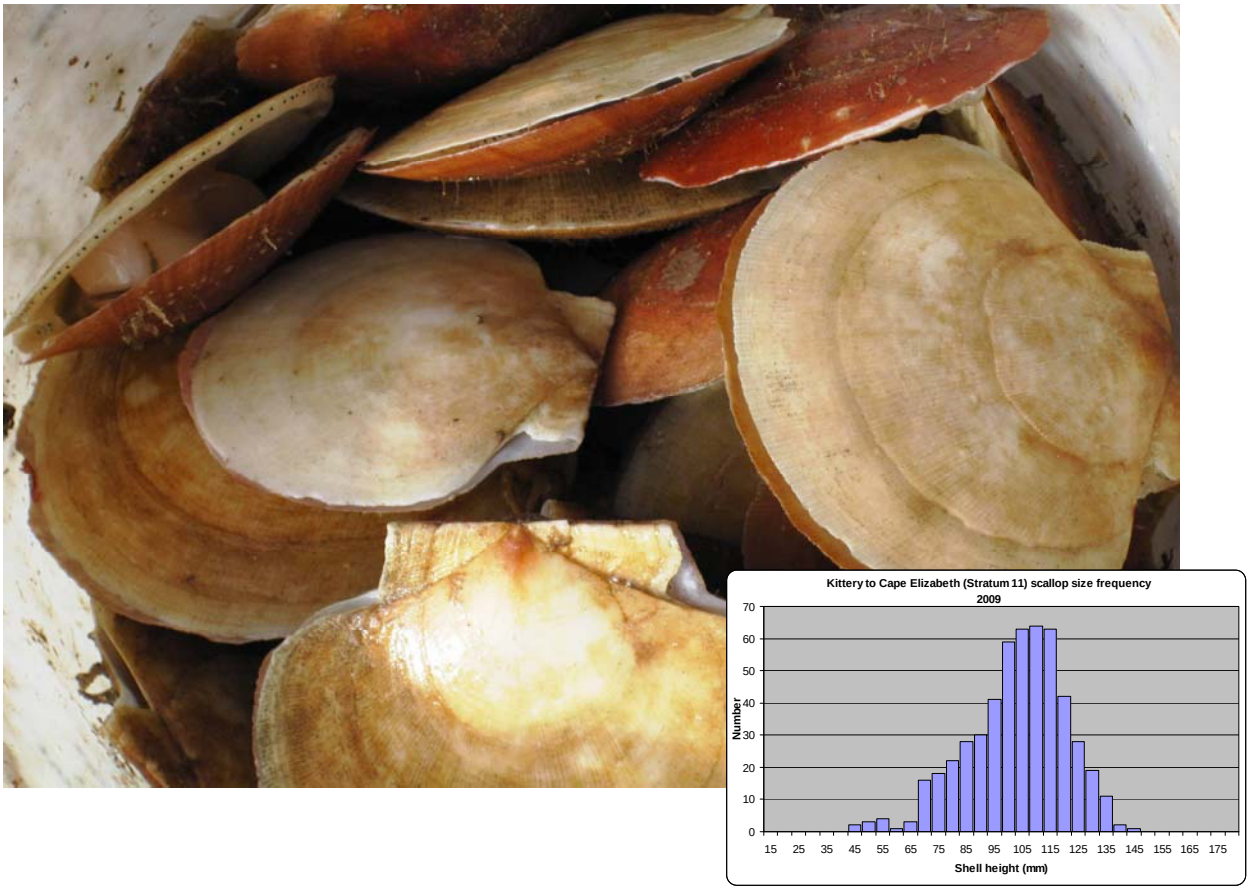


# Results from the 2009 Maine Sea Scallop Survey

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## Executive Summary

The 2009 Maine sea scallop survey was carried out in October-December (prior to the December 15 opening of the fishery) in survey strata 1 (Cobscook Bay), 1a (St. Croix River) and 8-11 (western Penobscot Bay to New Hampshire border). There were also two offshore, state waters strata (2a: Machias Seal Is. and 5a: Mt. Desert Rock) surveyed in July during the federal waters Northern Gulf of Maine survey.

Cobscook Bay had an above average amount of harvestable ($\geq$ 4 in. shell height) biomass (196.5 $\pm$ 28.0 thsd. lbs.) with a large amount of it present in Johnson Bay and around Moose Is., as well as South Bay. This differed from previous surveys where South Bay was the predominant area. A large number of pre-recruits (within 10 mm SH of legal size) were present in '09 which should be available to the fishery in 2010-11. Increased amounts of seed were present in Cobscook Bay in '09 with higher densities at Moose Is., Johnson Bay and Whiting Bay/Dennys Bay.

Scallop abundance increased significantly in the St. Croix River since '06, with the sublegal size class predominating in '09. Most of the St. Croix River is closed to scallop fishing during 2009-12.

In the western Maine strata, overall scallop densities improved 92-157% since '05. The largest increase was in Stratum 9 (Small Pt. to Pemaquid Pt.) but this was based on a fairly low number of tows. A large increase was also seen in Stratum 11 (Kittery to Cape Elizabeth) due to the addition of the Piscataqua River to the survey. Lower scallop densities were generally observed within portions of strata closed to fishing compared to open areas. The closed portion of the Damariscotta River however had higher densities of seed and harvestable-sized scallops than outside.

The two offshore strata (Machias Seal Is. and Mt. Desert Rock) were characterized by very little evidence of recruitment and larger, older scallops with poor meat quality.

## Introduction

The sea scallop (*Placopecten magellanicus*) fishery in the Gulf of Maine occurs primarily in state waters. Scallops have been harvested along the Maine coast since the late 1800's (Wallace 1997; Schick and Feindel 2005). The fishery has been characterized by wide fluctuations in abundance with fishing pressure increasing rapidly in times when scallops were more plentiful (Walton 1980; Alden and Perkins 2001; Schick and Feindel 2005). The primary gear type is the drag, or "dredge" (683 scallop dragger licenses issued by Maine DMR in 2009), although Maine also permits commercial and non-commercial harvest of scallops by diving (135 commercial diver licenses in '09).

Maine scallop landings are currently low. In some years however scallops have been second only to lobster in landed value in Maine. The 2008 landings were reported to be only 137 thsd. meat lbs. (Fig. 1).

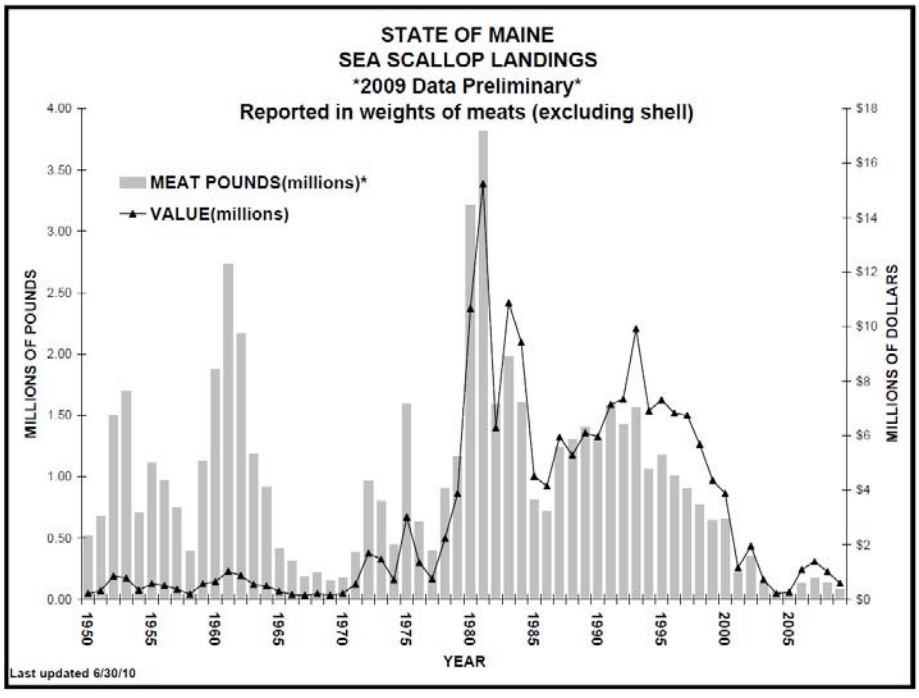


**Figure 1. Maine scallop landings 1950-2009 (source: Maine Department of Marine Resources (DMR)).**

An annual dredge-based fishery-independent survey by DMR of the scallop resource within Maine state waters has been conducted since 2002 (with the exception of 2004).

For the first two years (2002-03) the entire coast was surveyed. Subsequent to this one of three (1. Western Penobscot Bay to New Hampshire border, 2. Quoddy Head to eastern Penobscot Bay, and 3. Cobscook Bay) major sections of the coast has been surveyed each year on a rotating basis. The following is a chronology of survey coverage by year:

| Year | Area surveyed |
|---|---|
| 2002 | Coastwide, including Cobscook Bay |
| 2003 | Coastwide, including Cobscook Bay |
| 2004 | no survey |
| 2005 | Western Penobscot Bay to New Hampshire border |
| 2006 | Cobscook Bay/St. Croix River to eastern Penobscot Bay, including Mt. Desert Rock (*began higher intensity survey than previous years*) |
| 2007 | Cobscook Bay |
| 2008 | Quoddy Head to Matinicus Is. |
| 2009 | Cobscook Bay/St. Croix River, and western Penobscot Bay to New Hampshire border, plus Machias Seal Is. and Mt. Desert Rock |

***Purpose and extent of survey***

The purpose of the survey is to characterize and monitor the sea scallop resource within Maine's coastal waters, and to compare results to previous years' surveys in light of regulatory and environmental changes. It is necessary to monitor changes in abundance and stock size from year to year to evaluate effects of the fishery, document recruitment events and determine what is available for harvest. The survey provides information needed to evaluate potential management strategies such as rotational closures, harvest limits and area closures to protect spawning and enhance recruitment. The survey provides information on geographic distribution, relative abundance, population size

structure, meat yield and occurrence of seed and sublegal scallops as well as an estimate of harvestable biomass for Cobscook Bay.

In 2009, strata 8-11 (western Penobscot Bay to New Hampshire border), 5a (Mt. Desert Rock), 2a (Machias Seal Is.), 1 (Cobscook Bay) and 1a (St. Croix R.) were surveyed. The western Penobscot Bay to New Hampshire border strata were surveyed in November-December '09. These were last surveyed in '05. The Mt. Desert Rock and Machias Seal Is. strata are offshore (and thus were sampled during the '09 Northern Gulf of Maine federal waters survey) but are considered part of Maine state waters. Mt. Desert Rock was last surveyed in '06 and Machias Seal Is. has not previously been surveyed. Cobscook Bay was last surveyed in '07 and the St. Croix River in '06.

## Methods

### *Vessels and timing*

The '09 survey was conducted aboard two commercial scallop vessels each deploying a standardized survey drag. Vessels were the 39 ft. *F/V Kristin Lee* from Eastport (surveyed Cobscook Bay and St. Croix R.) and the 45 ft. *F/V Foxy Lady II* from Stonington (surveyed all other areas).

The Mt. Desert Rock and Machias Seal Is. areas were surveyed in July '09. Cobscook Bay and the St. Croix River were surveyed in October and the western Maine strata were covered in November-December prior to the opening of commercial scallop season on December 15.

### *Gear*

The survey gear was a 7 ft. wide New Bedford-style chain sweep dredge with 2 inch rings, 1¾ inch head bale, 3½ inch twine top (single hung) and 10 inch pressure plate. The dredge was equipped with rock chains and was not lined. Due to age and wear on the

original drags made for the first state waters survey in ‘02, the gear constructed for the ’09 Northern Gulf of Maine (NGOM) federal waters survey replaced the original gear for the fall ’09 state survey.

The new gear (Fig. 2) was of a configuration largely consistent with that used in previous state surveys (Kelly 2009a; Schick and Feindel 2005) but had smaller rings to allow better retention of small scallops and a slightly larger pressure plate to facilitate towing in deeper water. The gear was of a size which would allow it to be used in both nearshore and offshore parts of the Gulf of Maine, would facilitate sufficient bottom coverage and allow it to be transported over ground to various sampling locations throughout the region. The dredge frame and clubstick were fabricated by Blue Fleet Welding (New Bedford, MA) and the ring bag was constructed by Pacheco Gear (E. Freetown, MA). Final assembly of the dredge and installation of the twine top was by Capt. Wally Gray (Stonington, ME).


**Figure 2. View of survey drag constructed in ‘09.**

***Survey design***

A subset of the coastal zones (or "strata") defined for the 2002-03 surveys (Fig. 3) were used in subsequent surveys, including 2009, with some modification.

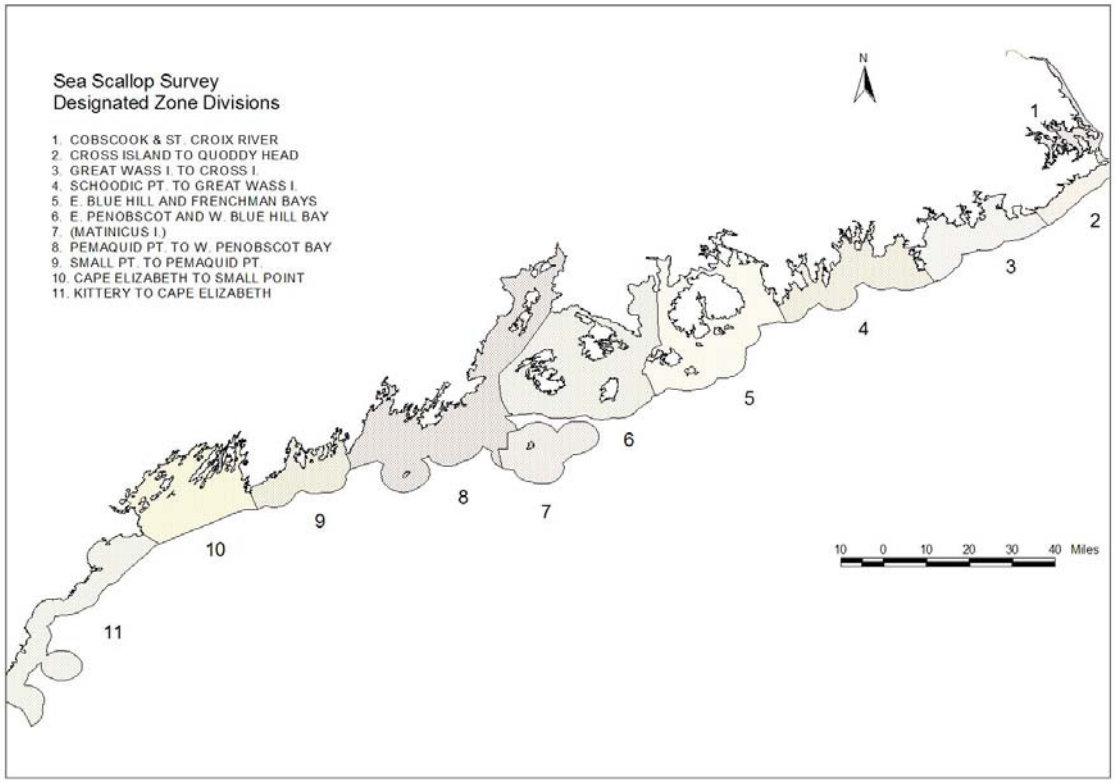


**Figure 3. Survey strata - Maine DMR scallop survey.**

Strata were sized to provide a manageable balance between area and sampling intensity. Scallop areas within the strata were mapped based on fisher information, prior survey data, surficial sediment maps (http://megisims.state.me.us/metadata/surf.htm) and coastal wildlife inventory maps (http://megisims.state.me.us/metadata/shell.htm) (Schick and Feindel 2005).

Within each stratum (except stratum 1), survey stations within scallop areas were selected randomly using a 500 m grid (stratified random design). The number of stations assigned within each region was roughly proportional to the size of the strata. Sampling was also structured to facilitate comparison of scallop abundance inside vs. outside of the "closed"

areas that went into effect in 2009. Tows were distributed to facilitate a balance between the open and closed portions of each stratum. There were also several "fixed" stations sampled which were generally in areas that were considered especially important to monitor on a regular basis (e.g., Damariscotta River).

Cobscook Bay (Stratum 1) has the most productive scallop fishery within Maine waters and is thus sampled with the most frequency and with the highest intensity of the survey zones. A direct assessment of scallop abundance for this stratum is made by using a systematic sampling design.

Six survey substrata (South Bay, Pennamaquan River, East Bay, Whiting Bay/Dennys Bay, Johnson Bay and Moose Island (formerly called "other")) within Cobscook Bay representing spatially contiguous fished areas were determined in consultation with fishing industry members prior to the '02 survey and have been repeated in subsequent surveys with only slight modification. The total number of stations sampled however was increased by 31% from previous surveys beginning in '06.

Cobscook Bay tow locations were based on a 500 m grid overlaying each substratum. This grid accommodated an average tow length of approximately 300 m. There were 84 tows completed in the '07 Cobscook Bay survey and 86 in '09 (two stations were added in Dennys Bay '09).

***Sampling procedure***

Stations to be sampled were plotted using Capn Voyager™ navigational software. A Garmin™ Map 76 GPS unit with Garmin™ GA 29 GPS antenna interfaced with a laptop computer displaying station location was used to position the vessel on station. Location and time were recorded at three points (dredge in, tow start and haulback) for each tow. A Juniper Allegro™ ruggedized handheld computer was also interfaced with a GPS unit to record time/date/location information.

Tow times were 2.5-5 minutes (2.5 minutes in Cobscook Bay) depending on bottom conditions and presence of lobster traps. Stations were sampled by a straight line tow. Boat speed averaged 3.5 knots.

A ruggedized handheld computer with an RS232 serial port input for digital calipers was used to facilitate rapid entry of shell measurements and other information while sampling. Data entry screens for the sampling programs and survey were configured using Data Plus Professional™ software, which aided in standardizing data entry, providing error checks and minimizing subsequent data auditing and keying (Schick and Feindel 2005).

The following sampling protocol was employed for each tow:

1.) Station information (location, time, depth) was entered from the wheelhouse.

2.) Bottom type was recorded as combinations of mud, sand, rock, and gravel based on sounder information and dredge contents. For example "Sg" designated a primarily sand substratum with some gravel (after Kelley et. al.1998).

3.) Once the drag was emptied, a digital picture of the haul was taken.

4.) Scallops, sea cucumbers (*Cucumaria frondosa*) and ocean quahogs (*Arctica islandica*) were culled from the drag contents for subsequent measurement. Catches of the latter species were quantified because of their importance in other drag fisheries. While the survey gear is not suitable for formally sampling ocean quahogs their presence in the catch does suggest the existence of a bed below the sediment.

5.) Bycatch was enumerated using a 0-5 qualitative abundance scale corresponding to "absent", "present", "rare", "common", "abundant", and "very abundant".

6.) Total number of scallops was recorded. The total weight and volume of the scallop, sea cucumber, and ocean quahog catch was recorded.

7.) The shell height (SH; distance from the umbo to the outer edge, perpendicular to the hinge line) of individual scallops was measured. All scallops from catches of 100 animals or less were measured for SH. If >100 scallops were present at least 100 were measured. Where n > 1,000 a subsample of 10% was measured.

8.) On selected tows (normally every third or fourth tow) a subsample of 24 scallops, chosen to represent the catch of scallops ≥ 3½ in. shell height, were measured (shell length, width and height) and shucked for meat weight determination. Meats were placed in a compartmentalized box in the order that the animals were measured and later individually weighed on shore (using an Ohaus Navigator™ balance interfaced with the ruggedized handheld computer) and matched to the corresponding shell measurements.

***Data analysis***

Area swept per tow was determined from tow distance (tow start to haulback) and drag width (7 ft., or 2.1 m). Tow distance was determined using Capn Voyager™ software. The scallop catch for each tow was standardized to density (number of scallops per square meter). Total scallop catch was divided into the following size categories:

- "seed": < 2½ in. (<63.5 mm) SH
- "sublegal": 2½ in. to < 4 in. (63.5 – <101.6 mm) SH
- "harvestable": ≥ 4 in. (≥101.6 mm) SH

Estimates of total abundance for each of the three size classes were calculated using the classic Cochran (1977) approach. For each of the six survey substrata identified above, the overall average abundance by area swept was estimated as:

$$\bar{X} = \sum_{h=1}^{H} W_h \bar{X}_h$$

where $\bar{X}_h$ is the average abundance of swept area for substratum h, H is the total number of substrata, and $W_h$ is proportion of the area of substratum h with respect to the survey area. The associated standard error can be calculated as

$$\textbf{std error}(\bar{X}) = \sqrt{\sum_{h=1}^{H} W_h^2 \frac{1 - f_h}{n_h} S_h^2}$$

where $S_h^2$ is the variance estimated for substratum h, $f_h = \frac{n_h}{N_h}$ is the finite population correction for substratum h, and $n_h$ and $N$ are the number of stations sampled and the total number of stations available for sampling, respectively, in substratum h. The finite population correction factor was ignored since the proportion of area sampled was small compared to the total area of each substratum.

**RESULTS:**

***Stratum 1 (Cobscook Bay)***

The '09 survey comprised 86 total tows within the six (6) substrata of Cobscook Bay (Fig.4). Two (2) tows were added to the survey in Dennys Bay which is now part of the combined Whiting Bay/Dennys Bay substratum. This entire substratum is within an area closed by DMR to scallop fishing during 2009-12.

There were 8,837 scallops measured for SH and an additional 786 scallops sampled for meat weight determination. The smallest individual sampled was 22.0 mm (0.87 in.) SH and the largest was 147.1 mm (5.79 in.) SH. Three (3) tows caught no scallops and the largest number of scallops in a single tow was 1,364 in South Bay. The new dredge with 2" rings seemed particularly effective at sampling across the full size range of the resource.

***Abundance***

Total scallop abundance in Cobscook Bay increased slightly (2.0%) from 2007 (Table 1). Abundance increased by 11.3% for seed and 17.7% for sublegals but was 57% lower for harvestables than '07 (however the abundance of harvestable scallops in '07 was 96% higher than the previous high reported in '03).

In South Bay, the largest substratum (48 stations), the estimated abundance of harvestable scallops decreased by 67.8% between '07 and '09 (1.742 mil. scallops in '07 vs. 558.3 thsd. in '09: Table 1; Fig. 5). The density of harvestables was significantly ($p<0.001$) less in '09 (0.047 per $m^2$) than '07 (0.147 per $m^2$).

Sublegal scallop density in South Bay was similar in '09 (0.358 per $m^2$) to '07 (0.345 per $m^2$). South Bay had the highest density of sublegals of any substrata in '09 and the largest amount was observed approx. 1 km W/NW of Red Is. Seed density was similar in '09 (0.057 per $m^2$) to '07 (0.064 per $m^2$).

East Bay is a small (3 stations) substratum that had significantly ($p<0.01$) less harvestable density in '09 (0.050 per $m^2$) than '07 (0.144 per $m^2$) (Table 1; Fig. 6). There was also a slight decrease in sublegal density between '07 (0.108 per $m^2$) and '09 (0.059 per $m^2$). Seed density remained very low in this area.

Pennamaquan River (5 stations) had a decrease in overall abundance from '07 (42.2%; NS, $p>0.05$), with a small decrease in sublegals and virtually no change in harvestable density (Table 1; Fig. 7). The density of seed was low.

**Table 1. Survey summary statistics for Cobscook Bay (2009) by substratum and overall (mean +/- standard error).**

**Stratum 1 (Cobscook Bay) scallop survey - 2009**

| substratum | total | | South Bay | | East Bay | | Penn. River | | Whiting/Dennys Bay | | Johnson Bay | | Moose Is. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| area (hec) | 2,181 | | 1,182 | | 92 | | 64 | | 158 | | 401 | | 284 | |
| no. sites | 85 | | 48 | | 3 | | 5 | | 11 | | 15 | | 3 | |
| | | | Density (scallops per sq m) | | | | | | | | | | | |
| | | | density | S.E | density | S.E | density | S.E | density | S.E | density | S.E | density | S.E |
| seed | | | 0.057 | 0.011 | 0.002 | 0.001 | 0.016 | 0.006 | 0.032 | 0.005 | 0.034 | 0.009 | 0.071 | 0.017 |
| sublegal | | | 0.358 | 0.060 | 0.059 | 0.028 | 0.101 | 0.035 | 0.237 | 0.029 | 0.329 | 0.060 | 0.311 | 0.100 |
| harvestable | | | 0.047 | 0.007 | 0.050 | 0.011 | 0.048 | 0.020 | 0.046 | 0.007 | 0.115 | 0.016 | 0.180 | 0.127 |
| all sizes | | | 0.462 | 0.074 | 0.111 | 0.040 | 0.166 | 0.054 | 0.315 | 0.037 | 0.478 | 0.082 | 0.563 | 0.226 |
| | | | Abundance (no. scallops) | | | | | | | | | | | |
| | abundance | | abundance | S.E | abundance | S.E | abundance | S.E | abundance | S.E | abundance | S.E | abundance | S.E |
| seed | 1,073,557 | | 673,165 | 131,206 | 2,107 | 1,340 | 10,257 | 3,684 | 50,454 | 8,460 | 135,059 | 34,484 | 202,515 | 48,799 |
| sublegal | 6,931,809 | | 4,234,634 | 708,373 | 54,268 | 25,653 | 64,885 | 22,117 | 374,230 | 46,555 | 1,320,115 | 240,714 | 883,677 | 283,929 |
| harvestable | 1,679,466 | | 558,301 | 78,904 | 46,103 | 10,081 | 31,019 | 13,018 | 72,734 | 10,693 | 459,692 | 65,557 | 511,617 | 360,779 |
| all sizes | 9,684,831 | | 5,466,101 | 878,781 | 102,478 | 36,839 | 106,161 | 34,721 | 497,417 | 58,817 | 1,914,866 | 327,846 | 1,597,809 | 641,394 |
| | | | | | | | | | | | | | | |
| | Harvestable biomass (kg) (unadjusted) | | | | | | | | | | | | | |
| | biomass | S.E | biomass | S.E | biomass | S.E | biomass | S.E | biomass | S.E | biomass | S.E | biomass | S.E |
| | 38,862 | 12,705 | 12,532 | 1,770 | 1,099 | 235 | 697 | 302 | 1,583 | 226 | 10,604 | 1,470 | 12,348 | 8,701 |

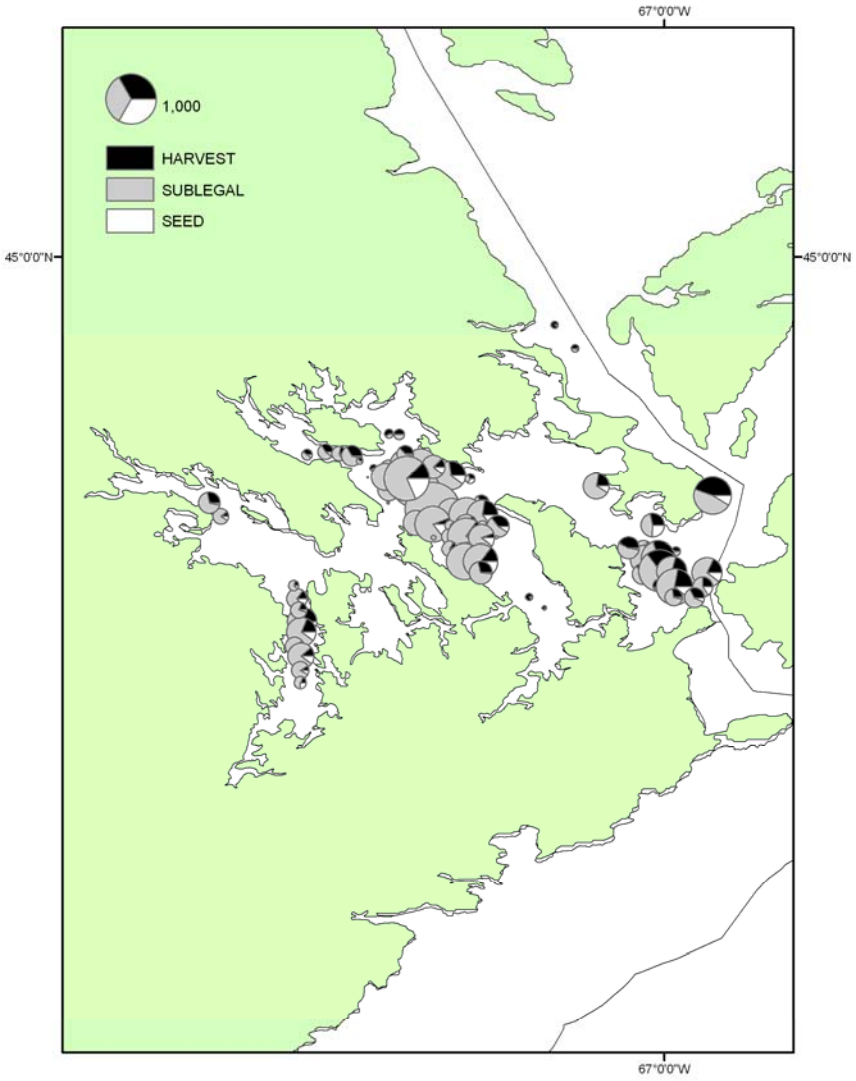


**Figure 4. Number of scallops and size class composition by tow (Cobscook Bay), 2009 survey (tows with 0 scallops not shown).**

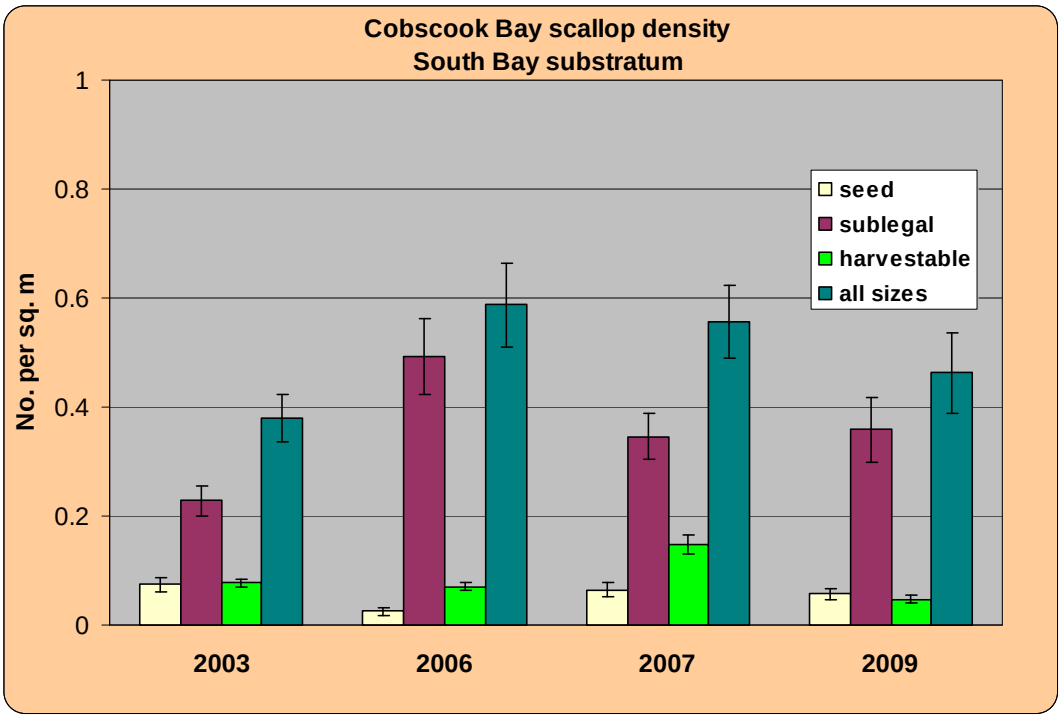


**Figure 5. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, South Bay substratum of Cobscook Bay.**

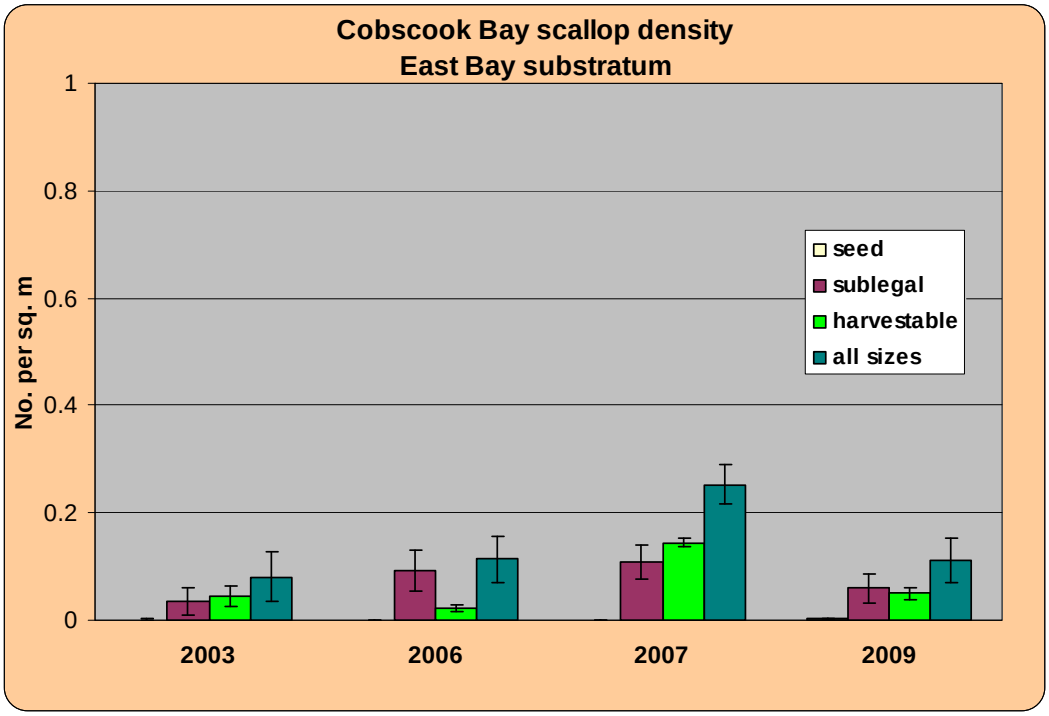


**Figure 6. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, East Bay substratum of Cobscook Bay.**

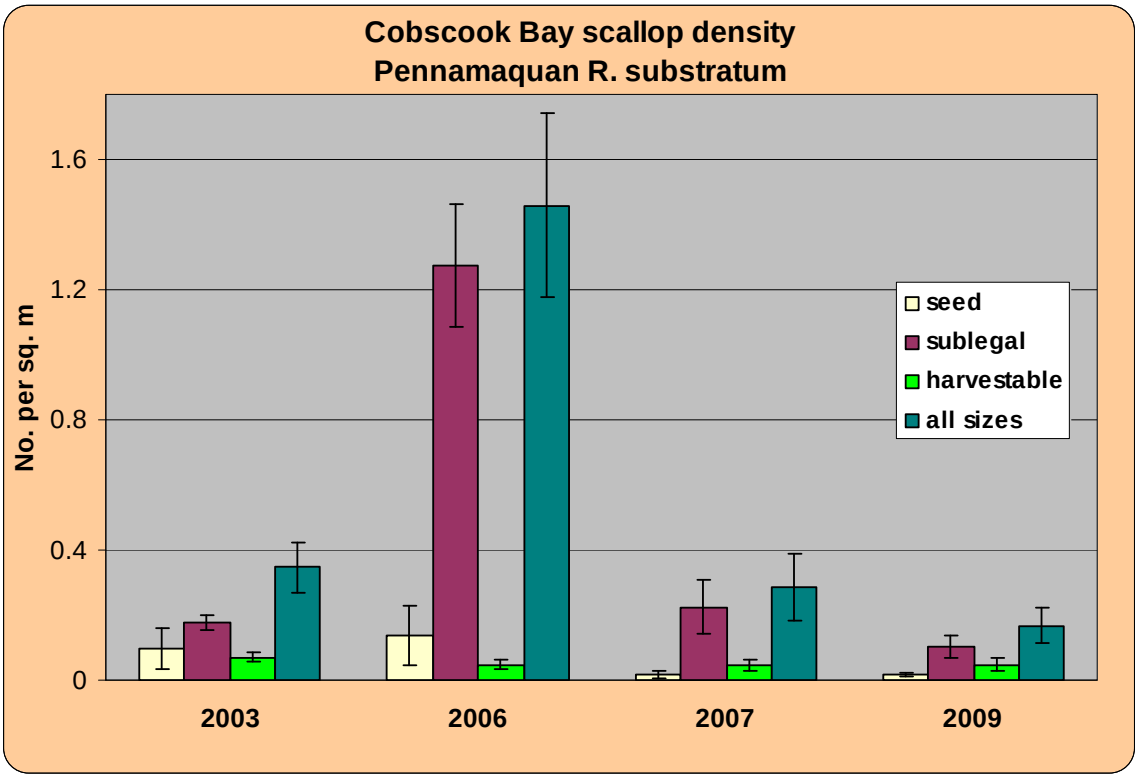


**Figure 7. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Pennamaquan R. substratum of Cobscook Bay.**

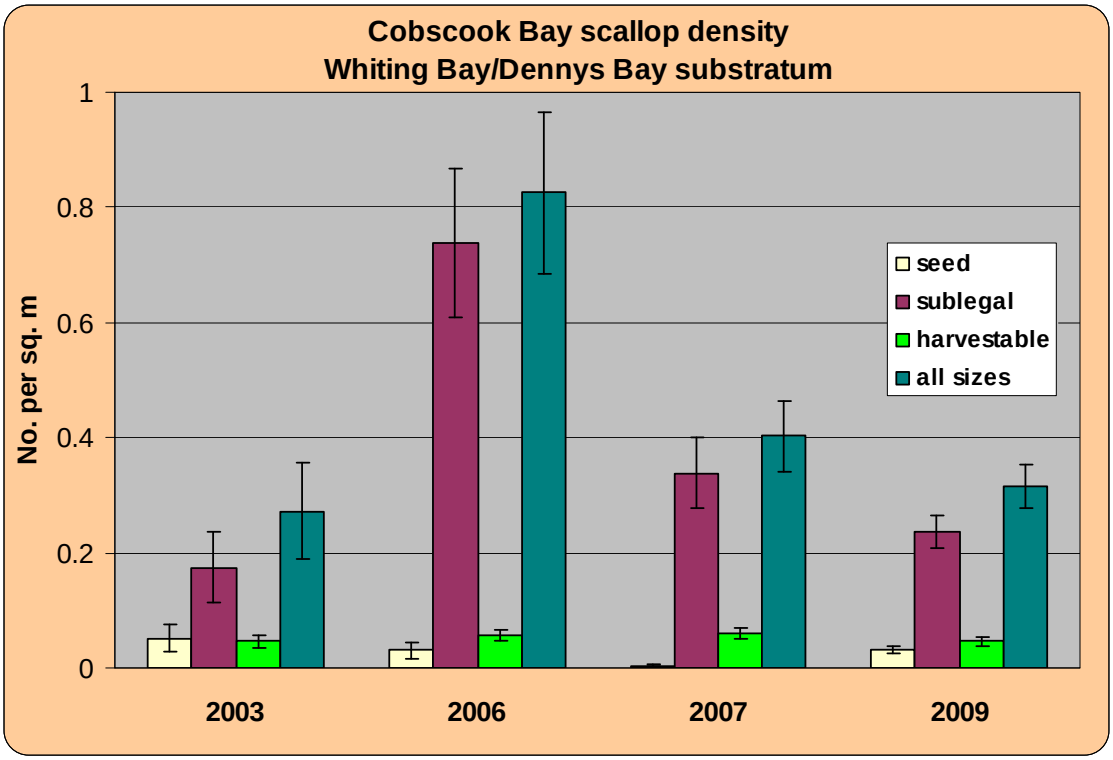


**Figure 8. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Whiting Bay/Dennys Bay substratum of Cobscook Bay.**

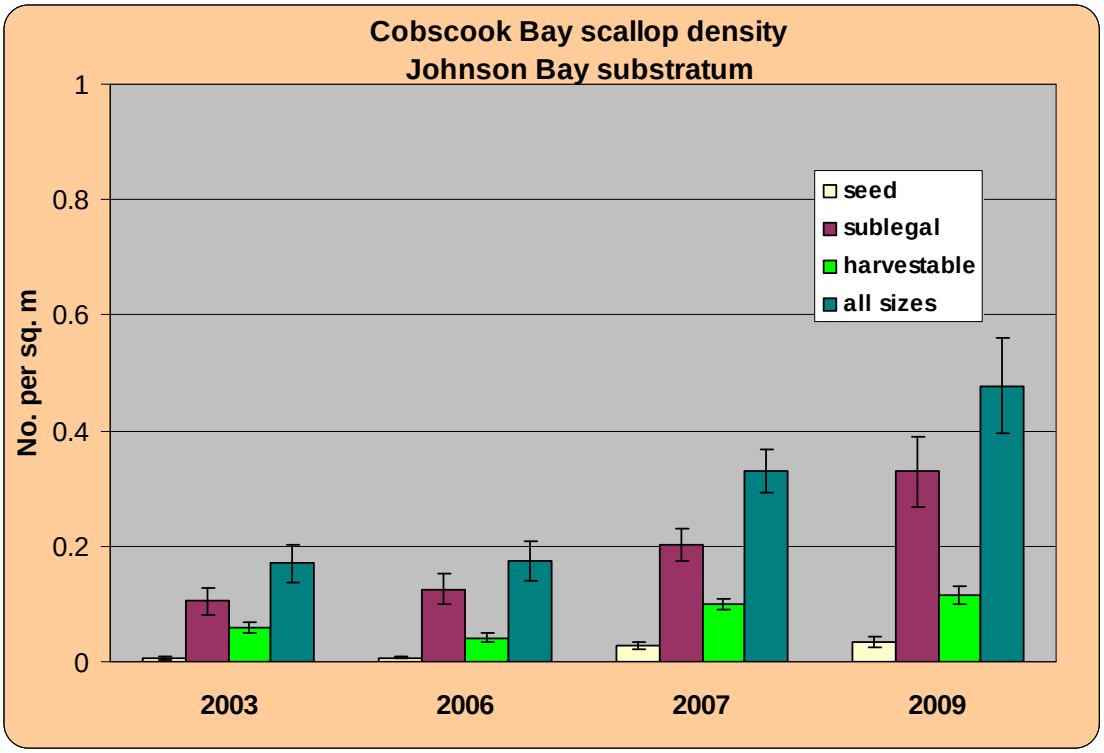


**Figure 9. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Johnson Bay substratum of Cobscook Bay.**

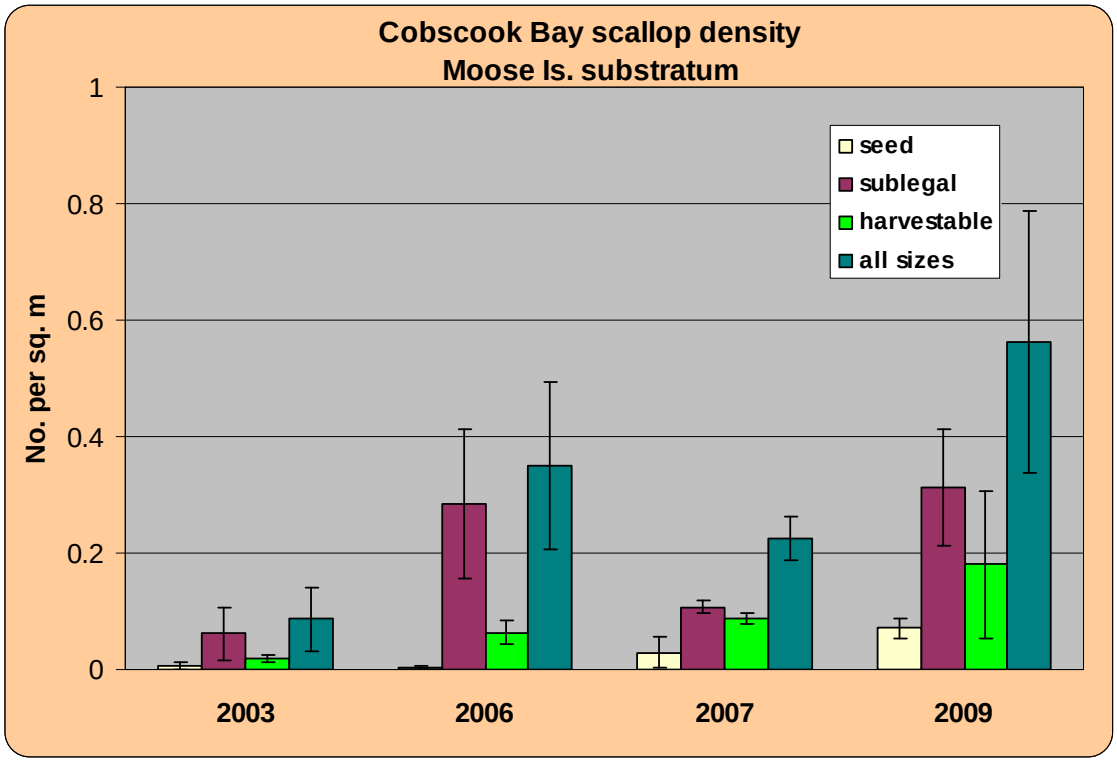


**Figure 10. Mean scallop density (with standard error) by size class, Moose Is. substratum of Cobscook Bay.**

Whiting Bay/Dennys Bay (11 stations) had a 21.7% decrease in overall abundance from ’07 largely from sublegals but the decrease in this size class was not significant ($p>0.05$) (Table 1; Fig. 8). Harvestables (0.046 per m²) decreased slightly from ’07 (0.060 per m²) and there was an increased amount of seed (0.032 per m² in ’09 compared to 0.004 per m² in ’07).

Johnson Bay (15 stations) had an increase in scallop abundance among all size classes (Table 1; Fig. 9). Seed (0.034 per m²) increased 25.0% between ’07 and ’09, sublegals (0.329 per m²) increased 61.8% (NS, $p>0.05$), and harvestable density (0.115 per m²) was 15.3% greater.

Moose Island consists of three (3) stations (Eastport breakwater, Broad Cove and Deep Cove). Moose Is. had an increase (150.6%) in overall scallop abundance since ’07 (Table 1; Fig. 10). Seed density (0.071 per m²) increased 144.9%. This was the highest seed density substratum of the survey and the largest amount was observed at the Eastport breakwater. Sublegal density (0.311 per m²) increased 191.6% (NS, $p>0.05$). Harvestables (0.180 per m²) increased 103.2% (NS, $p>0.05$) since ’07. Despite very large increases in both sublegal and harvestable density at Moose Is. the differences were not statistically significant due to high variability within the substratum. Moose Is. had the highest harvestable density of the survey and the largest amount was observed at the Eastport breakwater.

***Size frequency***

Size distributions between 2007 and 2009 are fairly similar, each showing three (3) distinct size groupings. In 2007, modal sizes were 31-40 mm, 66-75 mm and 96-105 mm (Fig. 11). In 2009, the modes were 36-40 mm, 66-75 mm and 86-95. The 2007 survey had a larger number within the harvestable size range, while 2009 had a larger number approx. 10 mm below that size. The latter would be expected to make a large contribution to the 2010-11 fishery. Each survey showed evidence of fairly consistent scallop recruitment within Cobscook Bay.

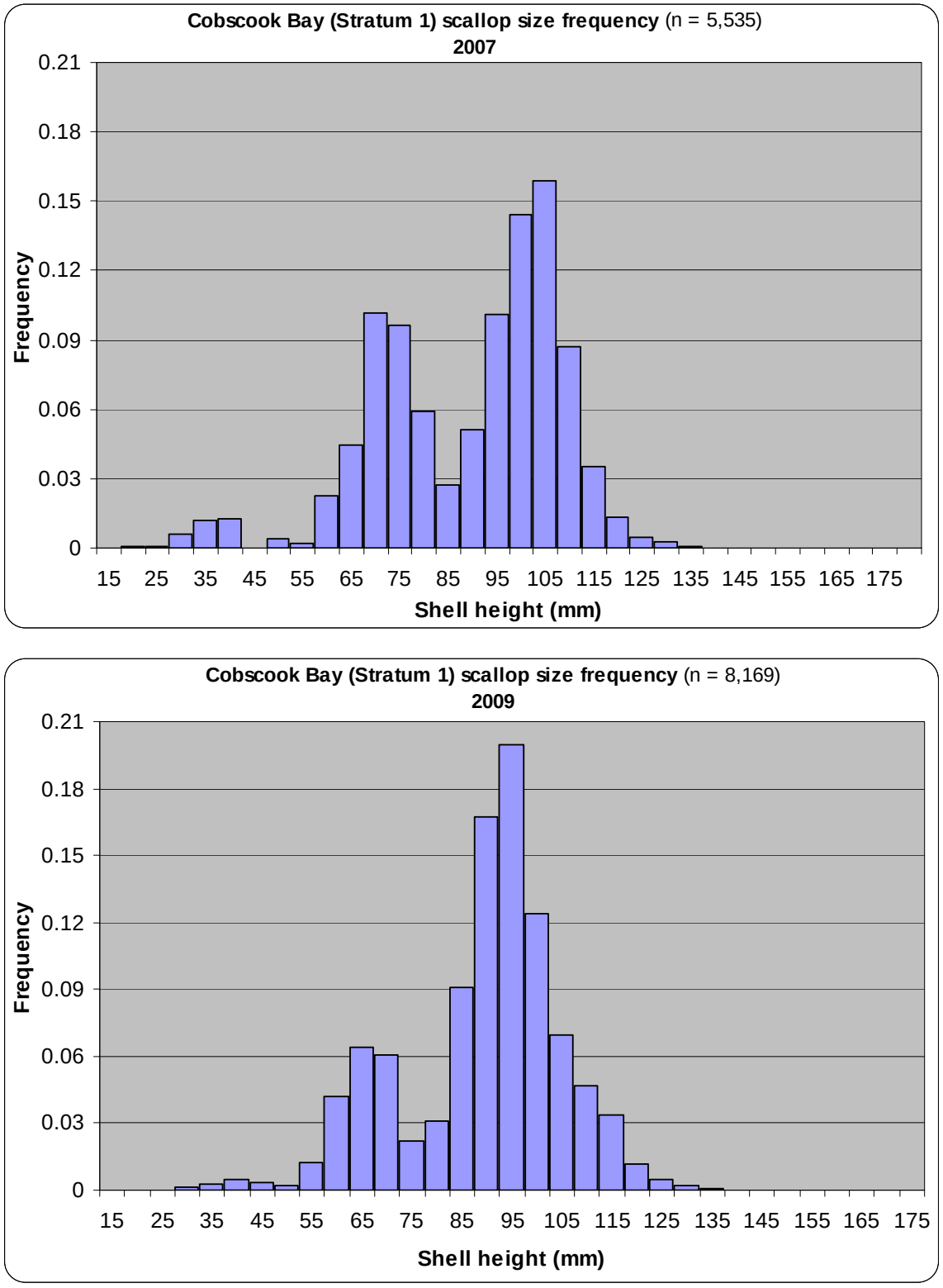


**Figure 11. Size frequency (5 mm increments) of scallops in Cobscook Bay, 2007 and 2009.**

***Meat weight***

A meat weight to shell height relationship was calculated based on samples taken in 2009 (Fig. 12).

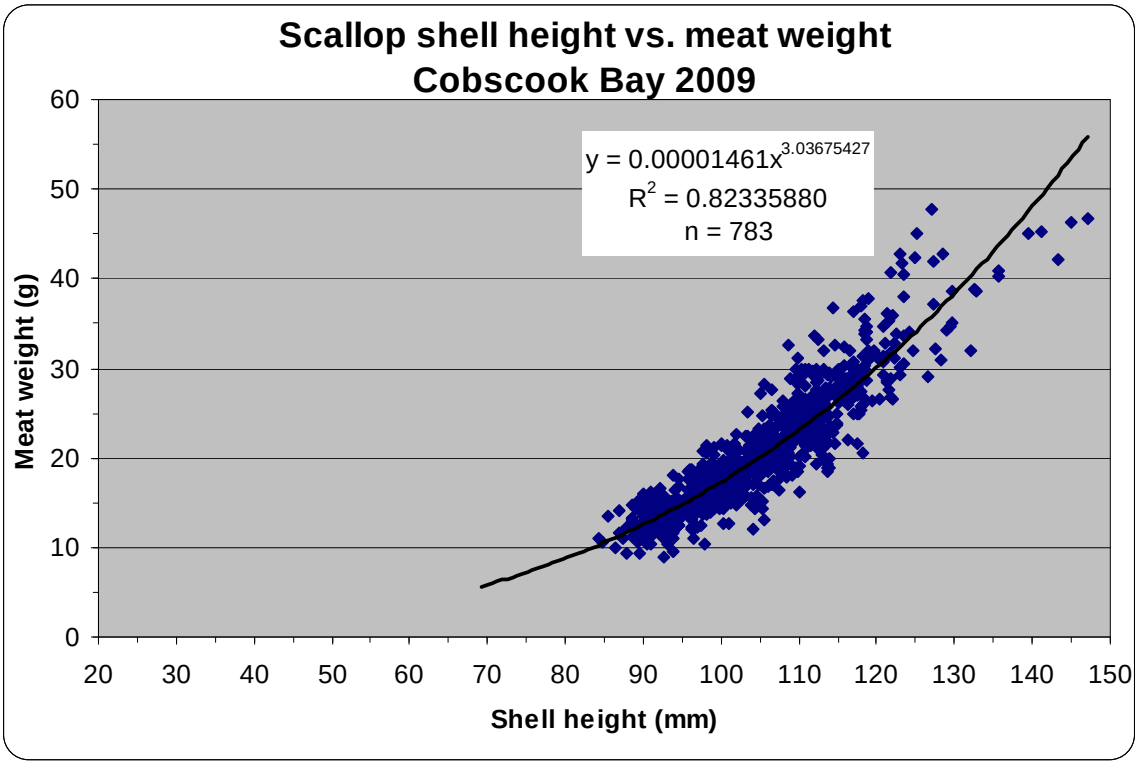


**Figure 12. Scallop meat weight (MW) as a function of shell height (SH) for Cobscook Bay, 2009.**

The 2009 relationship ($MW = 0.00001461\ SH^{3.03675427}$) differed significantly ($p<0.05$) from the 2006-07 relationship ($MW = 0.00000453\ SH^{3.2794}$) for Cobscook Bay. The difference can be seen by comparing predicted meat weight for various shell heights using the two formulas (Table 2).

| | | Shell height (inches) | | |
|---|---|---|---|---|
| | | 4.0 | 4.5 | 5.0 |
| 1987, 1991 (DMR unpublished) | **Meat weight (g)** | 14.8 | 21.7 | 30.4 |
| | **Count per lb.** | 31 | 21 | 15 |
| 2002-03 (from Schick and Feindel 2005) | **Meat weight (g)** | 21.0 | 31.2 | 44.4 |
| | **Count per lb.** | 22 | 15 | 10 |
| 2006-07 | **Meat weight (g)** | 17.2 | 25.4 | 35.8 |
| | **Count per lb.** | 26 | 18 | 13 |
| 2009 | **Meat weight (g)** | 18.2 | 26.0 | 35.8 |
| | **Count per lb.** | 25 | 18 | 13 |

**Table 2. Predicted scallop meat weight and meat count at size based on 1987/91 (DMR unpubl.) and 2002-03, 2006-07 and 2009 Cobscook Bay survey data.**

Meat weights were greater in 2009 than in 2006-07 but less than 2002-03 (Table 2). 2009 average meat counts at the 4 in. SH minimum size appeared well below the legal maximum (35/lb.) for Cobscook Bay.

***Harvestable biomass***

Scallop harvestable biomass (by meat weight) was calculated by applying the '09 SH-MW relationship to survey size frequency data on a tow-by-tow basis to determine mean harvestable biomass (g) per m² for each substratum. This number was then expanded to the total area of each substratum to determine the total harvestable biomass per substratum. Total harvestable biomass for Cobscook Bay was the sum of biomass over all six substrata.

For 2009 the mean total harvestable biomass (adjusted with a dredge efficiency factor of 0.436 (Kelly 2007)) was 89,134 $\pm$ 12,705 kg (196,506 $\pm$ 28,010 lbs.; Fig. 13). This was

above average for the four-year time series. South Bay and Moose Is. each contained 32% of the biomass in '09 while Johnson Bay had the next largest amount (27%).

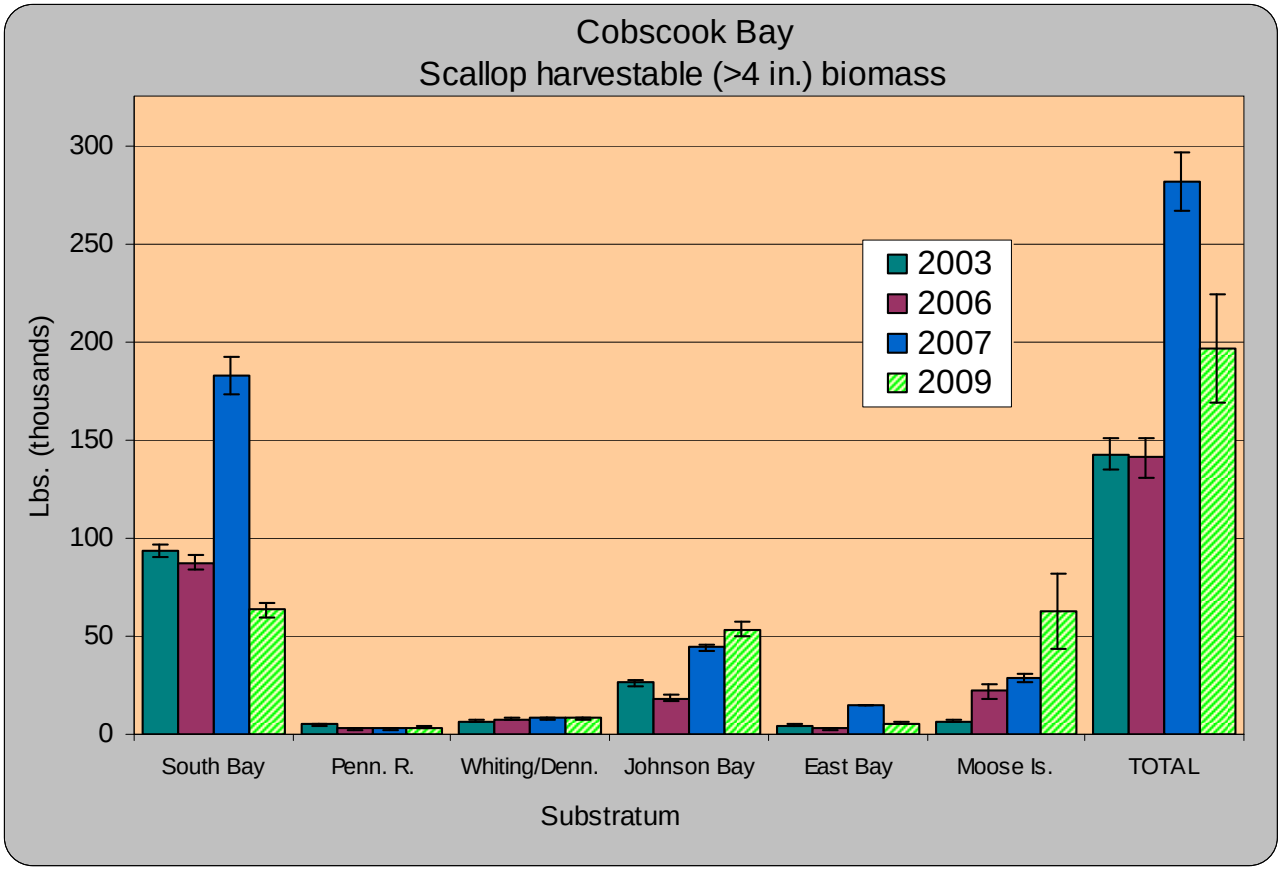


**Figure 13. Biomass (meat weight, with standard error) of harvestable (legal-size) scallops in Cobscook Bay, 2003-09.**

***Exploitation rate***

Landings data upon which to determine scallop exploitation rate for Cobscook Bay were not available for the time series. Scallop harvesters in Maine have been required to report trip level information, including landings, only since the 2008-09 season. Prior to this there has been no information available from which to specifically determine Cobscook Bay scallop landings. Maine landings prior to 2008 were obtained by a voluntary dealer reporting system which did not provide information on where the scallops were caught.

Furthermore, many Cobscook Bay harvesters have traditionally "peddled" or retailed their scallops directly rather than sell to a dealer, so many landings would be unreported.

It is assumed, based on industry input, observations from port sampling, the size of the resource as observed on the dredge survey and the high level of fishing activity, that a very large portion (perhaps 80-90%) of overall Maine scallop landings are from Cobscook Bay. A comparison of estimated harvestable biomass for Cobscook Bay and reported total Maine landings showed some correlation (Fig. 14) but is hoped that a better evaluation can be made beginning with area-specific catch data from 2009-10 harvester reports.

***Conclusions***

Cobscook Bay continued to exhibit relatively high scallop production despite the intense fishing effort still present there. It is interesting that a larger percentage of harvestable biomass was from the "outside" portions of the Bay (Johnson Bay and Moose Is.) whereas all previous surveys have shown most of the resource to be in South Bay. Cause(s) for this are unknown but it are possibly related to changes in oceanographic patterns (e.g., current or temperature) in this tidally energetic estuary which favored more retention and survival of larvae and spat in Johnson Bay and outside Cobscook Bay proper. This could have begun around 2005 since a significant increase in seed was observed in Johnson Bay in 2007 (Kelly 2008).

Overall scallop abundance and size distribution in the Whiting Bay/Dennys Bay closure area remained relatively unchanged from '07.

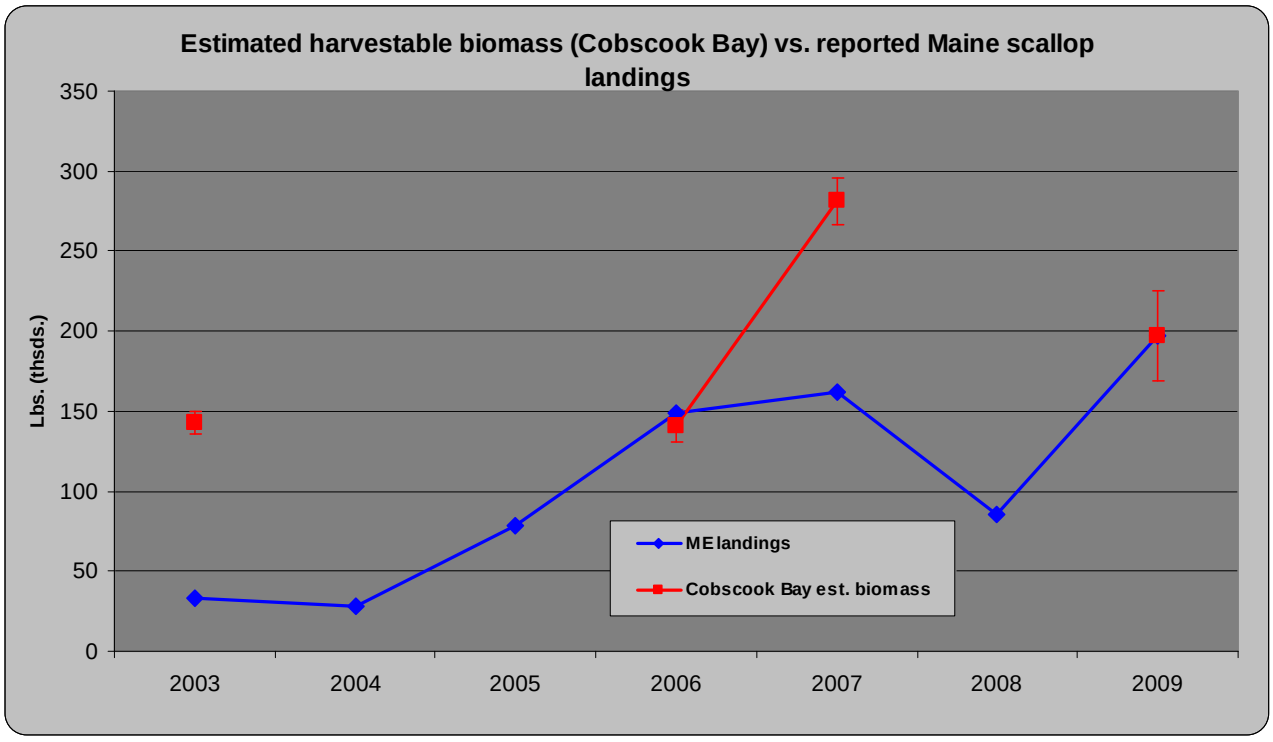


**Figure 14. Cobscook Bay harvestable biomass as estimated by DMR survey in relation to reported Maine scallop landings, 2003-09.**

***Stratum 1A (St. Croix River)***

Most of this substratum is closed to scallop fishing during 2009-12. Seven (7) stations were completed inside the closed area between Devils Head and Gleason Point and one (1) station (Frost Ledge) was outside the closed area (Fig. 15).

This area saw a marked improvement in scallop abundance with overall density (0.230 per $m^2$) higher by a factor of 28 since '06 (0.005 per $m^2$) (Fig.16). Most (84%) of the scallops were present as sublegals which increased from 0.003 per $m^2$ in '06 to 0.194 per $m^2$ in '09 (Figs. 16-17). The sublegals were predominantly 76-85 mm SH. Seed increased significantly ($p<0.05$) from virtually none in '06 to 0.025 per $m^2$ in '09. Harvestable abundance did increase slightly but remained very low (0.010 per $m^2$). Highest catch rate overall in '09 was approx. 1 km N/NW of St. Croix Is.

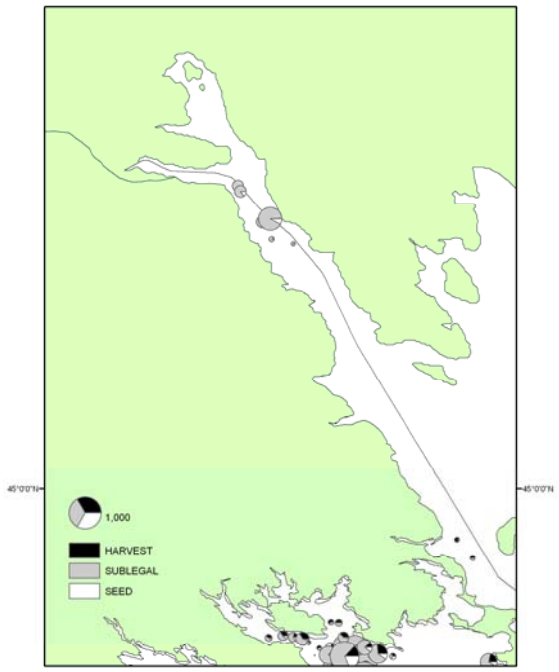


**Figure 15. Number of scallops and size class composition by tow (St. Croix R.), 2009 survey (tows with 0 scallops not shown).**

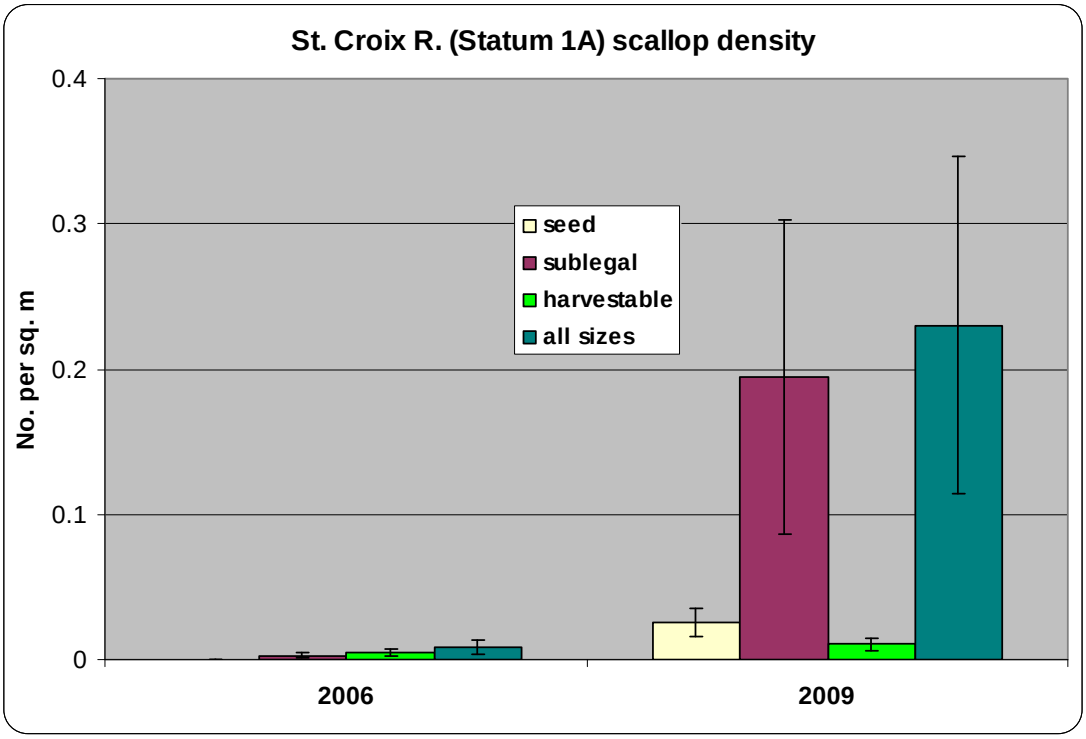


**Figure 16. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Stratum 1A, 2006 and 2009.**

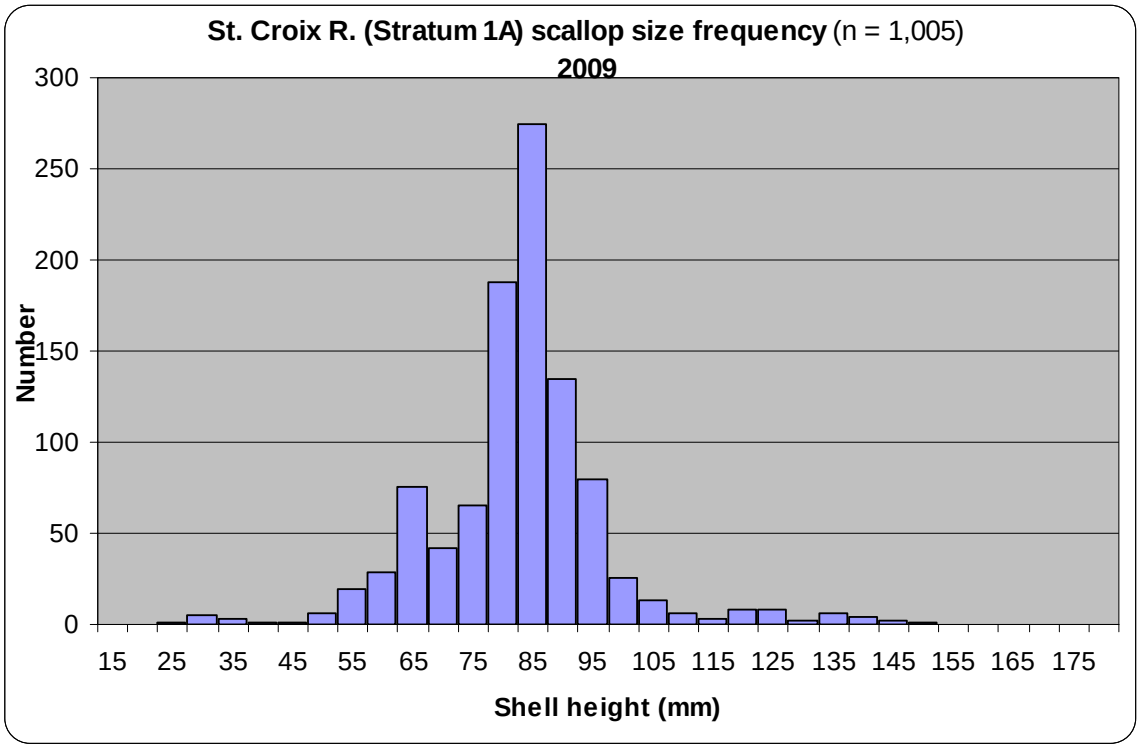


**Figure 17. Size frequency (5 mm increments) of scallops in Stratum 1A, 2009.**

***Stratum 2A (Machias Seal Is.)***

This stratum is composed of the three-mile zone around Machias Seal Is. and is part of the larger "gray zone", so called because the U.S. and Canadian governments recognize separate international boundaries in these waters. Historically there has been sporadic scallop fishing activity around Machias Seal Is., presumably by Maine-based vessels as well as Canadian. Discussions with Maine scallop fishermen have indicated that Machias Seal Is. is not currently fished due to a large presence of lobster gear and its distance offshore (approx. 10 nm from Cutler). There may be some light fishing by Canadian vessels but it is not an area included in the Canada DFO scallop survey (S. Smith, DFO, pers. comm.). We took advantage of the proximity of the federal waters NGOM project (Truesdell et al. 2010) to survey Machias Seal Is., apparently for the first time.

Five (5) tows were completed in the area (Fig. 18). Densities were not particularly high but were greater than adjacent federal waters. The predominant size class was harvestables (0.018 per $m^2$) (Figs. 19-20). Machias Seal Is. was characterized by mostly larger, older scallops with poor meat quality.

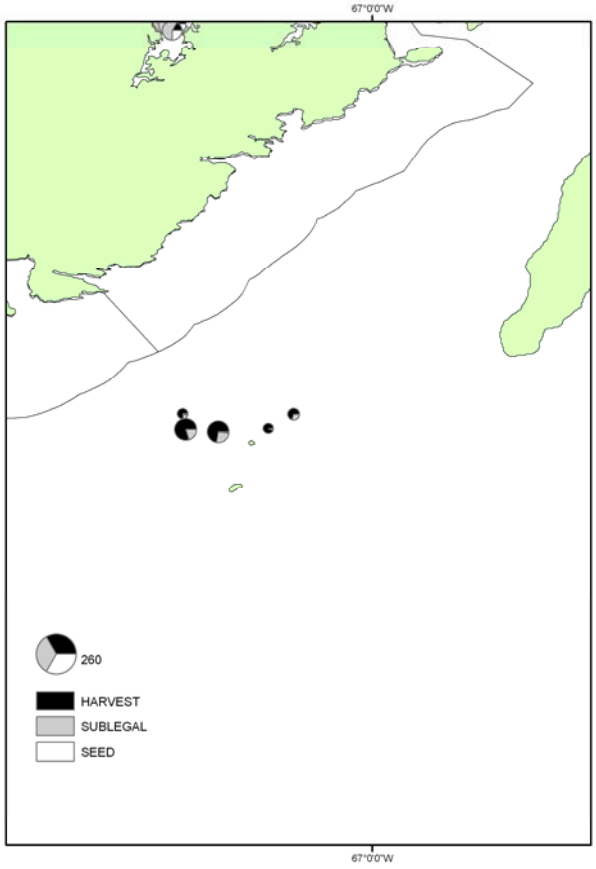


**Figure 18. Number of scallops and size class composition by tow (Machias Seal Is.), 2009 survey (tows with 0 scallops not shown).**

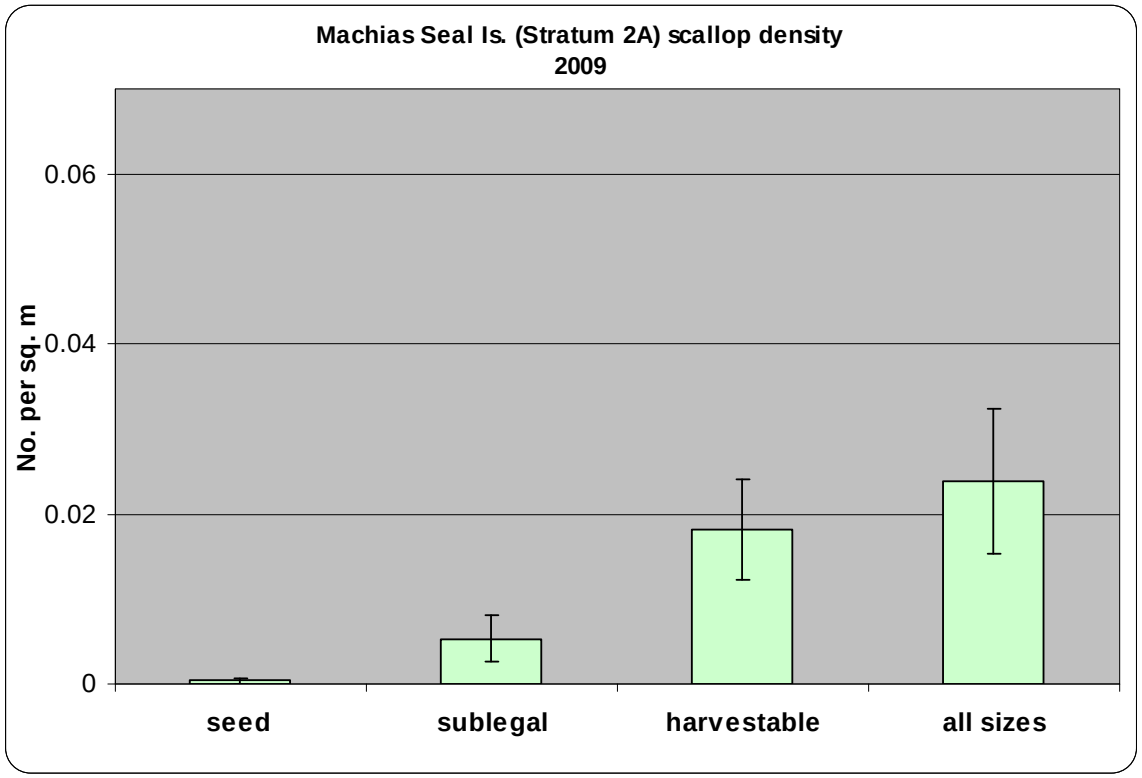


**Figure 19. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Stratum 2A, 2009.**

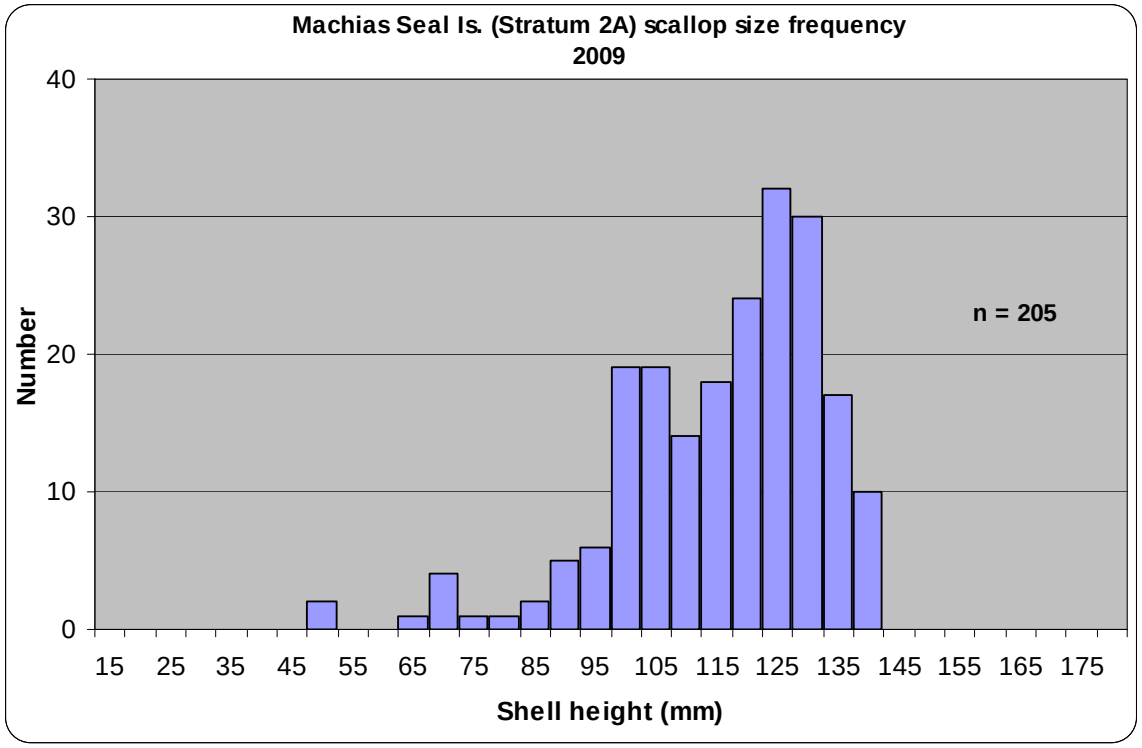


**Figure 20. Size frequency (5 mm increments) of scallops in Stratum 2A, 2009.**

***Stratum 5A (Mt. Desert Rock)***

Similar to Machias Seal Is., this stratum is located well offshore (approx. 21 nm from Southwest Harbor) and is surrounded by federal waters. It was surveyed during the '09 NGOM survey and was also surveyed by DMR in '06.

Three (3) tows were completed in this area in '09 (Fig. 21). As in '06 there were no seed or sublegal scallops seen. There was a decline in harvestables from '06 (0.030 per $m^2$) to '09 (0.016 per $m^2$) (Figs. 22-23) but this was not statistically significant probably due to high variability (most of the scallops in both '06 and '09 were from just a single tow). This stratum was characterized by virtually all very large, old scallops with poor meats.

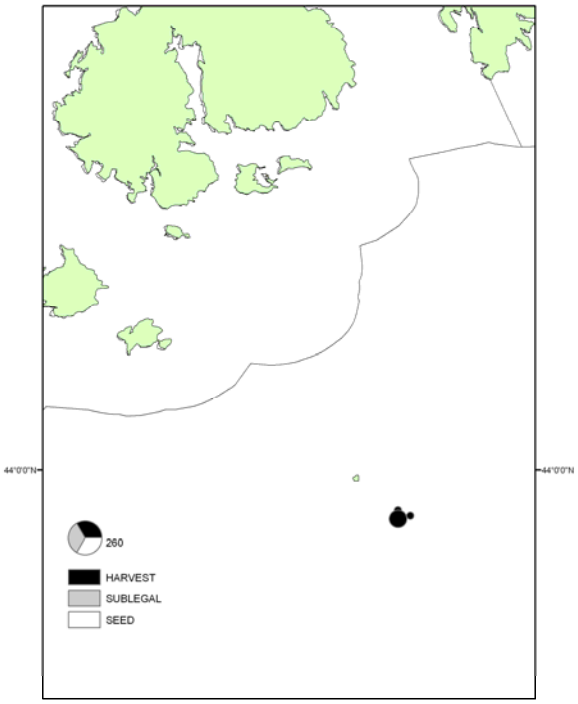


**Figure 21. Number of scallops and size class composition by tow (Mt. Desert Rock), 2009 survey (tows with 0 scallops not shown).**

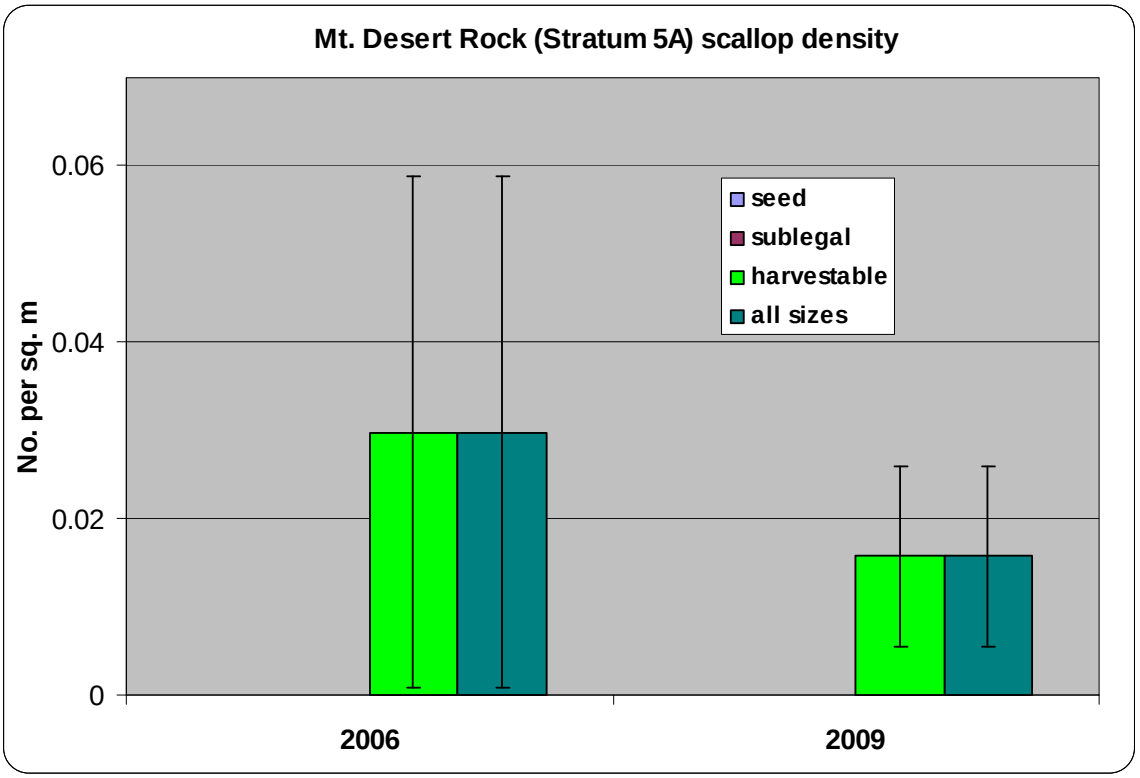


**Figure 22. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Stratum 5A, 2009.**

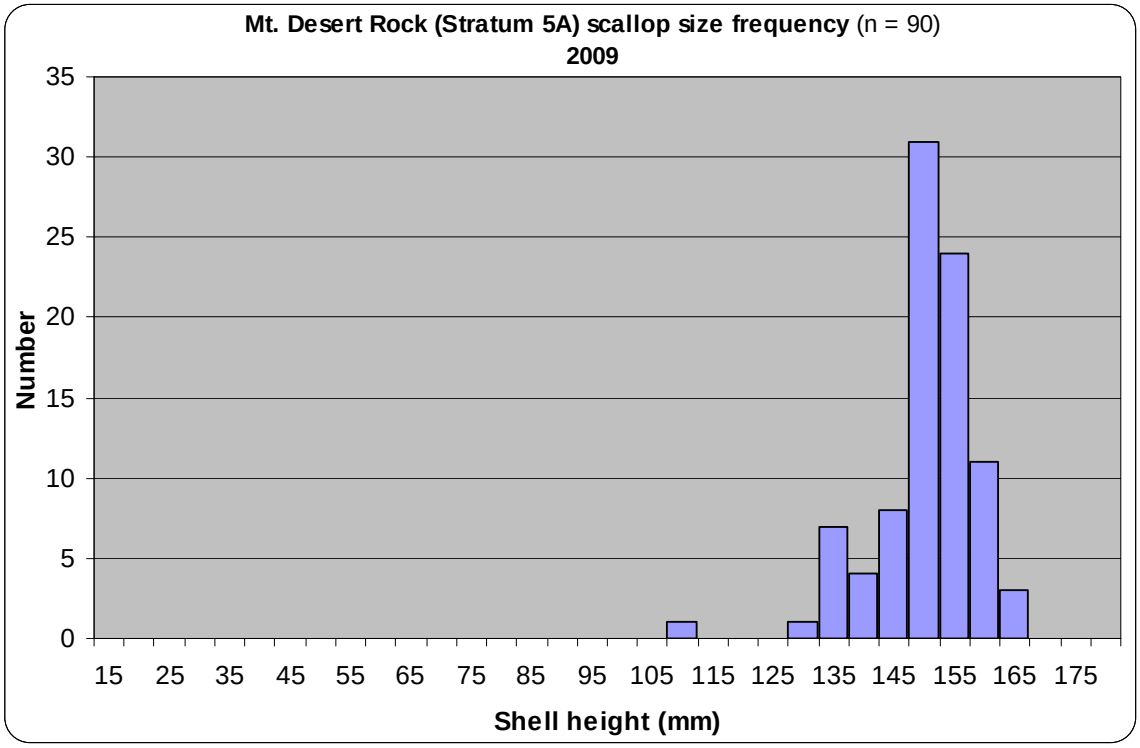


**Figure 23. Size frequency (5 mm increments) of scallops in Stratum 5A, 2009.**

***Stratum 8 (Pemaquid Pt. to W. Penobscot Bay)***

There were 35 stations completed in this stratum in ’09 (Fig. 24). Ten (10) of these stations were within an area closure that went into effect in ’09 and will expire in ’12.

Overall scallop density was 91.6% greater between ’05 (0.009 per $m^2$) and ’09 (0.018 per $m^2$) (Figs. 25-26). Seed increased slightly from virtually none in ’05 to 0.001 per $m^2$ in ’09. The highest density of seed was near Graffam Is. in Muscle Ridge Channel (this is within an open area). There was a small increase in sublegal density between ’05 (0.004 per $m^2$) and ’09 (0.009 per $m^2$). The highest sublegal density was at the Graffam Is. site mentioned above. Harvestable density also increased slightly between ’05 (0.005 per $m^2$) and ’09 (0.007 per $m^2$) and the highest catch rate of legal-size scallops was at Graffam Is. as well. Although density was not as high as ’03, the size distribution was notably robust and well-balanced (Fig. 26), largely reflecting Muscle Ridge Channel.

**Closed area**

For purposes of the survey, the closed area was divided into two (2) sections: “upper Muscongus” and “western Penobscot”.

In the upper Muscongus closed region, scallop densities were low. Densities were:

Seed: none
Sublegal: 0.0004 per $m^2$
Harvestable: 0.001 per $m^2$

In the western Penobscot closed region, scallop densities were slightly lower than the overall stratum. Densities were:

Seed: 0.001 per $m^2$
Sublegal: 0.007 per $m^2$
Harvestable: 0.006 per $m^2$

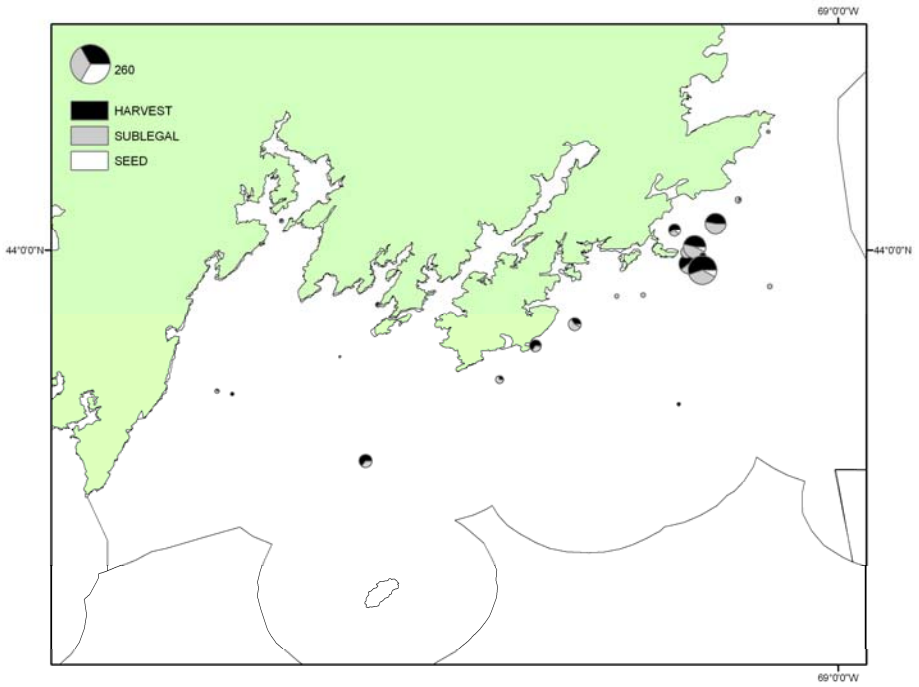


**Figure 24. Number of scallops and size class composition by tow (Pemaquid Pt. to W. Penobscot Bay), 2009 survey (tows with 0 scallops not shown).**

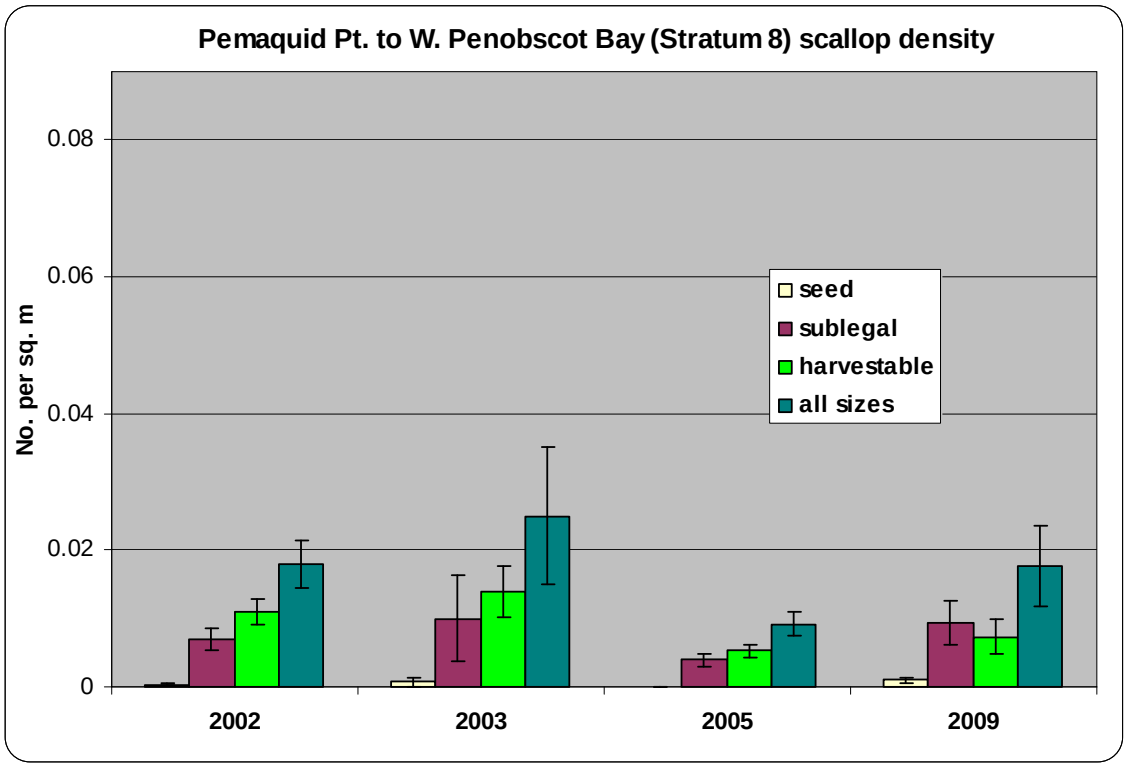


**Figure 25. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Stratum 8, 2002-09.**

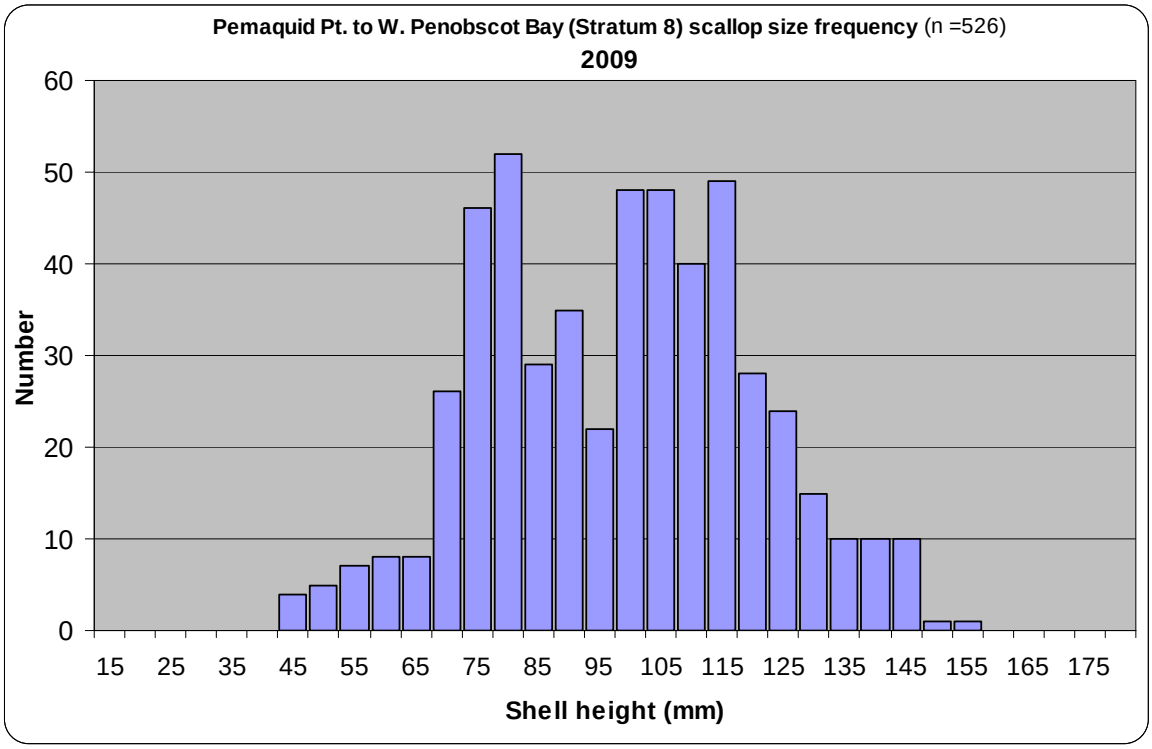


**Figure 26. Size frequency (5 mm increments) of scallops in Stratum 5A, 2009.**

***Stratum 9 (Small Pt. to Pemaquid Pt.)***

There were only eight (8) stations completed in ’09 (Fig. 27). Five (5) of the stations were within an area closure. Lobster gear was an impediment as it prohibited performing 15 tows.

Overall density was 156.5% higher in ’09 (0.034 per $m^2$) than ’05 (0.013 per $m^2$) (Figs. 28-29). Seed increased from virtually none in ’05 to 0.004 per $m^2$ in ’09. The highest density of seed was near Inner Heron Is. in the Damariscotta River (this is within a closed area). Sublegals increased from 0.010 per $m^2$ in ’05 to 0.021 in ’09 (NS, $p>0.05$), with the highest density being in the open portion of the Damariscotta River. Harvestable density increased from 0.003 per $m^2$ (’05) to 0.010 per $m^2$ (’09) (NS, $p>0.05$) with the highest density at the Inner Heron Is. Site mentioned above.

## Closed area

For purposes of the survey, the closed area was divided into two (2) sections: "Sheepscot" and "Damariscotta".

In the Sheepscot closed region, scallop densities were low. Densities were:

Seed: none

Sublegal: 0.002 per $m^2$

Harvestable: 0.004 per $m^2$

In the Damariscotta closed region, scallop densities were slightly higher than the overall stratum. Densities were:

Seed: 0.013 per $m^2$

Sublegal: 0.025 per $m^2$

Harvestable: 0.018 per $m^2$


**Figure 27. Number of scallops and size class composition by tow (Small Pt. to Pemaquid Pt.), 2009 survey (tows with 0 scallops not shown).**

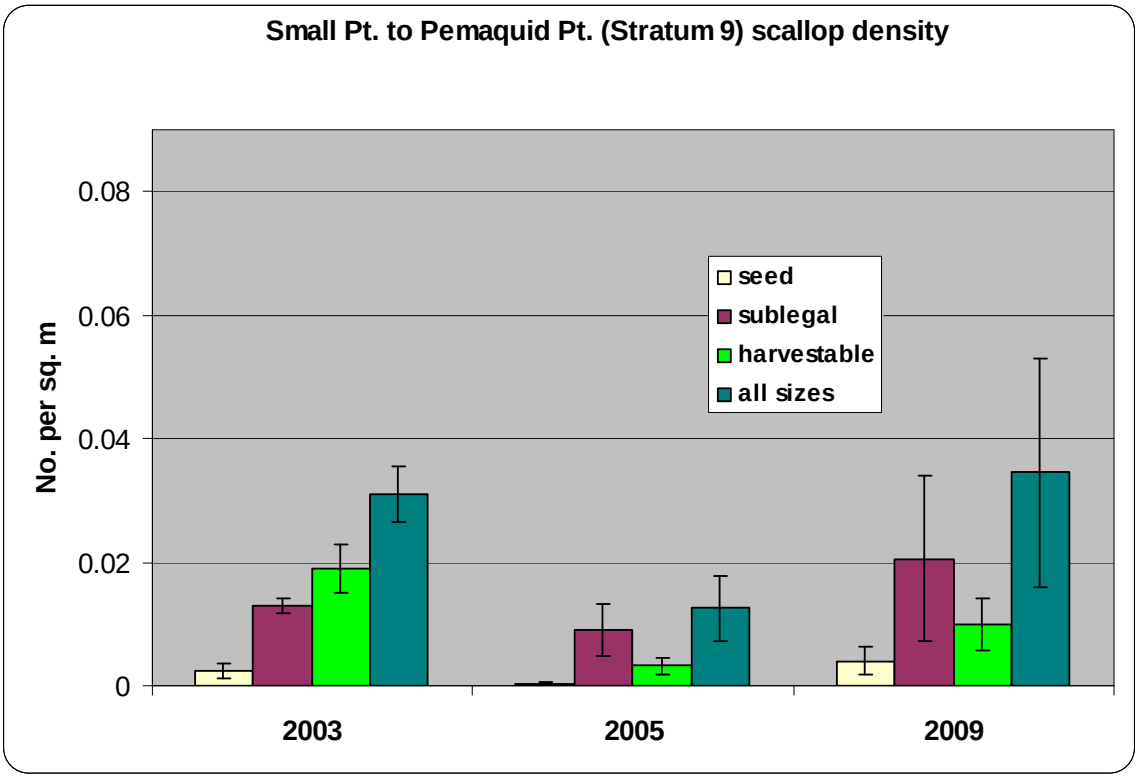


**Figure 28. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Stratum 9, 2003-09.**

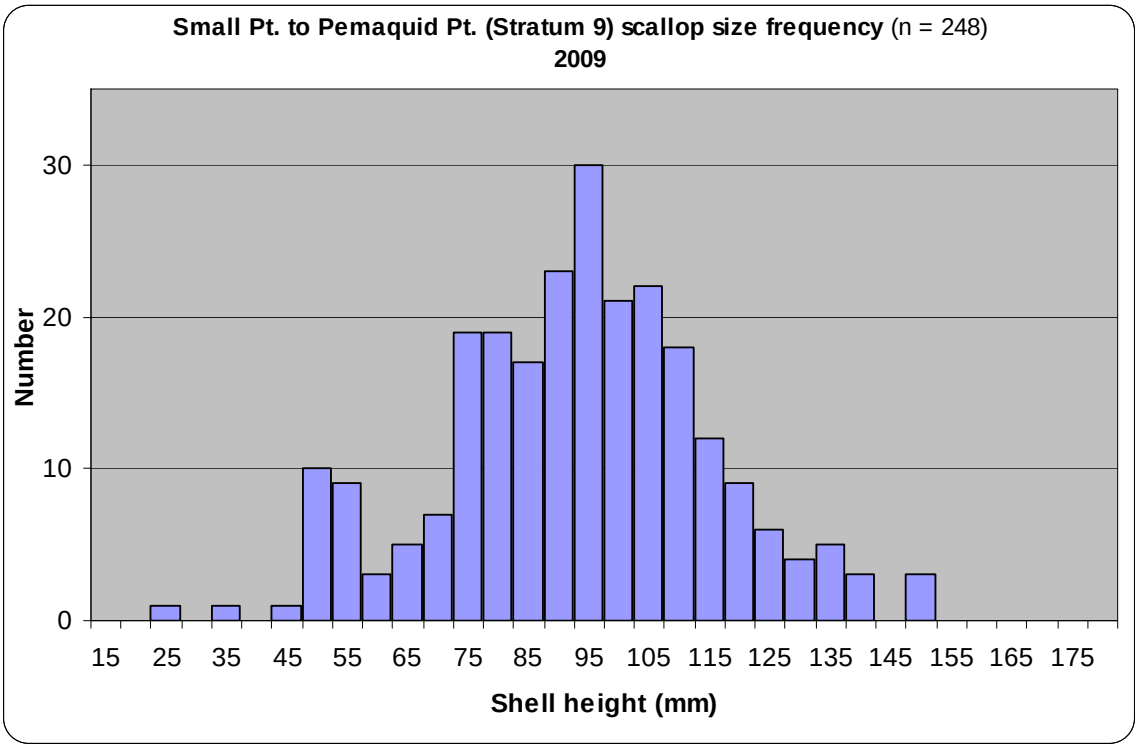


**Figure 29. Size frequency (5 mm increments) of scallops in Stratum 9, 2009.**

***Stratum 10 (Cape Elizabeth to Small Pt.)***

Seventeen (17) stations were completed on the ’09 survey (Fig. 30). Two (2) stations were within an area closure. Fourteen (14) tows could not be completed due to presence of lobster gear.

Overall scallop density was significantly (p=0.05) higher in ’09 (0.030 per $m^2$) than ’05 (0.013 per $m^2$) (Figs. 31-32). Seed increased from virtually none in ’05 to 0.002 per $m^2$ in ’09. The largest amount of seed was approx. 400 m W of Cushing Is. in Casco Bay. Sublegals increased 130.9% (NS, p=0.09) between ’05 (0.006 per $m^2$) and ’09 (0.014 per $m^2$). The most sublegals were found approx. 500 m NE of Spring Pt. in Casco Bay. Harvestable density increased significantly (p = 0.04) from 0.006 to 0.14 per $m^2$, with highest abundance also at Spring Pt.

**Closed area**

In the Casco Bay closed area, scallop densities were lower than the rest of the stratum:

Seed: 0.003 per $m^2$

Sublegal: 0.006 per $m^2$

Harvestable: 0.003 per $m^2$

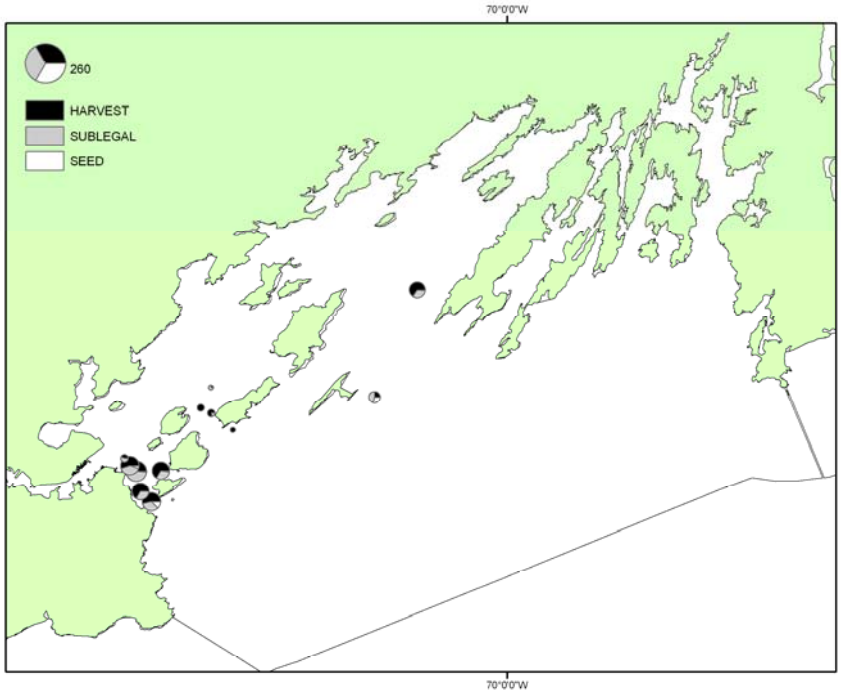


**Figure 30. Number of scallops and size class composition by tow (Cape Elizabeth to Small Pt.), 2009 survey (tows with 0 scallops not shown).**

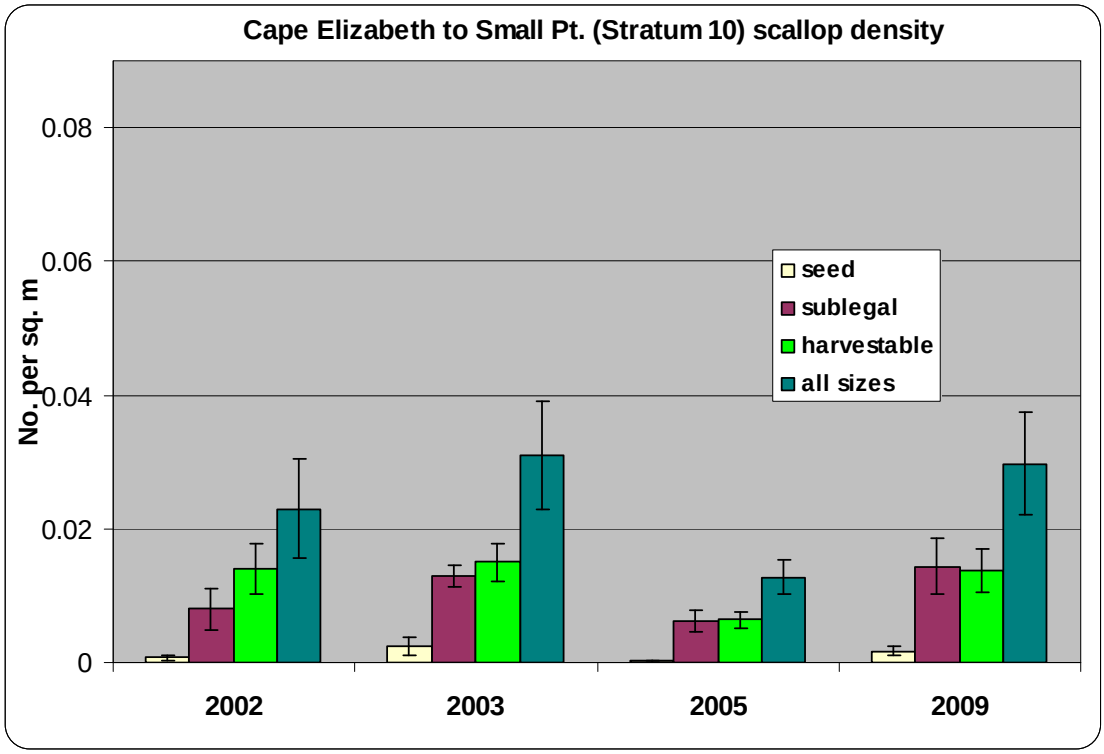


**Figure 31. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Stratum 10, 2002-09.**

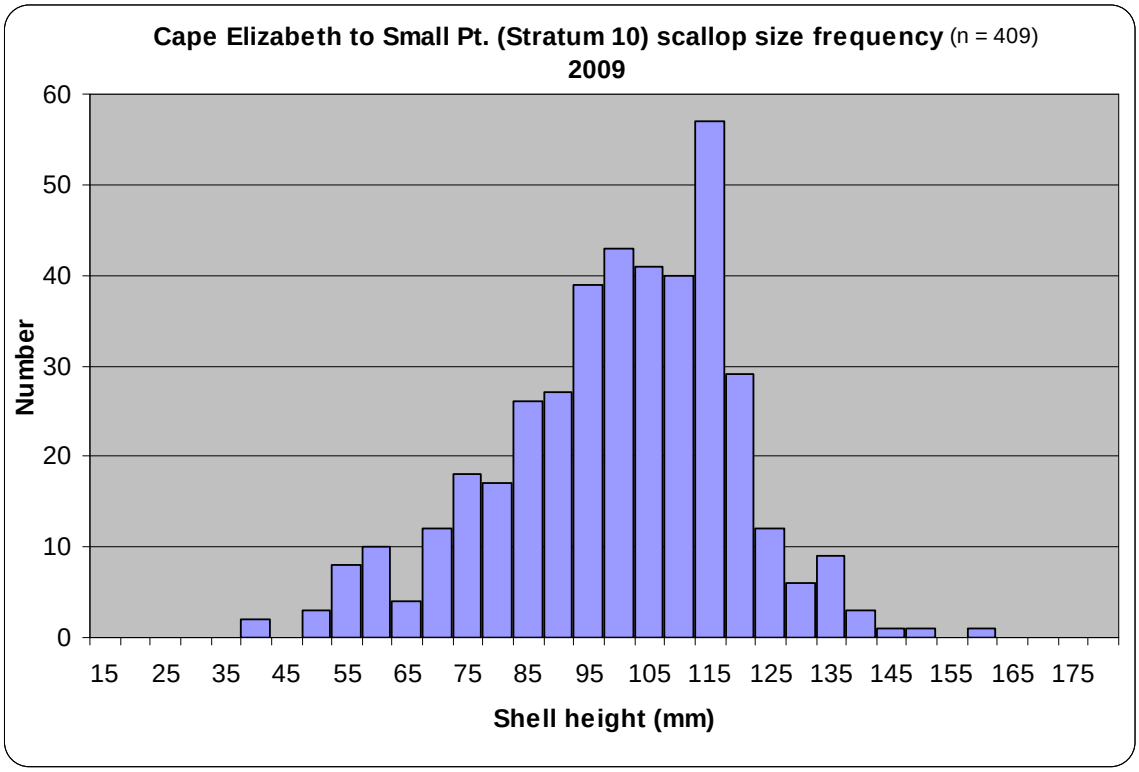


**Figure 32. Size frequency (5 mm increments) of scallops in Stratum 10, 2009.**

***Stratum 11 (Kittery to Cape Elizabeth)***

This stratum had not been surveyed until '05 when seven (7) exploratory tows were performed in Saco Bay (Kelly 2009b). Five tows were done in Saco Bay in '09 (Fig. 33). Five exploratory tows were also performed in the Piscataqua River (n = 4) and Boon Is. (n = 1) areas in '09.

The large majority of scallops were observed in the newly-added Piscataqua R., contributing to a large increase in the reported scallop abundance for this stratum. Overall density increased from 0.008 per $m^2$ in '05 to 0.056 per $m^2$ in '09 (Figs. 34-35). By far, the latter is the highest scallop density observed for a western ME strata since the start of the survey in '02. However there is a large amount of variability with the '09 Stratum 11 estimate due to the difference between Saco Bay (low density) and Piscataqua R. (high density).

Seed density was 0.001 per $m^2$ and all seed were from the Piscataqua R. Sublegal density was 0.026 per $m^2$ and all were from the Piscataqua R. Harvestable density was 0.030 per $m^2$, virtually all from Piscataqua R. Highest density of harvestables was from Piscataqua R. near Kittery Pt.

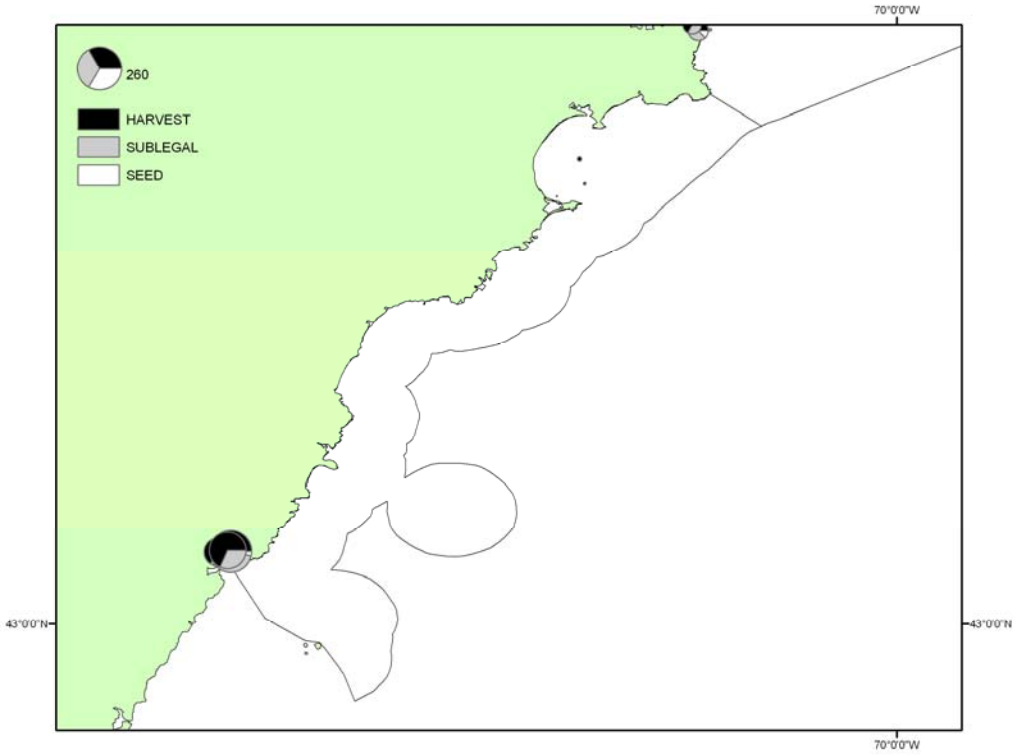


**Figure 33. Number of scallops and size class composition by tow (Kittery to Cape Elizabeth), 2009 survey (tows with 0 scallops not shown).**

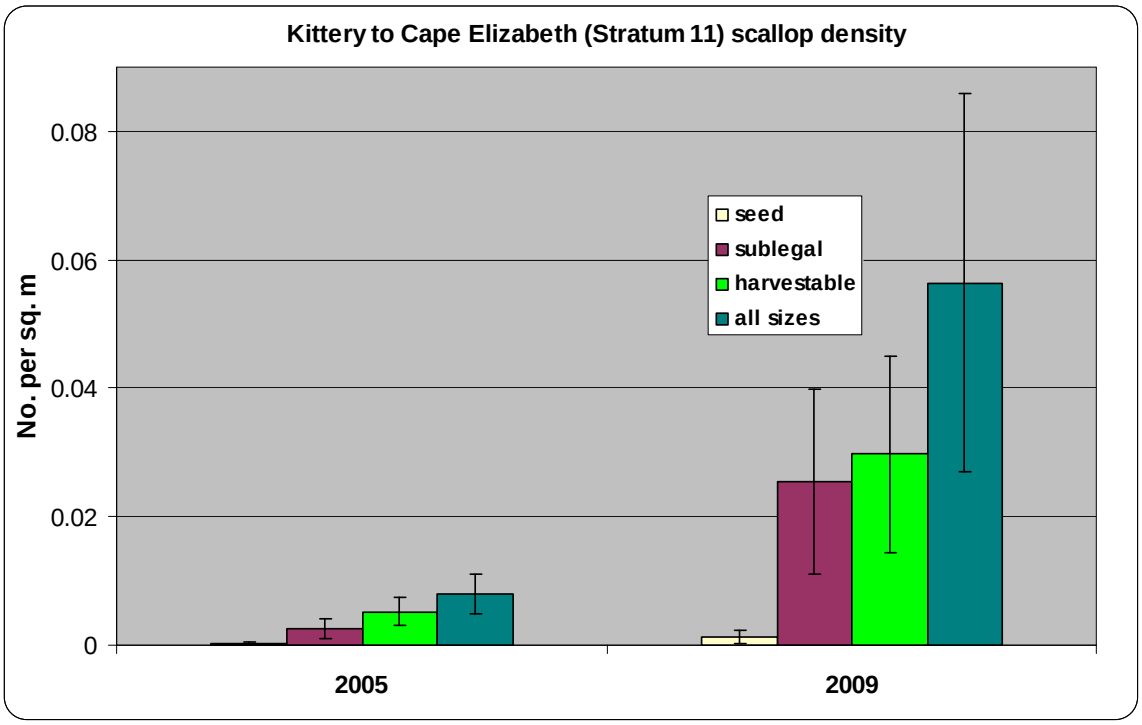


**Figure 34. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Stratum 9, 2005 and 2009.**

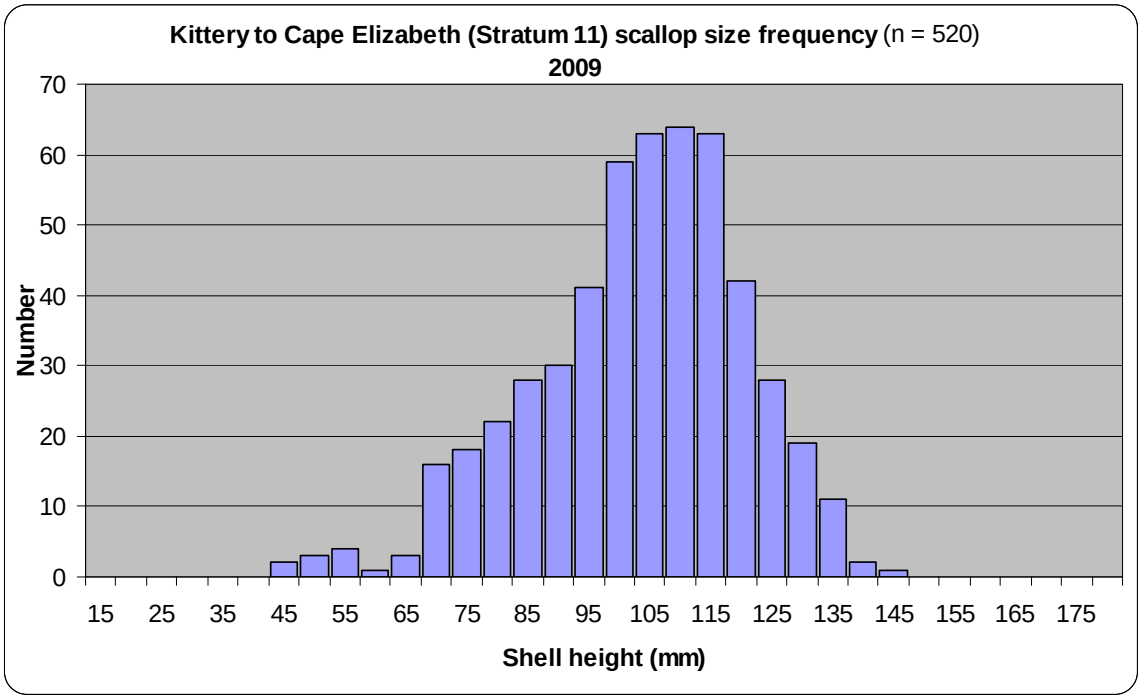


**Figure 35. Size frequency (5 mm increments) of scallops in Stratum 11, 2009.**

### *Conclusions*

Scallop abundance improved since 2005 in most of western Maine. Sublegals were the predominant size class with the exception of Stratum 11 where there was a high density of harvestable scallops in the lower Piscataqua River, a relatively small area. Closed areas had generally lower amounts of scallops than areas open to fishing. The density of seed and harvestable scallops observed in the closed portion of the Damariscotta River, however, was higher than outside of the area. Aside from the Piscataqua and Damariscotta Rivers, the highest densities of harvestable scallops were in western Casco Bay and Muscle Ridge Channel. The most robust size and balanced size distribution was from Stratum 9 (Pemaquid Pt. to W. Penobscot Bay).

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Vic Nordahl (NMFS) was very helpful in procurement of components for the new gear.

The surveys were funded under NMFS Scallop RSA Project 08-SCA-03. Wally Gray and Gary Hatch (*F/V Shearwater*) harvested the research TAC allocated to the project.

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Kohl Kanwit (DMR) provided additional figures for this report.

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