Results from the 2012 Cobscook Bay Sea Scallop Survey

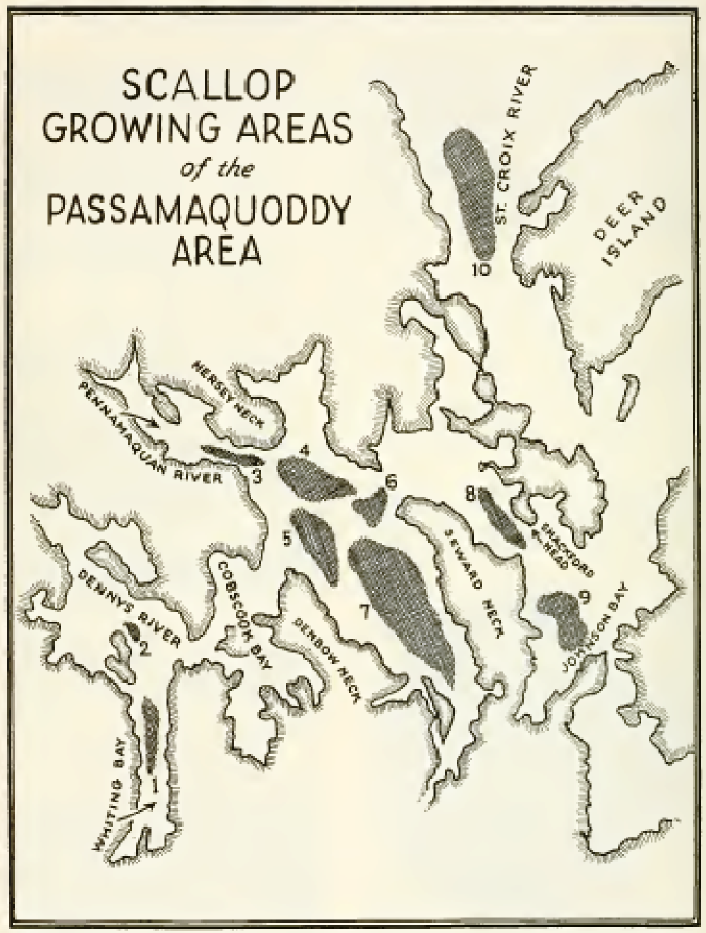

Figure 3,--Chart showing distribution of scallop-growing areas in the Quoddy Region.

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Executive Summary

The 2012 Maine Department of Marine Resources sea scallop survey was carried out in October (prior to the December 2 opening of the fishery) in survey stratum 1 (Cobscook Bay). This survey covered the subareas of Whiting Bay/Dennys Bay, South Bay, East Bay, Pennamaquan River, Johnson Bay and Moose Island. In total 86 tows were completed, at a rate of 2 tows per km^2.

In 2012 Cobscook Bay had the highest amount of harvestable ($\geq$ 4 in. shell height) meat biomass (434.7 $\pm$ 31.0 thsd. lbs.) yet observed since the survey began in 2002. Meat weight in relation to shell height was slightly greater than the previous survey (2010) of this area.

Harvestable biomass in Whiting Bay/Dennys Bay, which had been closed to fishing since 2009, increased from 45.6 thsd. lbs. (2010) to 83.0 thsd. lbs. (2012). Whiting Bay/Dennys Bay had the highest harvestable scallop density (0.386 per m^2) ever observed on the Cobscook Bay survey (since 2002).

South Bay had the largest proportion (65%) of harvestable biomass in Cobscook Bay in 2012, as well as the highest density (1.023 per m^2) of sublegals. Harvestable density (0.192 per m^2) was the highest yet seen for this substratum.

Introduction

The sea scallop (*Placopecten magellanicus*) currently supports a 70 day commercial fishery along coastal Maine during December-March each year. Maine 2012 landings (preliminary) of scallop meats were approximately 0.25 million lbs. with an ex-vessel value of $2.87 million (Fig. 1). The primary gear type is the dredge, although Maine also permits commercial and non-commercial harvest of scallops by diving. There were 235 draggers and 57 divers that commercially harvested scallops during the 2011-12 season in Maine (Department of Marine Resources (ME DMR) catch report data, May 2013).

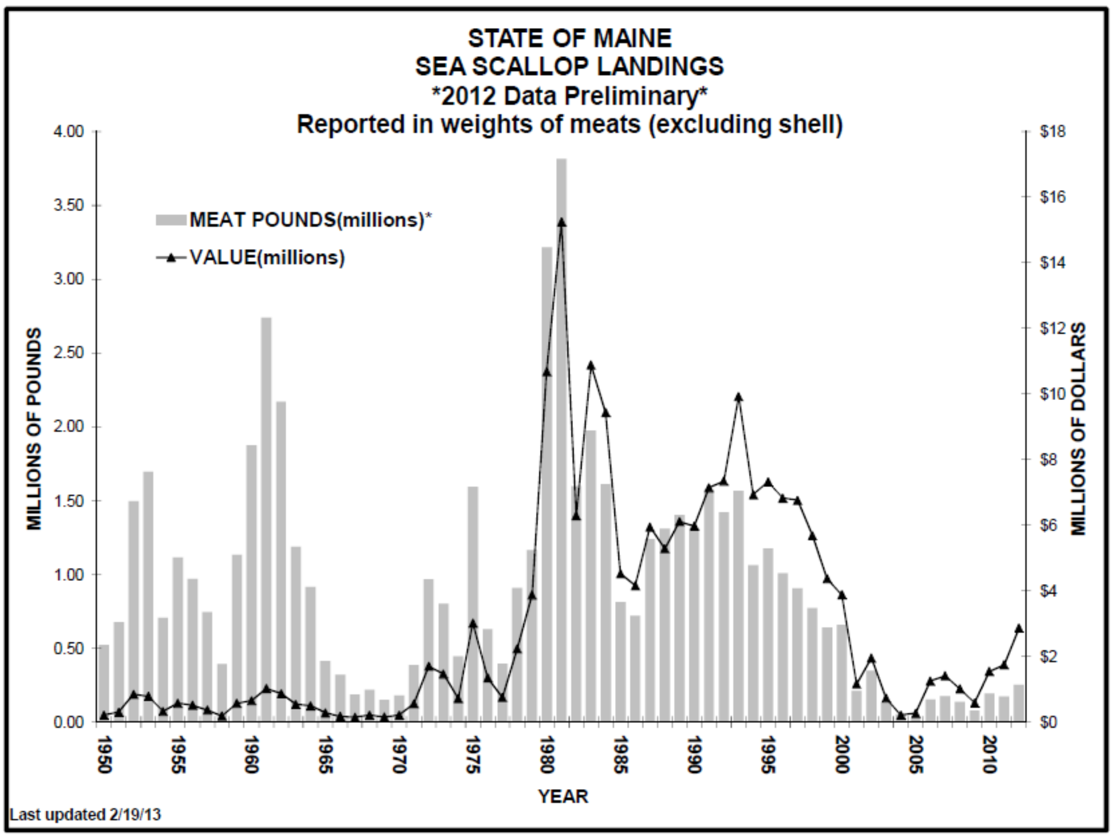


Figure 1. Maine scallop landings 1950-2012 (source: ME DMR).

Scallops have been harvested along the Maine coast since the late 1800's (Wallace 1997; Schick and Feindel 2005). The scallop fishery in the Gulf of Maine occurs primarily in state waters. At times the dollar value of the fishery in Maine has been second only to lobster. 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).

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

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 management strategies such as harvest limits and area closures. The survey provides information on geographic distribution, relative abundance, population size structure, meat yield and occurrence of seed and sublegal scallops as well as estimates of harvestable biomass.

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/St. Croix River) major sections of the coast has been surveyed each year on a rotating basis (Table 1).

In 2012, strata 1 (Cobscook Bay), 1a (St. Croix R.), 2a (Machias Seal Is.) and 5a (Mt. Desert Rock) were surveyed. Machias Seal Is. and Mt. Desert Rock were both last surveyed in 2009 and Cobscook Bay and the St. Croix R. were last surveyed in 2010.

Methods

The Cobscook Bay survey was conducted during 17-26 October aboard the 39 ft. *F/V Kristin Lee* from Eastport. The survey gear was a 7 ft. wide New Bedford-style chain sweep dredge with 2 inch rings, 1¾ inch head bale, 3 inch twine top (double hung) and

Table 1 . Chronology of Maine DMR scallop survey, 2002-12.

Area	Year										
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cobscook Bay/St. Croix R.	**S**	**S**	NS	NS	**S (begin higher intensity survey)**	**S**	NS	**S**	**S**	NS	**S**
Eastern Maine	**S**	**S**	NS	NS	**S (begin higher intensity survey)**	NS	**S**	**S (Machias Seal Is. and Mt. Desert Rock only)**	NS	**S (incl. closures 4A-8C)**	**S (Machias Seal Is. and Mt. Desert Rock only)**
Western Maine	**S**	**S**	NS	**S**	NS	NS	NS	**S**	NS	**S (closures 1-3 only)**	NS

S = surveyed
NS = not surveyed

10 inch pressure plate. The dredge was equipped with rock chains and was not lined. The survey dredge was constructed in ’09 (Fig. 2; also see Kelly 2010).

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 2012, with some modification (e.g., St. Croix River (stratum 1A), Machias Seal Is. (stratum 2A), Mt. Desert Rock (stratum 5A)).

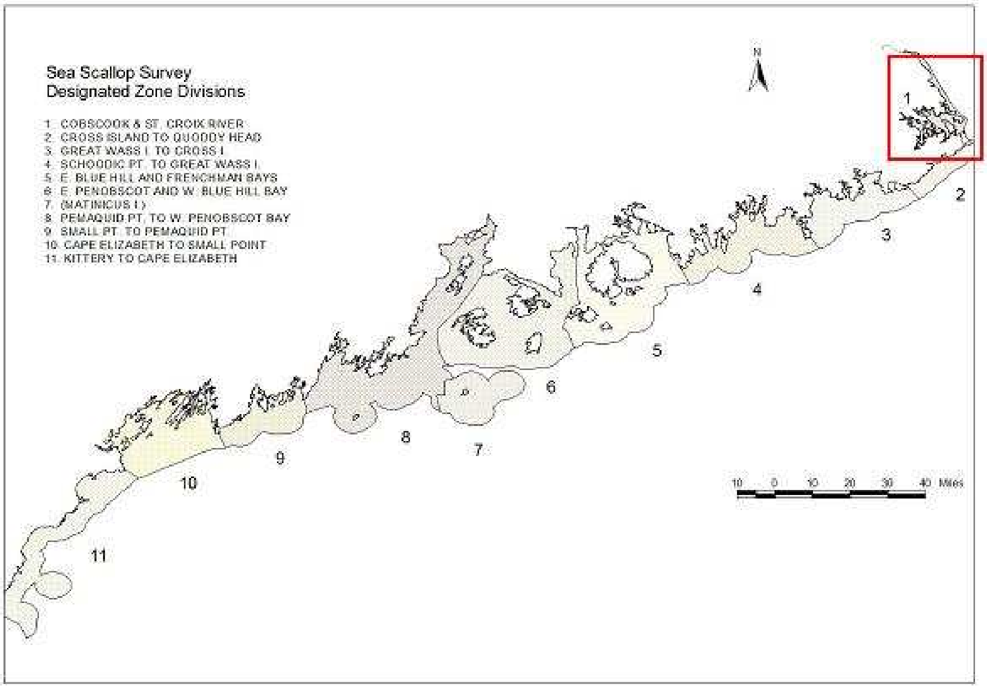


Figure 3. Survey strata - ME DMR scallop survey (with Cobscook Bay area highlighted).

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).

Cobscook Bay (Fig. 4) 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 was made by using a systematic grid design.

Figure 4. Cobscook Bay and surrounding area (source: Cobscook Bay Resource Center).

Six survey substrata (South Bay, Pennamaquan River, East Bay, Whiting Bay/Dennys Bay, Johnson Bay and Moose Island) 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 slight modification. The total number of stations sampled was increased by 31% from previous surveys beginning in ‘06.

Cobscook Bay tow locations were based on a 500 m grid overlaying each substratum and all stations were sampled along this grid (Figs. 5-7). The grid accommodated an average tow length of approximately 300 m. There were 86 tows completed in the ’12 Cobscook Bay survey.

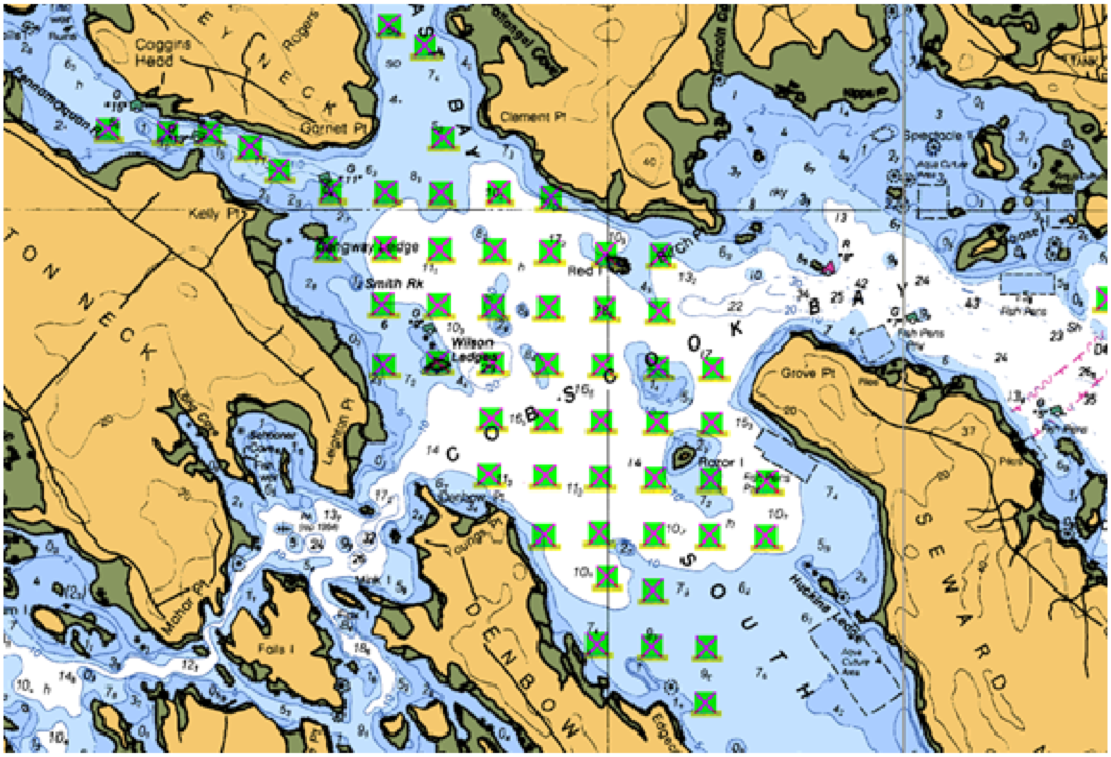


Figure 5. Sampling stations for South Bay, Pennamaquan River and East Bay.

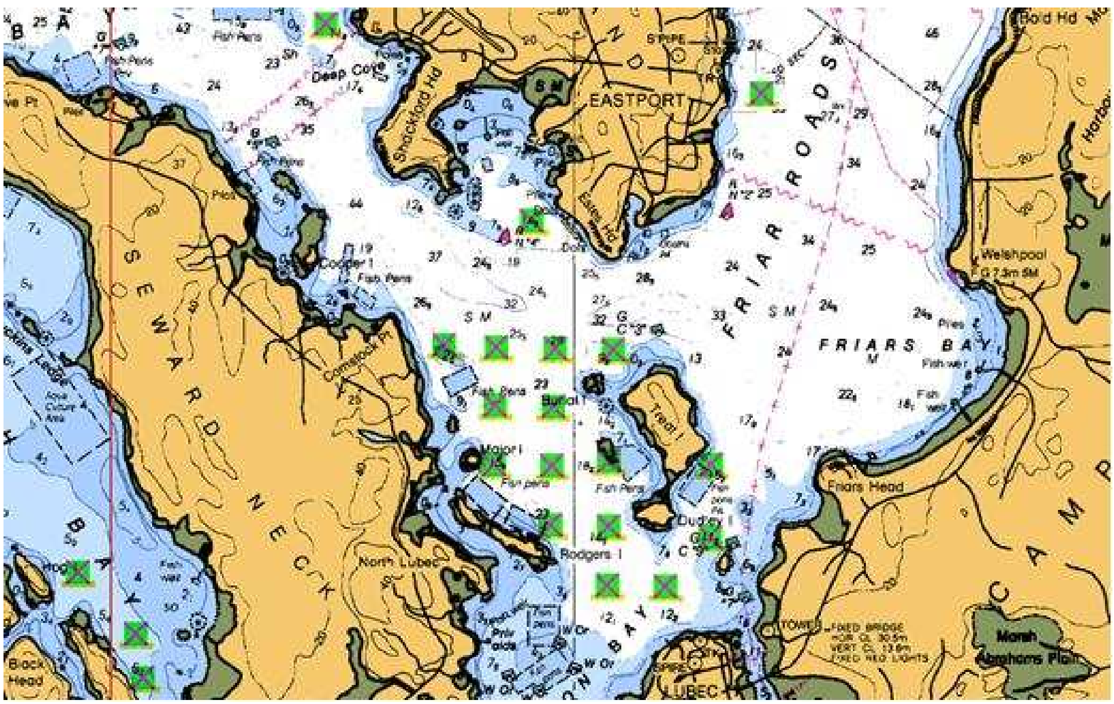


Figure 6. Sampling stations for Johnson Bay and Moose Island.

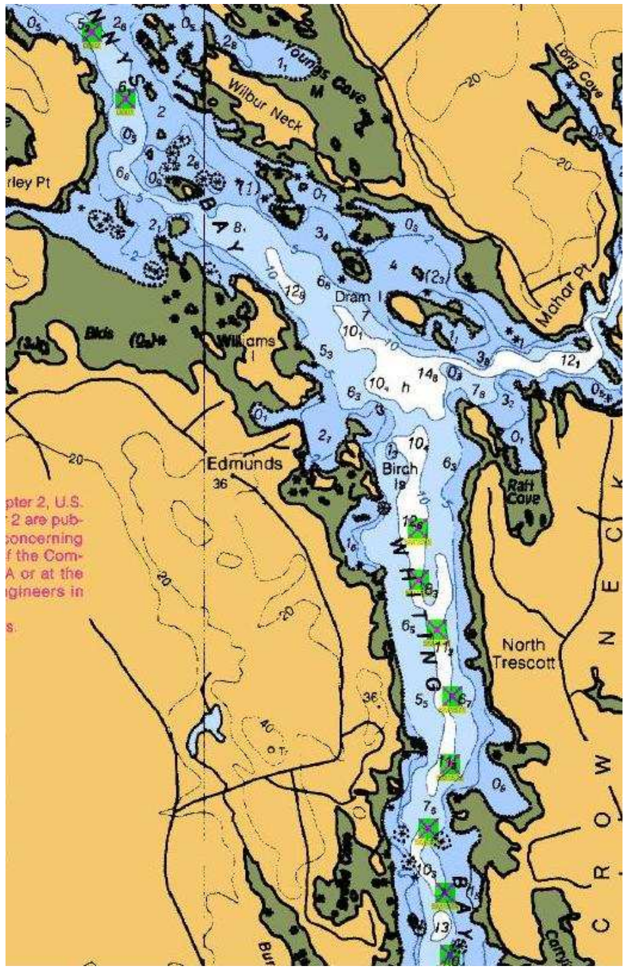


Figure 7. Sampling stations for Whiting Bay/Dennys Bay (one station at lower end of Whiting Bay not visible).

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 an onboard 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. Stations were sampled by a straight line tow at an average speed of 3.5 knots for 2½ minutes.

The handheld computer was interfaced with digital calipers 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 were culled from the drag contents, enumerated and set aside for measurement.

5.) Bycatch was enumerated using a 0-5 qualitative abundance scale corresponding to “absent”, “present”, “rare”, “common”, “abundant”, and “very abundant”. Numbers of sea cucumbers (*Cucumaria frondosa*) were recorded along with their weight and volume in order to provide information which may be helpful in the evaluation of this resource.

6.) 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.

7.) 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 the navigation 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
- **sublega**l: 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

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

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.

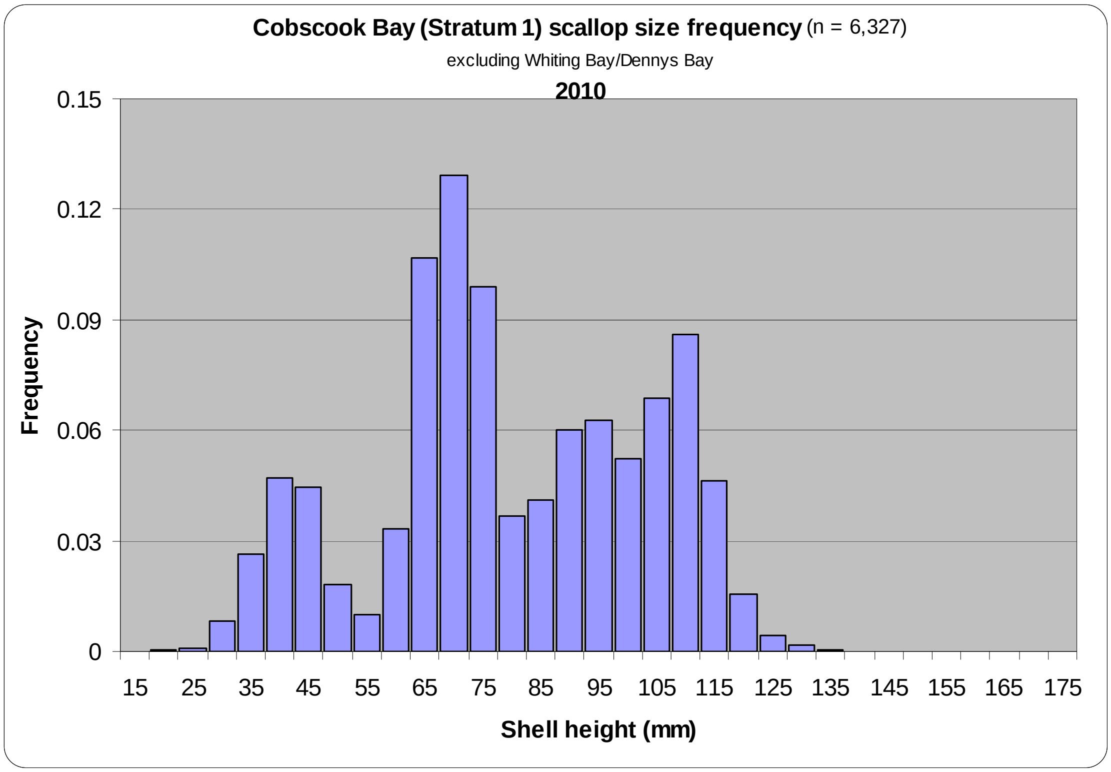
Results

<u>Stratum 1 (Cobscook Bay)</u>

The 2012 survey comprised 86 total tows within the six (6) substrata of Cobscook Bay. Approximately 59,500 scallops were caught and counted, 7,760 were measured for shell height (SH) and an additional 482 were sampled for shell size-meat weight determination (Fig. 8). The smallest individual sampled was 14.6 mm (0.58 in.) SH and the largest was 149.7 mm (5.89 in.) SH. The largest number of scallops in a single tow was 3,085 in South Bay.

Size frequency

A significant feature of Cobscook Bay in ’12 was the dominance of the 70-80 mm and 90-100 mm size groups (Fig. 8). The strong presence of these size groups masked the high abundance of harvestable scallops, particularly in South Bay. In comparison the 2010 size distribution featured modes at 36-40 mm and 60-70 mm as well as 91-95 mm.



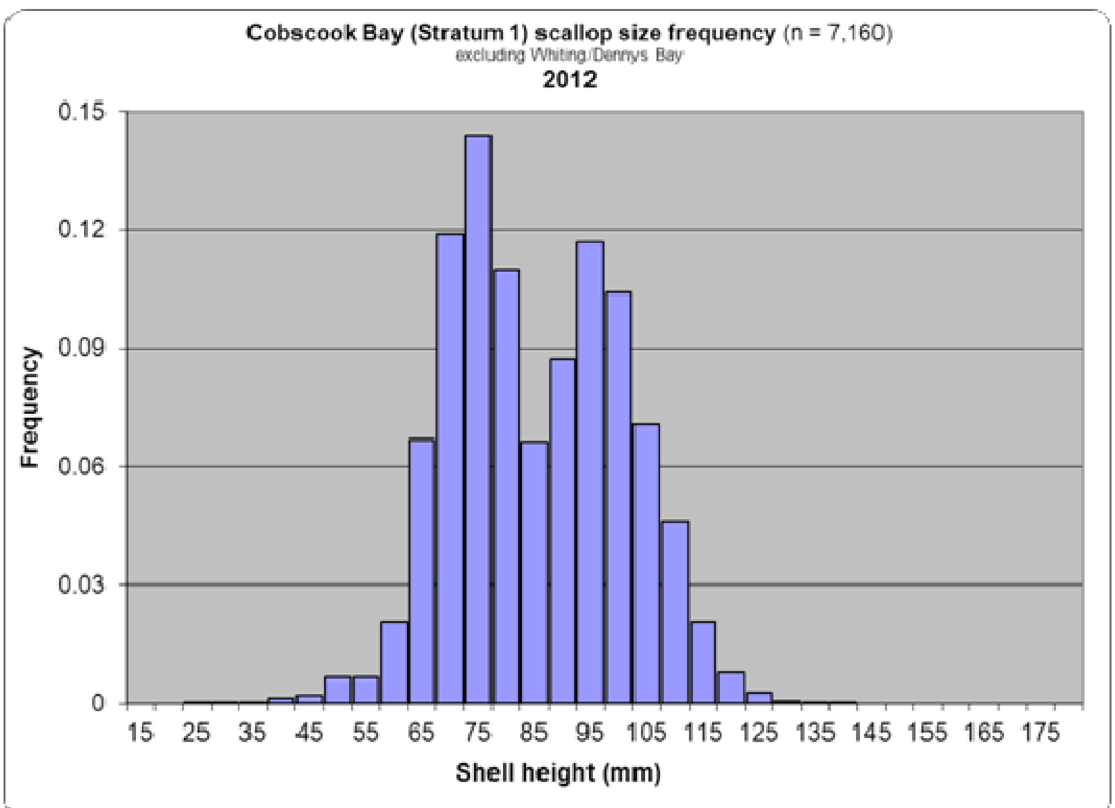


Figure 8. Size frequency (5 mm increments) of scallops in Cobscook Bay, 2010 and 2012.

Open areas

In South Bay, the largest substratum (49 stations), the estimated total scallop abundance increased by 128% between ‘10 and ‘12 (0.573 per m² in ’10 vs. 1.306 per m² in ’12) (Figs. 10-12). The density of harvestable scallops was significantly ($p < 0.001$) higher in ’12 (0.192 per m²) than ’10 (0.103 per m²) (Fig. 12).

Sublegal scallop density in South Bay was significantly ($p < 0.001$) greater in ’12 (1.023 per m²) than ’10 (0.326 per m²) (Fig. 12). South Bay had the highest density of sublegals in Cobscook Bay in ’12 and the highest density of sublegals ever observed on the survey for this substratum. The ’10 survey had indicated an elevated density of seed in Cobscook Bay (Fig. 8), particularly South Bay (Kelly 2011), so the ’12 survey would indicate that this large year class had moved into the sublegal size range.

Seed density in South Bay decreased from the time series high of ’10 (0.144 per) to 0.087 per m² in ’12 (Fig. 12).

The large amount of sublegal scallops in South Bay was further evidenced by tows of high abundance (≥ 750 scallops) from this area (Fig. 9). These tows contained an average of 86% seed/sublegal (≤ 101.6 mm SH) scallops.

East Bay is a small (3 stations) substratum that had similar harvestable density between ’10 (0.059 per m²) and ‘12 (0.068 per m²) (Figs. 10, 13-14). Sublegal density (0.180 per m²) was variable in East Bay but increased to a time series high in ‘12 (Fig. 14).

Pennamaquan River (5 stations) increased over 4X in overall abundance from ‘10 (0.247 per m²) to ’12 (0.994 per m²) (Figs. 10, 15-16). The largest increase (nearly 5X) was in sublegal abundance between ’10 (0.164 per m²) and ’12 (0.769 m²) (Fig. 16).

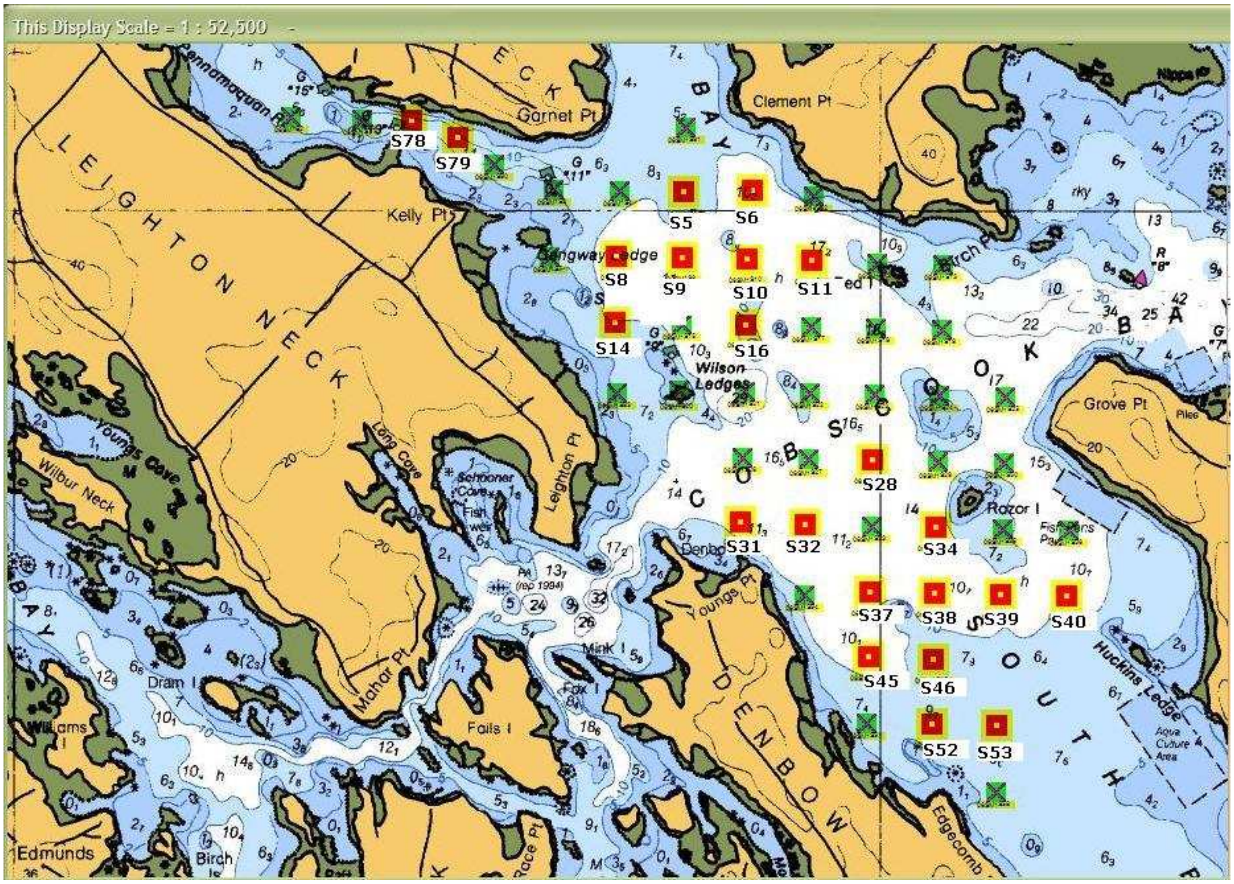


Figure 9 . High abundance ($\geq$750 scallops) tows (indicated by ◘) in South Bay, 2012.

Johnson Bay (15 stations) had a significant ($p = 0.021$) increase in overall scallop abundance between ’10 (0.269 per m²) and ’12 (1.014 per m²) (Figs. 10, 17-18). The increase was most significant ($p = 0.014$) in the sublegal size group between ’10 (0.128 per m²) and ’12 (0.867 per m²) (Fig. 18). Densities of seed (0.078 per m²) and harvestables (0.069 per m²) in ’12 were not significantly different than ’10.

Moose Island consists of three (3) stations (Eastport breakwater, Broad Cove and Deep Cove). There was an overall increase (2.4X) in scallop abundance at Moose Is. between ’10 and ’12 (Figs. 10, 19-20). Sublegal density had the largest increase (3.2X) between ’10 and ’12 (Fig. 20). Seed abundance was unchanged and harvestables were slightly higher.

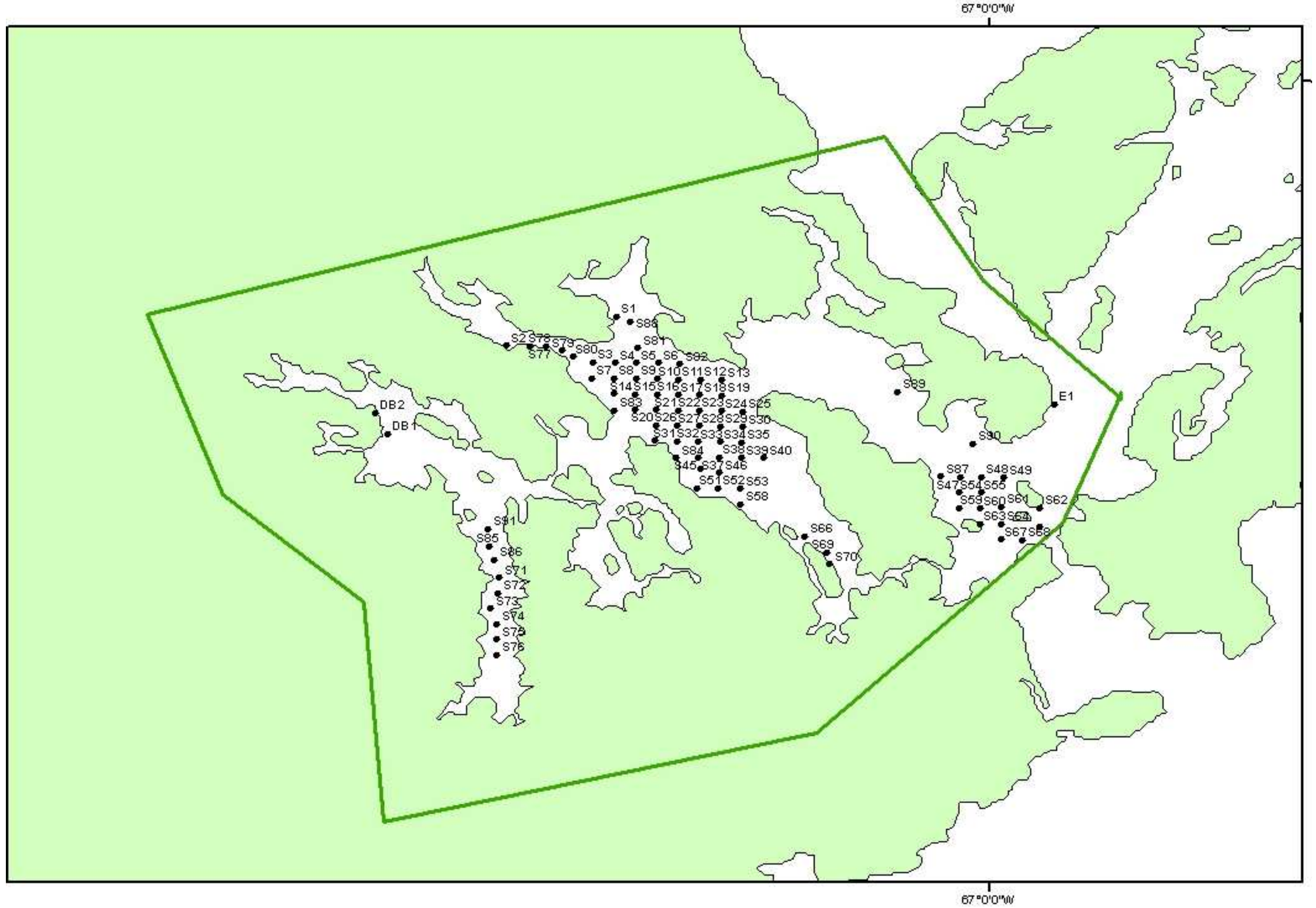


Figure 10 . ME DMR scallop survey stations, Cobscook Bay, 2012.

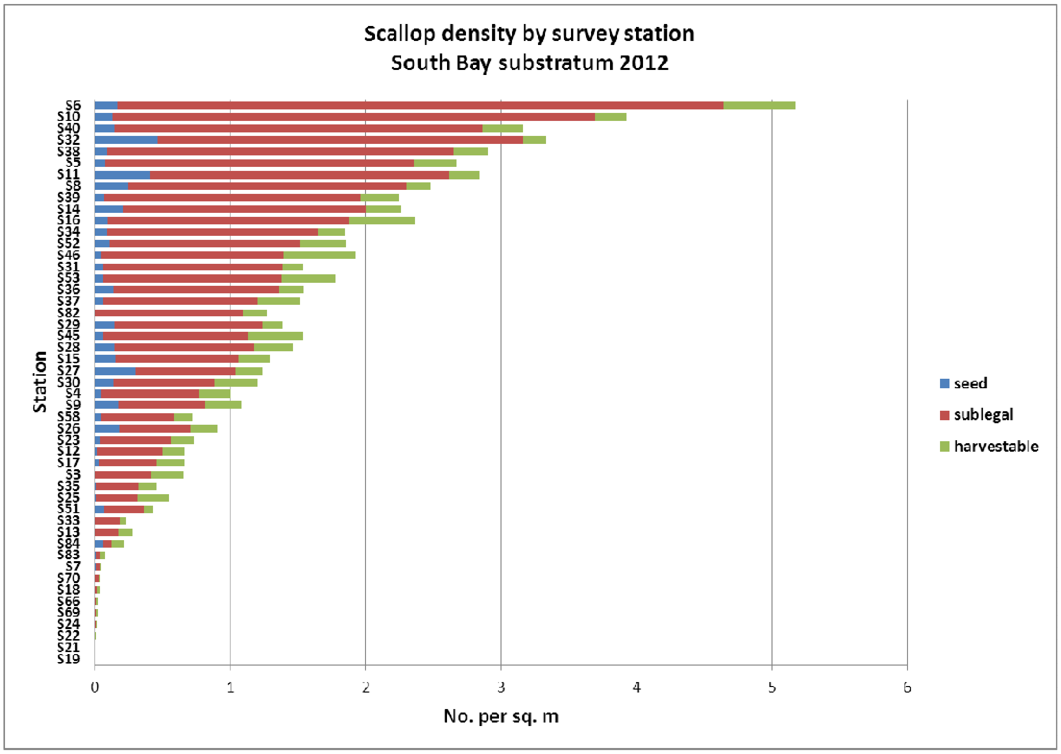


Figure 11 . Scallop density by size class and survey station, South Bay substratum of Cobscook Bay, 2012.

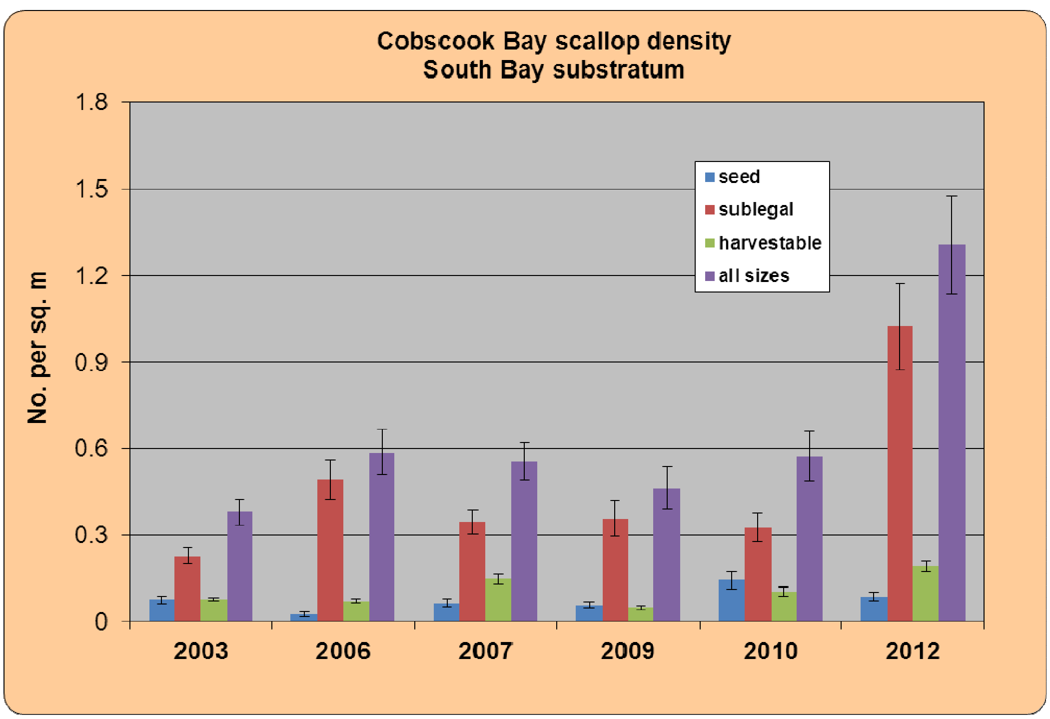


Figure 12. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, South Bay substratum of Cobscook Bay, 2003-12.

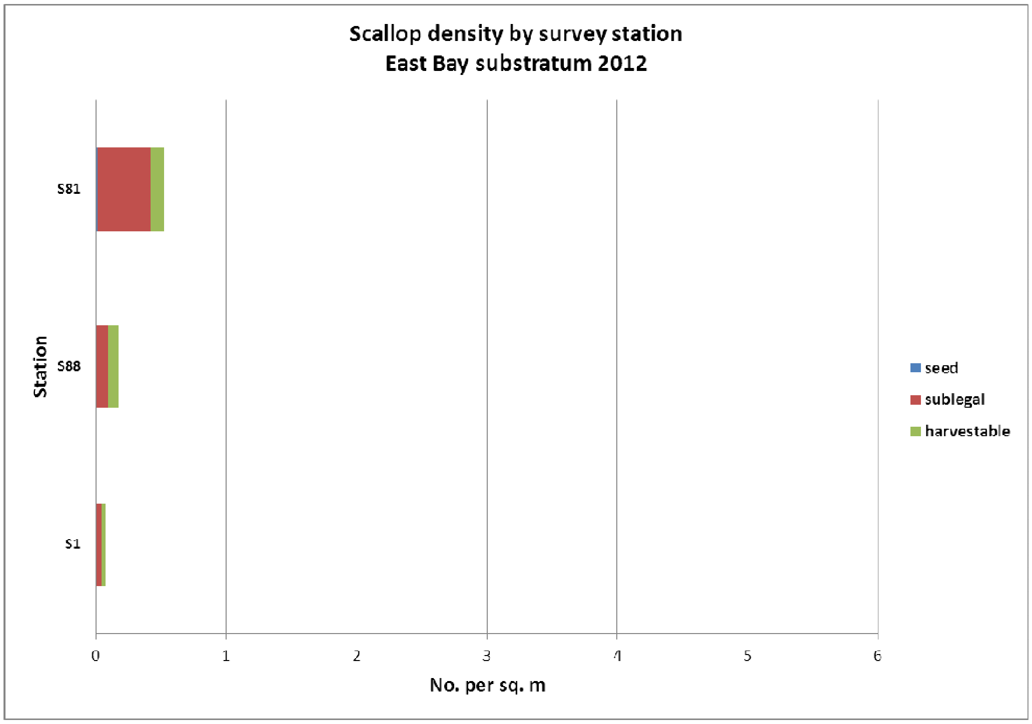


Figure 13. Scallop density by size class and survey station, East Bay substratum of Cobscook Bay, 2012.

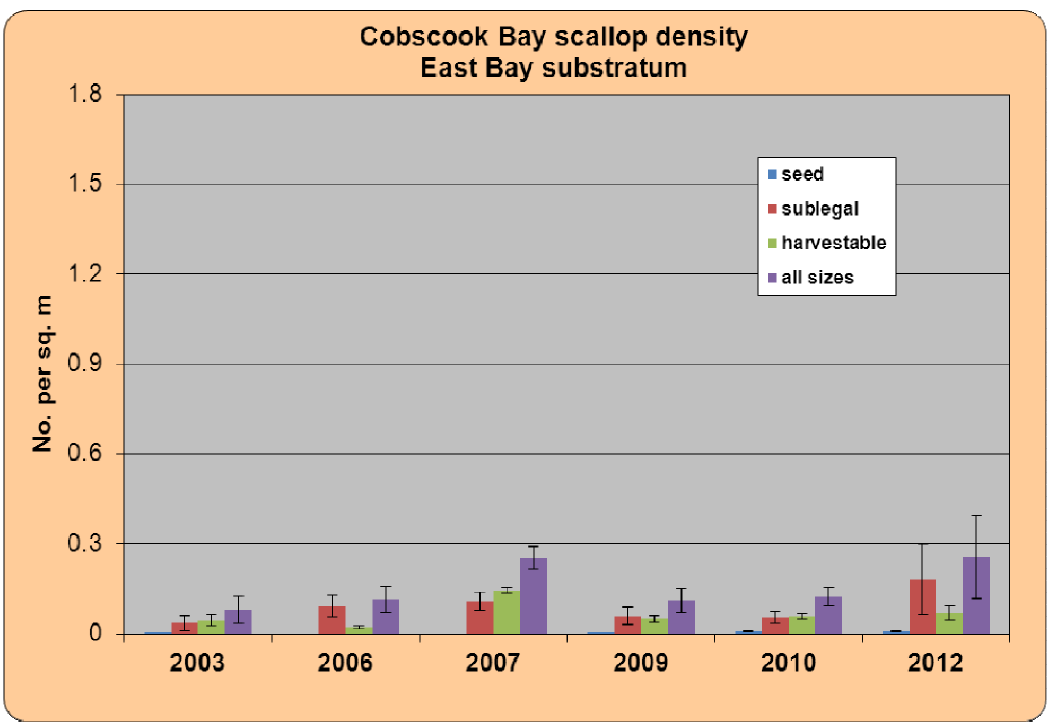


Figure 14. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, East Bay substratum of Cobscook Bay, 2003-12.

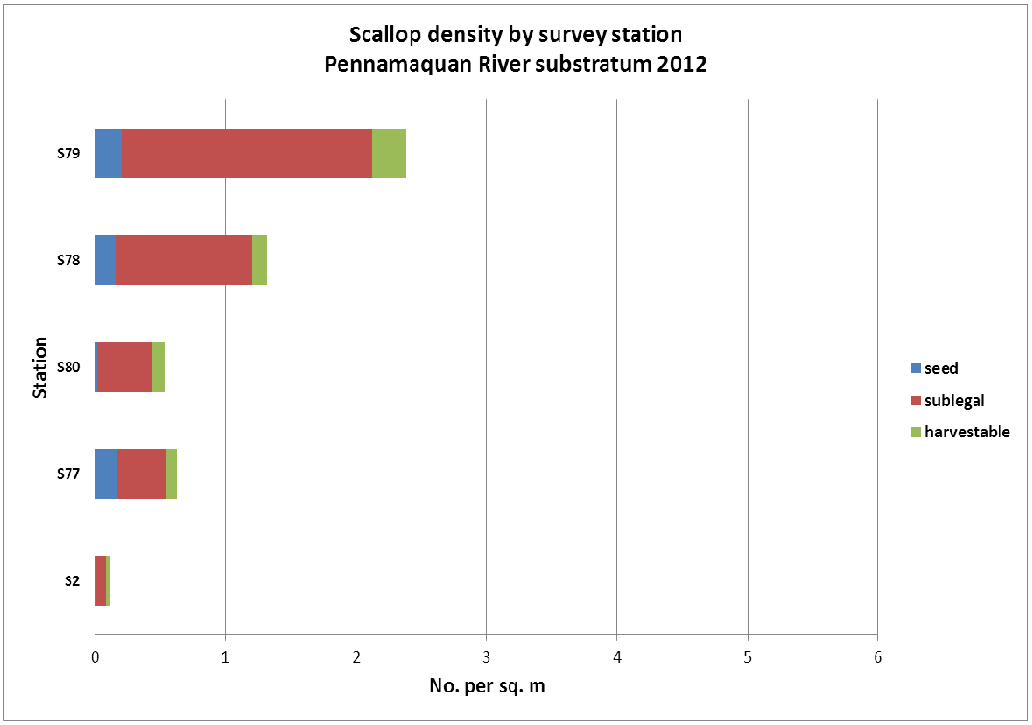


Figure 15. Scallop density by size class and survey station, Pennamaquan R. substratum of Cobscook Bay, 2012.

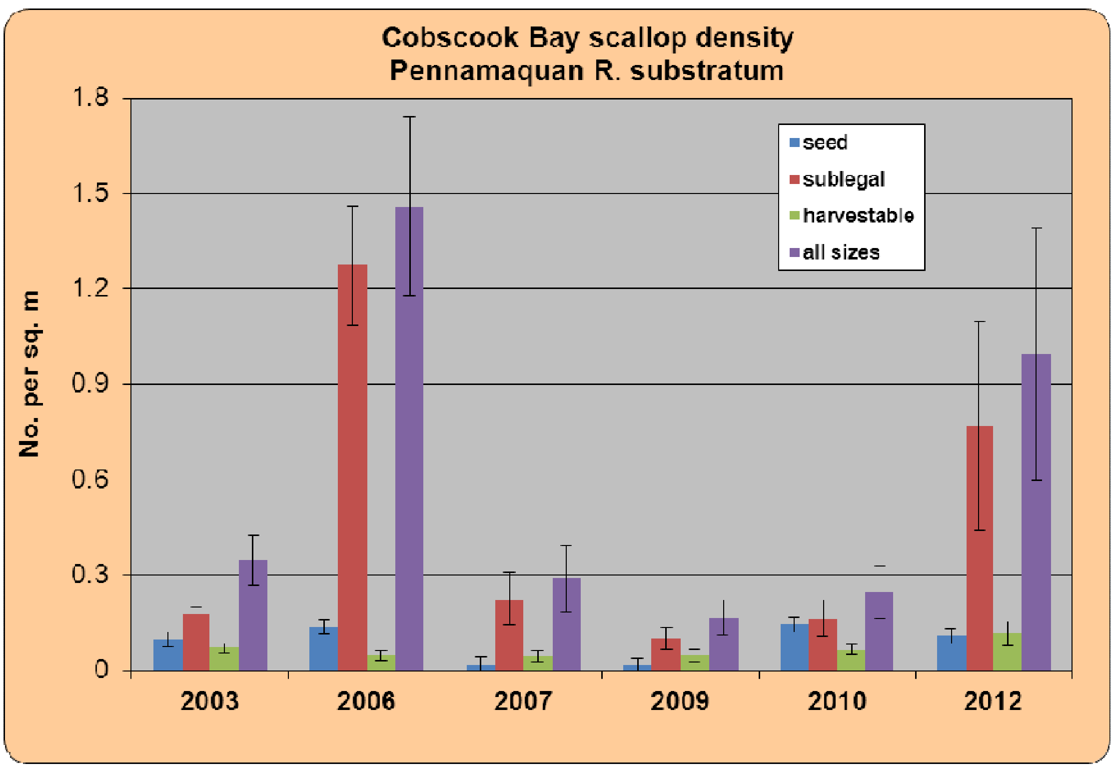


Figure 16. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Pennamaquan R. substratum of Cobscook Bay, 2003-12.

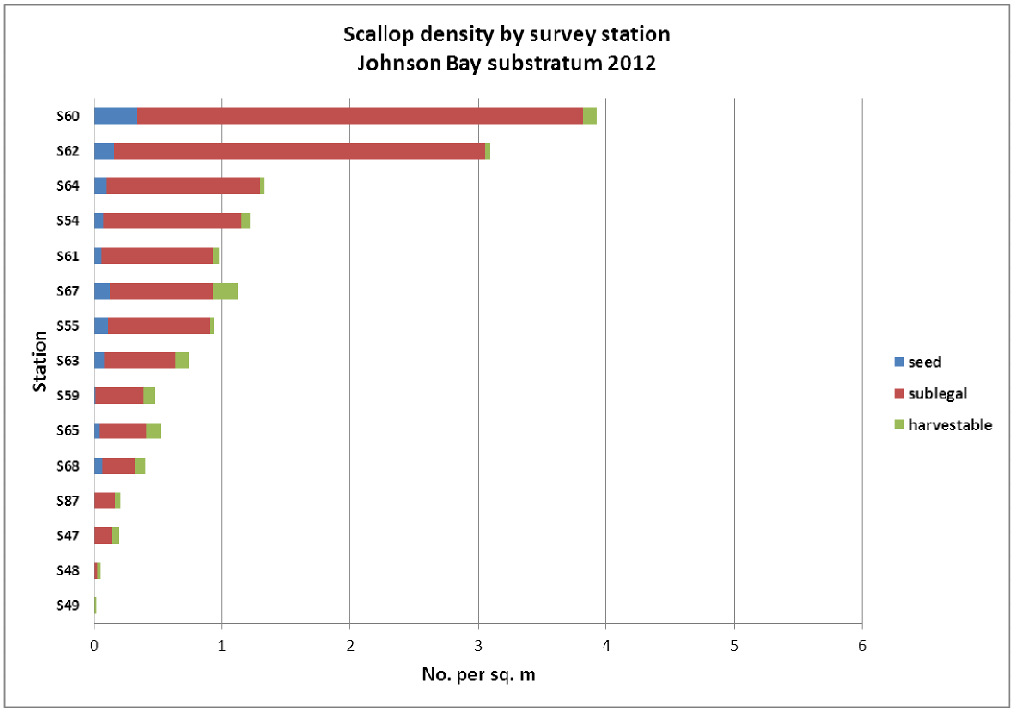


Figure 17. Scallop density by size class and survey station, Johnson Bay substratum of Cobscook Bay, 2012.

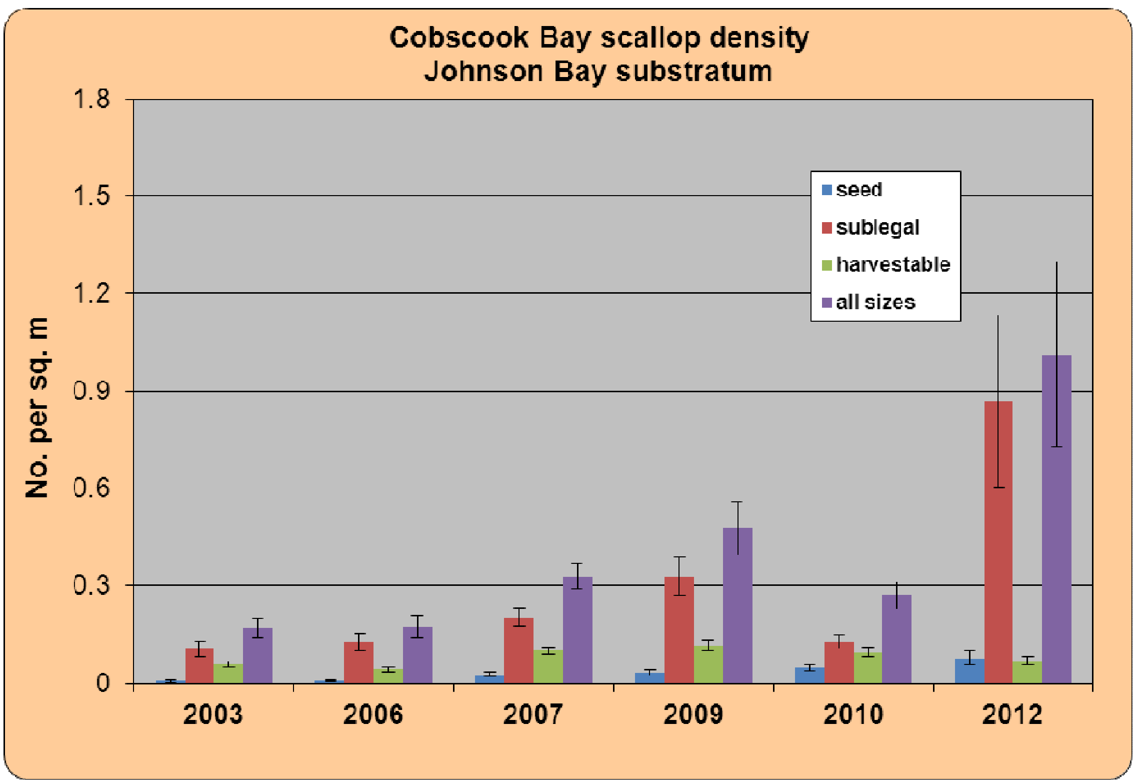


Figure 18. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Johnson Bay substratum of Cobscook Bay, 2003-12.

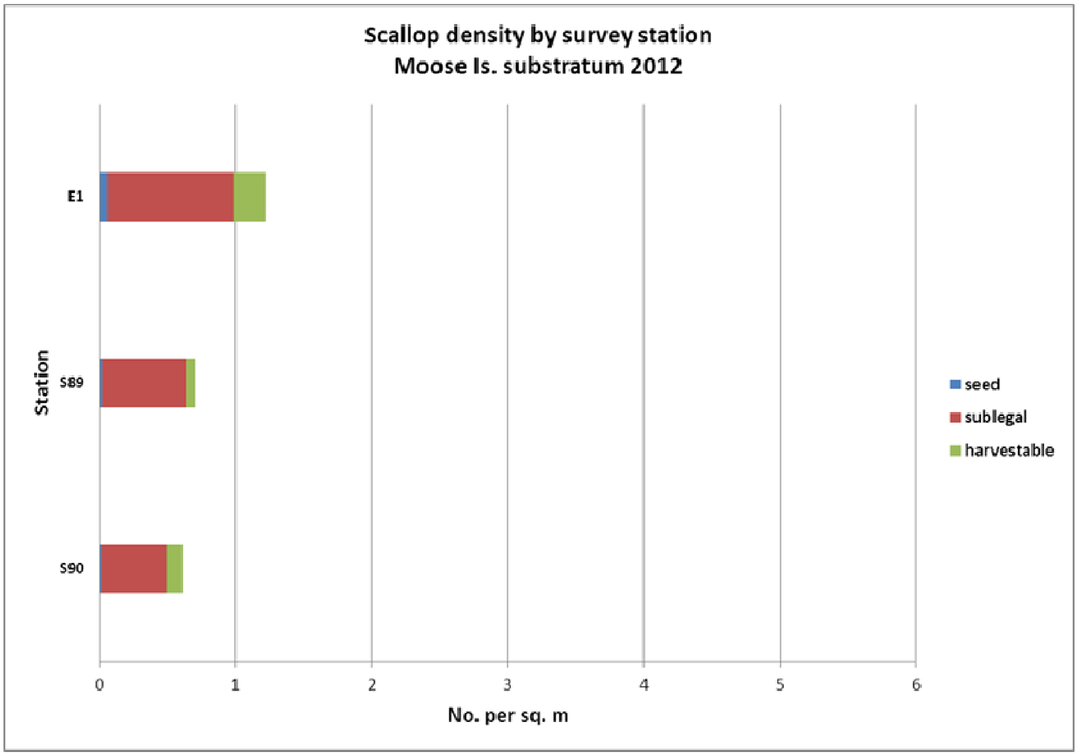


Figure 19. Scallop density by size class and survey station, Moose Is. substratum of Cobscook Bay, 2012.

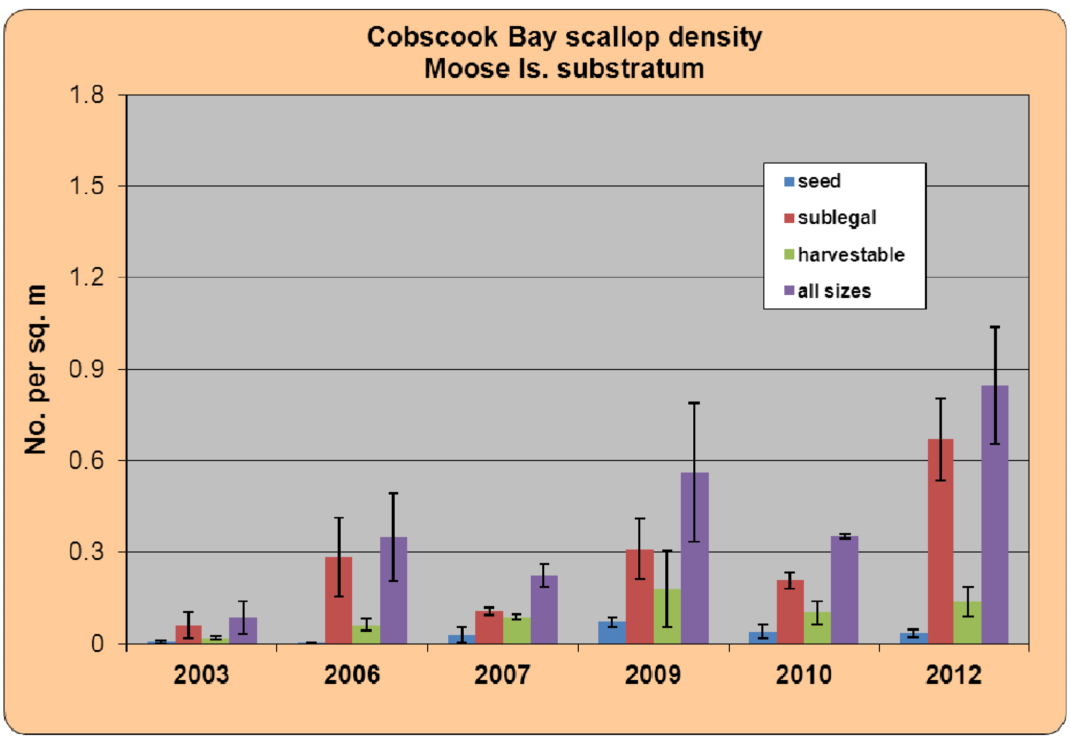


Figure 20. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Moose Is. substratum of Cobscook Bay, 2003-12.

Closed area (Whiting Bay/Dennys Bay)

There was a significant ($p = 0.013$) increase in overall scallop abundance between ’10 (0.699 per m^2) and ’12 (1.098 per m^2) in the Whiting Bay/Dennys Bay closed area (11 stations) (Figs. 10, 21-22). Seed abundance (0.035 per m^2) decreased significantly ($p = 0.013$) however from the ’10 peak (0.159 per m^2) (Fig. 19). Sublegal abundance (0.667 per m^2) increased significantly ($p = 0.006$) from ’10 (0.307 per m^2). Density of harvestable scallops was 1.7X greater in ’12 (0.386 per m^2) than ’10 (0.233 per m^2) (Fig. 22).

Whiting Bay/Dennys Bay contained the highest density (0.386 per m^2) of harvestable scallops in Cobscook Bay in ’12 (Fig. 22). This represented the greatest density of harvestable scallops ever observed for an area in Cobscook Bay on the ME DMR survey.

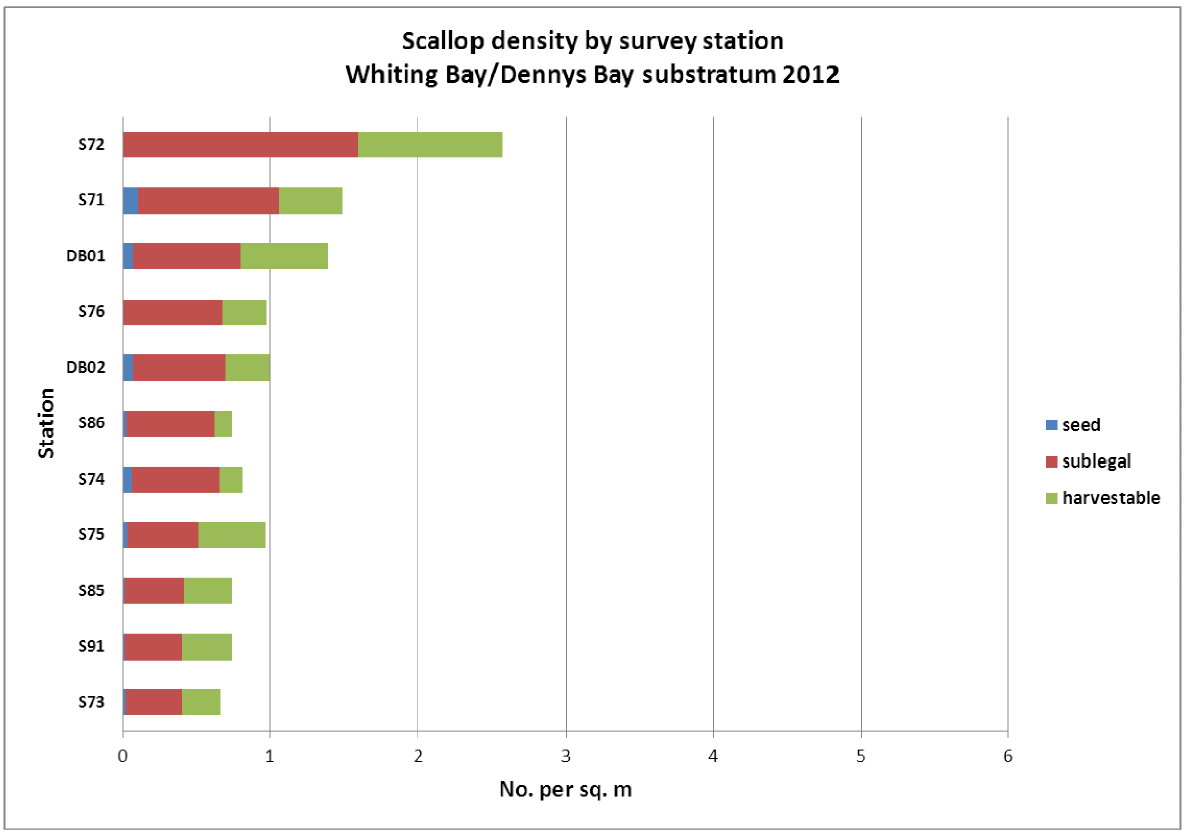


Figure 21. Scallop density by size class by survey station, Whiting Bay/Dennys Bay substratum of Cobscook Bay, 2012.

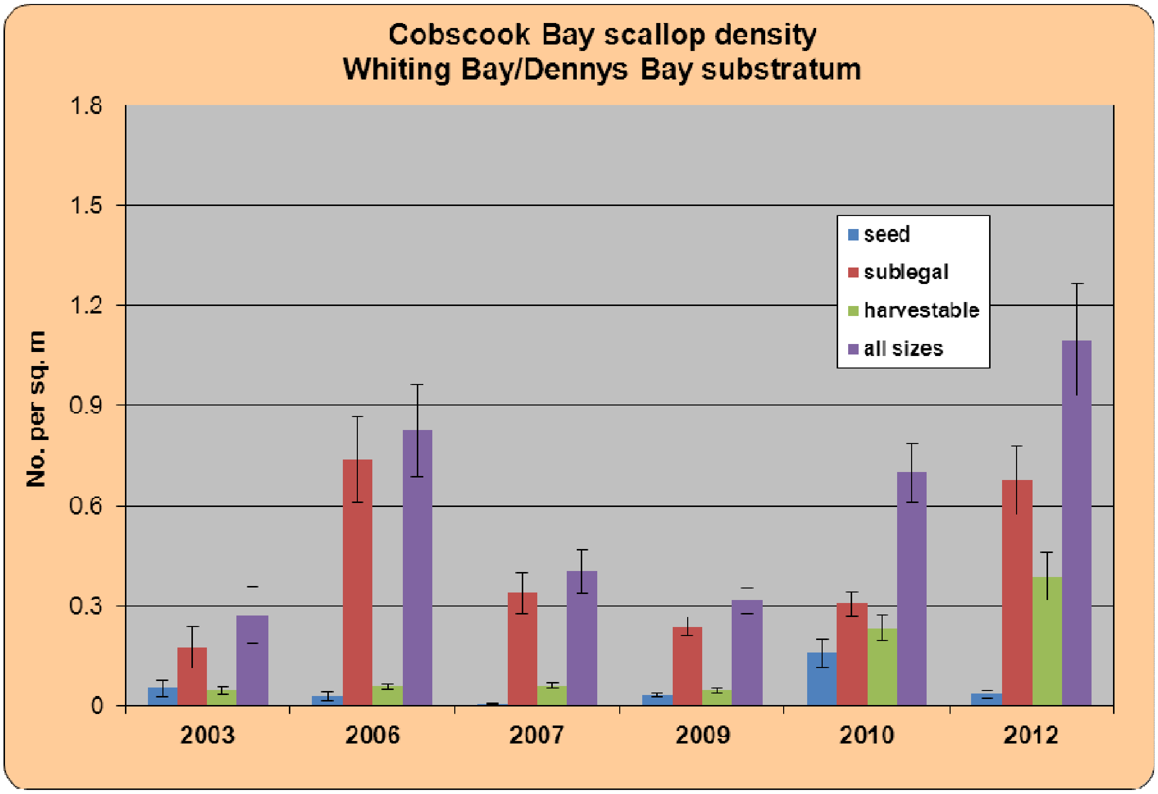


Figure 22. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Whiting Bay/Dennys Bay substratum of Cobscook Bay.

Whiting Bay/Dennys Bay contained predominantly 85-110 mm SH scallops in ’12 and had a smaller proportion of 70-80 mm SH scallops than the open portion of Cobscook Bay (Fig. 23).

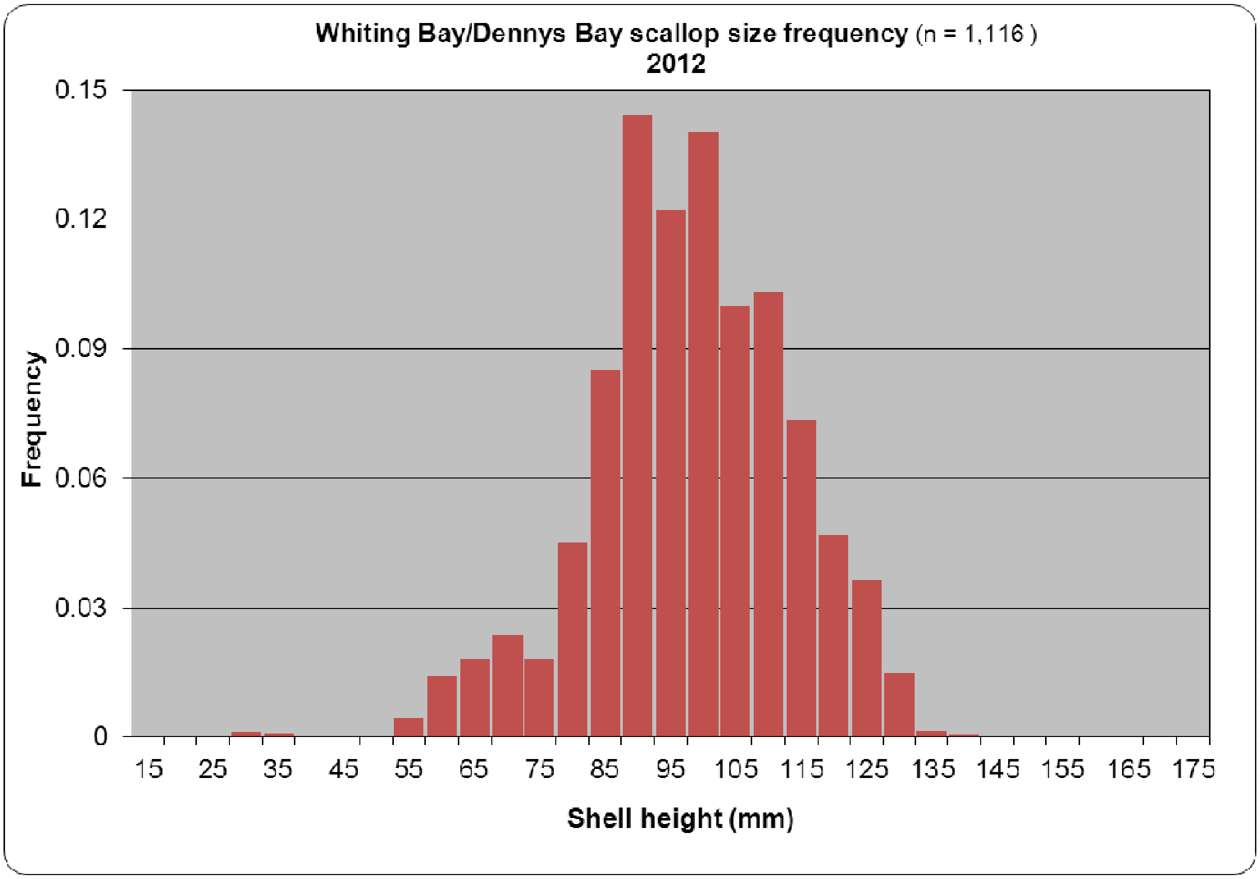


Figure 23. Size frequency (5 mm increments) of scallops in Whiting Bay/Dennys Bay, 2012.

Meat weight

A meat weight to shell height relationship ($MW = 0.00001358*(SH)^{3.06973021}$) was calculated based on samples taken in 2012 (Fig. 24).

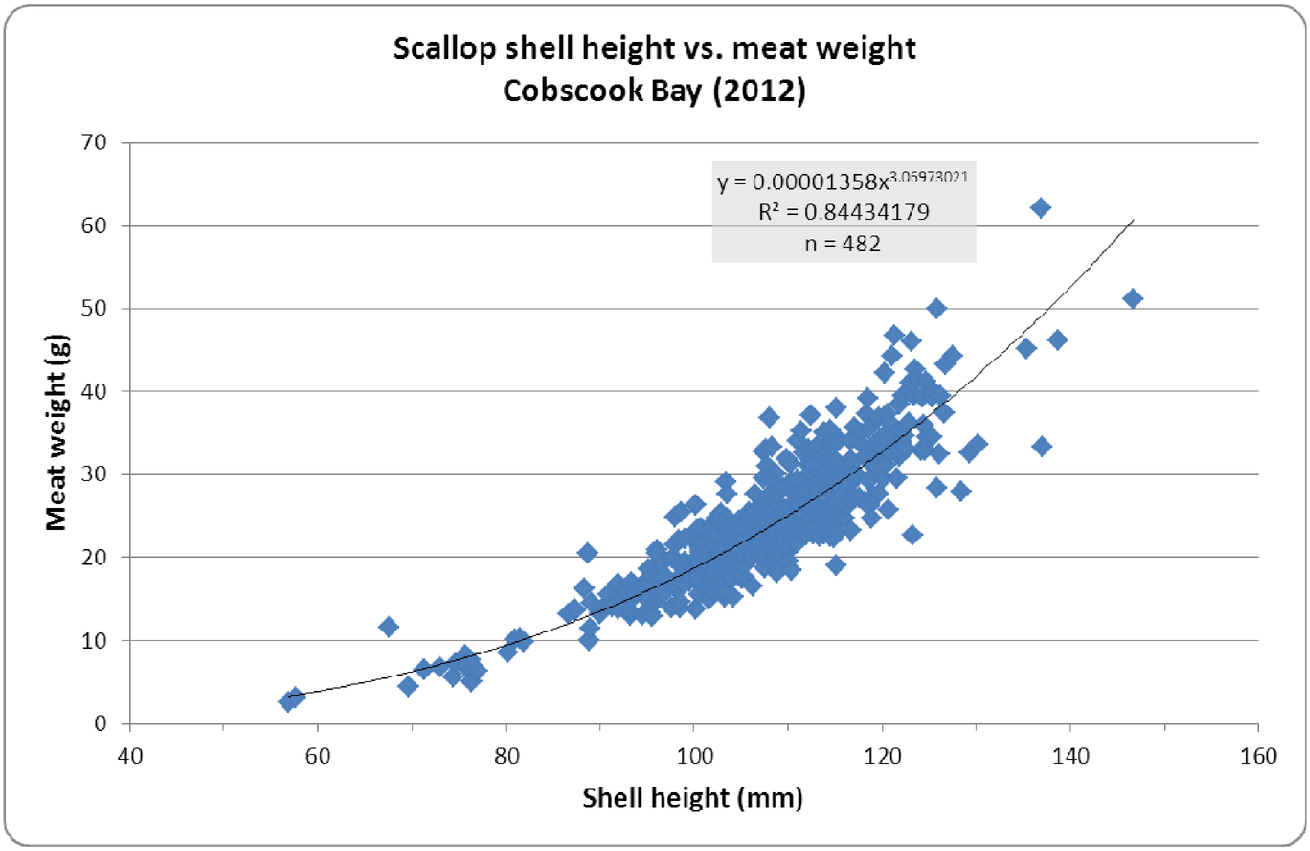


Figure 24 . Scallop meat weight (MW) as a function of shell height (SH) for Cobscook Bay, 2012.

The 2012 meat weight vs. shell height relation in Cobscook Bay was slightly higher than 2010 as indicated by comparison of predicted meat weight vs. shell height for these two years (Table 2). Mean Cobscook Bay scallop meat weight in 2012 was the largest since 2002-03.

		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
2010	**Meat weight (g)**	19.1	27.6	38.2
	Count per lb.	24	17	12
2012	**Meat weight (g)**	19.7	28.2	39.0
	Count per lb.	23	16	12

Table 2. Predicted scallop meat weight and meat count at size based on 1987/91 (DMR unpubl.) and 2002-03, 2006-07, 2009, 2010 and 2012 Cobscook Bay survey data.

Harvestable biomass

Scallop harvestable ($\geq$ 4 in. SH) biomass (by meat weight) was calculated by applying the 2012 shell height-meat weight relationship to survey size frequency data on a tow-by-tow basis. Mean harvestable biomass (g) per m² for each substratum was calculated and 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.

In 2012 the mean total harvestable biomass of Cobscook Bay (adjusted with a dredge efficiency factor of 0.429) was 197,155 $\pm$ 14,076 kg (434,652 $\pm$ 31,033 lbs.; Fig. 25). This was the highest value of the six-year time series. South Bay contained 65.2% of the harvestable biomass followed by Whiting Bay/Dennys Bay (19.1%) and Johnson Bay (7.8%). Harvestable biomass in the Whiting Bay/Dennys Bay closure increased 1.8X from 45,600 lbs. (2010) to 83,000 lbs. (2012) (Fig. 26).

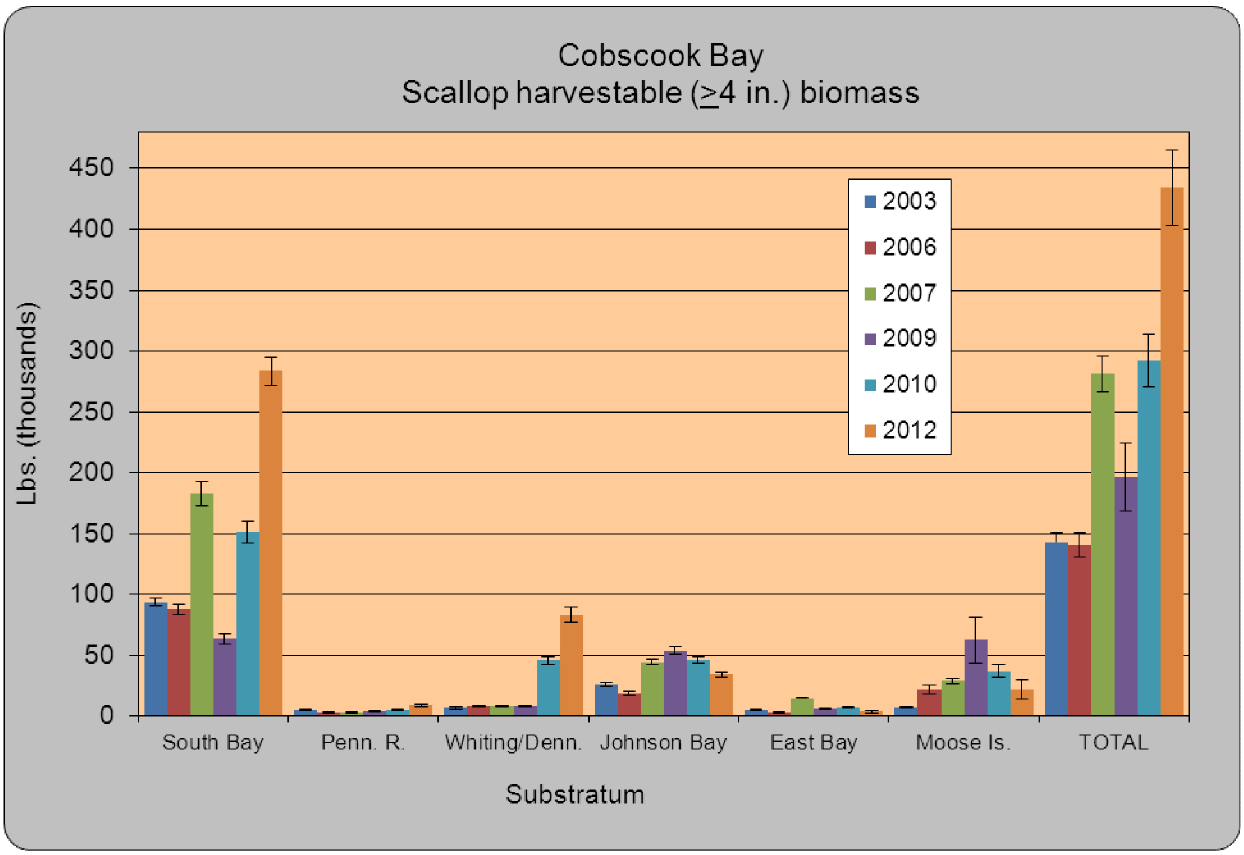


Figure 25. Biomass (meat weight, with standard error) of harvestable (legal-size) scallops in Cobscook Bay, 2003-12.

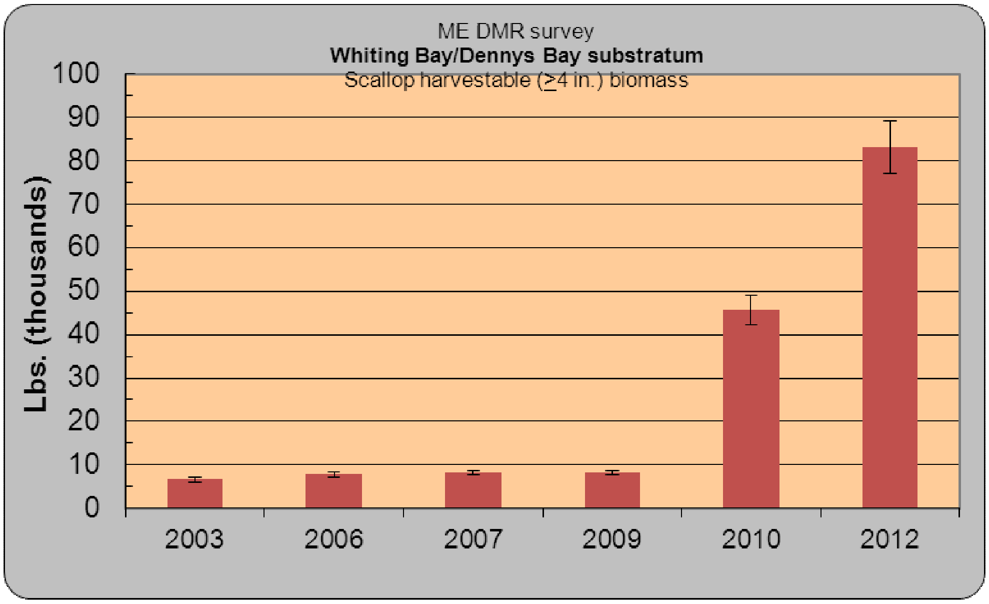


Figure 26. Biomass (meat weight, with standard error) of harvestable (legal-size) scallops in Whiting Bay/Dennys Bay, 2003-12.

Conclusions

Cobscook Bay had time-series high levels of scallop production in 2012. Strong recruitment into the legal size range, historically high sublegal abundance in South Bay and higher than average meat weight were all observed in the 2012 survey. It is possible that reduced fishing effort was a contributing factor since the Cobscook Bay scallop season was abbreviated during 2011-12. (On 2 January 2012 ME DMR responded to reports by the fishing community of "small catches, small meats, and large quantities of sublegal scallops sustaining damage as a result of fishing pressure" by closing a large portion of the area, including South Bay, after only 11 days of fishing). This action may have allowed a larger portion of sublegal scallops to recruit to harvestable size by the time of the 2012 survey.

Whiting/Dennys Bay appeared to have additional benefits from being closed for two (2) more years following the '10 survey. Density of harvestable scallops was nearly 2X greater than '10. Harvestable biomass in this area increased by a factor of 10.2 over the period of its 3-year closure.

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