



Results from the 2014 Cobscook Bay Sea Scallop Survey

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Executive Summary

The fall 2014 Maine Department of Marine Resources (DMR) sea scallop survey was carried out in October (prior to the December 1 opening of the fishery) in survey strata 1 (Cobscook Bay) and 1a (St. Croix River). This survey covered the Cobscook Bay subareas of Whiting Bay/Dennys Bay, South Bay, East Bay, Pennamaquan River, Johnson Bay and Moose Island. In total 103 tows were completed, at a rate of 2 tows per km².

Some key findings were:

- In 2014 Cobscook Bay had the highest amount of harvestable (≥ 4 in. shell height) meat biomass (635,900 \pm 41,900 lbs.) observed since the survey began in 2002.
- Meat weight in relation to shell height was greater than the previous survey (2013) of Cobscook Bay and the highest since 2002-03.
- Johnson Bay had the highest density (0.264 per m²) of harvestable scallops in Cobscook Bay in 2014. Highest densities of both seed (0.125 per m²) and sublegals (0.950 per m²) were also found in Johnson Bay. This was the highest amount of seed, sublegals and harvestables in Johnson Bay of the time series.
- South Bay had the largest proportion (50%) of harvestable biomass in Cobscook Bay in 2014. Harvestable density increased in South Bay in 2014 and was the highest since 2012.
- Harvestable biomass in the Whiting Bay/Dennys Bay limited access area decreased 44% between 2013 and 2014 and was the lowest since 2009.
- Scallop abundance was variable within the St. Croix River. There was a low abundance of harvestable scallops. One tow had a large presence of sublegal scallops.

Introduction

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).

The sea scallop resource currently supports a December-March commercial and recreational fishery along coastal Maine. Maine 2014 landings of scallop meats were approximately 0.48 million lbs. with an ex-vessel value of \$7.46 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 547 dragger and 84 dive licenses issued by ME DMR in 2013.

DMR conducts a fishery-independent dredge-based scallop survey and fishery-dependent port and sea sampling programs as its primary resource assessment methods. The dredge survey has been conducted annually since 2002 (with the exception of 2004).

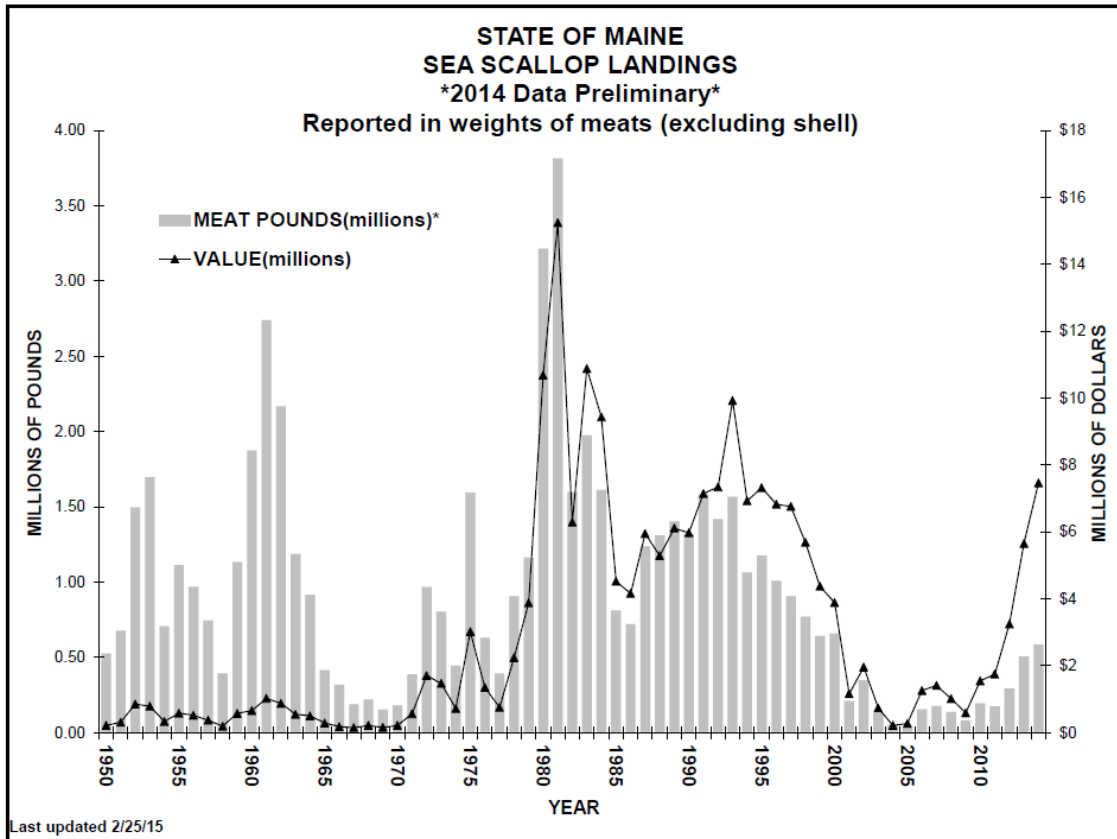


Figure 1. Maine scallop landings 1950-2014 (source: Maine Department of Marine Resources (DMR)).

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. During 2005-12 one of three major sections of the coast (1. Western Penobscot Bay to New Hampshire border, 2.

Quoddy Head to eastern Penobscot Bay, and 3. Cobscook Bay/St. Croix River) was surveyed each year on a rotating basis (Table 1). All 2002-12 surveys were conducted in the fall, prior to the opening of the fishing season. However in 2013 a spring survey of the 2012-13 and 2013-14 limited access and eastern Maine (management Zone 2) rotational areas was added. The 2014 Cobscook Bay/St. Croix R. survey was conducted in the fall.

Methods

The 2014 Cobscook Bay/St. Croix R. survey was conducted during 19-24 October aboard the 40 ft. *F/V Bad Company* from Cutler. 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 10 inch pressure plate. The dredge was equipped with rock chains and was not lined. The survey dredge was constructed in 2009 (Fig. 2; also see Kelly 2010).



Figure 2. View of survey drag constructed in 2009.

Table 1. Chronology of Maine DMR scallop survey, 2002-14.

		Year												
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Area	Cobscook Bay/St. Croix R.	S	S	NS	NS	S (begin higher intensity survey)	S	NS	S	S	NS	S	S (fall)	S (fall)
	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)	S (spring - all open areas in mgt. Zone 2)	S (spring - all open areas in mgt. Zone 2)
	Western Maine	S	S	NS	S	NS	NS	NS	S	NS	S (closures 1-3 only)	NS	NS	NS

S = surveyed
 NS = not surveyed

Survey design

A subset of the coastal zones (or “strata”) defined for the 2002-03 surveys (Fig. 3) were used in subsequent surveys, including 2014, with some modification (e.g., St. Croix River (stratum 1A), Machias Seal Is. (stratum 2A), Mt. Desert Rock (stratum 5A)).

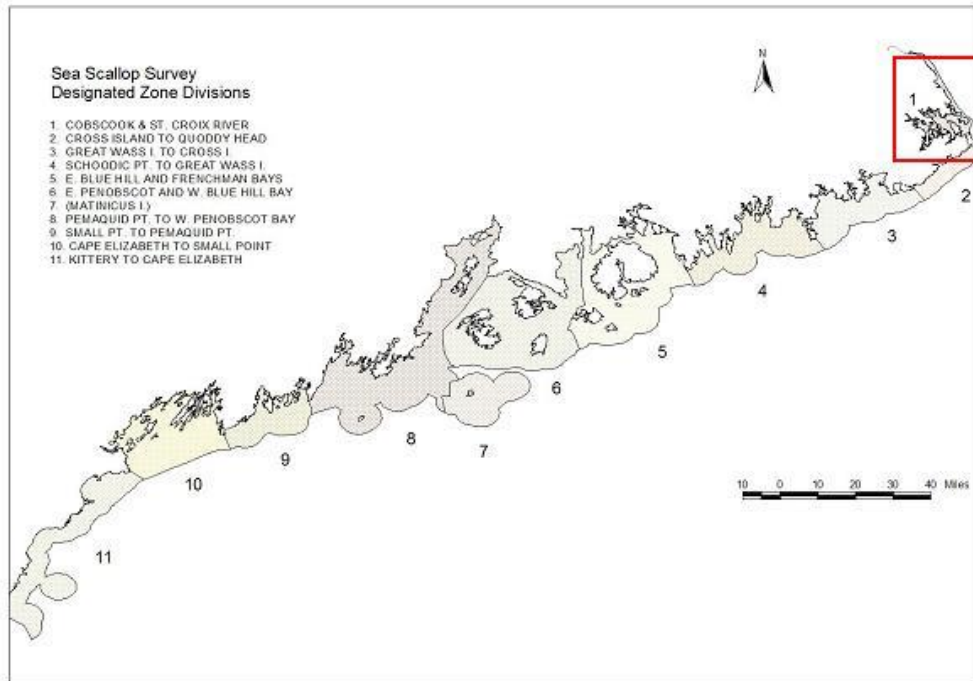


Figure 3. Survey strata - ME DMR scallop survey (with Cobscook Bay area highlighted).

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 2002 survey and have been repeated in subsequent surveys with slight modification. The total number of stations sampled has been increased by 41% since 2006.

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 92 tows completed in the 2014 Cobscook Bay survey. Three (3) stations were added to both Moose Island and Whiting Bay/Dennys Bay in 2014.

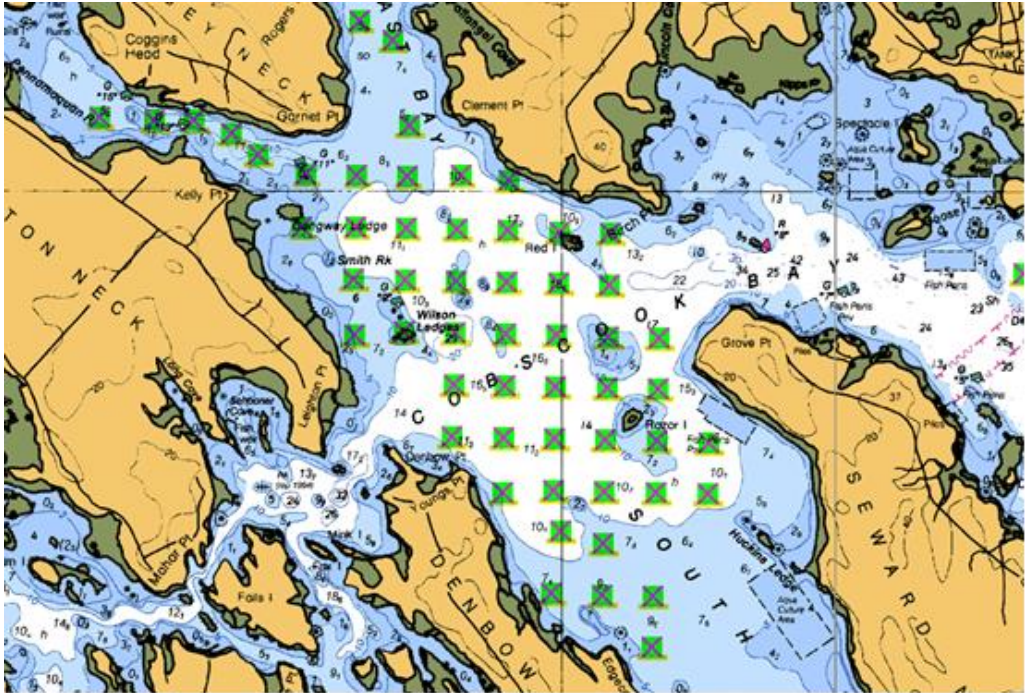


Figure 5. Sampling stations for South Bay, Pennamaquan River and East Bay, 2014.

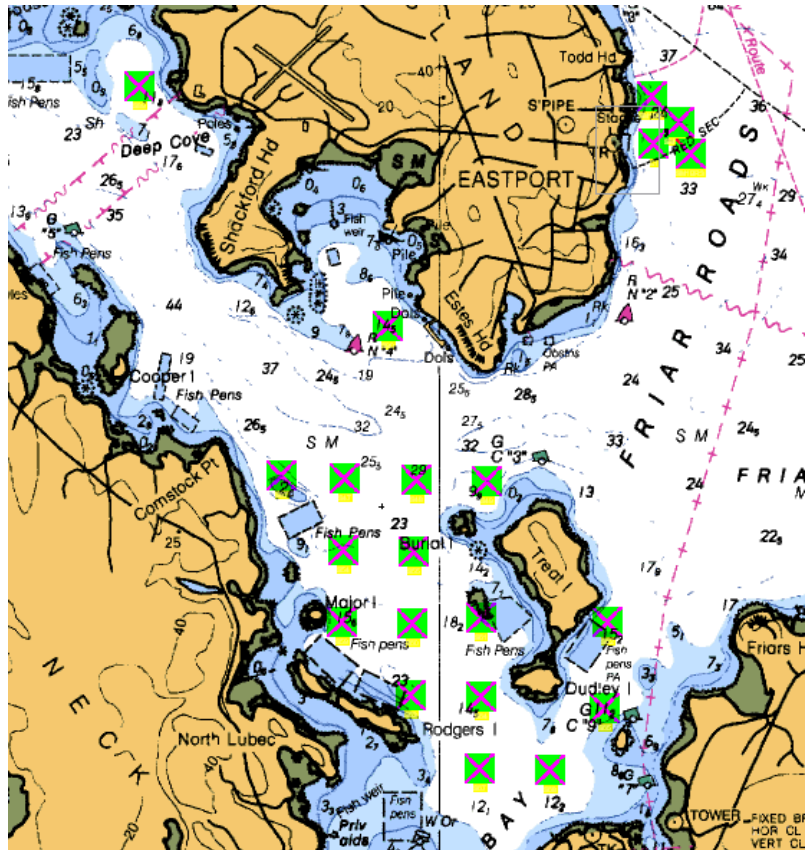


Figure 6. Sampling stations for Johnson Bay and Moose Island, 2014.

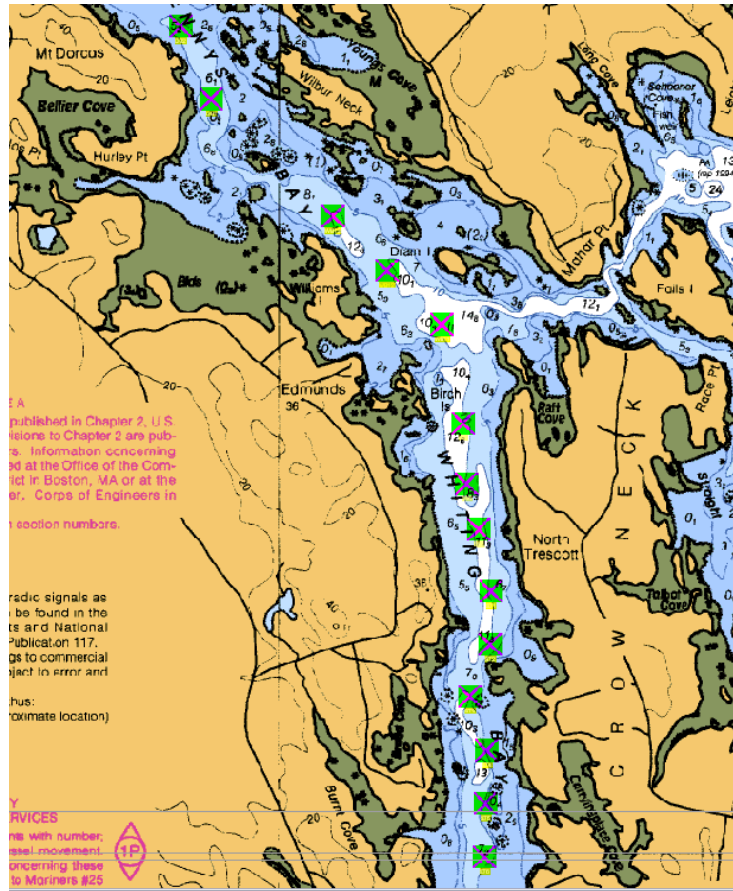


Figure 7. Sampling stations for Whiting Bay/Dennys Bay, 2014.

Sampling procedure

Stations to be sampled were plotted using Capn Voyager™ navigational software. An onboard computer displaying station location was used to position the vessel for the start of each tow. Location and time were recorded at three points (dredge in, tow start and haulback) for each station. A Juniper Allegro™ ruggedized handheld computer with an internal GPS unit recorded time/date/location information. Stations were sampled by a straight line tow at an average speed of 3.5-4 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 $\geq 3\frac{1}{2}$ 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

- **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

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

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_h 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 2014 survey comprised 92 total tows within the six (6) substrata of Cobscook Bay. Approximately 32,000 scallops were caught and counted, 6,700 were measured for shell height and an additional 675 were sampled for shell size-meat weight determination. The largest number of scallops in a single tow was 1,378 in Johnson Bay.

Size frequency

A significant feature of Cobscook Bay in 2014 was the dominance of the 66-80 mm size group (Fig. 8). This size group comprised 34% of the total measured catch. Scallops which were newly-recruited to harvestable size (101-110 mm SH) represented 19% in 2014 (compared to 22% in 2013). A higher proportion (11%) were at 111-120 mm SH than in 2013 (9%). The occurrence of seed was 13% in 2014 compared to 10% in 2013.

Cobscook Bay proper

In South Bay, the largest substratum (49 stations), the density of harvestable scallops was higher in 2014 (0.189 per m²) than 2013 (0.157 per m²) and the second highest of the time series (Figs. 9-10).

Sublegal scallop density in South Bay was slightly less in 2014 (0.272 per m²) than 2013 (0.300 per m²) (Fig. 10). Seed density in South Bay however increased from 0.037 per m² in 2013 to 0.070 per m² in 2014. One station in particular had a very high seed density (1.109 per m²) (Fig. 9).

Harvestable density in Johnson Bay (13 stations; 0.264 per m²) increased significantly ($p < 0.001$) from 2013 (0.104 per m²) and was the highest of the time series (Figs. 11-12). Sublegal density (0.950 per m²) also increased significantly ($p < 0.001$) from 2013 (0.333 per m²) and was the highest of the time series (Fig. 12), surpassing 2012 (0.867 per m²). Seed density (0.127 per m²) increased slightly from 2013 (0.101 per m²) and was the highest of the time series.

Pennamaquan River (5 stations) had a significant ($p < 0.001$) increase in density of harvestable scallops between 2013 (0.086 per m²) and 2014 (0.251 per m²) (Figs. 13-14). The 2014 estimate was the highest of the time series. Sublegal density declined from 0.180 per m² in 2013 to 0.093 per m² in 2014 (Fig. 14). Seed abundance remained very low (0.016 per m²).

Moose Island (6 stations) harvestable density (0.180 per m²) increased slightly from 2013 (0.155 per m²) and was at the maximum of the time series (Figs. 15-16). Sublegal density (0.382 per m²) increased slightly from 2013 (0.318 per m²) and was the second-highest of the time series (Fig. 16). Seed abundance (0.048 per m²) increased from 2013 (0.008 per m²).

East Bay is a small (3 stations) substratum that had lower harvestable density in 2014 (0.073 per m²) than 2013 (0.179 per m²) (Figs. 17-18). Sublegal density declined significantly ($p < 0.001$) from 0.174 per m² in 2013 to 0.025 per m² in 2014 (Fig. 18). Seed density remained very low (0.008 per m²) in 2014.

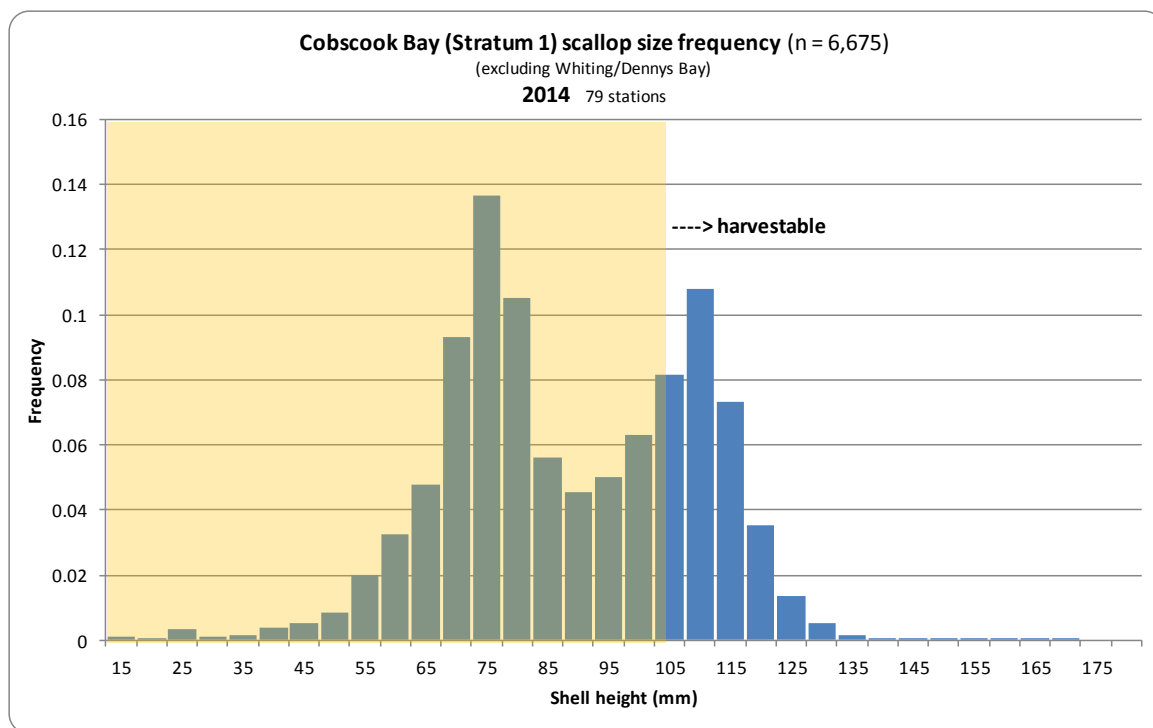
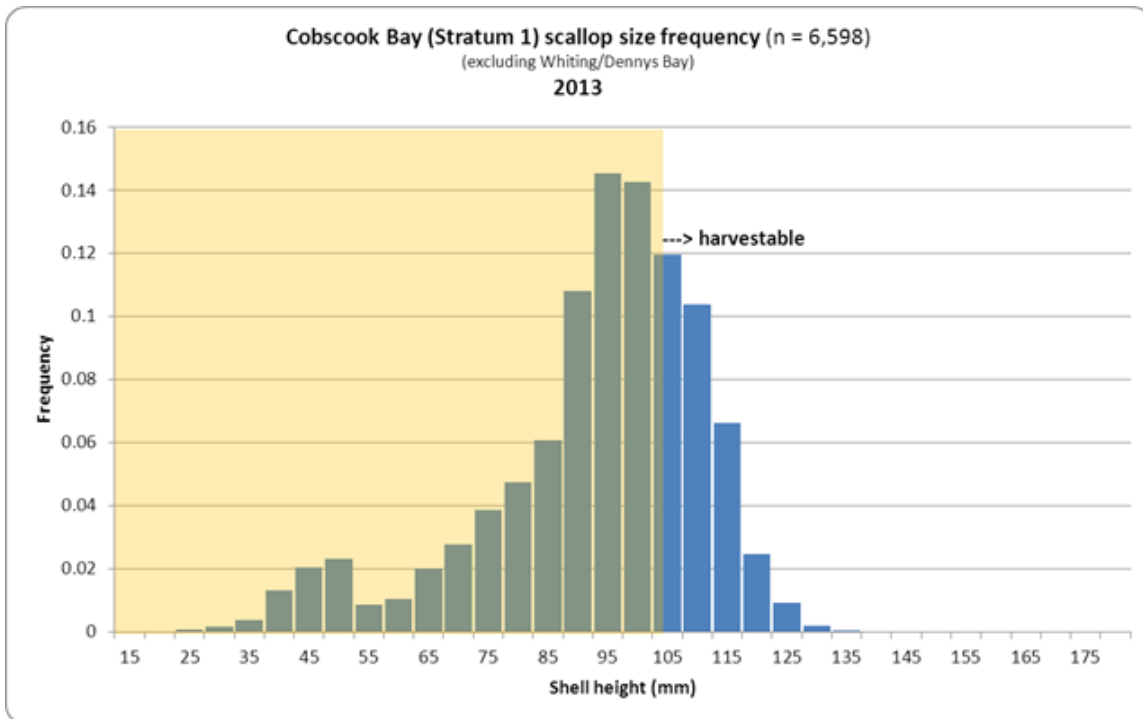


Figure 8. Size frequency (5 mm increments) of scallops in Cobscook Bay, 2013 and 2014.

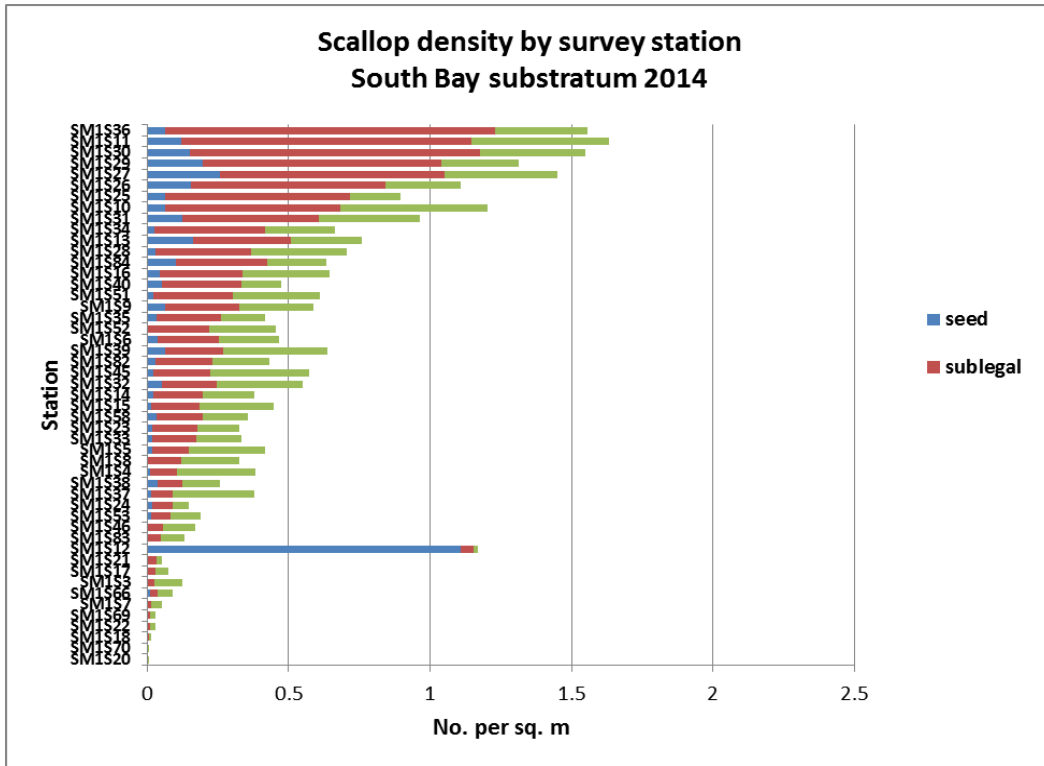


Figure 9. Scallop density by size class and survey station, South Bay substratum of Cobscook Bay, 2014.

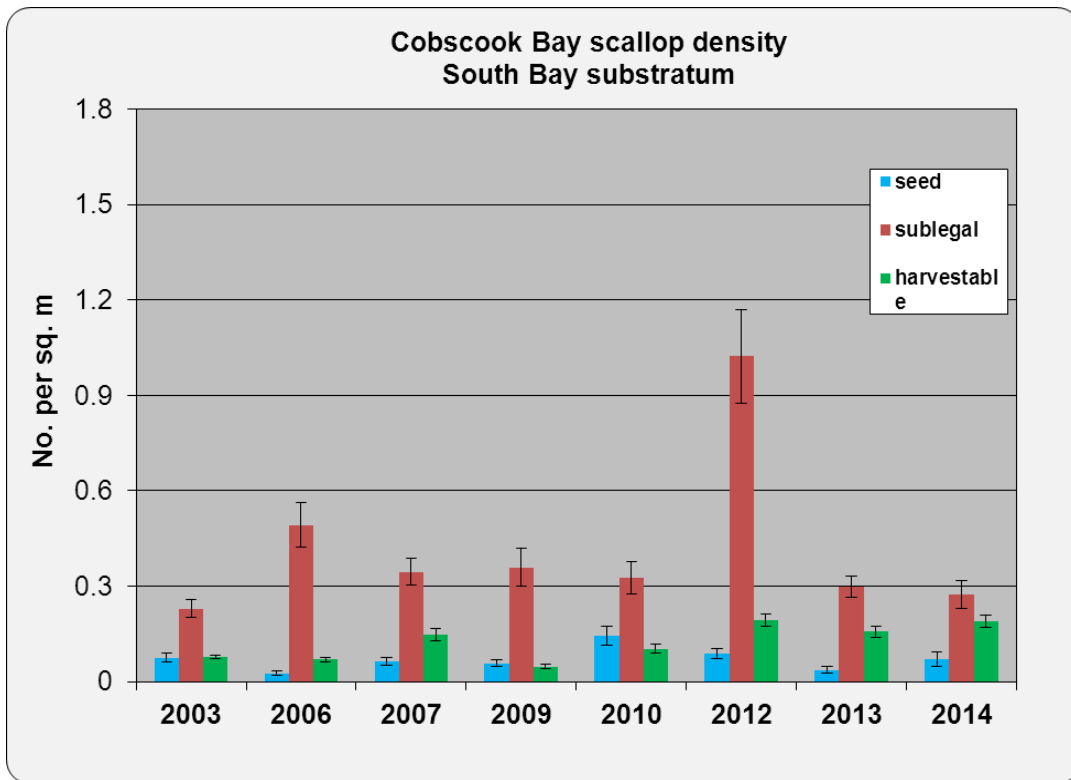


Figure 10. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, South Bay substratum of Cobscook Bay, 2003-14.

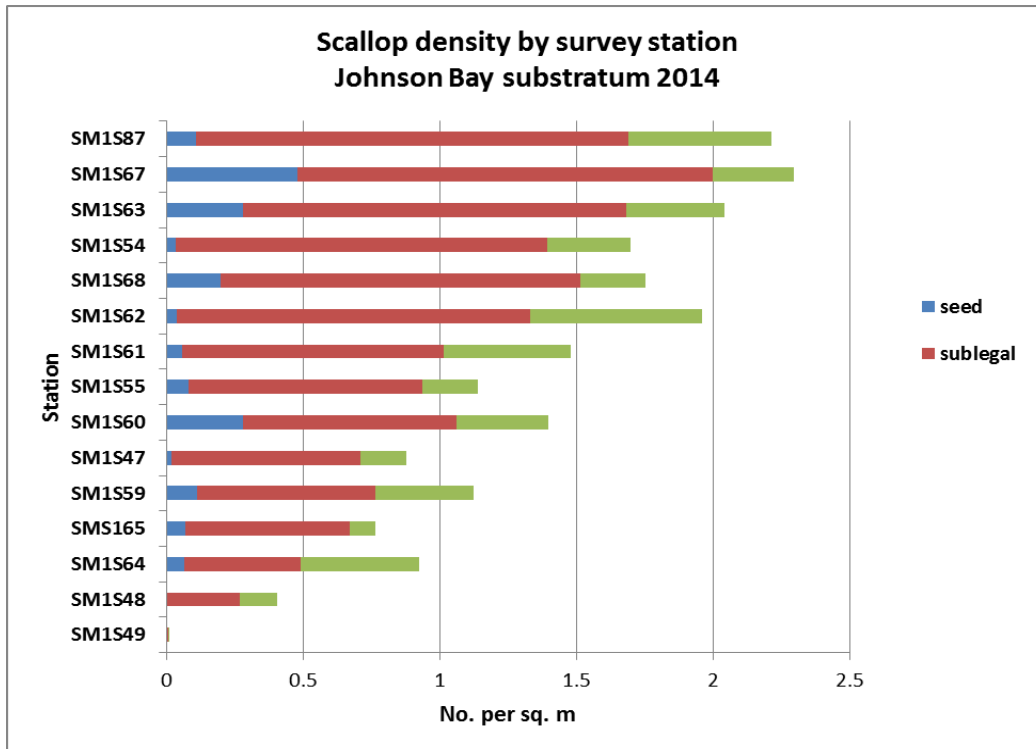


Figure 11. Scallop density by size class and survey station, Johnson Bay substratum of Cobscook Bay, 2014.

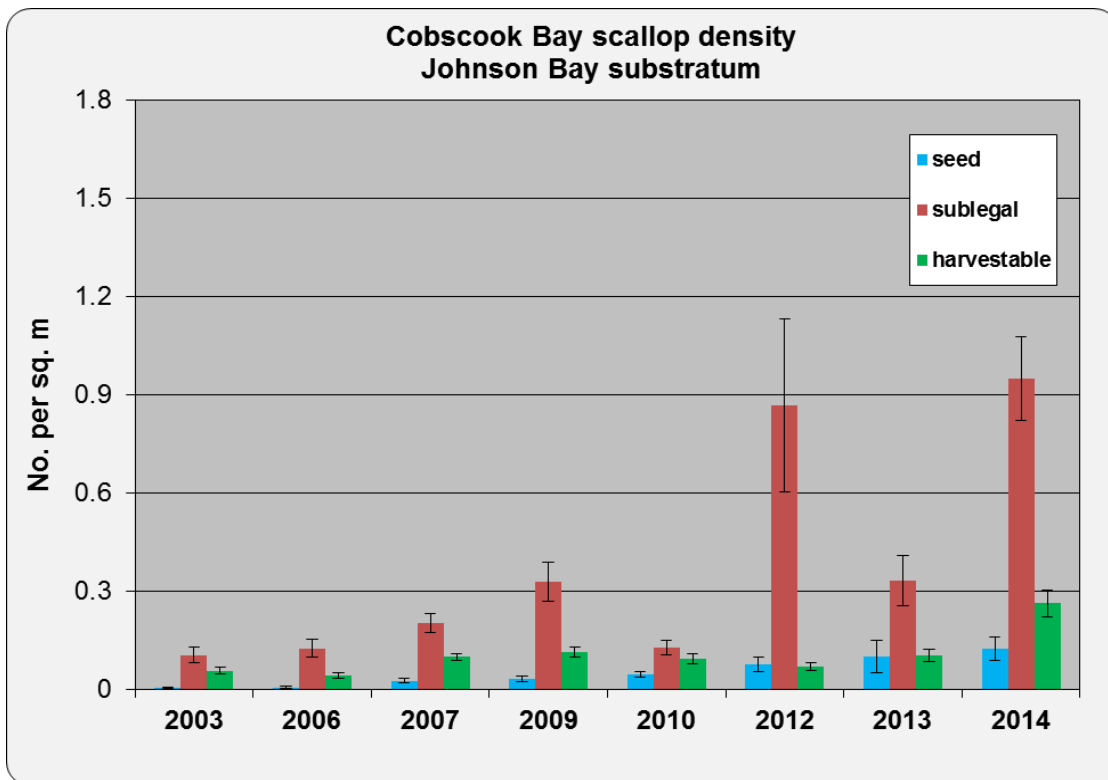


Figure 12. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Johnson Bay substratum of Cobscook Bay, 2003-14.

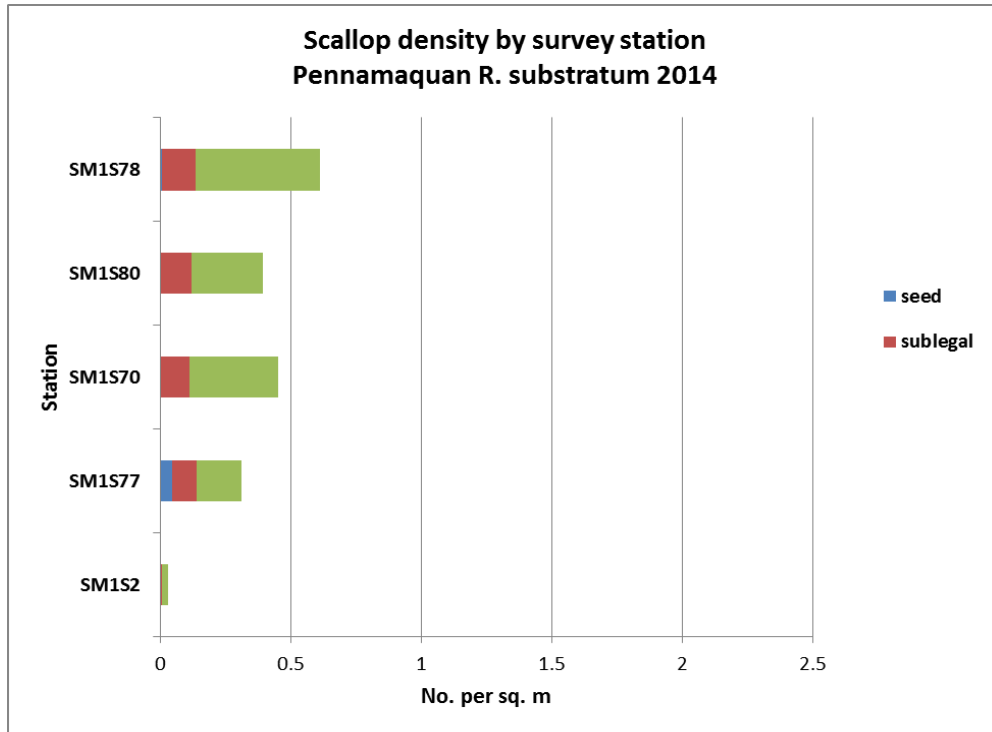


Figure 13. Scallop density by size class and survey station, Pennamaquan R. substratum of Cobscook Bay, 2014.

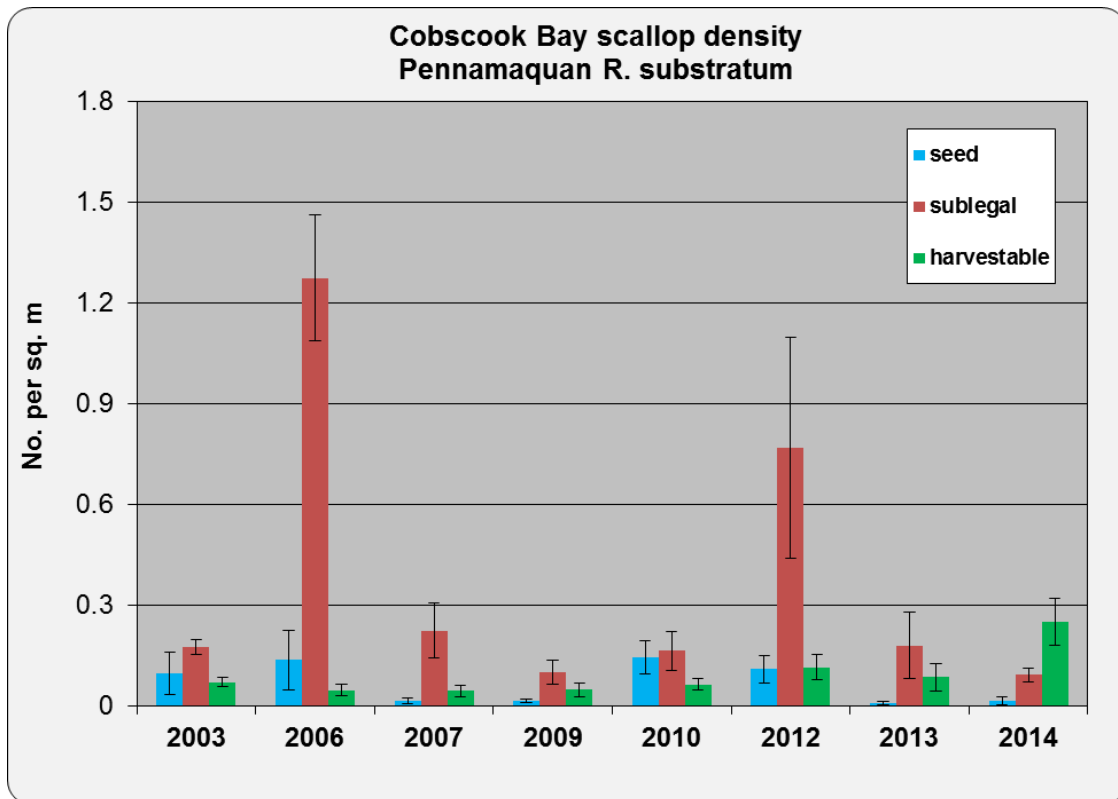


Figure 14. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Pennamaquan R. substratum of Cobscook Bay, 2003-14.

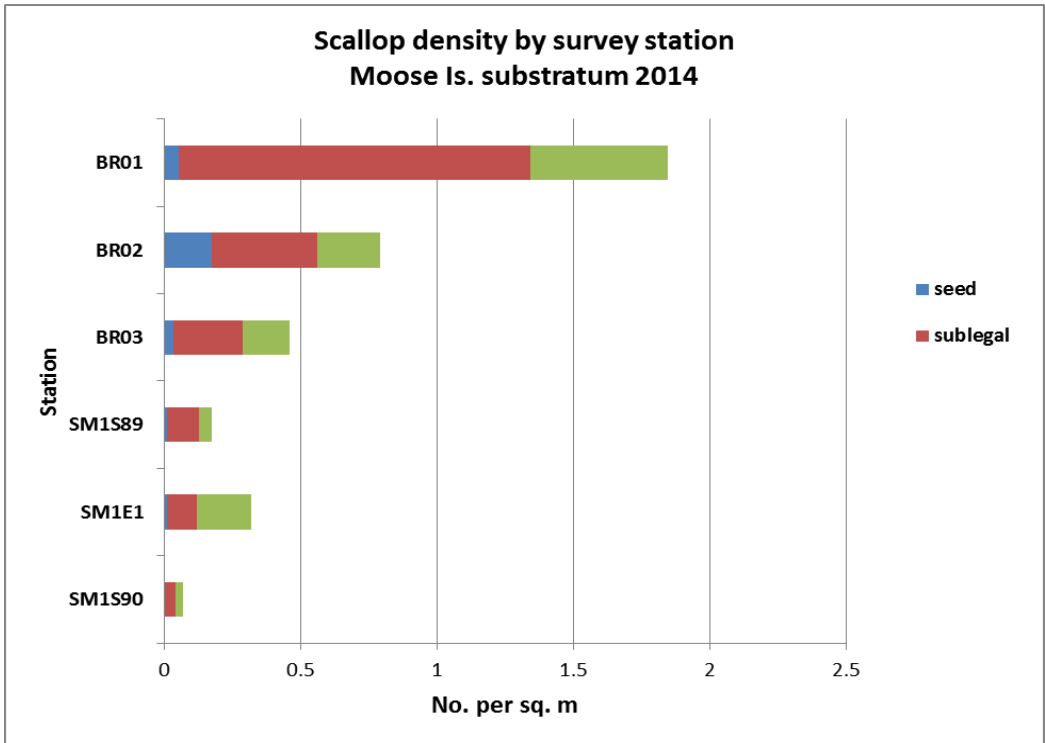


Figure 15. Scallop density by size class and survey station, Moose Is. substratum of Cobscook Bay, 2014.

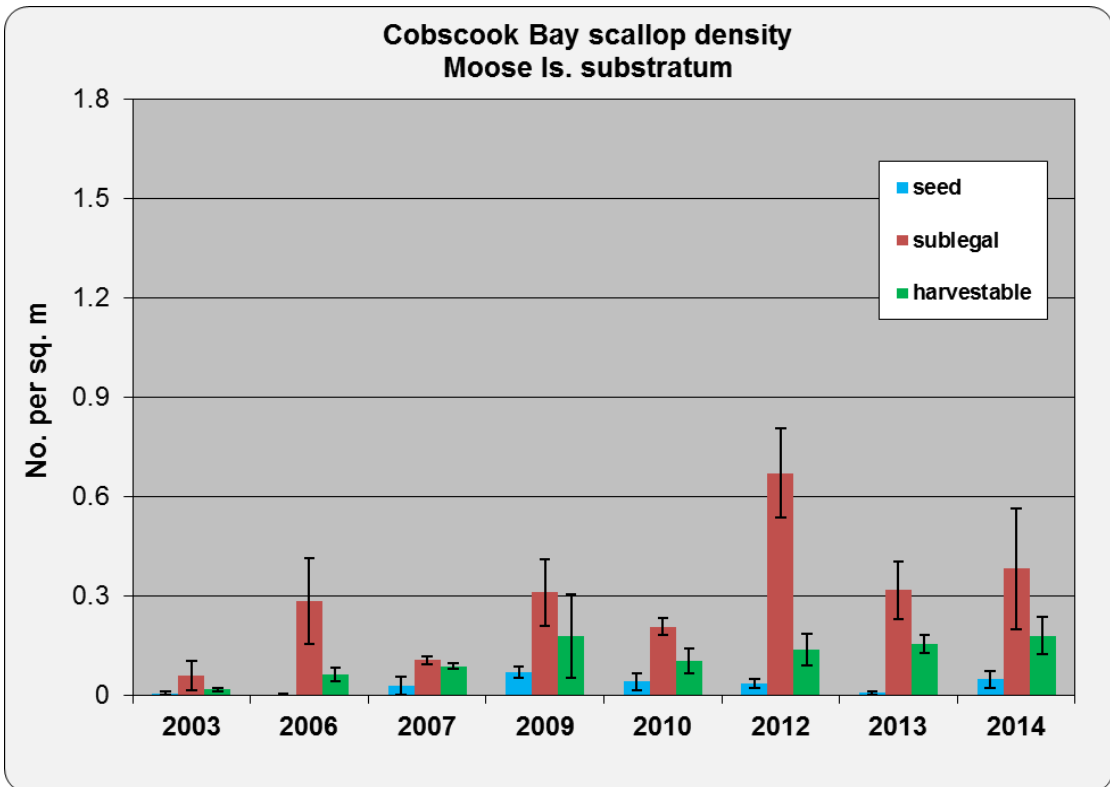


Figure 16. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Moose Is. substratum of Cobscook Bay, 2003-14.

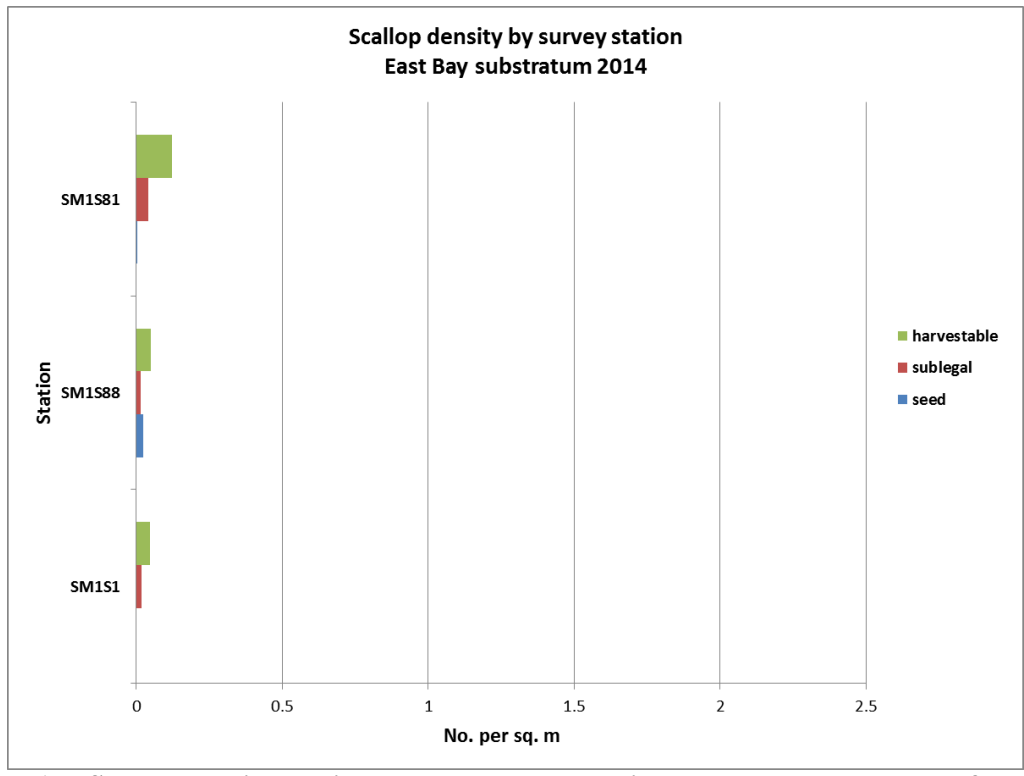


Figure 17. Scallop density by size class and survey station, East Bay substratum of Cobscook Bay, 2014.

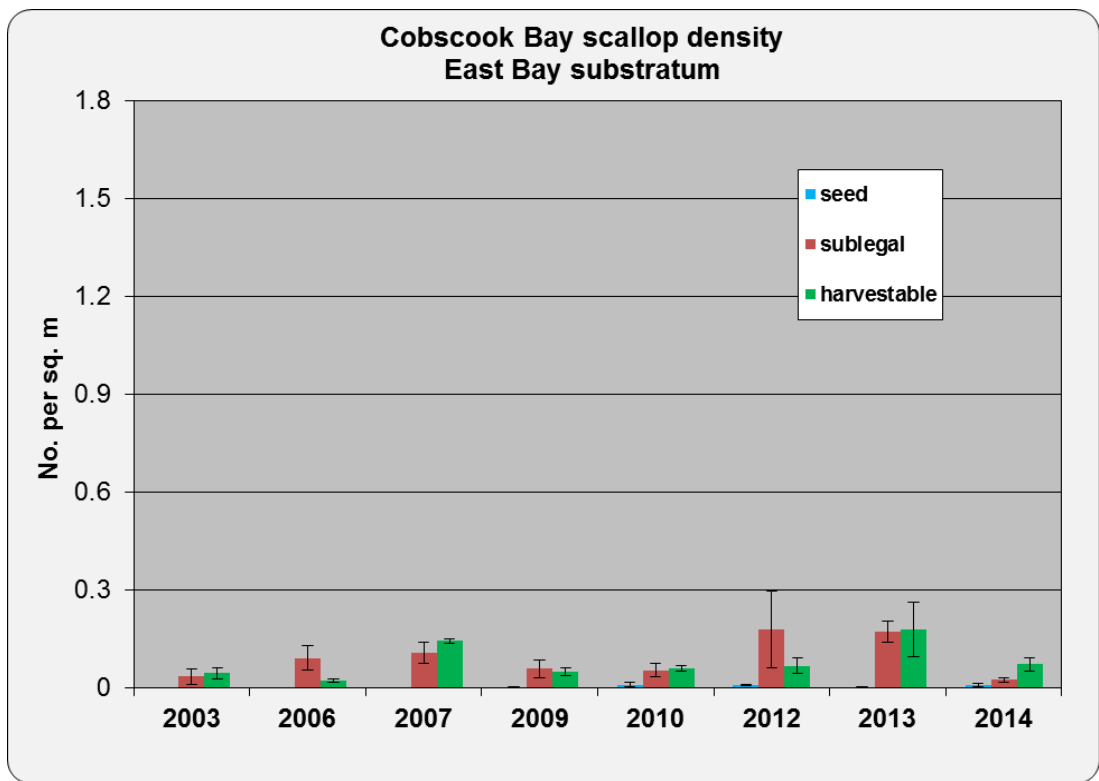


Figure 18. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, East Bay substratum of Cobscook Bay, 2003-14.

Limited Access Area (Whiting Bay/Dennys Bay)

There was a significant ($P < 0.001$) decline in harvestable density between 2013 (0.331 per m^2) and 2014 (0.172 per m^2) (Figs. 19-20). This was the second consecutive year of decline in harvestable density in Whiting Bay/Dennys Bay.

Seed abundance (0.035 per m^2) remained unchanged from 2012 (Fig. 20). Sublegal abundance (0.0312 per m^2) however declined significantly ($p < 0.001$) from the previous year (0.667 per m^2).

Size distribution in Whiting Bay/Dennys Bay was fairly similar to Cobscook Bay proper. Scallops were more prominent at 56-70 mm however than at 66-80 mm as in Cobscook Bay proper (Fig. 21) (i.e., a higher proportion of seed in Whiting Bay/Dennys Bay).

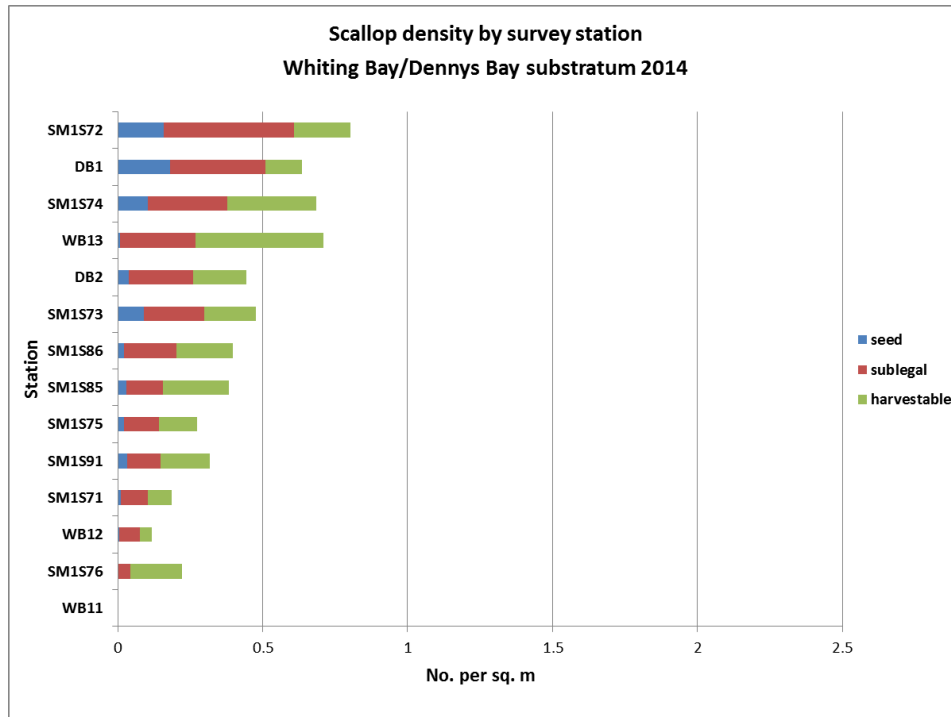


Figure 19. Scallop density by size class by survey station, Whiting Bay/Dennys Bay substratum of Cobscook Bay, 2014.

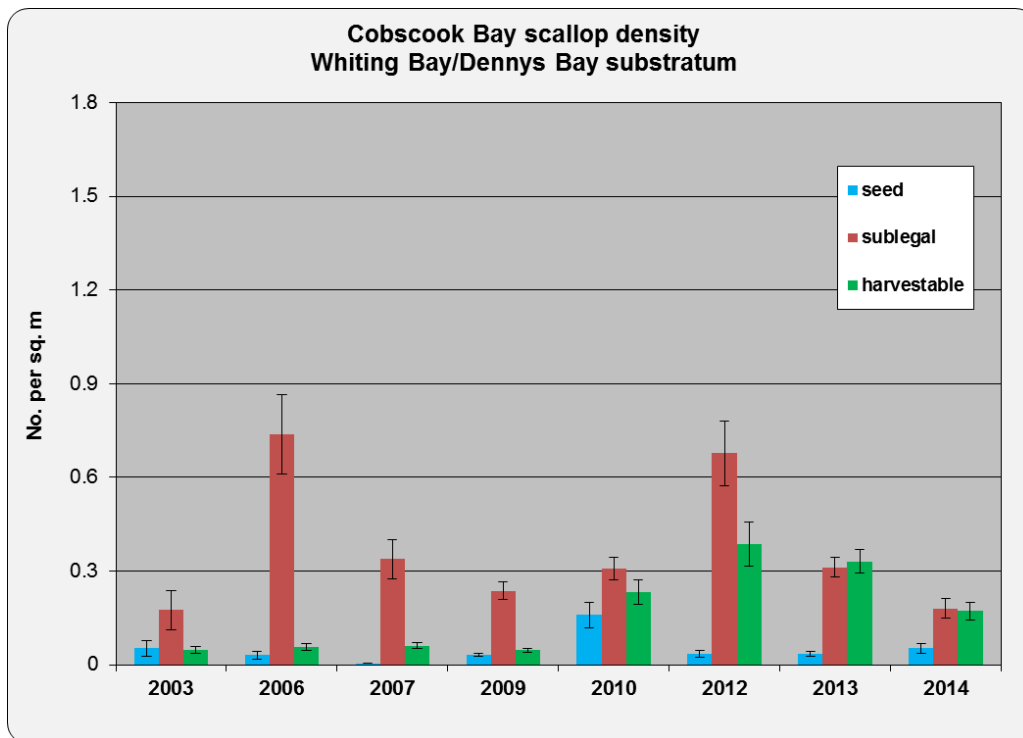


Figure 20. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Whiting Bay/Dennys Bay substratum of Cobscook Bay, 2003-14.

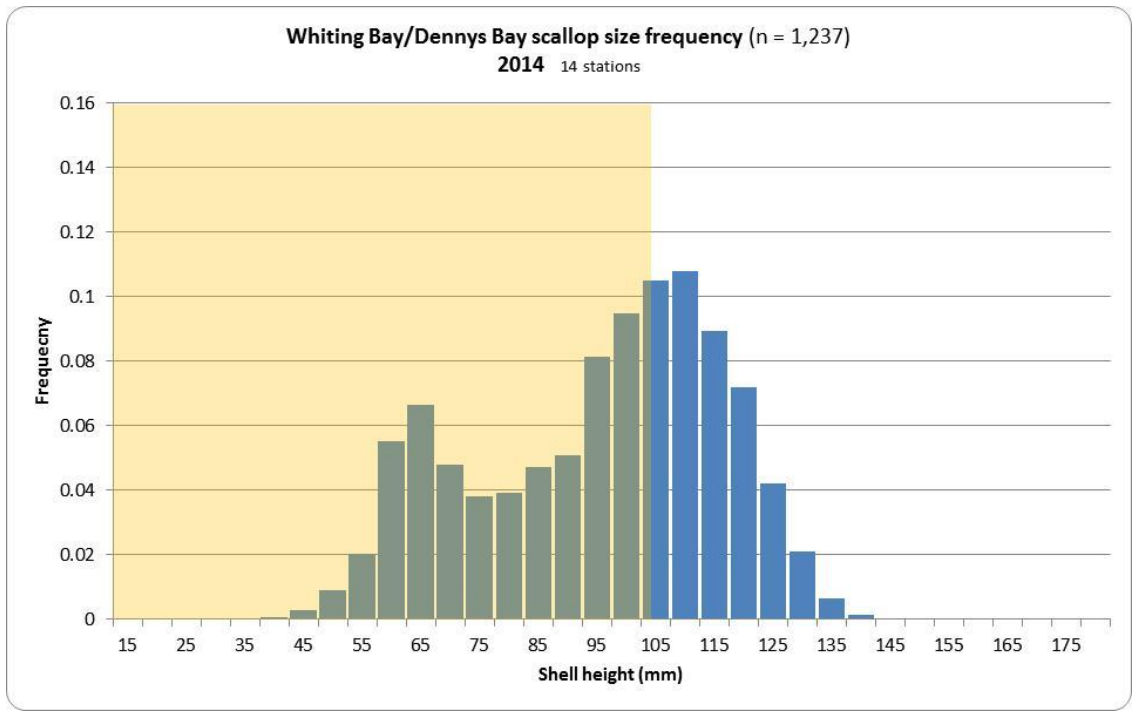
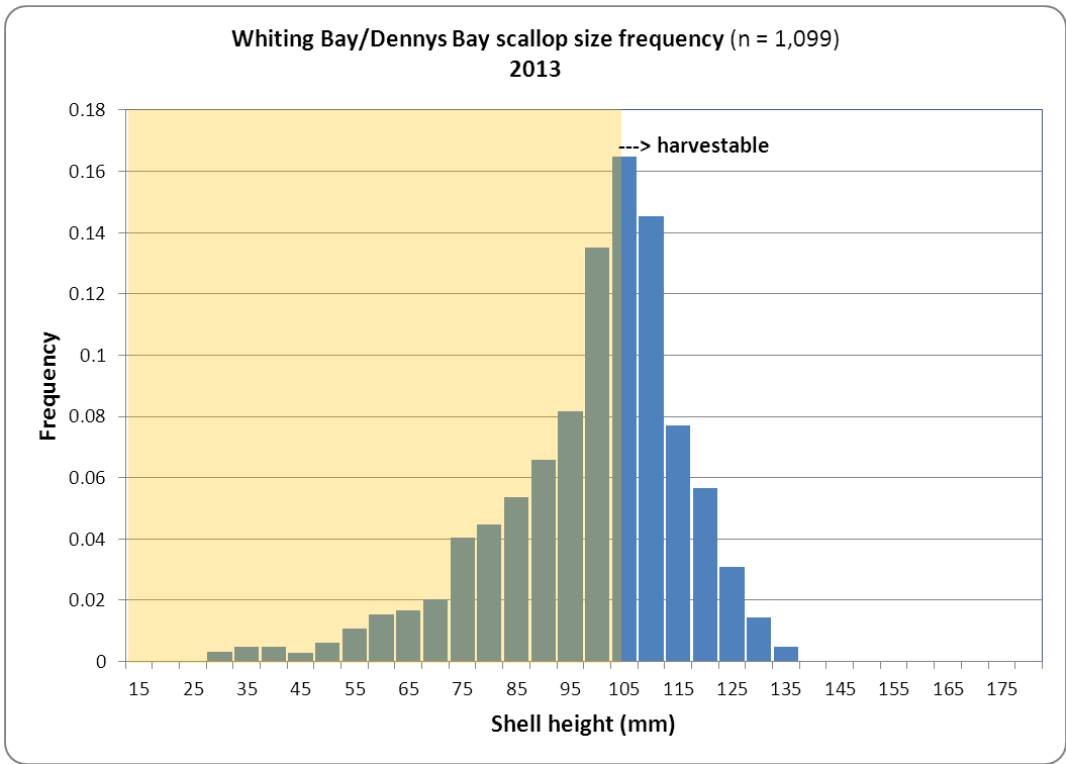


Figure 21. Size frequency (5 mm increments) of scallops in Whiting Bay/Dennys Bay, 2013 and 2014.

Meat weight

A shell height to meat weight relationship ($MW = 0.000043*(SH)^{2.839967}$) was calculated based on samples (n = 647) from the 2014 survey (Fig. 22). Scallop meat weight in 2014 was greater than 2013. Estimated meat size at 4.0 inch SH was in fact the highest of the time series. Overall 2014 meat weights were the highest since 2002-03 (Table 2).

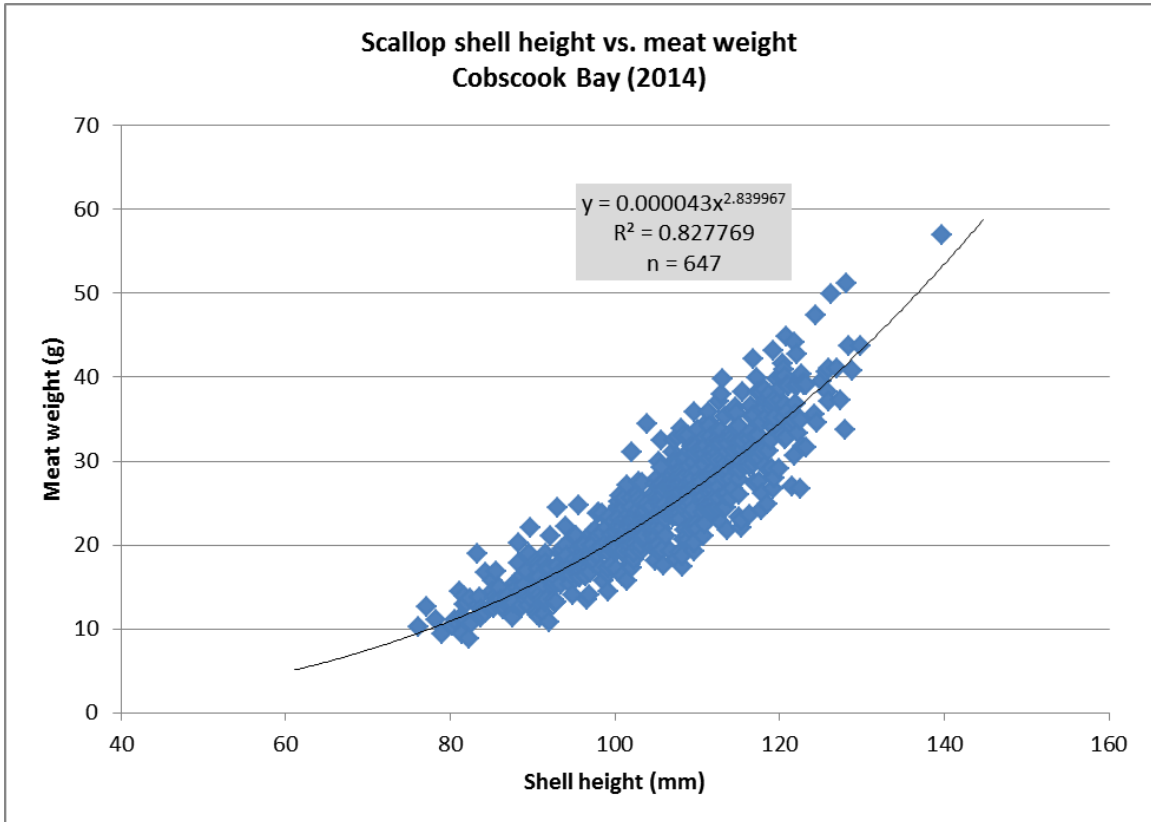


Figure 22. Scallop meat weight (MW) as a function of shell height (SH) for Cobscook Bay, 2014.

		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
2013	Meat weight (g)	20.0	28.9	40.3
	Count per lb.	23	16	11
2014	Meat weight (g)	21.5	30.1	40.6
	Count per lb.	21	15	11

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 2012-2014 Cobscook Bay survey data.

Harvestable biomass

Scallop harvestable (≥ 4 in. SH) biomass (by meat weight) was calculated by applying the 2014 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 (6) substrata.

In 2014 the mean total harvestable biomass of Cobscook Bay (including Whiting Bay/Dennys Bay) was $288,400 \pm 19,000$ kg ($635,900 \pm 41,900$ lbs.; Fig. 23). This was greater than 2013 and was the highest value of the eight-year time series. South Bay contained 50% of the harvestable biomass followed by Johnson Bay (23%) and Moose Is. (15%).

Harvestable biomass in the Whiting Bay/Dennys Bay limited access area decreased 44% from 72,100 lbs. (2013) to 40,700 (Figs. 23-24). This was the second consecutive year of decline in this area. Harvestable biomass was the lowest since prior to the three-year closure in 2009.

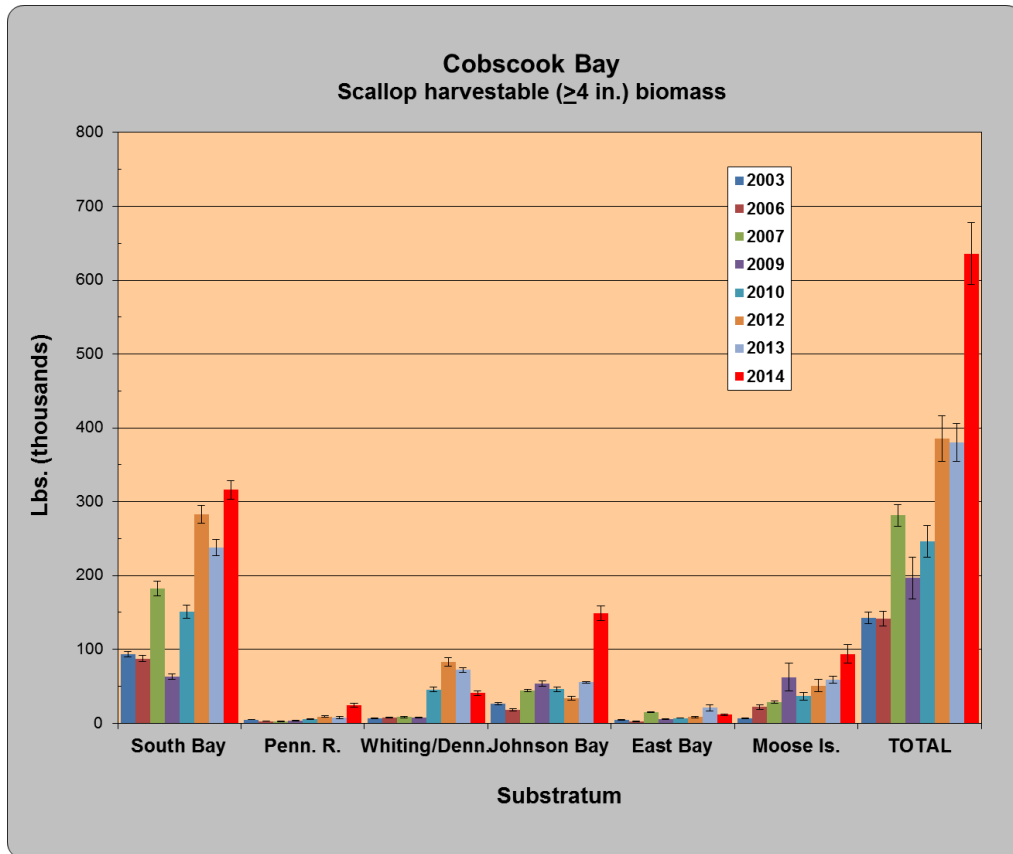


Figure 23. Biomass (meat weight, with standard error) of harvestable (legal-size) scallops in Cobscook Bay, 2003-14.

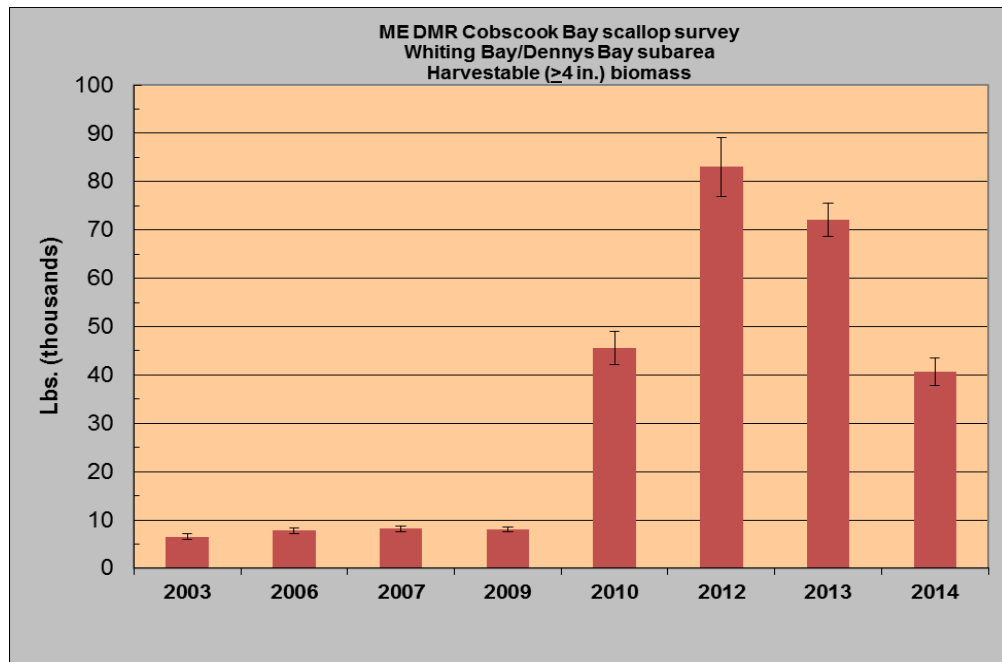


Figure 24. Biomass (meat weight, with standard error) of harvestable (legal-size) scallops in Whiting Bay/Dennys Bay, 2003-14.

Stratum 1A (St. Croix River)

Ten stations were completed between Devils Head and Kendalls Head in 2014 (Fig. 25). Seed density (0.002 per m²) remained very low. Sublegal density declined significantly ($p < 0.001$) from 0.321 per m² in 2013 to 0.056 per m² in 2014. Harvestable density (0.062 per m²) however increased from 2013 (0.031 per m²) and was the highest of the time series (Figs. 25-26). The predominant size mode was at 101-105 mm (Fig. 27).

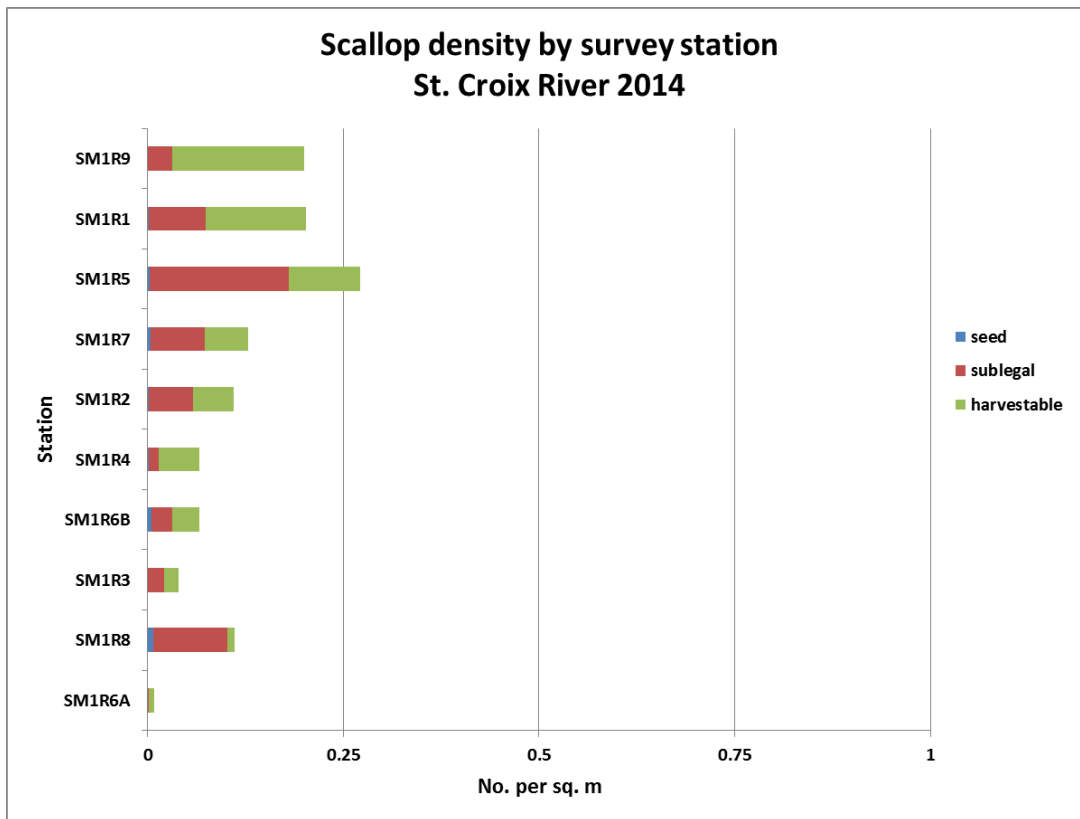


Figure 25. Scallop density by size class and survey station, Stratum 1A, 2014.

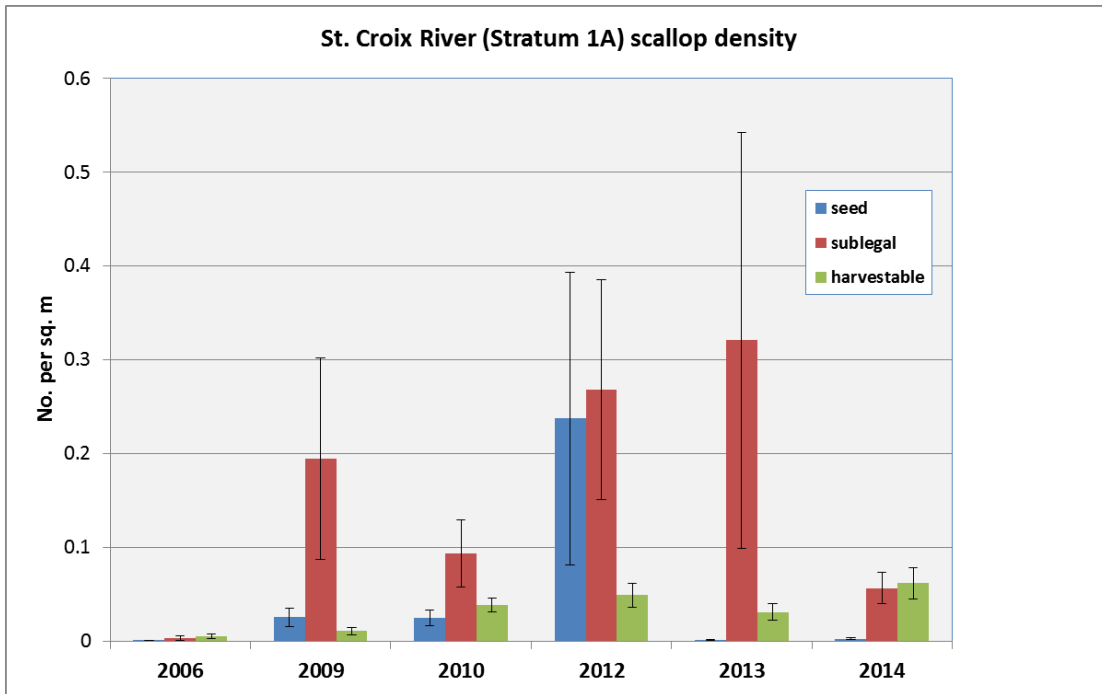


Figure 26. Mean scallop density (with standard error, unadjusted for dredge efficiency) by size class, Stratum 1A, 2006-13.

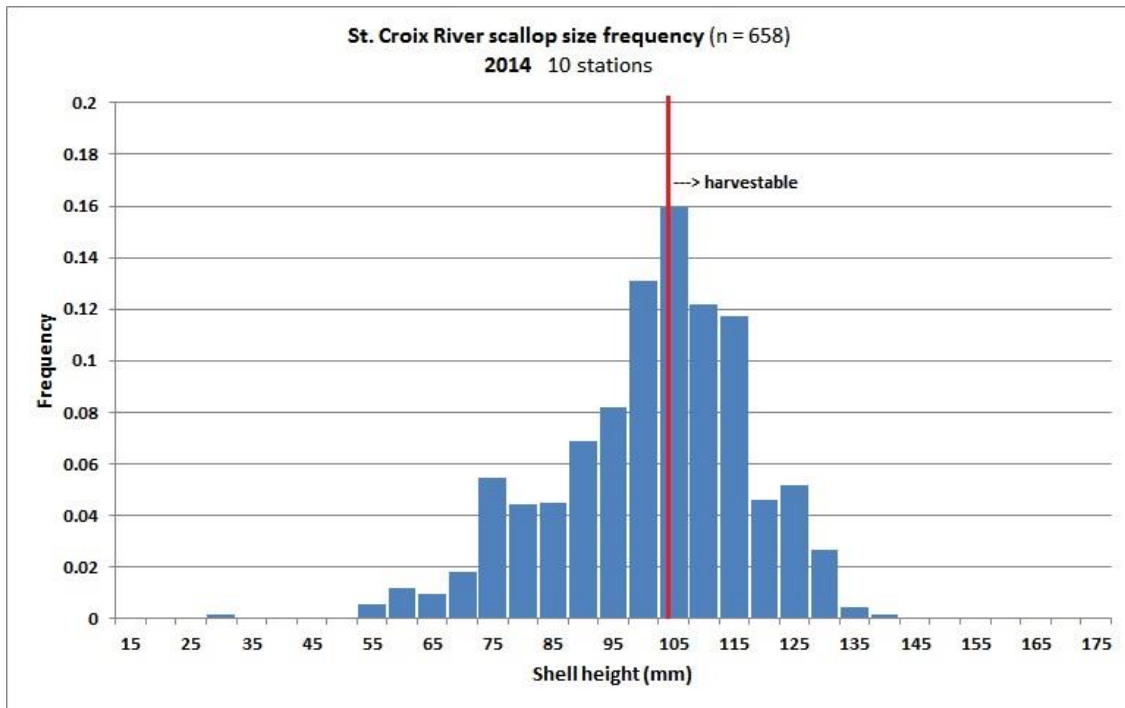


Figure 27. Size frequency (5 mm increments) of scallops in Stratum 1A, 2014.

Conclusions

Cobscook Bay in 2014 had the largest amount of harvestable scallop biomass yet observed on the survey. The harvestable biomass was estimated to be 65% greater than the previous high in 2012. The size distribution of harvestable scallops appeared more protracted than in previous years. Thus there were more larger scallops which contributed greater meat yield. Higher than average meat weight, particularly for 101.6 mm (4 inch) SH scallops, was also observed in the 2014 survey.

Along with South Bay there was a particularly large amount of harvestable biomass in the Johnson Bay and Moose Is. substrata. The areas having time-series high densities of harvestable scallops were Pennamaquan R., Johnson Bay and Moose Is.

Whiting/Dennys Bay had a decline in harvestable scallops for the second consecutive year. Both harvestable biomass and density were at their lowest point since the area was closed to fishing for three years in 2009 and became a limited access area in 2012. The St. Croix River had a relatively poor abundance of scallops, particularly seed and harvestables. A high amount of sublegals were observed at one location near St. Croix Is., following a high abundance of seed in 2012

Acknowledgements

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