TABLES

B. Stock assessment for ocean quahogs (*Arctica islandica*)

Invertebrate Subcommittee
SAW/SARC 48

October 5, 2009

Table B1. Annual landings and quotas (1000 metric tons meats) for ocean quahog from state waters (including Maine) and from the Exclusive Economic Zone (EEZ, state waters excluded). EEZ landings are from logbooks. Landings from state waters are not used in this assessment unless stated otherwise.

Year	Dealer Database	EEZ (Logbook)	State Waters (Logbook - Dealer)	Percent Landings in EEZ	EEZ Quota	EEZ Landings / Quota (%)
1967[a]	0.020		0.020			
1968	0.102		0.102			
1969	0.290		0.290			
1970	0.792		0.792			
1971	0.921		0.921			
1972	0.634		0.634			
1973	0.661		0.661			
1974	0.365		0.365			
1975	0.569		0.569			
1976	2.510	1.854	0.656	0.739		
1977	8.411	7.293	1.118	0.867		
1978	10.415	9.197	1.218	0.883		
1979	15.748	14.344	1.404	0.911	13.608	105%
1980[b,c]	11.623	13.407		1.000	15.876	84%
1981	11.202	13.101		1.000	18.144	72%
1982	16.478	14.234	2.244	0.864	18.144	78%
1983	16.200	14.586	1.614	0.900	18.144	80%
1984	17.939	17.975		1.000	18.144	99%
1985	22.035	20.726	1.309	0.941	22.226	93%
1986	20.585	18.902	1.683	0.918	27.215	69%
1987	22.709	21.514	1.195	0.947	27.215	79%
1988	21.007	20.273	0.734	0.965	27.215	74%
1989	23.147	22.359	0.787	0.966	23.587	95%
1990	21.235	20.965	0.270	0.987	24.040	87%
1991	22.119	22.064	0.055	0.998	24.040	92%
1992	22.871	22.477	0.395	0.983	24.040	93%
1993	24.843	21.876	2.967	0.881	24.494	89%
1994	21.159	20.985	0.173	0.992	24.494	86%
1995	23.253	21.108	2.145	0.908	22.226	95%
1996	21.122	20.061	1.061	0.950	20.185	99%
1997	19.930	19.628	0.301	0.985	19.581	100%
1998	18.098	17.897	0.201	0.989	18.144	99%
1999	17.557	17.381	0.175	0.990	20.412	85%

Table B1. (cont.)

Year	Dealer Database	EEZ (Logbook)	State Waters (Logbook - Dealer)	Percent Landings in EEZ	EEZ Quota	EEZ Landings / Quota (%)
2000	14.899	14.723	0.176	0.988	20.412	72%
2001	17.234	17.069	0.165	0.990	20.412	84%
2002	18.144	17.947	0.197	0.989	20.412	88%
2003	18.997	18.815	0.182	0.990	20.412	92%
2004	17.812	17.655	0.157	0.991	22.680	78%
2005	13.793	13.635	0.158	0.989	24.190	56%
2006	14.461	14.273	0.188	0.987	24.190	59%
2007	15.734	15.574	0.161	0.990	24.190	64%
2008	14.442	15.479		1.000	24.190	64%

[a] Figures for 1967-1979 are from NEFSC (1990)

[b] Figures for 1980-1993 from NEFSC (2003).

[c] For 1980-2005, "Dealer Database Total" landings are from commercial landings

[d] Dealer database total for 2008 may not be complete.

Table B2. Ocean quahog landings (mt meats) by region reported in logbooks for the US EEZ. Figures for 1978-1979 are not from logbooks may be less reliable.

YEAR	SVA	DMV	NJ	LI	SNE	GBK	MNE	UNK	Grand Total
1978		1,290	6,350					2,775	10,415
1979		5,450	6,030					4,268	15,748
1980		4,230	7,750	6				1,421	13,407
1981	56	3,637	8,402	3				1,003	13,101
1982	6	4,598	8,538					1,092	14,234
1983		5,396	8,249	21	629			291	14,586
1984	6	7,171	8,851		822			1,125	17,975
1985	160	7,200	10,676	40	693			1,956	20,726
1986		8,237	9,059	396	562			649	18,902
1987		10,540	9,070	1,180	696			27	21,514
1988	42	11,716	7,015	640	841			20	20,273
1989		6,439	14,100	605	1,196			20	22,359
1990	14	3,685	15,590	739	934		3		20,965
1991		4,839	14,575	1,674	865		110		22,064
1992		2,378	6,942	11,940	1,143		75		22,477
1993		1,953	10,205	8,642	1,020		56		21,876
1994		992	6,938	12,015	954		65	22	20,985
1995		699	5,357	9,527	5,412		114		21,108
1996		736	4,864	5,943	8,350		142	26	20,061
1997		1,072	4,229	5,141	8,968		218		19,628
1998		1,365	2,684	6,856	6,736		218	39	17,897
1999		1,090	3,039	6,329	6,618		279	27	17,381
2000		1,048	3,318	4,745	5,083	49	357	123	14,723
2001		894	4,560	5,692	4,694	13	326	889	17,069
2002		1,732	2,781	9,113	3,884		387	51	17,947
2003		896	3,683	11,626	2,177		359	73	18,815
2004		624	2,761	10,690	3,273		307		17,655
2005		910	669	9,714	2,021		301	19	13,635
2006		494	467	11,101	1,847		365		14,273
2007		100	1,566	11,290	2,311		306		15,574
2008		270	1,733	11,123	2,151		201	0	15,479

[c] All data for 1980-1993 fron NEFSC (2003), all other data from logbooks.

Table B3. Ocean quahog landings by region as reported in logbooks for the US EEZ. Landings (except for Maine) are in thousands of ITQ bushels.

YEAR	SVA	DMV	NJ	LI	SNE	GBK	MNE	MNE (Maine bushels)	UNK	Grand Total
1980		933	1,709	1					313	2,956
1981	12	802	1,852	1					221	2,888
1982	1	1,014	1,882						241	3,138
1983		1,190	1,819	5	139	64			64	3,280
1984	1	1,581	1,951		181	248			248	4,211
1985	35	1,587	2,354	9	153	431			431	5,001
1986		1,816	1,997	87	124	143			143	4,310
1987		2,324	2,000	260	153	6			6	4,749
1988	9	2,583	1,546	141	185	4			4	4,474
1989		1,420	3,108	133	264	4			4	4,934
1990	3	812	3,437	163	206		1	1		4,623
1991		1,067	3,213	369	191		24	37		4,901
1992		524	1,530	2,632	252		16	25		4,980
1993		431	2,250	1,905	225		12	19		4,841
1994		219	1,530	2,649	210	5	14	21	5	4,653
1995		154	1,181	2,100	1,193		25	38		4,691
1996		162	1,072	1,310	1,841	6	31	47	6	4,476
1997		236	932	1,133	1,977		48	73		4,400
1998		301	592	1,511	1,485	9	48	72	9	4,026
1999		240	670	1,395	1,459	6	62	93	6	3,931
2000		231	732	1,046	1,121	27	79	119	27	3,381
2001		197	1,005	1,255	1,035	196	72	109	196	4,065
2002		382	613	2,009	856	11	85	129	11	4,097
2003		198	812	2,563	480	16	79	120	16	4,284
2004		138	609	2,357	722		68	102		3,994
2005		201	148	2,142	446	4	66	100	4	3,110
2006		109	103	2,447	407		80	121		3,268
2007		22	345	2,489	510		68	102		3,535
2008		59	382	2,452	474	0	44	67	0	3,479

[c] All data for 1980-1993 are landings in NEFSC (2003) / 220.463.

Table B4. Real and nominal prices for ocean quahog based on dealer data. Average price was computed as total revenues divided by total landed meat weight during each year, rather than as annual averages of prices for individual trips, to reduce bias due to small deliveries at relatively high prices. The consumer price index (CPI) used to convert nominal dollars to 1991 equivalent dollars is for unprocessed and packaged fish, which includes shellfish and finfish (Eric Thunberg, NEFSC, pers. comm.).

Year	CPI	Excluding Maine			Maine only		
		Nominal ($/lb)	Real price (1991 $/lb)	Real price (1991 $/ITQ bu)	Nominal ($/lb)	Real price (1991 $/lb)	Real price (1991 $/Maine bu)
1982	0.67	0.31	0.46	4.58	NA	NA	NA
1983	0.71	0.31	0.43	4.33	NA	NA	NA
1984	0.75	0.31	0.41	4.06	0.78	1.03	6.83
1985	0.77	0.31	0.40	4.00	NA	NA	NA
1986	0.84	0.30	0.36	3.62	1.75	2.10	13.88
1987	0.94	0.29	0.31	3.09	2.30	2.46	16.27
1988	0.99	0.29	0.29	2.90	1.90	1.91	12.64
1989	0.96	0.29	0.31	3.06	2.72	2.85	18.86
1990	0.98	0.32	0.32	3.23	2.70	2.75	18.19
1991	1.00	0.34	0.34	3.39	4.10	4.10	27.15
1992	1.04	0.36	0.34	3.40	4.07	3.90	25.80
1993	1.05	0.40	0.38	3.82	3.58	3.42	22.62
1994	1.08	0.38	0.36	3.57	3.83	3.55	23.49
1995	1.14	0.40	0.35	3.52	3.46	3.02	20.03
1996	1.11	0.41	0.37	3.74	3.10	2.79	18.50
1997	1.19	0.42	0.35	3.49	2.62	2.20	14.58
1998	1.23	0.42	0.34	3.45	2.50	2.04	13.52
1999	1.28	0.42	0.33	3.30	2.75	2.16	14.28
2000	1.33	0.43	0.33	3.26	2.74	2.07	13.69
2001	1.28	0.55	0.43	4.32	3.23	2.53	16.77
2002	1.28	0.54	0.42	4.19	3.69	2.88	19.10
2003	1.31	0.53	0.41	4.05	3.75	2.87	19.03
2004	1.38	0.52	0.38	3.75	3.79	2.75	18.20
2005	1.49	0.51	0.34	3.41	3.60	2.42	16.02
2006	1.59	0.51	0.32	3.18	3.23	2.03	13.47
2007	1.62	0.52	0.32	3.18	3.16	1.95	12.90
2008	1.71	0.54	0.32	3.16	3.29	1.93	12.77

Table B5. Ocean quahog fishing effort (hours fished) by region in the US EEZ based on logbook data. "Sub-trips" (deliveries from the same trip to different dealers) are counted only once.

YEAR	SVA	DMV	NJ	LI	SNE	GBK	MNE	UNK	Grand Total
1983		7,131	13,937	50	1,535			56	22,709
1984	15	11,106	15,477		2,523			1,231	30,352
1985	204	10,058	17,890	87	2,066			2,955	33,260
1986		12,260	14,360	361	1,138			1,012	29,130
1987		15,818	14,698	806	1,340			49	32,711
1988	64	19,100	11,598	615	1,639			64	33,079
1989		12,124	24,262	797	2,327			50	39,560
1990	25	8,166	29,327	1,283	1,838		286		40,924
1991		12,048	30,397	1,844	1,433		17,110		62,832
1992		5,513	15,998	13,148	1,964		13,424		50,047
1993		4,622	25,457	12,883	1,783		5,720		50,465
1994		2,260	20,543	19,165	2,082		5,056	57	49,162
1995		1,621	13,598	16,015	8,561		5,731		45,526
1996		1,521	9,340	10,239	11,866		8,404	54	41,423
1997		2,742	9,382	8,295	13,515		11,734		45,669
1998		3,225	6,983	10,509	10,639		11,631	79	43,066
1999		2,595	7,623	9,132	12,258		10,821	90	42,518
2000		2,517	7,966	7,071	10,542	63	12,215	612	40,986
2001		2,170	10,844	7,813	11,404	22	13,113	1,454	46,820
2002		4,290	6,683	11,605	7,797		16,779	85	47,240
2003		2,617	10,750	16,113	4,596		17,832	108	52,016
2004		2,495	7,905	14,582	6,642		19,014		50,638
2005		3,445	1,972	12,519	4,043		16,905	45	38,928
2006		1,811	1,386	14,542	3,314		14,638		35,691
2007		346	3,719	15,618	4,286		13,821		37,791
2008		956	4,768	14,980	3,965		10,734	11	35,414

Table B6. Ocean quahog landings per unit effort (LPUE, total bushels / total hours fished) based on logbook data for all vessels operating in the US EEZ.

YEAR	DMV	NJ	LI	SNE	MNE	Total ITQ
1983	131	123	26			130.16
1984	72	120				95.16
1985	101	105				94.35
1986	97	127	13	122		112.59
1987	100	133		135		129.86
1988	83	203	14	93		313.14
1989	150	82	109	53		164.92
1990	285	68	203	84		134.90
1991	214	51	77	129		77.43
1992	257	194	10	134		111.33
1993	176	135	13	115		109.89
1994	472	156	19	92		130.29
1995	323	113	164	29		146.44
1996	283	241	186	19	0.08	157.81
1997	80	163	319	16	1.21	138.65
1998	48	169	200	112	2.16	155.79
1999	63	141	143	150	2.89	172.67
2000	94	117	160	188	3.94	187.95
2001	139	55	193	130	3.66	143.08
2002	56	100	120	187	3.67	127.55
2003	88	68	65	244	4.41	88.34
2004	79	127	86	156	3.78	108.45
2005	111	311	160	212	5.04	142.28
2006	109	586	176	145	5.41	117.81
2007	398	164	151	168	4.90	103.91
2008	210	31	143	112	6.18	85.95

Table B7. Number of quahogs measured, trips sampled, percentage of trips sampled, and the number quahogs measured per bushel landed by year and region, from port samples.

Region	Year	Quahogs sampled	Trips sampled	% of trips sampled	Samples per bushel landed
SNE	1996	30	1	0.12	0.00002
	1997	310	10	1.20	0.00016
	1998	796	25	3.88	0.00054
	1999	634	21	2.67	0.00043
	2000	822	27	4.12	0.00073
	2001	761	25	3.84	0.00074
	2002	1353	42	7.18	0.00158
	2003	606	20	6.31	0.00126
	2004	1302	43	10.39	0.00180
	2005	1280	42	14.58	0.00287
	2006	996	32	12.45	0.00245
	2007	1282	42	14.84	0.00252
	2008	2406	80	34.19	0.00507
Region	**Year**	**Quahogs sampled**	**Trips sampled**	**% of trips sampled**	**Samples per bushel landed**
LI	1996	30	1	0.12	0.00002
	1997	1012	32	5.02	0.00089
	1998	480	16	2.28	0.00032
	1999	1440	48	7.12	0.00103
	2000	390	13	2.63	0.00037
	2001	180	6	1.05	0.00014
	2002	150	5	0.63	0.00007
	2003	990	33	3.26	0.00039
	2004	360	12	1.37	0.00015
	2005	1866	62	9.00	0.00087
	2006	2928	98	12.68	0.00120
	2007	2099	68	8.58	0.00084
	2008	2482	81	11.81	0.00101
Region	**Year**	**Quahogs sampled**	**Trips sampled**	**% of trips sampled**	**Samples per bushel landed**
NJ	1996	30	1	0.14	0.00003
	1997	390	13	2.03	0.00042
	1998	420	14	3.47	0.00071
	1999	420	14	3.13	0.00063
	2000	600	20	4.13	0.00082
	2001	780	26	3.99	0.00078
	2002	510	17	4.59	0.00083
	2003	390	13	2.68	0.00048
	2004	1080	36	9.92	0.00177
	2005	90	3	3.23	0.00061
	2006	243	8	11.59	0.00236
	2007	343	11	6.04	0.00099
	2008	330	11	4.74	0.00086
Region	**Year**	**Quahogs sampled**	**Trips sampled**	**% of trips sampled**	**Samples per bushel landed**
DMV	1996	180	6	5.08	0.00111
	1997	570	19	10.86	0.00241
	1998	390	13	6.70	0.00130
	1999	960	32	19.39	0.00399
	2000	690	23	14.65	0.00299
	2001	660	22	18.64	0.00335
	2002	120	4	1.78	0.00031
	2003	390	13	10.66	0.00197
	2004	150	5	4.46	0.00109
	2005	511	17	12.32	0.00255
	2006	743	24	29.63	0.00683
	2007	195	6	42.86	0.00887
	2008	120	4	10.00	0.00202

Table B8. Number of random and nearly random NEFSC survey tows used to estimate trends in abundance of ocean quahog. Figures in each cell are the number of tows in calculations for each combination of stratum and cruise. Figures in plain text are the number of original tows (without borrowing). Bold and outlined figures are for cells that had zero tows originally but were filled by borrowing tows from the same strata during previous and/or subsequent cruises. Black cells are for cells with zero tows that could not be filled by borrowing. Survey/region combinations with relatively poor sampling (a relatively large number or relatively large strata) are shown in grey.

Region	Stratum	Area (nm2)	%Total Stratum Area	Survey Year											
				1982	1983	1984	1986	1989	1992	1994	1997	1999	2002	2005	2008
SVA	5	690	0.97	4	9	13	8	8	8	8	8	**16**	8	8	**8**
	6	22	0.03	1	1	1	1	1	1	1	1	**3**	2	1	**1**
DMV	9	1894	0.47	30	26	35	29	37	37	39	39	38	39	39	31
	10	190	0.05	2	2	3	3	3	3	3	3	3	3	3	2
	11	246	0.06	2	2	**4**	2	2	2	2	2	2	2	2	**2**
	13	1149	0.28	19	18	25	20	20	20	21	22	19	20	20	15
	14	205	0.05	2	2	3	3	3	3	5	3	3	3	3	**3**
	15	387	0.10	4	4	**8**	4	4	4	5	4	5	4	4	**4**
NJ	17	703	0.11	11	11	18	12	12	12	12	14	12	12	12	12
	18	240	0.04	3	3	**6**	3	3	3	3	3	3	3	3	3
	19	266	0.04	3	3	**6**	3	3	3	3	3	3	3	3	3
	21	1693	0.26	18	18	22	19	20	20	23	26	39	29	29	28
	22	305	0.05	3	3	**6**	3	3	3	5	3	3	3	3	3
	23	724	0.11	7	6	**11**	5	4	5	5	5	5	5	5	5
	25	647	0.10	9	9	13	8	9	9	9	12	8	9	9	13
	26	190	0.03	2	2	**5**	3	3	3	3	3	3	3	3	3
	27	442	0.07	4	4	**8**	4	4	4	4	4	4	4	4	4
	87	356	0.05	8	7	10	9	9	9	9	9	9	16	16	9
	88	484	0.07	15	15	24	17	20	20	20	21	22	20	20	19
	89	343	0.05	15	15	21	15	18	17	17	19	18	18	18	18
	90	117	0.02	2	2	3	2	2	2	2	2	2	2	2	1

Table B8. (cont.)

Region	Stratum	Area (nm2)	%Total Stratum Area	Survey Year											
				1982	1983	1984	1986	1989	1992	1994	1997	1999	2002	2005	2008
LI	29	1078	0.24	11	10	20	10	10	10	10	10	11	10	10	16
	30	667	0.15	7	8	14	6	6	6	6	6	7	6	6	12
	31	932	0.21	9	7	12	5	7	8	8	8	9	8	8	8
	33	361	0.08	4	4	8	4	4	4	5	4	4	4	4	10
	34	207	0.05	2	2	4	2	2	2	5	2	2	2	2	8
	35	614	0.14	4	2	4	2	5	6	6	6	6	6	6	6
	91	342	0.08	3	2	4	4	3	3	3	3	3	3	3	5
	92	165	0.04	2	2	3	2	2	2	2	2	2	2	2	5
	93	97	0.02	1	1	2	1	1	1	1	1	1	2	2	4
SNE	37	660	0.13	7	4	7	3	6	3	5	4	4	3	3	
	38	268	0.05	3	2	5	3	3	3	5	3	3	3	3	3
	39	946	0.19	6	4	6	2	5	5	5	5	5	5	5	5
	41	580	0.12	6	5	7	5	6	6	6	6	5	6	6	6
	45	407	0.08	3	7	9	4	4	4	4	4	4	3	3	4
	46	205	0.04	2	5	5	3	2	3	5	3	3	2	2	3
	47	873	0.18	4	3	4	2	2	4	5	4	3	1	1	4
	94	215	0.04	1	2	2		1	1	2	2	4	2	2	
	95	278	0.06	4	14	11	4	4	4	4	4	4	4	8	4
	96	490	0.10	12	12	13	1	1	3	2	4	4		1	1

Table B8. (cont.)

Region	Stratum	Area (nm2)	%Total Stratum Area	Survey Year											
				1982	1983	1984	1986	1989	1992	1994	1997	1999	2002	2005	2008
GBK	54	295	0.04		3	3	3	6	3	3	3	3		2	2
	55	386	0.05	3	3	3	3	1	3	3	3	2	2	4	2
	56	214	0.03								4	4	4		
	57	176	0.02			2	2	1	2	5	2	2	2	4	2
	58	303	0.04								5	5	5		
	59	512	0.07		4	5	1	2	6	5	5	4	5	9	4
	60	801	0.10			2	2	2	4	2	5	5	5	9	4
	61	588	0.08	8	1	6	5	12	7	6	6	6	6	11	5
	62	731	0.09			1	1	1	4	4	4	4	4	7	3
	65	184	0.02			3	3	5	2	2	3	4	1	1	
	67	196	0.03		5	5	5	7	7	7	7	7		2	2
	68	380	0.05	1	8	7	3	6	6	5	5	5		6	6
	69	902	0.12	2	5	11	6	6	6	7	6	7	7	4	4
	70	544	0.07	1	2	6	4	8	4	4	4	3	2	6	4
	71	168	0.02		2	2	3	1	2	3	3	1	2	3	1
	72	472	0.06	2	10	8	1	8	8	8	8	6	6	4	4
	73	526	0.07	1	1	4	3	6	6	6	6	5	6	9	3
	74	443	0.06	3	4	1	3	7	4	4	4	3	3	6	3

Table B9. Parameter estimates for the relationship between shell length (L, mm) and meat weight (W, g) in ocean quahog (same as in NEFSC 2004). The equation for the relationship is $W=e^{\alpha}L^{\beta}$.

Region	Alpha	Beta
SVA	-9.042313	2.787987
DMV	-9.042313	2.787987
NJ	-9.847183	2.94954
LI	-9.233646	2.822474
SNE	-9.124283	2.774989
GBK	-8.969073	2.767282

Table B10. Trends in survey, stock and fishable abundance and biomass for ocean quahog ≥ 50 mm SL during 1982-2008 based on NEFSC clam survey data. Figures include original plus borrowed tows. "Number Strata" for a particular year includes strata sampled by the survey during the same year plus strata sampled by tows borrowed from the previous and subsequent surveys. Survey data for 1994 should be ignored because of gear problems that artificially boosted sampling efficiency. Survey coverage was incomplete on GBK prior to 1986 and 2005.

		survey				stock				fishable						
region	year	N/tow	CV	Kg/tow	CV	N/tow	CV	Kg/tow	CV	N/tow	CV	Kg/tow	CV	tows per region	positive tows	strata surveyed in region
GBK	1986	278.06	0.19	6.99	0.18	430.11	0.23	9.66	0.19	233.54	0.19	5.99	0.18	47	21	16
GBK	1989	92.29	0.26	2.72	0.25	126.71	0.24	3.37	0.25	80.19	0.26	2.41	0.25	78	38	16
GBK	1992	346.25	0.21	10.44	0.21	485.71	0.19	12.86	0.20	302.84	0.21	9.30	0.21	74	41	16
GBK	1994	405.23	0.20	12.34	0.20	578.46	0.19	15.22	0.19	355.56	0.20	11.03	0.20	76	40	16
GBK	1997	269.76	0.19	7.99	0.19	389.38	0.19	10.08	0.18	234.25	0.19	7.11	0.19	83	44	18
GBK	1999	273.40	0.17	8.88	0.19	365.97	0.16	10.63	0.18	241.90	0.17	8.04	0.19	77	47	18
GBK	2002	328.37	0.18	10.29	0.19	478.14	0.15	12.68	0.18	288.96	0.18	9.26	0.19	61	38	15
GBK	2008	323.77	0.30	7.09	0.28	693.48	0.31	12.01	0.29	265.74	0.29	6.03	0.27	49	30	15
SNE	1982	277.61	0.27	9.41	0.25	345.84	0.28	11.07	0.26	245.46	0.27	8.47	0.25	48	30	10
SNE	1983	173.21	0.29	5.61	0.30	237.69	0.31	6.92	0.29	151.40	0.29	5.02	0.30	58	37	10
SNE	1984	188.46	0.27	6.40	0.29	234.35	0.26	7.52	0.28	166.80	0.27	5.77	0.29	69	38	10
SNE	1986	289.15	0.31	9.37	0.31	394.36	0.35	11.51	0.32	253.12	0.31	8.39	0.31	27	23	9
SNE	1989	274.66	0.19	9.03	0.18	353.18	0.21	10.83	0.19	241.36	0.19	8.09	0.18	34	29	10
SNE	1992	333.08	0.19	11.64	0.19	400.10	0.19	13.40	0.19	297.00	0.19	10.53	0.20	36	31	10
SNE	1994	529.09	0.22	18.12	0.20	670.13	0.25	21.44	0.21	467.48	0.22	16.37	0.20	43	32	10
SNE	1997	292.89	0.54	8.23	0.45	447.96	0.61	11.27	0.51	246.94	0.52	7.17	0.43	39	27	10
SNE	1999	252.43	0.54	8.31	0.48	312.91	0.56	9.84	0.51	221.84	0.53	7.42	0.47	39	30	10
SNE	2002	180.67	0.22	6.89	0.22	206.74	0.22	7.64	0.22	164.25	0.22	6.34	0.22	29	28	9
SNE	2005	157.78	0.26	4.81	0.23	333.78	0.42	6.93	0.27	137.54	0.25	4.33	0.22	40	34	10
SNE	2008	201.41	0.25	5.48	0.22	523.90	0.42	9.07	0.27	172.65	0.24	4.88	0.22	37	31	8

Table B10. (cont.)

		Survey				Stock				Fishable						
Region	Year	N/tow	CV	Kg/tow	CV	N/tow	CV	Kg/tow	CV	N/tow	CV	Kg/tow	CV	N tows	N positive tows	N strata surveyed
LI	1982	277.91	0.15	6.98	0.16	433.99	0.16	9.29	0.15	238.75	0.15	6.22	0.16	42	36	9
LI	1983	185.88	0.21	5.23	0.21	253.51	0.22	6.36	0.21	163.62	0.21	4.74	0.21	38	36	9
LI	1984	239.24	0.17	6.67	0.16	323.92	0.17	8.11	0.16	210.02	0.17	6.03	0.16	71	63	9
LI	1986	319.60	0.22	8.89	0.20	426.26	0.22	10.78	0.21	280.44	0.21	8.02	0.20	36	31	9
LI	1989	226.21	0.34	5.06	0.29	367.49	0.38	7.15	0.33	190.10	0.33	4.38	0.28	40	36	9
LI	1992	323.33	0.18	8.31	0.16	465.23	0.20	10.62	0.17	279.03	0.17	7.40	0.16	42	36	9
LI	1994	592.57	0.16	15.35	0.16	827.85	0.17	19.30	0.16	513.28	0.16	13.66	0.16	46	44	9
LI	1997	401.64	0.16	11.16	0.16	518.85	0.17	13.35	0.16	353.15	0.16	10.05	0.16	42	35	9
LI	1999	232.27	0.17	6.28	0.15	310.52	0.19	7.67	0.16	202.72	0.17	5.63	0.14	45	41	9
LI	2002	253.06	0.21	6.97	0.20	330.41	0.21	8.39	0.20	222.21	0.21	6.27	0.20	43	40	9
LI	2005	149.38	0.19	4.07	0.19	215.78	0.19	5.06	0.18	131.16	0.19	3.68	0.20	45	39	9
LI	2008	155.33	0.16	4.55	0.15	206.67	0.19	5.41	0.16	137.71	0.16	4.14	0.15	74	66	9
NJ	1982	112.34	0.20	5.09	0.20	129.33	0.20	5.61	0.20	102.55	0.20	4.73	0.20	99	50	13
NJ	1983	86.09	0.21	4.05	0.21	98.42	0.21	4.42	0.21	79.20	0.21	3.79	0.21	98	55	13
NJ	1984	147.61	0.24	6.69	0.24	170.30	0.24	7.37	0.24	134.86	0.24	6.21	0.24	151	79	13
NJ	1986	144.02	0.23	7.03	0.22	159.78	0.24	7.56	0.22	133.62	0.23	6.61	0.22	103	52	13
NJ	1989	72.24	0.22	3.10	0.21	88.60	0.22	3.51	0.21	65.22	0.22	2.85	0.21	109	52	13
NJ	1992	88.04	0.18	4.33	0.17	97.82	0.18	4.65	0.17	81.73	0.18	4.07	0.17	110	52	13
NJ	1994	235.41	0.22	10.90	0.21	269.04	0.22	11.92	0.21	216.05	0.22	10.16	0.20	115	59	13
NJ	1997	122.26	0.15	6.11	0.15	135.78	0.16	6.55	0.15	113.72	0.15	5.76	0.15	124	59	13
NJ	1999	59.48	0.15	2.89	0.14	72.27	0.15	3.18	0.14	54.89	0.15	2.72	0.14	132	61	13
NJ	2002	89.79	0.23	4.62	0.24	101.12	0.22	4.94	0.23	83.82	0.24	4.38	0.24	127	60	13
NJ	2005	47.08	0.16	2.24	0.15	62.36	0.15	2.53	0.15	43.12	0.15	2.11	0.14	103	54	13
NJ	2008	45.15	0.17	2.14	0.16	60.59	0.17	2.43	0.16	41.27	0.17	2.01	0.16	121	65	13

Table B10. (cont.)

		survey				stock				fishable						
Region	Year	N/tow	CV	Kg/tow	CV	N/tow	CV	Kg/tow	CV	N/tow	CV	Kg/tow	CV	N tows	N positive tows	N strata surveyed
DMV	1982	79.16	0.32	2.96	0.34	86.64	0.31	3.16	0.33	73.84	0.32	2.79	0.34	59	24	6
DMV	1983	86.23	0.49	2.55	0.42	106.61	0.52	2.99	0.45	76.16	0.48	2.30	0.41	54	28	6
DMV	1984	52.01	0.35	1.67	0.30	63.19	0.36	1.90	0.31	46.65	0.34	1.53	0.30	78	34	6
DMV	1986	75.68	0.23	2.53	0.22	86.74	0.24	2.80	0.22	68.94	0.23	2.34	0.22	61	28	6
DMV	1989	64.35	0.58	1.80	0.46	82.47	0.62	2.18	0.51	55.95	0.55	1.61	0.44	69	31	6
DMV	1992	71.98	0.36	2.29	0.31	85.41	0.40	2.59	0.33	64.68	0.35	2.09	0.30	69	25	6
DMV	1994	39.46	0.25	1.33	0.23	47.97	0.27	1.49	0.24	35.89	0.25	1.23	0.23	75	28	6
DMV	1997	47.74	0.21	1.67	0.21	56.44	0.22	1.85	0.21	43.72	0.21	1.56	0.21	73	28	6
DMV	1999	28.36	0.29	0.95	0.27	33.39	0.29	1.06	0.27	25.82	0.29	0.88	0.26	70	23	6
DMV	2002	31.81	0.25	1.11	0.23	38.77	0.26	1.23	0.23	29.14	0.24	1.03	0.22	71	19	6
DMV	2005	19.41	0.49	0.69	0.53	24.84	0.45	0.78	0.50	17.91	0.50	0.65	0.53	66	21	6
DMV	2008	17.76	0.54	0.62	0.59	22.61	0.49	0.70	0.56	16.34	0.55	0.58	0.59	57	16	6
SVA	1982	0.039	0.000	0.002	0.000	0.039	0.000	0.002	0.000	0.038	0.000	0.002	0.000	5	1	2
SVA	1983	1.892	0.578	0.099	0.577	1.916	0.577	0.101	0.577	1.854	0.579	0.097	0.577	10	3	2
SVA	1984	0.189	0.846	0.010	0.870	0.191	0.845	0.010	0.868	0.185	0.848	0.010	0.871	14	2	2
SVA	1986	0.285	0.000	0.013	0.000	0.294	0.000	0.013	0.000	0.275	0.000	0.012	0.000	9	1	2
SVA	1989	0.392	0.000	0.018	0.000	0.401	0.000	0.019	0.000	0.380	0.000	0.018	0.000	9	1	2
SVA	1992	0.000		0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9	0	2
SVA	1994	4.467	0.787	0.225	0.807	4.559	0.782	0.229	0.805	4.349	0.790	0.220	0.810	8	2	2
SVA	1997	0.154	0.000	0.004	0.000	0.282	0.000	0.006	0.000	0.132	0.000	0.003	0.000	9	1	2
SVA	1999	0.081	0.551	0.002	0.607	0.182	0.501	0.003	0.541	0.069	0.556	0.002	0.614	19	2	2
SVA	2002	0.045	1.000	0.001	1.000	0.133	1.000	0.002	1.000	0.037	1.000	0.001	1.000	10	1	2
SVA	2005	0.000		0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9	0	2
SVA	2008	0.000		0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9	0	2

Table B11. Survey abundance trends for small quahogs (1-69 mm SL). Mean numbers per tow (N/Tow) are standardized to a 0.15 nm tow distance based on start and end tow position data. Figures include original plus borrowed tows. "Number Strata" for a particular year includes strata sampled by the survey during the same year plus strata sampled by tows borrowed from the previous and subsequent surveys. Survey data for 1994 should be ignored because of gear problems that artificially boosted sampling efficiency. Survey coverage was incomplete on GBK prior to 1986 and 2005.

Year	SVA		DMV		NJ		LI		SNE		GBK	
	N/tow	CV	N/tow	CV	N/tow	CV	N/tow	CV	N/tow	CV	N/tow	CV
1982	0.00		0.74	0.28	2.01	0.33	68.51	0.23	9.50	0.35	10.83	0.16
1983	0.00		1.77	0.57	2.29	0.52	22.24	0.31	22.67	0.73	12.07	0.39
1984	0.00		1.62	0.47	3.30	0.41	26.50	0.22	7.89	0.35	37.12	0.66
1986	0.00		0.54	0.58	1.99	0.59	30.82	0.28	23.76	0.70	40.73	0.59
1989	0.00		1.07	0.78	3.45	0.36	51.56	0.52	14.17	0.59	7.13	0.31
1992	0.00		0.99	0.63	1.02	0.38	42.30	0.36	5.91	0.35	31.75	0.35
1994	0.03	0.00	1.34	0.55	4.02	0.30	62.43	0.27	30.77	0.61	36.29	0.32
1997	0.04	0.00	1.47	0.53	1.50	0.26	21.81	0.29	58.00	0.80	61.97	0.35
1999	0.03	0.50	0.96	0.49	3.65	0.32	14.11	0.30	6.77	0.75	35.35	0.34
2002	0.02	1.00	1.44	0.48	2.29	0.19	16.08	0.41	2.14	0.42	39.72	0.18
2005	0.00		1.26	0.36	4.05	0.19	19.42	0.36	47.95	0.60	97.92	0.34
2008	0.00		1.10	0.40	4.57	0.20	14.15	0.50	82.74	0.55	150.58	0.37

Table B12. Linear correlations between sensor data summary statistics that dredge performance of individual successful random tows during the 2005 (top, above diagonal) and 2008 (bottom, below diagonal) NEFSC clam surveys. Performance statistics were calculated using data from periods when the dredge was potentially fishing (i.e. between the first and last seconds of each tow when smoothed y-tilt ≤ 5.16°). Sample sizes vary between surveys. However, with the exception of backup y-tilt, samples involved several hundred stations and tens of thousands of sensor measurements at 1 second intervals. Backup y-tilt data for 2008 were from only 8 tows and 2341 sensor measurements. No backup suitable y-tilt data are available for 2005. Correlations with absolute value ≥ 0.5 are shown in bold.

2008 survey	Tow time	Proportion time fishing	X-tilt	SD X-tilt	Y-tilt	SD Y-tilt	Depth	Speed over ground	Backup y-tilt
Tow time		-0.08	0.04	-0.01	0.07	0.13	***0.65***	-0.25	NA
Proportion time fishing	***0.94***		0.18	***-0.64***	***-0.68***	***-0.49***	-0.04	-0.19	NA
X-tilt	***0.56***	0.31		0.25	-0.20	0.03	0.12	0.00	NA
SD X-tilt	0.35	0.36	0.31		0.31	***0.54***	0.03	0.08	NA
Y-tilt	***-0.87***	***-0.79***	***-0.51***	***-0.42***		0.11	0.15	0.34	NA
SD Y-tilt	***-0.63***	***-0.76***	0.07	0.13	0.26		0.14	-0.05	NA
Depth	-0.08	0.21	***-0.44***	0.12	0.17	-0.35		0.23	NA
Speed over ground	***-0.91***	***-0.85***	-0.32	-0.30	***0.82***	***0.59***	0.22		NA
Backup y-tilt	***0.87***	***0.81***	***0.54***	***0.55***	***-0.98***	-0.25	-0.05	***-0.77***	

2005 survey

Table B13. Summary of linear correlations for sensor data summary statistics that survey dredge performance in NEFSC clam surveys. Correlations ≥ 0.5 are marked "++". Correlations ≤ -0.5 are marked "- -". No backup y-tilt data were available in 2005.

Variable 1	Variable 2	Survey 2005	2008
Tow time	Proportion time		++
	X-tilt		++
	SD X-tilt		
	Y-tilt		--
	SD Y-tilt		--
	Depth	++	
	Speed over ground		--
	Backup y-tilt	na	++
Proportion time	X-tilt		
	SD X-tilt	--	
	Y-tilt	--	--
	SD Y-tilt	--	--
	Depth		
	Speed over ground		--
	Backup y-tilt	Na	++
X-tilt	SD X-tilt		
	Y-tilt		--
	SD Y-tilt		
	Depth		--
	Speed over ground		
	Backup y-tilt	na	++
SD X-tilt	Y-tilt		--
	SD Y-tilt	++	
	Depth		
	Speed over ground		
	Backup y-tilt	na	--
Y-tilt	SD Y-tilt		
	Depth		
	Speed over ground		++
	Backup y-tilt	na	--
SD Y-tilt	Depth		
	Speed over ground		++
	Backup y-tilt		
Depth	Speed over ground		
	Backup y-tilt		
Speed over ground	Backup y-tilt	na	--

Table B14. DE2DE2 (Delaware II-Delaware II) repeat station tow data (50+ mm SL). Catch are numbers of ocean quahogs caught adjusted to a standard area swept based on sensor tow distance data (4,557 ft^2 = 423 m^2). Stations with useful data are at the top of the table. Stations excluded from the analysis because both tows were zero or because of poor dredge performance (based on differential pressure and amperage sensors) are shown at the bottom. "HG" codes are NEFSC survey database codes that describe results of the haul and damage to the dredge based on observations by the watch chief (without using sensor data). By convention, tows with HG ≤ 36 are used in most analyses.

	Original station					Repeat station				
Stratum	Station	Catch	Cable	Pump	SHG	Station	Catch	Cable	Pump	HG
Useful repeat stations										
6250	16	5.754	old	old	11	315	4.233	new	new	36
6250	17	1.4855	old	old	11	292	2.100	new	new	11
6250	23	3.1124	old	old	11	294	0.000	new	new	11
6250	25	0.9655	old	old	11	313	0.000	new	new	11
6930	170	2.9155	old	new	23	325	1.485	new	new	11
6930	172	21.295	old	new	34	329	284.070	new	new	35
6250	38	0.8368	old	old	11	296	0.000	new	new	11
6930	172	21.2954	old	new	34	327	7.068	new	new	11
6930	173	611.722	old	new	11	328	341.535	new	new	11
6330	174	105.004	old	new	36	328	341.535	new	new	11
6330	178	280.119	old	new	11	333	260.802	new	new	35
6930	179	19.830	old	new	11	335	13.517	new	new	11
6330	180	288.316	old	new	11	336	102.231	new	new	11
6920	181	10.588	old	new	11	337	7.724	new	new	11
6290	182	453.819	old	new	11	338	230.036	new	new	11
6290	183	359.921	old	new	11	339	121.018	new	new	11
6250	214	1.047	old	new	11	295	24.768	new	new	11
Both catches zero										
6890	13	0.0000	old	old	11	316	0.000	new	new	11
6890	26	0.0000	old	old	11	314	0.000	new	new	11
6890	30	0.0000	old	old	11	312	0.000	new	new	11
6210	37	0.0000	old	old	11	302	0.000	new	new	36
6210	41	0.0000	old	old	11	303	0.000	new	new	11
6890	42	0.0000	old	old	11	304	0.000	new	new	11
6890	45	0.0000	old	old	35	310	0.000	new	new	34
6890	48	0.0000	old	old	35	317	0.000	new	new	11
6880	51	0.0000	old	old	11	318	0.000	new	new	11
6880	53	0.0000	old	old	11	319	0.000	new	new	48
Poor dredge performance										
6250	22	26.069	old	old	11	293	27.008	new	new	23
6330	171	31.390	old	new	35	326	6.525	new	new	36
6300	206	327.657	old	new	11	287	420.315	new	new	11

Table B15. DE2FV (Delaware II – F/V Endurance) repeat tow data. Catches are numbers or ocean quahogs per standard area swept (4557 ft^2 = 423 m^2). "HG" codes are NEFSC survey database codes that describe results of the haul and damage to the dredge based on observations by the watch chief (without using sensor data). All of the stations shown in the table are useable based on differential pressure and amperage data from sensors. By convention, tows with HG ≤ 36 are used in most analyses.

Sequential FV tow number	DE2 station number	Pump	Electrical cable	HG code	W code	DE2 catch (N per standard tow area)	FV catch (N per standard tow area)	Summary of DE2 Configuration
76	304	New	New	11	2	0.000	0.000	New pump-New cable
77	303	New	New	11	0	0.000	0.000	New pump-New cable
79	312	New	New	11	0	0.000	0.382	New pump-New cable
80	313	New	New	11	0	0.000	0.597	New pump-New cable
81	314	New	New	11	0	0.000	0.000	New pump-New cable
82	316	New	New	11	0	0.000	0.000	New pump-New cable
84	290	New	New	11	1	93.661	286.865	New pump-New cable
84	289	New	New	11	1	81.602	286.865	New pump-New cable
85	290	New	New	11	1	93.661	305.617	New pump-New cable
85	289	New	New	11	1	81.602	305.617	New pump-New cable
102	272	New	New	11	3	71.985	263.336	New pump-New cable
103	274	New	New	36	3	0.966	30.072	New pump-New cable
104	276	New	New	11	-2	28.000	65.263	New pump-New cable
105	278	New	New	11	2	33.736	383.916	New pump-New cable
106	282	New	New	11	0	145.733	320.499	New pump-New cable
107	280	New	New	11	2	0.702	3.541	New pump-New cable
118	354	New	New	11	1	162.193	674.015	New pump-New cable
118	355	New	New	11	1	161.239	674.015	New pump-New cable
118	353	New	New	11	1	143.319	674.015	New pump-New cable
159	319	New	New	48	1	0.000	0.000	New pump-New cable
160	318	New	New	11	2	0.000	0.000	New pump-New cable
161	296	New	New	11	0	0.000	0.000	New pump-New cable
162	295	New	New	11	2	23.642	45.174	New pump-New cable
167	339	New	New	11	1	35.257	200.715	New pump-New cable
168	336	New	New	11	0	62.378	96.687	New pump-New cable
169	334	New	New	11	4	55.518	168.281	New pump-New cable
170	333	New	New	35	0	93.726	315.868	New pump-New cable
171	324	New	New	11	0	66.136	191.406	New pump-New cable
172	326	New	New	36	5	2.175	0.000	New pump-New cable
174	328	New	New	11	0	148.925	430.130	New pump-New cable
191	338	New	New	11	1	113.000	178.561	New pump-New cable

Table B15. (cont.)

Sequential FV tow number	DE2 station number	Pump	Electrical cable	HG code	W code	DE2 catch (N per standard tow area)	FV catch (N per standard tow area)	Summary of DE2 Configuration
192	293	New	New	23	2	24.847	142.024	New pump-New cable
193	294	New	New	11	0	0	7.608	New pump-New cable
194	292	New	New	11	0	1.05	9.009	New pump-New cable
195	315	New	New	36	1	3.175	5.853	New pump-New cable
196	310	New	New	34	5	0	0	New pump-New cable
101	205	New	Old	11	1	52.228	153.64	New pump-Old cable
163	201	New	Old	11	1	70.373	429.723	New pump-Old cable
164	209	New	Old	11	4	101.89	395.804	New pump-Old cable
165	207	New	Old	23	3	47.045	341.305	New pump-Old cable
166	203	New	Old	11	1	46.442	323.178	New pump-Old cable
167	183	New	Old	11	1	110.22	200.715	New pump-Old cable
168	180	New	Old	11	0	150.835	96.687	New pump-Old cable
170	178	New	Old	35	0	97.339	315.868	New pump-Old cable
174	173	New	Old	11	0	374.091	430.13	New pump-Old cable
174	176	New	Old	11	0	113.529	430.13	New pump-Old cable
174	174	New	Old	36	1	44.657	430.13	New pump-Old cable
174	177	New	Old	11	0	43.126	430.13	New pump-Old cable
191	182	New	Old	11	1	221.989	178.561	New pump-Old cable
200	199	New	Old	11	1	16.213	77.062	New pump-Old cable
78	36	Old	Old	11	1	3.435	13.902	Old pump-Old cable
169	2	Old	Old	11	4	25.028	168.281	Old pump-Old cable
171	1	Old	Old	11	0	150.771	191.406	Old pump-Old cable
197	49	Old	Old	11	0	0	0	Old pump-Old cable
198	60	Old	Old	11	1	0	0	Old pump-Old cable
199	64	Old	Old	11	0	0	0	Old pump-Old cable

Table B16. Summary of 2008 commercial depletion experiments for ocean quahog with comparisons to results of experiments during 1997-2005. Depletion experiments are identified by a sequential and field ID codes. The sequential codes are ordered by date (e.g. OQ2008-3 was the third study for ocean quahog completed during 2008). The field identification codes were used in planning and carrying out the experiments (e.g. field ID OQ08-6 for the experiment with sequential ID OQ2008-03). Sequential ID codes are used in this assessment.

Depletion experiment ID (Field ID)	**Commercial dredge efficiency estimate**	**Population density estimate (N/ft^2)**	**Negative binomial k estimate**	**Setup tow station numbers**	**Setup Configuration**	**Setup Density (N/tow)**	**Setup Density (N/ft^2)**	**Setup Density CV**	**Survey dredge efficiency**	**Comment**
OQ2008-01 (OQ08-1)	1.000	0.068	7.55	173, 174, 176, 177	Old cable; new pump	143.851	0.032	0.546	0.467	Poor Patch model fit, note high CV for stock density from Patch model and setup tow density
OQ2008-02 (OQ08-2)	0.780	0.086	14.55	289	New cable; new pump	81.602	0.018	NA	0.207	Good Patch model fit; only 1setup tow
OQ2008-03 (OQ08-6)	1.000	0.120	5.95	353, 354, 355	New cable; new pump	155.584	0.034	0.039	0.285	Good Patch model fit
Mean OQ-08 (N=3)	0.927	0.091	9.349	NA	NA	127.012	0.028	NA	0.320	2008 commercial efficiency estimates higher than average from previous studies; 2008 population density estimates about the same as average from previous studies; survey dredge efficiencies 25% higher than average of previous estimates
All 1997-2005 (N=17)	0.596 (95% CI 0.469 to 0.723)	0.097 (95% CI 0.032 to 0.162)		NA	NA	NA	NA	NA	0.248	

Table B17. Patch model estimates for ocean quahogs 90+ mm SL in commercial and NEFSC survey clam dredges based on depletion experiments during 1997-2008. "NA" means not available. The sequential codes are ordered by date (e.g. OQ2008-3 was the third study for ocean quahog completed during 2008). The field identification codes were used in planning and carrying out the experiments (e.g. field ID OQ08-6 for the experiment with sequential ID OQ2008-03). Sequential ID codes are used in this assessment. Footnotes are on the page following the table.

Study area						Depletion Tows						Patch Model							Setup Tows (if applicable)				
Experiment	Region	Latitude (decimal degrees)	Longitude (decimal degrees)	Depth (m)	Mean Sediment Size (microns)	Depletion Vessel	Date	Ship Position Data (source / nominal accuracy / time interval)	N tows used	N Bushel Counts / Length samples	Depletion Vessel Blade Width (ft)	Cell Size (ft)	Density ($N\ ft^{-2}$)	Depletion Vessel Efficiency	Neg. binomial k	Gamma γ	Neg. Log likelihood	Fit to Catch Data (R2s)	Setup Date	RV stations	Setup or RV Density ($N\ ft^{-2}$)	NEFSC Survey Dredge Efficiency	Foot-notes
OQ2008-01 (OQ08-1)	LI	-72.04765	40.93762	27	530	F/V Endurance	2-Sep	GPS / 6 ft / 6 sec	17	4 / 4	12.5	25	0.068	1.000	7.55	0.50	118.5	Poor	16-Jul	173-174, 176, 177	0.032	0.467	19
OQ2008-02 (OQ08-2)	LI	-72.84397	40.27445	49	258	F/V Endurance	16-Sep	GPS / 6 ft / 6 sec	17	4 / 4	12.5	25	0.086	0.781	14.55	0.50	115.0	Ok	22-Jul	289	0.018	0.207	19
OQ2008-03 (OQ08-6)	SNE	-70.85472	41.02307	46	357	F/V Endurance	18-Sep	GPS / 6 ft / 6 sec	17	4 / 4	12.5	25	0.120	1.000	5.95	0.50	127.5	Ok	30-Jul	353-355	0.034	0.285	19
Mean				*41*	*382*								*0.091*	*0.927*	*9.350*						*0.0279*	*0.320*	
CV for Mean				*17%*	*21%*								*17%*	*8%*	*28%*						*18%*	*0.241*	
OQ2005-1	LI	40.51903	72.07617	57	536	F/V Lisa Kim	5-Sep	GPS / 6 ft / 6 sec	20	4 / 4	10	20	0.073	0.183	1.97	0.50	127.0	Ok	Jun-05	165, 231-234	0.0120	0.165	1
OQ2005-2	LI	40.38957	72.38950	53	438	F/V Lisa Kim	5-Sep	GPS / 6 ft / 6 sec	21	4 / 4	10	20	0.047	0.402	8.57	0.50	131.8	Ok	Jun-05	162, 235-238	0.0080	0.169	1
OQ2005-3	LI	40.64220	72.65170	35	267	F/V Lisa Kim	5-Sep	GPS / 6 ft / 6 sec	20	4 / 4	10	20	0.085	0.733	9.57	0.50	125.9	Ok	Jun-05	3, 239-242	0.0101	0.119	1
OQ2005-4	LI	40.68817	72.18147	46	308	F/V Lisa Kim	5-Sep	GPS / 6 ft / 6 sec	17	4 / 4	10	20	0.027	0.815	12.31	0.50	89.4	Ok	Jun-05	168, 243-246	0.0042	0.154	1
OQ2005-6	LI	40.05550	72.41673	65	554	F/V Lisa Kim	5-Sep	GPS / 6 ft / 6 sec	20	4 / 4	10	20	0.137	0.660	2.55	0.50	146.3	Ok	Jun-05	252-256	0.0210	0.153	1
Mean				*51*	*421*								*0.074*	*0.559*	*6.99*						*0.0110*	*0.152*	
CV for Mean				*10%*	*14%*								*25%*	*21%*	*29%*						*25%*	*0.058*	
OQ2002-1 (LK-1)	LI	40.72762	71.73730	60	331	F/V Lisa Kim	5-Mar	GPS / 1 ft / 6 sec	24	5 / 5	10	20	0.295	0.489	6.56	0.50	173.1	Ok	Jun-02	5 - 9	0.0290	0.098	1, 2, 5
OQ2002-2 (LK-2)	LI	40.10312	73.19108	48	277	F/V Lisa Kim	5-Mar	GPS / 1 ft / 6 sec	22	4 / 4	10	20	0.165	0.785	10.57	0.50	149.7	Ok	Jun-02	25- 29	0.0245	0.149	1, 2
OQ2002-3 (LK-3)	NJ	38.81491	73.81335	50	195	F/V Lisa Kim	5-Mar	GPS / 1 ft / 6 sec	20	4 / 4	10	20	0.081	0.777	11.57	0.50	133.4	Ok	Jun-02	213 - 217	0.0239	0.297	1, 2
OQ2002-4 (LK-4)	DMV	37.88755	74.64486	48	135	F/V Lisa Kim	4-Mar	GPS / 1 ft / 6 sec	24	5 / 5	10	20	0.073	0.254	12.46	0.50	136.0	Ok	Jun-02	272 - 276	0.0210	0.287	1, 2,9, 16
Mean		*39.38330*	*73.34665*	*52*	*235*								*0.153*	*0.576*	*10.29*						*0.0246*	*0.208*	
CV for Mean				*6%*	*18%*								*34%*	*22%*	*13%*						*7%*	*0.239*	
OQ2000-1 (JN-1)	LI	40.60217	71.98750	58	N/A	F/V John N	1-Mar	GPS / 1 ft / 30 sec	22	5 / 5	12.5	25	0.100	0.730	5.55	0.50	157.4	Ok	Jun-99	194 - 199	NA	NA	1, 2,6
OQ2000-2 (JN-2)	LI	40.39450	72.54300	48	N/A	F/V John N	1-Mar	GPS / 1 ft / 30 sec	16	4 / 3	12.5	25	0.062	0.554	15.10	0.50	98.1	Ok	Jun-99	178 - 180	0.0145	0.234	1, 2,7,11,12, 17
OQ2000-3 (DM-1)	LI	40.58300	72.79683	40	N/A	F/V Danielle Maria	1-May	GPS / 1 ft / 30 sec	27	6 / 6	10	20	0.089	0.560	4.57	0.50	184.2	Ok	Jun-99	3 - 8	0.0147	0.165	1, 2,8,10,12, 18
Mean		*40.52656*	*72.44244*	*49*									*0.084*	*0.615*	*8.405*						*0.0146*	*0.199*	
CV for Mean				*11%*									*14%*	*9%*	*40%*						*1%*	*0.175*	
OQ1999-01 DE2	LI	40.60227	71.98483	57	N/A	R/V Delaware II	1-Jun	GPS / 36 ft / 1 sec	60	8 / 8	5	10	0.007	0.990	4.05	0.25	253.1	Poor		N/A		0.990	14, 15
OQ1998-1 (SH-3)	LI (Shinnecock)	40.76650	72.17950	41	N/A	F/V Cape Fear	1-Mar	Loran / 40 ft / 30 sec.	14	3 / 3	10	20	0.017	1.000	3.48	0.50	76.5	Poor					1, 13
OQ1998-2 (SH-2)	LI (Shinnecock)	40.72200	72.00750	45	N/A	F/V Cape Fear	1-Mar	Loran / 40 ft / 30 sec.	23	5 / 5	10	20	0.067	0.869	10.57	0.50	140.3	Ok		NA		NA	15
OQ1998-3 (NS-1)	SNE (Nantucket Shoals)	40.46700	69.48300	63	N/A	F/V Cape Fear	1-Apr	Loran / 40 ft / 30 sec.	24	5 / 5	10	20	0.255	0.710	7.56	0.50	195.5	Ok					15
Mean		*40.65183*	*71.22333*	*50*									*0.113*	*0.860*	*7.204*								
CV for Mean				*14%*									*64%*	*10%*	*29%*								
OQ1997-1 (SH-1)	LI (Shinnecock)	40.26950	72.29850	58	N/A	F/V Laura Ann	1-Jul	Loran / 40 ft / 30 sec.	28	7 / 7	7.75	20	0.083	0.458	10.57	0.39	164.2	Ok					1,3
OQ1997-2 (WW-1)	NJ (Wildwood)	38.50950	74.11150	49	N/A	F/V Agitator	1-Aug	Loran / 40 ft / 30 sec.	28	13 / 6	10	20	0.084	0.150	2.37	0.50	176.0	Ok		NA		NA	1,4
Mean		*39.38950*	*73.20500*	*54*									*0.083*	*0.304*	*6.47*								
CV for Mean				*8%*									*0%*	*51%*	*63%*								

Footnotes for Table B17

[1] NA
[2] NA
[3] Depletion tows 1, 2, 12 & 18 omitted per NEFSC 1998, Figure E18
[4] Depletion tows 1, 19, 23 & 27 omitted per NEFSC 1998, Figure E21
[5] Setup station 5 dropped because sensor tow distance < 0.04 nm
[6] Length composition data collected at setup tow 194 only for OQ2000-1 (indicated 6% of catch >= 90 mm SL), setup data not useable.
[7] Length composition data collected at setup tow 178 only for OQ2000-2 (indicated 28% of catch >= 90 mm SL), used for all setup tows.
[8] Length composition data collected at setup tows 3 and 6 only for OQ2000-3 (average 33% and 28% of catch >= 90 mm SL), used for all setup tows.
[9] Length composition data collected at setup tow 272 only for OQ2000-4 (33% of catch >= 90 mm SL), used for all setup tows.
[10] Sensor tow distance missing for setup station 4, average tow distance at stations 3, 5, 6, 7, 8 used instead.
[11] Depletion tow 1 omitted because it was outside the study area.
[12] Adjustments for apparent trends in numbers per bushel during depletion experiment.
[13] Original estimates appear to have used incorrect mean number per bushel in depletion tows
[14] Missing GPS location data at survey stations 198 and 216 (depletion tows 5 and 23) replaced by approximate start/stop locations and interpolation.
[15] Anomalously high bushel count and length data at station 200 were not used.
[16] One setup tow with length data for OQ2002-4.
[17] One setup tow with length data for OQ2000-2.
[18] Two setup tows with length data for OQ2000-3.
[19] Used backup GPS and backup depth sensor data in place of SSP sensor data for depletion tows. Setup tows used SSP data.

Table B18. Summary of density, commercial dredge efficiency, and NEFSC dredge efficiency estimates for ocean quahog 90+ mm SL from the Patch model. The 90% confidence interval calculated by bootstrapping the fifteen survey efficiency estimates (15,000 iterations) ranged from 0.154 to 0.285.

Statistic	Density ($N\ ft^{-2}$)	Commercial Vessel Efficiency	NEFSC Survey Dredge Efficiency
N experiments	21	20	15
Minimum	0.007	0.150	0.098
Maximum	0.295	1.000	0.990
Median	0.083	0.720	0.169
Mean	0.096	0.646	0.263
Distribution of point estimates[1]			
Standard deviation	0.070	0.259	0.222
CV (sd/mean)	0.728	0.402	0.845
Lo 95%	0.000	0.137	0.000
Hi 95%	0.233	1.000	0.697
Distribution of average estimates[1]			
Standard error	0.015	0.058	0.057
CV (se/mean)	0.159	0.090	0.218
Lo 95%	0.066	0.532	0.150
Hi 95%	0.126	0.759	0.375

Table B19. Efficiency corrected swept-area fishable biomass estimates (1,000 mt meats) and CVs for ocean quahog during 1997, 2000, 2002, 2005 and 2008 (years with NEFSC clam surveys), by region. Figures for SVA and GBK during 2005 are, in effect, averages of figures for 2002 and 2008 because little data were available for 2005.

Area of assessment region (A, nm^2) - no correction for stations with unsuitable clam habitat

S. Virginia and N. Carolina (SVA)	712	10%
Delmarva (DMV)	4,071	10%
New Jersey (NJ)	6,510	10%
Long Island (LI)	4,463	10%
Southern New England (SNE)	4,922	10%
Georges Bank (GBK)	7,821	10%
Total	28,499	

INPUT: Fraction suitable habitat (u)

S. Virginia and N. Carolina (SVA)	100%	10%
Delmarva (DMV)	100%	10%
New Jersey (NJ)	100%	10%
Long Island (LI)	100%	10%
Southern New England (SNE)	96%	10%
Georges Bank (GBK)	90%	10%

Habitat area in assessment region (A', nm2)

S. Virginia and N. Carolina (SVA)	712	14%
Delmarva (DMV)	4,071	14%
New Jersey (NJ)	6,510	14%
Long Island (LI)	4,463	14%
Southern New England (SNE)	4,714	14%
Georges Bank (GBK)	7,039	14%

INPUT: Biomass fraction in unsurveyd deep water

S. Virginia and N. Carolina (SVA)	0%	10%
Delmarva (DMV)	0%	10%
New Jersey (NJ)	0%	10%
Long Island (LI)	0%	10%
Southern New England (SNE)	2%	10%
Georges Bank (GBK)	13%	10%

INPUT: Original survey mean catch from fishable stock (kg/tow, for tows adjusted to nominal tow distance using sensors)

	Estimates for 1997	CV	Estimates for 1999	CV	Estimates for 2002	CV	Estimates for 2005	CV	Estimates for 2008	CV
S. Virginia and N. Carolina (SVA)	0.0013	100%	0.0007	55%	0.0004	100%	0.0004	100%	0.0004	100%
Delmarva (DMV)	0.6528	23%	0.4449	26%	0.6879	24%	0.4221	48%	0.3908	52%
New Jersey (NJ)	1.7341	15%	0.9728	14%	1.8752	23%	1.0553	14%	1.2071	19%
Long Island (LI)	4.5648	17%	3.0065	14%	3.5561	18%	2.1791	16%	3.4396	15%
Southern New England (SNE)	2.2252	37%	2.6964	45%	3.2654	26%	2.0689	22%	2.8049	22%
Georges Bank (GBK)	2.6710	16%	3.1454	18%	3.8760	17%	4.3336	20%	4.7733	27%

Swept-area biomass without efficiency correction (B', 1000 mt):

S. Virginia and N. Carolina (SVA)	0.008	102%	0.004	59%	0.002	102%	0.002	102%	0.002	102%
Delmarva (DMV)	22	30%	15	33%	23	31%	14	52%	13	56%
New Jersey (NJ)	91	25%	51	24%	99	30%	56	24%	64	28%
Long Island (LI)	165	26%	109	24%	129	27%	79	26%	124	25%
Southern New England (SNE)	87	42%	105	49%	127	33%	81	30%	109	30%
Georges Bank (GBK)	172	26%	203	27%	250	26%	279	28%	308	34%
Total fishable biomass less GBK	365	17%	280	21%	378	17%	229	15%	310	16%
Total fishable biomass	537	14%	483	17%	627	14%	508	17%	618	19%

INPUT: Survey dredge efficiency (e)	0.169	21%	0.169	21%	0.169	21%	0.169	21%	0.169	21%

Efficiency adjusted swept area fishable biomass (B, 1000 mt)

S. Virginia and N. Carolina (SVA)	0.045	104%	0.024	62%	0.013	104%	0.013	104%	0.013	104%
Delmarva (DMV)	127	37%	87	39%	134	38%	82	56%	76	60%
New Jersey (NJ)	541	33%	304	32%	585	37%	329	32%	377	35%
Long Island (LI)	977	34%	644	32%	761	34%	466	33%	736	33%
Southern New England (SNE)	513	47%	622	54%	753	39%	477	36%	647	36%
Georges Bank (GBK)	1,019	33%	1,200	34%	1,479	34%	1,653	35%	1,821	40%
Total fishable biomass less GBK	2,159	27%	1,656	30%	2,234	27%	1,355	26%	1,836	26%
Total fishable biomass	3,178	25%	2,856	27%	3,713	25%	3,009	27%	3,657	28%

Lower bound for 80% confidence intervals on fishable biomass (1000 mt, for lognormal distribution with no bias correction)

	Estimates for 1997	Estimates for 1999	Estimates for 2002	Estimates for 2005	Estimates for 2008
S. Virginia and N. Carolina (SVA)	0.015	0.011	0.004	0.004	0.004
Delmarva (DMV)	81	54	84	42	38
New Jersey (NJ)	360	203	370	220	245
Long Island (LI)	643	430	498	309	490
Southern New England (SNE)	290	327	465	304	412
Georges Bank (GBK)	674	785	973	1,067	1,117
Total fishable biomass less GBK	1,539	1,138	1,596	978	1,320
Total fishable biomass	2,311	2,037	2,693	2,142	2,573

Upperbound for 80% confidence intervals on fishable biomass (1000 mt, for lognormal distribution with no bias correction)

S. Virginia and N. Carolina (SVA)	0.134	0.049	0.039	0.039	0.039
Delmarva (DMV)	202	141	214	161	154
New Jersey (NJ)	814	454	926	493	580
Long Island (LI)	1,485	962	1,164	705	1,106
Southern New England (SNE)	909	1,182	1,218	749	1,016
Georges Bank (GBK)	1,540	1,835	2,248	2,561	2,969
Total fishable biomass less GBK	3,029	2,409	3,127	1,879	2,555
Total fishable biomass	4,371	4,004	5,118	4,226	5,198

Table B20. Ocean quahog fishing mortality estimates based on catch and efficiency corrected swept-area biomass for fishable ocean quahog during 1997, 1999, 2002, 2005 and 2008 with NEFSC clam surveys. CVs are based on analytical variance calculations assuming log normality, and include uncertainty in catch, survey data, swept-area, amount of suitable habitat, and survey dredge efficiency.

INPUT: Upper bound incidental mortality allowance	5%
INPUT: Assumed CV for catch	10%

INPUT: Landings (1000 mt, discard ~ 0)	**Estimates for 1997**	**Estimates for 1999**	**Estimates for 2002**	**Estimates for 2005**	**Estimates for 2008**
S. Virginia and N. Carolina (SVA)	0	0.000	0.000	0.000	0.000
Delmarva (DMV)	1.072	1.092	1.737	0.912	0.270
New Jersey (NJ)	4.229	3.043	2.789	0.670	1.733
Long Island (LI)	5.141	6.339	9.140	9.728	11.123
Southern New England (SNE)	8.968	6.628	3.895	2.024	2.151
Georges Bank (GBK)	0.000	0.000	0.000	0.000	0.000
Total	19.410	17.102	17.561	13.334	15.278

Catch (1000 mt, landings + upper bound incidental mortality allowance)					
S. Virginia and N. Carolina (SVA)	0.000	0.000	0.000	0.000	0.000
Delmarva (DMV)	1.126	1.146	1.824	0.957	0.283
New Jersey (NJ)	4.441	3.195	2.928	0.704	1.820
Long Island (LI)	5.398	6.656	9.597	10.215	11.679
Southern New England (SNE)	9.416	6.960	4.090	2.125	2.259
Georges Bank (GBK)	0.000	0.000	0.000	0.000	0.000
Total	20.380	17.957	18.439	14.001	16.042

INPUT: Efficiency Corrected Swept Area Biomass for Fishable Stock (1000 mt)	**Estimates for 1997**	**CV**	**Estimates for 1999**	**CV**	**Estimates for 2002**	**CV**	**Estimates for 2005**	**CV**	**Estimates for 2008**	**CV**
S. Virginia and N. Carolina (SVA)	0	104%	0	62%	0	104%	0	104%	0	104%
Delmarva (DMV)	127	37%	87	39%	134	38%	82	56%	76	60%
New Jersey (NJ)	541	33%	304	32%	585	37%	329	32%	377	35%
Long Island (LI)	977	34%	644	32%	761	34%	466	33%	736	33%
Southern New England (SNE)	513	47%	622	54%	753	39%	477	36%	647	36%
Georges Bank (GBK)	1,019	33%	1,200	34%	1,479	34%	1,653	35%	1,821	40%
Total fishable biomass less GBK	2,159	27%	1,656	30%	2,234	27%	1,355	26%	1,836	26%
Total fishable biomass	3,178	25%	2,856	27%	3,713	25%	3,009	27%	3,657	28%

Fishing mortality (y^{-1})										
S. Virginia and N. Carolina (SVA)	0.000	105%	0.000	63%	0.000	105%	0.000	105%	0.000	105%
Delmarva (DMV)	0.009	38%	0.013	40%	0.014	39%	0.012	57%	0.004	60%
New Jersey (NJ)	0.008	34%	0.011	34%	0.005	38%	0.002	34%	0.005	36%
Long Island (LI)	0.006	NA	0.010	NA	0.013	36%	0.022	35%	0.016	34%
Southern New England (SNE)	0.018	48%	0.011	54%	0.005	40%	0.004	38%	0.003	38%
Georges Bank (GBK)	0.000	NA	0.000	NA	0.000	NA	0.000	0%	0.000	0%
Total fishable biomass less GBK	0.009	29%	0.011	32%	0.008	29%	0.010	28%	0.009	28%
Total fishable biomass	0.006	27%	0.006	29%	0.005	27%	0.005	29%	0.004	30%

Lower bound for 80% confidence intervals for fishing mortality (y^{-1}, for lognormal distribution with no bias correction)	**Estimates for 1997**	**Estimates for 1999**	**Estimates for 2002**	**Estimates for 2005**	**Estimates for 2008**
S. Virginia and N. Carolina (SVA)	NA	NA	NA	NA	NA
Delmarva (DMV)	0.005	0.008	0.008	0.006	0.002
New Jersey (NJ)	0.005	0.007	0.003	0.001	0.003
Long Island (LI)	NA	NA	0.008	0.014	0.010
Southern New England (SNE)	0.010	0.006	0.003	0.003	0.002
Georges Bank (GBK)	NA	NA	NA	NA	NA
Total fishable biomass less GBK	0.007	0.007	0.006	0.007	0.006
Total fishable biomass	0.005	0.004	0.004	0.003	0.003

Upper bound for 80% confidence intervals for fishing mortality (y^{-1}, for lognormal distribution with no bias correction)					
S. Virginia and N. Carolina (SVA)	NA	NA	NA	NA	NA
Delmarva (DMV)	0.014	0.022	0.022	0.023	0.008
New Jersey (NJ)	0.013	0.016	0.008	0.003	0.008
Long Island (LI)	NA	NA	0.020	0.034	0.024
Southern New England (SNE)	0.033	0.021	0.009	0.007	0.006
Georges Bank (GBK)	NA	NA	NA	NA	NA
Total fishable biomass less GBK	0.014	0.016	0.012	0.015	0.012
Total fishable biomass	0.009	0.009	0.007	0.007	0.006

Table B21. "Best" biomass estimates for ocean quahogs during 1978-2008. SVA estimates are from "VPA" and other regional estimates are from KLAMZ models. Whole stock and exploited stock biomass are sums of regional estimates. "KLAMZ (1R)" means from a KLAMZ model that has constant recruitment in each year. "KLAMZ (2R)" means from a KLAMZ model assuming two periods of constant recruitment. "*Q* for ESB" is the estimated (KLAMZ model) or assumed (VPA) survey scaling parameter for efficiency corrected swept area biomass. *Q* values are a diagnostic for KLAMZ model fits and expected to be near one.

Biomass	VPA		KLAMZ (1R)		KLAMZ (1R)		KLAMZ (2R)		KLAMZ (2R)		KLAMZ (1R)		Sum of best regional estimates			
Q for ESB	1.00		0.96		0.96		1.04		1.04		0.98					
Year	SVA	CV	DMV	CV	NJ	CV	LI	CV	SNE	CV	GBK	CV	Exploitable stock	CV	Whole Stock	CV
1978	0.3344	0.96	298	0.14	897	0.13	663	0.28	553	0.38	1,169	0.41	2,412	0.24	3,580	0.21
1979	0.3344	0.96	290	0.15	872	0.13	676	0.26	564	0.36	1,175	0.39	2,403	0.24	3,577	0.21
1980	0.3344	0.96	277	0.15	848	0.13	689	0.25	575	0.34	1,181	0.37	2,389	0.23	3,570	0.20
1981	0.3344	0.96	267	0.15	824	0.14	702	0.24	586	0.32	1,186	0.36	2,378	0.22	3,564	0.19
1982	0.2708	0.96	257	0.15	800	0.14	714	0.23	596	0.30	1,192	0.34	2,368	0.22	3,560	0.19
1983	0.2639	0.96	247	0.16	776	0.14	727	0.22	607	0.28	1,198	0.32	2,358	0.21	3,555	0.18
1984	0.2639	0.96	237	0.16	754	0.14	740	0.21	616	0.26	1,203	0.31	2,347	0.21	3,550	0.17
1985	0.2571	0.96	225	0.17	731	0.14	752	0.20	626	0.24	1,209	0.29	2,334	0.20	3,542	0.17
1986	0.0712	0.96	212	0.17	706	0.14	764	0.19	635	0.23	1,214	0.28	2,318	0.20	3,532	0.16
1987	0.0712	0.96	200	0.18	684	0.15	776	0.19	645	0.22	1,220	0.27	2,305	0.19	3,524	0.16
1988	0.0712	0.96	185	0.19	662	0.15	787	0.18	654	0.21	1,225	0.25	2,289	0.19	3,514	0.15
1989	0.0272	0.96	170	0.20	643	0.15	798	0.17	663	0.20	1,231	0.24	2,275	0.19	3,506	0.15
1990	0.0272	0.96	160	0.21	618	0.15	810	0.17	672	0.19	1,236	0.23	2,260	0.18	3,496	0.14
1991	0.0130	0.96	154	0.22	591	0.16	821	0.17	681	0.18	1,241	0.22	2,247	0.18	3,488	0.14
1992	0.0130	0.96	146	0.22	566	0.16	831	0.16	690	0.17	1,246	0.21	2,233	0.18	3,479	0.14
1993	0.0130	0.96	140	0.23	549	0.16	813	0.16	684	0.17	1,251	0.20	2,187	0.18	3,438	0.13
1994	0.0130	0.96	136	0.23	529	0.16	799	0.17	678	0.17	1,256	0.20	2,142	0.18	3,398	0.13
1995	0.0130	0.96	132	0.23	513	0.17	781	0.17	672	0.17	1,261	0.19	2,098	0.18	3,359	0.13
1996	0.0130	0.96	129	0.23	499	0.17	765	0.17	661	0.17	1,266	0.19	2,054	0.18	3,320	0.13
1997	0.0130	0.96	125	0.24	485	0.17	753	0.17	647	0.17	1,271	0.18	2,011	0.18	3,282	0.13
1998	0.0130	0.96	122	0.24	472	0.17	742	0.17	633	0.17	1,276	0.18	1,969	0.18	3,245	0.13
1999	0.0130	0.96	118	0.24	461	0.17	728	0.17	621	0.18	1,280	0.18	1,928	0.18	3,209	0.13
2000	0.0130	0.96	115	0.24	450	0.17	715	0.17	608	0.18	1,285	0.18	1,888	0.18	3,173	0.13
2001	0.0130	0.96	111	0.25	439	0.17	704	0.17	597	0.18	1,290	0.18	1,852	0.18	3,141	0.13
2002	0.0130	0.96	108	0.25	426	0.17	691	0.17	587	0.18	1,294	0.18	1,813	0.18	3,107	0.13
2003	0.0130	0.96	104	0.25	416	0.18	675	0.18	577	0.18	1,298	0.18	1,773	0.18	3,071	0.13
2004	0.0130	0.96	101	0.25	405	0.18	657	0.18	569	0.18	1,303	0.18	1,732	0.18	3,035	0.13
2005	0.0130	0.96	99	0.26	396	0.18	639	0.18	559	0.18	1,307	0.18	1,693	0.19	3,000	0.13
2006	0.0130	0.96	96	0.26	388	0.18	623	0.18	551	0.18	1,311	0.19	1,658	0.19	2,969	0.13
2007	0.0130	0.96	94	0.26	381	0.18	605	0.19	544	0.18	1,315	0.19	1,623	0.19	2,938	0.13
2008	0.0130	0.96	92	0.26	373	0.18	587	0.19	535	0.18	1,319	0.20	1,586	0.19	2,905	0.13
Min	0.0130	0.96	92	0.145	373	0.132	587	0.163	535	0.171	1,169	0.176	1,586	0.176	2,905	0.127
Median	0.0130	0.96	140	0.226	549	0.160	728	0.178	616	0.182	1,251	0.209	2,187	0.185	3,438	0.135
Mean	0.0934	0.96	166	0.210	586	0.157	727	0.191	616	0.217	1,249	0.242	2,094	0.193	3,343	0.150
Max	0.3344	0.96	298	0.260	897	0.178	831	0.278	690	0.383	1,319	0.407	2,412	0.244	3,580	0.213

Table B22. Best fishing mortality estimates for ocean quahogs during 1978-2008. . Whole stock, exploited region, and SVA estimates are from solving the catch equation for catch given best biomass estimates and instantaneous rates for growth and recruitment. Other regional estimates are from KLAMZ models that provided the best biomass estimates.

Year	SVA	CV	DMV	CV	NJ	CV	LI	CV	SNE	CV	GBK	CV	Exploitable stock	CV	Whole Stock	CV
1978	0.0000	0.00	0.0060	0.15	0.0098	0.13	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0045	0.24	0.0031	0.24
1979	0.0000	0.00	0.0264	0.15	0.0096	0.13	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0069	0.24	0.0046	0.24
1980	0.0000	0.96	0.0174	0.15	0.0104	0.14	0.0000	0.25	0.0000	0.00	0.0000	0.00	0.0059	0.23	0.0039	0.23
1981	0.2135	0.96	0.0150	0.15	0.0112	0.14	0.0000	0.24	0.0000	0.00	0.0000	0.00	0.0058	0.23	0.0039	0.23
1982	0.0258	0.00	0.0197	0.16	0.0117	0.14	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0063	0.22	0.0042	0.22
1983	0.0000	0.96	0.0227	0.16	0.0110	0.14	0.0000	0.22	0.0011	0.28	0.0000	0.00	0.0065	0.21	0.0043	0.21
1984	0.0264	0.96	0.0331	0.16	0.0127	0.14	0.0000	0.00	0.0014	0.26	0.0000	0.00	0.0081	0.21	0.0053	0.21
1985	1.3050	0.00	0.0364	0.17	0.0164	0.14	0.0001	0.20	0.0012	0.24	0.0000	0.00	0.0094	0.20	0.0062	0.20
1986	0.0000	0.00	0.0414	0.18	0.0135	0.14	0.0005	0.19	0.0009	0.23	0.0000	0.00	0.0086	0.20	0.0056	0.20
1987	0.0000	0.96	0.0548	0.19	0.0135	0.15	0.0015	0.19	0.0011	0.22	0.0000	0.00	0.0098	0.19	0.0064	0.19
1988	0.9770	0.00	0.0660	0.20	0.0108	0.15	0.0008	0.18	0.0013	0.21	0.0000	0.00	0.0093	0.19	0.0061	0.19
1989	0.0000	0.96	0.0390	0.21	0.0224	0.15	0.0008	0.17	0.0018	0.20	0.0000	0.00	0.0104	0.19	0.0067	0.19
1990	0.7487	0.00	0.0235	0.21	0.0258	0.15	0.0009	0.17	0.0014	0.19	0.0000	0.00	0.0098	0.18	0.0063	0.18
1991	0.0000	0.00	0.0324	0.22	0.0252	0.16	0.0020	0.17	0.0013	0.18	0.0000	0.00	0.0103	0.18	0.0066	0.18
1992	0.0000	0.00	0.0166	0.23	0.0125	0.16	0.0145	0.16	0.0017	0.17	0.0000	0.00	0.0106	0.18	0.0068	0.18
1993	0.0000	0.00	0.0141	0.23	0.0189	0.16	0.0107	0.17	0.0015	0.17	0.0000	0.00	0.0106	0.18	0.0067	0.18
1994	0.0000	0.00	0.0074	0.23	0.0133	0.16	0.0152	0.17	0.0014	0.17	0.0000	0.00	0.0103	0.18	0.0065	0.18
1995	0.0000	0.00	0.0054	0.23	0.0106	0.17	0.0123	0.17	0.0081	0.17	0.0000	0.00	0.0106	0.18	0.0066	0.18
1996	0.0000	0.00	0.0058	0.24	0.0099	0.17	0.0078	0.17	0.0128	0.17	0.0000	0.00	0.0103	0.18	0.0063	0.18
1997	0.0000	0.00	0.0087	0.24	0.0088	0.17	0.0069	0.17	0.0140	0.17	0.0000	0.00	0.0102	0.18	0.0062	0.18
1998	0.0000	0.00	0.0114	0.24	0.0058	0.17	0.0093	0.17	0.0108	0.18	0.0000	0.00	0.0095	0.18	0.0058	0.18
1999	0.0000	0.00	0.0094	0.24	0.0067	0.17	0.0088	0.17	0.0108	0.18	0.0000	0.00	0.0094	0.18	0.0056	0.18
2000	0.0000	0.00	0.0093	0.24	0.0075	0.17	0.0067	0.17	0.0085	0.18	0.0000	0.00	0.0081	0.18	0.0048	0.18
2001	0.0000	0.00	0.0086	0.25	0.0111	0.17	0.0082	0.17	0.0084	0.18	0.0000	0.00	0.0096	0.18	0.0056	0.18
2002	0.0000	0.00	0.0163	0.25	0.0066	0.17	0.0133	0.18	0.0067	0.18	0.0000	0.00	0.0103	0.18	0.0060	0.18
2003	0.0000	0.00	0.0087	0.25	0.0090	0.18	0.0175	0.18	0.0038	0.18	0.0000	0.00	0.0110	0.18	0.0063	0.18
2004	0.0000	0.00	0.0062	0.25	0.0069	0.18	0.0165	0.18	0.0058	0.18	0.0000	0.00	0.0106	0.18	0.0060	0.18
2005	0.0000	0.00	0.0094	0.26	0.0017	0.18	0.0154	0.18	0.0036	0.18	0.0000	0.00	0.0083	0.19	0.0047	0.19
2006	0.0000	0.00	0.0052	0.26	0.0012	0.18	0.0181	0.19	0.0034	0.18	0.0000	0.00	0.0089	0.19	0.0049	0.19
2007	0.0000	0.00	0.0011	0.26	0.0042	0.18	0.0190	0.19	0.0043	0.18	0.0000	0.00	0.0100	0.19	0.0055	0.19
2008	0.0000	0.00	0.0030	0.26	0.0047	0.18	0.0193	0.19	0.0041	0.18	0.0000	0.00	0.0102	0.19	0.0056	0.19
Min	0.0000	0.00	0.0011	0.15	0.0012	0.13	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0045	0.18	0.0031	0.18
Median	0.0000	0.00	0.0146	0.23	0.0107	0.16	0.0068	0.17	0.0016	0.18	0.0000	0.00	0.0095	0.19	0.0059	0.19
Mean	0.1099	0.19	0.0193	0.21	0.0113	0.16	0.0069	0.16	0.0039	0.16	0.0000	0.00	0.0090	0.19	0.0056	0.19
Max	1.3050	0.96	0.0660	0.26	0.0258	0.18	0.0190	0.25	0.0140	0.28	0.0000	0.00	0.0110	0.24	0.0068	0.24

Table B23. Biological reference points from per recruit models for ocean quahogs. Reference points from model runs with natural mortality M=0.02 y^{-1} are for potential use by managers. Results with M=0.015 and 0.025 are for sensitivity analyses.

Policy	Fishing mortality rate (F)	Yield per recruit (g)	Spawning biomass per recruit (g)	Total biomass per recruit (g)
***M*=0.015**				
F=0	0.0000	0.00	1124	1341
F_{MAX}	0.0540	9.54	215	346
$F_{0.1}$	0.0220	8.53	431	592
$F_{25\%}$	0.0390	9.41	282	425
$F_{40\%}$	0.0200	8.31	459	623
$F_{45\%}$	0.0170	7.89	507	676
$F_{50\%}$	0.0140	7.32	566	740
$F_{55\%}$	0.0110	6.56	638	819
$F_{60\%}$	0.0090	5.89	696	882
***M*=0.02**				
F=0	0.0000	0.00	704	877
F_{MAX}	0.0759	7.52	129	234
$F_{0.1}$	0.0277	6.59	275	407
$F_{25\%}$	0.0517	7.39	176	292
$F_{40\%}$	0.0266	6.51	282	415
$F_{45\%}$	0.0219	6.11	317	454
$F_{50\%}$	0.0180	5.67	353	495
$F_{55\%}$	0.014	5.05	399	545
$F_{60\%}$	0.0120	4.66	426	575
***M*=0.025**				
F=0	0.0000	0.00	466	608
F_{MAX}	0.1030	6.11	82	169
$F_{0.1}$	0.0360	5.34	179	289
$F_{25\%}$	0.0660	5.98	117	214
$F_{40\%}$	0.0330	5.21	189	300
$F_{45\%}$	0.0270	4.87	212	327
$F_{50\%}$	0.0220	4.49	237	355
$F_{55\%}$	0.0180	4.09	261	382
$F_{60\%}$	0.015	3.72	282	406

Table B24. Input parameters for length based per recruit models used to estimate biological reference points for ocean quahog. The shell height-meat weight relationship is $W = e^{\alpha+\beta \ln L}$ where W is meat weight in grams and L is shell height (mm). Meat weights are in grams. Logistic functions for maturity and fishery selectivity at length were $p_L = 1 \Big/ \left[1 + e^{-(\alpha+\beta L)}\right]$ where L is shell height in mm and p_L is the corresponding proportion.

Parameter	Value
von Bertalanffy growth curve	
L_∞	97.28
K	0.0311
Shell height-meat weight relationship	
ln(α)	-9.258
β	2.825
Natural mortality (M)	0.02
Logistic fishery selectivity at size	
α	-7.63
β	0.105
Logistic maturity at size	
α	-5.92
β	0.0927

Table B25. Factors considered in choosing an F_{MSY} proxy for ocean quahogs between $F_{40\%}$ and $F_{50\%}$.

Factors affecting MSY estimates for fishable quahogs	Groundfish proxy ($F_{40\%}$)	Less resilient than groundfish proxy ($F_{50\%}$)
Temporal recruitment pattern (regularity)		x
Accurate catch data	x	
Low bycatch mortality	x	
Long time lags between spawning and recruitment to the fishery and spawning stock		x
Heterogeneous fishing patterns	x	x
Longevity		x
Mature before entering the fishery	x	
Slow growth		x
Time to fix errors if we are wrong	x	

Table B26. Stochastic projection results for ocean quahogs in 2015 with natural mortality M=0.02 under various constant quotas. Starting biomass levels in 2008 are from a bootstrap analysis (1673 iterations) with the KLAMZ model ocean quahogs in the exploited area. Biomass on GBK was assumed constant at the 2008 estimate. Actual landings were used in simulations for 2008 and expected landings (3.8 million bushels or 17.2 mt meats) were used for 2009. For 2010-2015, simulated managers specified a constant level of annual landings (quota) based on a harvest policy. Quotas are calculated by multiplying the target fishing mortality times the current best estimate of biomass during 2008, where the biomass estimate is for either the exploited or entire stock area. Simulated catches were equal to the quota plus 5% to account for incidental mortality. Probabilities of overfished stock conditions ($B_{2015} \leq B_{Threshold}$) and probabilities of overfishing ($F_{2015} \geq F_{45\%}$) in 2015 are shown in the last three columns. The probability of overfishing is for either the exploited stock (F_{2015} for exploited stock $\geq F_{45\%}$) or the entire stock (F_{2015} for entire stock $\geq F_{45\%}$).

How are the landings calculated? (alternative management actions, under constant annual removal)	Annual landings 2010-2015 (million bushels)	Annual landings 2010-2015 (1000 mt meats)	Probability overfished in 2015 ($B_{2015} \leq B_{Threshold}$)	Probability of overfishing for exploited stock in 2015 (F_{2015} for exploited stock $\geq F_{45\%}$)	Probability of overfishing for entire stock in 2015 (F_{2015} for entire stock $\geq F_{45\%}$)
Status quo landings	3.8	17.2	0	0.00	0.00
Current quota	5.3	24.2	0	0.19	0.00
FMP min landings	4.0	18.1	0	0.00	0.00
FMP max landings	6.0	27.2	0	0.54	0.00
Recommended F threshold ($F_{45\%}$) x 2008 biomass in exploited area	7.7	34.8	0	0.90	0.00
Current F target ($F_{0.1}$) x 2008 biomass in exploited area	9.7	44.0	0	0.99	0.00
Current F threshold ($F_{25\%}$) x 2008 biomass in exploited area	18.1	82.2	0	1.00	1.00
Recommended F threshold ($F_{45\%}$) x biomass in entire area	14.0	63.7	0	1.00	0.97
Current F target ($F_{0.1}$) x biomass in entire area	17.8	80.6	0	1.00	1.00
Current F threshold ($F_{25\%}$) x biomass in entire area	33.1	150.4	0	1.00	1.00

Table B27. Probabilities of overfishing and overfished stock status by 2015 for ocean quahogs under various harvest policies and three states of nature (M=0.015, 0.02 and 0.025) based on stochastic projection analyses for 2008-2015. Actual landings were used for 2008 and expected landings were used for 2009. For 2010-2015, simulated managers specify annual landings in terms of a constant landings policy (e.g. status-quo landings) or by multiplying an F based reference point (e.g. F20%) times the best estimate of stock biomass in 2008, where the biomass estimate may be for either the whole stock or the exploited stock only. The specified level of annual landings (+ 5% for incidental mortality) is then extracted from the simulated population during 2010-2015. Figures on the left side of the figure describe management actions (harvest policies) and calculation of annual landings during 2010-2015. Figures on the right hand side of the figure give the probability of overfishing for the exploited stock and the entire stock relative to the true mortality threshold $F_{45\%}$, as well as the probability of overfished stock conditions for the whole stock relative to the assumed true biomass threshold $B_{threshold} = 0.4B_{1978}$. The mortality and biomass thresholds depend on the state of nature because $F_{45\%}$ and B_{1978} depend on M. Probabilities equal zero are not shown to enhance the readability of the table. Figures above the dash line are for constant landings policies. Figures below the dashed line are for F based harvest policies.

Harvest policies (management actions)							States of nature								
							M=0.015			M=0.02			M=0.025		
Policy	Reference point F	Stock area for target landings	Best estimate 2008 biomass for catch calculations	Landings (million bushels)	Landings (1000 mt meats)	Landings + indicidental mortality (1000 mt meats)	Biomass	F for exploit. stock	F whole stock	Biomass	F for exploit. stock	F whole stock	Biomass	F for exploit. stock	F whole stock
Current quota		NA	NA	5.33	1.175	1.234	0.00	0.68	0.00	0.00	0.19	0.00	0.00	0.01	0.00
FMP max landings	NA	NA	NA	6.00	1.323	1.389	0.00	0.86	0.00	0.00	0.54	0.00	0.00	0.12	0.00
FMP min landings	NA	NA	NA	4.00	0.882	0.926	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Status quo landings	NA	NA	NA	3.80	0.838	0.880	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F0.1	0.0277	Whole	2,908	17.76	80.557	84.584	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00
F25%	0.0517	Whole	2,908	33.15	150.353	157.871	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00
F40%	0.0266	Whole	2,908	17.05	77.358	81.226	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	0.99
F45%	0.0219	Whole	2,908	14.04	63.689	66.874	0.00	1.00	1.00	0.00	1.00	0.97	0.00	1.00	0.70
F50%	0.0180	Whole	2,908	11.54	52.347	54.965	0.00	1.00	0.98	0.00	1.00	0.60	0.00	1.00	0.00
F0.1	0.0277	Exploitable	1,589	9.70	44.015	46.216	0.00	1.00	1.00	0.00	0.99	0.00	0.00	0.96	0.00
F25%	0.0517	Exploitable	1,589	18.11	82.151	86.259	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00
F40%	0.0266	Exploitable	1,589	9.32	42.267	44.381	0.00	1.00	1.00	0.00	0.99	0.00	0.00	0.93	0.00
F45%	0.0219	Exploitable	1,589	7.67	34.799	36.539	0.00	0.99	0.01	0.00	0.90	0.00	0.00	0.73	0.00
F50%	0.0180	Exploitable	1,589	6.31	28.602	30.032	0.00	0.90	0.00	0.00	0.65	0.00	0.00	0.24	0.00

Table B28. Harvest policies (management actions) considered in projection analyses for ocean quahogs. Constant landings policies are shown with the corresponding approximate true F for the whole and exploited stock components. Constant F policies are shown with the corresponding landings level determined by multiplying the target *F* by the biomass for the whole stock in 2008.

Whole stock 2008 biomass (1000 mt meats)		2,908		
Constant landings policies				
Policy (management action)	F (whole stock)	Landings		F exploited stock (for comparison)
		Million bu	Thousand mt meats	
Status quo landings	0.006	3.80	17.24	0.011
FMP maximum landings	0.009	6.00	27.22	0.017
FMP minimum landings	0.006	4.00	18.14	0.012
FMP current landings quota	0.008	5.33	24.18	0.015
Constant F policies				
F0.1 (current target)	0.028	17.76	80.56	0.052
F25% (current threshold)	0.052	33.15	150.35	0.100
F40%	0.027	17.05	77.36	0.050
F45% (recommended target)	0.022	14.04	63.69	0.041
F50%	0.018	11.54	52.35	0.034

Table B29. Input data used in simple projection analyses for ocean during 2009-2015.

Year	SVA	DMV	NJ	LI	SNE	GBK	Total Less GBK	Total
Somatic growth rate (G y^{-1})								
2008	1.05011E-07	1.05011E-07	0.00122	0.00792	0.00841	0.01116	0.00588	0.00837
Recruitment rate (r = Recruitment / Average Biomass in 2005 y^{-1})								
2008	0	1.0686E-08	0.00142	0.00002	0.00002	0.01182	0.00035	0.00548
Natural mortality (M y^{-1})								
2008	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Initial biomass proportions by region								
2008	4.46199E-06	0.03151	0.12819	0.20270	0.18399	0.45361	0.54639	1.00000
Proportions landings and catch by region								
2008	0	0.01766	0.11345	0.72807	0.14081	0.00000	1.00000	1.00000