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# An Assessment of Sea Scallop Abundance and Distribution in Selected Closed Areas: Georges Bank Closed Area I and Hudson Canyon Closed Area

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Submitted to:
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**Summary**

During July of 2010, VIMS and the sea scallop industry conducted abundance surveys of Georges Bank Closed Area I (GBCAI) and Hudson Canyon Closed Area (HCCA). The primary objective of these surveys was to estimate the exploitable biomass of sea scallops in the access area of CAI and the entire HCCA. During the cruises, we sampled 86 stations within the boundaries of the GBCAI and 97 stations in the HCCA. The resulting catch data as well as scallops sampled to estimate the length-weight relationships formed the basis for the analysis. Our results indicate that, depending upon the length weight relationship used roughly 10,000 to 14,000 metric tons of exploitable sea scallops (meat weight) are contained within the GBCAI and 13,000 to 17,000 metric tons (meat weight) are contained within the HCCA.

While the overall levels of biomass in the areas were sufficient to support an opening to the industry in 2011, a couple of cautionary observations were made during the cruises. In the case of the GBCAI, we observed large numbers of very old scallops, whose meats at the time of the sampling were of dubious quality and potentially not as desirable by the marketplace. In the case of the HCCA, while there was significant biomass within the area, it is a quite large area and overall scallop density and size was relatively low with the spatial distribution of animals focused on the western and southern borders of the area.

**Methods**

*Survey Area and Sampling Design*

The proposed access area of GBCAI, (contained in Amendment 15 to the Sea Scallop Fishery Management Plan) in addition to the entire HCCA was surveyed during the course of this project. The boundary coordinates of the surveyed areas can be found in Table 1. Sampling stations for this study were selected within the context of a systematic random grid. With the patchy distribution of sea scallops determined by some unknown combination of environmental gradients (i.e. latitude, depth, hydrographic features, etc.), a systematic selection of survey stations results in an even dispersion of samples across the entire sampling domain. The systematic grid design was successfully implemented during industry-based surveys since 1998. This design has also been utilized for the execution of a trawl survey in the Bering Sea (Gunderson, 1993).

*Sampling Protocols*

While at sea, the vessel simultaneously towed two dredges. A NMFS survey dredge, 8 feet in width equipped with 2-inch rings, 4-inch diamond twine top and a 1.5-inch diamond mesh liner was towed on one side of the vessel. On the other side of the vessel, a 14 or 15 foot commercial scallop dredge equipped with 4-inch rings, a 10-inch diamond mesh twine top and no liner was utilized. The dredge frame used in this study was the recently developed “Coonamessett Farm Turtle Dredge” design. Position of twine top within the dredge bag was standardized throughout the study and rock chains/and turtle chains were used in configurations as dictated by the area surveyed and current regulations. In this paired design, it is assumed that the dredges cover a similar area of substrate and sample from the same population of scallops. The dredges were switched to opposite sides of the vessel mid-way throughout the trip to help minimize any bias.

For each survey tow, the dredges were fished for 15 minutes with a towing speed of approximately 3.8-4.0 kts. High-resolution navigational logging equipment was used to accurately determine and record vessel position. A Star-Oddi™ DST sensor was used on the dredge to measure and record dredge tilt angle as well as depth. With these measurements, the start and end of each tow was estimated. Synchronous time stamps on both the navigational log and DST sensor were used to estimate the linear distance for each tow.

Sampling of the catch was performed using the protocols established by DuPaul and Kirkley, 1995 and DuPaul *et. al.* 1989. For each survey tow, the entire scallop catch was placed in baskets. Depending on the total volume of the catch, a fraction of these baskets were measured for sea scallop length frequency. The shell height of each scallop in the sampled fraction was measured on NMFS sea scallop measuring boards in 5 mm intervals. This protocol allows for the estimation of the size frequency for the entire catch by expanding the catch at each shell height by the fraction of total number of baskets sampled. Finfish and invertebrate bycatch were quantified, with finfish being sorted by species and measured to the nearest 1 cm.

Samples were taken to determine area specific shell height-meat weight relationships. At roughly 25 randomly selected stations the shell height of a sample of 10 scallops was measured to the nearest 0.1 mm. These scallops were then carefully shucked and the adductor muscle individually packaged and frozen at sea. Upon return, the adductor muscle was weighed to the nearest 0.1 gram. The relationship between shell height and meat weight was estimated using a generalized linear mixed model (gamma distribution, log link) incorporating depth as an explanatory variable in SAS v. 9.2. with the model:

$$\ln MW = \ln\alpha + \beta^*\ln SH + \gamma^*\ln Depth$$

where MW=meat weight (grams), SH=shell height (millimeters), Depth=depth (meters). α, β and γ are parameters to be estimated.

The standard data sheets used since the 1998 Georges Bank survey were used. The bridge log maintained by the captain/mate recorded location, time, tow-time (break-set/haul-back), tow speed, water depth, catch, bearing, weather and comments relative to the quality of the tow. The deck log maintained by the scientific personnel recorded detailed catch information on scallops, finfish, invertebrates and trash.

*Data Analysis*

The catch and navigation data were used to estimate swept area biomass within the areas surveyed. The methodology to estimate biomass is similar to that used in previous survey work by VIMS. In essence, we estimate a mean abundance from the point estimates and scale that value up to the entire area of the domain sampled. This calculation is given:

$$TotalBiomass = \sum_j \left( \frac{\left( \frac{CatchWtperTowinSubarea_j}{AreaSweptperTow} \right)}{Efficiency} \right) SubArea_j$$

Catch weight per tow of exploitable scallops was calculated from the raw catch data as an expanded size frequency distribution with an area and depth appropriate shell height-meat weight relationship applied (length-weight relationships were obtained from SARC 50 document as well as the actual relationship taken during the cruise) (NEFSC, 2010). Exploitable biomass, defined as that fraction of the population vulnerable to capture by the currently regulated commercial gear, was calculated using two approaches. The observed catch at length data from the NMFS survey dredge (assumed to be non size selective) was adjusted based upon the size selectivity characteristics of the commercial gear (Yochum and DuPaul, 2008). The observed catch-at-length data from the commercial dredge was not adjusted due to the fact that these data already represent that fraction of the population that is subject to exploitation by the currently regulated commercial gear.

Utilizing the information obtained from the high resolution GPS, an estimate of area swept per tow was calculated. Throughout the cruises the location of the ship was logged every three seconds. By determining the start and end of each tow based on the recorded times as determined by the tilt sensor data of, a survey tow can be represented by a series of consecutive coordinates (latitude, longitude). The linear distance of the tow is calculated by:

The linear distance of the tow is multiplied by the width of the gear to result in an estimate of the area swept by the gear during a given survey tow.

The final two components of the estimation of biomass are constants and not determined from experimental data obtained on these cruises. Estimates of survey dredge gear efficiency have been calculated from a prior experiment using a comparison of optical and dredge catches (NEFSC, 2010). Based on this experiment, an efficiency value of 38% was used for the survey dredge on Georges Bank and a value of 44% was used in the mid-Atlantic. Estimates of commercial sea scallop dredge gear efficiency have been calculated from prior experiments using a variety of approaches (Gedamke *et. al.,* 2005, Gedamke *et. al.,* 2004, D. Hart, pers. comm.). The efficiency of the commercial dredge is generally considered to be higher and based on the prior work as well as the relative efficiency from the data generated from this study; a efficiency values of 60%and 65% were used for the GBCAI and HCCA, respectively. To scale the estimated mean scallop catch to the full domain, the total area of the GBCAI and HCCA was calculated in ArcView v. 3.3.

**Results**

Summary statistics including the dates of the cruises as well as the number of tows included in the biomass estimates are shown in Table 2. Mean total and exploitable scallop densities observed during the cruises are shown in Table 3. From the density data, an estimate of the total number of scallops contained in the access area of GBCAI and the HCCA is shown in Table 4. From the catch data, an estimate of the average meat weight per scallop for both total catch as well as exploitable animals is shown in Table 5. Mean catch per tow for both areas is shown in Table 6. Total and exploitable biomass estimates are shown for both areas in Tables 7 and 8, respectively. The length weight relationships used in the analyses representing estimates from the actual cruises or SARC 50 are shown in Table 9. Length frequency distributions for both of the cruises are shown in Figures 1 and 2.

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**Table 1** Boundary coordinates of Nantucket Lightship Closed Area sampled during 2009.

| **Georges Bank Closed Area I (exemption area)** | **Latitude** | **Longitude** |
|---|---|---|
| CAI-1 | 41° 26' N | 68° 30' W |
| CAI-2 | 40° 58' N | 68° 30' W |
| CAI-3 | 40° 55' N | 68° 53' W |
| CAI-4 | 41° 4.54' N | 69° 0.9' W |
| | | |
| HCCA-1 | 41°00' | 67°20' |
| HCCA-2 | 41°00' | 66°35.8' |
| HCCA-3 | 41°18.6' | 66°24.8' |
| HCCA-4 | 41°30' | 66°34.8' |
| HCCA-5 | 41°30 | 67°20' |

**Table 2** Summary statistics for the survey cruise.

| **Area** | **Cruise dates** | **Number of stations included in biomass estimate (survey dredge)** | **Number of stations included in biomass estimate (comm. dredge)** |
|---|---|---|---|
| Georges Bank Closed Area I (exemption area) | July 13-19, 2010 | 86 | 86 |
| Hudson Canyon Closed Area | July 24-30, 2010 | 97 | 97 |

**Table 3** Mean total and mean exploitable scallop densities observed during the July 2010 cooperative sea scallop surveys of GBCAI and HCCA.

| Gear | Efficiency | Average Total Density (scallops/m^2) | SE | Average Density of Exploitable Scallops (scallops/m^2) | SE |
|---|---|---|---|---|---|
| **GBCAI** | | | | | |
| Commercial | 60% | | | 0.164 | 0.022 |
| Survey | 38% | 0.244 | 0.033 | 0.206 | 0.028 |
| **HCCA** | | | | | |
| Commercial | 65% | | | 0.138 | 0.020 |
| Survey | 44% | 0.242 | 0.036 | 0.128 | 0.015 |

**Table 4** Estimated number of scallops in the Georges Bank Closed Area I (access area) and Hudson Canyon Closed Area. The estimate is based upon the estimated density of scallops at commercial dredge efficiencies of 60% and 65% and survey dredge efficiencies of 38% and 44% for the GBCAI and HCCA cruises, respectively. The total area surveyed was estimated at 1,440 km^2 (GBCAI) and 4,356 km^2 (HCCA).

| Gear | Efficiency | Estimated Total | Estimated Total Exploitable |
|---|---|---|---|
| **GBCAI** | | | |
| Commercial | 60% | | 236,160,000 |
| Survey | 38% | 351,360,000 | 296,208,000 |
| **HCCA** | | | |
| Commercial | 65% | | 595,726,870 |
| Survey | 44% | 1,052,060,925 | 557,723,459 |

**Table 5** Estimated average scallop meat weights for the access area of the Georges Bank Closed Area I and the Hudson Canyon Closed Area. Estimated weights are for the total size distribution of animals as represented by the catch from the NMFS survey dredge as well as the mean weight of exploitable scallops in the area as represented by the catches from both the survey and commercial dredge. Length:weight relationships from both SARC 50 as well as that observed from the cruise are shown.

| Gear | SH:MW | Mean Meat Weight (g) Total scallops | Mean Meat Weight (g) Exploitable scallops |
|---|---|---|---|
| **GBCAI** | | | |
| Commercial | SARC 50 | | 47.87 |
| Survey | SARC 50 | 42.31 | 46.04 |
| | | | |
| Commercial | July, 2010 | | 42.02 |
| Survey | July, 2010 | 37.8 | 41.02 |
| **HCCA** | | | |
| Commercial | SARC 50 | | 23.58 |
| Survey | SARC 50 | 17.71 | 23.45 |
| | | | |
| Commercial | July, 2010 | | 26.20 |
| Survey | July, 2010 | 19.35 | 25.96 |

**Table 6** Mean catch of sea scallops observed during the 2010 VIMS-Industry cooperative closed area survey of the Georges Bank Closed Area I and the Hudson Canyon Closed Area. Mean catch is depicted as a function of various shell height meat weight relationships, either an area specific relationship derived from samples taken during the survey, or a relationship from SARC 50.

| Gear | Samples | SH:MW | Mean (grams/tow) | Standard Error |
|---|---|---|---|---|
| **GBCAI** | | | | |
| Commercial | 86 | SARC 50 | 41,649.0 | 5,824.5 |
| Survey | 86 | SARC 50 | 18,507.68 | 2,555.8 |
| | | | | |
| Commercial | 86 | July, 2010 | 37,082.3 | 5,224.6 |
| Survey | 86 | July, 2010 | 16,534.0 | 2,293.8 |
| | | | | |
| **HCCA** | | | | |
| Commercial | 97 | SARC 50 | 18,193.7 | 2,541.5 |
| Survey | 97 | SARC 50 | 6,120.1 | 692.8 |
| | | | | |
| Commercial | 97 | July, 2010 | 20,215.64 | 2,836.1 |
| Survey | 97 | July, 2010 | 9,562,8 | 1,123.8 |

**Table 7** Estimated total biomass of sea scallops observed during the July 2010 VIMS-Industry cooperative closed area survey of the Georges Bank Closed Area I and the Hudson Canyon Closed Area. Biomass is presented as a function of two different shell height meat weight relationships, either an area specific relationship derived from samples taken during the actual survey or a regional relationship from SARC 50.

| Gear | SH:MW | Efficiency | Total Biomass (mt) | 95% CI | Lower Bound 95% CI | Upper Bound 95%CI |
|---|---|---|---|---|---|---|
| **GBCAI** | | | | | | |
| Survey | SARC 50 | 38% | 14,864.2 | 2,480.1 | 12,384.5 | 17,344.8 |
| Survey | July, 2010 | 38% | 13,279.0 | 2,225.9 | 11,053.2 | 15505.7 |
| **HCCA** | | | | | | |
| Survey | SARC 50 | 44% | 18,678.7 | 2,868.3 | 15,810.4 | 21,546.9 |
| Survey | July, 2010 | 44% | 25,320.8 | 3,118.8 | 17,292.8 | 23,530.0 |

**Table 8** Estimated exploitable biomass of sea scallops observed during the 2010 VIMS-Industry cooperative closed area surveys. Biomass is depicted as a function of various shell height-meat weight relationships, either an area specific relationship derived from samples taken during the survey, and a relationship from SARC 50

| Gear | SH:MW | Efficiency | Exploitable Biomass (mt) | 95% CI | Lower Bound 95% CI | Upper Bound 95%CI |
|---|---|---|---|---|---|---|
| **GBCAI** | | | | | | |
| Commercial | SARC 50 | 60% | 11,209.1 | 2,398.9 | 8,900.1 | 13,697.0 |
| Survey | SARC 50 | 38% | 13,648.3 | 2,313.0 | 13,697.0 | 15,961.8 |
| | | | | | | |
| Commercial | July, 2010 | 60% | 10.060.1 | 2,151.8 | 7,908.7 | 12,211.9 |
| Survey | July, 2010 | 38% | 12,159.5 | 2,070.9 | 10,088 | 14,230.4 |
| **HCCA** | | | | | | |
| Commercial | SARC 50 | 65% | 15,021.6 | 3,315.8 | 11,705.7 | 18,337.4 |
| Survey | SARC 50 | 44% | 13,063.2 | 1,922.2 | 11,140.4 | 14,986.0 |
| | | | | | | |
| Commercial | July, 2010 | 65% | 16,690.4 | 3,700.2 | 12,990.6 | 20,391.1 |
| Survey | July, 2010 | 44% | 14,459.1 | 2,130.2 | 12,328.9 | 16,589.3 |

**Table 9** Summary of area specific shell height-meat weight parameters used in the analyses. Parameters were obtained from two sources: (1) samples collected during the course of the surveys (July of 2010), and (2) SARC 50 (NEFSC, 2010)*.

| Area surveyed | Date | α | β | γ | δ |
|---|---|---|---|---|---|
| **Survey data** | | | | | |
| **GBCAI** | July, 2009 | -7.1666 | 2.6411 | -0.4944 | |
| **HCCA** | July, 2009 | -8.7372 | 3.1413 | -0.6967 | |
| | | | | | |
| **SARC 50** | | | | | |
| **GBCAI** | - | -6.3757 | 2.7999 | -0.8405 | |
| **mid-Atlantic** | | -16.88 | 4.64 | 1.57 | -0.43 |

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*The length weight relationship for sea scallops from data collected on the cruise and SARC 50 (GBCAI) is modeled as:

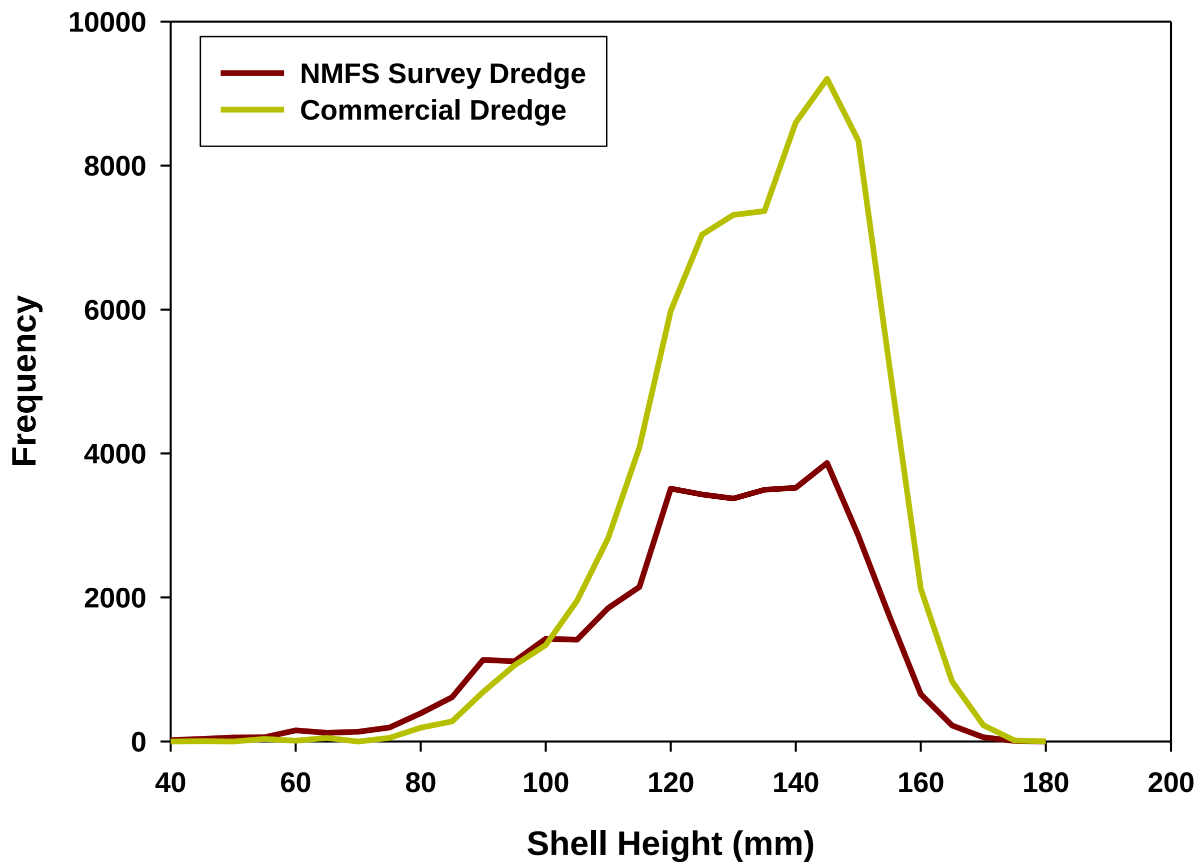
$$W=\exp(\alpha+ \beta*\ln(L) + \gamma*\ln(D))$$

For SARC 50 (mid-Atlantic) an interaction term is included in the model as follows:

$$W=\exp(\alpha+ \beta*\ln(L) + \gamma*\ln(D) + \delta*\ln(L)*\ln(D))$$

Where *W* is meat weight in grams, *L* is scallop shell height in millimeters (measured from the umbo to the ventral margin) and *D* is depth in meters.

**Figure 1** Shell height frequencies for the two dredge configurations used to survey the access area of Georges Ban Closed Area I during July, 2010. The frequencies represent the expanded but unadjusted catches of the two gears for all sampled tows.



**<u>Figure 2</u>** Shell height frequencies for the two dredge configurations used to survey the Hudson Canyon Closed Area during July, 2010. The frequencies represent the expanded but unadjusted catches of the two gears for all sampled tows.