Recruitment Failure in The Southern New England Lobster Stock

April 17, 2010

Prepared by:

American Lobster Technical Committee
Atlantic States Marine Fisheries Commission

Executive Summary

The executive summary represents the consensus statements crafted during the March 23 and 24, 2010, Lobster Technical Committee meeting in New Bedford, Massachusetts. These statements have formed the basis for the larger research document contained within.

Status of the Stock:

The Southern New England stock (SNE) is critically depleted and well below the minimum threshold abundance (25th percentile) (Figure 1). Abundance indices are at or near time series lows (ASMFC 2009) and this condition has persisted (ASMFC 2006).

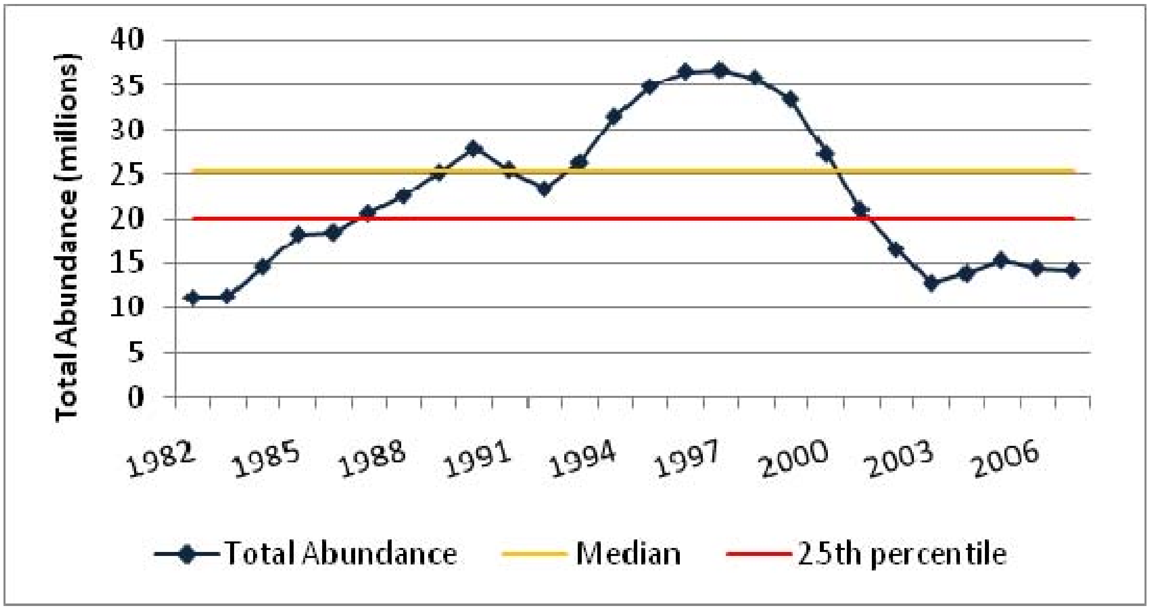


Figure 1. Total lobster abundance as measured by the University of Maine Length Based Model for the 2009 assessement. The median (yellow) and 25th percentile (red) of the 1984-2003 reference period are noted.

Since the release of the 2009 Assessment, additional monitoring information has been reviewed which documents that the reproductive potential and abundance of the SNE stock is continuing to fall lower than data presented in the latest assessment. The TC contends that the stock is experiencing recruitment failure caused by a combination of environmental drivers and continued fishing mortality. It is this recruitment failure in SNE that is preventing the stock from rebuilding. The TC formed this conclusion only after an extensive review of a number of long-term monitoring programs which include sea sampling data, YOY indices, state and federal trawls study results, ventless trap data, and post larval studies.

In all cases, the last several years have produced indices below the median and at or below the 25^{th} percentile relative to the 1984-2003 reference years (Figure 2-4). Larval production and settlement are inherently variable. However, sustained poor production can only lead to reduced recruitment and ultimately to reduced year class strength and lower future abundance levels.

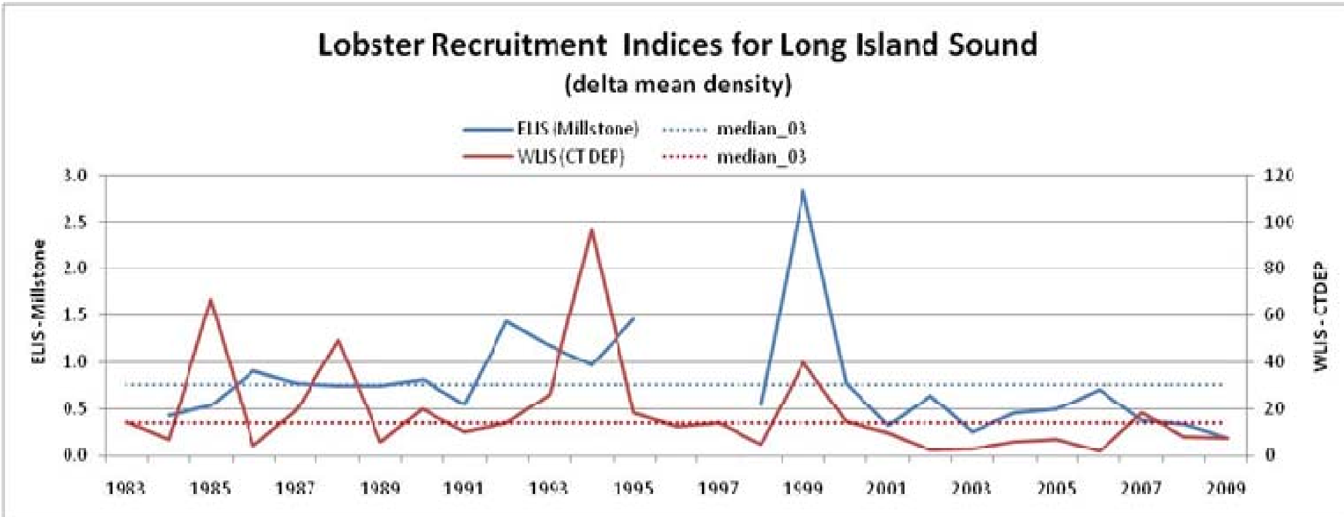


Figure 2. Larval indices for the Long Island Sound lobster population. Eastern Long Island Sound (ELIS) data are entrainment densities of lobster larvae at the Millstone Power Station; data provided courtesy of Dominion Nuclear Connecticut. Western Long Island Sound (WLIS) data are densities of stage 4 lobster larvae caught in the CT DEP plankton survey at seven fixed stations in NY and CT waters of western Long Island Sound.

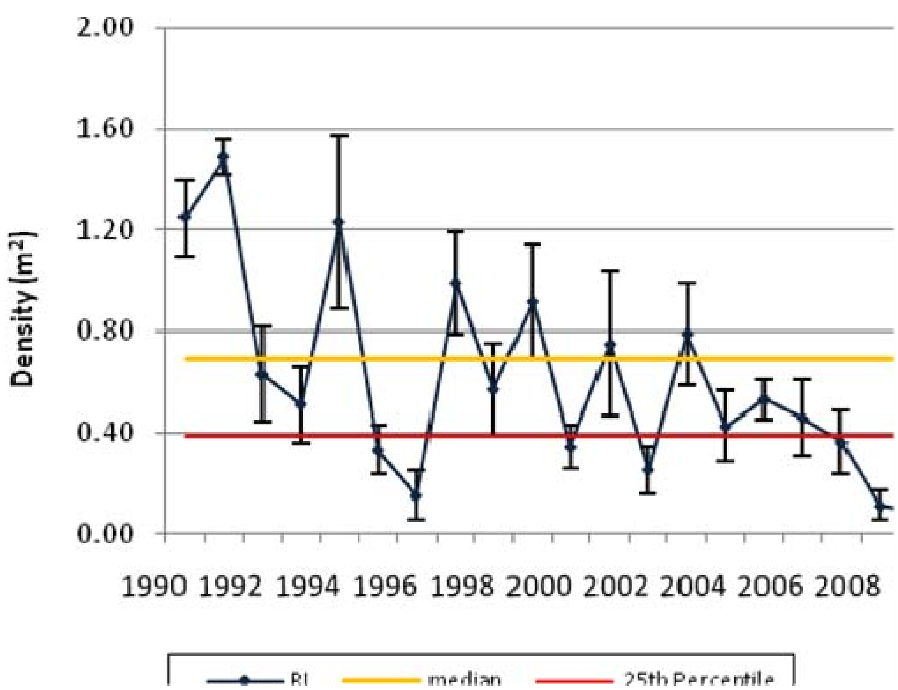


Figure 3. Rhode Island YOY Settlement Survey. The median (yellow) and 25th percentile (red) of the 1984-2003 reference period are indicated.

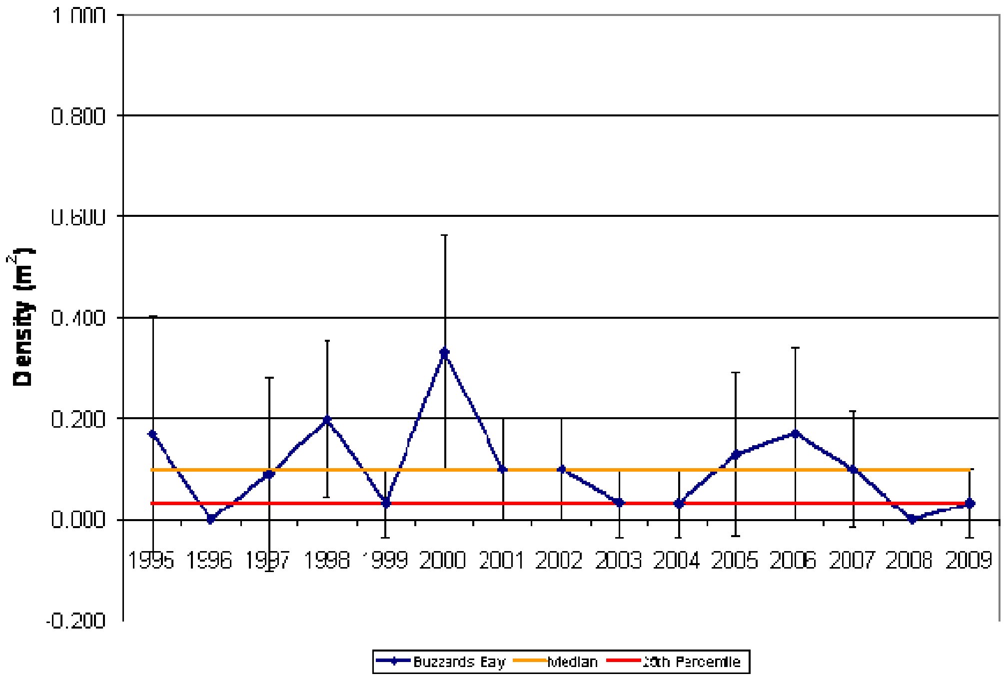


Figure 4. Massachusetts DMF YOY Settlement Survey in Buzzards Bay, Area 2. The median (yellow) and 25th percentile (red) of the 1984-2003 reference period are indicated.

Additional evidence suggests that the distribution of spawning females has shifted away from inshore SNE areas into deep water in recent years. This shift may impact larval supply to inshore nursery grounds. All but one of the SNE fall trawl survey relative abundance indices for recruit and legal size lobster are generally consistent, with a peak in the 1990's and then a decline to low levels in recent years. Recent recruit and legal indices have generally remained at or below the 25th percentile since 2002.

Impediments to Rebuilding:

Overwhelming environmental and biological changes coupled with continued fishing greatly reduce the likelihood of SNE stock rebuilding. There has been a widespread increase in the area and duration of water temperatures above 20^{0}C throughout SNE inshore waters. Long term trends in the inshore portion of SNE show a pronounced warming period since 1999. Prolonged exposure to water temperature above 20^{0}C causes respiratory and immune system stress (Worden et al. 2006, Dove et al 2005, Crossin et al 1998), increased incidence of shell disease (Glenn and Pugh, 2006), acidosis and suppression of immune defenses in lobster (Dove et al. 2004, Robohm et al. 2005). Lobster avoid water > 19^{0}C (Crossin et al. 1998). Loss of optimal shallow habitat area is causing the stock to contract spatially into deeper water (see Appendices A, B, and C). In Area 6, the potential expansion of chronic hypoxia under conditions of high temperature compounds the physical effects of both factors (Draxler et al. 2005) as well as additionally limiting the spatial extent of suitable habitat. In addition the shift in abundance to deeper water may reflect increased mortality in shallow water by mid-Atlantic predators (e.g. striped bass, dogfish, and scup) whose abundance has increased substantially in the last decade. The routine discarding of lobster (sublegal, egg bearing, V-notched) from traps increases the exposure of lobster to the now abundant predators as lobster sink to the bottom and seek new shelter.

In Area 2, recent larval drift studies suggest that the re-distribution of spawning females into deep water areas may be causing larvae to be transported away from traditional settlement areas and potentially into less favorable areas.

In addition to environmental drivers, continued fishing pressure reduces the stock's potential to rebuild, even though overfishing is currently not occurring in SNE. Total trap hauls have declined significantly yet have not declined at the same rate as lobster abundance. Although current measures prevent the harvest of egg-bearing and v-notched lobster, the legal catch represents a loss of egg production to the system. In deep water areas where the fishery remains or has moved to, the majority of the catch (>75%) is comprised of females (Table 1). In the case of Area 6, the largest proportion of landings now come from the eastern Sound which has been traditionally dominated by females (>70%) compared to catch from the western Sound.

Table 1. Percent of the marketable female catch in SNE by region, 2007-2009.

	2007	2008	2009
CT - WLIS	14%	31%	24%
CT - CLIS	16%	19%	16%
CT - ELIS	21%	35%	36%
RI	55%	55%	53%
MA	82%	80%	82%

Management Response:

In August 2009, the TC submitted recommended management recommendations which were designed to promote stock rebuilding using existing parent stock by significantly reducing landings. Given additional evidence of recruitment failure in SNE and the impediments to stock rebuilding, the TC now recommends a 5 year moratorium on harvest in the SNE stock area. The TC acknowledges the severity of this recommendation and understands the catastrophic effects on the fishery participants, support industries, and coastal communities. This recommendation provides the maximum likelihood to rebuild the stock in the foreseeable future to an abundance level that can support a sustainable long-term fishery.

During the 5 year moratorium period, monitoring of all phases of the lobster life cycle should be intensified. Fishery dependent sampling will no longer be collected, therefore assessment of stock status will rely on current fishery-independent surveys (e.g., ventless trap, YOY sampling, larvae) which will need to be continued and intensified.

New surveys and research are needed to further characterize lobster settlement and habitat in SNE.

1. Status of the Southern New England Lobster Stock

The condition of the SNE lobster stock is depleted having declined dramatically since the late 1990s. This determination has remained consistent over the last two stock assessments that used a variety of models to determine total abundance. From a peak in 1997, lobster abundance declined below the 1984-2003 reference median in 2000 and has remained below the 25th percentile since 2002 (Figures 1 and 2; ASMFC 2009, ASMFC 2006).

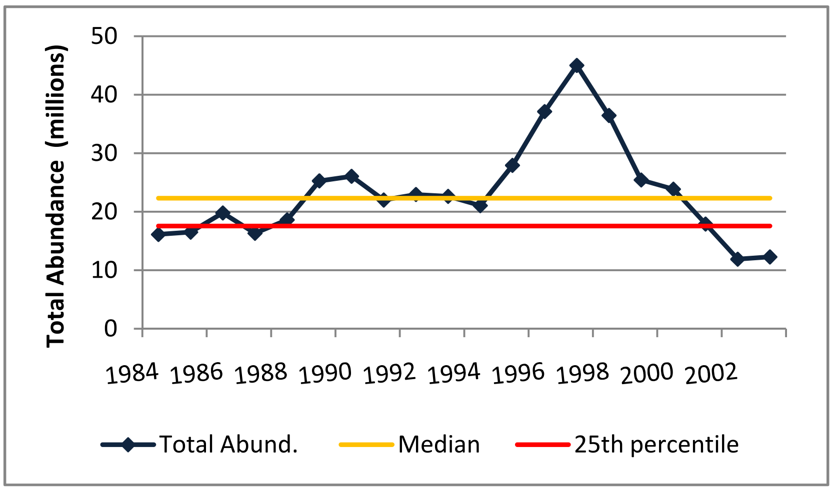


Figure 1. Total lobster abundance as measured by the Collie-Sissenwine model for the 2006 assessment. The median (yellow) and 25th percentile (red) of the 1984-2003 reference period are noted.

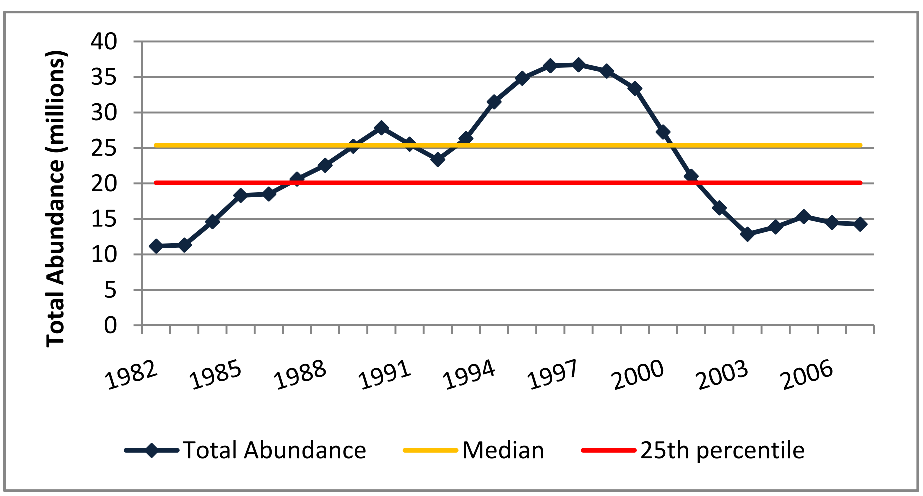


Figure 2. Total lobster abundance as measured by the University of Maine Length Based Model for the 2009 assessement. The median (yellow) and 25th percentile (red) of the 1984-2003 reference period are noted.

The Technical Committee is particularly concerned because recent abundance data indicate the SNE stock is experiencing recruitment failure. We define recruitment failure as the point where environmental conditions and/or fishing have resulted in successive years of poor recruitment. Environmental conditions play a large roll in recruitment regardless of parent stock size. However, when the parent stock is small, the likelihood of favorable recruitment regardless of environmental conditions is greatly reduced (Barnes and Hughes 1998, pp 175). The extent of recruitment failure leading to reduced adult abundance is dependent on the severity and duration of recruitment failure, population turnover and adult longevity (Gibson et al. 2008, pp 266). Recruitment failure prevents stock rebuilding and the decline in adult spawning stock size is only exacerbated by continued fishing.

Evidence of recruitment failure

Spawning Stock Biomass

Review of data from various fishery independent surveys point toward recruitment failure as the major factor impeding stock rebuilding. SNE spawning stock biomass indicators from 2002 -2009 in general were average to poor (Table 1). Figure 3 indicates the detailed spawning stock abundance estimates from the four trawl surveys. The Spawning stock abundance from the RI trawl survey increased to levels at or above the median from 2005 through 2008, but the 2009 estimate is below the 25th percentile.

Table 1. SNE Spawning Stock Biomass. Calculated as the product of the number per tow of recruit and fully recruited females and the SNE maturity curve. Shading indicates the 75 percentile (white), 25-75 percentile (gray) and lower 25 percentile (black) relative to the 1984-2003 reference period.

	RI	CT	NMFS	MA
1981	14,052			11
1982	4,401		206	56
1983	6,904		123	1
1984	14,085	136,864	273	5
1985	9,307	68,450	193	2
1986	8,452	98,894	124	58
1987	28,653	116,198	181	53
1988	32,939	93,728	159	16
1989	18,174	61,373	204	205
1990	11,069	112,243	319	69
1991	16,817	133,285	243	148
1992	13,162	136,128	277	204
1993	43,493	274,312	176	116
1994	15,943	257,049	88	151
1995	18,132	138,625	251	13
1996	30,032	187,330	474	71
1997	29,088	371,033	328	33
1998	11,300	144,739	232	60
1999	7,411	134,275	115	30
2000	11,364	103,752	230	24
2001	11,884	78,337	257	23
2002	1,501	23,853	130	0
2003	9,178	21,947	100	0
2004	12,868	39,270	181	41
2005	14,953	28,411	176	114
2006	20,699	8,274	97	0
2007	15,199	13,321	174	46
2008	17,822	918	96	0
2009	8,204		87	5
25th	10,628	89,880	152	15
50th	13,624	124,741	217	43
75th	20,794	140,153	261	82

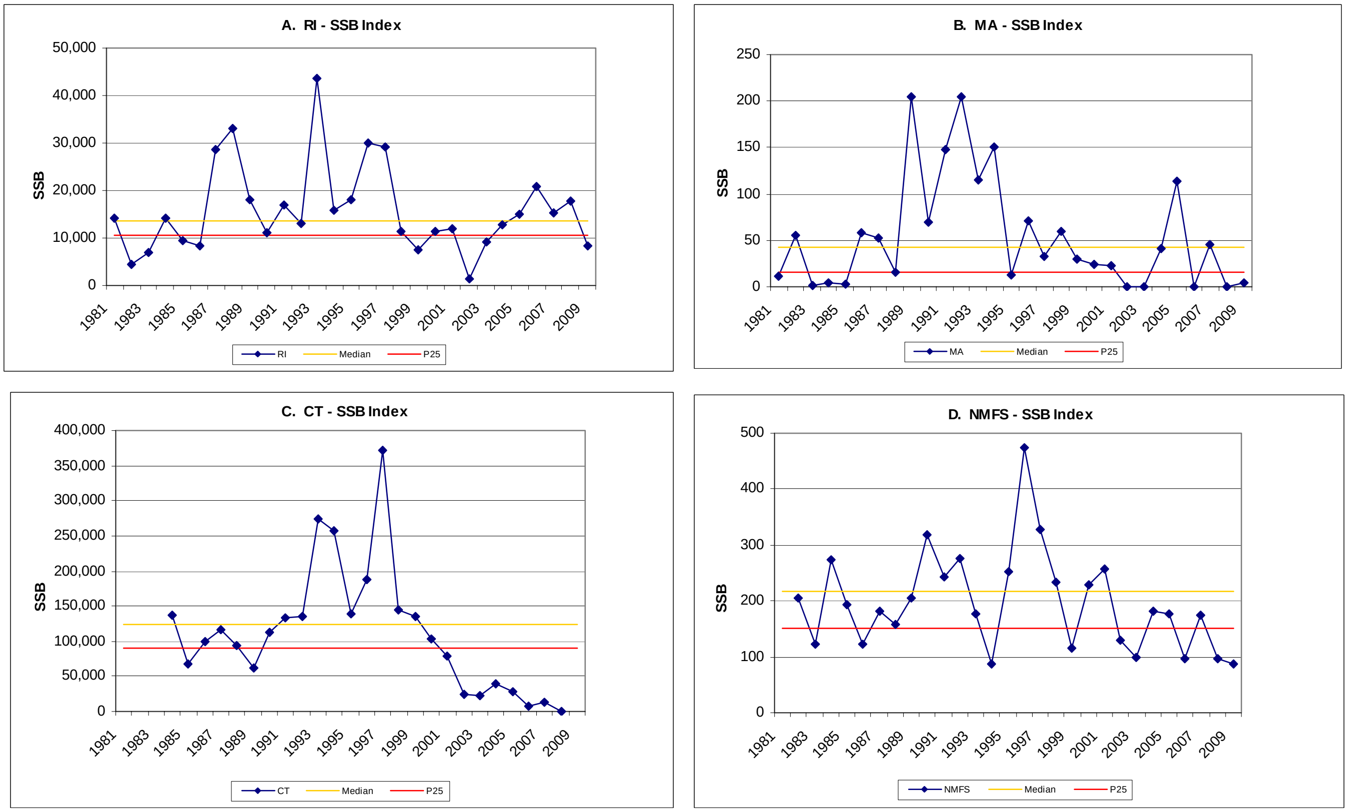


Figure 3. Spawning Stock Biomass Indices from the RI (A), MA (B), CT (C), and NMFS (D) trawl surveys for SNE. (The number per tow of recruit and fully recruited females times the maturity curve). The median (yellow) and 25th percentile (red) of the 1984-2003 reference period are indicated.

Recruitment Indices

Multiple post-larval and young-of-year (YOY) indices are available to monitor larval production and successful settlement annually in SNE. In all cases, the last several years have produced indices below the median and at or below the 25th percentile relative to the 1984-2003 reference years. Larval production and settlement are inherently variable. However, sustained poor production can only lead to reduced recruitment and ultimately to reduced year class strength and lower future abundance levels.

Two indices are available for Area 6 (Long Island Sound). The Connecticut Department of Environmental Protection (CT DEP) Western Long Island Sound Larval Survey has indexed stage 4 post larval abundance annually since 1983. From 1983 through 2001, annual density fluctuated with only single years falling below the time series median (Figure 4). However, this pattern changed dramatically following the 1999 die off; indices for 2001 through 2009 have all been below the median and the lowest in the time series with the one exception of 2007. Annual densities recorded at Millstone power station in eastern Long Island Sound for all larval stages have followed a similar pattern. The 2009 index is the lowest recorded in the 25-year time series.

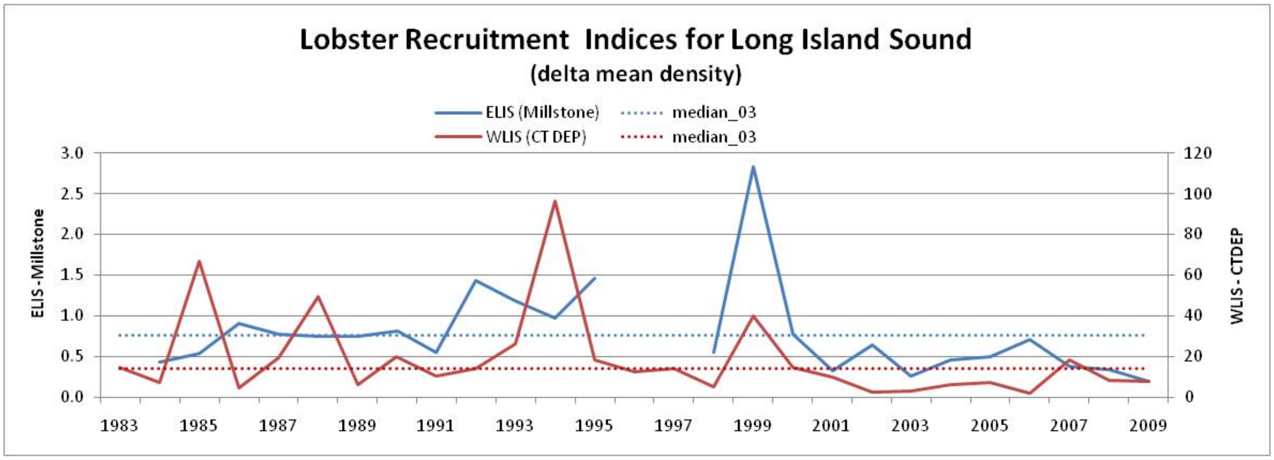


Figure 4. Larval indices for the Long Island Sound lobster population. Eastern Long Island Sound (ELIS) data are entrainment densities of lobster larvae at the Millstone Power Station; data provided courtesy of Dominion Nuclear Connecticut. Western Long Island Sound (WLIS) data are densities of stage 4 lobster larvae caught in the CT DEP plankton survey at seven fixed stations in NY and CT waters of western Long Island Sound.

Two YOY indices are available for Area 2. The YOY settlement index for Narragansett Bay and Rhode Island Sound maintained by Rhode Island Division of Environmental Management (RI DEM) showed a similar fluctuation, with only single or double low-density years, beginning in 1990 through 2007 (figure 5). However, indices for 2008-2009 were recorded as the lowest production years in two decades, leaving the last four years (2006-2009) all below the median. The 20-year time series has a significant negative slope, indicating a decline in settlement over the time series. The Massachusetts Division of Marine Fisheries (MA DMF) YOY settlement time series for Buzzards Bay has been very low and varied without trend since it's inception in 1995 (Figure 6). Without a longer time series it is difficult to determine if current settlement densities in Buzzards Bay are representative of long term conditions or represent a depressed state. Commercial landings and trawl survey indices for Buzzards Bay were high in the late 1980's and early 1990's, suggesting historical settlement in this region would have been much higher. To put the current densities of YOY lobster in Buzzards Bay in context, in 2003, 2004, and 2009 only 1 YOY lobster was observed at 5 stations among sixty 0.5 m quadrat samples. In 2008 not a single YOY lobster was observed in Buzzards Bay.

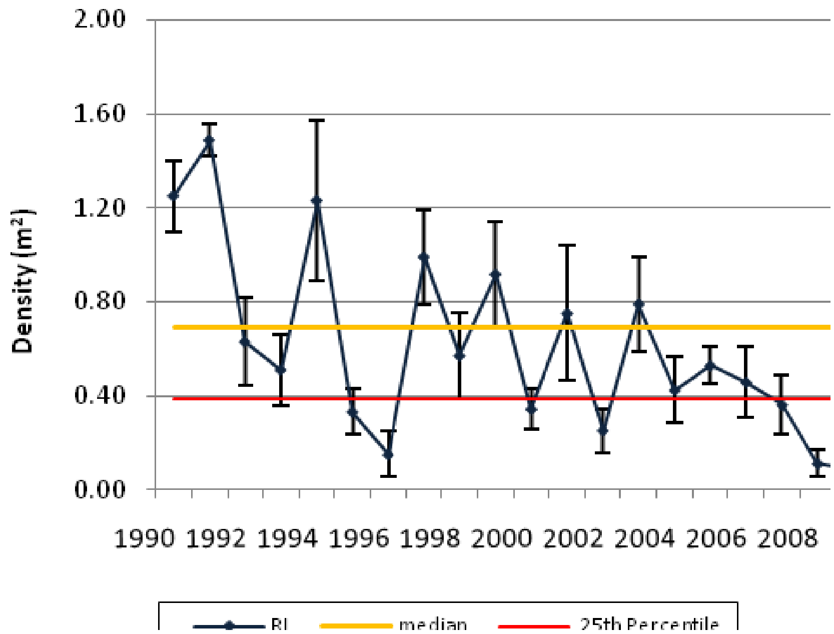


Figure 5. Rhode Island YOY Settlement Survey. The median (yellow) and 25th percentile (red) of the 1984-2003 reference period are indicated.

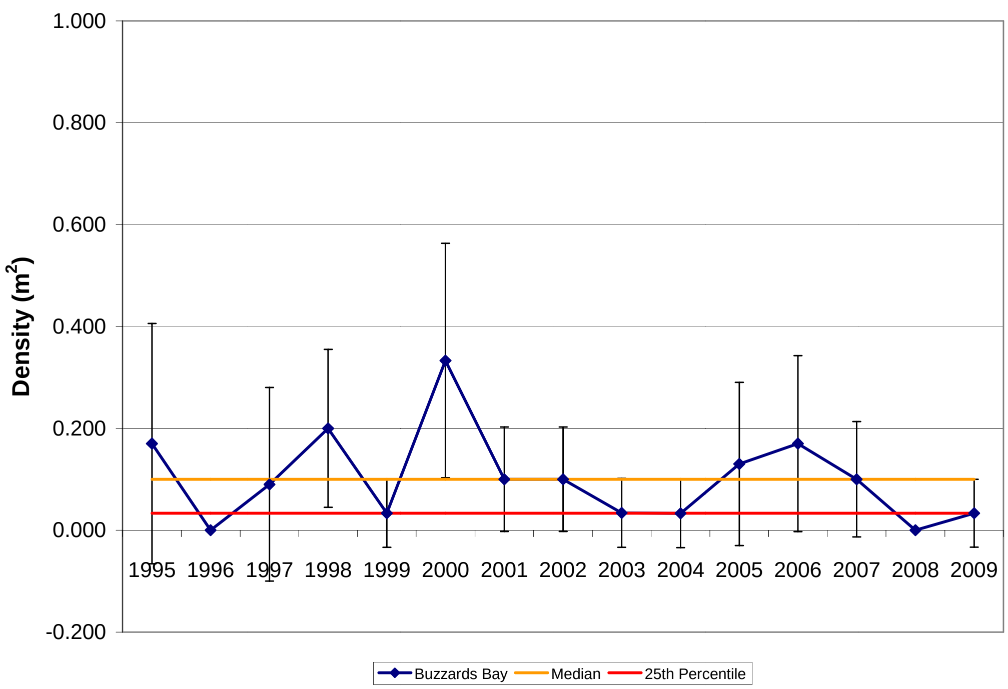


Figure 6. Massachusetts DMF YOY Settlement Survey in Buzzards Bay, Area 2. The median (yellow) and 25th percentile (red) of the 1984-2003 reference period are indicated.

Redistribution of spawning females in SNE

Additional evidence suggests that the distribution of spawning females has shifted away from inshore SNE areas into deep water in recent years. This shift may impact larval supply to inshore nursery grounds. Data from the CT trawl survey in Long Island Sound indicate there has been a shift in lobster catches from inshore shallow sites in the 1980's to deeper sites in the last decade. (In 1984-1991, the geometric mean catch at sites <30ft depth was comparable to the mean for sites >90ft depth; in 2000-2008, the mean catch at shallow sites was less than half the mean for deep sites . The regional Ventless Trap Survey data indicate higher relative abundance of lobster in deeper strata in SNE. This pattern is reversed in the Gulf of Maine, where the highest relative abundance is observed in the shallowest strata (Appendix A). Data collected during the MA lobster sea sampling program detail a shift in the fishery from inshore shallow waters to more offshore deeper waters (Appendix B). This shift in adult abundance may have implications on larval drift and settlement.

Wahle et al. (2009) have developed a passive post-larval collector that has been demonstrated to replicate diver-based YOY estimates. In 2009 MA DMF and RI DEM conducted a larval transport project which revealed that larvae released in deeper areas, which now have the highest relative abundance of spawning females, may be transported away from traditional settlement areas. Little is known about the fate of these larvae. Initial results from collector deployments stratified by depth in SNE, GOM, and most recently in GBK, indicate settlement below 20 m is greatly diminished, confirming earlier work completed along the Coast of Maine (Wahle et al. unpublished, Wilson 1999).

Trawl Survey indices

The SNE fall trawl survey relative abundance indices for recruit and legal size lobster are generally consistent, with a peak in the 1990's and then a decline to low levels in recent years (Figures 7 and 8). Recent recruit and legal indices have generally remained at or below the 25th percentile since 2002. The RI trawl indices have shown somewhat different trends. Consistent with the other SNE indices, the RI indices peaked in the 1990's and then declined to a low in 2002, but then increased from 2003 through 2008.

The somewhat different trend in abundance in RI is not unexpected. As mitigation for an oil spill in 1996, a v-notch program was initiated in 2001. This program ran through 2006. A review of the program (Stokesbury and Bigelow, 2009) confirmed that the target number of V-notches and the intended egg production was achieved. Results of mark-recapture analyses indicate there was a significant increase in the population during the program. In addition, a number of more restrictive management measures was also implemented during this time period. Unfortunately, the increase in the population appears to be short lived.

The 2009 RI trawl survey recruit and legal relative abundance indices are at or below the 25th percentile, and the RI settlement index has declined since 2005 and is currently the lowest value of the survey. Both the MA and CT Fall survey indices for recruits show a consistent decline from peaks in the late 1990s. Abundance fell below the median in 1999-2000 and below the 25th percentile in 2000-2001. Abundance levels have remained below the 25th percentile since that time. In both surveys, the abundance of legal sized lobster has been below 25th percentile levels in all recent years except 2006 in the MA survey only.

The NJ trawl survey also showed declining legal and recruit indices since peaks in the mid-late 1990s. Abundance levels have remained below the 25th percentile since 2002 (Figure 7). The NEFC Fall trawl survey, our best survey for offshore areas in SNE, peaked in the mid-1990s and has remained at or near the 25th percentile since 2002.

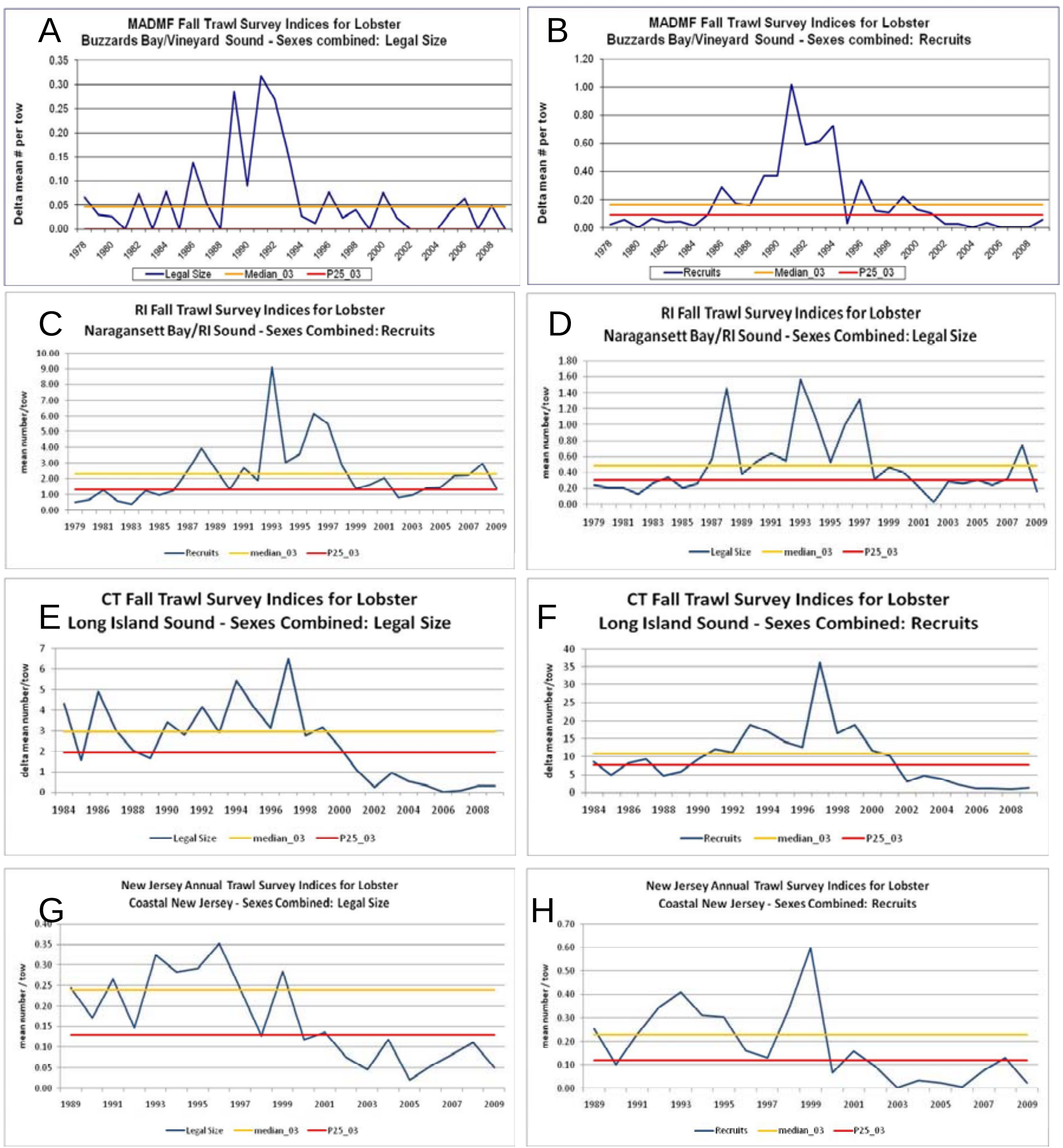
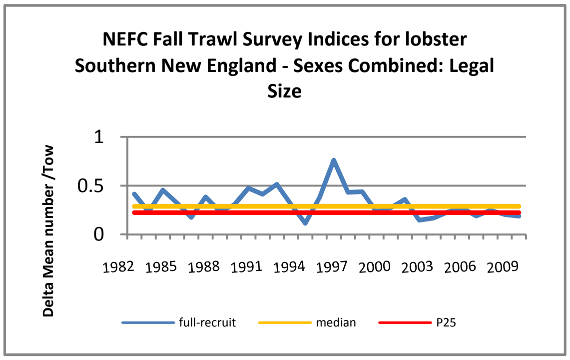


Figure 7. Abundance indices for legal and recruit (10 mm below legal) size lobster captured in MA (south of Cape Cod), RI, CT (including LIS), and NJ Trawl surveys. Medians (red) and 25th percentiles (yellow) were computed for the reference period 1984 – 2003.



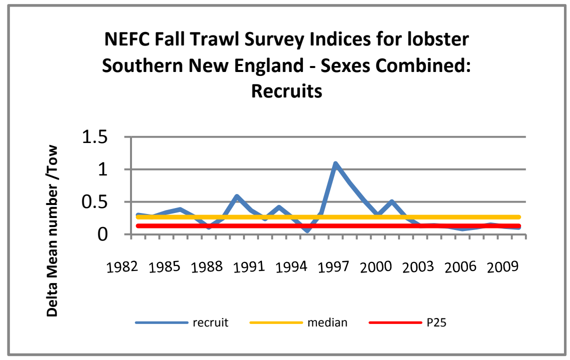


Figure 8. Abundance indices for legal and recruit (10 mm below legal) size lobster captured in NMFS Northeast Fisheries Trawl Survey in SNE

The fishery independent data portray a bleak picture. Since the declines from peak abundance in the 1990's, abundance has generally remained low. Spawning stock biomass is average to poor compared to the last 25 years, and larvae, YOY, and recruits are at low levels. This information indicates the SNE lobster stock is experiencing recruitment failure.

Changes in the SNE Fishery

The SNE landings peaked in 1997 and then declined to a low in 2003. Landings have remained low through 2007 (Figure 9). The data for 2008 and 2009 are preliminary and are thought to be underestimated. NMFS landings information was not available for landings from NJ and south. In the last assessment the NJ and south landings ranged from 4 % – 14% of SNE landings from 2003 – 2007. Landings have been below the 25th percentile of reference period landings since 2002.

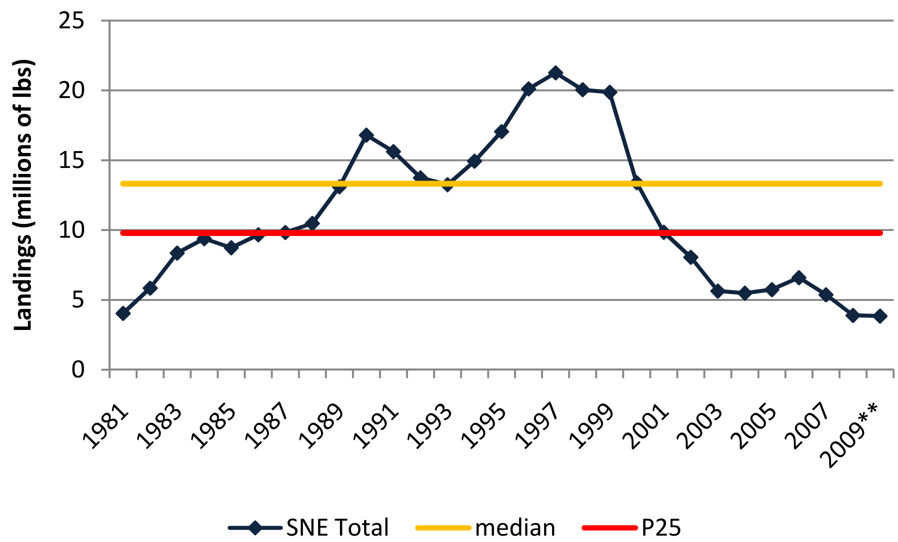


Figure 9. SNE Total Landings. We are missing the 2008 and 2009 NJ-south (NMFS) and NY 2008 and 2009 landings are probably underestimated. The median (yellow) and lower 25th percentile (red) are based on the 1984-2003 reference period.

SNE landings were examined by NMFS statistical areas (Map of NMFS statistical areas – Appendix C). Landings peaked and fell below the 25th percentile in different years in the different stat areas, though there were similarities among a number of areas. Landings in areas 611 (Long Island Sound) and 539 (RI inshore) peaked in the late 1990's and have remained below the 25th percentile since 2003 (Figure 10 and Appendix E). Though there was a small increase in inshore RI landings from 2004 – 2006, they remained below the 25th percentile. Landings trends in areas 613 (eastern south shore of Long Island) and 538 (south of Cape Cod) are somewhat similar to each other and to areas 611 and 539 (Figure 11 and Appendix D). There was a peak in landings in 1998 and landings fell and remained below the 25th percentile starting in 2003 or 2004. It is not surprising to see such similar trends in these areas (538, 539, 611 and 613) since they are all adjacent. The landings trends in areas 527 (offshore RI and MA), 612 (NY Bight), and areas from NJ and south (combined) are similar to each other, and somewhat different from inshore areas to their north (Figure 12 and Appendix D). Landings in these areas peaked in the late 1980's to early 1990's and then declined. Landings in all three areas dropped below the 25th percentile in 2001, and then showed a small increase in some of the areas. Preliminary 2008 and 2009 landings estimates for area 537 are still below the 25th percentile. Current status of area 612 and NJ south are unknown since NMFS-NE landings have not been updated.

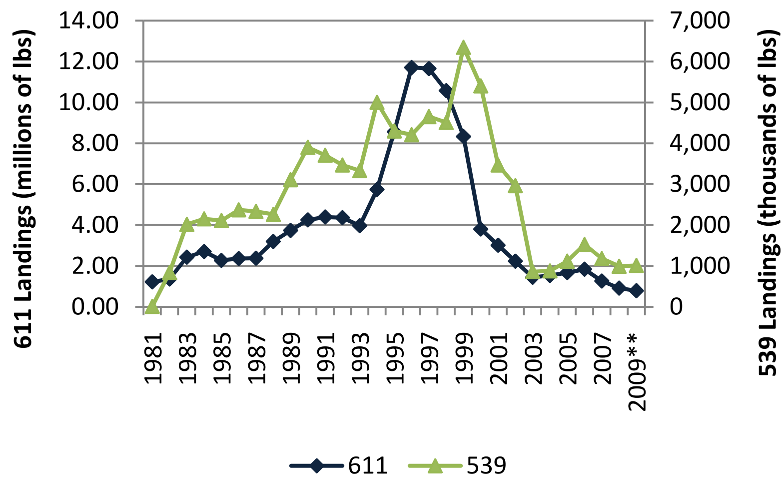


Figure 10. Comparison of Landings in NMFS Statistical Areas 611 and 539

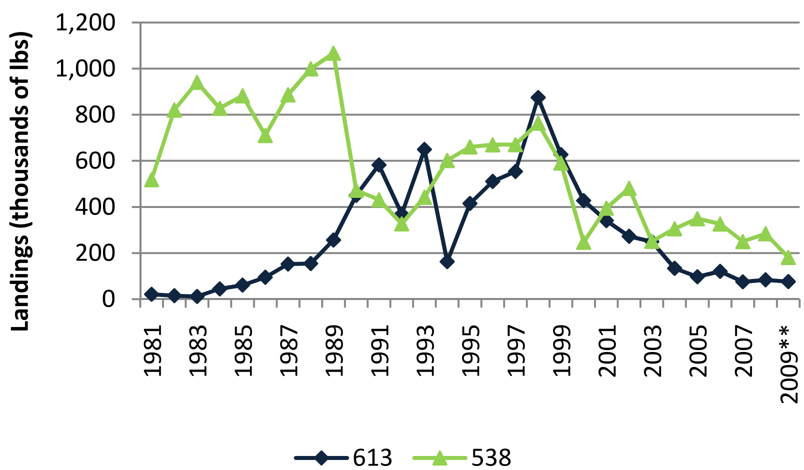


Figure 11. Comparison of Landings in NMFS Statistical Areas 613 and 538

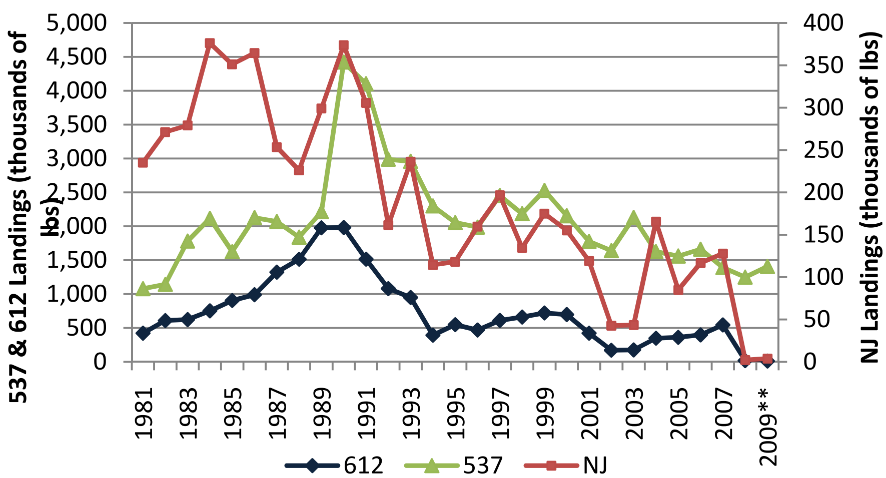


Figure 12. Comparison of Landings in NMFS Statistical Areas 537, 612, and NJ - south

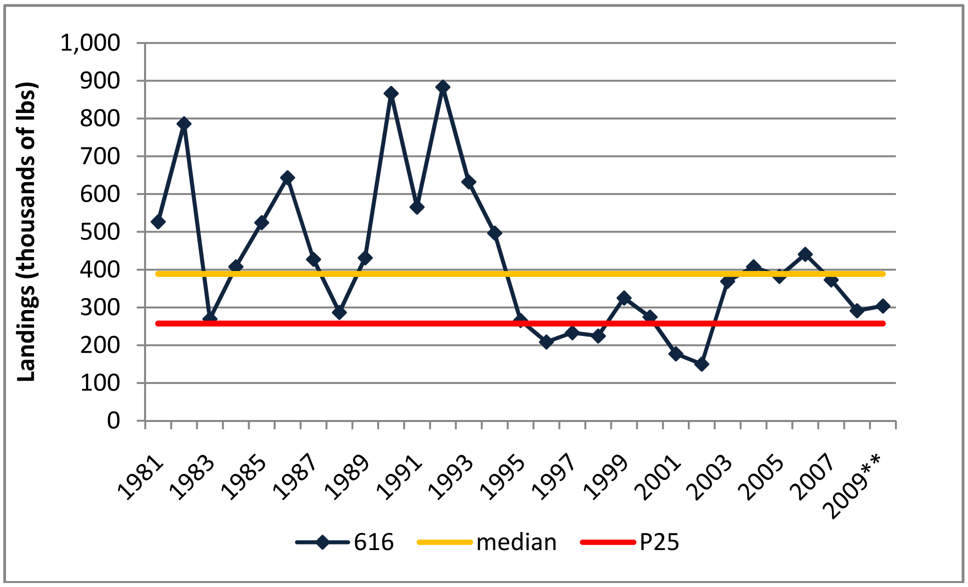


Figure 13. NMFS Statistical Area 616 landings (thousands of lbs). The median (yellow) and lower 25th percentile (red) are based on the 1984-2003 reference period.

Landings trends in area 616 stand out from the rest (Figure 13). Trends were similare to 537, 612, and NJ south with a peak in the early 1990's follwed by a decline and low levels in 2002. Unlike the other areas, landings increased in 2003 and stayed above median landings for a number of years. Recent estimates have declined, but are still above the 25th percentile and may be underestimated due to the lack of NMFS-SNE landings data.

2. Impediments to Rebuilding:

Increased Water Temperature

Water temperature has a pervasive effect on all of the major life history processes of American lobster including growth, maturity, spawning, egg maturation, and larval maturation. Regional differences observed in these parameters are largely due to the differences in thermal regime experienced by lobster. Growth rate is proportional to temperature between 8 and 25 °C (Aiken and Waddy, 1986), meaning that lobster which experience warmer average temperatures grow faster (molt more frequently) than lobster which experience colder temperature regimes.

Similarly, size at sexual maturity is directly related to mean summer water temperatures (Templemen, 1936a; Briggs and Mushacke, 1980; Estrella and McKiernan, 1989). Lobster in warmer temperature regimes, SNE, reach sexual maturity at much smaller sizes (younger ages) than lobster which live in colder environments (e.g. Gulf of Maine or

Georges Bank). The early onset of maturity in warmer areas confounds the proportional relationship between temperature and growth rate in female lobster, as the synchronization of the molt/mate/spawn cycle lengthens, the intermolt duration lengthens to accommodate the brooding of eggs. As a result the average population growth rate of the SNE stock is slower than that of GOM or GBK.

Embryonic development is directly related to the thermal regime experienced by the egg clutch, with the duration from extrusion to hatching lasting for 39 weeks at 10 °C and for only 16 weeks at 20 °C (Annis et al 2007, Perkins 1972). Temperature is also the major factor controlling the incidence, timing and synchronization of spawning (Waddy *et al.*, 1995). Extended periods of winter temperatures below 8 °C are required for ovary maturation and spawning in nearshore stocks (Waddy and Aiken, 1992). In addition, temperature has a profound effect on the rate of larval development. The duration from hatching to the post-larval stage ranges from 11 to 54 days at 20 and 10 °C respectively (Mackenzie 1988, Templemen, 1936b).

Southern New England represents the southern extent of the geographic range of American lobster. The primary habitat constraint within this region is water temperature. American lobster are capable of detecting temperature changes of 1°C (Jury and Watson, 2000), demonstrate a thermal preference between 12 and 18 °C, and will avoid temperatures > 19 °C (Crossin *et al*., 1998). Water temperatures > 28 °C cause mortality to adult lobster within 48 hours and this is exacerbated when the dissolved oxygen is reduced below 6.4 mg/L (McLeese, 1956). Prolonged exposure to water temperature above 20 °C causes physiological stress as indicated by marked hemolymph acidosis (Dove *et al*., 2005), increased respiration rate (Powers *et al.*, 2004), and depression of immunocompetence (Dove *et al.*, 2005; Steenbergen *et al.*, 1978). It has also been linked to increased incidence of disease including epizootic shell disease (Glenn and Pugh, 2006), and a newly described disease, excretory calcinosis (Dove *et al.*, 2004).

There has been a dramatic and widespread increase in the spatial range and duration of water temperatures above 20 °C in the coastal waters of SNE. Long term trends in the inshore portion of SNE show a pronounced warming period since 1999. Specifically, there has been a substantial increase in the duration of the number of days in the late summer when the mean bottom water temperature remains above 20 °C. These trends were observed in sea-surface temperatures recorded in Woods Hole, MA (NOAA unpublished data) (Figure 14), as well as bottom water temperatures from upper Buzzards Bay (Cleveland Ledge 30 ft- MADMF unpublished data) (Figure 15) and eastern Long Island Sound (Millstone Station unpublished data) (Figure 16). Additionally, there has been a substantial increase in the number of days > 18 °C (the upper thermal preference for lobster, Crossin *et al*., 1998) in the deeper water near the mouth of Buzzards Bay (70 ft- MADMF unpublished data) (Figure 17). Although there are no complementary temperature time series from Narragansett Bay or Rhode Island Sound, it is reasonable to expect that temperature trends observed in the rest of SNE have also occurred in Rhode Island coastal waters given the similarities in latitude and bathymetry in these areas.

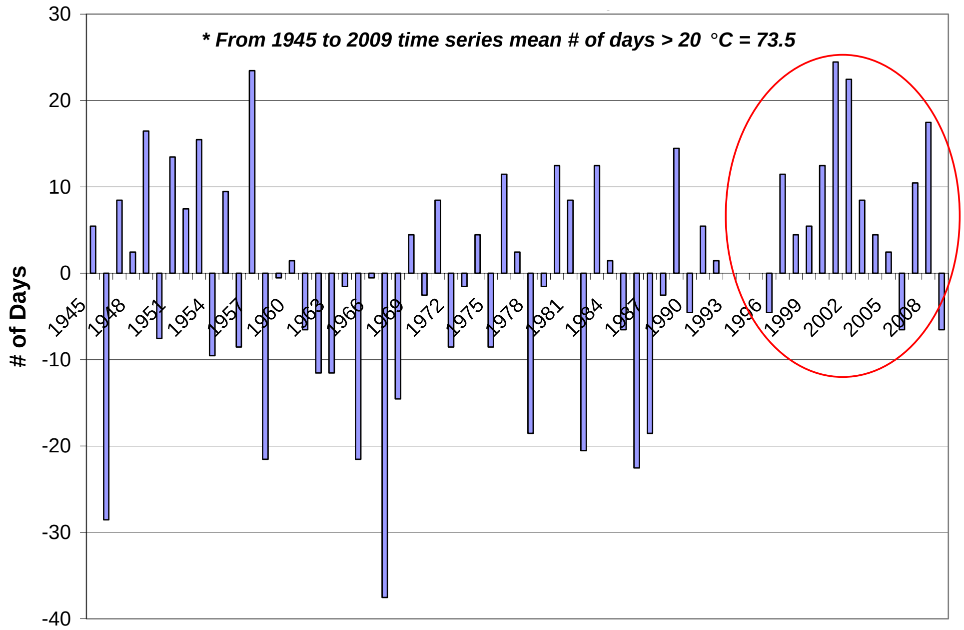


Figure 14. Anomalies from the mean number of days > 20˚C of the Woods Hole sea-surface temperature, 1945 - 2009.

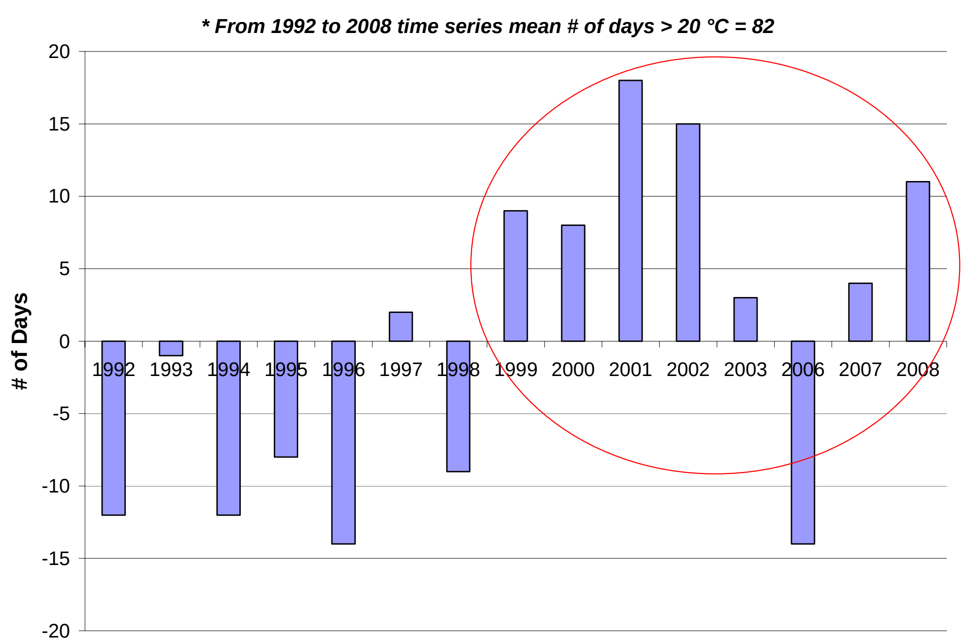


Figure 15. Anomalies from the mean number of days > 20˚C of Cleveland Ledge, Buzzards Bay, bottom water (30 ft.) temperature: 1992 - 2008

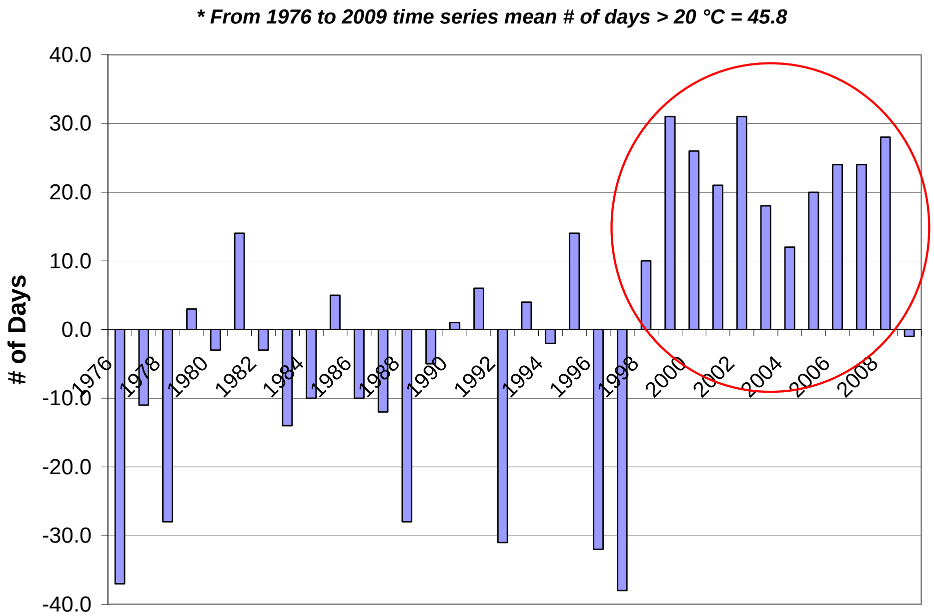


Figure 16. Anomalies from the mean number of days > 20˚C of the Millstone Power Station bottom temperature, 1945 - 2009.

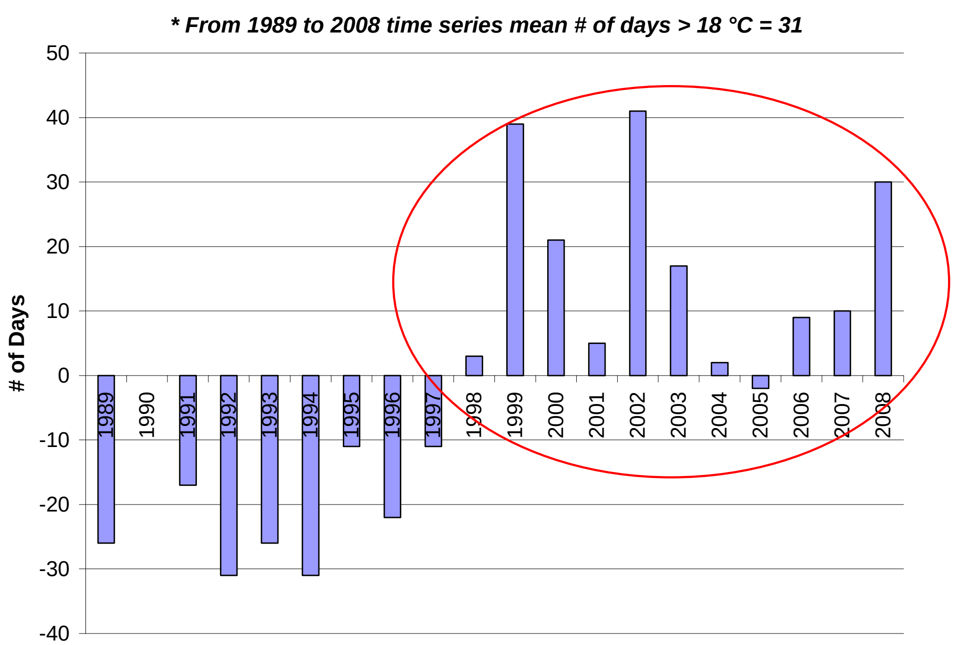


Figure 17. Anomalies from the mean number of days > 18˚C at the mouth of Buzzards Bay, bottom water (70 ft.) temperature: 1989 – 2008

The observed increases in water temperature are not above the upper lethal limits to lobster (28.4 ˚C), nor are the minimum temperatures above the minimum winter temperatures necessary for successful maturation and spawning (8 ˚C). However, the duration and areal extent of coastal waters of SNE above the thermal tolerance of lobster have increased. The loss of viable habitat area has caused the stock to contract spatially into deeper water (MADMF & CTDEP unpublished data, Appendices A and B) and into areas more prone to chronic hypoxia (Pearce and Balcom, 2005). The coastal waters of SNE are relatively shallow, most less than 20 m (70 feet). Adult lobster exposed to this temperature regime would experience increased physiological stress, and may adjust their movement patterns to avoid these warmer areas, seasonally migrating into deeper waters which provide thermal refugia. This contraction into relatively small deep water areas likely causes crowding, where lobster are forced to compete for resources (food and shelter), and where they are more vulnerable to commercial exploitation. Early benthic phase lobster (5 to 40 mm CL) are habitat restricted (Wahle and Steneck, 1991) typically requiring shallow water with cobble substrate, and have very small home ranges (Copper and Uzmann, 1977). Lobster in this life history phase are generally considered to be incapable of making substantial migrations to deeper water to find thermal refugia, and as such would be exposed to stressful inshore temperatures for a prolonged period. The effects of prolonged exposure to warm temperatures on early benthic phase lobster are not well known, however it is safe to surmise chronic physiological stress and suppression of the immune system would lead to increases in natural mortality within this life history phase.

There has also been a re-distribution of spawning females (as indicated by the presence of females with fully developed embryos or spent clutches) from shallow water areas throughout Buzzards Bay into deep water areas near the mouth of Buzzards Bay and Vineyard Sound (Appendix B). Preliminary data from satellite-tracked drifter deployments released at locations representing the current locations of spawning females, suggest that larvae hatched outside of the mouths of Buzzards Bay and Narragansett Bay may be transported to the west via coastal currents away from traditional settlement areas and potentially into less favorable areas to the south of Long Island (MADMF unpublished data). Alternatively, drifters released at locations inside Buzzards Bay, where spawning females were previously observed in the early 1990's, were generally transported to the east by wind driven currents to traditional settlement locations. The relationship between the location of spawning females and the ultimate fate of their larvae is still not well understood. However these preliminary data suggest that changes in the geographic distribution of spawning females may be impacting larval transport and settlement success in some portions of SNE.

It is not possible to draw a direct relationship between the decline of the Southern New England lobster stock and increased water temperatures. However, the strong coincidence in the timing of the increase in water temperature with the timing of the decline in landings, spawning stock biomass, and recruitment, coupled with overwhelming experimental evidence of increased physiological stress, immunosupression, and increased rates of disease in lobster exposed to prolonged periods of temperatures ≥ 20 °C, strongly suggest that increasing water temperatures have played a primary role.

Shell Disease

An outbreak of chitinoclastic shell disease has been observed throughout eastern Long Island Sound (Howell *et al.*, 2005), Narragansett Bay and Rhode Island Sound (Castro and Angell, 2000), and Buzzards Bay and Vineyard Sound (Glenn and Pugh, 2005, 2006) since 1997. Since this time the incidence of the disease in the population has varied annually, but has generally remained above 15% of the population (Figures 18). This form of shell disease is characterized by lesions penetrating inwards from the carapace surface. Bacteria are seen at the leading edge of lesions and have been identified as the primary causative organism (Smolowitz *et al.*, 2005). Chistoserdov *et al.* (2005) have described similar microbial communities in lesions of lobster from different locations, and several investigators have suggested that the bacterial activity may be interacting with environmental factors (Chistoserdov *et al.,* 2005; O'Kelly, 2005; Shiaris, 2005; Smolowitz *et al.,* 2005). The high prevalence of disease symptoms observed in some regions, and the wide scale geographic distribution of disease symptoms has led researchers to label this disease as epizootic.

In a recent paper by Wahle, Gibson and Fogarty (2009), the linkage between lobster settlement and subsequent recruitment to the fishery was established. After 1997, when shell disease first became prevalent in Rhode Island waters, this relationship breaks down. They propose the supply of new recruits was greatly impacted by shell disease induced mortality after settlement. When a disease term was added to the model a statistical fit to the observed data was possible. In this case, temperature trends, as measured in the August trawl survey and a composite index of predatory fish did not provide an explanation for variability and downward trend in pre-recruit abundance.

Figure 18. The percent incidence of shell disease observed in the commercial catch of Southern New England

Lobster infected with shell disease, particularly egg-bearing females, have been shown to have high concentrations of ecdysone, the hormone responsible for promoting molting (Laufer *et al.*, 2005). This suggests that shell-diseased lobster molt more frequently to combat the effects of the disease. This observation has been recorded *in situ* in Rhode Island coastal waters, where shell-diseased egg-bearing females were observed prematurely molting, hence losing an entire clutch of eggs (Castro and Angell, 2000). Ecdysis (molting) is a physiologically stressful process and lobster are extremely vulnerable in their “soft” post-molt condition. Lobster experience higher rates of natural mortality in the molting process and post-molt condition than when hard-shelled. Given the high prevalence of the disease observed among sexually mature females, it is likely that any increase in mortality has had a substantial negative impact on the reproductive output in the SNE lobster stock. Of additional concern to reproductive processes, Canadian researchers have described damaged or deformed vas deferens and damaged spermatozoa in male lobster afflicted with shell disease (Comeau and Benhalima 2009).

Commercial Exploitation

In addition to environmental and disease factors, continued fishing pressure reduces the stock’s potential to rebuild. Current management measures are designed to protect the spawning stock by preventing harvest of egg-bearing and v-notched female lobster, and the minimum legal size allows 92-100% of females to reach maturity before they are vulnerable to harvest. However, in the deep water areas to which the fishery has shifted and where catch rates are highest, a substantial portion of the catch is comprised of females (Table 2). This legal catch of mature females represents a loss of potential egg production to the system. In light of the current low spawning stock biomass and poor recruitment in SNE, continued harvest of sexually mature females represents a serious threat to the long term viability of this stock.

Table 2. Percent of the marketable catch in SNE comprised of females by region, 2007 – 2009.

	2007	2008	2009
CT - WLIS	14%	31%	24%
CT - CLIS	16%	19%	16%
CT - ELIS	21%	35%	36%
RI	55%	55%	53%
MA	82%	80%	82%

3. Management Response and Future Advise

Since 2005 the technical committee has recommended several changes to management strategies in SNE including output and input controls. Table 3 shows management changes by lobster conservation management area (LCMA) for all areas that fall within the SNE stock unit. The table lists all new measures and the year they were implemented. The table also indicates if a program is ending, such as the v-notching program in LCMA 2 that was a part of the oil spill mitigation program. The technical committee recommended specific advice to the board after the 2005 and 2009 stock assessments, both indicating the SNE stock was in poor health. Appendix E and F are the memos to the Board with the recommended measures.

Table 3. Changes in management measures for the SNE stock by LCMA and year.

	LCMA 2	LCMA 3	LCMA 4	LCMA 5	LCMA 6	OCC
2005						
Gauge		3 13/32			3 9/32	3 13/32
v-notching						
2006						
Gauge		3 7/16			3 5/16	3 3/8
v-notching	Last year of oil spill mitigation notching					
2007						
Gauge		3 15/32				
Traps		limited entry trap allocation program				
v-notching (Fall)					notching in CT only replaced gauge increase	
2008						
Gauge		3½ (delayed corresponding vent increase until 2010)				
V notch definition	1/8" with or without setal hairs	1/8" with or without setal hairs	1/8" with or without setal hairs	1/8" with or without setal hairs	1/8" with or without setal hairs	
Max size	5 ¼ male & female	7 male & female	5 ¼ male & female	5 ¼ male & female	5 ¼ male & female	
2009						
Max size		6 7/8 male & female				
v-notching (Spring)					CT program to replace gauge increase ends	
2010						
Gauge					3 3/8	
Max size		6 3/4				

Given additional evidence of recruitment failure in SNE and the impediments to stock rebuilding, the technical committee now recommends a five year moratorium on harvest in the SNE stock area. Declines in survey indices, larval production, settlement, and landings all point to a systemic recruitment failure of the Southern New England lobster stock.

The SNE lobster fishery has declined as the resource has declined, although not at the same rate nor scaled to current levels of abundance. Environmental changes, most notably temperature, likely have forced lobster to seek more suitable habitat in deeper water. Larvae produced by displaced lobster may be lost to traditional inshore nursery grounds. The fishery has adapted to the changes in the resource by shifting effort further offshore. However, fishing continues in most inshore portions of SNE, and continued harvest represents lost spawning stock.

A moratorium provides the maximum likelihood to rebuild the stock to a level that can support a sustainable fishery. Rebuilding the currently depleted SNE stock may take longer than five years. Caddy and Agnew (2004) reviewed stock recoveries of depleted marine resources and reported that invertebrate fisheries most likely to recover were those with reductions in predator pressure, in the center of their geographic range and under favorable regimes. They suggest that the predicted length of recoveries should be treated with caution and conclude that a few stocks have recovered within a decade, but that most require longer.

Crustacean Case Studies

We draw on three examples of crustacean fisheries in the Northwest Atlantic that have implemented complete closures, closed areas or greatly reduced seasons in an attempt to rebuild a depleted stock. The first known lobster fishery that was completely closed in the NW Atlantic for an extended period of time, was the Newfoundland American lobster fishery in the late-1920s. After nearly fifty years of uncontrolled harvest, where nearly all lobster were retained the landings had declined from an average of 5000 to 6000t in the late 1880s (with a peak of 8,000 t in 1889) to 400 t in 1924. A three year fishery moratorium ensued from 1925 through 1927. The fishery was reopened in 1928. One immediate result in landings was an increase to approximately 2000 tons. For several years afterward landings declined to 800 tons, which is typical of exploiting the interest gained during a closure, followed by returning to harvesting the principle (current stock size + any interest carried forward). Within 10 years after the closure landings rose to 2000 t and have remained at or near that level until the present. . . One should apply the caution in comparing historical to current data. The information in the period from the 1870s to the closure were collected in a different manner than from the closure to 1976, and from 1977 to present (Williamson 1992).

The most recent assessment document (DFO 2006) states that minimum size and egg bearing prohibitions were not enforced until the early 1930s. Changes in productivity, a valuable measure of management, as inferred from landings, is problematic. In this case, one should not compare the “productivity”/landings of the recent commercial fishery with that of a completely unregulated fishery, with different means of attaining landings data. Perhaps if all regulations currently in place were lifted, the “productivity” of the American lobster stock in NL, as indicated by landings data, would exceed 8000 t. However this would almost certainly be followed by the same stock collapse as seen in 1924. This is not an advisable experiment to try.

According to the most recent Newfoundland lobster assessment (DFO 2006), reproductive potential is, in some part, aided by the current management measures, though "the population structure appears to be unhealthy as it is predominately composed of relatively small animals; this may be constraining egg production. Enhanced v-notching could help improve structure of the stock, while reducing exploitation rates and enhancing egg production. Additionally, the establishment of further closed areas may help to achieve these goals.”

The second case study that may be informative when considering the likelihood of a 5-year moratorium improving conditions in SNE comes from Browns Bank located southwest of Nova Scotia. This mid shelf area was a known productive fishing ground for many species. In the 1970s, the inshore lobster fleet (LFA 34) was slowly expanding to offshore grounds and the offshore fishery (LFA 41) was expanding following the decline of the swordfish fleet as a result of high mercury levels in swordfish. The convergence of these two competing groups led the DFO to close Browns Bank permanently in 1979. The believed importance of Browns Bank for brood stock has not been quantified. Larval studies suggest tidal and wide transport can disperse larvae to Nova Scotia, the Bay of Fundy and along the Coast of Maine. Large reproductive lobster have limited protection within the closed areas as they have been found to migrate off the bank and are susceptible to fishing in adjacent LFA 34 and 41. The greatest benefit of the closed area may be in the protection to immature lobster which do not migrate. However, a major concern with the closed area is the unknown impact of mobile gear activity, which was allowed to continue, on the lobster resource at various times of year (juvenile, spawning and molting; DFO 1999).

Our final case study involves the northern shrimp Fishery, which has had two instances since the 1970s where the resource crashed, recruitment failed, and the stock rebuilt after either a moratorium of one season (1978) or greatly reduced season length (1979, 2000-2003; Figure 19). Like lobster in SNE, the northern shrimp is at its southern extent of its range and may be heavily influenced by environmental conditions for successful recruitment. Unlike lobster, northern shrimp are fast growing and only live to five years. Recruitment pulses are monitored annually with harvest levels recommended on a yearly basis. Managed under ASMFC, the northern shrimp Fishery is an example where decisive management action, combined with favorable recruitment conditions, can help a depleted resource recover to the benefit of industry participants (ASMFC 2009b).

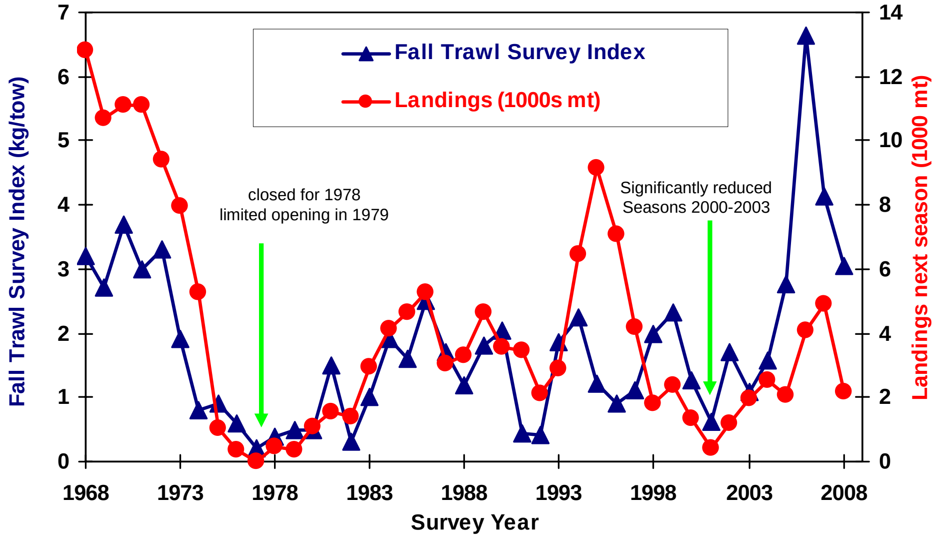


Figure 19. Landings in metric tons and Fall trawl survey index for northern shrimp in New England. The fishing season was closed in 1978 and limited in 1979. In 2000-2003 the season length was greatly reduced. In both cases the stock recovered and exceeded the biological reference points.

Based on the three case studies listed above for crustacean fisheries in the Northwest Atlantic, there are several important lessons to be learned. First, if a moratorium is enacted there is a need to understand the consequences of renewed fishing after the moratorium is lifted. In the case of the Newfoundland closure, short term gains were immediately lost when fishing resumed following pre-moratorium practices. Second, in the case of the Browns Bank closure, it is important to scale the area to reflect the life history of the target species. Lobster movement out of the closed area may erode any benefits to regional egg production and mobile gear may unnecessarily impact lobster during spawning and molting seasons. Finally, for a species at the limit of its range, like the northern shrimp, decisive management action based on reliable survey data can provide the necessary ingredients to capitalize on favorable recruitment conditions to rebuild a depleted stock. In the case of northern shrimp, the rebuilding of the stock twice in 40 years has defied the review of Caddy and Agnew (2004) that suggested depletions aggravated by unfavorable environmental conditions for stocks at the limit of their range are unlikely. In the Newfoundland and northern shrimp examples, a measurable impact was observed after a moratorium or strict seasonal limits. While on Browns Bank, the political nature of the implementation of the closed area likely limited its effectiveness and would have benefited from increased information prior to the closure.

Evaluation of moratorium

During the 5 year moratorium period, monitoring of all phases of the lobster life cycle should be intensified. Fishery dependent sampling will no longer be collected, therefore assessment of stock status will rely on current fishery-independent surveys (e.g., ventless trap, YOY sampling, larvae) which will need to be continued and intensified. Caddy and Agnew (2004) suggest that a sentinel Fishery with observer coverage could track changes in catch rate, recruitment and size class distributions in previously heavily fished areas not bound by prior stratification schemes. New surveys and research are needed to further characterize lobster settlement and habitat in SNE.

The multi-phased approach for recovery monitoring will allow evaluation of annual YOY recruitment, and subsequent survival larger sizes. The moratorium will have the greatest chance of promoting a windfall recruitment event that will greatly increase the recovery rate.

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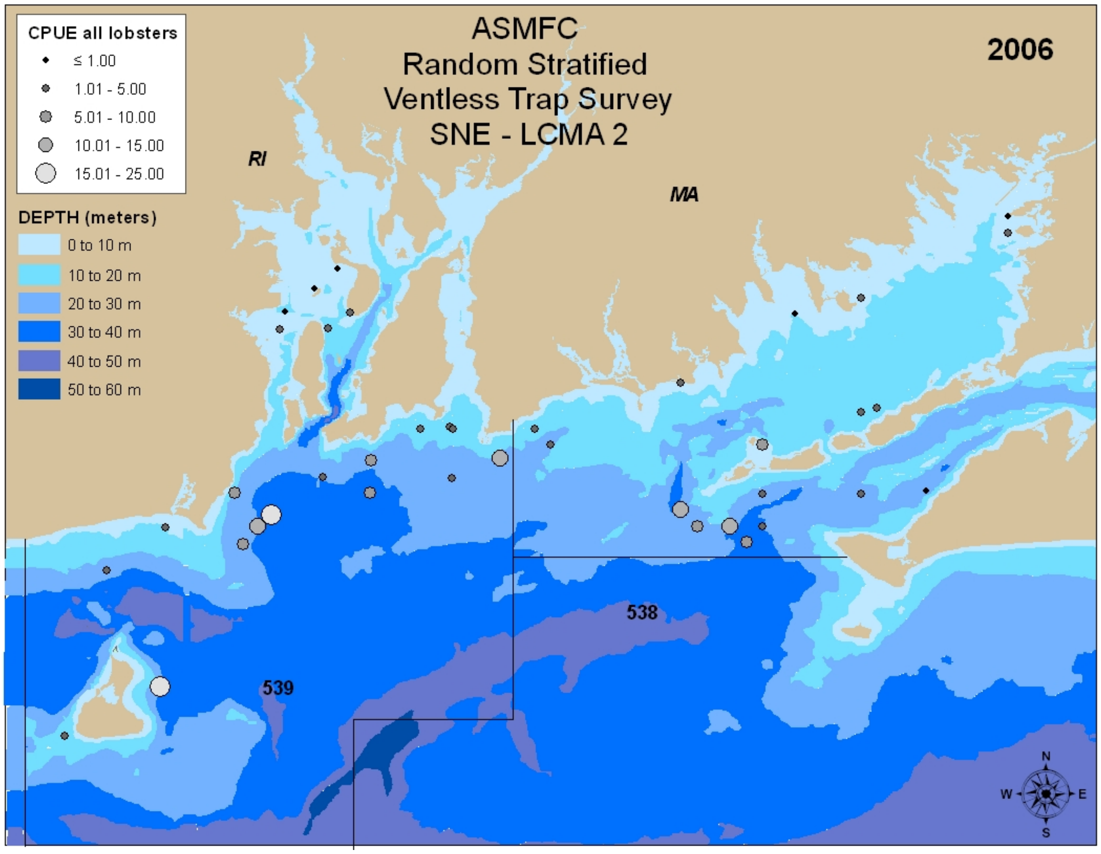
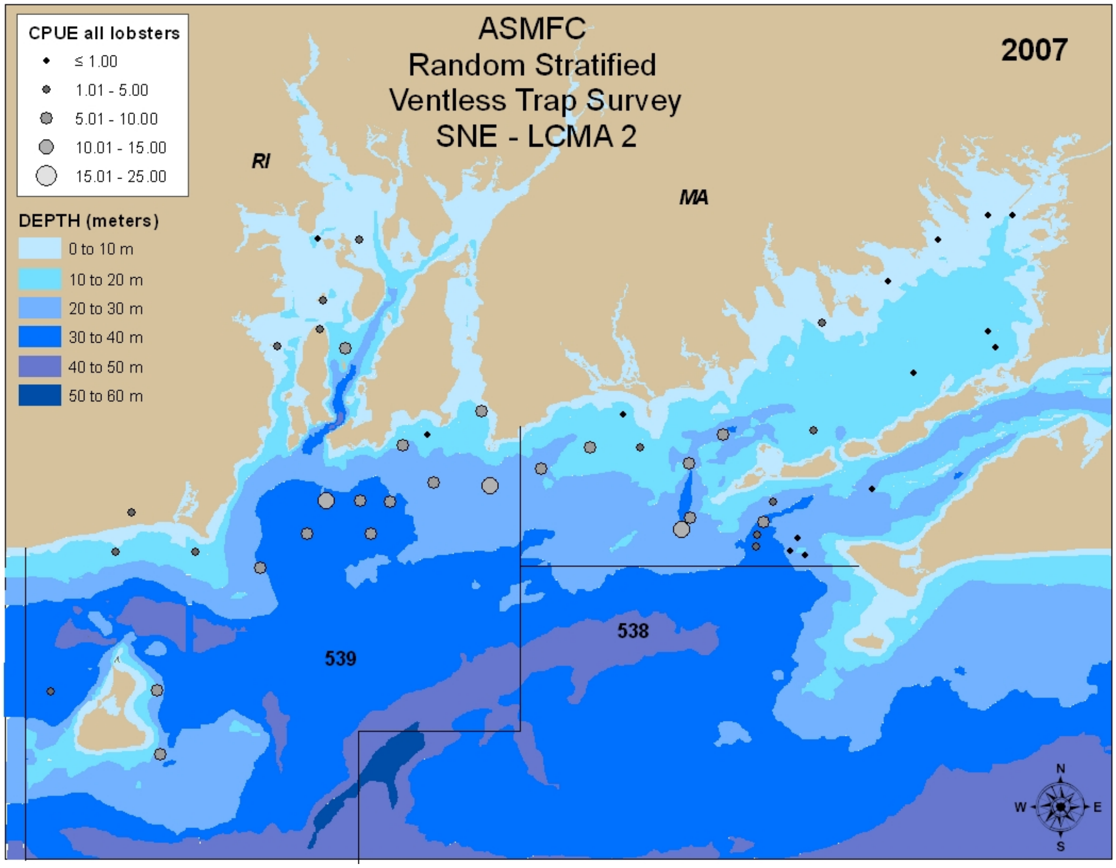
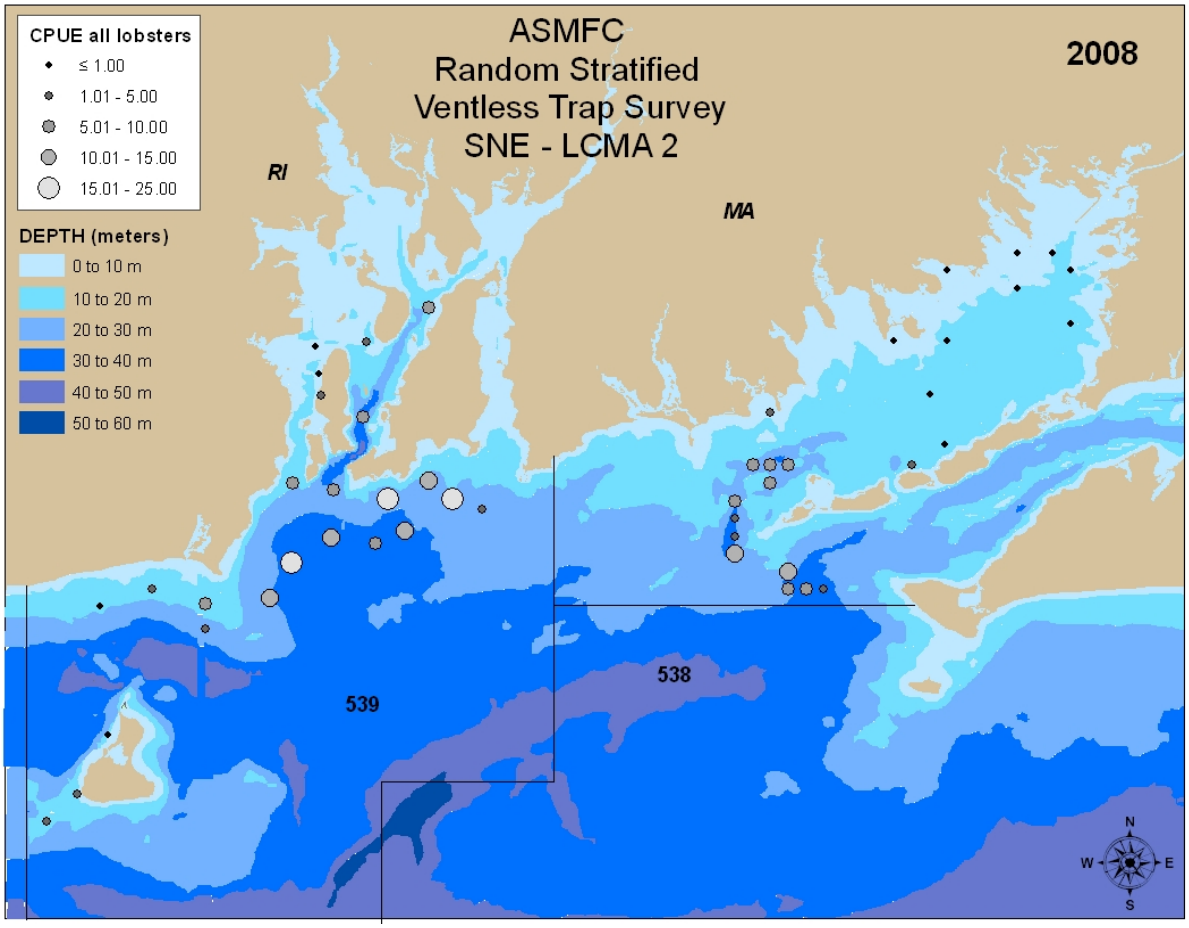
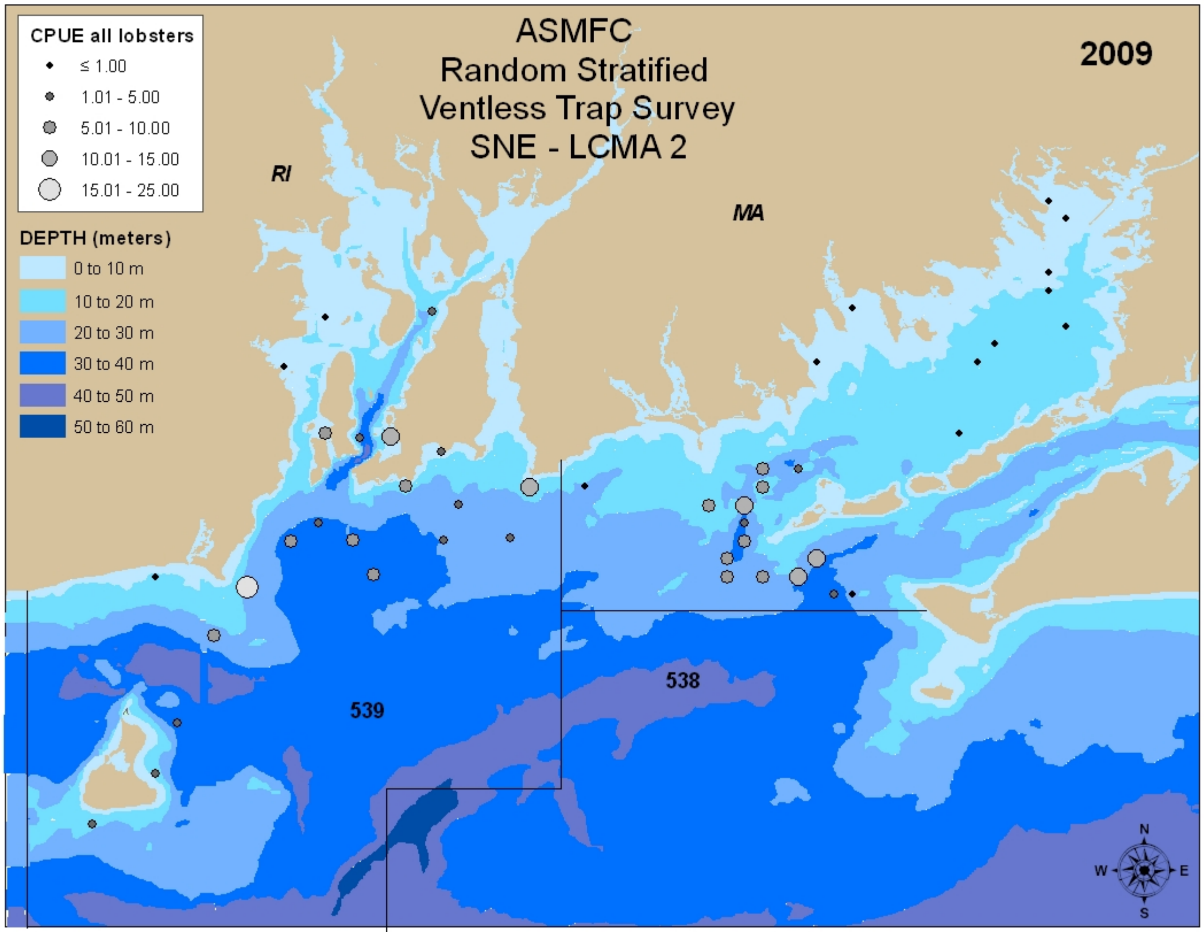
<u>Appendix A</u>

Coastwide Ventless Trap Survey CPUE by station and depth

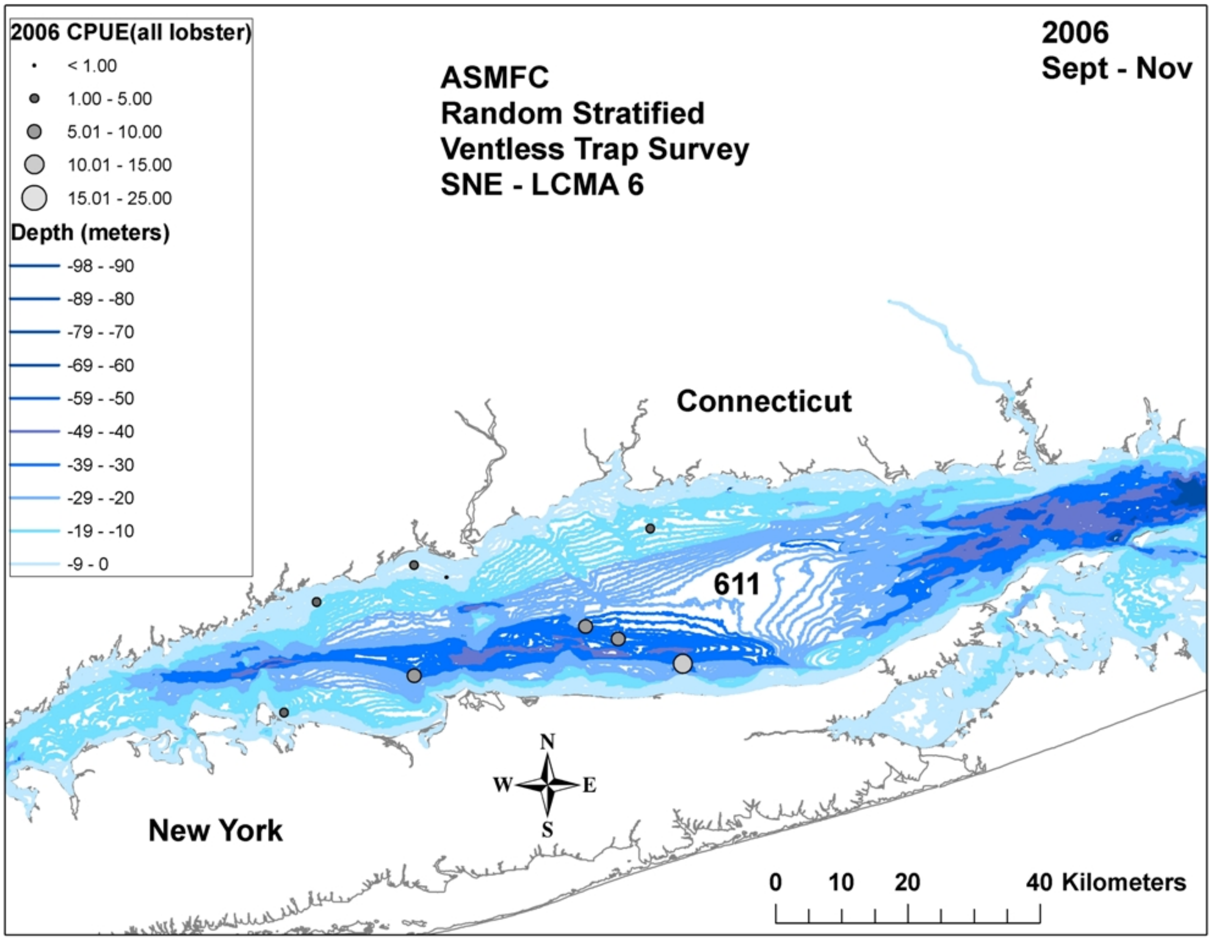


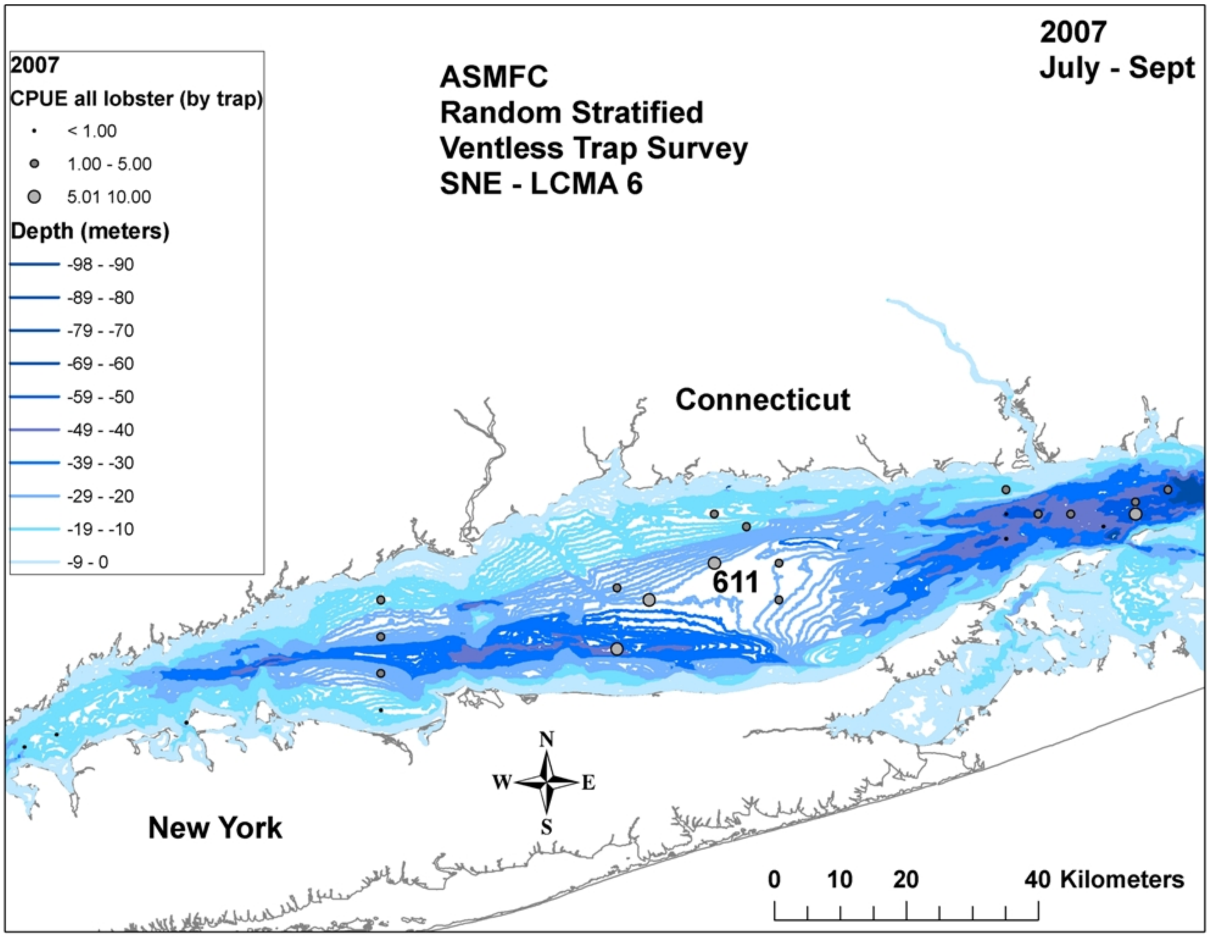

ASMFC
Random Stratified
Ventless Trap Survey
SNE - LCMA 2
2007
CPUE all lobsters
≤ 1.00
1.01 - 5.00
5.01 - 10.00
10.01 - 15.00
15.01 - 25.00
DEPTH (meters)
0 to 10 m
10 to 20 m
20 to 30 m
30 to 40 m
40 to 50 m
50 to 60 m
RI
MA
539
538
N
W
E
S


ASMFC
Random Stratified
Ventless Trap Survey
SNE - LCMA 2
2008
CPUE all lobsters
≤ 1.00
1.01 - 5.00
5.01 - 10.00
10.01 - 15.00
15.01 - 25.00
DEPTH (meters)
0 to 10 m
10 to 20 m
20 to 30 m
30 to 40 m
40 to 50 m
50 to 60 m
RI
MA
539
538
N
W
E
S



ASMFC
Random Stratified
Ventless Trap Survey
SNE - LCMA 2
2009
CPUE all lobsters
≤ 1.00
1.01 - 5.00
5.01 - 10.00
10.01 - 15.00
15.01 - 25.00
DEPTH (meters)
0 to 10 m
10 to 20 m
20 to 30 m
30 to 40 m
40 to 50 m
50 to 60 m
RI
MA
539
538
N
W
E
S


2006 CPUE(all lobster)
< 1.00
1.00 - 5.00
5.01 - 10.00
10.01 - 15.00
15.01 - 25.00
Depth (meters)
-98 - -90
-89 - -80
-79 - -70
-69 - -60
-59 - -50
-49 - -40
-39 - -30
-29 - -20
-19 - -10
-9 - 0
ASMFC
Random Stratified
Ventless Trap Survey
SNE - LCMA 6
2006
Sept - Nov
Connecticut
611
New York
N
W
E
S
0 10 20 40 Kilometers


2007
July - Sept
ASMFC
Random Stratified
Ventless Trap Survey
SNE - LCMA 6
2007
CPUE all lobster (by trap)
< 1.00
1.00 - 5.00
5.01 10.00
Depth (meters)
-98 - -90
-89 - -80
-79 - -70
-69 - -60
-59 - -50
-49 - -40
-39 - -30
-29 - -20
-19 - -10
-9 - 0
Connecticut
611
New York
N
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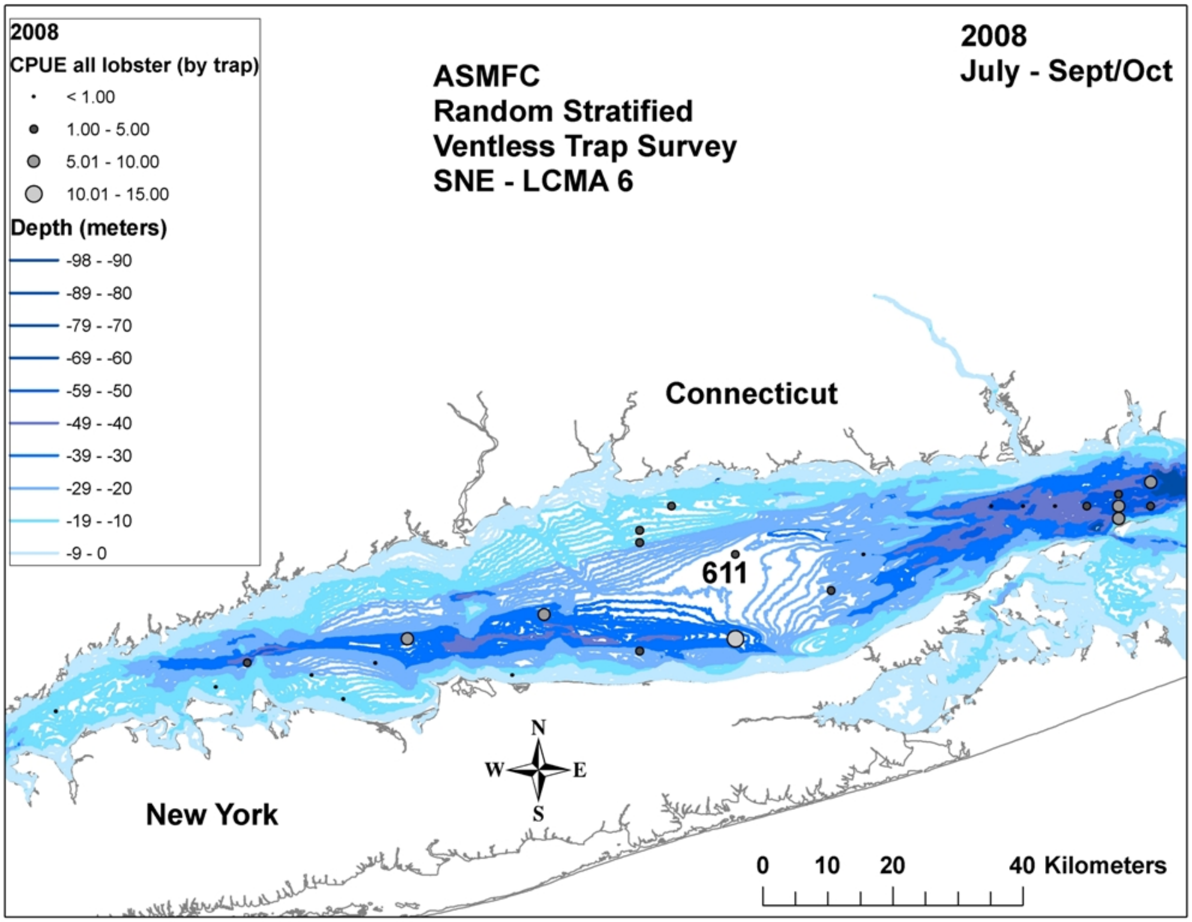
40 Kilometers


2008
CPUE all lobster (by trap)
< 1.00
1.00 - 5.00
5.01 - 10.00
10.01 - 15.00
Depth (meters)
-98 - -90
-89 - -80
-79 - -70
-69 - -60
-59 - -50
-49 - -40
-39 - -30
-29 - -20
-19 - -10
-9 - 0
ASMFC
Random Stratified
Ventless Trap Survey
SNE - LCMA 6
2008
July - Sept/Oct
Connecticut
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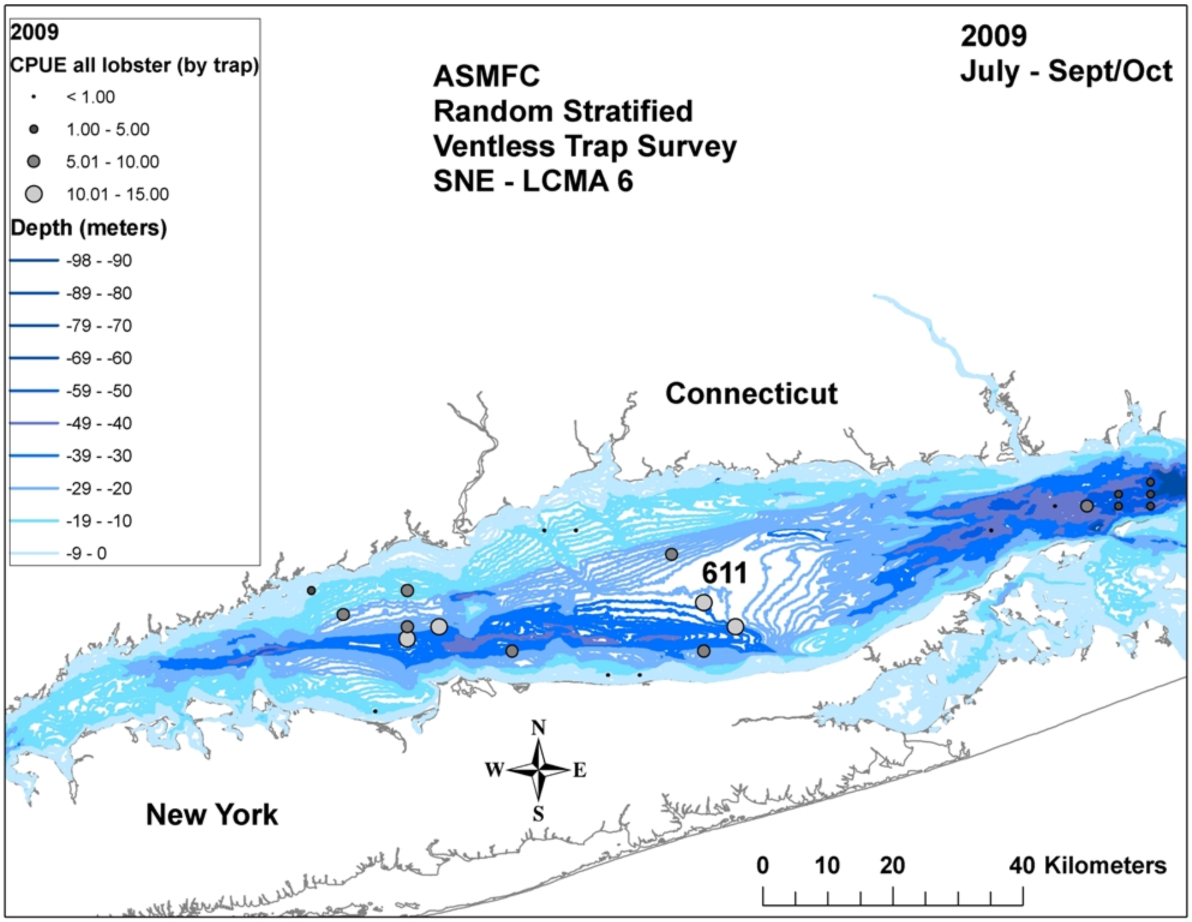
2009
CPUE all lobster (by trap)
< 1.00
1.00 - 5.00
5.01 - 10.00
10.01 - 15.00
Depth (meters)
-98 - -90
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ASMFC
Random Stratified
Ventless Trap Survey
SNE - LCMA 6
2009
July - Sept/Oct
Connecticut
611
New York
N
W
E
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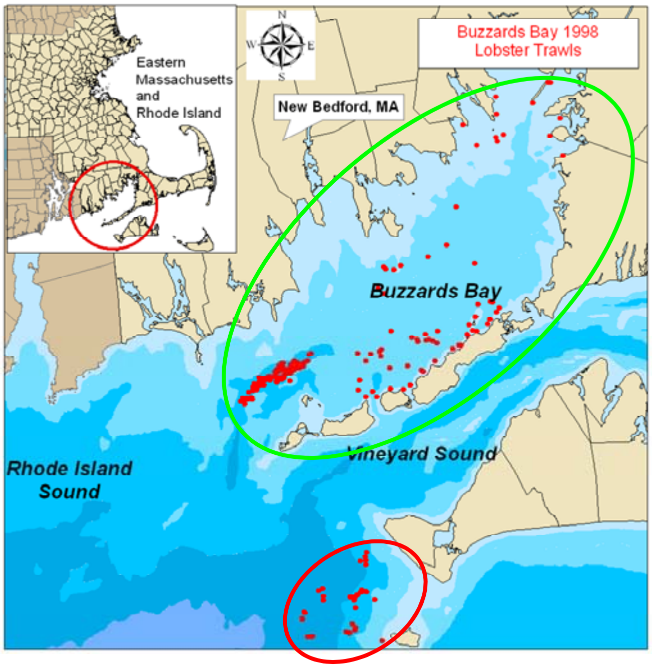
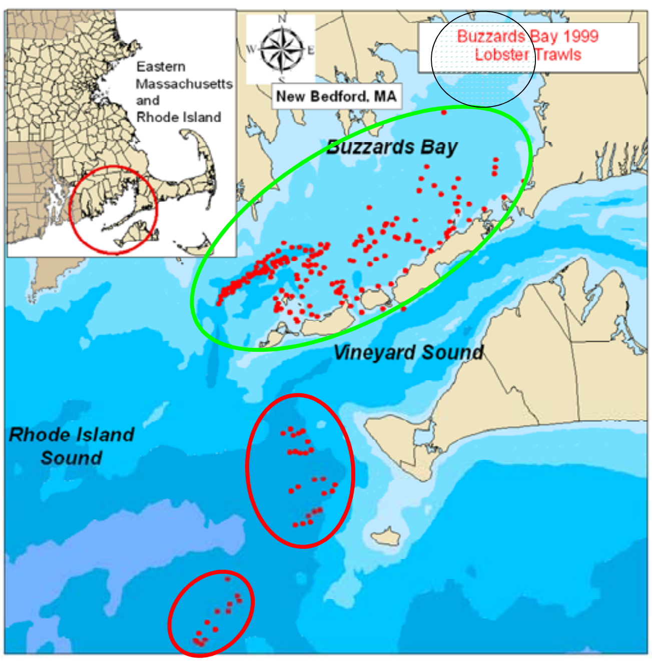
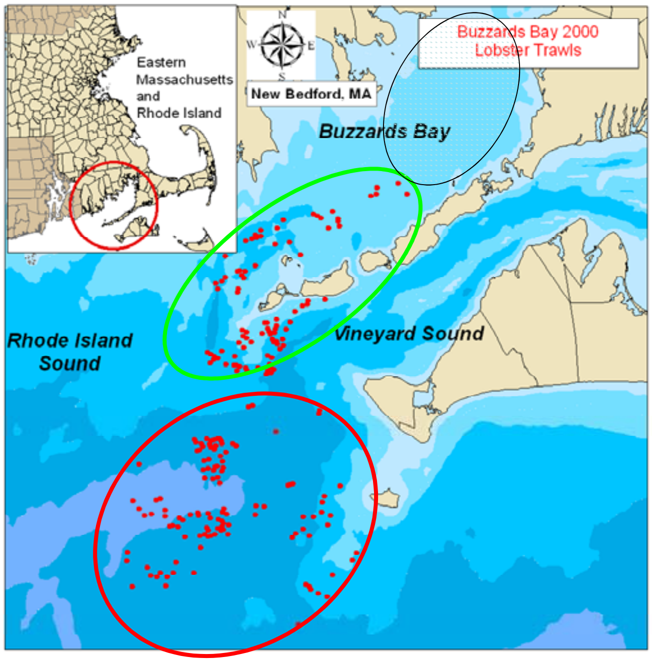
0 10 20 40 Kilometers

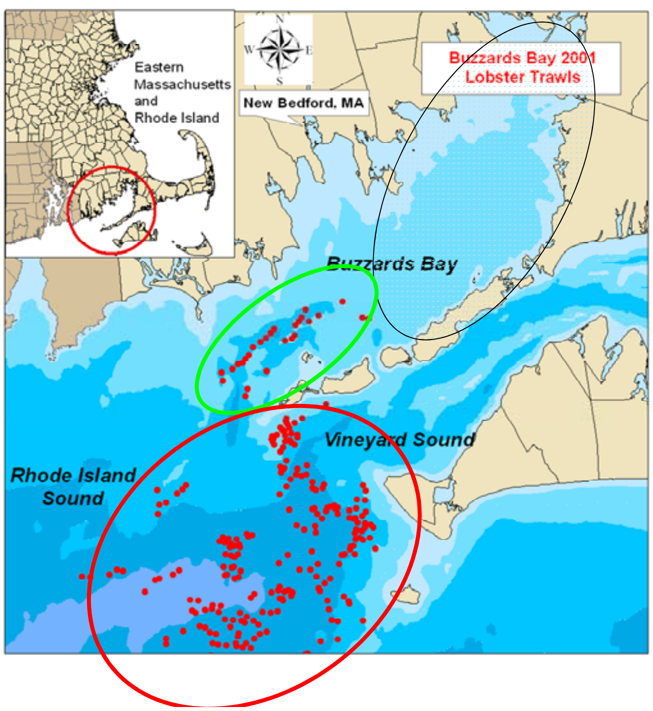
Appendix B

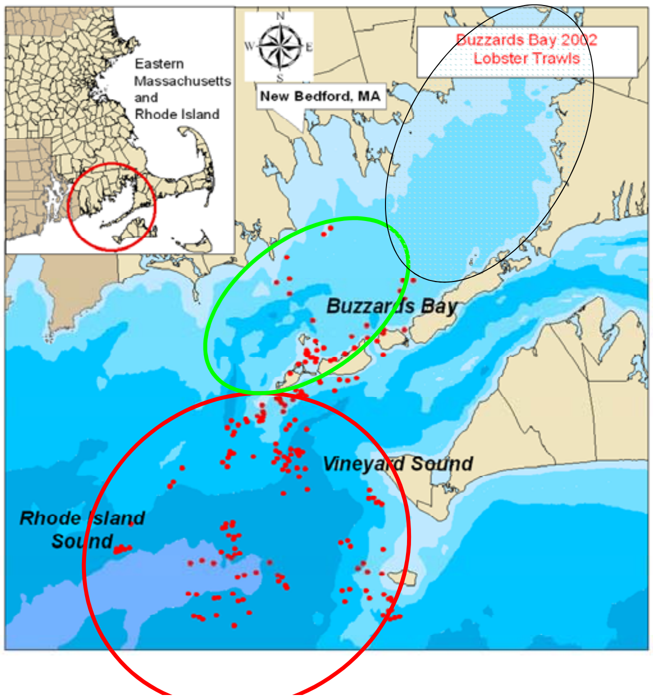
MA Sea Sampling catch by trawl and depth

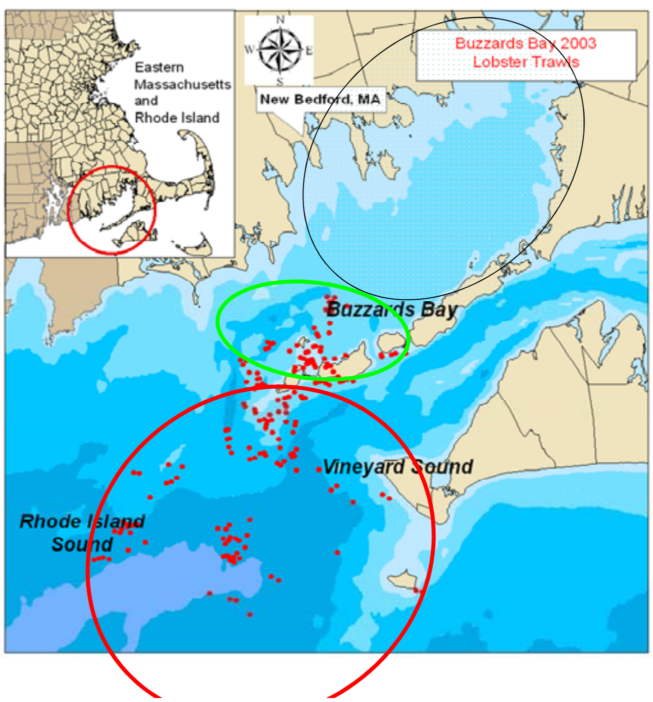


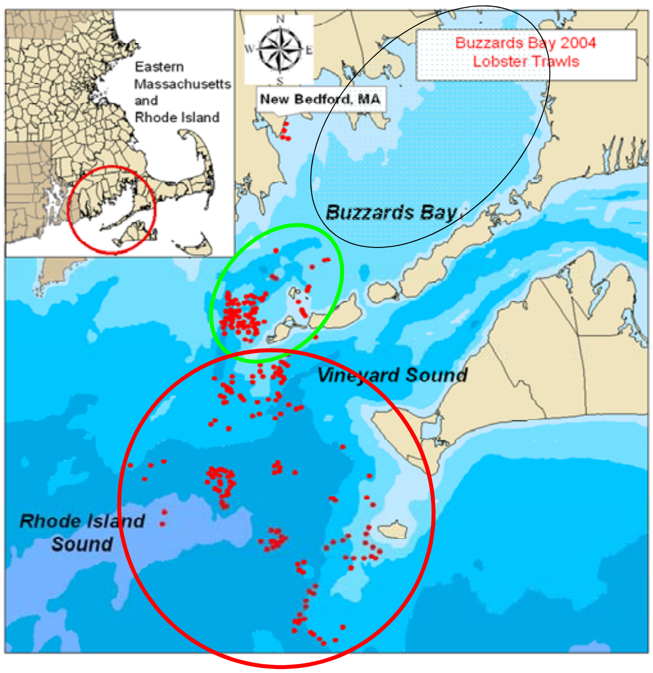


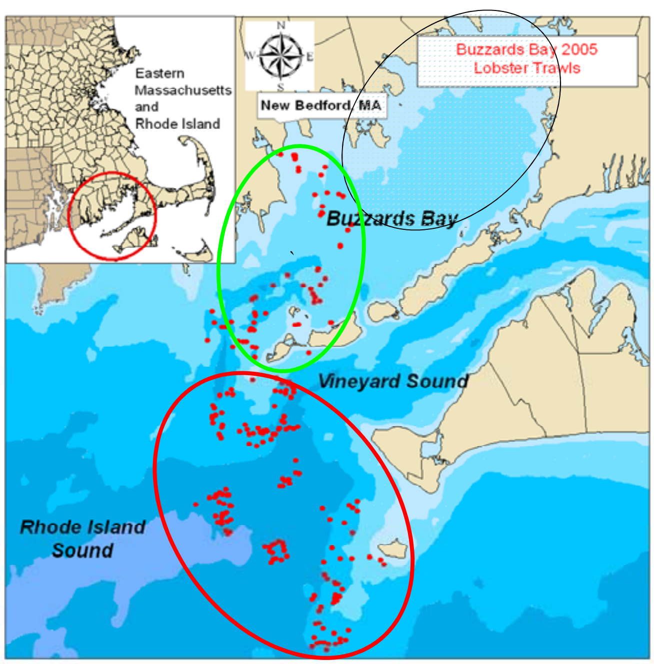

Eastern
Massachusetts
and
Rhode Island
New Bedford, MA
Buzzards Bay 2000
Lobster Trawls
Buzzards Bay
Rhode Island
Sound
Vineyard Sound


Eastern
Massachusetts
and
Rhode Island
New Bedford, MA
Buzzards Bay 2001
Lobster Trawls
Buzzards Bay
Vineyard Sound
Rhode Island
Sound


Eastern
Massachusetts
and
Rhode Island
New Bedford, MA
Buzzards Bay 2002
Lobster Trawls
Buzzards Bay
Vineyard Sound
Rhode Island
Sound


Eastern
Massachusetts
and
Rhode Island
New Bedford, MA
Buzzards Bay 2003
Lobster Trawls
Buzzards Bay
Vineyard Sound
Rhode Island
Sound


Eastern Massachusetts and Rhode Island
Buzzards Bay 2004 Lobster Trawls
New Bedford, MA
Buzzards Bay
Vineyard Sound
Rhode Island Sound


Eastern Massachusetts and Rhode Island
Buzzards Bay 2005 Lobster Trawls
New Bedford, MA
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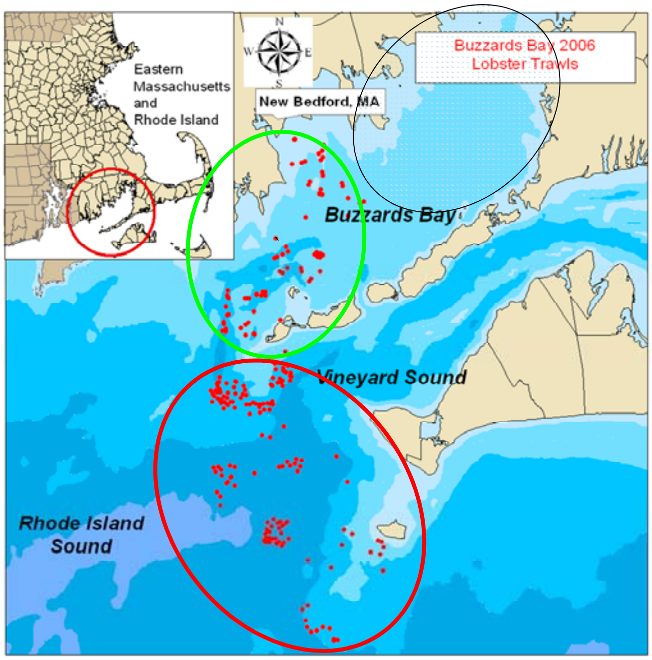
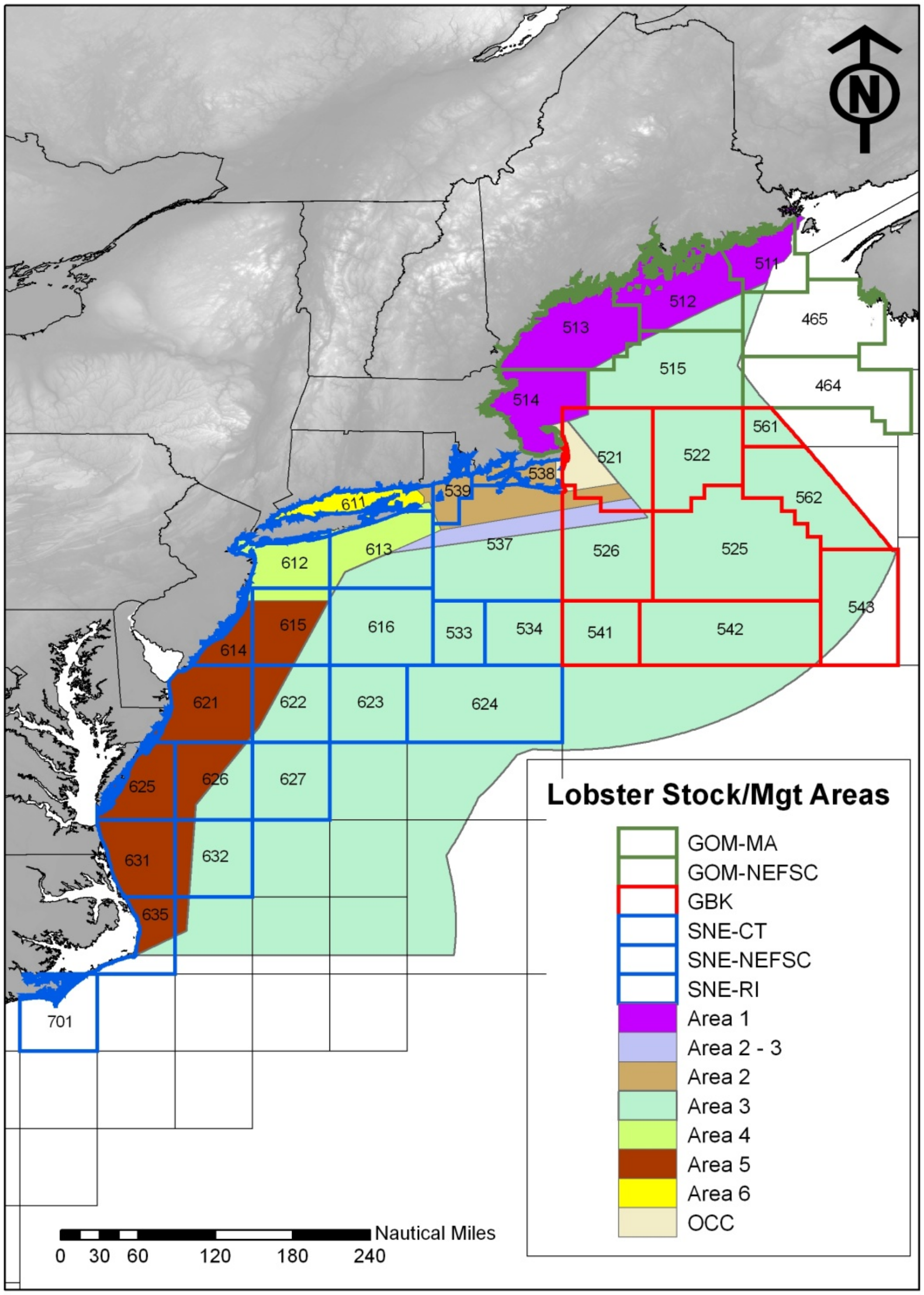
Vineyard Sound
Rhode Island Sound


Eastern
Massachusetts
and
Rhode Island
New Bedford, MA
Buzzards Bay 2006
Lobster Trawls
Buzzards Bay
Vineyard Sound
Rhode Island
Sound

Appendix C
National Marine Fisheries Service Statistical Area Map



<u>Appendix D</u>

SNE lobster landings (lbs) by NMFS statistical area

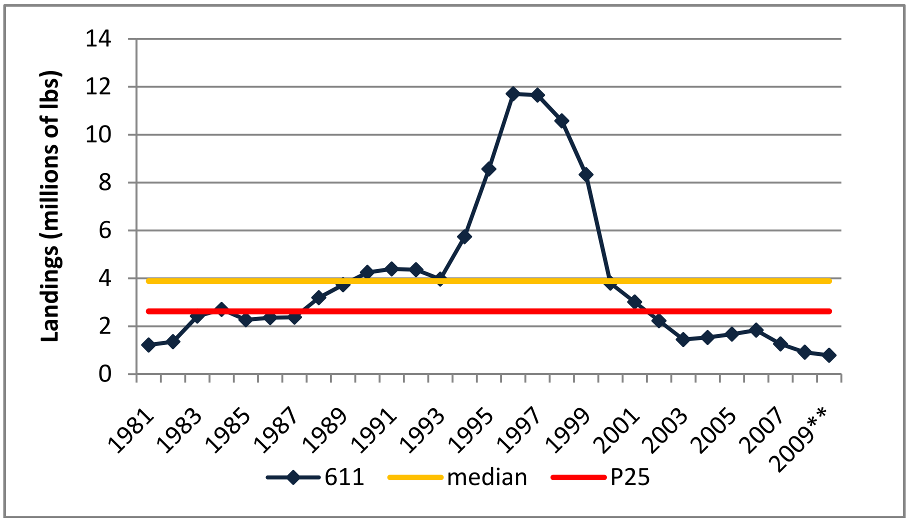


Figure E1. 611 landings (millions of lbs). 2008 & 2009 data preliminary (NY underestimate)

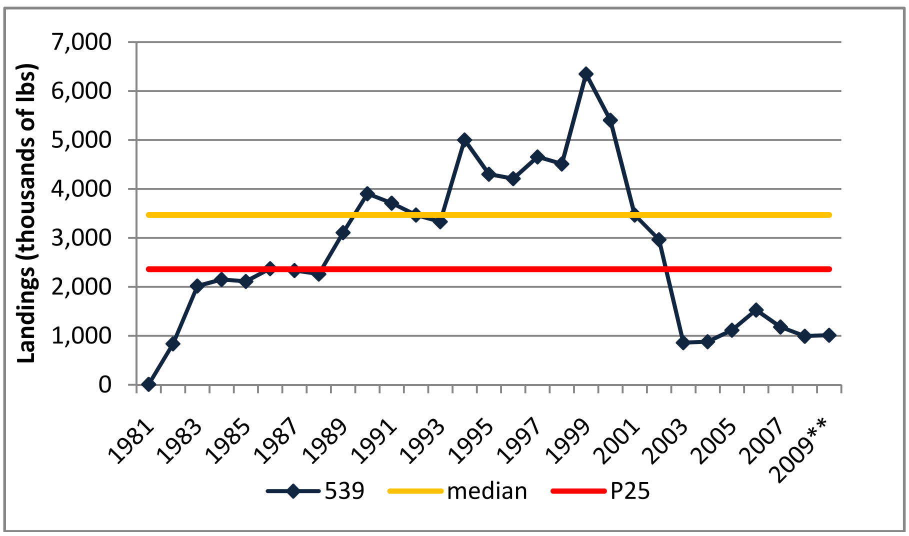


Figure E2. 539 landings (thousands of lbs). 2008 & 2009 data preliminary

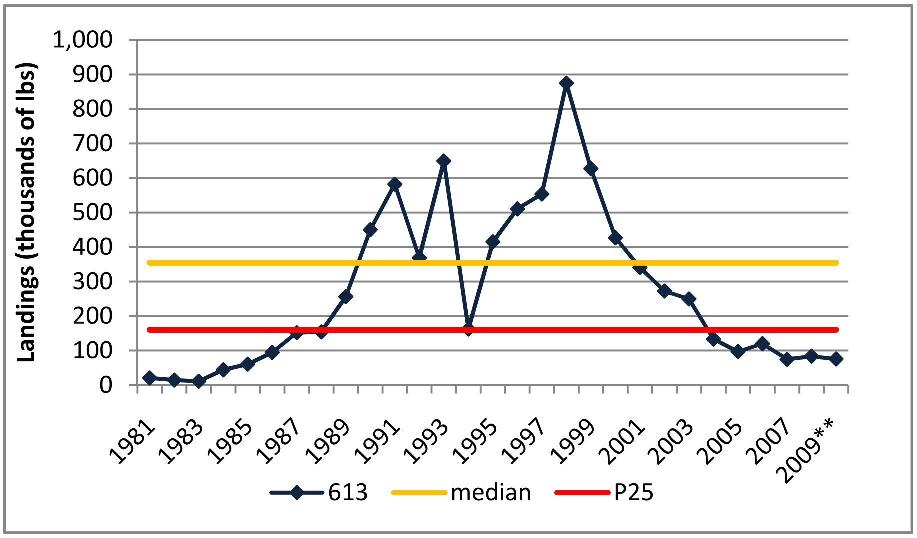


Figure E3. 613 landings (thousands of lbs). 2008 & 2009 data preliminary (2008 & 2009 NJ-south missing, NY underestimate)

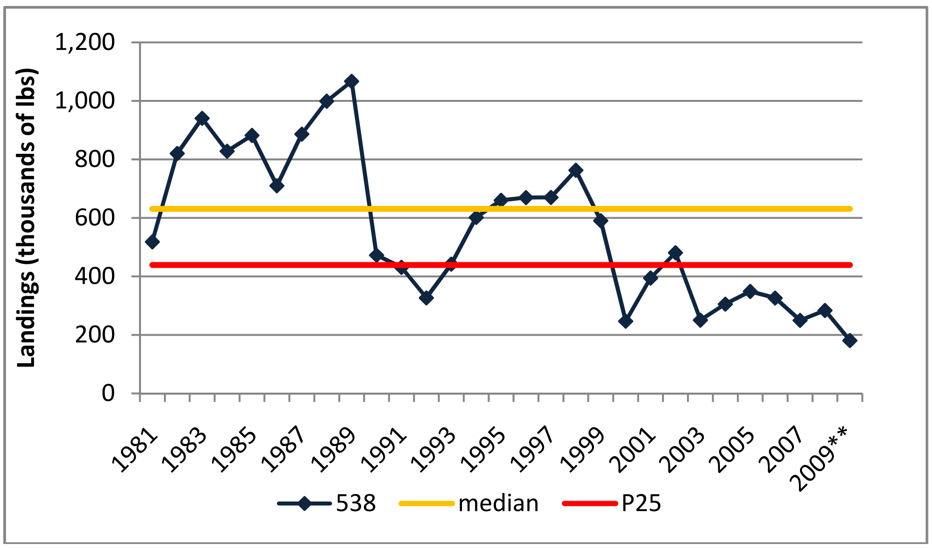


Figure E4. 538 landings (thousands of lbs). 2008 & 2009 data preliminary

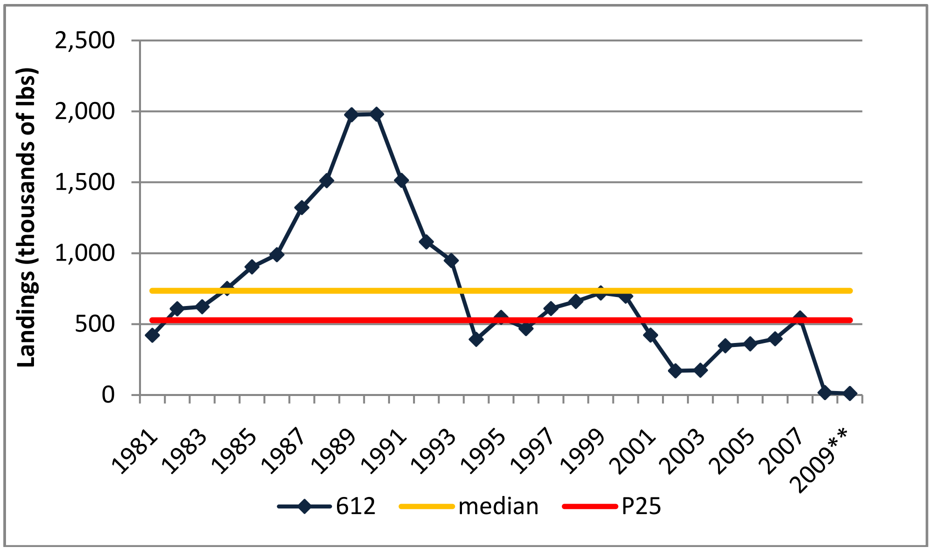


Figure E5. 612 landings (thousands of lbs). 2008 & 2009 data preliminary (2008 & 2009 NJ-south missing, NY underestimate)

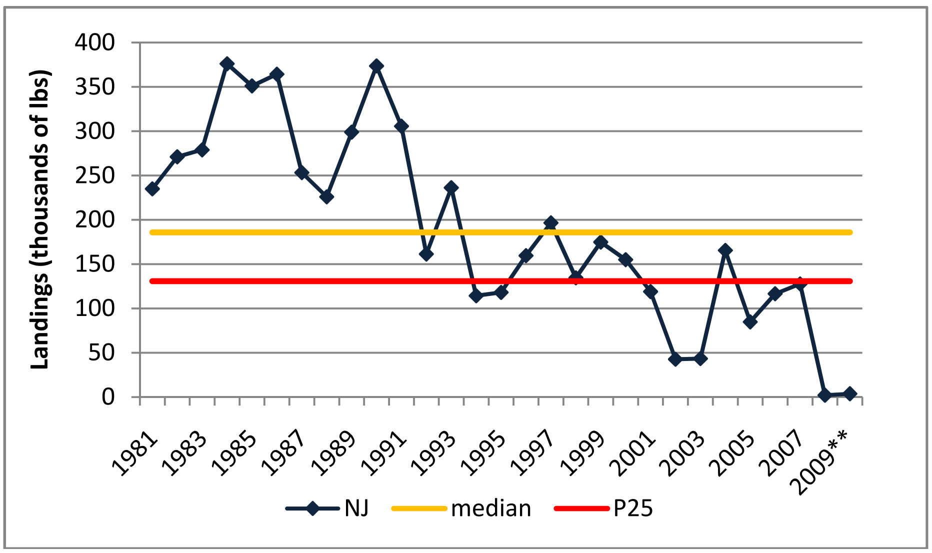


Figure E6. NJ & south landings (thousands of lbs). 2008 & 2009 data preliminary (2008 & 2009 NJ-south missing)

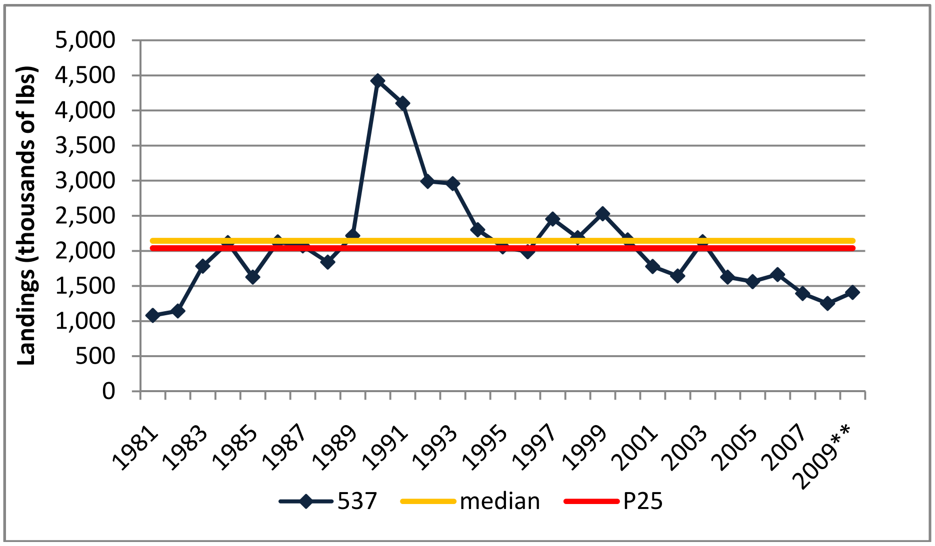


Figure E7. 537 landings (thousands of lbs). 2008 & 2009 data preliminary

Appendix E

Technical Committee Report to the Board in Response to the 2005 Assessment

F10:

- Management measures relevant to achieving F10 may not be meaningful in regards to the new reference points.
- Current measures have contributed to stock status up to 2003. Current can be changed to achieve the goals of the new assessment.
- Because of the poor condition of the SNE stock, the TC recommends that current management strategies remain in place, while the board develops a new strategy based on the results of the 2006 stock assessment.

New Reference Points:

- Proposed reference points cannot be used to compute a quantified rebuilding schedule because they don't have a time step.
- For stocks that need a lot of help, output controls are more effective than input controls. We can't determine effects of input controls such as gauge increases with the new reference points, but we can give advice on output controls such as percent reduction in landings that can be equated to a short-term reduction in fishing mortality.
- The current F generated in the last assessment (2001-2003) can be used to project percentage drops in F for the next few years. As the Length Based Model becomes available for all stock areas, projection scenarios under different management measures will be possible.
- Reducing F through Season closures, Quota, and Area closures
- A suite of measures could be developed that the TC believes would rebuild the stock, then we would continue to evaluate and fine tune the management measures as we go along.

Stock Status by Management Area:

The status of the stocks is clearly pointed out in the 2006 assessment document.

- Area 1 and north Area 3 (GOM) as a whole are ok, though there is concern about Stat area 514.
- Areas 2, 4, 6, 5, and SW portion of Area 3 (SNE) are depleted
- Outer Cape Cod and mid-Area 3 (GBK) are ok.
- Because Area 3 spans the entire coast, its status changes from north to south: East of 70^{o} longitude is ok, West of 70^{o} longitude is depleted

Stock Recommendations:

<u>GOM</u>

Recommend status quo

- The amount of effort in the GOM is a concern, not necessarily for its current impact on F and N but its impact on the fishery.

- The TC recommends that the ASMFC Socio-Economic Subcommittee conduct an economic assessment of the risk to the fishery if abundance were to decline to median levels in the GOM. The Subcommittee should examine whether the industry could respond to a serious drop in abundance without economic hardship.
- Stat Area 514 – Trawl survey indices are at all time low. Recommend more conservative management strategies to rebuild the stock.

There was discussion on the lack of relationship between effort (number of traps) and F. Work in GOM at Monhegan Island has shown that the cumulative catch were similar in areas with 500 and 150 traps, suggesting the ability to compensate for catch even with significant reductions in traps. There is some concern that if the fishery is more efficient, lobstermen can continue to harvest even when abundance is very low. Conversely, a large amount of gear will not increase harvest proportionally. It will only make the fishery inefficient. There were other comments that the Monhegan Island study may not be applicable to all areas or all stock densities. Decreasing trap numbers could, in some cases, decrease the area that can be fished. Data from these trap reduction studies are instructive and should be provided to Economic Subcommittee for their analyses.

GBK

Recommend status quo

- As with the GOM stock, increases in effort in GBK are a concern. There is also concern about the shifting of effort from the SNE canyons to GBK (Area 2-3 overlap to Area 3) due to the depleted stock status in SNE (serial depletion).
- The TC recommends that the board consider limiting movement across a line drawn at 70^{o} longitude and 42^{o} 30’ latitude. To prevent effort shifts from south to north within Area 3.
- The TC also voiced some concern that the newly established allocations for Area 3 may be higher than the original 2000 allocations due to allocation decisions made for Area 2-3 overlap.

Preliminary port sampling in Stat Areas 525 and 562 (GBK) sampled very large lobsters. Bob examined potential effect of a maximum size based on the sampling:
5” max size – 50-60% reduction in catch in weight
6” max size – 20-30% reduction in catch in weight
6.5” max size – 10% reduction in catch in weight

There was discussion pro and con about the usefulness of instituting a maximum size on GBK to protect these big lobsters. Pro –these large lobsters produce many more young than small lobsters if they are protected for their lifetime; they are “proven spawners” that may be genetically and behaviorally superior. As result of low harvest rates or migration, areas with a high proportion of large lobster exist. They could be protected now, not waiting for a recovery in other areas. Con – Fishermen would need to harvest a lot more lobsters in the slot size to compensate for the loss of the large lobsters with the max size; harvest rate may be so high that few lobsters reach maximum size. Maximum gauge size could work if you reduce the F below current levels so the lobsters can grow through the slot limit and reach the maximum gauge size.

SNE

➼ F is at or near median levels but abundance is depleted well below median levels.
Stock rebuilding options:

1. Most effective way to increase N is to have a complete harvest moratorium.

2. Limit harvest by implementing an annual harvest quota lower than current landings.

3. Input Controls - Propose a suite of iterative measures to reach target abundance levels no later than 2015.

10 year rebuilding plan.
Goal: Reach target abundance levels no later than 2015 through a 30 – 40% decrease in F
End point is 3 1/2" minimum length, trap levels 50% lower than 2005 levels, and a 5" maximum length.

Year	Trap Reduction	Min Gauge mm	Min Gauge "	Max Gauge
1 (2006)	5%	84 mm	3 5/16	5"
2 (2007)	5%	85	3 11/32	"
3 (2008)	5%	86	3 3/8	"
4 (2009)	5%	86	3 3/8	"
5 (2010)	5%	87	3 13/32	"
6 (2011)	5%	87	3 7/16	"
7 (2012)	5%	88	3 15/32	"
8 (2013)	5%	88	3 15/32	"
9 (2014)	5%	89	3 1/2	"
10 (2015)	5%	89	3 1/2	"

Monitor and evaluate annually and revise management as needed since there is no direct relationship between reductions in F and increases in N. This schedule could be initially accelerated, followed by a period of years with no change during which stock status could be evaluated. When the target abundance is met, the schedule will be suspended.

Closed season *(this addresses water quality/ lobster health issues):*

August 1 – October 1 Closed Season
The closed season would be instituted during the time period of high water temperatures in Area 6. This is also a time of year when lobsters concentrate in isolated deep cool areas which may make effort more effective or stressed animals more susceptible to disease or death. The closed season by itself would not have a substantial effect on increasing N. If closed season instituted, it should be effective immediately.

Recommendation to Socio-Economic Committee

The TC recommends that the Socio – economic subcommittee examine effects of closed season in relation to elimination of harvest of paper shell lobsters, and an examination of trap reductions in all LCMAs.

Appendix E

Atlantic States Marine Fisheries Commission
1444 Eye Street, N.W., Sixth Floor
Washington, D.C. 20005
(202) 289-6400 phone
(202) 289-6051 fax
www.asmfc.org

MEMORANDUM

July 23, 2009

To: American Lobster Management Board

From: American Lobster Technical Committee

RE: Recommendations for rebuilding

At the May Board meeting the Technical Committee (TC) was tasked to provide the Board guidance on responding to the results of the 2009 lobster stock assessment. The TC suggests the Board adopt the reference points recommended in the stock assessment document rather than those recommended by the peer reviewers because they are more risk averse and reflect conditions experienced by the fishery in the last 25 years. The Southern New England (SNE) stock, currently at historic (1982-2007) low abundance and experiencing relatively low exploitation, will need a rebuilding strategy to attempt to regain its former recruitment productivity. Setting a reference threshold abundance below the current level and exploitation above it, as suggested by the Peer Review, will make these goals almost impossible to accomplish. For the Gulf of Maine stock (GOM), the Assessment reference points increase the probability of maintaining the current high abundance and steady exploitation rate that population has experienced for the last 15-20 years. The Georges Bank (GBK) stock condition is similar, with similar goals of maintaining this fishery as small and productive.

Regardless of the reference points chosen by the board there is an immediate need to address rebuilding in the entire SNE stock area and in portions of the GOM. The following recommendations are based on rebuilding the lobster stock to the assessment document reference points.

Overfishing is not occurring in any of the three lobster stocks. The SNE stock is the only one that is depleted. Current abundance of the SNE stock is the lowest observed since the 1980s and exploitation rates and effort have declined since 2000. Recruitment has remained low in SNE since 1998. Given current low levels of spawning stock biomass and poor recruitment further restrictions are warranted.

In the GOM stock, the assessment showed that Area 514 (the southern most portion of the GOM stock) has continued to experience very high exploitation rates and declines in recruitment and abundance since the last assessment. The TC recommends further restrictions here given the persistence of low recruitment and its negative effect on total abundance and egg production potential (Xue et al. 2008) . Across GOM, effort levels in recent years are the highest observed since 1982 (both in number of traps and soak time) and further increases in effort are not advisable.

As highlighted in the Advisory Report, the TC recommends that data collection be improved; specifically, increase the percent of harvester trip reports and initiate recreational data collection, standards, and requirements as part of state compliance within the Fishery Management Plan (FMP).

For all three lobster stocks it is important to scale the fishery to match the current abundance and environmental conditions. The recommended management actions have the maximum likelihood of rebuilding depleted stocks even if the environment becomes less favorable. Some of the reasons for decline in abundance are external to the fishery (Balcom and Howell, 2006 and Glenn and Pugh, 2006), however reducing harvest removals of mature adults has the highest likelihood of restoring abundance. The goal is to rebuild and maintain all three stocks at or above historic (1982/4 – 2003) median abundance with a healthy stock structure able to sustain itself within the constraints of the existing environment.

Recommendation for Southern New England (Applicable to LMA's 2, 3, 4, 5, and 6)

Changes to existing management strategies are required in order to rebuild the SNE lobster stock by 2022, as required by the FMP. The magnitude of changes that are necessary to potentially see sustained improvements in stock abundance are significant. Using Assessment modeling results and abundance reference point, the SNE stock abundance 'deficit' is 10.7 million adult lobsters, requiring an increase equivalent to 73% of the current stock size of 14.7 million. In order to see an abundance increase of this magnitude, landings should be reduced by at least 50% from the average of the last 3 years.

The TC recommends output controls as the best method to rebuild the SNE stock.

Alternatively, input controls can accomplish rebuilding, but only if latent effort (traps and permits/licenses) are minimized or removed – and actively fished traps are reduced to a level where effort and catch are linear. Input controls are less certain in obtaining catch reductions that may lead to stock rebuilding, an additional measure is needed to work in concert with effort reduction. Several alternatives were discussed by the TC members. Some members support using a substantial (as listed below) seasonal closure while a minority supports a narrow slot limit. Those that do not support the slot are concerned that such a measure could increase discard mortality and will substantially increase the inefficiency of the fishery. Both of these concerns stem from the substantial increase in the discard rate that would result from having a very narrow slot limit. Those that do not support the season closure are concerned about the potential loss of market and the probability of some recoupment by the fishery; possible larger catches in the open season could negate an unknown portion of the gains in protection during the closed season and make the fishery economically less stable. The TC believes the recommended input and output controls may have substantial socio-economic and law enforcement effects, and suggests that the Socio-Economic and law enforcement Committees investigate effects of these controls to provide guidance to the Board.

The controls listed below should apply universally to all gear types, both commercial and recreational.

Output Controls:

1. Harvest Moratorium: this measure will eliminate fishing mortality directly and facilitate the fastest rebuilding.
    a. There are concerns that the inshore fishing effort may be displaced into federal waters. Biological and economic problems may occur.
2. Quota/landings reduction (e.g. TACs, ITQs): Quota can directly control total harvest and fishing effort. Quota can promote efficiency within the fishery without the need of direct effort controls. A quota would be the most effective way to reduce harvest of lobster in the Southern New England stock.
    a. There are concerns that under-reporting, no reporting, or mis-reporting will occur under a quota management system due to the large number of points of sale.
    b. Quotas should be designed to minimize discard mortality.

Input controls:

If choosing these measures, the Board will need to implement severe adjustments to current input controls. Minor input controls as adopted in previous years, such as small changes in gauge size or minimal changes in trap numbers, will not be effective in rebuilding the stock. All input controls must be supported by a concurrent reduction in effective effort.

1. Effort reduction
    a. Minimizing/removal of latent effort
    b. Trap reduction
        i. Initially 50% of current reported trap usage.
    c. License reduction

2. Closed Seasons
    a. Summer closure (at minimum June – October) would substantially reduce harvest, while maximizing the reproductive potential of the stock, by allowing lobsters to molt, mate and extrude eggs without being disturbed by the fishery. This seasonal closure would also help minimize discard mortality related to molting and high summer water temperatures. Instituting gear removal during the closed season would facilitate

compliance, eliminate incidental mortality of lobster and other species, and allow for easier collection of abandoned gear.

   b. A closed season could have a positive effect on protected species (marine mammals, sea turtles) efforts by greatly reducing gear entanglements.
   c. Close seasons generally encourage harvest immediately after opening and likely need to be enacted in conjunction with significant effort reductions.
   d. Reduction of gear conflicts among other commercial and recreational activities.

3. Slot limit: biologically could increase the size and productivity of the population. By not harvesting the largest lobster, this measure has the potential to increase abundance at the fastest rate if the existing maximum size is substantially reduced.   Larger multiparous animals can provide periodic waves of larval recruitment which have been shown to have a higher survival rate than larvae produced by first-spawners. This production can better compensate for low adult stock size and reduced juvenile survival. The historic record of larval production in Long Island Sound shows spikes of production every 3-5 years during the two decades prior to the 1999 die-off, with an absence of any strong production from 2000 -2008. Retaining larger animals in the population may restore the historic pattern. In SNE the maximum size would have to be reduced from 5 ¼" (133mm) CL to within one molt-size of the minimum size of 3 3/8" (86mm) CL (e.g. 3 ¾" (95mm) CL) to be immediately effective.
   a. There is concern that the discard mortality may be unacceptably high.
   b. There is also great concern that there would be a substantial decrease in the efficiency of the SNE fishery, whereby the fleet would have to expend substantial effort (trap hauls) and resources (bait and fuel) to catch substantially fewer lobsters.
4. Closed Areas
   a. Could be effective if large concentrations of spawning adults were protected from fishing and incidental mortality.
   b. Must be large enough to minimize migration out of closed area

<u>Recommendation for GOM/Area 514 Stock</u>

The TC is concerned with a ~15 year decline in abundance to time series low, a loss of local spawning stock biomass, and decreasing catch rates coupled with increasing soak times. The TC recommends attempting to rebuild productivity in this area by increasing the gauge to 3 3/8 inches (86mm) and reducing the effort by 50% by removal of half of all active traps in Stat Area 514. Anyone fishing in 514 should abide by these regulations. Not only will this improve stock health, it will also promote economic efficiency in the fishery. These actions address the harvest of immature females in 514 (12% of females are mature at the current minimum length of 82.6mm or 3 ¼”) which may be undermining stock production.

GBK

TC warns against any increases in effort or shifts in effort from other stock areas.

Citations

Balcom, N. and P. Howell, 2006. Responding to a resource disaster: American lobsters in Long Island Sound, Sea Grant Project Final Report CTSG-06-02, 22p.

Glenn, R. and T. Pugh, 2006. Epizootic shell disease in American lobster (Homarus americanus) in Massachusetts coastal waters: interactions of temperature, maturity, and intermolt duration. J Crustacean Biol 26(4):639-645.

Xue, H., L. Incze, D. Xu, N. Wolff, and N. Pettigrew. 2008. Connectivity of lobster populations
in the coastal Gulf of Maine. Part I: Circulation and larval transport potential. Ecological Modelling **210**:193-211.