Results from the 2007 Maine Sea Scallop Survey

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Executive Summary

The Maine scallop survey was carried out in fall 2007 prior to the December 1 opening of the fishery in Cobscook Bay (Stratum 1). Cobscook Bay was last surveyed in fall 2006. The systematic survey of 84 stations indicated a large increase in abundance and biomass of harvestable (≥ 4 in. shell height (SH)) scallops in Cobscook Bay in 2007. The abundance of harvestable scallops was 96.2% greater than the previous high observed in ’03. This followed the high abundance of sublegal (2.5 – 3.9 in. SH) scallops observed in 2006. Meat weights from 2006-07 were lower than those in 2002-03 (18% less meat weight at 4 in. SH). The 2007 estimate of harvestable biomass (281.3 thsd. lbs.) was 99.4% higher than the previous year. South Bay had the largest proportion (65%) of harvestable biomass. Although sublegal scallop abundance declined in ’07 from the high level of ’06 the density of seed (< 2.5 in. SH) was significantly higher in South Bay in ’07 than ’06.

Introduction

Sea scallops (*Placopecten magellanicus*) 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 dredge, although Maine also permits commercial and non-commercial harvest of scallops by diving. Although Maine scallop landings are currently low (Fig. 1), at times the value of the Maine scallop fishery has been second only to lobster. The scallop fishery in the Gulf of Maine occurs primarily in state waters.

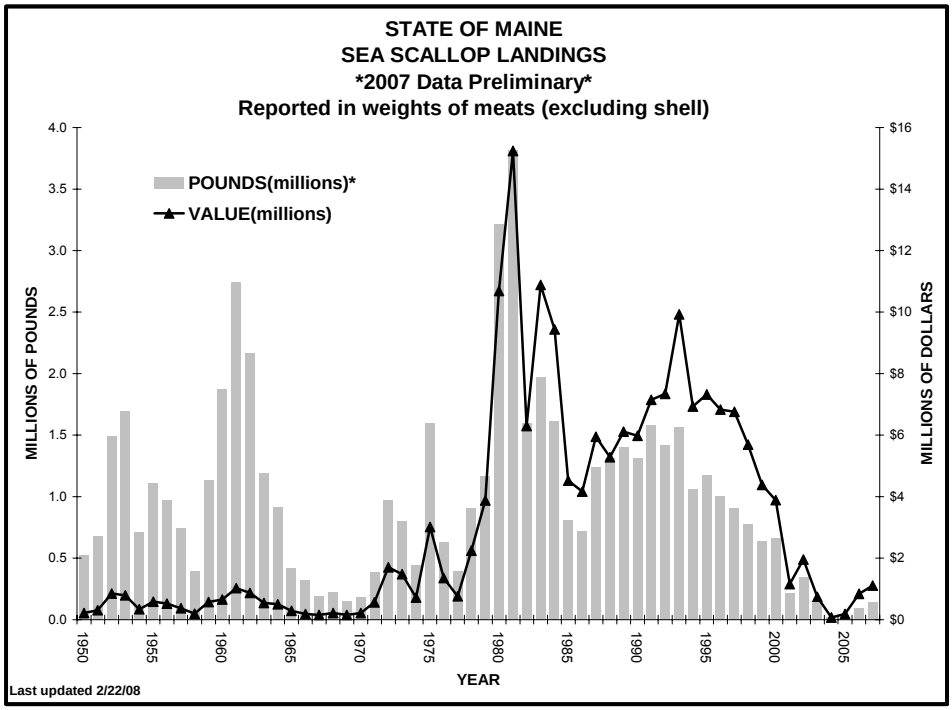


Figure 1. Maine scallop landings 1950-2007 (source: Maine Department of Marine Resources (DMR)).

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). This survey provides information on size distribution, the shell height-meat weight relationship, abundance, stock size and spatial distribution of scallops from nearshore waters. For the first two years (2002, 2003) the entire coast was surveyed. Subsequent to this one of three (New Hampshire border to western Penobscot Bay, eastern Penobscot Bay to Quoddy Head, 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	New Hampshire border to western Penobscot Bay
2006	eastern Penobscot Bay to St. Croix River, including Cobscook Bay (*higher intensity survey than '02 and '03*)
2007	Cobscook Bay

Total harvestable biomass has been estimated for the most productive and heavily-fished section of the coast (Cobscook Bay) based on this survey (Kelly 2007; Schick and Feindel 2005).

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. The survey provides information on geographic distribution, relative abundance, population size structure, meat yield and occurrence of seed and sublegal scallops.

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, closed areas to protect spawning and enhance recruitment, and area-specific strategies such as for Cobscook Bay.

The 2007 survey took place in survey stratum 1 (Cobscook Bay). Cobscook Bay is a large macrotidal estuary located adjacent to the U.S./Canada border at the extreme eastern edge of the Maine coast. It has particular importance as a scalloping area in Maine and also also supports drag fisheries for sea urchins and sea cucumbers. Scallop fishing in Cobscook Bay is subject to a special set of regulations on drag width (5½ ft. max.), meat count (35/lb. max.) and possession (15 gal. meats/day max.).

The '07 survey followed the '06 survey which indicated Cobscook Bay had the highest scallop density of all Maine coastal strata (Kelly 2007). This finding was consistent with previous surveys (Schick and Feindel 2005). The '06 survey also indicated a large increase in abundance of sublegal scallops in Cobscook Bay compared to '03 when this area was previously surveyed. Following the '06 survey there was interest in determining if high sublegal abundance would carry through to the harvestable population in '07.

Methods

Vessels and timing

The '07 survey was carried out over 5½ survey days during Nov. 1-10. The contracted vessel was the 40 ft. *F/V Bad Company* from Lubec. An option had been proposed in July by the DMR Scallop Advisory Council to perform the survey using one or more volunteer vessels whose owners would be reimbursed only for basic costs such as fuel and insurance. This option was pursued with several captains for approximately 2½ months until it was determined that no boats in the survey area that were rigged to handle the survey dredge were available on a volunteer basis. Therefore a captain was recruited who a.) had previous survey experience, b.) had a vessel that could handle the survey drag and was homeported in the survey area, c.) was willing to do the survey for a reduced monetary amount and d.) was available at the required time to do the survey and on relatively short notice to get a contract in place.

Gear

The survey dredge (Fig. 2) was a 7 ft. wide chain sweep**.** Drag specifications had been determined prior to construction of the gear for the inaugural DMR scallop survey ('02) in consultation with several Maine scallop industry members. There were 2½ in. rings in the ring bag to retain small scallops. The dredge was unlined and had rock chains. The twine top was double hung with 3½ in. mesh. The drag size and weight represented a compromise between being wide enough to cover a significant area per tow, heavy enough to sample deeper waters and of a size while still small enough to be transported by a large pickup truck (Schick and Feindel 2005).

Figure 2. View of survey drag showing position of rock chains.

Survey design

Stratum 1 (Cobscook Bay) is one of of 13 survey zones, or "strata", used for the DMR scallop survey. Cobscook Bay 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, Johnson Bay and area: 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. The total number of stations sampled was increased by 31% in '06 from previous surveys.

Tow locations are based on a 500 m grid overlaying each stratum (Figs. 3-5). This grid accommodates an average tow length of approximately 300 m. There were 84 tows completed in the '07 Cobscook Bay survey. Forty-nine tows were in South Bay, the largest substratum (1,182 hectares).

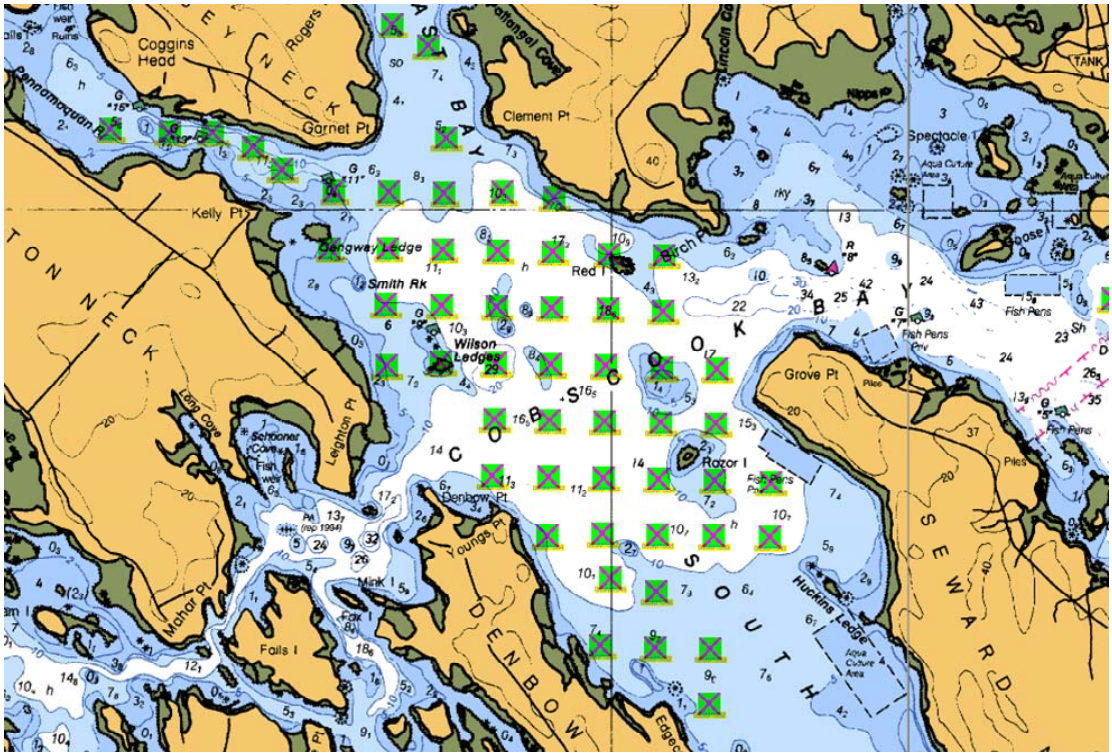


Figure 3. Sampling stations for South Bay, Pennamaquan River and East Bay.

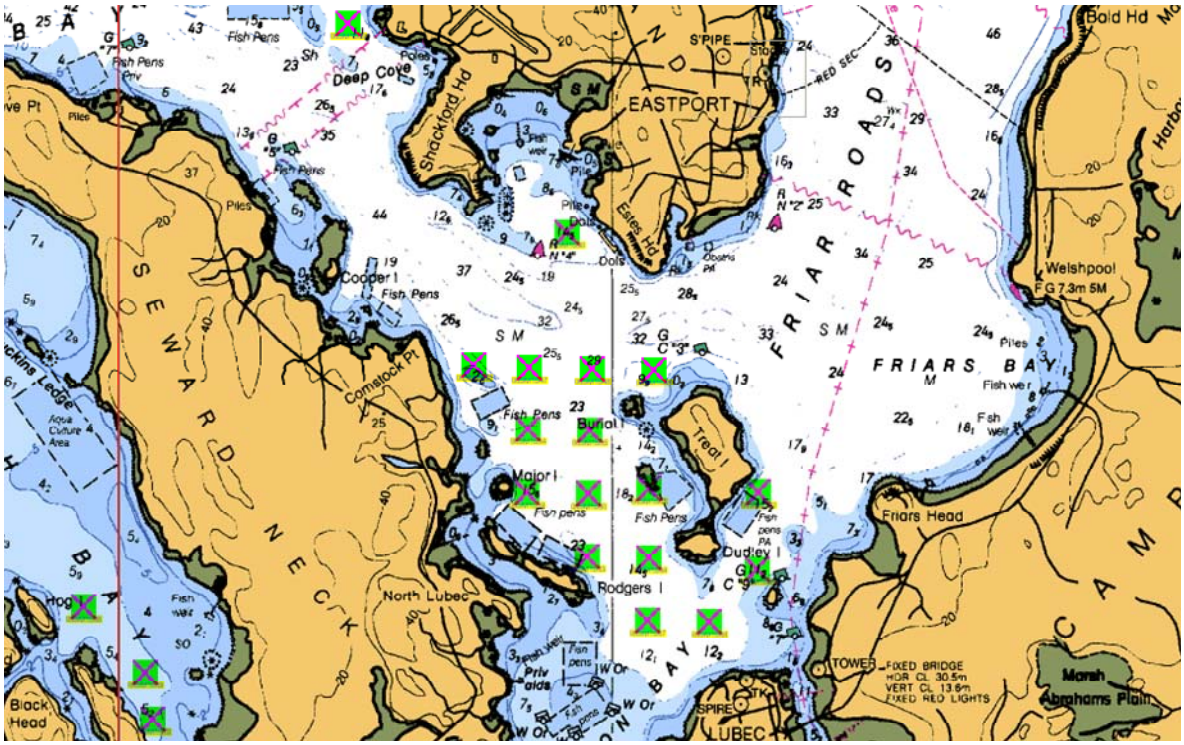


Figure 4. Sampling stations for Johnson Bay and area: other.

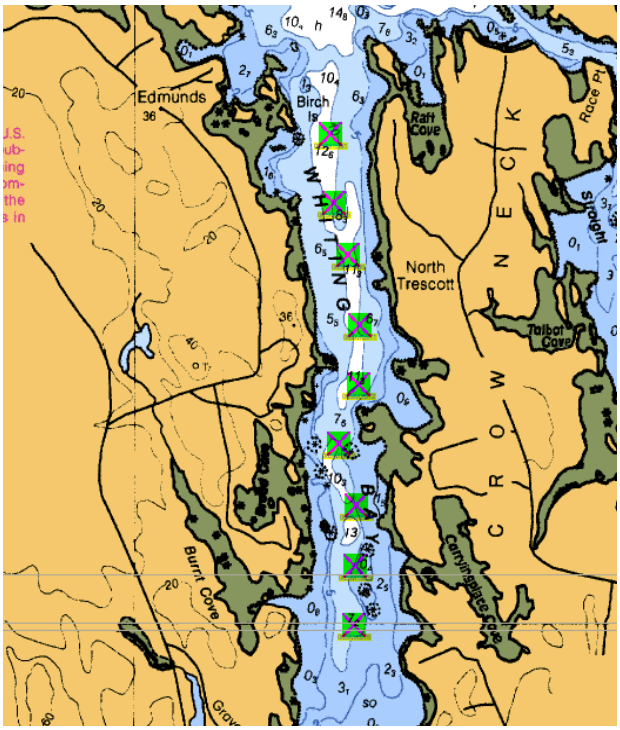


Figure 5. Sampling stations for Whiting Bay.

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. Each tow was approximately 2½ minutes at a vessel speed of 3½ knots in a straight line.

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.) 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. At least 100 scallops (or all scallops if $n \leq 100$) from each tow were measured for SH. 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 (using an Ohaus Navigator™ balance interfaced with the ruggedized handheld computer) on shore and matched to the corresponding shell measurements.

The following table summarizes data collected for each tow:

Data items collected – ME DMR Sea Scallop survey

COLLECTED DATA - FIELD SUMMARY

TRIP	STATION INFORMATION IDENTIFIERS	TOW LOCATION	TOW INFO	ENVIRON. DATA
Trip identifier	Tow identifier	Dredge in (Lat, Lo, Time stamp)	Tow time elapsed	Bottom type
Trip date	Zone	Tow start (Lat, Lo, Time stamp)	Depth	Bottom temperature
Port sailed from	Strata	Haulback (Lat, Lo, Time stamp)	Bearing	
Weather	Location (description)	Drag off-bottom (Lat, Lo, Time stamp)	Wire out	
Precipitation	Tow number	Distance towed	Tow speed	
Wind/ sea stata	Sample type			
Return time	(random, exploratory, "fixed", other)			
Comments				

SCALLOP DATA CATCH	SIZE STRUCTURE	BIOMETRICS	BYCATCH
Number scallops caught	Shell height	Shell height	Tow photo ID
Volume of catch (shellstock)		Shell length	Species
Weight of catch (shellstock)		Shell depth	Abundance (1-5 scale)
Proportion of tow sampled (100, 50, 25%)		Meat weight	Trash type
Number of clappers			Trash amount (1-5 scale)
Coments			Comments

AUXILLARY DATA QUAHOG CATCH	SEA CUCUMBER CATCH	CTD DATA
Number of quahogs	Number of cucumbers	Location (lat/ long)
Shell height	Catch weight	File identifier
Shell length	Catch volume	
Shell depth	Coments	
Shell (dead) abundance (1-5 scale)	Size index (SL x diam 1 x diam 2)	

from Schick and Feindel (2005)

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 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 – 101.5 mm) SH
- "harvestable": ≥ 4 in. (101.6 mm) SH

(For '03, the legal standard for harvestable size was ≥ 3¾ in. (95.25 mm) SH and sublegal was 2½ in. to < 3¾ in. (63.5 – 95.24 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. Harvestable biomass was calculated by applying a calculated shell height-meat weight relationship to the numbers of harvestable scallops at shell height per substratum. Biomass was summed across substrata to determine total harvestable biomass for Cobscook Bay.

Results

The survey comprised 84 total tows within the six substrata of Cobscook Bay. There were 5,488 scallops measured for shell height and an additional 433 scallops measured and sampled for meat weight determination. The smallest individual sampled was 17.0 mm (0.67 in.) SH and the largest was 145.0 mm (5.71 in.) SH. Two tows caught no scallops and the largest number of scallops in a single tow was 627 in South Bay.

Abundance

Overall scallop abundance in Cobscook Bay declined slightly from ’06 but remained at a relatively high level (56.3% higher than ’03: Table 1; Fig. 6). Abundance increased by 109.3% for seed and 102.2% for harvestable over ‘06. The abundance of harvestable scallops in ’07 was 96.2% higher than the previous high reported in ’03. Sublegal abundance declined from ’06 as high numbers from that size class grew to harvestable size in ‘07.

In South Bay, the largest substratum (48 stations), the estimated abundance of harvestable scallops increased by 110.2% between ’06 and ’07 (828.7 thsd. scallops in ’06 vs. 1.742 mil. scallops in ’07: Table 1; Fig. 7). The density of harvestables was significantly ($p<0.001$) greater in ’07 (0.147 per m²) than ’06 (0.070 per m²). South Bay had the highest density of harvestable scallops in Cobscook Bay in ’07.

Although sublegal scallop abundance declined in ’07 from the high level of ’06, the density of seed (< 2.5 in.) was significantly ($p=0.008$) higher in South Bay in ’07 (0.064 per m²) than ’06 (0.025 per m²). Seed abundance in South Bay was the highest of any of the substrata. Sublegal density (0.345 per m²) was lower (not statistically significant) than in ’06 (0.492 per m²) but slightly higher than in ’03 (0.228 per m²). South Bay had the highest density of sublegals of any substrata in ’07.

East Bay is a small substratum (3 stations) that had 120.7% higher abundance in ’07 than in ’06 and 212.1% higher abundance than in ’03 (Table 1; Fig. 8). Most notably there were significantly ($p<0.001$) more harvestable scallops in ’07 (0.144 per m²) than in either ’03 or ’06. Sublegal abundance was at approximately the same level as ’06.

Pennamaquan River (7 stations), which had a very high presence of sublegals in ’06 (1.274 per m²), did not realize an increase in harvestable abundance in ’07 (Table 1; Fig. 9). Very few seed were observed and sublegal abundance was much more like ’03 than ’06. Harvestable density (0.045 scallops per m²) was similar to previous years.

Whiting Bay (9 stations) also did not realize an increase in number of harvestables following the high abundance of sublegals in ’06 (Table 1; Fig. 10). Harvestables (0.060 per m²) were at similar levels to ’03 and ’06. Sublegal density (0.338 per m²) although lower than ’06 was higher than ’03.

There was a 89.8% increase in scallop abundance in Johnson Bay (15 stations) between ’06 and ’07 among all sizes (Table 1; Fig. 11). Harvestable density was significantly ($p<0.001$) higher (0.099 per m²) in ’07 than ’06 (0.042 per m²). Sublegals increased slightly (not statistically significant) from 0.126 per m² in ’06 to 0.203 per m² in ’07. Seed abundance was significantly ($p=0.008$) higher in ’07 (0.027 per m²) than in ’06 (0.007 per m²).

The substrata identified as “other” consists of 3 stations (Eastport breakwater, Broad Cove and Deep Cove). Overall scallop abundance was 36.0% lower than ’06 largely due to a reduced number (which was still 75.1% higher than ’03) of sublegals. Harvestable density (0.089 per m²) was slightly (not statistically significant) higher than ’06 (0.063 per m²) (Table 1; Fig. 12).

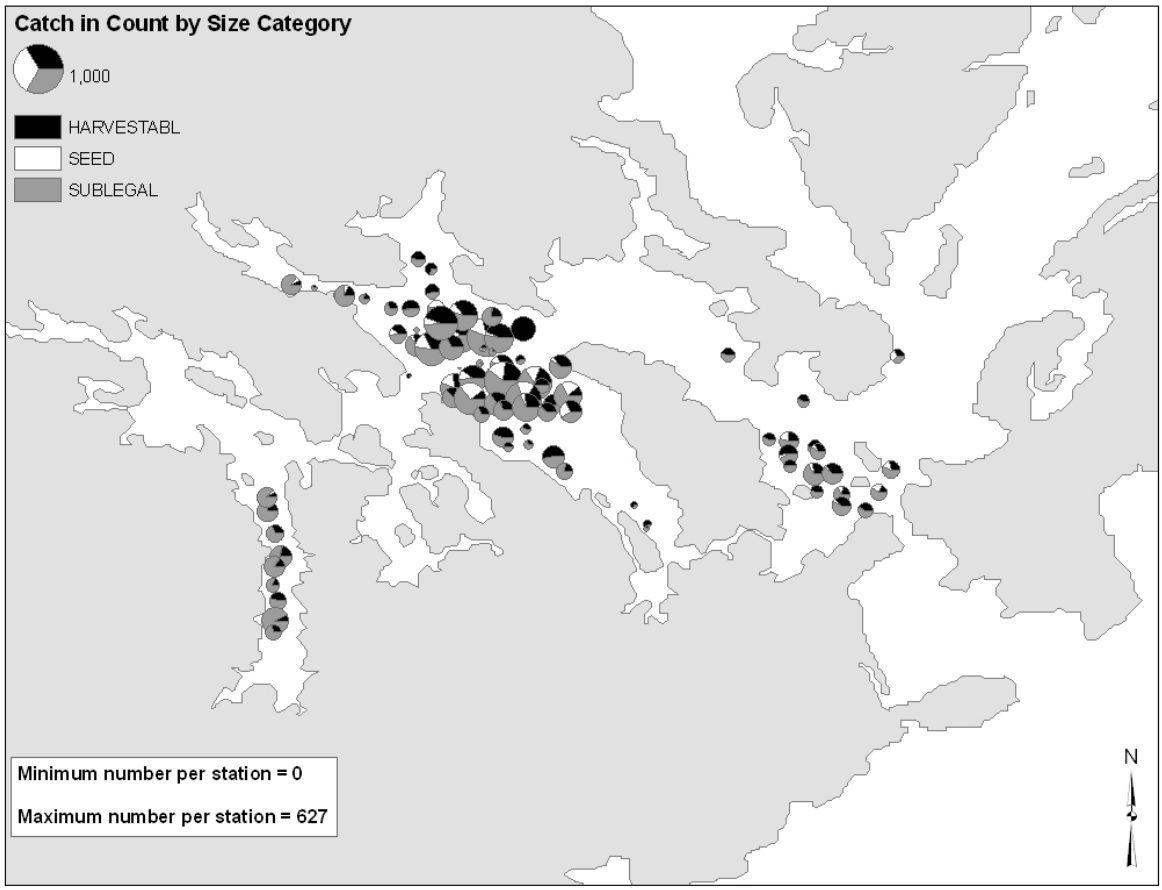


Figure 6. Scallop size class composition and abundance (Cobscook Bay), 2007 survey.

Table 1. Survey summary statistics for Cobscook Bay (2007) by substratum and overall (mean +/- standard error).

Stratum 1 (Cobscook Bay) scallop survey - 2007

substratum	total		South Bay		East Bay		Penn. River		Whiting Bay		Johnson Bay		other	
area (hec)	2,158		1,182		92		64		135		401		284	
no. sites	83		48		3		5		9		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			0.064	0.013	0	0	0.017	0.009	0.004	0.002	0.027	0.006	0.029	0.027
sublegal			0.345	0.042	0.108	0.031	0.225	0.083	0.338	0.062	0.203	0.028	0.107	0.011
harvestable			0.147	0.018	0.144	0.008	0.045	0.017	0.060	0.009	0.099	0.010	0.089	0.010
all sizes			0.556	0.066	0.252	0.037	0.287	0.103	0.402	0.063	0.330	0.038	0.224	0.037
			Abundance (no. scallops)											
	abundance		abundance	S.E	abundance	S.E	abundance	S.E	abundance	S.E	abundance	S.E	abundance	S.E
seed	964,714		757,544	147,935	0	0	10,792	5,531	5,655	2,487	108,018	25,975	82,706	76,000
sublegal	5,891,034		4,073,386	500,090	99,133	28,358	143,899	53,111	455,899	83,118	815,680	111,276	303,037	31,850
harvestable	2,635,277		1,741,962	210,599	132,439	7,599	28,885	10,665	81,462	12,449	398,798	39,610	251,731	27,170
all sizes	9,491,025		6,572,892	785,229	231,572	33,669	183,576	66,200	543,016	84,968	1,322,495	153,474	637,474	105,264
	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
	55,637	6,712	36,084	4,444	2,921	128	560	202	1,620	256	8,757	857	5,696	825

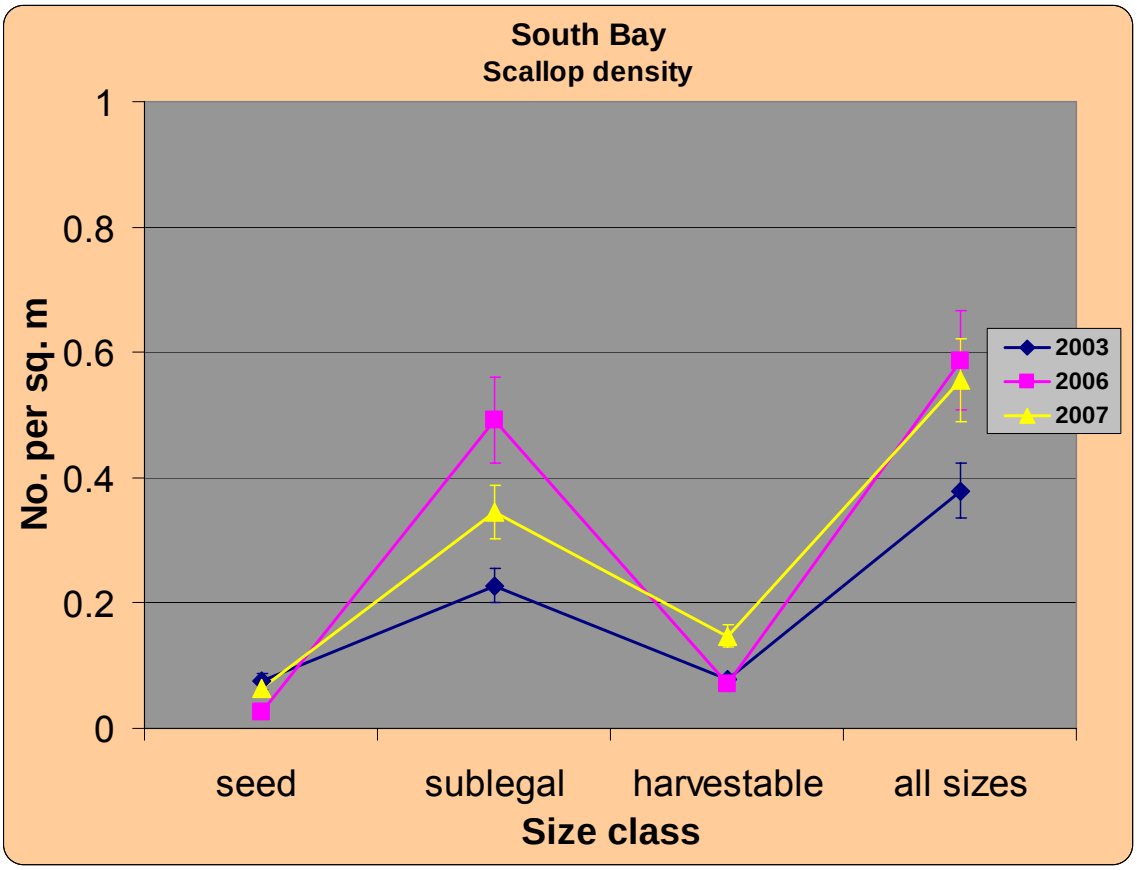


Figure 7. Mean scallop density (with standard error) by size class, South Bay.

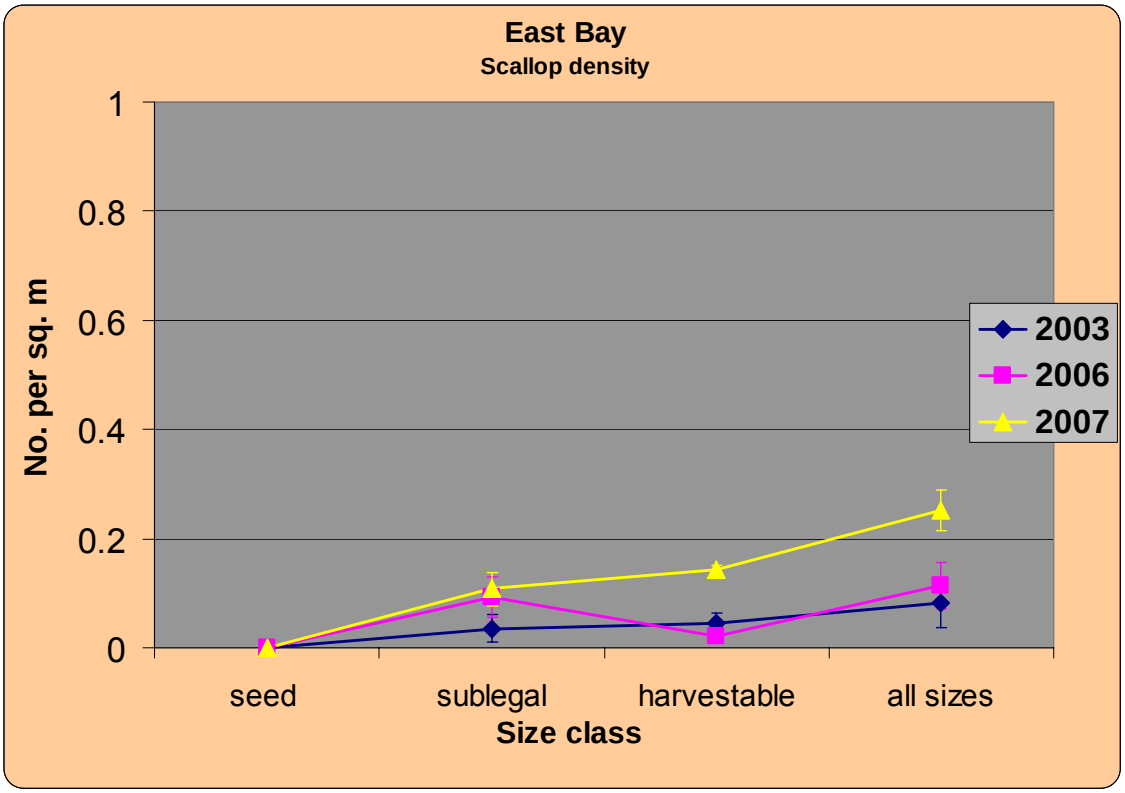


Figure 8. Mean scallop density (with standard error) by size class, East Bay.

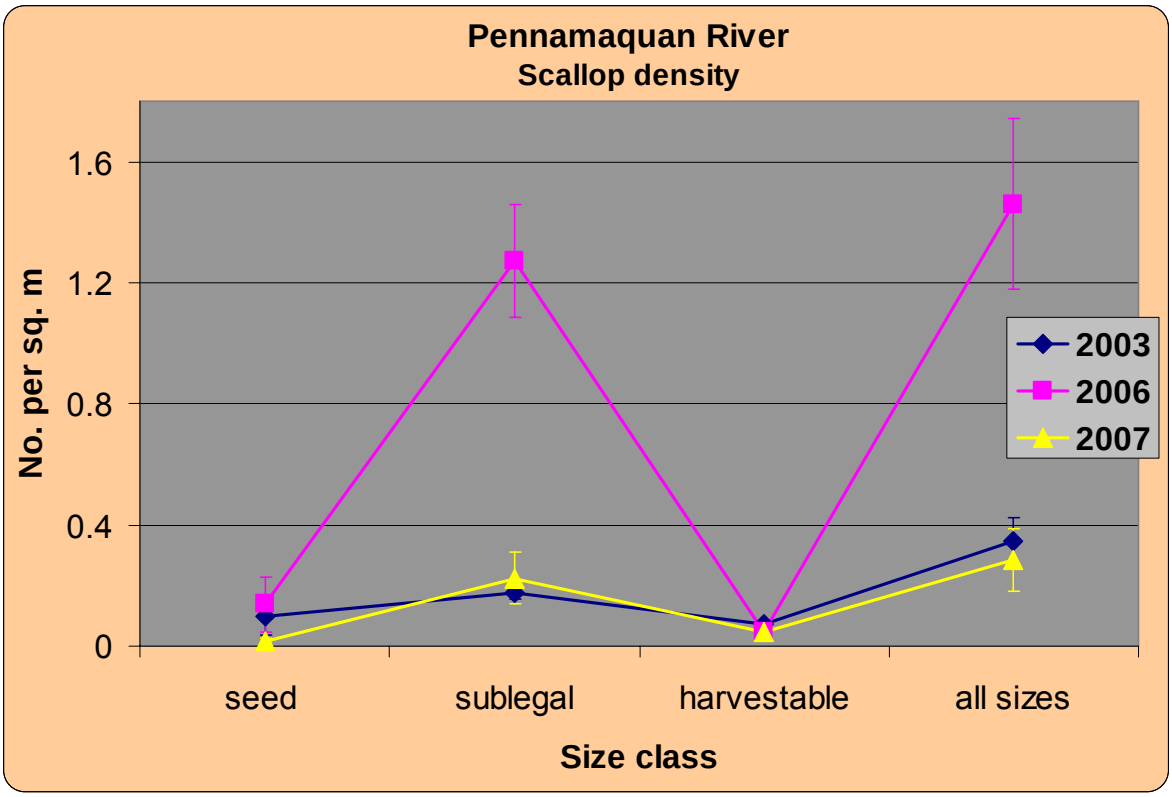


Figure 9. Mean scallop density (with standard error) by size class, Pennamaquan River.

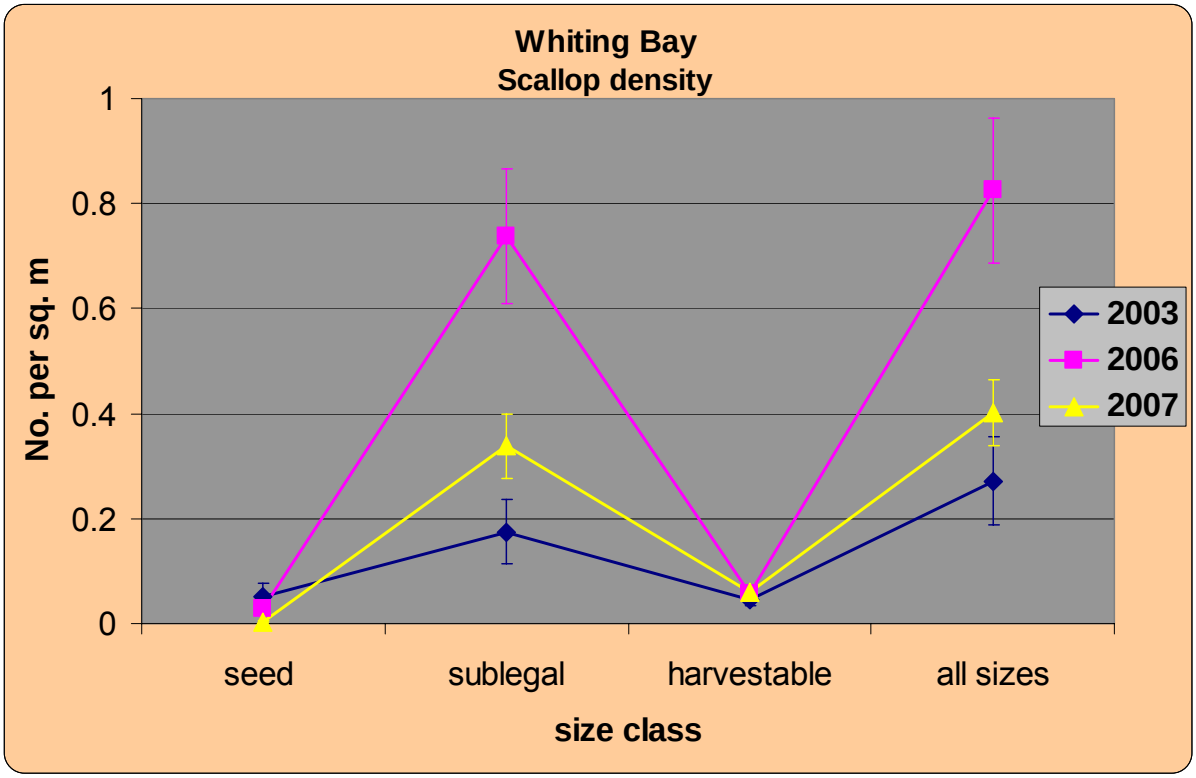


Figure 10. Mean scallop density (with standard error) by size class, Whiting Bay.

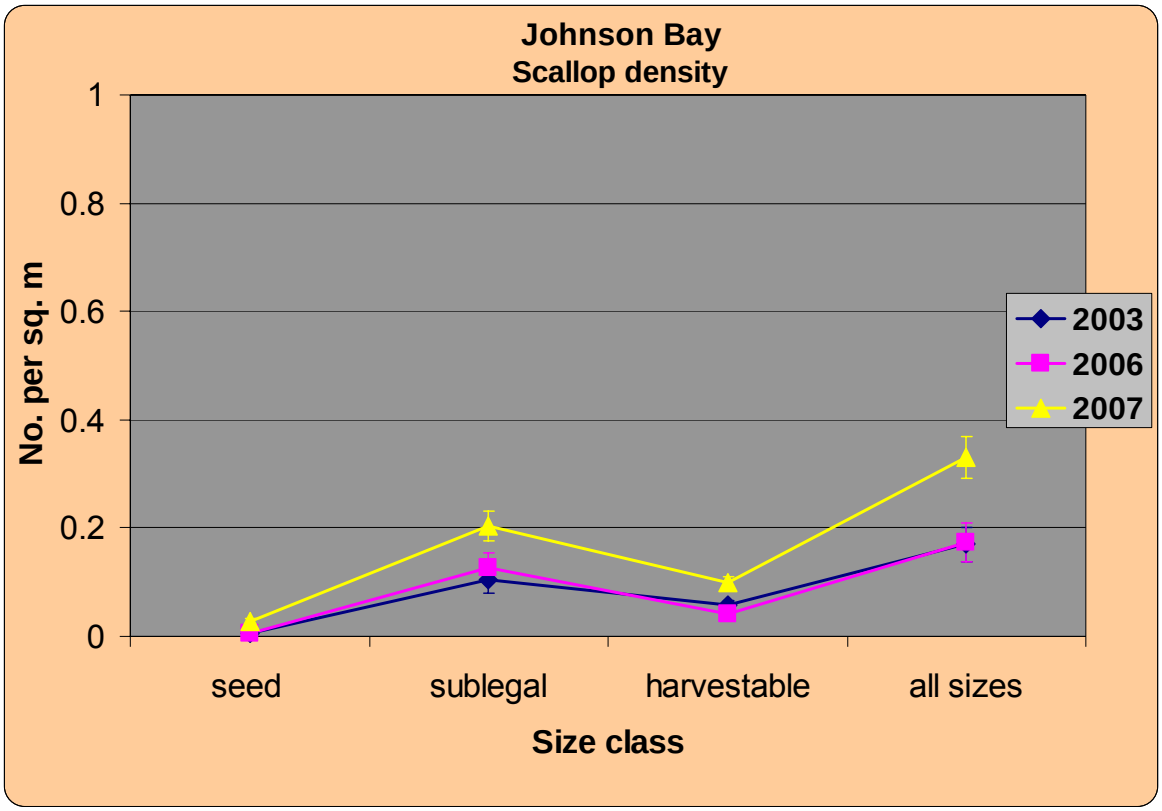


Figure 11. Mean scallop density (with standard error) by size class, Johnson Bay.

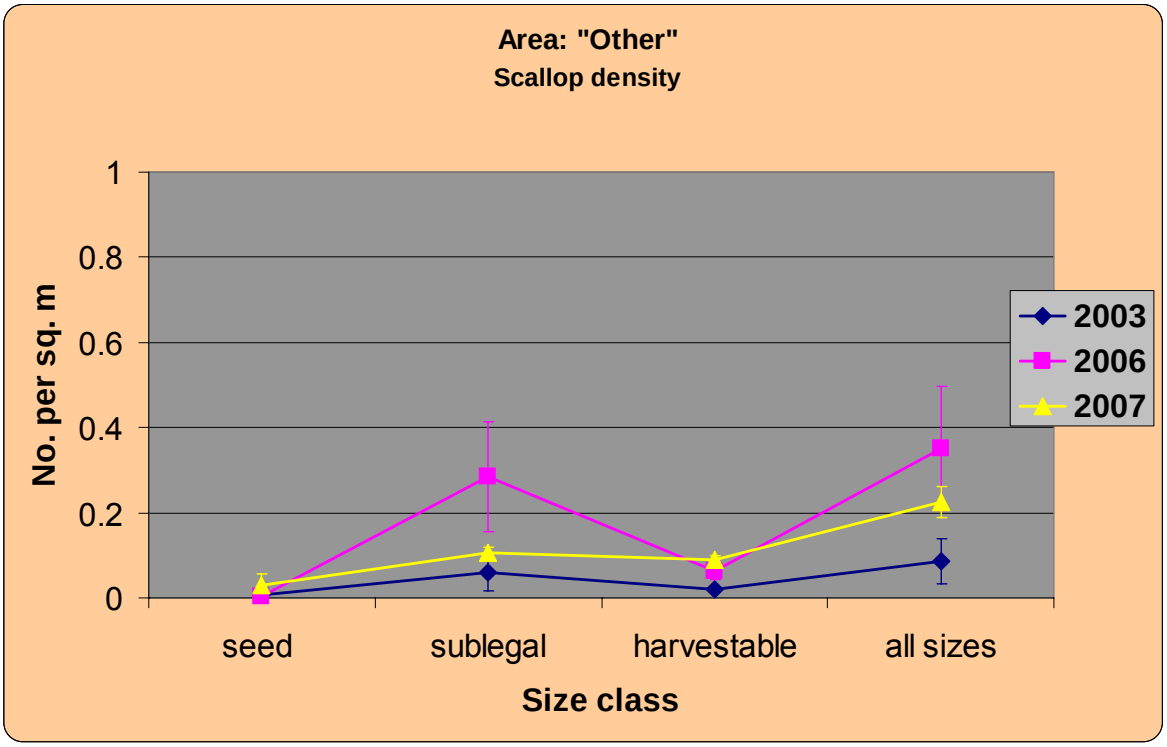
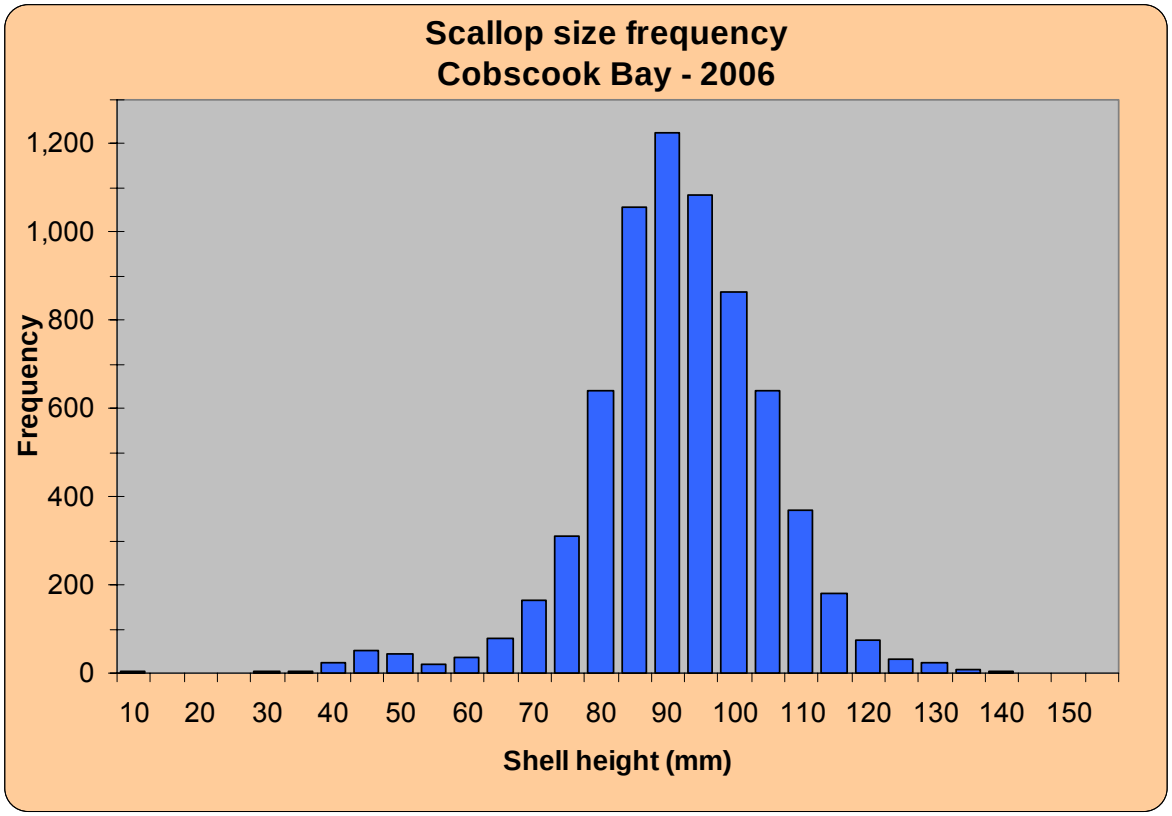


Figure 12. Mean scallop density (with standard error) by size class, area: other.



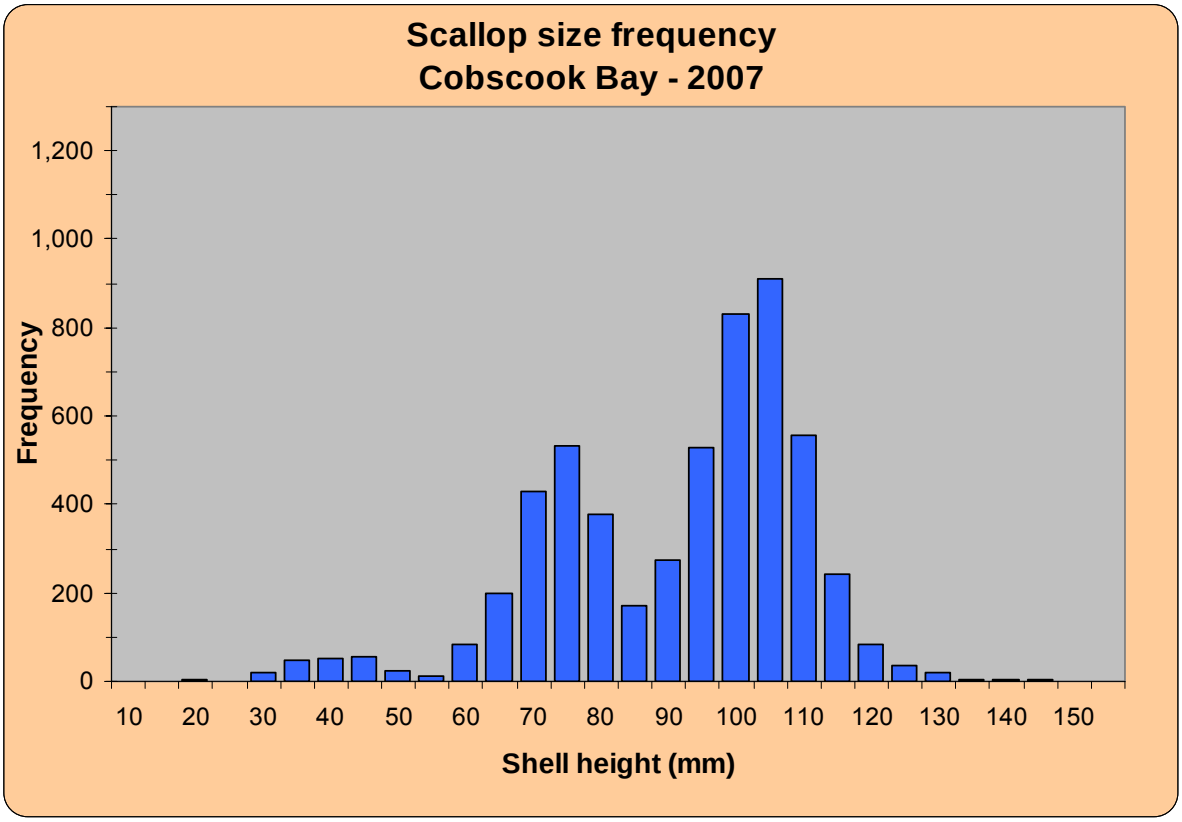


Figure 13. Size frequency of scallops in Cobscook Bay, 2006 (*top*) and 2007 (*bottom*).

Meat weight

A meat weight to shell height relationship was calculated based on samples taken in 2006-07 (Fig. 14).

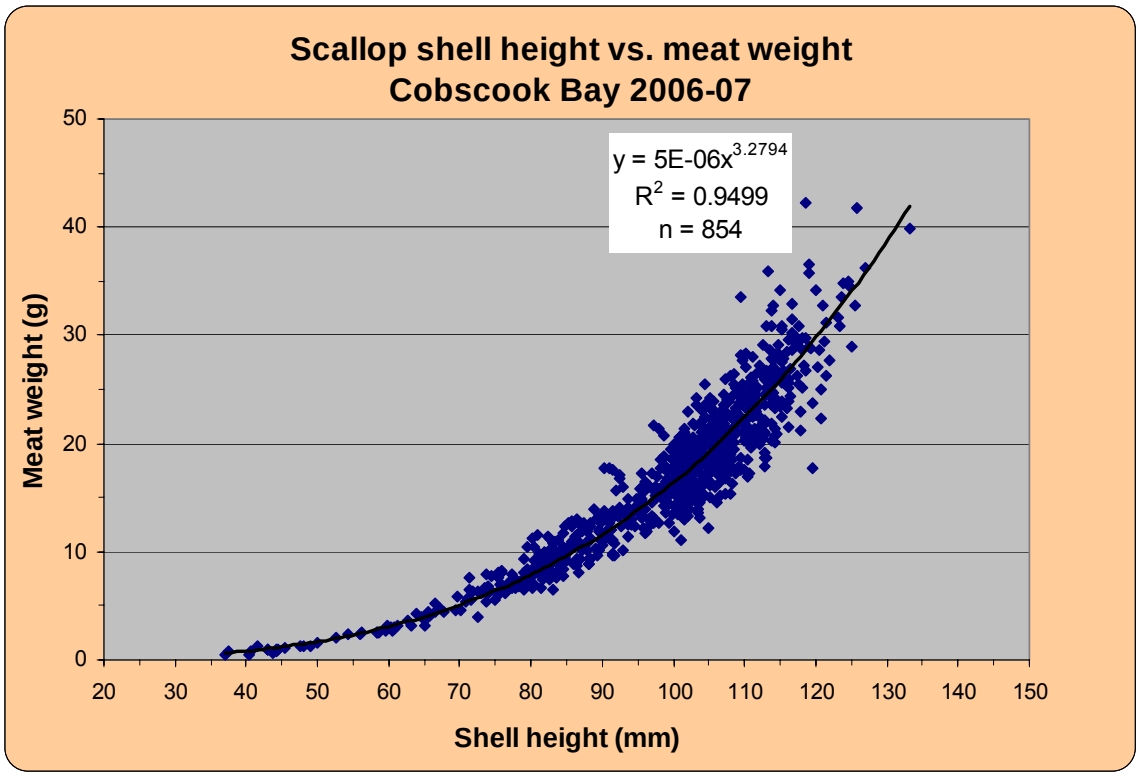


Figure 14. Scallop meat weight (MW) as a function of shell height (SH) for Cobscook Bay, 2006-07.

The 2006-07 relationship ($MW = 0.00000453\ SH^{3.2794}$) differed significantly from the 2002-03 equation ($MW = 0.000037\ SH^{3.365}$) for Cobscook Bay (Schick and Feindel 2005). 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

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

Meat weights were greater in 2002-03 than in 2006-07. The 2006-07 meat weights were larger however than those reported for 1987 and 1991 in an unpublished DMR study where the relation was $MW = 0.000005\ SH^{3.2247}$ (Table 2). It should be noted that the 1987 and 1991 studies were based mainly on smaller (80-100 mm) scallops than those sampled in the more recent surveys (minimum legal size was 3.0 in. (76.2 mm) until 1999). Thus predicted meat weights for scallops in the current legal size range (≥ 4 in.) from the 1987/91 report may be less reliable than the more recent studies. Furthermore the 1987 and 1991 sample sizes were relatively small (n = 296). The 1987 and 1991 studies do provide some evidence that the 2006-07 data are within a "normal" range for Cobscook Bay and still higher than overall meat weights for coastwide Maine (Schick and Feindel 2005). Current meat counts at the 4 in. SH minimum size also appear well below the legal maximum (35/lb.) for Cobscook Bay (Table 2).

Harvestable biomass

Scallop harvestable biomass (by meat weight) was calculated by applying the 2006-07 shell height-meat weight relationship to size frequency data on a tow-by-tow basis to determine mean harvestable biomass per m² for each substratum. This number was then expanded to the respective size of each substratum to determine the total harvestable biomass per substratum. Total harvestable biomass for Cobscook Bay represents the sum over all six substrata.

In 2007 the total harvestable biomass (adjusted with a dredge efficiency factor of 0.436 (Kelly 2007)) was 127,608 kg (281,327 lbs.; Fig. 15). This is by far the highest harvestable biomass of the three surveys. South Bay had the largest proportion (65%) of this biomass in '07 while Johnson Bay contained the next largest amount (16%).

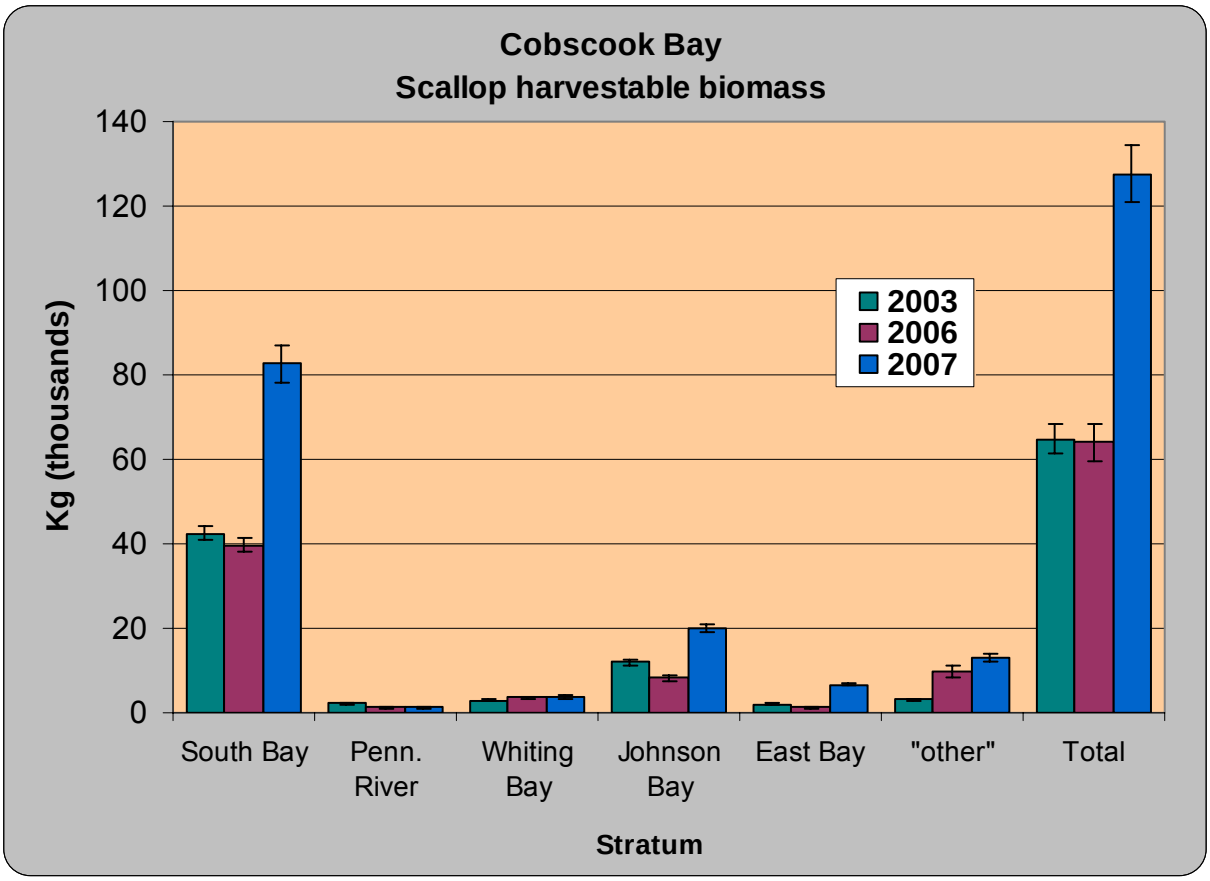


Figure 15. Biomass (meat weight) of harvestable (legal-size) scallops in Cobscook Bay in 2003, 2006 and 2007.

Due to the change in the meat weight relation between 2002-03 and 2006-07 discussed previously the harvestable biomass for ’06 was re-calculated with the 2006-07 equation. This changed the harvestable biomass for ’06 from 78,284 kg (172,590 lbs.) as reported in Kelly (2007) to 64,009 kg (141,116 lbs.). It should be noted therefore that harvestable biomass actually had a very slight decrease between ’03 and ’06 rather than the previously reported (Kelly 2007) 20.9% increase.

Harvestable biomass increased 99.4% between ’06 and ’07. The strong presence of sublegal (particularly 3½ - 3¾ in.) scallops observed in ’06 was realized with a significant increase in harvestable scallops available in ’07 particularly in South Bay, as well as Johnson Bay, East Bay and area: other. However two substrata with very high numbers of sublegals in ’06 (Whiting Bay and Pennamaquan River) did not have increased abundance of harvestable scallops in ’07. Some reports from industry and law enforcement suggest there was significant taking of undersized scallops in portions of Cobscook Bay during the ’06-’07 season. These reports may explain some of the lack of increased harvestable resource observed in these particular areas in ’07.

Conclusions

Cobscook Bay continues to exhibit relatively high scallop production despite the intense fishing effort which exists there. There are not official reports of fishing activity but it has been stated for example that 170 boats were operating there on opening day 1995 (Cobscook Bay Resource Center 2007). Maine Marine Patrol estimated that 90-100 vessels were fishing in Cobscook Bay by mid-December of this past season (Lt. A. Talbot, pers. comm.).

The ’07 survey indicated a large biomass of harvestable-size scallops was available to the fishery prior to the opening of the season. The significantly high numbers of sublegal scallops present in ’06 largely recruited to the ’07-’08 fishery. Recruitment, although not as high as in ’06, appears healthy as significant numbers of both seed and sublegals were present in South Bay, the largest and most important fishing ground.

Meat weights were lower in ’06-’07 than ’02-’03 but appear to be within a “normal” range for Cobscook Bay. Interannual differences in meat weight are normally observed in scallops and may be due to food availability (Serchuk and Rak 1983) or temperature and other factors (NEFSC 2004).

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