C. ATLANTIC SURFCLAM ASSESSMENT SUMMARY FOR 2006

State of Stock: The Atlantic surfclam stock in the US EEZ (Exclusive Economic Zone, 3 to 200 nm from shore, Figure C1) is not overfished and overfishing is not occurring. Estimated fishable stock biomass in 2005 (120+ mm shell length, SL) was 1.17 million mt meats, which is above the management target of ½ 1999 biomass = 900 thousand mt meats (Figures C2-C5). Estimated fishing mortality in 2005 was F= 0.0192 y^{-1}, which is below the management threshold $F_{0.1}$ = 0.15 y^{-1} (Figures C6 and C7). These estimates are for the entire EEZ stock, including the portion of the EEZ stock on Georges Bank. Surfclam resources in state waters are not included.

All figures and information in this summary are for surfclams in the EEZ only, unless otherwise specified.

Projections: Based on example calculations (below), biomass is projected to decline gradually through 2010, although uncertainty about future conditions is high (CVs larger than 250% for all years); (The CV measures variability among 2000 stochastic projection runs; it does not measure precision of mean projected estimates.) Biomass is projected to decline because recent recruitment has been low and is likely to remain low over the next five years. For scenarios with landings equal to constant quotas, catch was calculated as landings plus an additional 12% to account for incidental mortality.

Year	Example 1: Landings = min quota = 1.85 million bu	Example 2: Status quo landings = mean 2003-2005 = 3.042 million bu	Example 3: Landings = max quota = 3.4 million bu	Example 4: $F = F_{MSY} = M = 0.15$	CV
		Annual Catch in 1000s mt (= landings + 12%)			
All	16.0	26.3	29.4	variable	NA
		Biomass (1000 mt)			
2005	1,198	1,198	1,198	1,198	251%
2006	1,093	1,093	1,093	1,093	275%
2007	1,010	1,001	998	889	322%
2008	944	925	920	739	417%
2009	892	866	858	632	560%
2010	856	823	813	559	744%
		Fishing mortality (annual rate)			
2005	0.0188	0.0188	0.0188	0.0188	255%
2006	0.0156	0.0258	0.0288	0.1500	279%
2007	0.0169	0.0282	0.0317	0.1500	327%
2008	0.0181	0.0306	0.0345	0.1500	412%
2009	0.0193	0.0329	0.0372	0.1500	531%
2010	0.0202	0.0349	0.0396	0.1500	676%

Status Table: Atlantic surfclams (EEZ only, 1000 mt)

Year:	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Min[1]	Max[1]	Mean[1]
Quota:	19.8	19.8	19.8	19.8	19.8	22	24.2	25.1	26.2	26.2	13.9	26.2	20.9
Landings:[2,3,4]	19.8	18.6	18.2	19.6	19.7	22	24	25	24.2	21.2	6.4	33.8	19.8
Biomass: [4]	1,780	1,842	1,824	1,799	1,723	1,628	1,531	1,415	1,292	1,170	1,020	1,842	1,403
Fishing mortality: [3,4]	0.0115	0.0105	0.0104	0.0114	0.0120	0.0142	0.0166	0.0187	0.0199	0.0192	0.0104	0.0266	0.0175
Recruitment:[4]	185	189	116	121	76	62	63	43	32	27	27	289	121

[1] Min, max and mean for 1965-2005 (landings), 1978-2005 (quota), 1981-2005 (biomass and fishing mortality), or 1982-2005 (recruitment).
[2] Landings not adjusted for incidental mortality, assumed to be <= 12% of landings. Discards are very low.
[3] Fishing mortality is an annual rate assuming incidental mortality was 12% of landings.
[4] See assessment for regional estimates.

Stock Distribution and Identification: Atlantic surfclams are distributed along the US coast from Maine through North Carolina at depths ranging from the sub-tidal zone in state waters to about 50 m in the EEZ. The information in this report pertains only to the stock in the EEZ. All Atlantic surfclams in the EEZ are assessed and managed as a single unit stock (Figure C1). From north to south, the regions of particular interest are: Georges Bank (GBK), Southern New England (SNE), Long Island (LI), New Jersey (NJ), Delmarva (DMV) and southern Virginia (SVA). No fishing occurs currently on GBK because of potential paralytic shellfish poisoning (PSP).

Catches: Annual landings varied widely prior to 1979, but have since been relatively stable (Figure C9). Landings decreased from 15,000 mt (meats) during 1965 to the record low of 6,000 mt in 1970. Landings subsequently increased to the record high of 34,000 mt in 1974 and then declined to about 13,000 mt in 1979. Landings increased after 1979 and ranged between 19,000 to 25,000 mt from 1983 to 2005. The EEZ quota and landings are generally similar, although landings were less than the quota during 2004-2005 partly due to markets.

Since 1979, 85-100% of landings have been taken from the Mid-Atlantic Bight (SVA, DMV and NJ). Areas of highest landings shifted from DMV north to NJ over time (Figure C10). In particular, surfclam landings were primarily from DMV during 1979-1980 and almost evenly split between DMV and NJ during 1981-1983. After 1983, the importance of DMV declined and NJ has supplied the bulk of landings since 1985. Some landings were taken from SVA during the 1980s. Appreciable landings are sometimes taken from SNE and LI, and landings from SNE and LI increased during 2001-2005.

Discarding reached substantial levels (e.g., 33% by weight of the total catch in the NJ region) in the early 1980s because of minimum size limits, declined through the mid- to late-1980s, and has been low since 1990, a period when there were no minimum size limits.

The regional distribution of fishing effort (Figure C11) is similar to that of landings (Figure C10). LPUE trends for the entire fishery tend to mirror recent declining trends in stock biomass (Figure C2).

Catches are assumed to be 12% higher than landings in stock assessment calculations to account for incidental mortality during harvesting. The 12% incidental mortality estimate is considered to be an upper bound. Incidental mortality may occur when surfclams contact fishing equipment (i.e. dredge and sorting equipment) but are not landed

Data and Assessment: The updated assessment is similar to the SAW-37 2003 assessment, but with improvements to tabulate data, estimate survey gear efficiency, estimate biomass and make projections. New data from cooperative studies to estimate survey dredge efficiency and also from NEFSC clam surveys were important. NEFSC clam survey data from 1982-2005, data from a 2004 cooperative survey, fishery data from 1981-2005, and survey dredge efficiency estimates from cooperative studies during 1997-2005 were used in a KLAMZ delay-difference model to estimate fishable biomass and fishing mortality for surfclams in DMV, NJ and for the entire stock during 1981-2005. Fishable biomass in the updated assessment was considered to comprise clams 120+ mm SL in all regions (in contrast to 110+ or 120+ in the last assessment, depending on region). The assumed natural mortality rate was M=0.15 in all years, as in the last assessment. Catch was assumed equal to landings plus 12% of landings. Discards were assumed to be zero.

Efficiency corrected swept area biomass estimates were calculated for 1997, 1999, 2002, 2004 and 2005. Alternate estimates of fishing mortality were calculated as the ratio of catch and swept-area biomass. Results from these relatively simple alternate approaches were similar to KLAMZ model estimates.

Biomass for surfclam in individual regions, calculated for years with NEFSC clam surveys, was estimated by prorating the best estimate of total biomass using survey swept-area biomass data (Figures C3-C4). Survey and fishery age and length data were used to evaluate fishery and population age composition, but were not used in an analytical model.

The previous assessment used efficiency corrected swept area biomass estimates for status determination and did not include stochastic projections. The KLAMZ model was used only for DMV in the previous assessment.

Biological Reference Points: Overfishing occurs whenever the fishing mortality rate on the entire stock is higher than F_{MSY} (Figure C7). The stock is overfished if total biomass falls below $B_{Threshold}$ (estimated as ½ B_{MSY}, Figure C5). When stock biomass is less than the biomass threshold, the fishing mortality rate threshold is reduced from F_{MSY} in a linear fashion to zero.

The current best proxy for F_{MSY} is $F = M = 0.15\ y^{-1}$ (Figure C7). The proxy for B_{MSY} is one-half of the estimated fishable biomass during 1999 (Figure C5). Original and revised reference point values are shown in the table below.

Reference Point	Previous assessment	Revised
F_{MSY}	M=0.15 y^{-1}	Same
B_{1999}	1,460 thousand mt meats	1,799 thousand mt meats
$B_{MSY}=½B_{1999}$ (target)	730 thousand mt meats	900 thousand mt meats
$B_{Threshold}$ = ½ B_{MSY}	365 thousand mt meats	450 thousand mt meats

Biomass reference points were revised with new information about NEFSC clam dredge efficiency. Ratios of biomass estimates to biomass reference points are almost unaffected by the new information because the relative increase in biomass estimates and the B_{MSY} proxy are nearly identical. Fishing mortality estimates and the F_{MSY} proxy are more sensitive. Fortunately, conclusions about fishing mortality and reference points are robust because fishing mortality rates for the stock are relatively low. In particular, conclusions about stock status would not change unless either the mortality estimate or threshold was changed by 8-9 fold (Figure C7).

Fishing Mortality: Fishing mortality for surfclams in 2005 was F = 0.0192 (KLAMZ model for the entire stock, Figure C7). Annual estimates of fishing mortality are relatively low and precise (Figure C6). However, fishing mortality rates have increased since 1997 and are currently near the levels observed in the mid 1980s (Figure C6). As landings have been relatively constant during recent years (Figures C9 and C10), the recent increases in fishing mortality have been due to decreases in biomass (Figure C2).

Recruitment: The 1991 (age 14 during 2005) and 1998 (age 7 during 2005) year classes were relatively strong in the DMV and NNJ regions. Recruitment (Figure C8) has declined since the mid-1990s. In 2005, recruitment levels were at or near record lows in all regions but LI (GBK was not surveyed). No strong incoming year classes were evident in the 2005 survey data.

Recruitment to the commercial fishery occurs at about 120 mm SL, depending on region, markets, availability of large surfclams and other factors. Prior to 1993, surfclams in the DMV region reached 120 mm at about age 5. After 1993, surfclams in DMV reached 120 mm at about age 7. Surfclams in the NJ region reached 120 mm at about age 4 (prior to 1993) or age 5 (after 1993). Thus age at recruitment has changed, particularly in the southern DMV region, due to slower growth rates in recent years. Reductions in growth are important for the DMV region because a 2 y delay in recruitment means a reduction of about 26% in numbers of recruits from a cohort (assuming annual mortality rate M=0.15 y^{-1}). Slower growth also reduces potential fishery productivity after clams recruit.

Stock Biomass: The Atlantic surfclam stock is declining from record-high levels during the late 1990s toward lower levels similar to the early 1980's (Figure C2). High biomass during the late 1990s was due to relatively high recruitment (Figure C8) and relatively fast growth. Fishable biomass in 2005 was 1.17 million mt, which is less than the long term average (1.403 million mt) from 1981 to 2005.

The recent decline in surfclam biomass (Figure C2) is due to negative surplus production (Figure C13) caused by record low recruitment (Figure C8) and slower growth. The fishery appears to have been a secondary factor (Figure C13). When surplus production is negative, stock biomass will decline, even when no fishing occurs. When fishing occurs, stock biomass will decline whenever catch exceeds surplus production.

Regions with highest fishable biomass shifted from the south to the north during 1982-2005 (Figure C3). During 1982, DMV held the largest fraction of fishable surfclam biomass (Figure C4). The fraction of total biomass in DMV increased through the late-1980s and then declined to the current relatively low level (Figure C3). NJ held the largest share of surfclam biomass during 1994-2002. During 2005, the largest share of surfclam biomass was in GBK (Figure C4) due to declining biomass in NJ.

LPUE, biomass estimates, and survey biomass trends for surfclams in DMV and NJ declined in a consistent fashion after 1994 (Figure C12). LPUE generally increased during 1982-2005 in LI and varied without trend in SNE. LPUE appears to provide some independent confirmation about recent trends in surfclam biomass in the DMV and NJ regions, probably because the fisheries in DMV and NJ operate over most of the available surfclam habitat (NEFSC 2003).

Special Comments: Given the recent declining trends in stock biomass, a survey conducted in 2008 is critical.

Agency, academic and industry personnel have made progress in estimating efficiency of the NEFSC clam survey dredge during the 1997-2005 surveys. Survey dredge efficiency is the principal source of uncertainty. Collaborative depletion studies designed to measure dredge efficiency should continue to be part of the clam survey program.

The size-selectivity of the NEFSC survey dredge has not been sufficiently characterized, although survey selectivity information is essential to fully evaluate depletion experiments and to derive abundance and biomass estimates. Selectivity experiments should be part of the 2008 clam survey.

A constant M equal to 0.15 was assumed in the assessment. Reductions in biomass of surfclam in inshore southern regions are due partly to changes in environmental conditions. Assumptions about natural mortality should be re-evaluated in the next assessment.

The current biomass reference points were based on an assumption that the stock was at or near an equilibrium level in 1999. Recent evidence indicates that the 1999 biomass level was temporary due to strong recruitment. This assumption should be reviewed during the next assessment, and it may therefore be advisable to also review the current proxy reference points.

The 2008 clam survey should sample GBK, as GBK was not sampled during the 2005 survey. No fishing occurs on GBK but it accounts for the largest fraction of stock biomass and is becoming more important as biomass declines in southern regions.

Sources of Information:

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Northeast Fisheries Science Center (NEFSC). 2003. Atlantic surfclam. In: 37th Northeast Regional Stock Assessment Workshop (37th SAW), Stock Assessment Review Committee (SARC) Consensus Summary of Assessments, NEFSC Ref. Doc. 03-16, 603 p.[3]

Northeast Fisheries Science Center (NEFSC). 2003. 37th Northeast Regional Stock Assessment Workshop (37th SAW), Advisory Report. NEFSC Ref. Doc. 03-17, 60 p.[4]

Northeast Fisheries Science Center (NEFSC). 2005. Resource survey report, surfclam/ocean quahog. Northeast Fisheries Science Center, Woods Hole, MA, 17 p.[5]

Weinberg, J. R., T.G. Dahlgren, and K. M. Halanych. 2002. Influence of rising sea temperature on commercial bivalve species of the U.S. Atlantic coast. Amer. Fish. Soc. Symp. 32: 131-140.

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Weinberg, J.R. 2005. Bathymetric shift in the distribution of Atlantic surfclams: response to warmer ocean temperature. ICES J. Mar. Sci. 62: 1444-1453.

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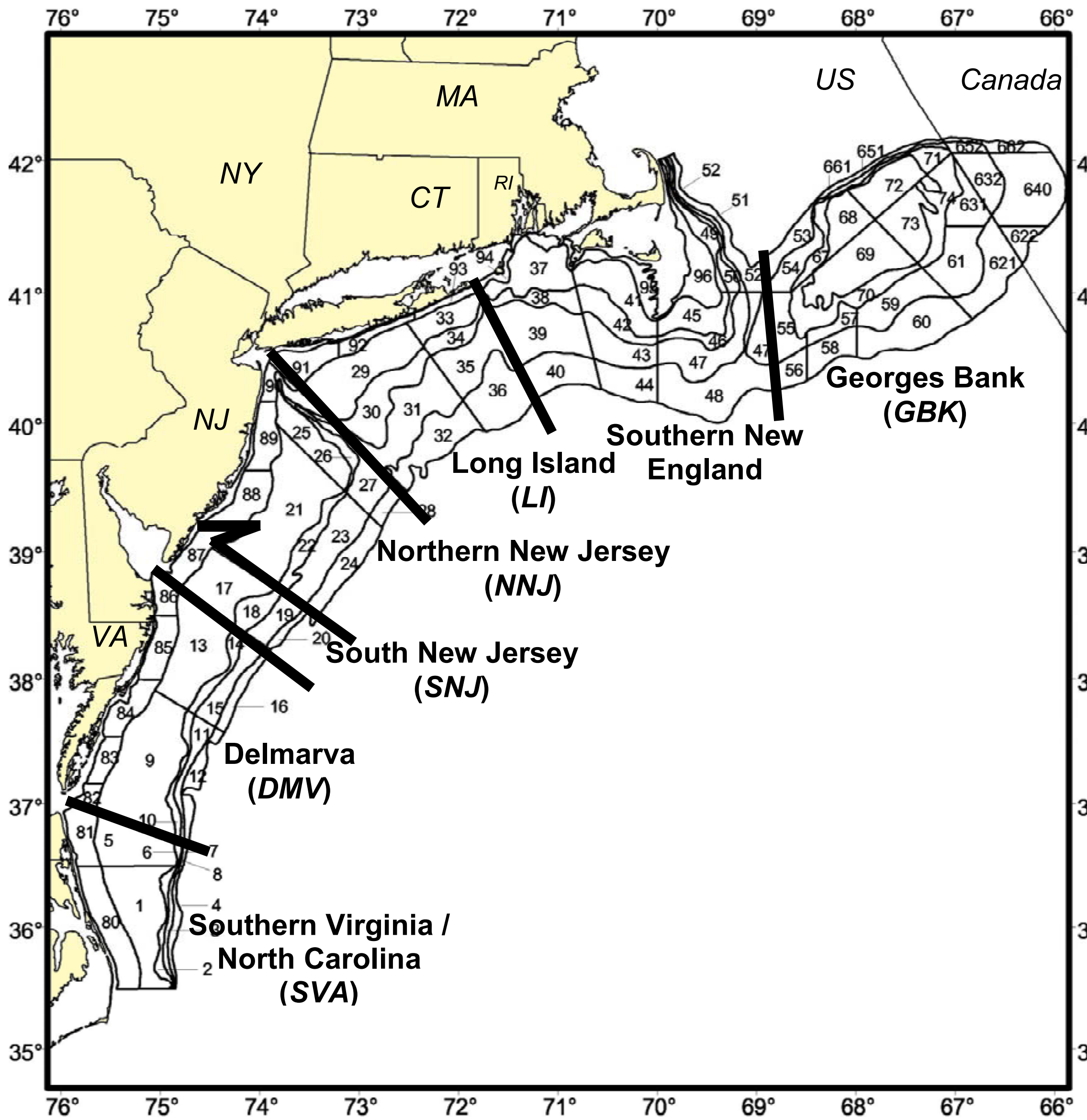
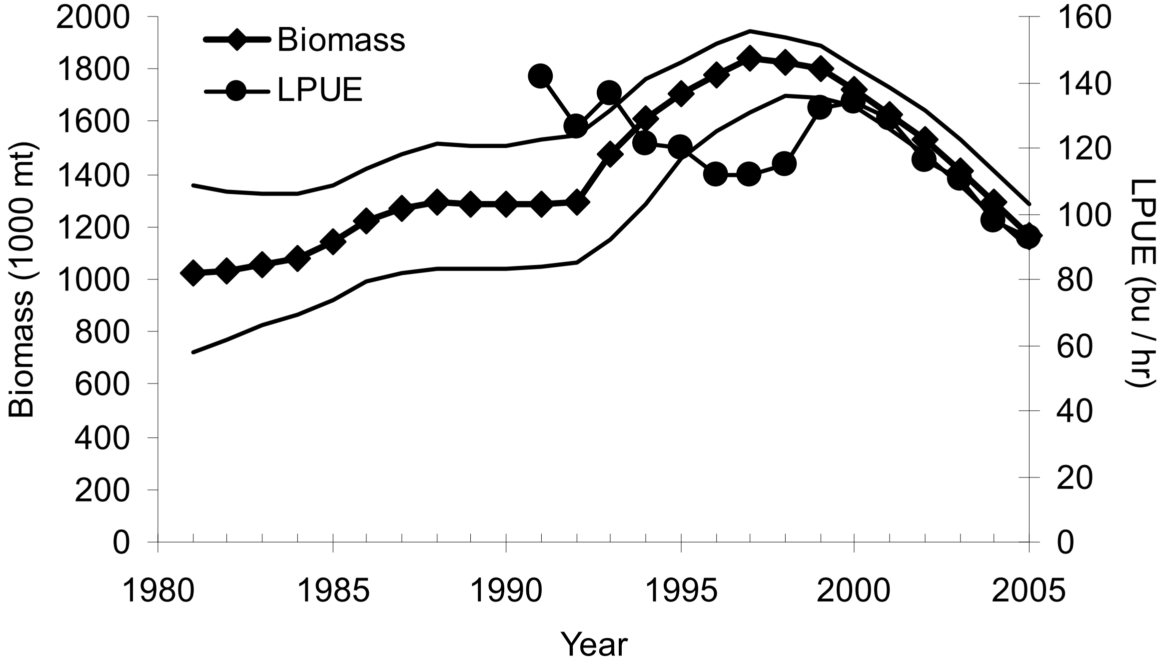
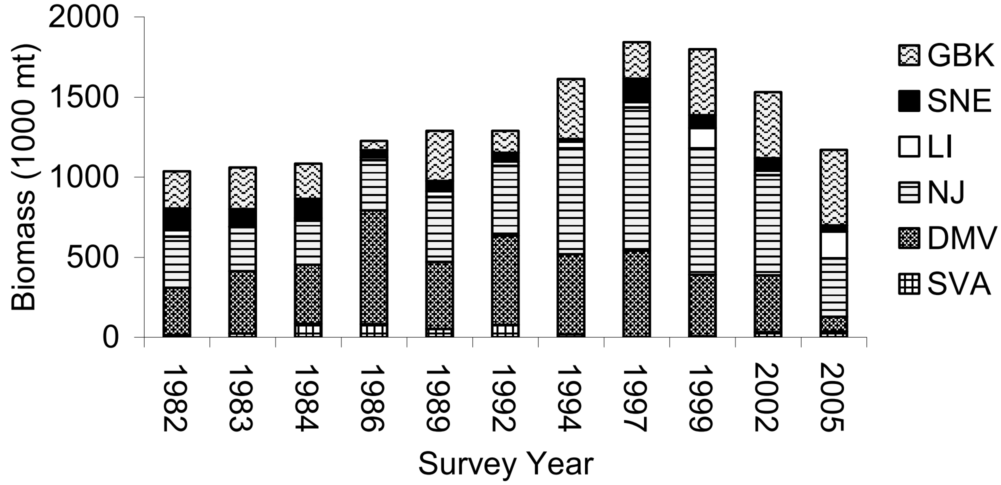
[3] Available at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0316/surfclam.pdf.
[4] Available at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0317/atlsurfclam.pdf.
[5] Available at: http://www.nefsc.noaa.gov/esb/survey_reports/Clam%202005/all.pdf.
[6] Available at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0501/.

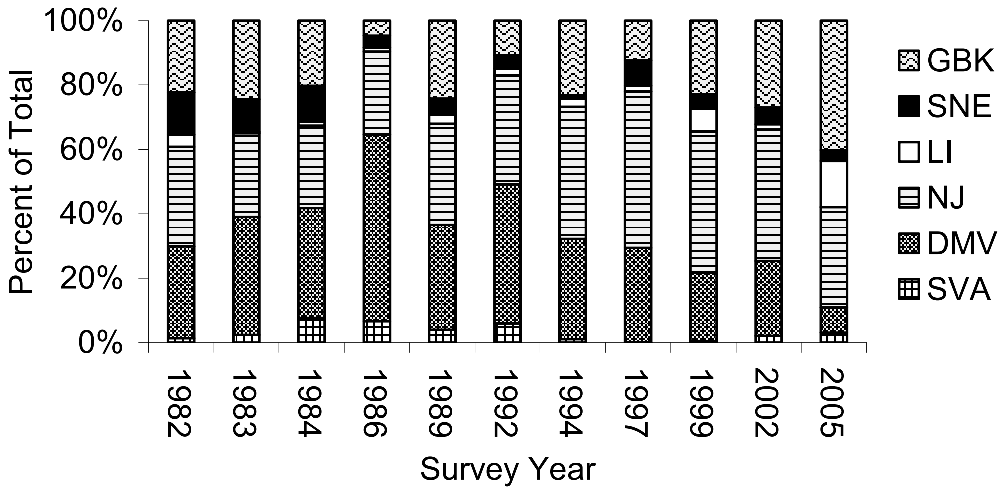


C1. Assessment regions for the Atlantic surfclam stock in the US EEZ with NEFSC shellfish survey strata and stratum numbers. In this assessment, the Southern New Jersey (SNJ) and Northern New Jersey (NNJ) regions were combined to form a single New Jersey (NJ) region.

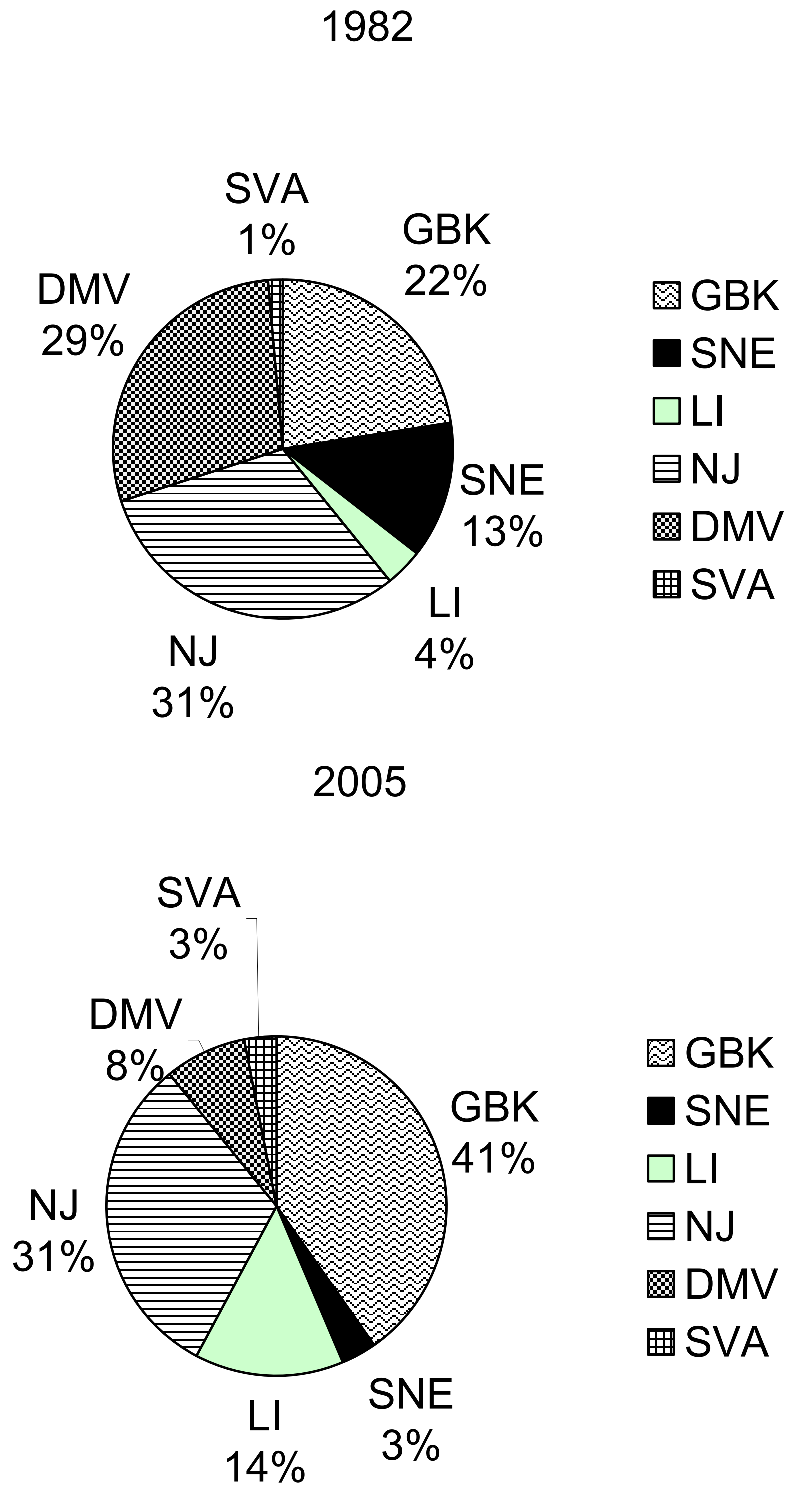


C2. Fishable surfclam biomass estimates with 80% empirical confidence intervals. Nominal LPUE from logbooks (total reported landings / total reported hours fished, all vessels and all trips) for the entire fishery are shown for comparison. LPUE data were not used in estimating biomass.

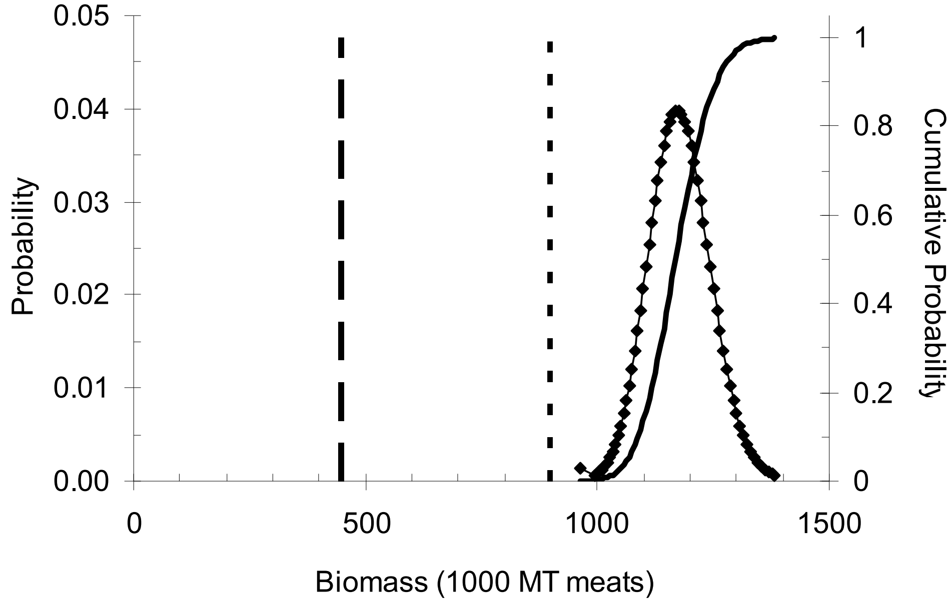




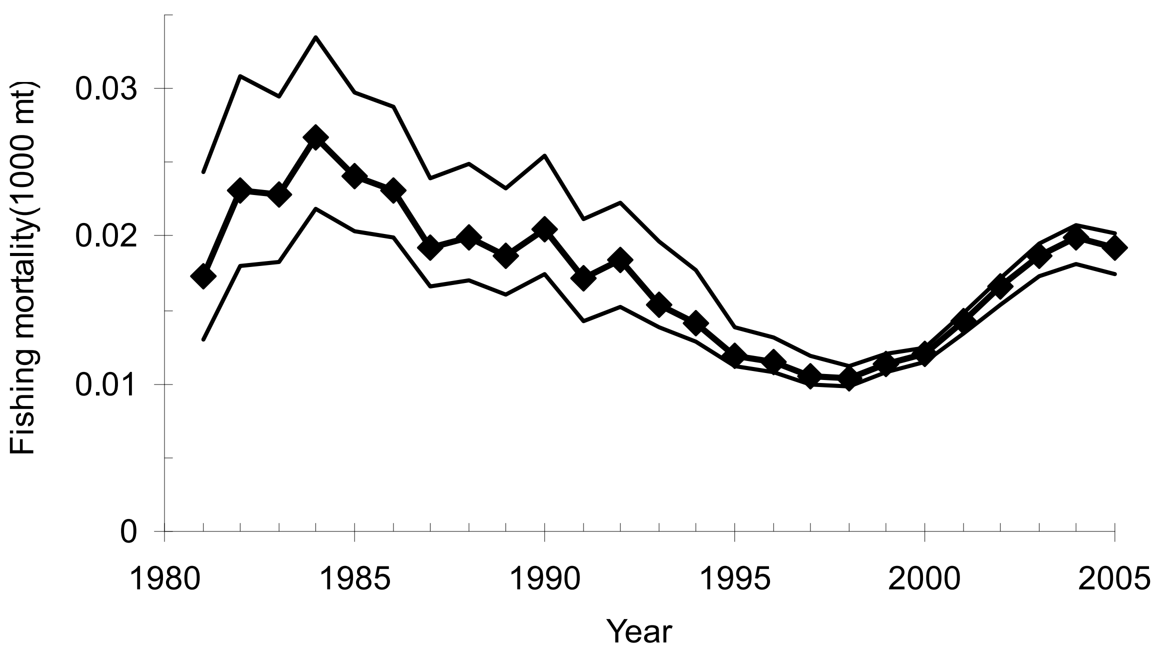
C3. Fishable surfclam biomass by region during years with NEFSC clam surveys.



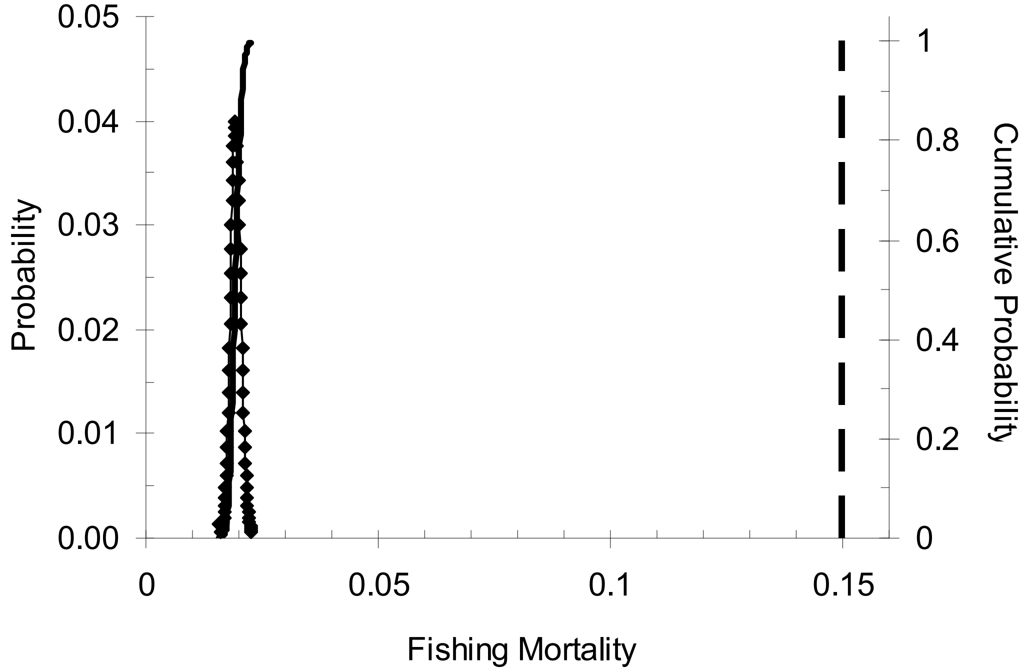
C4. Percentage of fishable surfclam biomass during 1982 and 2005, by region.



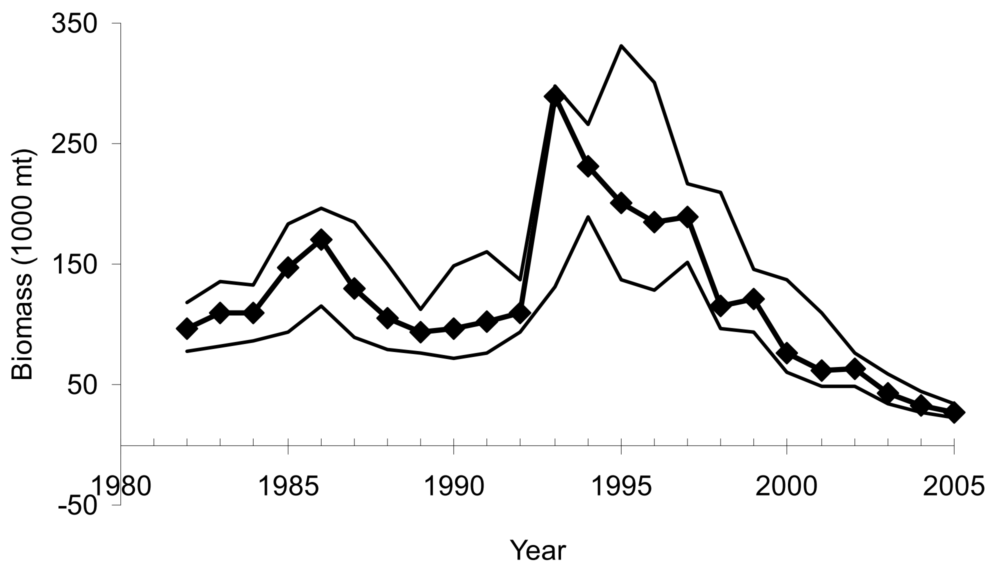
C5. The confidence interval describes uncertainty about estimated fishable biomass of surfclams in 2005. For comparison, the vertical lines are at the biomass threshold (long dash line left of center) and the biomass target (short dash line near center).



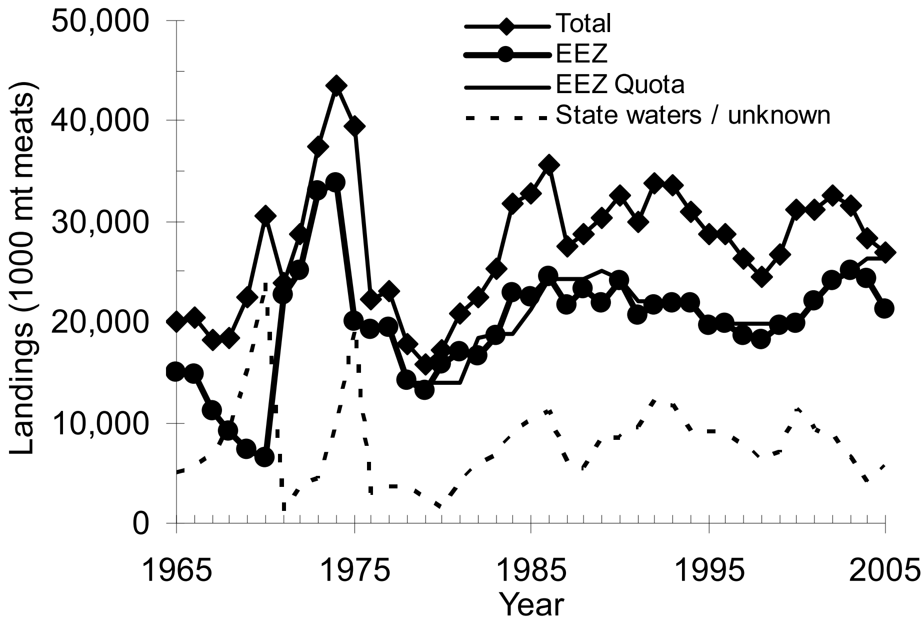
C6. Fishing mortality estimates for surfclams (with 80% confidence intervals).



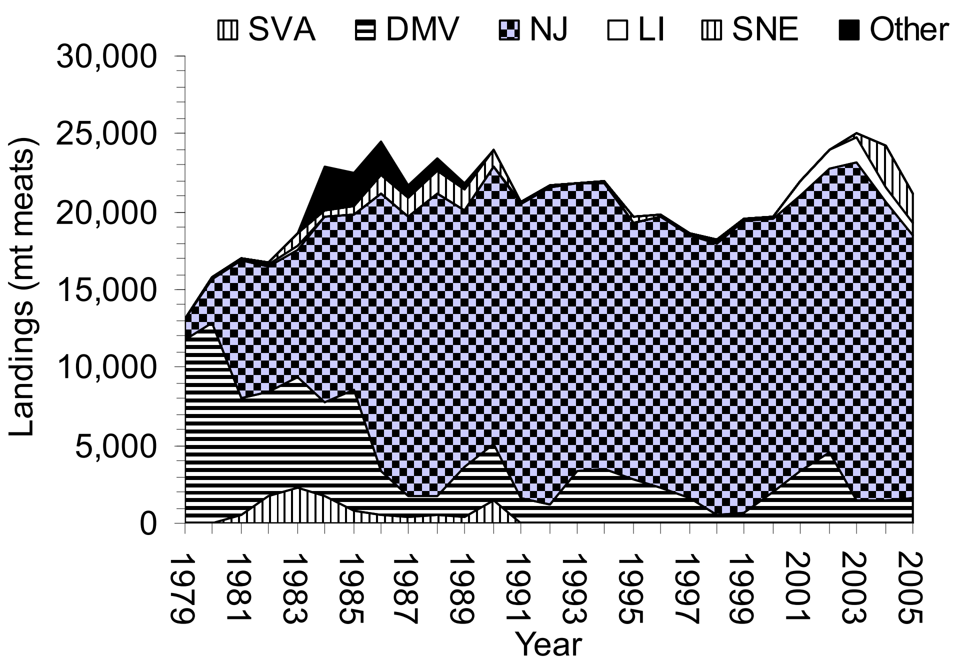
C7. The confidence interval describes uncertainty in estimated fishing mortality for surfclams in 2005. The dashed vertical line shows the fishing mortality threshold for comparison.



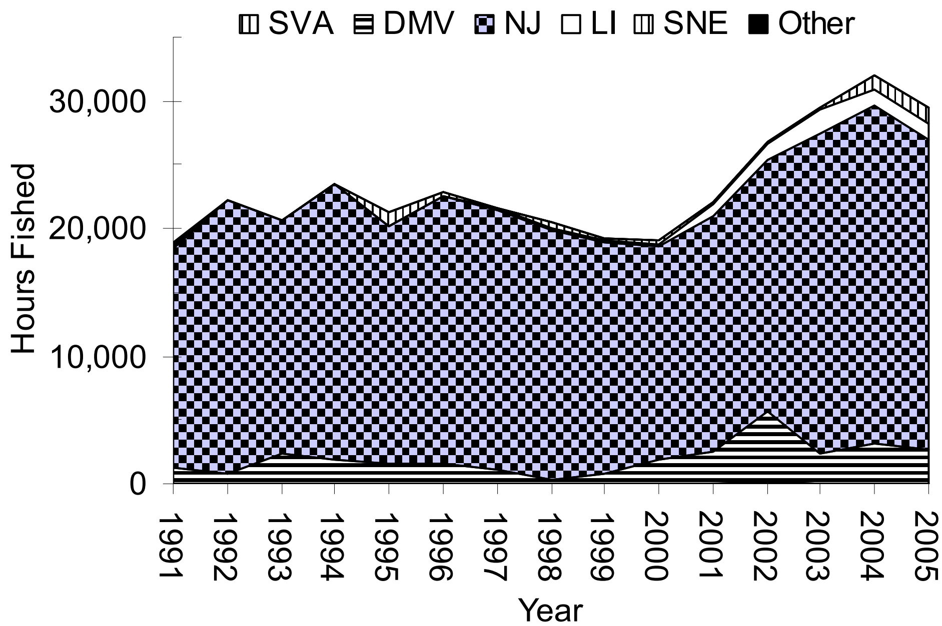
C8. Recruit biomass estimates for surfclams (with 80% empirical confidence intervals).



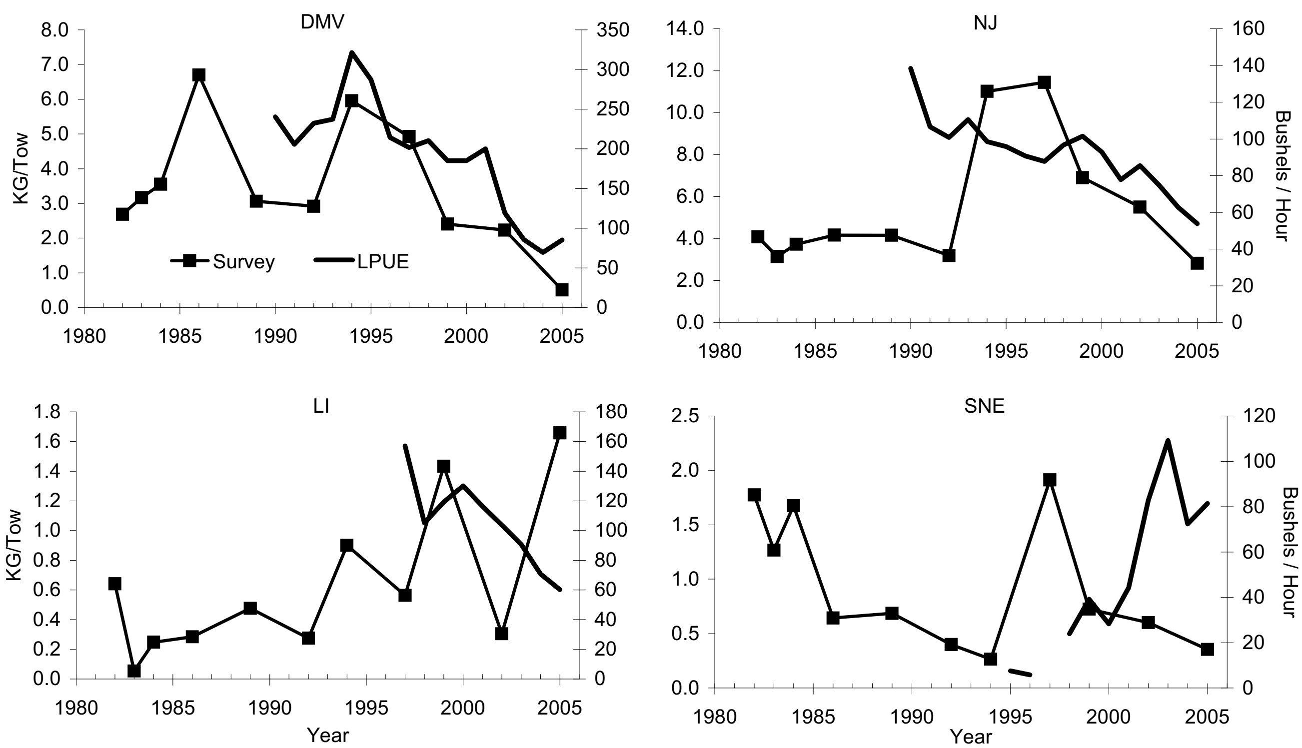
C9. Atlantic surfclam landings and EEZ surfclam quotas (in mt meats). Landings data for state waters are shown as well, but were not used in the assessment. The line for the EEZ quota is nearly the same as the line for EEZ landings and therefore difficult to see.



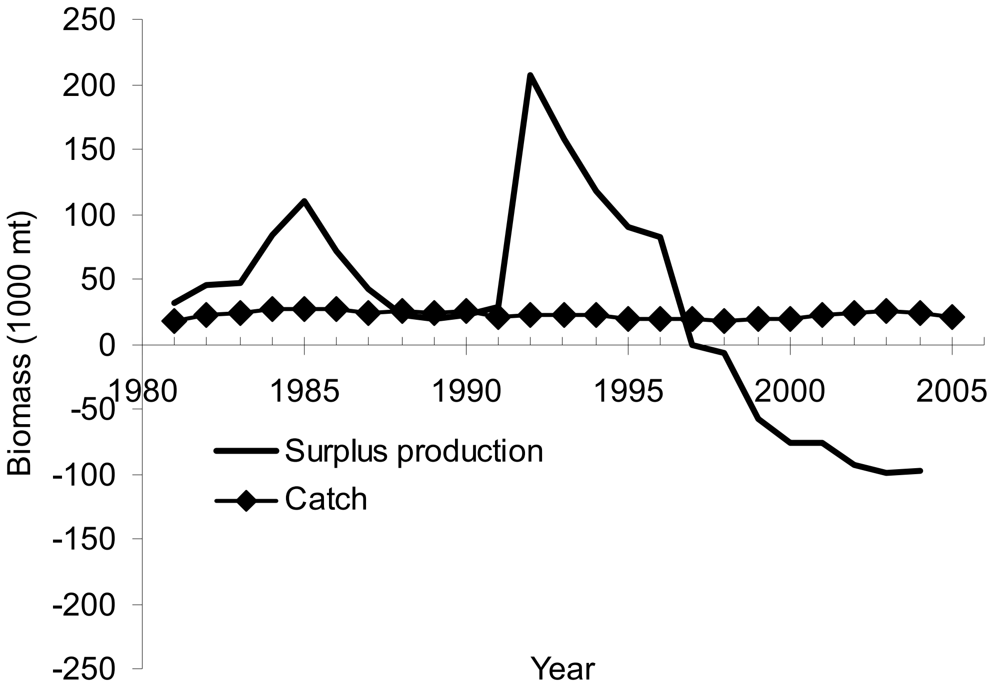
C10. Surfclam landings during 1979-2005 by stock assessment region.



C11. Total fishing effort (hours fished, all trips and all vessels) during 1991-2005 by stock assessment region.



C12. Trends in fishable biomass for surfclams 120+ mm SL based on the NEFSC clam survey and standardized LPUE from logbooks.



C13. Estimated surplus production for surfclams during 1982-2004, with catches for comparison.