APPENDIX 3. EFFICIENCY ESTIMATES FOR THE NEFSC SURVEY DREDGE

The ratio densities from the NEFSC scallop dredge and SMAST video surveys were used to estimate absolute NEFSC scallop dredge efficiency assuming that the detection probability of scallops in the video survey was 100%. This ratio can be examined at levels of spatial resolution ranging from tow level estimates (10^{-3} km^2) to population level (10^4 km^2). Fine scale spatial comparisons were not possible because of insufficient data. Analysis at wide spatial scales may mask important regional variations in dredge efficiency associated with bottom type and depth. For this analysis, dredge efficiency was examined on the scale of subareas of about 10^2 to 10^3 km^2. Data from video and dredge surveys were post-stratified into subareas occupied by both surveys. Bootstrap methods were used to estimate precision of efficiency estimates for each subarea.

To identify subareas with maximum overlap between video and dredge surveys, waters along the coast were subdivided into 8 discrete subareas (Appendix Table 3-1). Within each subarea, NMFS shellfish strata boundaries were used to partition the video observations into corresponding sets. Strata with greater than 80% video coverage were included in subareas and calculations. Scallops less than 80 mm shell height were excluded from the analysis because the probability of detection in the video survey is lower and the selectivity of the NEFSC survey dredge differs for scallops smaller than 80 mm.

On average, the distance between video stations was 3 nm so that the area of each quadrant is 9 nm^2. The sum of video quadrants within a NMFS stratum was used to measure the effective stratum size for the post-stratified video survey. For example, NMFS stratum 11 is 213.5 nm^2 (Appendix Table 3-2). Ten dredge samples were taken in this stratum and 24 video stations were visited. The estimated stratum size for the video survey in this case was 24 * 9 =216 nm^2.

Each survey type was then analyzed as a stratified random design. For the dredge survey this simply meant estimation of density for a smaller number of original strata. For the video survey this process implies that the video estimates can be considered (approximately) as a random sample within an arbitrary new boundary (D'Orazio 2003; Thompson 2002, p. 135; Gunderson 1995; Hilborn and Walters 1992).

Bootstrap estimation methods (Smith 1997) and SPlus software provided by Stephen J. Smith (Department of Fisheries and Oceans, Bedford Institute of Oceanography, Halifax Nova Scotia) were used to estimate the sampling distributions of scallop densities and dredge efficiency for each subarea. A total of 2500 bootstrap densities were computed for each survey and subarea combination and used to compute sampling distributions for density and efficiency estimates. Sampling distributions for efficiency estimates were approximated by dividing each bootstrap density value for the dredge survey by a corresponding bootstrap density value for the video survey. Results were summarized by percentiles (Appendix Table 3-3).

Efficiency estimates compared favorably with estimates by Gedamke et al. (in press) and previous stock assessments (NEFSC 2001). Survey dredge efficiency estimates (medians of bootstrap sampling distributions) were generally higher in the Mid-Atlantic region with estimates of 38% in the Delmarva region, 63% in the New York Bight, and 51% in the Hudson Canyon closed area. On Georges Bank, dredge efficiency in Closed Areas I and II were 55% and 40%, respectively. The low efficiency found in the Nantucket Lightship estimate may be due to insufficient overlap in the western portion of the Nantucket Lightship Area, and the exclusion of non-random tows in the high-density northeast portion of the area. Pooled estimates of dredge efficiency for the entire Mid-Atlantic and Georges Bank areas were 46% and 33%. Note, however, that the lack of overlap in certain areas (e.g., the New York Bight, Nantucket Lightship Closed Area, and the Southeast Part) may cause the combined estimates to be biased, because some areas were covered more completely than others. The combined estimate for Closed Area I and II on Georges Bank was 45%.

Importance of considering efficiency in comparing survey results

Analysis of the SMAST video (Stokesbury et al., 2004) and NEFSC scallop survey (minimum swept-area) results for 2003 demonstrated shortcomings in direct comparison of simple abundance and biomass estimates. Comparisons may be misleading without accommodation for differences in survey gear efficiency, area surveyed, size composition and, for biomass estimates, length-weight relationships. Of these, survey gear efficiency is the most important factor for computations of biomass. In this analysis, sensitivity estimates (number per square meter) from two surveys are a proxy for differences in gear efficiency because, other things equal, surveys with the same gear efficiency should give the same density estimates Results for simple biomass calculations are summarized here because naïve comparison of biomass estimates is most problematic.

Estimates of total scallop biomass (in meat weight) from a survey can be expressed as a function of the average density, the survey domain (or total area), the size frequency of individuals, and the relationship between shell height and meat-weight. For a survey distributed over L strata with scallops in J shell-height intervals, the simple biomass estimate B_{TOT} is

$$B_{TOT} = \sum_{h=1}^{L} d_h A_h \sum_{j=1}^{J} f_{j,h} MW_{j,h}$$

where:
d_h = average density within stratum h (affected by gear efficiency)
A_h = area of stratum h
$f_{j,h}$ = proportion of individuals of size j within stratum h
$MW_{j,h}$ = average meat weight of individuals of shell height j in stratum h.

This general equation can be expanded further by substituting the relationship between shell height and meat weight as

$$MW_{j,h} = \alpha_h SH_j^{\beta_h}$$

where α_h and β_h represent stratum-specific parameters for the shell height-meat weight relationship. The general equation can now be written as

$$B_{TOT} = \sum_{h=1}^{L} d_h A_h \sum_{j=1}^{J} f_{j,h} \alpha_h SH_j^{\beta_h}$$

The terms inside the second summation represent the average weight of scallops within a stratum. Differences in average weight can arise from differences in the size frequency distribution as well as from the shell height-meat weight relationship. This distinction is important because of measurement errors in shell height measurements from video surveys and differences in procedures for estimating shell height-meat weight relationships.

Following Keyfitz (1968, p. 189), the "decomposition of observed changes" method was used to measure discrepancies that arise in naïve comparisons that do not account for the factors listed above. To measure the effect of differences in shell height-meat weight relationships, for example, one can calculate the percent change in either SMAST video (Stokesbury et al. 2004) or NEFSC scallop survey (minimum swept area) estimates when shell height-meat weight parameters are used from the other survey. Effects due to differences in more than one factor can be evaluated in an analogous manner.

Results show that the estimate of survey gear efficiency is the most important factor when estimating biomass from the 2003 NEFSC survey. If dredge efficiency were assumed to be 100% , the biomass implied by the SMAST video (Stokesbury et al. 2004) survey changed by –53% when the minimum swept area density from the NEFSC scallop survey was substituted, and the minimum swept area biomass from the NEFSC scallop survey increased by +115% when density from the video survey was substituted. This indicates that dredge efficiency is less than 100% in the dredge survey, consistent with other dredge efficiency studies (e.g., NEFSC 2001; Gedamke et al. in press) and results in this stock assessment. Substituting shell height composition decreased SMAST estimated biomass by 12% and increased NEFSC estimated biomass by 17%. Substituting shell height/meat weight parameters increased the SMAST estimate by 8% and decreased the NMFS estimate by 7%.

Appendix Table 3-1 Summary of sampling effort by stratum and group for dredge and video surveys for 2003 used to estimate efficiency of the NEFSC survey dredge.

SMAST video survey data:									
Count of Photo Station	Subarea								
NMFS Strata	1	2	3	4	5	6	7	8	Grand Total
10	12								12
11	24								24
14	19								19
15	42								42
18	24								24
19	27								27
22	16		19						35
23			79						79
24			28						28
27			15						15
30		70							70
31		91							91
34		24							24
46								16	16
47				26				56	82
49				27					27
50				18					18
51				11					11
52				28	10				38
53					22				22
54				8	25				33
55				25	15				40
61						64			64
71							7		7
621						39			39
651							10		10
661						3	10		13
Grand Total	164	185	141	143	72	106	27	72	910

NEFSC dredge survey data:									
Count of Station	Group								
2-3 digit stratum	1	2	3	4	5	6	7	8	Grand Total
10	6								6
11	10								10
14	10								10
15	12								12
18	9								9
19	10								10
22	4		6						10
23			20						20
24			5						5
27			8						8
30		9							9
31		16							16
34		6							6
46								5	5
47				3				10	13
49				9					9
50				14					14
51				10					10
52				10	4				14
53					11				11
54				4	9				13
55				7	3				10
61						16			16
71							4		4
621						13			13
651							10		10
661						3	9		12
Grand Total	61	31	39	57	27	32	23	15	285

Appendix Table 3-2. Summary of subarea definitions and stratum sizes for comparisons of SMAST video survey and NMFS dredge survey efficiency estimates.

				Photo Survey Sample Information		Dredge Survey Sample Information	
Subarea	Region	Open or Closed Area?	NMFS Strata	Area Sampled (nm^2)	Number of Potential Stations	Area Sampled (nm^2)	Number of Potential Stations
1	MAB	OPEN	10	108	28,625,623	124.1247421	99,234
1	MAB	OPEN	11	216	57,251,247	213.46	170,653
1	MAB	OPEN	14	171	45,323,904	206.16	164,818
1	MAB	OPEN	15	378	100,189,682	387.77	310,014
1	MAB	OPEN	18	216	57,251,247	236.59	189,148
1	MAB	OPEN	19	243	64,407,652	242.59	193,944
1	MAB	OPEN	22	144	38,167,498	139.00	111,124
2	MAB	OPEN	30	630	166,982,803	668.68	534,592
2	MAB	OPEN	31	819	217,077,643	933.55	746,352
2	MAB	OPEN	34	216	57,251,247	208.02	166,305
3	MAB	HCCA	22	171	45,323,904	175.61	140,395
3	MAB	HCCA	23	711	188,452,020	749.31	599,053
3	MAB	HCCA	24	252	66,793,121	270.45	216,217
3	MAB	HCCA	27	135	35,782,029	137.34	109,800
4	GBK	OPEN	47	234	62,022,184	250.60	200,346
4	GBK	OPEN	49	243	64,407,652	223.02	178,297
4	GBK	OPEN	50	162	42,938,435	156.41	125,049
4	GBK	OPEN	51	99	26,240,155	113.73	90,924
4	GBK	OPEN	52	252	66,793,121	238.79	190,903
4	GBK	OPEN	54	72	19,083,749	73.26	58,567
4	GBK	OPEN	55	225	59,636,715	252.26	201,677
5	GBK	Closed Area I	52	90	23,854,686	108.72	86,921
5	GBK	Closed Area I	53	198	52,480,309	204.76	163,697
5	GBK	Closed Area I	54	225	59,636,715	222.58	177,947
5	GBK	Closed Area I	55	135	35,782,029	137.10	109,607
6	GBK	Closed Area II	61	576	152,669,991	632.53	505,691
6	GBK	Closed Area II	621	351	93,033,276	361.29	288,840
6	GBK	Closed Area II	661	27	7,156,406	12.35	9,872
7	GBK	OPEN	71	63	16,698,280	73.13	58,462
7	GBK	OPEN	651	90	23,854,686	88.00	70,353
7	GBK	OPEN	661	90	23,854,686	104.82	83,803
8	GBK	Nantucket Lightship Closed Area	46	144	38,167,498	136.19	108,884
8	GBK	Nantucket Lightship Closed Area	47	504	133,586,242	544.39	435,226
8a	GBK	NLSA--Access Area in 2000	46 & 47			147.09	117,595

Appendix Table 3-3. Summary of video and dredge survey density and efficiency estimates for scallops greater than 80 mm shell height in the dredge survey.

Subarea	Region	Sub Area	Open or Closed Area?	Density ($\#/m^2$) or ratio	Percentile						
					5%	10%	25%	50%	75%	90%	95%
1	MAB	DMV	OPEN	Video	0.243	0.254	0.271	0.291	0.312	0.332	0.345
				Dredge	0.087	0.092	0.101	0.110	0.121	0.130	0.135
				Ratio	0.281	0.304	0.339	0.380	0.423	0.468	0.493
2	MAB	NYB	OPEN	Video	0.044	0.047	0.054	0.075	0.093	0.112	0.129
				Dredge	0.023	0.027	0.035	0.046	0.058	0.071	0.076
				Ratio	0.252	0.318	0.438	0.625	0.882	1.143	1.336
3	MAB	HCCA	CLOSED	Video	0.206	0.216	0.234	0.253	0.273	0.291	0.302
				Dredge	0.091	0.098	0.112	0.128	0.145	0.159	0.167
				Ratio	0.346	0.377	0.438	0.507	0.586	0.661	0.709
4	GBK	SCh	OPEN	Video	0.038	0.042	0.047	0.054	0.062	0.070	0.075
				Dredge	0.011	0.011	0.013	0.015	0.017	0.018	0.019
				Ratio	0.169	0.187	0.224	0.269	0.323	0.379	0.416
5	GBK	CA1	CLOSED	Video	0.091	0.105	0.128	0.157	0.186	0.214	0.234
				Dredge	0.053	0.060	0.072	0.085	0.101	0.116	0.124
				Ratio	0.295	0.340	0.428	0.549	0.705	0.903	1.078
6	GBK	CA2	CLOSED	Video	0.199	0.218	0.246	0.283	0.326	0.366	0.394
				Dredge	0.064	0.074	0.092	0.115	0.141	0.164	0.178
				Ratio	0.211	0.245	0.312	0.403	0.512	0.638	0.711
7	GBK	NEP	OPEN	Video	0.026	0.030	0.042	0.055	0.066	0.079	0.086
				Dredge	0.007	0.008	0.010	0.012	0.014	0.016	0.017
				Ratio	0.121	0.139	0.179	0.241	0.315	0.412	0.496
8	GBK	NLSA??	CLOSED	Video	0.181	0.201	0.234	0.272	0.316	0.356	0.381
				Dredge	0.020	0.024	0.031	0.040	0.049	0.057	0.062
				Ratio	0.067	0.082	0.111	0.147	0.186	0.234	0.265
9	MAB	All	ALL	Video	0.174	0.179	0.188	0.199	0.210	0.221	0.229
				Dredge	0.075	0.079	0.084	0.091	0.098	0.105	0.109
				Ratio	0.363	0.384	0.417	0.456	0.502	0.549	0.576
10	GBK	All	BOTH	Video	0.138	0.145	0.155	0.169	0.183	0.196	0.204
				Dredge	0.042	0.045	0.050	0.056	0.063	0.069	0.073
				Ratio	0.236	0.255	0.291	0.332	0.378	0.428	0.462
11	GBK	All Open		Video	0.040	0.043	0.048	0.055	0.062	0.068	0.072
				Dredge	0.010	0.011	0.012	0.014	0.016	0.017	0.018
				Ratio	0.174	0.188	0.217	0.258	0.305	0.353	0.386
12	GBK	All Closed	CLOSED	Video	0.196	0.207	0.225	0.248	0.270	0.292	0.304
				Dredge	0.059	0.063	0.071	0.081	0.090	0.099	0.105
				Ratio	0.225	0.244	0.278	0.329	0.380	0.429	0.466
12a	GBK	Closed Areas 1 and 2	Closed	Video	0.176	0.187	0.208	0.233	0.259	0.285	0.299
				Dredge	0.072	0.078	0.090	0.104	0.119	0.134	0.144
				Ratio	0.283	0.315	0.374	0.450	0.535	0.626	0.674