A. OCEAN QUAHOG ADVISORY REPORT

State of Stock: The ocean quahog resource in EEZ waters from Southern New England (SNE) to Southern Virginia (SVA) is not overfished and overfishing is not occurring. The current biomass is high (Figures A1, A2), current fishing mortality (F= 0.014 for the exploited area, Efficiency-Corrected Swept Area Biomass (ESB) Model) is 50% of the target ($F_{0.1}$= 0.028; note: the value of $F_{0.1}$, the target F, was recalculated for this assessment). Unlike in most marine populations, which may show large and variable recruitment, annual recruitment is approximately 0-2% of stock biomass. Since the fishery began in the late 1970s, biomass has declined slowly (Figures A1, A2, A5). The percentage of the 1977 biomass remaining in 2002 in the assessed area is 80% (all regions) and 72% (exploited regions only; i.e. all regions except Georges Bank). Biomass and exploitation status of ocean quahog in the Gulf of Maine are unknown because the efficiency of the dredge used to do the Maine survey has not been determined. Stock status relative to Biological Reference Points is shown in Figure A5.

Management Advice: Maintaining status quo exploitation rates should result in a sustainable biomass approximately equal to the BMSY. In addition, because ocean quahogs are sedentary and fishing in concentrated in relatively small areas, it may be advantageous to avoid localized depletion.

Projections: At current catch and F (based on KLAMZ time series table), biomass is projected to decline gradually over the next decade.

Stock projections for ocean quahog during 2003-2007 based on assumptions about *F* or landings. Projected landings do not include a 5% allowance for incidental mortality used in calculations.

Year	Biomass All Regions (1000 mt)	Biomass less GBK (1000 mt)	Landings (1000 mt)	*F* All Regions (y^{-1})	*F* less GBK (y^{-1})
	Status-quo Catch				
2003	1,825	1,182	18	0.010	0.016
2004	1,794	1,164	18	0.010	0.016
2005	1,764	1,146	18	0.010	0.016
2006	1,733	1,128	18	0.011	0.016
2007	1,704	1,110	18	0.011	0.017
	Status-quo F				
2003	1,826	1,183	16	0.009	0.015
2004	1,796	1,167	16	0.009	0.015
2005	1,767	1,150	16	0.009	0.015
2006	1,739	1,134	15	0.009	0.015
2007	1,711	1,118	15	0.009	0.015
	Catch = Quota				
2003	1,825	1,182	18	0.010	0.016
2004	1,791	1,161	20	0.012	0.018
2005	1,755	1,138	23	0.014	0.021
2006	1,720	1,114	23	0.014	0.021
2007	1,684	1,091	23	0.014	0.022
	F = $F_{0.1}$ in exploited regions (F=0 for GBK)				
2003	1,811	1,168	30	0.018	0.028
2004	1,767	1,137	29	0.018	0.028
2005	1,724	1,106	29	0.018	0.028
2006	1,682	1,077	28	0.018	0.028
2007	1,641	1,048	27	0.018	0.028

Catch and Status Table (weights in '000 mt meats): Ocean Quahogs

[1]1980-2002. [2]Values are reported landings not adjusted for indirect mortality.

Year :	1994	1995	1996	1997	1998	1999	2000	2001	2002	[1]Max	[1]Min	[1]Mean
Quota:												
EEZ	24.5	22.2	20.2	19.6	18.1	20.4	20.4	20.4	20.4	--	--	--
[2]Landings:												
SVA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	<0.1
DMV	1.0	0.7	0.7	1.1	1.4	1.1	1.0	0.9	1.7	11.7	0.7	4.0
NJ	7.0	5.4	4.9	4.2	2.7	3.0	3.3	4.5	2.8	15.6	2.7	7.7
LI	12.0	9.5	5.9	5.1	6.6	6.3	4.7	5.7	9.1	12.0	0.0	3.9
SNE	1.0	5.4	8.3	9.0	6.4	6.6	5.1	4.7	3.9	9.0	0.0	2.6
GBK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other (in EEZ)	0.1	0.2	0.3	0.3	1.0	0.4	0.7	1.4	0.6	2.0	0.0	0.6
EEZ	21.0	21.2	20.1	19.7	18.0	17.5	14.9	17.2	18.1	22.5	13.1	18.8

Biomass and Mortality Estimates, Efficiency-Corrected Swept Area Biomass (ESB)

Year :	1997	1998	1999	2000	2001	2002
Biomass, '000 mt (ESB):						
SVA	<0.1	--	<0.1	--	--	<0.1
DMV	65	--	58	--	--	71
NJ	277	--	194	--	--	330
LI	505	--	422	--	--	454
SNE	249	--	416	--	--	428
GBK	447	--	686	--	--	833
EEZ Less GBK	1097	--	1090	--	--	1283
EEZ	1544	--	1776	--	--	2116
[1]Annual Fishing Mortality Rate (ESB):						
SVA	0.000	--	0.000	--	--	0.000
DMV	0.017	--	0.020	--	--	0.026
NJ	0.016	--	0.016	--	--	0.009
LI	0.011	--	0.016	--	--	0.021
SNE	0.038	--	0.017	--	--	0.010
GBK	0.000	--	0.000	--	--	0.000
EEZ Less GBK	0.019	--	0.016	--	--	0.014
EEZ	0.013	--	0.010	--	--	0.009

KLAMZ time series table

Year	SVA	DMV	NJ	LI	SNE	GBK	Total less GBK	Total
			[1] Model (scenario #)					
	VPA	KLAMZ 5	KLAMZ 3	VPA	KLAMZ 3	Aver. ESB	NA	NA
	Biomass ('000s mt)							
1977	0.297	298	455	534	386	655	1,674	2,329
1978	0.297	289	448	534	387	655	1,659	2,315
1979	0.297	281	442	534	388	655	1,645	2,300
1980	0.297	268	436	534	388	655	1,626	2,282
1981	0.297	257	428	534	389	655	1,608	2,264
1982	0.241	247	419	534	390	655	1,590	2,246
1983	0.235	236	411	534	391	655	1,572	2,227
1984	0.235	225	403	534	391	655	1,552	2,208
1985	0.229	212	394	534	390	655	1,531	2,186
1986	0.069	200	384	534	390	655	1,508	2,163
1987	0.069	187	375	534	390	655	1,486	2,141
1988	0.069	172	367	532	390	655	1,461	2,117
1989	0.027	156	361	532	390	655	1,438	2,094
1990	0.027	146	347	531	390	655	1,414	2,069
1991	0.013	138	333	530	389	655	1,391	2,046
1992	0.013	130	319	529	389	655	1,367	2,023
1993	0.013	125	314	517	389	655	1,344	1,999
1994	0.013	120	305	508	388	655	1,321	1,976
1995	0.013	116	300	496	388	655	1,299	1,955
1996	0.013	112	296	487	383	655	1,278	1,933
1997	0.013	109	293	481	376	655	1,258	1,913
1998	0.013	105	290	476	367	655	1,238	1,893
1999	0.013	101	289	469	362	655	1,221	1,876
2000	0.013	97	288	463	356	655	1,204	1,860
2001	0.013	94	286	468	352	655	1,201	1,856
2002	0.013	91	284	478	349	655	1,201	1,856
	Fishing Mortality (y^{-1})							
1977	0.000	0.003	0.014	0.000	0.000	0.000	0.004	0.003
1978	0.000	0.005	0.014	0.000	0.000	0.000	0.005	0.003
1979	0.000	0.020	0.014	0.000	0.000	0.000	0.007	0.005
1980	0.188	0.016	0.018	0.000	0.000	0.000	0.008	0.005
1981	0.021	0.014	0.020	0.000	0.000	0.000	0.008	0.005
1982	0.000	0.019	0.021	0.000	0.000	0.000	0.008	0.006
1983	0.026	0.023	0.020	0.000	0.002	0.000	0.009	0.007
1984	0.690	0.033	0.022	0.000	0.002	0.000	0.011	0.008
1985	0.000	0.035	0.028	0.000	0.002	0.000	0.012	0.009
1986	0.000	0.042	0.024	0.001	0.001	0.000	0.012	0.009
1987	0.608	0.059	0.025	0.002	0.002	0.000	0.015	0.010
1988	0.000	0.071	0.019	0.001	0.002	0.000	0.014	0.010
1989	0.501	0.043	0.040	0.001	0.003	0.000	0.016	0.011
1990	0.000	0.026	0.046	0.001	0.002	0.000	0.015	0.010
1991	0.000	0.036	0.045	0.003	0.002	0.000	0.016	0.011
1992	0.000	0.019	0.022	0.023	0.003	0.000	0.017	0.011
1993	0.000	0.016	0.033	0.017	0.003	0.000	0.016	0.011
1994	0.000	0.008	0.023	0.024	0.002	0.000	0.016	0.011
1995	0.000	0.006	0.018	0.019	0.014	0.000	0.016	0.011
1996	0.000	0.007	0.017	0.012	0.022	0.000	0.016	0.010
1997	0.000	0.010	0.015	0.011	0.024	0.000	0.016	0.010
1998	0.000	0.013	0.009	0.014	0.018	0.000	0.014	0.009
1999	0.000	0.011	0.011	0.014	0.019	0.000	0.014	0.009
2000	0.000	0.011	0.012	0.010	0.014	0.000	0.012	0.008
2001	0.000	0.010	0.016	0.012	0.013	0.000	0.013	0.009
2002	0.000	0.019	0.010	0.019	0.011	0.000	0.015	0.009

[1]From KLAMZ delay-difference model (for quahog 70+mm length), ESB, and VPA models, as indicated in table. The VPA is a cumulative catch model. “Aver. ESB” for GBK based on 1997, 1999, 2002. For DMV, KLAMZ3 and KLAMZ5 result were the same.

Stock Distribution and Identification: Ocean quahogs are distributed on both sides of the North Atlantic. They occur from Norway to Spain, intermittently across the North Atlantic and southward along the North American coast to Cape Hatteras. Commercial concentrations occur on the continental shelf off the coast of Maine and between Georges Bank and the Delmarva Peninsula (Figure A4), to at least 90 m. The assessment and management regime assumes a unit stock off the northeast US coast.

Catches: EEZ landings generally account for about 95-100% of total US landings. Annual EEZ quotas have been set since 1978. EEZ landings increased from 0 in 1975 to 14 thousand mt (meats) in 1979, and peaked at 23 thousand mt in 1992 (Figure A3). The spatial distribution of fishing effort has changed markedly over last two decades (Figure A3) in response to a variety of factors, including reductions in local catch rates and relocation of processing plants. The fishery was concentrated off Delmarva and Southern New Jersey from the 1970s to mid-1980s. During the late 1980s and early 1990s, the fishery expanded northward into the Northern New Jersey and Long Island regions. In 1995, it expanded to the Southern New England region. In 2001 and 2002, landings from Long Island fishery predominated, accounting for 33 and 50%, respectively of the landings from the EEZ. Total annual landings off the coast of Maine ranged from 92,000-129,000 "Maine" bushels (= 1 US Standard bushel = 1.2448 cu ft).

Data and Assessment: Ocean quahogs were last assessed in 2000 (SAW-31). The present assessment uses efficiency-corrected swept area biomass (ESB) estimates for the EEZ from the 1997, 1999 and 2002 surveys. The catch-swept area assessment model estimates fishing mortality rates by dividing landings by biomass. The Delay-difference model (KLAMZ) used efficiency-corrected swept area biomass estimates from 1997, 1999, 2002, a von Bertalanffy growth curve, shell length-meat weight relationships, and long-term research survey data to estimate ocean quahog biomass, mean annual recruitment biomass and fishing mortality rates during 1977-2002. Discards were assumed to be zero in all analyses. Indirect mortality from commercial dredging was assumed equal to 5% of the landings by weight. A cumulative catch model was also used in some cases to estimate historical biomass.

Biological Reference Points: Reference points were recalculated for this assessment to be consistent with the assumed 70mm knife-edge selection used in the KLAMZ model. The new estimates are F_{MAX}= 0.18 y^{-1}, $F_{0.1}$= 0.028 y^{-1} and $F_{25\%MSP}$ = 0.08 y^{-1}(Figure A5). These estimates assumed M = 0.02 y^{-1}, recruitment to the fishery occurred at 70mm (Age 26), and all fully recruited animals are considered to be sexually mature.

The present management "targets" are one-half of the virgin biomass and the $F_{0.1}$ fishing mortality in the exploited region (which excludes Georges Bank). The present "thresholds" are one quarter of the total virgin biomass and $F_{25\%MSP}$.

Based on the F_{MSY} proxy ($F_{25\%MSP}$ = 0.08 y^{-1}) and the revised estimate of one-half virgin biomass (1.2 million mt), the MSY catch would be about 96,000 mt meats y^{-1} for the whole stock (see Special Comments).

Fishing Mortality: Based on the ESB Model, F for 2002 was estimated to be 0.014 y^{-1} for the EEZ excluding GBK and the Gulf of Maine (Figure A5) (80% confidence interval 0.009 - 0.022 y^{-1}). The stockwide estimate (excluding Gulf of Maine) of F is 0.009 (80% confidence interval 0.006 - 0.013 y^{-1}). Recent observed Fs do not exceed the overfishing threshold ($F_{25\%MSP}$ = 0. 08y^{-1}) or target ($F_{0.1}$ = 0.028). Uncertainty in estimated fishing mortality rates is shown in Figure A6. Fishing mortality estimates from the KLAMZ model were similar (Figure A5).

Recruitment: Mean annual recruitment to the whole stock was small, 0-2% of stock biomass depending on the region. In the 2002 NMFS survey, the greatest numbers of small (<70mm shell length) ocean quahogs per tow were collected in the GBK and LI regions. For projections regional recruitment was assumed to be 0-1.7% of biomass in 2002.

Stock Biomass: Biomass for 2002 was estimated to be 1.3 million mt (ESB model) for the EEZ excluding GBK and the Gulf of Maine (Figure A5) (80% confidence interval 0.8 – 2.0 million mt). Stockwide estimate of biomass, (including Georges Bank but excluding the Gulf of Maine) is 2.1 million mt (80% confidence interval 1.4 – 3.1 million mt). Uncertainty in ESB biomass estimates is shown in Figure A7. Biomass estimates from the KLAMZ model were similar (Figure A5).

In the previous quahog assessment (NEFSC 2000a, b), stock biomass in 1976 (unfished stock) was 1.5 million mt (excluding GBK), and 2.1 million mt (including GBK). New estimates of the prefished stock biomass in 1977 were computed in the present assessment. They are 1.7 million mt (excluding GBK), and 2.3 million mt (including GBK)

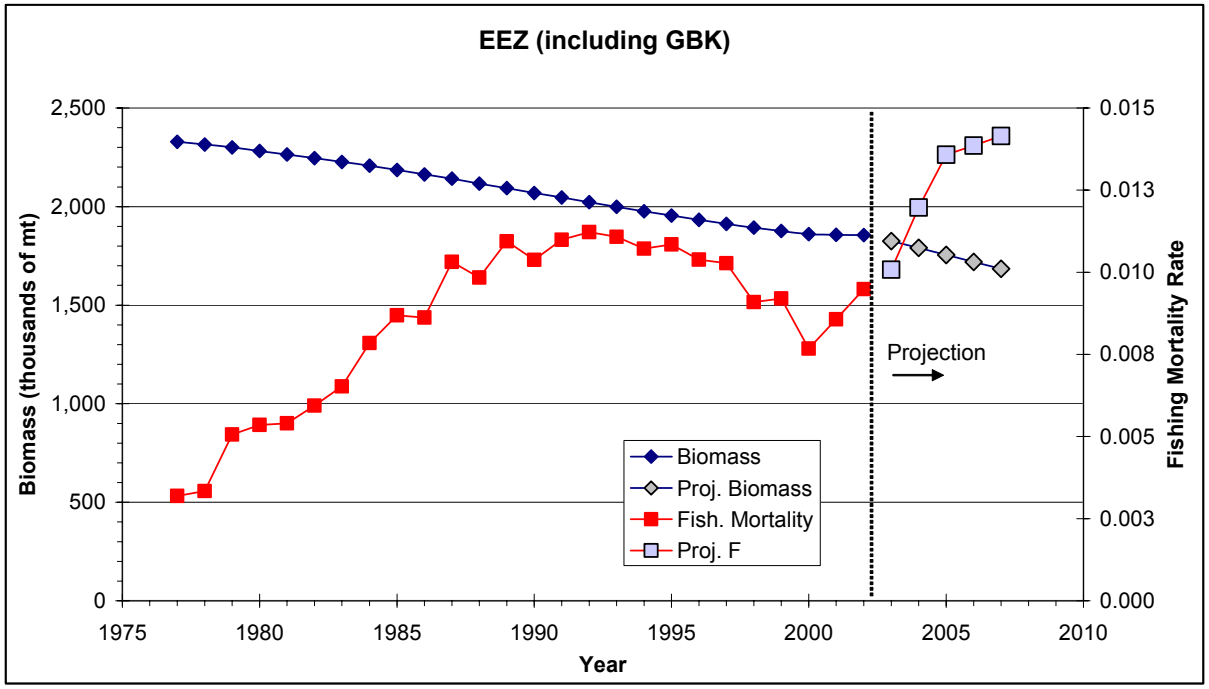
Special Comments: A major effort was made by NMFS, academia and industry collaborators from 1997-2002 to estimate the efficiency of the NMFS survey clam dredge. Nevertheless, a key source of uncertainty in the assessment is the survey dredge efficiency. The assumption that indirect mortality due to fishing is 5% is also a source of uncertainty.

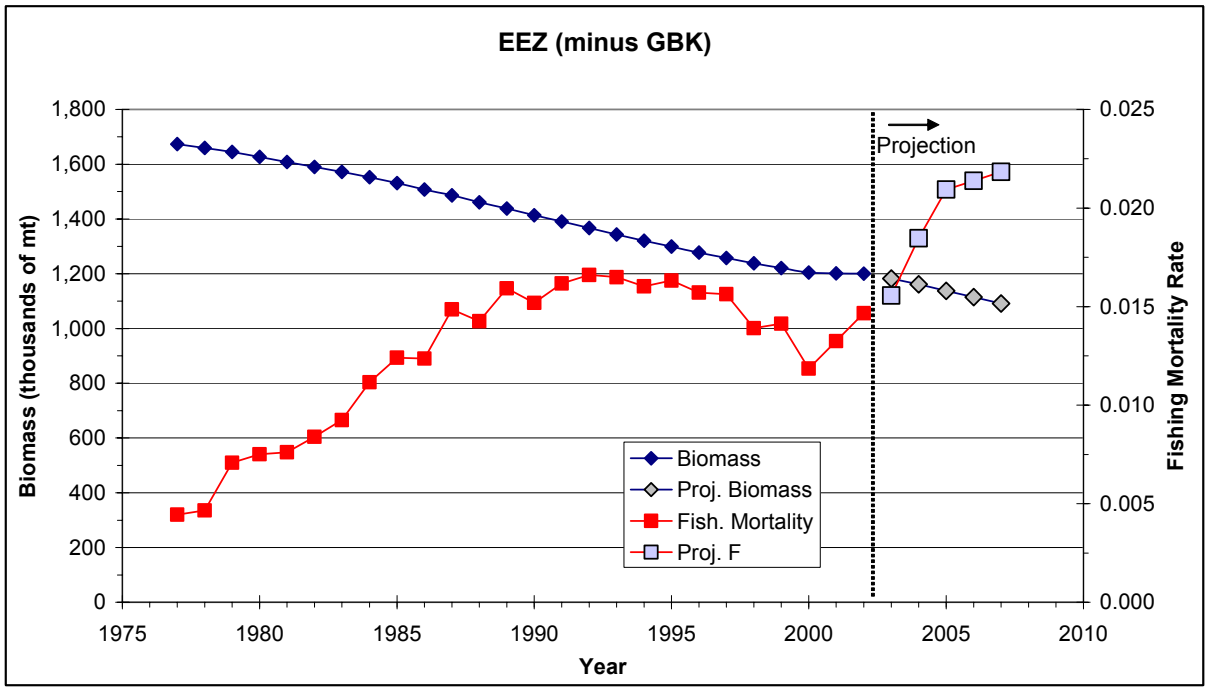
The results of a recent genetic study (Dahlgren *et al*., 2000) are consistent with the assumption that ocean quahogs throughout the EEZ are a single population.

The Surfclam-Ocean Quahog FMP currently utilizes a maximum fishing mortality threshold for ocean quahog based on the fishing mortality rate that generates 25% of the maximum spawning stock potential ($F_{25\% MSP}$). Based on more recent research on the use of such proxies for other resources, and concerns regarding the long term sustainability of the quahog resource, it is recommended that proxy MSP values be re-evaluated when this assessment is next updated.

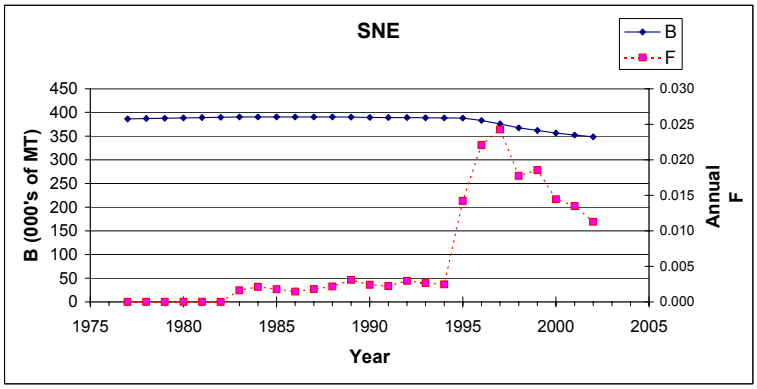
Sources of Information: Murawski, S.A., J.W. Ropes and F.M. Serchuk. 1982. Growth of the ocean quahog, *Arctica islandica*, in the Middle Atlantic Bight. Fishery Bulletin 80(1):21-34.
Dahlgren, T, J. Weinberg, and K. Halanych. 2002. Phylogeography of the ocean quahog (*Arctica islandica*): influences of paleoclimate on genetic diversity and species range. Mar. Biol. 137: 487-495.
NEFSC, 2000a. 31st Northeast Regional Stock Assessment Workshop (31st SAW). Public Review Workshop. C. Ocean quahog Advisory Report pp 24-32.
NEFSC Ref. Doc. 00-14. NEFSC, 2000b. 31st Northeast Regional Stock Assessment Workshop (31st SAW). Consensus Summary of Assessments. C. Ocean quahog. pp 172-304. NEFSC Ref. Doc. 00-15.

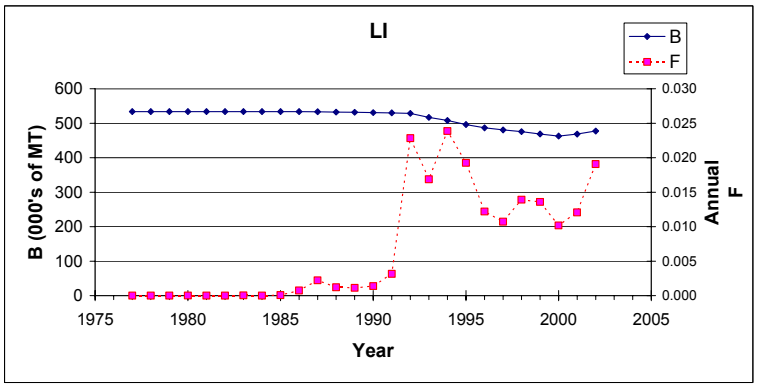
A1. Estimated and projected ocean quahog biomass and fishing mortality rate over time. Projections assume future catches = annual quotas.

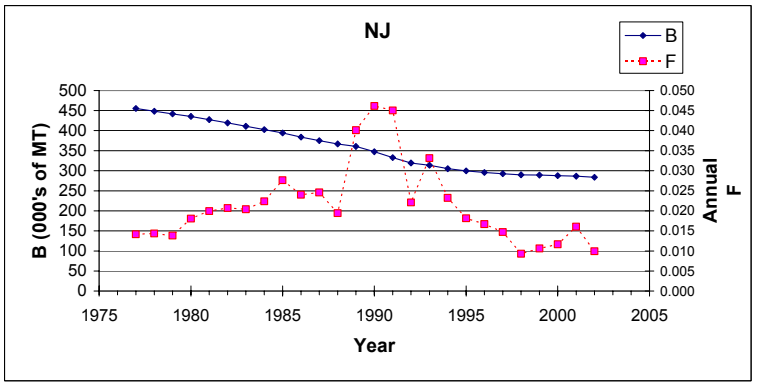


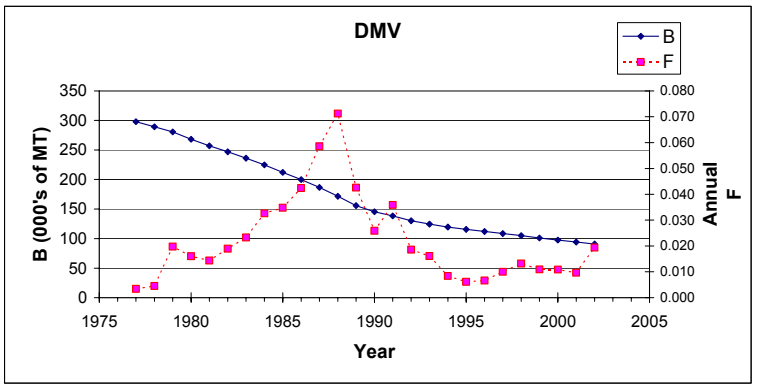


A2. Ocean quahog biomass and fishing mortality rate over time, by region.

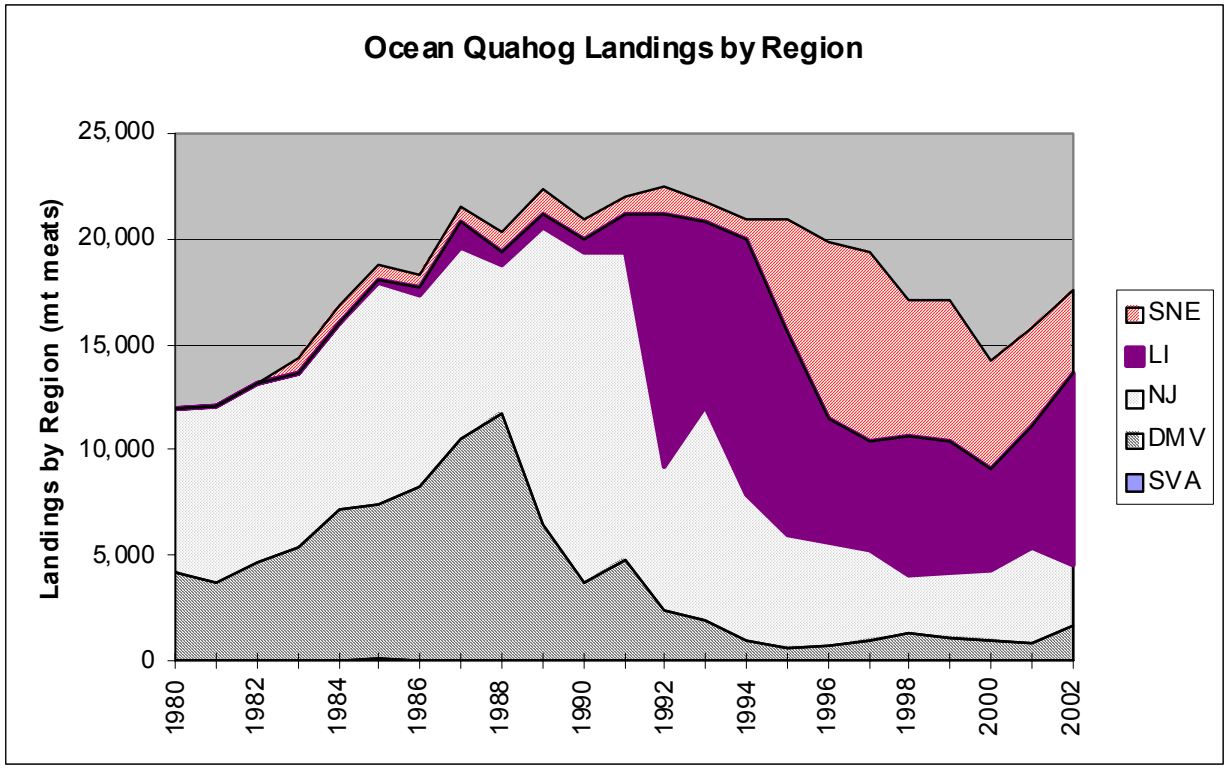




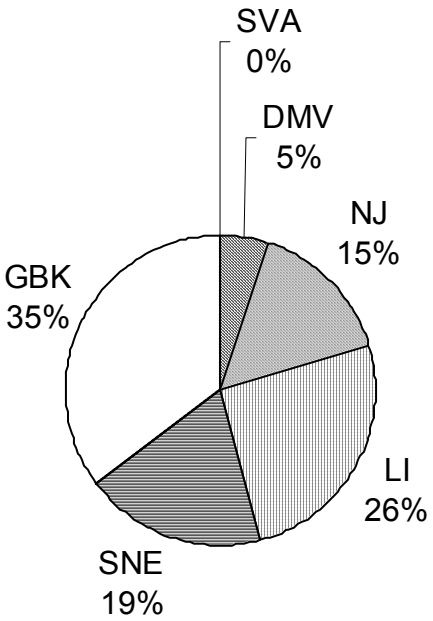




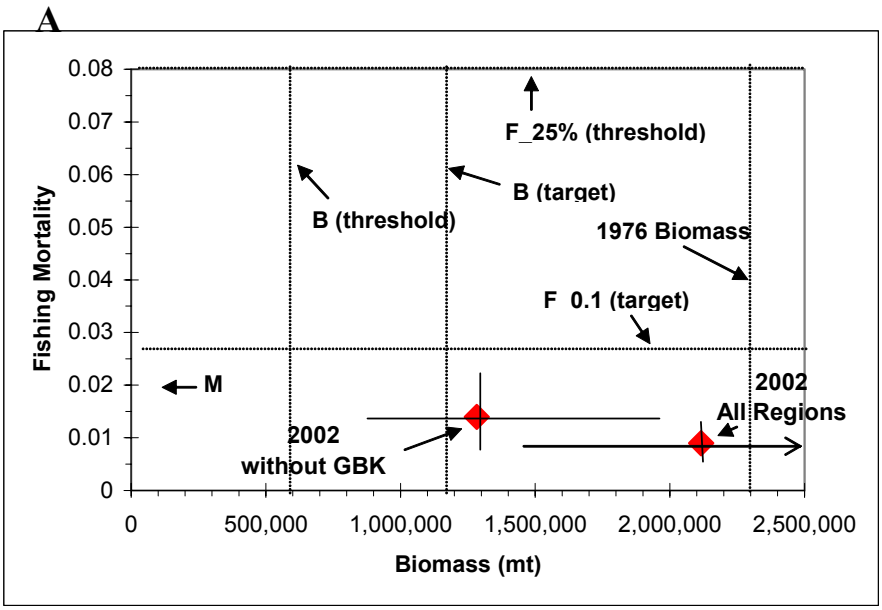
A3. Ocean Quahog landings by region, 1980-2002.

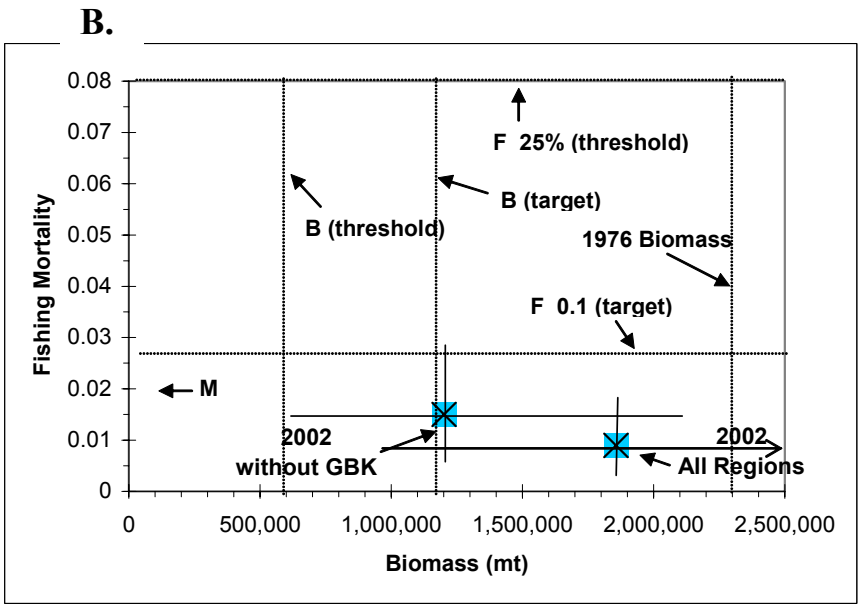


A4. Percentage of ocean quahog biomass by region, 2002.

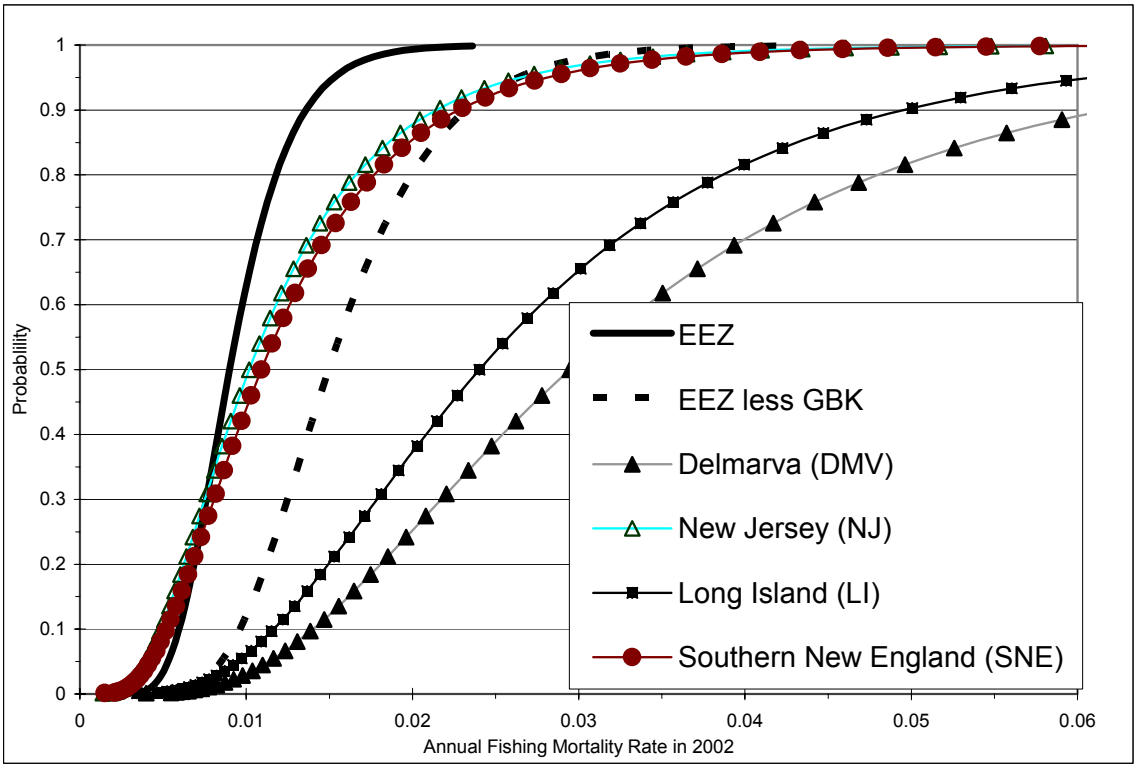


A5. Biological reference points for ocean quahogs, and estimates with 80% confidence intervals of recent biomass and annual fishing mortality rate. A ESB model or B KLAMZ model .





A6. Uncertainty in ocean quahog fishing mortality estimates for 2002.



A7. Uncertainty in ocean quahog biomass estimates for 2002.