6.0 APPLICABLE LAW

6.1 Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) – Consistency with National Standards

6.1.1 National Standard 1 – Optimum Yield

> *"Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the OY from each fishery for the U.S. fishing industry."*

Scallops

The management measures in the proposed action are designed to optimize yield from the scallop resource within the groundfish closed areas, while preventing overfishing. The Council is using a 40 percent dredge efficiency estimate to determine the TACs at a level that is consistent with F_{max}, a proxy for F_{MSY} according to Amendment 7. The dredge efficiency estimates and models were reviewed by the Stock Assessment Review Committee and the Council's Scientific and Statistics Committee, both deeming this estimate to be the best available science. Both committees concluded that the dredge efficiency could vary according to bottom type, environmental conditions, and scallop abundance. Since the dredge efficiency estimates were calculated on the basis of samples taken during 1998 in Closed Area II, there is more uncertainty for this assumption in Nantucket Lightship Area and in Closed Area I. Comparison of the commercial dredge experiment and photographic survey data, however, shows the two sources of data agree with a dredge efficiency of at least 40 percent.

In fact, a primary objective of the proposed action is to move fishing effort from areas with small scallops to areas with large scallops. To the extent that this action reduces fishing mortality on small scallops, the delayed fishing effort will enhance rebuilding by allowing greater survival of the fast-growing, small scallops. The change shift in fishing effort could result, at least temporarily, in a different overall exploitation pattern for the Georges Bank stock. This would increase the biological reference point (F_{max}), relieving overfishing for the Georges Bank scallop stock and increasing maximum sustainable yield. The analysis of the overfishing definition discusses this effect at length in Amendment 7 (NEFMC 1998).

At the same time, the proposed action is a step toward allowing the Scallop FMP to achieve optimum yield. Once scallops have grown to the sizes seen in many, but not all areas of the groundfish closed areas, the main effect of an area closure is to make that resource unavailable to the fishery. This eventually reduces yield as natural mortality removes a greater portion of the biomass increase caused by growth. As the resource within a closed area approaches its carry capacity, the productivity (as measured by surplus production) slows down, unless the individuals in the population (in this case scallops) emigrate from the closed area or contribute to reproduction in other areas. Although scallop biomass within the groundfish closed areas are probably a long way from the carrying capacity, the limited fishery proposed by this action lets the fishery harvest the large scallops, while letting the more productive (in terms of growth rate) scallops continue growing.

Multispecies

The target yellowtail flounder TAC and the provision to suspend the closed area scallop fishery if the catch exceeds this target is consistent with Amendment 7 to the Multispecies FMP and the existing rebuilding program. The 725 and 50 mt TAC is the difference in catch between the Amendment 7 target, $F_{0.1}$, and the expected catch by multispecies vessels during 1998. The proposed action will not, therefore, cause overfishing of Georges Bank or Southern New England yellowtail flounder (primary multispecies stocks) or jeopardize the rebuilding program established by Amendment 7.

Other regulated multispecies, especially winter and windowpane flounders, will also be impacted by the proposed closed area scallop fishery, but a rebuilding program has yet to be established for these stocks. SAW 28 (NEFSC 1999) concluded that Georges Bank winter flounder was overexploited and at a low level of biomass. Like yellowtail flounder, the closed area fishery could increase mortality on this stock, but might also benefit from reduced scallop fishing effort on other portions of Georges Bank. If the closed area fishery is suspended early from exceeding the yellowtail flounder TAC, the catch of Georges Bank winter flounder would likewise be kept to a minimum. There is a potential, however, that industry efforts to avoid catching yellowtail flounder might increase the catch of Georges Bank winter flounder, since the distribution of these species within Closed Area II differs. The status of windowpane flounder was assessed during SAW 30, reported in August 1999. Windowpane flounder biomass is near the target level and 1999 fishing mortality is also near the overfishing definition target.

Monkfish

Monkfish are widely distributed and bycatch on scallop vessels is high in many other areas. Projections (Section 6.2.6.1.10) however indicate that there could be a net increase in monkfish catches as a result of the closed area fishery. Since monkfish are overfished and will be in a rebuilding program (with the implementation of the Monkfish FMP), the increased catch could require complementary action under the Monkfish FMP. The basis for these projections of catch in the existing open scallop areas is weak and the effect of the expected effort shift into portions of the groundfish closed areas is very uncertain. Seasonal effects also could not be taken into account and could change the estimate.

6.1.2 National Standard 2 – Scientific Information

"Conservation and management measures shall be based upon the best scientific information available."

All available information and detailed studies of the 1998 and 1999 experimental fishery were used to assess the impacts of various management alternatives and options. This information includes the latest data on day-at-sea use, vessel trip reports, landings, sea sampling observations, and an intensively-sampled experimental fishery that was conducted within Closed Area II during 1998 and with Nantucket Lightship Area and Closed Area I during 1999. In addition to these data, the biomass estimates from a photographic survey conducted by the Center for Marine Science and Technology was included in the analyses to estimate the TACs for Nantucket Lightship Area and Closed Area I. Projections of the effects of various options on biomass and fishing mortality were based on the 1998 research survey. At the time that this document was developed, the 1999 Albatross research survey had just been completed and the data from that survey were not yet available for analysis.

6.1.3 National Standard 3 – Management Units

"To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination."

While the Council chose a TAC that it expects will provide maximum sustainable yield from the scallop resource within the groundfish closed areas, it did this with the knowledge that the action could reduce fishing effort in other areas where large scallops are not as abundant. Due to the anticipated effort shifts from areas that are now open to scallops and, the overall effect will be to reduce fishing mortality or at least be conservation neutral on the stock as a whole. The action takes advantage of the opportunity afforded by the rebuilt resource in the groundfish closed areas to manage the entire stock.

6.1.4 National Standard 4 – Allocations

"Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various U.S. fishermen, such allocation shall be:

- *Fair and equitable to all such fishermen*
- *Reasonably calculated to promote conservation*
- *Carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges."*

All vessels with a limited access scallop permit are eligible to fish in the closed area fishery, regardless of where they customarily fish or land their scallops. Due to proximity to the fishing grounds, there is some advantage to vessels in New England from lower costs to travel to and from port. All vessels, however, are limited to fishing in buffer zones or in the accessible portions of the groundfish closed areas.

Many distant vessels are likely to take back-to-back closed area trips to reduce costs. The first trip, in this case, will depart from a Mid-Atlantic port (where supplies would be purchased locally) and return to a New England port to unload after fishing. The second trip would depart from New England and return to a Mid-Atlantic port to unload scallops. During the last dominant year class of scallops on Georges Bank, this was a common strategy for vessels from Mid-Atlantic states.

6.1.5 National Standard 5 – Efficiency

"Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose."

This framework adjustment, allowing access to the groundfish closed areas by scallop vessels, proposes no sector allocations or limited access beyond the ones established by Amendment 4 to the Atlantic Sea Scallop FMP. All vessels with a limited access scallop permit are eligible to participate in the closed area fishery and all vessels except ones with occasional scallop permits will receive the same

opportunity to fish. Occasional vessels will only be able to take one closed area trip, because the automatic accumulation of days would use the vessel's entire annual allocation of days-at-sea.

While vessels that take closed area trips will probably accumulate more days than the actual trip duration, the proposed action avoids the economic waste often associated with a derby fishery. A derby fishery is one that the regulations encourage vessels to harvest the maximum amount of fish or shellfish before access is denied.

The yellowtail flounder TAC and the threat of an early suspension of the closed area fishery could create an incentive to take the initial allocations of closed area trips as early in the season as possible, however. Economic waste, in this situation, could arise because vessels cannot take trips during the most advantageous period when prices are high. For example, if the industry believes that it cannot complete the scallop fishery before the bycatch exceeds the yellowtail flounder TAC, all the vessels that plan to take a closed area trip might take their trips as quickly as possible. This could result in temporary price declines that reduce producer surplus, although the benefits could accrue to different sectors of the economy (as consumer surplus, for example).

6.1.6 National Standard 6 – Variations and Contingencies

"Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches."

The proposed action allows the Regional Administrator to either suspend the fishery because yellowtail flounder bycatch is to high (Section 5.1.5) or to make a mid-season adjustment to allocate more trips (Section 5.1.6.1) and change the scallop possession limit (Section 5.1.9.1). These adjustments address variations and contingencies that might occur during the progression of the proposed closed area fishery. Improved monitoring and reporting mechanisms are proposed that will allow timely in-season adjustment of management measures to respond to changing or unexpected conditions.

The estimated impacts and effects of the various management alternatives and options were based on the 1998 experimental fishery, conducted in Closed Area II and on the 1999 experimental fisheries, conducted in the Nantucket Lightship Area and in Closed Area I. Many factors including seasonality and inter-annual variations could affect the performance of a commercial fishery vs. the expectations derived from last year's experimental fishery. One of the more important assumptions that will be violated by the proposed action is the distribution of fishing effort within the open portion of the groundfish closed areas. Many vessels will target the highest concentrations of scallops and hopefully avoid areas with high bycatch of yellowtail flounder and other species. Other vessels may work in areas that scallops are less abundant to avoid other scallop vessels or gear conflict. It was impossible to predict to what extent vessels will fish in relation to scallop density and how much the average conditions (predicted by the model) would differ from actual results. Data is being collected during 1999 in Closed Area II to predict fishing behavior with regard to scallop abundance, scallop meat weight, and bycatch levels. At the time that this analysis was completed, this data was still being collected and not available for analysis. The proposed action, therefore, allows for responding to these uncertainties and changing conditions.

6.1.7 National Standard 7 – Costs and Benefits

"Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication."

Monitoring and reporting procedures use existing systems and technology to minimize the administrative burden on the government and on individuals. The minimum amount of reporting is required to ensure the fishery does not exceed the management targets and to enhance compliance. No duplicative reporting is required unless it is absolutely required to provide real-time monitoring of the fishery. Real-time monitoring will allow rapid response to contingencies that arise during the progress of the fishery.

6.1.8 National Standard 8 – Communities

"Conservation and management measures shall, consistent with the conservation requirements of the Magnuson-Stevens Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to:

- *Provide for the sustained participation of such communities; and*
- *To the extent practicable, minimize adverse economic impacts on such communities."*

Producer surplus will increase by $19 million for the proposed action compared to status quo (i.e. not allowing a closed area scallop fishery). These benefits will accrue to the vessel owners, the crew, and the communities that depend on them and their business. This action will enhance profitability of the scallop fleet, creating jobs (although there are existing limits on direct employment), and continuing to sustain communities with scallop vessels.

On the other hand, there may be some collateral impacts on communities that rely on groundfish landings, especially species that inhabit Georges Bank. The proposed action limits these negative impacts on communities that are depending on groundfish landings by capping the yellowtail flounder catch (Section 5.1.4), requiring scallop vessels to use a more-selective large mesh twine top (Section 5.1.8.2), and establishing incentives for the industry to adopt fishing methods that will reduce groundfish bycatch. A discussion of impacts from the perspective of both the scallop and groundfish fisheries is given in Section 6.2.6.1.8.

6.1.9 National Standard 9 – Bycatch

"Conservation and management measures shall, to the extent practicable:

- *Minimize bycatch; and*
- *To the extent bycatch cannot be avoided, minimize the mortality of such bycatch."*

The proposed action raises the possession limit for regulated multispecies, without increasing the incentive to target these overfished stocks after the vessel had caught its scallop possession limit. If the fleet takes all of the allocated trips, the action could significantly reduce discards, since it is expected that nearly all trips will catch more than the multispecies possession limit. Monkfish possession limits, regulated by the Monkfish FMP, appear to be sufficient to prevent discarding in most cases.

The management approach adopted by the Council will also minimize scallop discarding, compared with other forms of potential management. Compared to Alternative 2 that the Council considered for Framework Adjustment 11, the fixed day-at-sea tradeoff allowed a greater opportunity for fishermen to alter fishing behavior and avoid bycatch. Judging from the observer program data from Closed Area II during 1999, this appears to have worked very well. As opposed to other management alternatives, the proposed action allows vessels to slow down and carefully process the species that come on deck. Since the vessels will be able to catch the scallop possession limit in less than 10 days-at-sea, some vessels may take different approaches to avoid or reduce bycatch even though it might take more time to actually fish. On closed area trips, vessels will automatically accumulate a fixed number days-at-sea regardless of how short the trip is, eliminating the incentive to catch scallops as quickly as possible no matter how much bycatch the vessel encounters.

Although the proposed action has a scallop possession limit, there is no reason that vessels need to deck load or discard scallops. Highgrading is not expected to be a problem since the price differential between large and small scallops is not great enough to be an incentive to highgrade. Crews that shuck scallops often discard small scallops that are uneconomic to process in favor of larger scallops, but this is usually done within a short time period and scallop survival is thought to be high. Due to the low possession limits for other species, it is also unlikely that the vessels would continue scallop fishing after having caught and processed the scallop possession limit.

6.1.10 National Standard 10 – Safety of Life at Sea

> *"Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea."*

The proposed action spreads the expected fishing activity out in time and space, so as to avoid some of the problems that might compromise safety. The maximum amount of area is proposed to be open to scallop fishing within the Nantucket Lightship Area, Closed Area I, and Closed Area II, without increasing the potential impacts on habitat to unacceptable levels. These area options could reduce the potential for crowding and gear conflict, giving the vessel operator more flexibility to fish in the safest areas. The proposed scallop possession limits (Table 15) are commonly caught on many scallop vessels (albeit on longer trips) and can be safely stored onboard the vessel. One last factor that improves safety is that the closed area trips are expected to be shorter than usual. Compared to taking longer trips to catch the same amount of scallops in the existing open scallop areas, the proposed action places the vessel at-sea for shorter periods and reduces the risk of facing inclement weather and other at-sea hazards.

Other alternatives propose to allow a fishery in more restrictive areas, possibly causing crowding and other problems. Other ways that have been proposed to manage the fishery also could set up incentives to fish or travel as quickly as possible, under any weather condition, to reduce the amount of days the vessel accumulates on a closed area trip. Lastly, other forms of counting days-at-sea might cause vessels to deck load scallops to potentially unsafe levels.

6.2 National Environmental Policy Act (NEPA) – Environmental Assessment

The proposed action is not significant for the purposes of preparing an Environmental Impact Statement (EIS). The most recent EIS documents for the Multispecies FMP and the Atlantic Sea Scallop FMP adequately describe the fishery, the resource, the biological, and the human environment. The proposed action in this Framework Adjustment does not change the goals, objectives, or rebuilding plans

for either multispecies or sea scallops and the scope of this framework adjustment only includes the 1999 fishing year for sea scallops. This Environmental Assessment (EA) estimates and describes the potential impacts of the proposed action in the context of the existing management measures for multispecies and sea scallops.

6.2.1 Purpose and Need for the Proposed Action

The purpose and need for the proposed Framework Adjustment is described in Section 3.0.

6.2.2 Description of the Proposed and Alternative Actions

The description and rationale for the proposed measures is described in Section 3.0.

6.2.3 Description of the Physical Environment

The physical environment is described in the EIS for Amendment 9 to the Northeast Multispecies FMP and Amendment 7 to the Atlantic Sea Scallop FMP.

6.2.4 Description of the Biological Environment

The biological environment is described in the EIS for Amendment 9 to the Northeast Multispecies FMP and Amendment 7 to the Atlantic Sea Scallop FMP.

6.2.5 Description of the Human Environment

The human environment is described in the EIS for Amendment 9 to the Northeast Multispecies FMP and Amendment 7 to the Atlantic Sea Scallop FMP.

6.2.6 Impacts of the Proposed Action

If the groundfish closed areas are re-opened to scallop fishing in a way that effectively shifts the majority of actual (i.e., unused DAS) fishing effort away from the open areas, it could be an effective first step at rebuilding the scallop resource in the Great Sought Channel, the New York Bight and the Delmarva regions when it is coupled with the existing and planned effort reduction in Amendment 7. Closing areas on Georges Bank and the Mid-Atlantic to scalloping has concentrated the fishing effort into smaller areas, depleting the available resources more than if the closed areas had been left open. Re-opening the groundfish closed areas to scallop fishing would be a first step to reversing this trend and allowing the day-at-sea reduction schedule to have its full effect.

Selective closing of areas to scallop fishing is not without its benefits, however, especially if areas are closed at times when smaller scallops predominate. Closed areas could effectively impose a delayed exploitation pattern, taking advantage of the rapid growth rate of younger scallops, and significantly improving yield. This strategy will be the core issue for the next plan amendment.

Although the 1998 experimental scallop fishery in Closed Area II and the 1999 experimental fisheries in the Nantucket Lightship Area and Closed Area I provide highly-detailed information about the scallop resource and related bycatch, the commercial vessel tows were generally limited to 10 minutes. As a result, the experimental fishery data provided little direct evidence about how a commercial scallop

fishery will operate in the closed areas in 1999. The catches were not restrained by shucking capacity because the tow duration and gear handling differed so markedly from what is likely to occur under normal commercial operations. There were also no data to indicate how various management restrictions would influence how, where, and how long the vessels would fish in the re-opened closed areas.

Enough information was however available to make some statistical inferences and develop a fishery model, especially when combined with the annual research survey data and ancilary informaion from the industry about how long it takes to handle the gear, maximum tow duration, and how the vessels would respond to the different resource conditions within the closed areas. Another important piece of information came from Kirkley et. al. (1991) who measured the shucking capacity for vessels using seven to nine-man crews. The shucking capacity (in pounds) varied as a function of scallop size (i.e. meat count).

The information from these various sources were combined into a model that could estimate total fishing effort, scallop catch, and bycatch amounts for a variety of potential management options under consideration in Framework Adjustment 11/29. The results give an indication of the net change in fishing effort (measured in fishing time and days-at-sea) and whether the estimated catches will exceed the TACs for scallops and various bycatch species. The methods that describe this model are given in Section 8.1.1.4 in Framework Adjustment 11 (NEFMC 1999a).

6.2.6.1 Biological Impacts of closed area access options

6.2.6.1.1 General conclusions

Access to closed areas has the potential to increase total yield about 17 percent, while preventing increases in scallop fishing mortality. All the options presented here are conservation-neutral and decrease total dredge bottom time, inside and outside the closed areas. Since the proposed access allows the scallop fleet to harvest large scallops in the closed areas, it would reduce mortality on smaller scallops in the open areas and contribute to rebuilding biomass by increasing survival of rapidly-growing small scallops.

The alternatives for allowing scallop fishing within portions of the groundfish closed areas is a continuation of the highly successful program in Closed Area II and a possible expansion of the program to portions of Nantucket Lightship Area and Closed Area I. Continuing the management policy adopted under Framework Adjustment 11, the TAC is determined as the amount of harvest that is consistent with a maximum sustainable yield identified for the entire resource, applied to the projected standing biomass in each closed area. The former policy also required a day-at-sea tradeoff that is calculated to produce a conservation-neutral policy, with respect to scallop fishing mortality.

Exploitable scallop biomass in the three closed areas was estimated to be 28.5, 36.5, and 33.4 million lbs. for Nantucket Lightship Area, Closed Area I, and Closed Area II, respectively, assuming a 40 percent dredge efficiency. Twenty percent of this biomass gives a combined TAC of 19.1 million lbs., after deducting a one-percent set-aside to fund scallop research (**Table 20**).

The amount of allowable trips in each area, assuming that all trips land the scallop trip limit, ranges from zero to four trips per vessel (Table 21). Summed across all areas, the allowable allocation of trips to fish in the closed areas ranges from three trips with an 18,000 lb. scallop trip limit to eight trips with an 8,000 lb. trip limit.

These trip limits and allocations were analyzed over a range of day-at-sea tradeoffs to determine the minimum day-at-sea choice that produced a conservation-neutral result. These day-at-sea tradeoffs ranged from 7 – 10 days with an 8,000 lb. trip limit to 18 – 21 days with an 18,000 lb. trip limit (Table 31), approximately one day-at-sea for each 1,000 lbs. landed.

The proposed alternatives for access to the groundfish closed areas on Georges Bank were chosen by time and area to minimize bycatch, minimize habitat impacts, and to avoid gear conflict. Although a quantitative analysis of impacts for these factors is not possible with current information, there is sufficient information in Sections 6.2.6.1.8 and in Appendix II to subjectively assess these impacts.

The effects on habitat and bycatch can be assessed, however, in terms of fishing time. The proposed alternatives and trip limit options are expected to reduce dredge bottom time by 17 to 28 percent (Table 31). The lowest trip limit option appears to reduce dredge bottom time the most, because more days-at-sea are consumed by steaming to and from port, rather than by fishing.

The yellowtail flounder TACs, recommended in this document are based on the revised TAC recommendations by the Multispecies Monitoring Committee and on the historic proportion of landings of yellowtail flounder by vessels using dredges. Based on this analysis, the recommended TAC for yellowtail flounder by vessels fishing for scallops in the groundfish closed areas are 725 mt for Closed Area I and Closed Area II, combined and 50 mt for Nantucket Lightship Area. The former TAC is for the Georges Bank yellowtail flounder stock[28] and the latter TAC is for the Southern New England yellowtail flounder stock.

Yellowtail flounder catches have been estimated from the bycatch rates observed in the Closed Area II fishery and in the experimental fisheries in Nantucket Lightship Area and in Closed Area I. The net effects from the effort shifts cannot be quantified, however, because the catch rates and distribution of fishing effort with regard to the distribution of yellowtail flounder on Georges Bank and in Southern New England is unknown.

Based on these data and the Framework Adjustment 11 model for estimating the effort shifts and conservation-neutral day-at-sea tradeoffs, indicate that the lowest yellowtail flounder catches occur for the 15,000 lb. scallop trip limit option, followed by the 8,000 lb. option. These differences are relatively small however, ranging from 602 to 707 mt. The predicted bycatch for other species show similar patterns over the range of options in this framework adjustment.

6.2.6.1.2 Sources of data

Three types of surveys are available to measure current biomass and estimate the total 2000 biomass in the three groundfish closed areas: the annual research survey, a new photographic survey conducted in portions of Closed Area I and the Nantucket Lightship Area, and a systematic experimental commercial vessels surveys conducted throughout Closed Area I and the Nantucket Lightship Area during July and August 1999. Statistics for the estimated biomass and adjustments to account for biomass throughout the three areas is given in Table 23, and described in the following sections. All estimates from dredge surveys assumed a 40 percent dredge efficiency, consistent with the best scientific information. The gear efficiency for the photographic survey was assumed to be 100% for scallops that were large enough to be visible. Researchers at CMAST believed that scallops smaller than commercial sizes were observable.

[28] A small proportion of catches within Closed Area I are assigned to the Cape Cod and Southern New England yellowtail flounder stocks, based on previous tagging studies.

For the Nantucket Lightship Area, each data source gave comparable biomass estimates and the mean of the three was accepted to set the scallop TAC. The Albatros (annual research) survey in Closed Area I was sensitive to four anomalously large tows and gave a biomass estimate that was much higher than the other sources of data. This data was therefore omitted when estimating the scallop TAC. The size distribution for scallops in Closed Area I was only available from the research survey, so it was used to estimate the change in biomass during 1999 with no fishing mortality. The experimental fishery during 1998 in Closed Area II was comparable to the annual research survey data. Assuming that 3,678 mt of scallops would be removed from the portions south of 41°30', the estimated fishing mortality was 0.6 and the total biomass throughout Closed Area II at the end of 1999 will be 26.2 million lbs.

6.2.6.1.3 CMAST photographic survey

The Center for Marine and Science Technology (CMAST) conducted a video quadrat survey of discrete portions of the scallop population within closed Areas of Georges Bank. This survey provides:

- an independent estimates of absolute scallop abundance and size structure
- scallop spatial distribution on the scale of kilometers, meters and centimeters
- information on the associated benthos community including species composition of flora and fauna and percent coverage in fished and unfished areas
- sediment composition

These data are critical for managing and enhancing the scallop resource in the New England coastal states. Absolute estimates of scallop abundance and size structure are the primary factors required to determine yearly allowable catch. Small scale spatial distribution combined with abundance may dictate fertilization success which is the first component in determining if closed areas are a source of larvae to other areas. The succession of the benthic community may be the key factor in nursery areas for juvenile groundfish yet little is known of the community structure on different substrates of Georges Bank and the effects fishing has on this community.

This survey provided a series of quadrat samples, deployed within a statistically rigorous multistage survey design, to address these objectives.

Study site:

Presently, CMAST have surveyed the scallop aggregations within the Nantucket Lightship Area, Closed Area I, and Closed Area II (Figure 1). Locations were selected based on the fishermen's knowledge of historic scallop bed locations. We assume that we have surveyed the major aggregations of scallops within these areas, however, there may be other areas that also contain scallops.

Methods:

A preliminary survey to test the feasibility and statistical power was conducted from 24 -29 May 1999. This preliminary study examined scallop densities within a small area (16 NM^2) of the Nantucket Lightship Area. Eighteen randomly selected stations were sampled using a small quadrat with ≈ 1 m^2 sampling area. The vessel was anchored on site and the first quadrat was placed below the vessel and then retrieved. Then ≈ 10 m of anchor line was released and the quadrat was placed and retrieved until 20 images of the sea floor had been collected. This study indicated that the survey technique was feasible and

could provide a high degree of statistical precision (mean number of scallops per quadrat = 1.23, SE = 0.41). Analysis indicated that fewer quadrats at each station and more stations within a systematic design would provide the best estimates of scallop density, ≈128 to 800 stations are required for 25% to 10% precision.

Using these preliminary estimates we selected 798 stations using a systematic design within the Nantucket Lightship Area, Closed Area I and Closed Area II (Figure 1). Each station was separated by 0.85 nautical miles (1.57 km). At each station we completed 4 quadrat samples. Once the vessel was on station the pyramid (sample area 2.2 m^2) was deployed. Mounted on the pyramid were a video camera and several lights. Images of the sea floor including scallops and other macroinvertebrates and benthic fishes were relayed in real time to the surface. These images were video taped and the exact position (latitude and longitude from differential GPS) depth, time, and sea-state are recorded. We counted every scallop within our quadrat and those along the edge therefore we increased our quadrat area to 2.36 m^2 to correct for edge bias.

Upon return to the laboratory the video images are being digitized and image analysis techniques are used to determine size structure, verify counts of different benthic species and determine spatial distributions.

CMAST used a multistage sampling design and the following equations are used to determine means and standard error (Cochran 1977 p. 277, Krebs 1989).

The mean of the total sample is:

$$X = \sum_{i=1}^{n} (x_i/n)$$

The standard error (SE) of this mean is:

$$SE(X) = \sqrt{(1-f_1/n)s_1^2 + [f_1(1-f_2)/mn]\, s_2^2}$$

n = primary sample units
m = subsamples of each unit
x_{ij} = measured values for element j in primary unit i
x_i = mean value per element in primary unit i
f_1 = number of primary units sampled/total number of primary units
f_2 = number of elements sampled/total number of elements per units

$$s_1^2 = \sum_{}^{n} (x_i - X)^2/n - 1 = \text{variance among primary unit means}$$

$$s_2^2 = \sum_{}^{n} \sum_{}^{m} [(x_{ij} - x_i)^2/n(m - 1)] = \text{variance among elements within primary units}$$

If sampling fractions are small, the finite population corrections (f_1, f_2) can be omitted and as f_1 is near zero the second term in the SE equations disappears.

To provide a preliminary estimate of biomass within these areas we assumed that the mean shell height was 115 mm. A shell height of 115 mm was observed during the Closed Area II survey in October 1998 and preliminary observations of shell height from the video survey indicate that the majority of

scallops were very large. Based on a length/weight regression (n=123; log w = -4.416 + 2.8189 (log l); r^2 =0.93) also estimated during the October 1998 survey a scallop of 115 mm provides a meat weight of 25 g, therefore it would take 18 scallops to equal 1 lb. The average number of scallops m^{-2} was multiplied by the number of m^2 in a NM^2 (3429904) and by the total area surveyed.

Preliminary Results:

An average scallop density of 0.51 scallops m^{-2} occurred in the 143 NM^2 sample area of the Nantucket lightship area (Table 1). These scallops were highly aggregated into several very dense beds (highest count per quadrat area was 33 individuals) while large areas had low scallop densities. Of all observed scallop 11% were clappers (dead scallops with their hinge still attached). However this mortality was also site specific with 8 stations containing 76% of all the clappers.

An average of 0.33 scallops m^{-2} occurred in the 363 NM^2 sample area of Closed Area I. These scallops were also aggregated but quadrat densities were lower than in the Nantucket Lightship Area (highest count of scallops per quadrat area was 14 individuals). Of all observed scallops in Closed Area I only 1% were clappers.

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Table 16. Preliminary estimates of scallop density and meat weight in the Nantucket Lightship Area and Closed Area I.

	NLSA	CAI
Sample Area NM^2	143	363
n	204	454
m	4	4
Scallops m^{-2}	0.51	0.33
SE	0.08	0.03
Lower 95% C. limits	0.34	0.27
Upper 95% C. limits	0.68	0.39
meat weight lbs (millions)	13.5	22.4
Lower 95% CL	9.3	18.3
Upper 95% CL	17.9	26.4

Conclusions

This study provides an independent precise estimate of absolute scallop density in different areas and estimates of scallop spatial distribution on several scales from kilometers to centimeters. Application of indices of dispersion will allow us to determine distribution patterns and will suggest clump sizes. Further these data will provide size frequencies enabling estimates of recruitment and maturity. Nearest neighbor estimates will be calculated. These data coupled with information from the literature will allow

precise estimates of fertilization success and estimates of reproductive output from different areas of Georges Bank. Scallop natural mortality and variations of intensity of that mortality will be estimated based on clapper distributions. Distributions of scallop predators will also be determined. Data on benthic community structure, substrate type and structure will be collected.

Adjusted to the total area surveyed by the 1999 experimental fishery (Section 6.2.6.1.4), the adjusted biomass for all of Nantucket Lightship Area in 1999 is 15.8 million lbs. (Table 23), or 17 percent higher than the biomass estimated by CMAST above. Another way of saying this is that 85 percent of the estimated biomass is within the area surveyed by the photographic method. Although the photographic survey does not rely on a dredge efficiency parameter, the expanded estimate assumes constant dredge efficiency inside and outside the area surveyed by CMAST. If for some reason, dredge efficiency is lower outside the CMAST survey area than within, the total biomass would be more and vice versa.

The expansion based on experimental survey data of the 1999 biomass estimate for Closed Area I within the area surveyed by CMAST, gave a total biomass estimate of 36.7 million lbs. (Table 23), or 64 percent higher than the biomass within the CMAST survey area. Put another way, the biomass estimate for the CMAST survey area within Closed Area I was estimated to be 61 percent of the total. The same caveats about dredge efficiency apply to Closed Area I, also.