Final Report

Sea Scallop Research

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End Date: 5/31/2010

Extension End Date: 5/31/2011

Project Title:	**High-Resolution Video Survey of the Sea Scallop Resource, Recruitment Patterns and Habitat of the Elephant Trunk and Nantucket Lightship Closed Areas**
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Amount: We were granted 79 DAS (92,588lbs) from the Open Area ($699,039.00) and 18,270 lbs from the Elephant Trunk Area ($137,939). Of the total $836,978, $110,858 was dedicated to cover research costs, with the remaining $726,120 covering the costs of research and harvest for participating industry members.

Executive Summary:
We conducted a high-resolution video survey of the Elephant Trunk and Nantucket Lightship Closed Areas to examine spatial distribution, size composition, density and biomass of sea scallops as well as characterize habitat in 2009. We received a one-year no cost extension to complete analysis of the video images in 2010. We determined total and exploitable biomass for both areas and compared results to our 3nm video survey results conducted in the same areas. In the Elephant Trunk Closed Area, we observed a decrease in exploitable biomass between 2007 and 2008 due to intense fishing effort and recommended a reduction in allocated harvest for Framework 19 to the Scallop Fishery Management Plan in 2008. In the Nantucket Lightship Closed Area, we observed a reduction in exploitable biomass between 2006 and 2008 due to fishing effort and natural mortality resulting from the shortened 2006 fishing season, which resulted from an overage of the yellowtail flounder bycatch TAC. We conducted the high resolution video surveys in both the Elephant Trunk and Nantucket Lightship areas in 2009 to estimate scallop biomass in both areas in order to determine if the decreasing trend was continuing and to assist the New England Fishery Management Council in setting allocation levels for 2010 and beyond. Our recommendations were presented to the Scallop Plan Development Team and Northeast Fishery Science Center for consideration in management measures (Framework 21, NEFMC 2009). Additionally, we used information from the Nantucket Lightship high-resolution survey to assist the scallop fishing fleet in avoiding areas of high yellowtail bycatch in 2010. The 2009 high-resolution video survey of the Elephant Trunk and Nantucket Lightship Closed Areas has also been integral in the SMAST survey timeline, which was included in the 50th Stock Assessment Workshop for Atlantic Sea Scallops (SAW 50, NEFSC 2010).

Purpose:
To examine the sea scallop abundance and evaluate their spatial distribution, size composition and density as well as habitat characteristics in the Elephant Trunk and Nantucket Lightship Closed Areas using a high-resolution cooperative industry-based video survey.

Approach:
We conducted one video research cruise inside of a 1,266 km^2 sample area, within the Nantucket Lightship Closed Area (NLCA) from 14 -16 June 2009. Using a multistage systematic design we video surveyed 164 stations separated by approximately 1.5 nm (2.78 km) within the NLCA (Figure 1).

We conducted two video research cruises inside of a 4,515 km^2 sample area, within the Elephant Trunk Closed Area (ETCA) from 3 - 5 May and 13 -18 May 2009. We video surveyed 585 stations separated by approximately 1.5 nm (2.78 km) within the ETCA (Figure 1).

The underwater video surveys were conducted using the SMAST Video Survey Pyramid deployed from a commercial scallop vessel (Figure 2). The pyramid supports three live-feed S-VHS underwater video cameras (Stokesbury, 2002; Stokesbury et al., 2004) and one high-resolution (10.1 megapixel) digital still camera. The sampling pyramid is configured with two downward looking video cameras viewing 3.24 m^2 and 0.78 m^2 quadrats and a digital camera viewing a 1.29 m^2 quadrat (Figure 2).

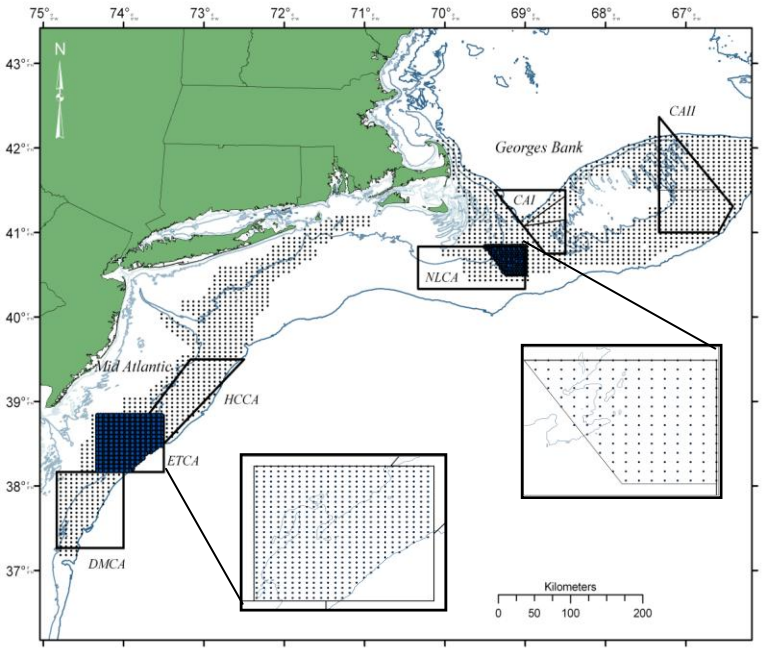

Figure 1. 2009 SMAST video survey stations (broad-scale 3nm survey) with detail of high-resolution Elephant Trunk and Nantucket Lightship Closed Areas (blue).

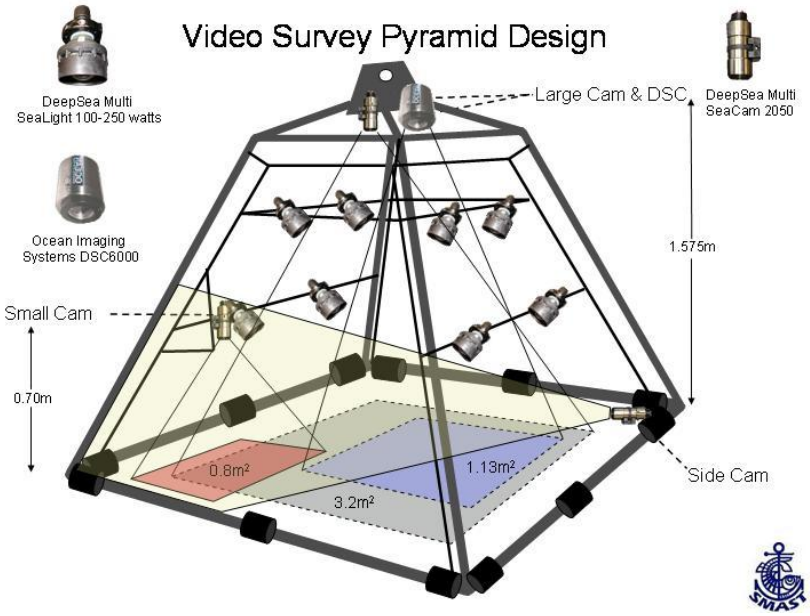

Figure 2. SMAST video survey pyramid including 3 deepsea video cameras, 10.1 megapixel digital still camera and quadrat areas.

Video footage of the sea floor was recorded on S-VHS tapes and DVDs. For each quadrat the time, depth, number of live and dead scallops, and latitude and longitude was recorded. After each survey the videotapes were reviewed in the laboratory and a still image of each quadrat was digitized and saved using Image Pro Plus® software (TIFF file format). Within each quadrat, macroinvertebrates and fish were counted and the substrate was identified (Stokesbury 2002).

When possible fish and macroinvertebrates were identified to species, otherwise animals were grouped into categories based on taxonomic orders. Counts were standardized to individuals/m^2. Sponges, hydrozoa/bryozoa and sand dollars were recorded as present or absent within each quadrat.

Sediments were visually identified following the Wentworth particle grade scale from the video images, where the sediment particle size categories were based on a doubling or halving of the fixed reference point of 1 mm; sand = 0.0625 to 2.0 mm, gravel = 2.0 to 256.0 mm and boulders > 256.0 mm (Lincoln et al. 1992). Gravel was divided into two categories, granule/pebble = 2.0 to 64.0 mm and cobble = 64.0 to 256.0 mm (Lincoln et al. 1992). Shell debris was also identified.

Mean densities and standard errors of scallops were calculated using equations for a two-stage sampling design (Cochran 1977):
The mean of the total sample is:

(1) $$\bar{\bar{x}} = \sum_{i=1}^{n} \left(\frac{\bar{x}_i}{n} \right)$$

where n is the number of stations and $\bar{x}_i$ is the mean of the 4 quadrats at station i.

The SE of this 2-stage mean is calculated as:

(2) $$S.E.(\bar{x}) = \sqrt{\frac{1}{n}(s^2)}$$

where: $s^2 = \sum^{n} (\bar{x}_i - \bar{\bar{x}})^2 / (n-1)$.

According to Cochran (1977) this simplified version of the 2-stage variance is appropriate when the ratio of sample area to survey area (n/N) is small. In this case, thousands of square meters (n) are sampled compared with millions of square meters (N) in the study areas. All calculations use number of scallops per square meter.

The absolute number of scallops in the survey areas was calculated by multiplying scallop density by the total area surveyed (Stokesbury 2002). Estimates of scallop meat weight in grams (w) were derived from shell height (mm) frequencies collected during each survey and shell height to meat weight regression used in SAW 45 (NEFSC, 2007). The mean meat weight for each 5 mm size bin was multiplied by the total number of scallops in the survey area to estimate the total biomass of scallop meats.

Results:

The total biomass surveyed within the Nantucket Lightship was 13.2 million pounds (Density = 0.19 scallops·m^{-2}; SE = 0.025; Figure 3; Table 1). The total biomass surveyed within the Elephant Trunk Closed Area was 39.9 million pounds (Density = 0.22 scallops·m^{-2}; SE = 0.022; Figure 3; Table 1). These results were provided to the Northeast Fishery Science Center and Scallop Plan Development Team for inclusion in Framework 21 (presented on July 22, 2009 at Plymouth, MA PDT meeting and emailed to D. Hart and D. Boelke on July 31, 2009).

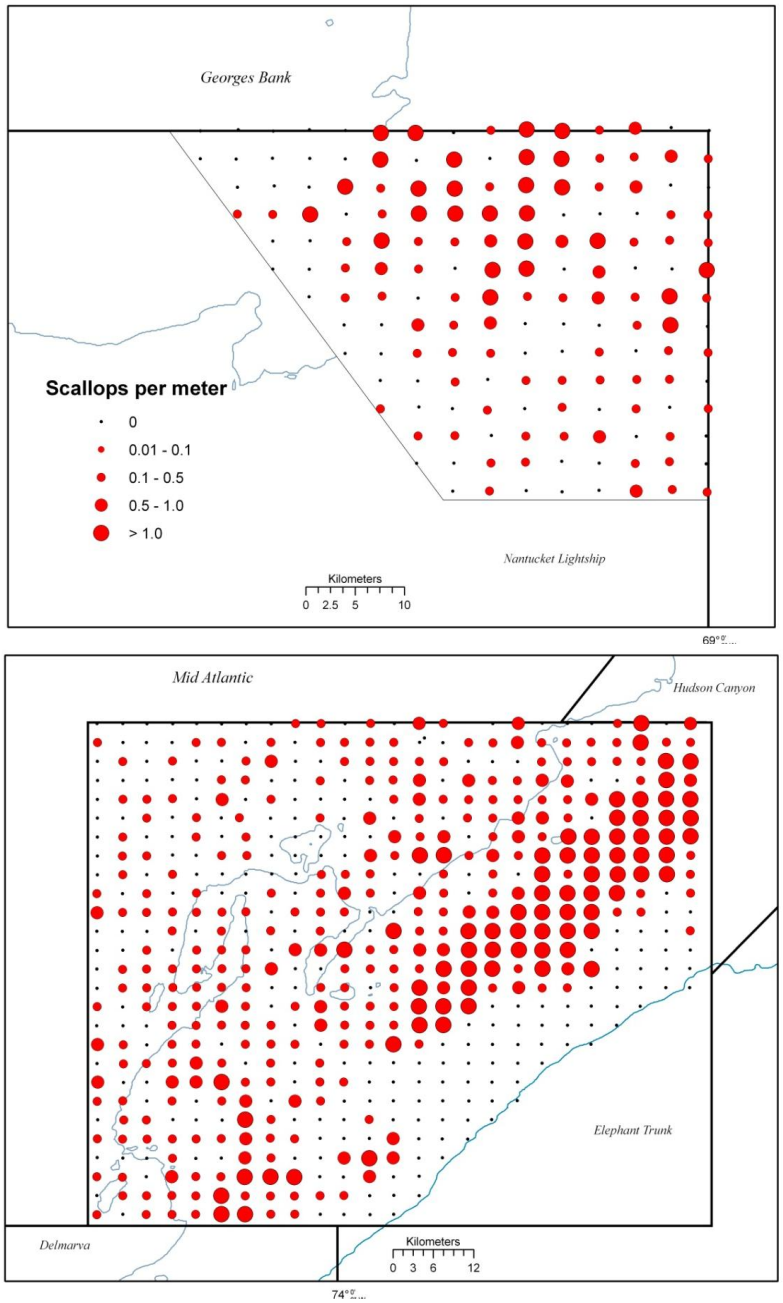

Figure 3. Scallop density and biomass estimates from the Nantucket Lightship (top) and the Elephant Trunk (bottom) Closed Areas.

We also examined the spatial structure of the scallop population in the Nantucket Lightship Area and Elephant Trunk Area by comparing the 2009 3.0nm grid (5.6km) survey data to the 1.5nm (2.78km) grid, both of which were conducted simultaneously. There were no statistical differences in the estimated density, abundance or total biomass of scallops based on survey results for either area (Table 1).

Table 1. Scallop density, mean meat weight and total abundance in the Elephant Trunk (ETCA) and Nantucket Lightship (NLCA) closed areas from the 3.0nm and RSA funded 1.5nm video surveys conducted in 2009.

	per m^2	stations	SE	CV%	mean mwt (g)	Total Biomass mill lbs	mt	SE
ETCA 3nm	0.1813	156	0.0288	15.90	18.37	**35.4**	**16037**	2550
ETCA 1.5nm	0.2200	585	0.0220	10.00	18.22	**39.9**	**18091**	1809
NLCA 3nm	0.1951	40	0.0462	23.69	24.50	**13.0**	**5902**	1398
NLCA 1.5 nm	0.1894	164	0.0251	13.28	24.99	**13.2**	**5991**	796

We measured a total of 315 scallops in the Nantucket Lightship and 1,416 scallops in the Elephant Trunk. The observed shell height frequencies show some small scallops between 40 and 80 mm in the Nantucket Lightship (Figure 4), and a majority of large scallops due to the premature closure of the access area fishery in 2006, and subsequent growth. In the Elephant Trunk we observed a low percentage of small scallops, and the majority of scallops were between 90 and 100 mm, potentially indicating a single year class (Figure 4).

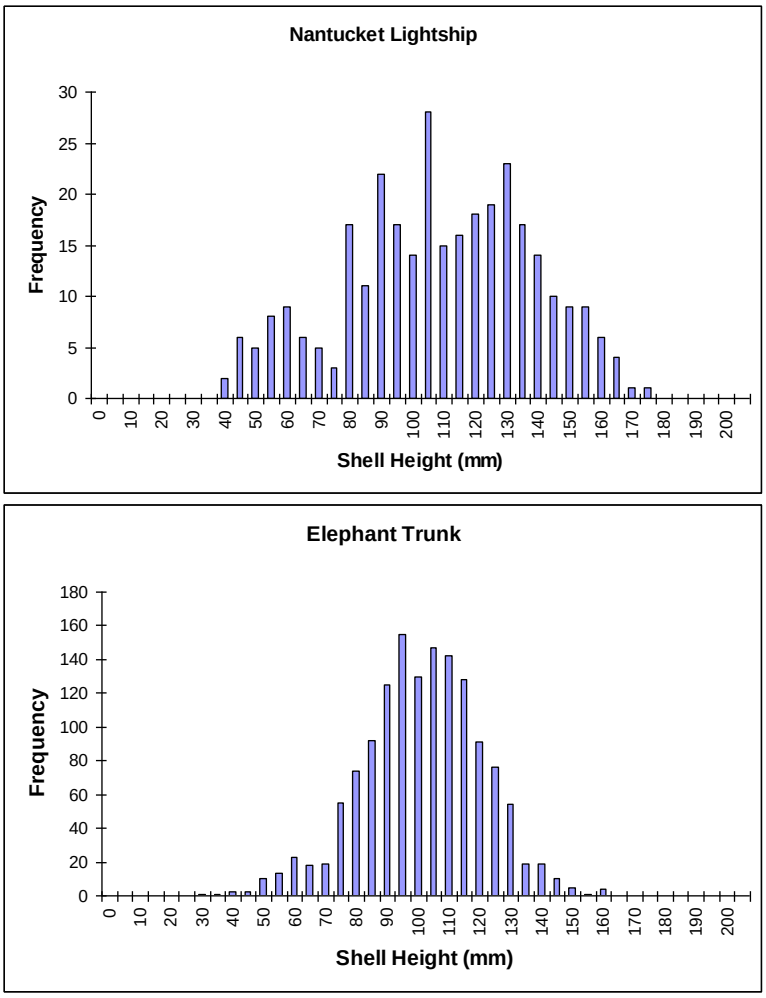

Figure 4. Shell height frequencies observed in the Nantucket Lightship (top) and Elephant Trunk (bottom) closed areas.

We plotted recruitment distribution (scallops <70 mm) in the Nantucket Lightship and Elephant Trunk Closed Areas. There was low recruitment in the Elephant Trunk compared with previous years, but patches of recruitment in the Nantucket Lightship that were not evident in 2008 (Figure 5).

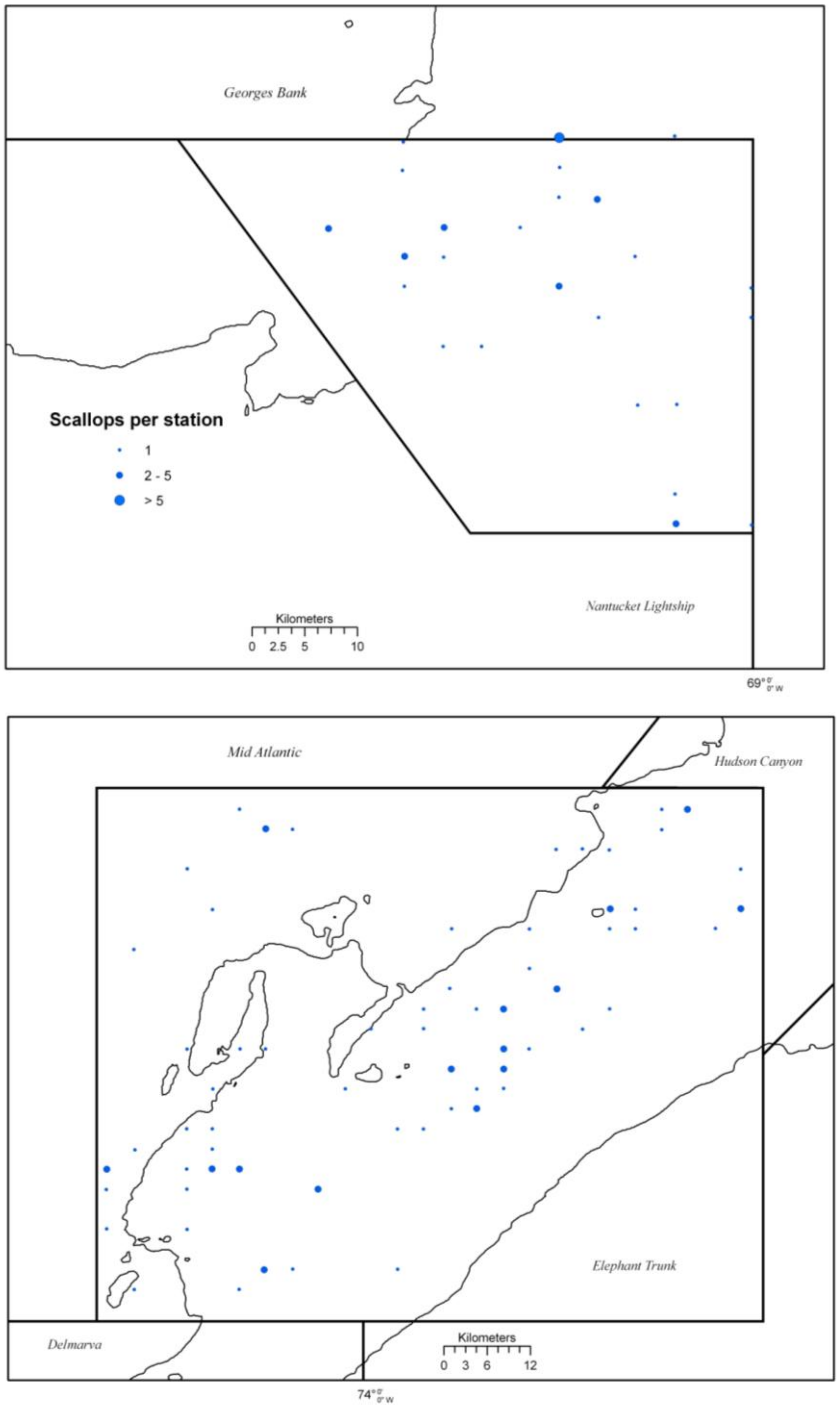

Figure 5. Scallop recruitment (distribution of scallops <70 mm) in the Nantucket Lightship (top) and Elephant Trunk (bottom) Closed Areas in 2009.

Dissemination of Project Results:

We completed an analysis of the Mid-Atlantic scallop resource abundance and biomass trends between 2003 and 2009, including the results from the high-resolution video survey in the Elephant Trunk Closed Area in 2009. We compared the Mid-Atlantic resource to the Georges Bank resource to examine recruitment and natural mortality patterns. We published these results in March, 2011 (Appendix 2; Stokesbury et al., 2011).

We also completed analysis of the spatial structure of surficial sediment characteristics on Georges Bank, including the results from the high-resolution video survey in the Nantucket Lightship Closed Area in 2009. We increased the spatial resolution of sediment information available for habitat assessments and spatial fisheries management on Georges Bank by two orders of magnitude by mapping the distribution of surficial sediments from 2003 through 2009. We published these results in August, 2010 (Appendix 3; Harris and Stokesbury, 2010).

We worked with the scallop Industry to implement a system for yellowtail flounder bycatch avoidance in the Nantucket Lightship closed area in June/July 2010. Data from the 2009 high-resolution survey was used to examine scallop distribution in the area. We compared the high-resolution survey results from 2009 with results from the SMAST 3nm survey conducted in May 2010. This information was disseminated to the scallop fishing fleet on May 10 and June 10, 2010 prior to the Nantucket Lightship scallop fishery access area (Figure 6).

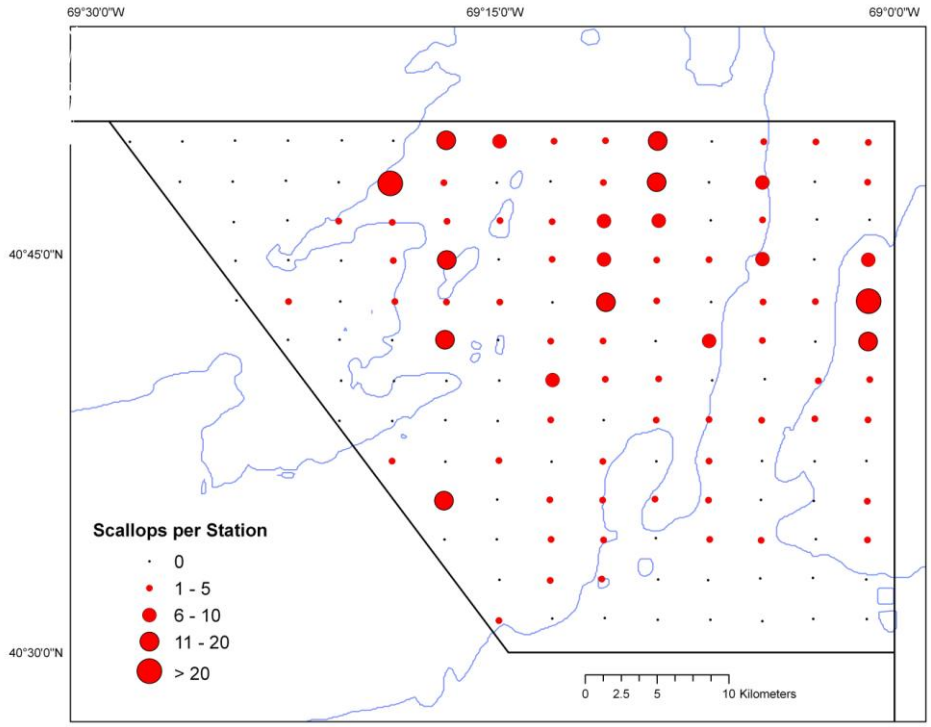

Figure 6. The 2009 1.5nm scallop video survey density estimates sent to the scallop fishing fleet on May 10 and June 10, 2010 to identify areas of high scallop density in efforts to avoid bycatch of yellowtail flounder.

In addition to the New England Fishery Management Council Scallop and Habitat Plan Development Teams, the data has been presented to the SMAST Fishermen's Steering Committee and to the public at the 2009 and 2010 Working Waterfront Festivals in New Bedford, MA, the ICES 2009 Annual Science Conference in Berlin, Germany and 2010 Annual Science Conference in Nantes, France, and the 2011 International Pectinid Workshop in Qingdao, China. Data collected from the "High-Resolution Video Survey of the Sea Scallop Resource, Recruitment Patterns and Habitat of the Elephant Trunk and Nantucket Lightship Closed Areas" RSA project were incorporated into B. Harris' PhD thesis, J. Carey's Master's thesis and are being used as part of C. O'Keefe's PhD thesis.

Expenditures:

We employed 8 commercial fishing vessels to collect the proposed research set-aside allocation ($110,858). All harvest trips were collected in the 2009 fishing year as proposed in grant NOAA/NA09NMF4540128 (Table 2; Appendix 1).

Table 2. Commercial vessels employed to collect RSA harvest allocation in Fishing Year 2009.

Date	F/V Conducting Trip	DAS / Access Area	Lbs. Scallops Landed
7/20/2009	Endeavor	12	40,488
8/22/2009	Guidance	12	31,395
9/8/2009	Karen Nicole	11	18,363
10/3/2009	Kathryn Marie	10	21,681
11/4/2009	Resolution	10	17,791
12/14/2009	Liberty	12	24,349
1/18/2010	Ranger	12	23,641
1/18/2010	Incentive	18,270 lbs ETCA	17,947

We requested and received a one-year No Cost Extension for the project with an extended end date of 5/31/2011. There were not any problems or differences between scheduled and actual expenditures.

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