DV0105_M2\files\ssonar\29JUL013.mst
- Ping Number: 298
- Range to Target: 9.92 Meters
- Fish Height: 2.17 Meters
- Heading: 125.500 degrees
- Event Number: 0
- Water Depth: 32.70
- Line Name: 29JUL013

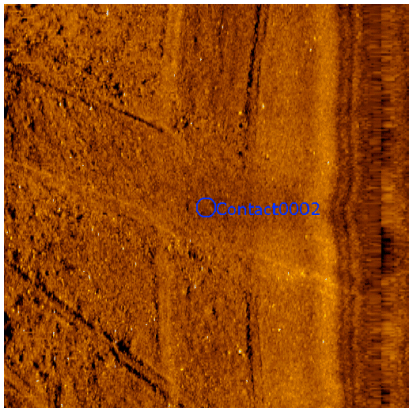
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 3 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: NMFS scallop survey dredge scar



Contact0001

- Sonar Time at Target: 07/29/2011 10:26:58
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110729_D4_DV0105_M2\files\ssonar\29JUL043.mst
- Ping Number: 207
- Range to Target: 10.51 Meters
- Fish Height: 2.21 Meters
- Heading: 304.210 degrees
- Event Number: 0
- Water Depth: 32.51
- Line Name: 29JUL043

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 4 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Commercial scallop dredge scar



Contact0002

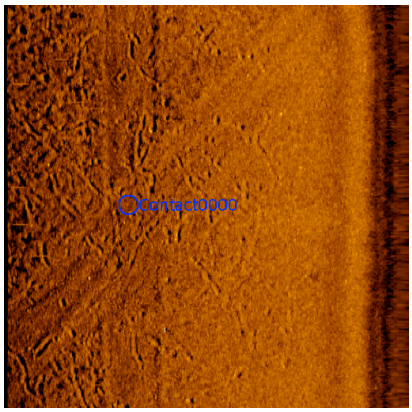
- Sonar Time at Target: 07/29/2011 11:16:56
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110729_D4_DV0105_M2\files\ssonar\29JUL102.mst
- Ping Number: 458
- Range to Target: 8.63 Meters
- Fish Height: 2.29 Meters
- Heading: 123.560 degrees
- Event Number: 0
- Water Depth: 33.24
- Line Name: 29JUL102

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 4 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Intersecting dredge scars

Report 110729_D4_DV0106_M1

Generated on: 08/13/2012 03:41:15 PM by SonarWiz.MAP targetReportGen2 V3.15.15

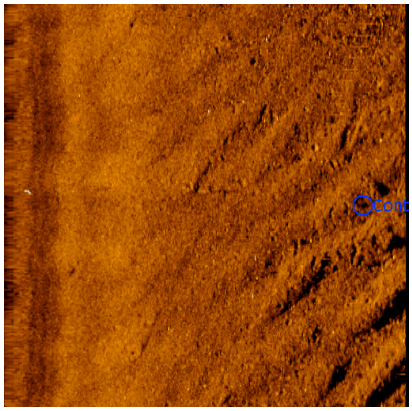
Contact Image | Contact Info | User Entered Info



Contact0000

- Sonar Time at Target: 07/29/2011 05:09:13
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110729_D4_DV0106_M1\files\ssonar\29JUL001.mst
- Ping Number: 204
- Range to Target: 13.83 Meters
- Fish Height: 2.64 Meters
- Heading: 293.340 degrees
- Event Number: 0
- Water Depth: 39.05
- Line Name: 29JUL001

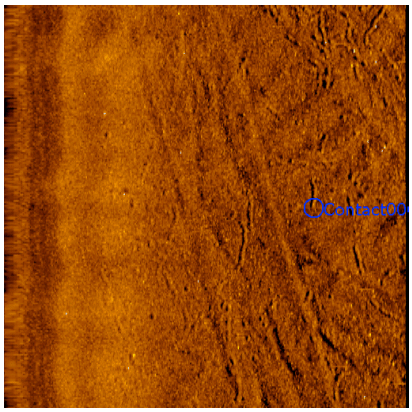
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 3 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Intersecting relic scallop dredges scars (NMFS and commercial)



Contact0001

- Sonar Time at Target: 07/29/2011 06:16:27
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110729_D4_DV0106_M1\files\ssonar\29JUL074.mst
- Ping Number: 171
- Range to Target: 17.73 Meters
- Fish Height: 2.32 Meters
- Heading: 113.110 degrees
- Event Number: 0
- Water Depth: 36.23
- Line Name: 29JUL074

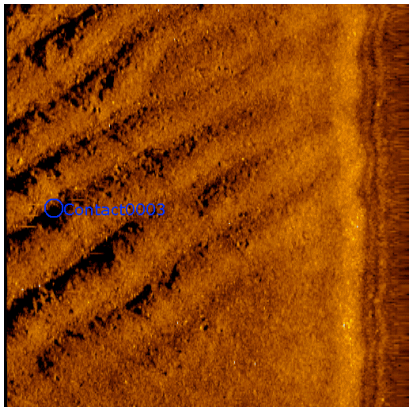
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 2 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Sand Waves
Classification 2:
Area:
Block:
Description:



Contact0002

- Sonar Time at Target: 07/29/2011 06:19:11
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110729_D4_DV0106_M1\files\ssonar\29JUL077.mst
- Ping Number: 184
- Range to Target: 15.31 Meters
- Fish Height: 2.32 Meters
- Heading: 112.670 degrees
- Event Number: 0
- Water Depth: 36.98
- Line Name: 29JUL077

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 4 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scars
Classification 2:
Area:
Block:
Description: Intersecting dredge scars



Contact0003

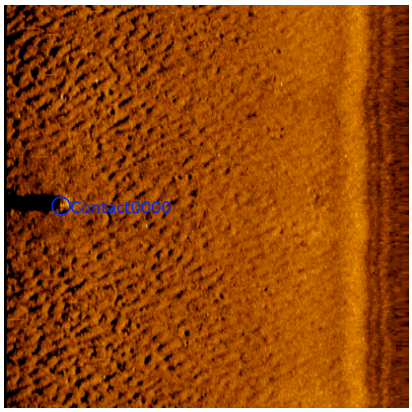
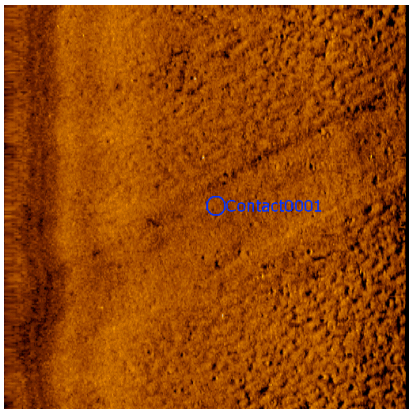
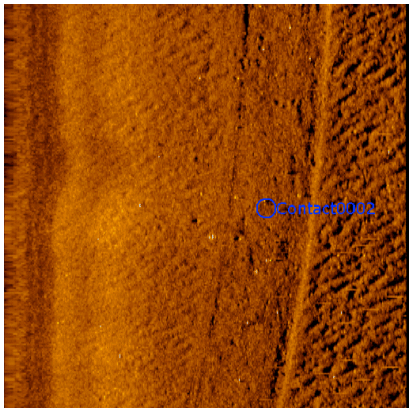
- Sonar Time at Target: 07/29/2011 06:57:07
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110729_D4_DV0106_M1\files\ssonar\29JUL120.mst
- Ping Number: 478
- Range to Target: 17.50 Meters
- Fish Height: 2.13 Meters
- Heading: 115.850 degrees
- Event Number: 0
- Water Depth: 35.84
- Line Name: 29JUL120

Dimensions

Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 3 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Sand Waves
Classification 2:
Area:
Block:
Description:

Report 110729_D4_DV0112_M3

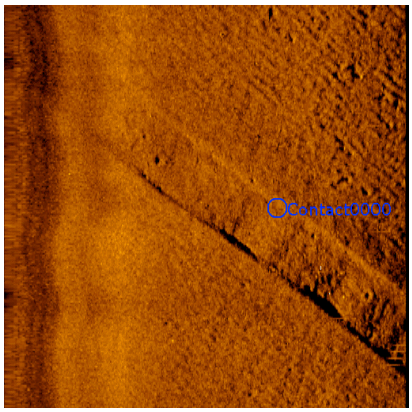
Generated on: 08/13/2012 03:45:57 PM by SonarWiz.MAP targetReportGen2 V3.15.15

Contact Image	Contact Info	User Entered Info
	**Contact0000** • Sonar Time at Target: 07/29/2011 14:05:11 • Map Proj: UTM84-18N • Acoustic Source File: H:\110729_D4_DV0112_M3\files\ssonar\29JUL171.mst • Ping Number: 613 • Range to Target: 17.15 Meters • Fish Height: 2.29 Meters • Heading: 276.140 degrees • Event Number: 0 • Water Depth: 38.04 • Line Name: 29JUL171	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 0 Meters Mag Anomaly: Avoidance Area: Classification 1: Classification 2: Area: Block: Description:
	**Contact0001** • Sonar Time at Target: 07/29/2011 14:11:54 • Map Proj: UTM84-18N • Acoustic Source File: H:\110729_D4_DV0112_M3\files\ssonar\29JUL179.mst • Ping Number: 733 • Range to Target: 10.47 Meters • Fish Height: 2.40 Meters • Heading: 275.560 degrees • Event Number: 0 • Water Depth: 38.78 • Line Name: 29JUL179	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 4 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Commercial scallop dredge scar
	**Contact0002** • Sonar Time at Target: 07/29/2011 16:06:24 • Map Proj: UTM84-18N • Acoustic Source File: H:\110729_D4_DV0112_M3\files\ssonar\29JUL313.mst • Ping Number: 298 • Range to Target: 12.97 Meters • Fish Height: 2.29 Meters • Heading: 274.930 degrees • Event Number: 0 • Water Depth: 36.18 • Line Name: 29JUL313	**Dimensions** Target Height: = 0 Meters Target Length: 0 Meters Target Shadow: 0 Meters Target Width: 4 Meters Mag Anomaly: Avoidance Area: Classification 1: Dredge Scar Classification 2: Area: Block: Description: Commercial scallop dredge scar

Report 110729_D4_DV0113_M4

Generated on: 08/13/2012 03:51:18 PM by SonarWiz.MAP targetReportGen2 V3.15.15

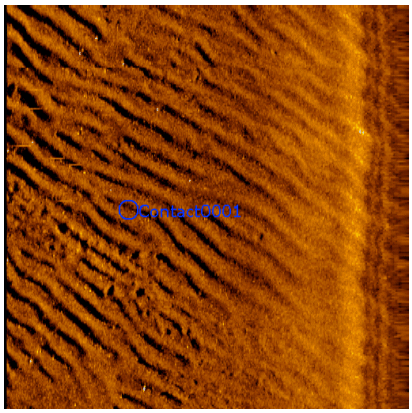
Contact Image | Contact Info | User Entered Info



Contact0000

- Sonar Time at Target: 07/29/2011 17:55:56
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110729_D4_DV0113_M4\files\ssonar\29JUL001.mst
- Ping Number: 579
- Range to Target: 13.52 Meters
- Fish Height: 2.48 Meters
- Heading: 312.540 degrees
- Event Number: 0
- Water Depth: 27.10
- Line Name: 29JUL001

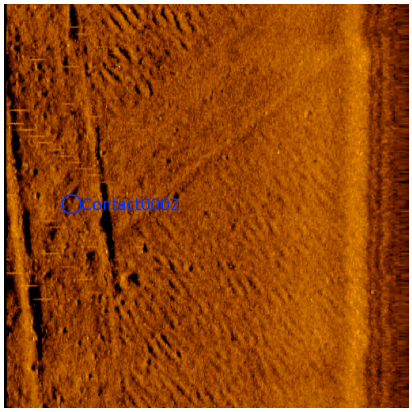
Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 3 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Commercial scallop dredge scar



Contact0001

- Sonar Time at Target: 07/29/2011 18:18:30
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110729_D4_DV0113_M4\files\ssonar\29JUL026.mst
- Ping Number: 144
- Range to Target: 13.79 Meters
- Fish Height: 2.21 Meters
- Heading: 129.950 degrees
- Event Number: 0
- Water Depth: 27.81
- Line Name: 29JUL026

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 1 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Sand Waves
Classification 2:
Area:
Block:
Description:



Contact0002

- Sonar Time at Target: 07/29/2011 20:05:20
- Map Proj: UTM84-18N
- Acoustic Source File: H:\110729_D4_DV0113_M4\files\ssonar\29JUL156.mst
- Ping Number: 440
- Range to Target: 16.60 Meters
- Fish Height: 2.21 Meters
- Heading: 311.550 degrees
- Event Number: 0
- Water Depth: 28.47
- Line Name: 29JUL156

Dimensions
Target Height: = 0 Meters
Target Length: 0 Meters
Target Shadow: 0 Meters
Target Width: 4 Meters
Mag Anomaly:
Avoidance Area:
Classification 1: Dredge Scar
Classification 2:
Area:
Block:
Description: Intersecting dredge scars