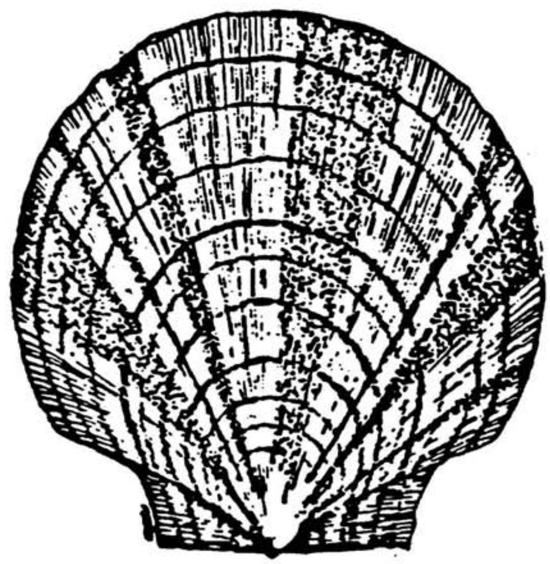
FISHERY MANAGEMENT PLAN

FINAL ENVIRONMENTAL IMPACT STATEMENT

REGULATORY IMPACT REVIEW

FOR

ATLANTIC SEA SCALLOPS (Placopecten magellanicus)



Prepared By

New England Fishery Management Council

In Consultation With

Mid-Atlantic Fishery Management Council

and

South Atlantic Fishery Management Council

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SUMMARY

Introduction

The New England Fishery Management Council and the Assistant Administrator for Fisheries (NOAA) propose to adopt and implement the Final Fishery Management Plan for Atlantic Sea Scallops. The Sea Scallop management program is needed to address resource and management problems which include the variable nature of sea scallop resource abundance, possible excessive levels of fishing effort, and the high potential for overexploitation due to increasing consumer demand. Although there presently is no estimate of absolute abundance of sea scallops, the FMP analyzes abundance indices and recruitment prospects for the Gulf of Maine, Georges Bank/Southern New England and Mid-Atlantic Bight resource areas.

Management Unit

The Management Unit includes all of the populations of sea scallops that occur along the continental shelf of the Northwest Atlantic from the shoreline to the outer boundary of the FCZ and encompasses all commercial and recreational fishing activity affecting those populations. This FMP encourages the adoption of complementary regulations by coastal states to ensure the effectiveness of the management program throughout the management unit.

Objective

The overall objective of the management program is to maximize over time the joint social and economic benefits from the harvesting and use of the sea scallop resource. In support of this overall objective, the Council adopted the following considerations and sub-objectives:

a. Restoration of the adult stocks in terms of their abundances and age distribution can be expected to reduce the year-to-year fluctuations in stock abundance caused by variation in recruitment.

b. Enhancement of the yield per recruit for each stock.

c. Evaluation of the impact of the Plan provisions on reserach, Plan development and enforcement costs.

d. Minimization of adverse environmental impacts on stock levels and utilization.

Alternative Strategies for Management

After considering and rejecting the "no action" alternative, as inappropriate given the identified resource problems, the Council evaluated 4 alternative management strategies capable of achieving the adopted management objectives. In brief, these alternative strategies are as follows:

1) to control total quantity of sea scallops landed (through, e.g., annual or seasonal quotas);

2) to control fishing practices in the sea scallop fishery (through, e.g., gear restrictions, cull size, closed areas and seasons);

3) to control fishing effort in the sea scallop fishery (through, e.g., limiting entry, number of vessels, or fishing time); and

4) to combine two or more of the above strategies.

Preferred Strategy

It is the Council's judgement after extensive public consideration and detailed analysis (Part 6) that controls on fishing effort and controls on the quantity of sea scallops landed are not practical or technically supportable at this time. Given this judgement, the Council has chosen as the "preferred alterative," controls on fishing practices (through minimum meat count and shell size regulations) along with delayed implementation of additional measures which will limit fishing mortality.

In brief, specific long-term conclusions of an analysis relating to the "preferred alternative" are as follows:

1. Although values of the biological parameters for resource components differ (e.g., growth rate, mortality rate), the analysis demonstrates a consistent increase in individual average sea scallop production (yield per recruit) associated with increases in the size at which the average sea scallop is retained by the fishery, and reductions in fishing mortality to the F(max) level.

2. Under prevailing exploitation conditions in the sea scallop fishery, an industry average meat count of 30 or 25 relative to 40 will result in significantly greater harvestable yield from all resource components, no matter what the prospects for recruitment happen to be. Further, as meat count in all resource areas is reduced, the productivity benefit associated with meat count becomes less sensitive to increasing fishing mortality (i.e., the resource is naturally buffered to wide-ranging fluctuations in fishing effort). As a result, control on meat count (or size at first capture) appears to be the most practical and efficient control measure for addressing the yield per recruit aspect of the overall management objective in the current resource and management context.

3. The analysis shows that for sea scallops reproductive tissue mass increases markedly as the size of the animal increases (i.e., meat count decreases), particularly during the early years. This general relationship holds for all sea scallop resource components. Assuming egg production is proportional to gonad weight, then management action to increase age at capture (i.e., decrease meat count), may significantly increase the reproductive potential of newly recruited scallops over their life in the fishery.

Management Measure Specification

Therefore, based on this long-term biological analysis (§710) and on an economic analysis (§720) of alternative specifications of the age-at-first-capture measure, the management program adopts a 40 meat count initially with automatic reduction to 30 meat count after one year, and a corresponding minimum size of 3 1/4" automatically increased to 3 1/2" after one year. The analysis indicates that this target specification of 30 meat count, as a maximum average value, will provide significant long-term benefits in terms of yield-per-recruit and the long-term, overall productivity of the resource. Consequently, the meat count/minimum size measures are expected to make a substantial contribution towards achievement of the management program's overall objective. The program specifies that enforcement of these measures be accomplished through a prohibition against the possession of non-conforming sea scallops up to and including the point of first transaction in the United States. Licensing and reporting requirements are also specified by the program.

Analysis of Impacts

A short-term bio-economic impact analysis of the alternative measure specifications in this FMP was conducted. This analysis provides short-term catch projections, estimated population size structures, and projected scallop populations in specific resource areas in relation to meat count control in the range of 40-25. Utilizing projected catch at size data, weighted average meat counts by resource area were calculated for 1982 and 1983. The highest average meat counts (i.e., smallest average scallop size) are expected to be reflected in the fishery in 1982 on the Northern Edge and Peak (22.1 meats per pound) as a result of recruitment from the relatively strong 1978 year class. These results indicate that the adopted meat counts of initially 40 then 30 included in this management program (reflecting the average in the catch) should not impact sea scallop harvesters who shuck scallops at sea. The calculated estimates reflect the expected average catch situation; depending upon the harvesting strategy pursued by individual fishermen, substantially higher meat counts could result with concentration of effort on beds of newly recruiting scallops.

The specification of the minimum shell height may entail short-term impacts upon some harvesters who do not shuck scallops at sea. For this sector (shell stockers) the expected impact (in terms of percent catch foregone) associated with adoption of a 3.25 inch minimum shell height (corresponding to a 40 meat count) in 1982 and 1983 would be about 3.0% and 2.4% respectively. Higher individual harvester impacts could be expected in areas such as the Northern Edge and Peak where younger age groups are more predominant in the scallop population. The foregone catch impact associated with a 3.5 inch minimum shell height (corresponding to a 30 meat count) would be expected to increase to about 21% in 1982 and about 7% in 1983 for the shell-stocking sector; although, greater individual impacts might again be expected on the Northern Edge and Peak.

Overall, however, and in consideration of the expected contribution to total catch by shell-stocking vessels (16.3%), the adoption of a 40 meat count management measure in 1982, followed by a decrease to 30 meat count after one year, together with their corresponding minimum size specifications for sea scallops landed in the shell, are expected to result in about a half million dollar overall loss to the economy in 1982, and about a 1.5 million dollar overall loss in 1983. These are not considered to represent a significant impact on the overall economy, the overall industry or individual components of the industry.

Management Parameters

OY: Optimum yield is defined as that amount of annual, domestic sea scallop catch that results from implementation of the sea scallop fishery management program.

DAH: Domestic annual harvest is estimated using two independent techniques (§831).

Interpolation Analysis (§330)

1982 = 32,500,000 lbs. (14,730 metric tons)
1983 = 32,700,000 lbs. (14,835 metric tons)

Resource Based Analysis (§712)

1982 = 29,061,000 lbs. (13,182 metric tons)
1983 = 33,984,000 lbs. (15,415 metric tons)

TALFF The total allowable level of foreign fishing is established as zero.

DAP: Domestic annual processing capacity is estimated to be 60,448,000 lbs. (27,420 metric tons) for 1982 and 61,685,000 lbs. (27,980 metric tons) for 1983.

JVP: Based on the estimates of DAP the Council determines that therer should be no opportunity for joint ventures.

Fishery Management Plan
for
Sea Scallops

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PART 1: INTRODUCTION

§110 Overview

The United States has declared management authority over the sea scallop (Placopecten magellanicus) resources that occur in the area designated as the Fisheries Conservation Zone (FCZ). The zone has as its inner boundary the seaward limit of the coastal states and as its outer boundary a line parallel to, and 200 nautical miles from, the baseline from which the territorial sea is measured. This authority became effective on March 1, 1977 pursuant to Public Law 94-265, the Magnuson Fishery Conservation and Management Act (MFCMA or Magnuson Act). Under the FCMA, the United States assumes responsibility for the establishment of management plans and policies, and the enforcement of regulations which implement the provisions of such plans and policies. Fisheries management must be conducted in a manner that will provide the greatest overall benefit to the nation from the harvesting and utilization of those resources.

Pursuant to the MFCMA, the sea scallop resource beyond the territorial seas will be managed according to objectives, policies, and regulations formulated by the New England Fishery Management Council in consultation with the Mid-Atlantic and South Atlantic Fiishery Management Councils and approved by the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce. In the Sea Scallop Fishery Management Plan (FMP) these objectives and policies are translated into management strategies designed to achieve optimum yield (OY) from the fishery. The optimum yield is based on the best available scientific information; it is sensitive to the potential for overfishing and it incorporates considerations of biological, social, economic, and environmental factors in determining the greatest overall benefit from the scallop fishery.

The FMP also establishes the expected domestic annual harvesting (DAH) from the scallop resources under the jurisdiction of the MFCMA, and in relation to optimum yield and the objectives adopted for management of the resource, defines any surplus that may be made available for harvest by foreign vessels (TALFF). Once in place, the FMP becomes the vehicle by which the Department of Commerce regulates the sea scallop fishery within the FCZ.

§120 Problems and Issues

The decision to develop a management plan for the sea scallop (Placopecten magellanicus) fishery resources in the waters off the Northeast coast of the United States arises from three problems:

(1) Historically, landings from Georges Bank and the Mid-Atlantic areas have fluctuated. It is believed that high rates of exploitation may increase these fluctuations in the stocks, and in fact high rates of exploitation have typically preceded sharp declines in abundance.

(2) The ability of these resources to support the current level of effort is questionable. Over the last several years the high abundance of sea scallops in all areas, coupled with increasing market value, have

supported significant increases in fishing effort. In 1978 total removals (U.S. and Canadian) from the overall resource surpassed all historic levels. Data for 1979 and 1980 indicate declines in catch in spite of increases in overall effort.

(3) Over-exploitation is a danger, in light of anticipated increases in demand. Consumer demand may be expected to support high exvessel prices, and thus, maintain an environment which encourages overexploitation.

The best available evidence suggests that harvests in the forseeable future cannot be maintained at the 1978/1979 level due to observed declines in stock abundance in many resource areas. Catch data for 1980 support this conclusion. With significantly falling catch rates, it is uncertain whether current levels of effort can continue to be accomodated. In addition, concerns can be justifiably raised with respect to (1) future benefits which may be derived from the sea scallop fishery, and (2) the impact of effort shifting away from scallops onto other commercially valuable species.

§130 Preliminary Specification of the Management Unit

This management plan addresses the sea scallop resource throughout its range in waters under the jurisdiction of the United States. Thus, all of the populations of sea scallops that occur along the continental shelf of the Northwest Atlantic from the shoreline to the outer boundary of the FCZ are included in the management unit. The sea scallop is principally found from the Northeast Peak of Georges Bank westward to the Great South Channel, and southward along the continental shelf of the Mid-Atlantic. However, commercially important resource components also occur within the territorial waters of the State of Maine, the offshore waters of the Gulf of Maine, and in Cape Cod Bay. The management unit, therefore, includes sea scallops in the territorial waters of the States throughout the range of the sea scallop as well as those found in offshore areas.

Four resource components within the management unit may be generally defined. These consist of (1) eastern Georges Bank, focusing principally on the Northern Edge and Northeast Peak of the Bank, (2) western Georges Bank, focusing principally on the Great South Channel, (3) the western Gulf of Maine, and (4) the Mid-Atlantic Bight as far south as North Carolina. Fishing for sea scallops within state territorial waters is not subject to regulation under this FMP; however, State water resources are included within the Management Unit in recognition of market interactions and the need for complementary state management action. Although there is little biological evidence, particularly concerning reproduction, that could serve as a basis for stock separation within the bounds of the resource described, the major resource components of Georges Bank and the Mid-Atlantic may be treated as independent stocks for analysis purposes based upon their geographic separation, historic trends in recruitment, levels of production, and proximity to user groups. Economic interactions and plan implementation considerations, however, argue strongly for uniformity in the management program.

PART 2: THE SEA SCALLOP RESOURCE

§210 Species and Its Distribution

§211 Introduction

The Atlantic sea scallop, Placopecten magellanicus (Gmelin), is a bivalve mollusc, roughly circular and rather flat, which is valued for the meat contained in the large muscle that holds the two valves of the shell together. Unlike most bivalve molluscs, sea scallops reside and interact with plants and animals that live on the surface of the bottom. They have been reported living on almost all types of bottom, but are most abundant on coarse sand, gravel and rock. Scallops obtain food and oxygen from seawater drawn through the mantle (i.e., body wall which lines the shell) cavity and over the gills where food particles are entrapped in a mucous film. The shell is usually held slightly open, displaying two rows of eyes on each mantle edge that may serve a sensory function.

Sea scallops are mobile animals. They propel themselves by means of an expulsion of water accompanying the rapid closing of the valves. The direction of movement is controlled by muscular activity of the free edges of the mantle. Although individual scallops move about (the younger scallops in particular), concentrations of individuals in an area generally remain fixed. Scallops are distributed over the bottom in patches, and in the more favorable parts of their range are found in dense, local populations, called beds. What governs the formation and the location of scallop beds is not well understood, but the nature of the bottom, the prevailing currents and the particular circumstances that annually govern the reproductive process all probably influence scallop distribution.

§212 Populations Affected by the FMP

Range and Depth

The sea scallop occurs only in the Northwest Atlantic on the continental shelf from the Strait of Belle Isle, 52° 30' N latitude, south to Cape Hatteras, 35° 30' N latitude. It is an animal that prefers cold water; adult scallops will not survive in water much above 68°F (Posgay 1953; Dickie 1955). Thus, the summer average 68°F (20°C) bottom isotherm (constant temperature boundary), that leaves the shore at Cape Hatteras and sweeps northward until it parallels the bottom contours at about 55 fm is considered to mark its southern boundary. Its northern distribution is apparently determined largely by summer temperatures either failing to reach that which induces spawning or prolonging larval development with resulting poor spatfall. North of Cape Cod, sea scallops are frequently found just below the low tide mark, further south they are restricted to the deeper, cooler water. They are rarely found below 110 fathoms.

Principal Areas of Production

Commercial concentrations of sea scallops are usually located at depths between 14 and 55 fathoms. Scallop beds of interest to the domestic sea scallop fishery are found along the Coast of Maine; in offshore Gulf of Maine waters; from Massachusetts Bay to the northeast part of Georges Bank; and along the outer continental shelf of the mid-Atlantic bight. The principal fishing areas are shown in Figure 211. The average annual landings of scallop meats listed in Table 211 identify, in a very general way, the production level of each area.

Commercial quantities of scallops are found in estuaries and embayments along the Maine coast. Populations occur discretely from the Piscataqua River, at the New Hampshire/Maine border, to the St. Croix River. Most commercial concentrations are found from Penobscot Bay eastward, and there is only sporadic commercial fishing in Western Maine. Although a 1974 scallop survey conducted offshore (beyond 3 miles) from Cape Ann, Massachusetts to the Maine-Canadian border in 1974 by the Maine Department of Marine Resources found very little in the way of commercially productive scallop beds, an offshore fishery in the waters north and east of Jeffreys Ledge occurred during the winter months of 1979-1980.

Traditionally, Georges Bank, particularly the northeast part, has produced the largest crops of sea scallops. Scallops occur over most of the Bank between 25-50 fathoms, but are relatively scarce in the central, shallow region. The beds are concentrated in well-defined areas that have been historically productive: the Northern Edge, the Northeast Peak, the Southeast Part and the Great South Channel. The Northern Edge is the biggest and most consistent producer, the Northeast Peak and the South Channel are consistent, but less productive and the Southeast Part is sporadic, but supports occasional large populations.

For the years 1961-1980, about 196,000 MT of sea scallop meats were landed from the Georges Bank grounds. Of this total, about 145,000 MT (74 %) were from the Northern Edge and Peak. About 38,000 MT (19%) were landed from the South Channel and about 13,000 MT (7%) were landed from the Southeast Part.

The Mid-Atlantic area usually supports a lower level sea scallop fishery relative to Georges Bank. Annual average catch from the Mid-Atlantic area (1961-1980) has been less than 40% of the annual average catch on Georges Bank. There are occasional strong year classes in the fishery, such as the 1961 year class which lead to high catches in 1965 and 1966 (8,000-9,000 MT) and the 1972 year class which was fished heavily in 1976-1977 (6,000-8,000 MT). All of the Mid-Atlantic continental shelf, between the 22 fathom and 55 fathom isobaths, is potentially productive for sea scallops, given good spatfall. However, in relation to other areas, the principal sea scallop grounds on Georges Bank, particularly the Northern Edge and Peak, exhibit more consistent levels of recruitment.

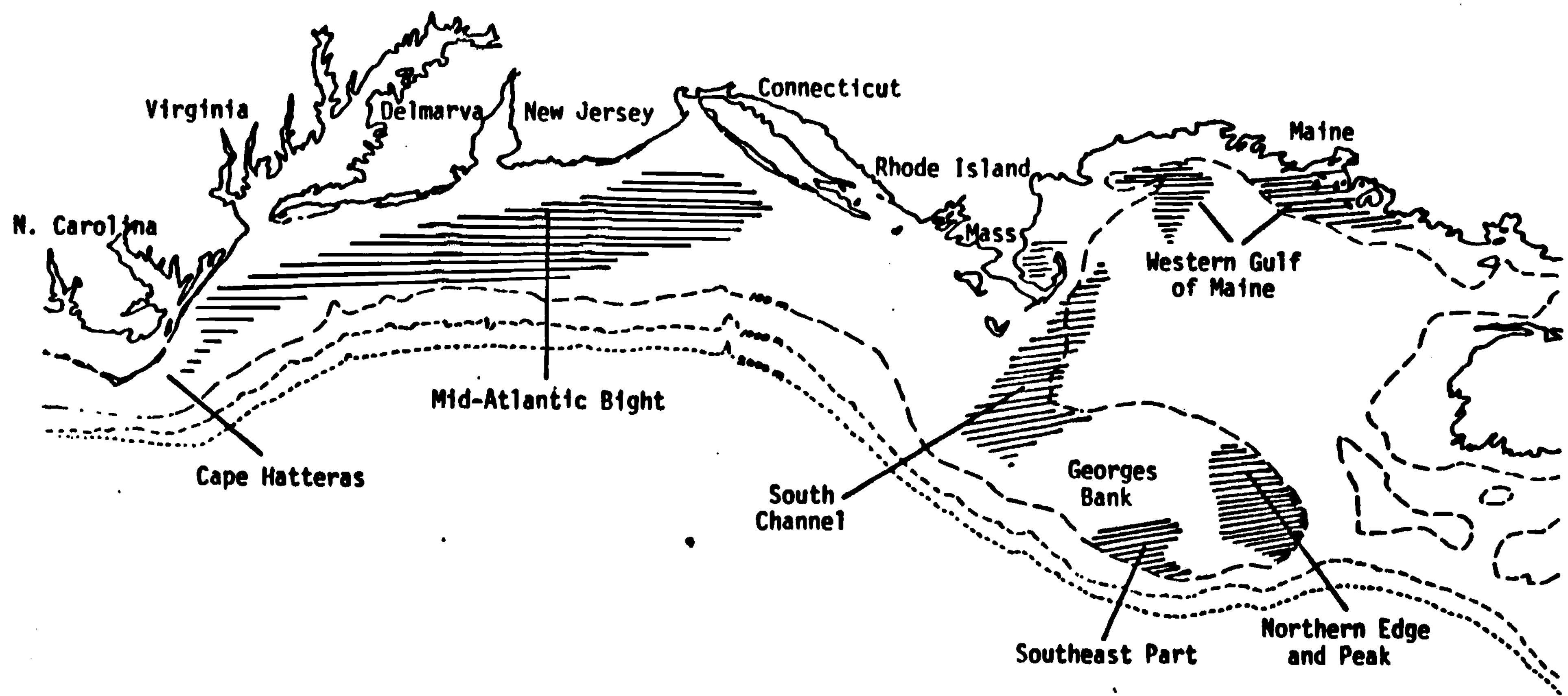


Figure 211: Sea Scallop Resources Off the Northeast United States

Table 211: Average Production of Scallop Meats
From Traditional Fishing Areas in the Northwest Atlantic

Area	Average Annual Landings Scallop Meats in MT		Average for the Years
	U.S.	Canada	
Western Gulf of Maine	322	*	1961 - 1980
Georges Bank	3,560	6,232	1961 - 1980
Mid-Atlantic	3,520	**	1961 - 1980

*No Canadian landing recorded.
**Canadian landings in 1965 (2,609 MT), 1966 (2,780 MT) and 1968 (422 MT) not included.

Source: NMFS, Northeast Fishery Center, 1981 Sea Scallop Assessment.

Stock Differentiation

There are no observed biological differences that would lead to a separation of stocks within the area regulated by this management plan. There are slight differences in growth rate between Georges Bank and Mid-Atlantic populations, apparently the result of differing temperature regimes. Variations in growth rates also exist between Gulf of Maine and other populations, as well as within the Gulf of Maine population. There may also be differences in the recruitment mechanisms between scallop populations occupying separate habitats. For instance, there may be some degree of reproductive isolation between scallops on Eastern Georges Bank and scallop populations to the south and west, as well as within the Gulf of Maine. But, considering the long pelagic phase of the larvae and the speed and complexity of the surface currents in which the larvae are transported, there is little biological basis for considering these populations as separate stocks.

§213 Spawning

The sea scallop is a late summer or fall spawner. Spawning has occurred in August and September on the Coast of Maine (Welch, 1950) and in late September or early October on Georges Bank (Posgay and Norman, 1958). Spawning generally occurs during August on the Mid-Atlantic shelf, but may begin as early as July in the most southern areas.

The sexes are separate and fertilization takes place in the water column, or perhaps in the mantle cavity of the females. Observations of spawning beds on Georges Bank (Posgay and Norman, 1958) have indicated that spawning may be accomplished in a matter of a few days (although it probably occurs over a more protracted period), and at bottom temperatures ranging between 46°F and 52°F. The mechanism by which spawning is triggered in the wild is not known, but the onset of vertical mixing in the water column, causing bottom temperatures to rise, has been suggested as a possibility. This mechanism would be difficult to apply to Georges Bank, however, because tidal currents keep the water column well mixed in all seasons. There have been very few successful laboratory spawnings, but some of these suggest that the presence of sperm in the water that females were pumping through their mantle cavity induced them to release their eggs.

Sea scallops begin to mature and spawn at age 3 on Georges Bank, but these small scallops do not produce very many eggs. At age 4 (about 85-90 mm) a female will release about two million eggs. The relationship between the number of eggs produced and the age of female scallops is not known, but considering that the size of the scallop's gonads increases in direct relation to shell height (distance from the hinge to the farthest point of the shell), it is likely that maximum egg production is not reached until several years after maturity.

Currently there are no data available to describe the relationship between parental (spawning) stock and subsequent recruitment. Although it is generally acknowledged that a correspondence does exist between stock and recruitment at low stock levels, nothing is known about the minimum abundance or local density of sea scallops that will still give a high probability of sustained recruitment or even of successful fertilization.

§214 Early Life History

After fertilization the eggs and larvae go through the usual molluscan development stages. The eggs are slightly heavier than sea water and probably remain on the bottom as they develop into the first of two free-swimming larval stages. The larval stages, trochophore and veliger, are pelagic (i.e., occurring in the water column), but they have never been positively identified in plankton collection, so it is impossible to trace their movements or to know precisely in which water layers they occur. Their presence in the surface layers seems indicated by observations of newly set scallops on surface buoys and the occurrence of larval scallops in stomachs of larval herring.

The pelagic stage probably lasts 4-6 weeks or more, after which the young scallops seek the bottom as post larvae. In the wild, the length of the pelagic phase is undoubtably variable because water temperatures vary. At the end of their pelagic existence, the larvae enter the pediveliger stage, which features the development of a foot with adhesive capabilities.

Considering the probable pelagic nature of the scallop's larval stage, it is unlikely that the progeny of any given scallop aggregation will settle out of the plankton among their parents, or even in the near vicinity. The mechanism by which recruitment occurs to major production areas is at this point conjectural. The beds on Georges Bank, particularly in the vicinity of the Northern Edge, Northeast Peak and Great South Channel, are thought to be self-sustaining at a fairly consistent and relatively high rate of recruitment. This is because the larvae are probably retained in the Georges Bank gyre long enough for metamorphosis to be complete. There is considerable uncertainty about the mechanism involved in recruitment to the Mid-Atlantic. Beds in productive areas, such as the New York Bight, may not be self-sustaining, but may supply recruits for beds located further down-current. The occasional heavy recruitment to the Mid-Atlantic may be the result of periodically occurring optimum reproductive conditions, or augmented recruitment from spawning on Georges Bank. It is not known if the beds on the coast of Maine or in the deeper waters of the Gulf of Maine are self-sustaining, or receive larvae from spawning in outside areas.

Spatfall (the settling of juvenile scallops on the bottom), and the period immediately following, is thought to be a time that is particularly important in the formation of scallop beds (Posgay, 1953) and in determining year class size (Bourne, 1964; Caddy, 1975). The availability of suitable surfaces on which to set seems to be universally accepted as a primary requirement for successful scallop reproduction, although there is uncertainty as to what the most suitable surfaces are. It has been suggested by Caddy (1968) that the presence of available setting space provided by the shells of dead or discarded adult scallops may stimulate heavy spatfall.

How the characteristic aggregations of individuals are formed prior to becoming vulnerable to the commercial dredge at about 70-80 mm (age 3) is not well understood, but scallops are highly mobile during this period. In the early stages, after setting, they adhere to the bottom by byssal threads which can be severed by the scallop when it swims in the water column. Swimming is considered an avoidance reaction. It may be the result of visual, chemical or vibration stimuli. Further, it is likely the reason that they are not taken in dredges before about age 3. Direct observation of the reaction of scallops to towed gear indicates that the young are capable of avoiding an approaching dredge by swimming out of its path (Edwards and Emery 1968; Caddy, 1968). There is no evidence to date for mass movements of scallops, at least for those age 3 and older. Numerous tagging experiments have shown that aggregations of adults remain fixed once they are formed (Posgay, 1963; Baird, 1954).

§215 Ecological Relationships

Position in the Food Chain

Like most bivalves, sea scallops are filter feeders, but there are few published reports that identify preferential food organisms. Specific items that have been observed include microscopic plants (e.g., diatoms) and animals (e.g., peridinians, tintinnids, ciliate protozoa), as well as fragments of larger plants and planktonic stages of crustaceans. From these observations, it is reasonable to conclude that sea scallops are primary consumers that characteristically obtain their energy requirements principally from the phytoplankton. Adult sea scallops do not have many predators. Evidently, their large size and hard shell with sharp edges make them unattractive prey. The larvae are, of course, extremely vulnerable to predation by plankton feeders, but the adults are preyed on principally by man.

Feeding Behavior

Sea scallops feed by drawing water through their mantle cavities, filtering it through a film of mucous that they secrete over their gill surfaces, and then transporting the trapped food particles along tracks of beating cilia to their mouths. Particles which are too large to be ingested are rejected by the mouth parts into the water current passing out of the mantle cavity. The mantle cavity is formed by the scallop relaxing its adductor muscle, allowing the two valves to gape slightly. The gap is closed by two flaps of muscular tissue, the velum, which are held closely pressed together around the circumference of the shell, except for two spaces left open near each ear of the hinge. Water, bearing food and oxygen, is drawn in through one of these spaces, the incurrent siphon, and feces, pseudofeces, and other metabolic products are expelled through the other, the excurrent siphon. Oxygen is absorbed into the scallops bloodstream through the gill surfaces and the mantle which covers the inner surface of each valve.

Sea scallops do not burrow in the substrate as do clams. They must remain on the surface to feed and breathe. If they are accidentally buried, they suffocate and die. Larger, undisturbed scallops on sandy bottom are usually found in shallow depressions which are created by the scouring action of water currents. These animals have the habit of occasionally rotating on their lower valve by jetting water out one of their siphons while clearing the mantle cavity of foreign objects. When disturbed, scallops swim away by filling the mantle cavity with water, compressing the velum all around the circumference, except for two gaps on each side of the hinge, and then firmly clapping the shells together. These actions force water through the gaps and propel the scallop through the water for a few meters to a new location.

Competition

Sea scallops compete for food with any other filter feeders, such as surf clams or ocean quahogs, that may be in their immediate vicinity. There is no evidence that competition for food among themselves or other species is ever limiting. Growth rates of dense aggregations have not been found to be any lower than sparse aggregations. Competition between individual scallops is rare if it occurs at all. Underwater photographs and observations by Scuba divers show sea scallops to be well separated from one another. Reports that they pile up on one another several layers deep are entirely mistaken. Observations of scallop beds on Georges Bank indicate that even in areas of high catch, adult scallop density seldom exceeds two scallops per square meter.

§220 Description of Habitat

The entire continental shelf inside the 100 meter isobath is potentially productive habitat for sea scallops, with the exception of the shallower inshore areas south of Cape Cod. The two major areas where sea scallop production occurs are Georges Bank and the Mid-Atlantic.

Georges Bank is a relatively shallow extension of the continental shelf from the southern New England coast to a point on the northeast corner that is about 90 nautical miles SSW of the southwestern tip of Nova Scotia. It forms the southern rim of the Gulf of Maine Basin. The Bank is essentially a submerged, flattened plateau (Clarke, Pierce and Bumpus, 1943). Physiographically, it is a submerged coastal plain cuesta with a steep cliff-like northern edge and a gently sloping southern face (Johnson, 1925), with an area of approximately 12,000 square miles within the 100 fathom isobath and 9,000 square miles within the 50 fathom isobath (Wigley, 1961). The water varies in depth from 20-100 fathoms (40-185 meters) but there are some shoal areas in the north central region of only 2-3 fathoms (3.5 - 5.5 meters). The shoals of the Bank are separated from those of Nantucket by the Great South Channel which connects the deeper waters of the Gulf of Maine with the open Atlantic.

Strong, turbulent currents predominate over most of the Bank. Rotary tidal currents are strong throughout the year, and there are many local currents and eddies (Bumpus, 1976; Bishop and Overland, 1977). Of primary importance is the large, non-tidal, clockwise gyre that is centered over the Bank during most of the year. Very little is known of the speed and direction of the surface currents except that they are highly variable seasonally and from year to year. In general, some water moves out of the southwest portion of the Gulf of Maine and along the northern and eastern edge of the Bank in a clockwise pattern. Gulf of Maine water also moves south and west through the Great South Channel and combines in its westerly flow with westward moving water from the slope and water from Georges Bank that does not get caught up in the gyre. The circulation in the gyre varies; in some years it is tight and retains most of the water on the Bank, in other years it is loose and water spills out to the west.

The temperature regime on Georges Bank can be described as cold and well mixed. Much of the water that spills over the Bank is from the Gulf of Maine and is generally intermediate between values of surface and bottom temperatures in the Gulf (Bumpus, 1976). The temperature of the Bank water is therefore much lower than that of the Mid-Atlantic. There is typically no thermocline over the Bank; the distribution of temperature is nearly uniform from top to bottom throughout the year because the turbulence produced by wind and tidal currents over relatively shallow water causes complete vertical mixing (Bumpus, 1976).

In general, the bottom on Georges Bank varies from sand to gravel. The particular bottom type in a given area results from the characteristic circulation that prevails in that area (Wigley, 1961). Turbulent and variable currents that occur in areas of the Great South Channel and along the northern part of the Bank result in sediment that is poorly sorted. Here gravel predominates, interspersed with areas of rock. Strong uniform currents over the central and southern parts of the Bank result in sediment that is sorted much better and the bottom is sandy.

The continental shelf from Nantucket Shoals to Cape Hatteras gradually narrows. It extends 100 miles seaward at Cape Cod, 70 miles off New Jersey and only 20 miles at Cape Hatteras. The bottom is relatively smooth (chiefly sand interspersed with large pockets of sand-gravel and sand-shell) and slopes gently seaward to the shelf edge at about the 200 meter isobath. The topography and hydrography of the Mid-Atlantic shelf are influenced on the landward side by the outflows of large estuarine and river systems, such as the Hudson, Delaware and Chesapeake and on the seaward side by major canyons.

In general, the surface circulation over the Mid-Atlantic shelf is a non-tidal, southwesterly drift at speeds in the order of 5 nautical miles per day, with a seaward exit between Chesapeake Bay and Cape Hatteras (Bumpus, Lynde and Shaw, 1973). There may be a shoreward component to the drift in the warm months, an offshore component in the cold months and occasional eddies and reverse currents, particularly off the mouths of the major estuaries. Persistent bottom drift, in the order of tenths of a nautical mile per day, occurs from just beyond mid-shelf towards the coast and into the estuaries.

Surface water temperatures, although generally warmer than those of Georges Bank, exhibit much wider seasonal variation. The annual range of surface temperature at any location near the shore may be greater than 20°C (Bumpus, Lynde and Shaw, 1973). During the coldest season the water column is close to isothermal, but a thermocline develops after late April and lasts until mid-November.

The principal environmental factor affecting the distribution of sea scallop beds is undoubtably the current patterns that exist during the larval scallop's pelagic existence. For about 4 to 6 weeks after hatching the larvae are somewhere in the water column, presumably moving with the currents which are known to vary considerably in speed and direction; therefore, their location at the time of spatfall will depend on the speed and direction of those currents.

Evidence for this type of dispersal mechanism can be seen from the erratic pattern of recruitment in some areas and the more or less consistent pattern of recruitment in others. In the Mid-Atlantic, in certain areas of Georges Bank and in some areas along the coast of Maine there are periodic abundances of scallops where traditionally population levels were low. The productive beds that suddenly developed off Chatham, Massachusetts, and in the Jeffrey's Basin/Cashes Ledge area of the Gulf of Maine in recent years are two cases in point. Many of these beds are comprised of scallops of a single age group, indicating that the production may be the result of a single successful spatfall. In other areas, particularly in the northern part of Georges Bank or the Great South Channel, more or less constant production is maintained; and many of the beds contain scallops of several age groups. It follows that, in areas where consistent current patterns persist, spatfall will also be consistent.

Unfortunately, our knowledge of the pelagic behavior of the larvae and of the speed and direction of currents, and their variation on a small scale, are insufficient to allow more than a general hypothesis to be advanced regarding the mechanism whereby young scallops are recruited to the Georges Bank and Mid-Atlantic populations. Strong currents on Georges Bank undoubtably play a role in determining the abundance and distribution of scallop populations on the Bank and may, at times, be influential in determining the pattern of abundance and distribution in the Mid-Atlantic. Metamorphosing larvae probably pass the first 4-6 weeks of their lives within the Bank's surface currents. The clockwise gyre on Georges Bank may retain the larvae on the Bank until they settle to the bottom, thereby accounting for the replenishment of recruits year after year. The southwest eddy drift of water in the Mid-Atlantic has been estimated to be in the order of 5 nautical miles per day by Bumpus, et al (1973); and the eddies pinched off from the inner edge of the Gulf Stream (warm core rings) that drift southwestward in the slope water were estimated by Richardson (1976) to travel from 2-4 nautical miles per day. If the coastal water in which the sea scallop larvae are entrained moves at comparable speeds, then the progeny of the adults that are spawned at centers of abundance at the Great South Channel (and possibly Georges Bank during years of a weak gyre), Hudson Canyon, off Delaware Bay and Chesapeake Bay will be transported anywhere from 100 to 300 km downstream before they are ready to take up their bottom dwelling existence. It should be emphasized that, lacking adequate data and recognizing the complexity that may be imposed by other as yet unknown dispersion factors, this hypothesis should be considered tentative.

Variations in water temperature may also have an effect on the distribution of sea scallops. The rate of development of the larvae, and therefore the length of time they are present in the water column, is a function of temperature. Annual variation in temperature has been proposed by Dickie (1955) to account, in part, for the variation in spatfall success in the Bay of Fundy. Larvae, whose planktonic existence was extended during years of cooler temperatures, tended to drift out of the Bay of Fundy before settling to the bottom.

Dow (1962), noting that scallop landings from coastal Maine waters since 1889 have exhibited periodic highs alternating with poor catches at approximately 10-year intervals, suggests that water temperature may be a significant factor in influencing scallop abundance. Coastal Maine scallop landings were found to be well correlated with sea water temperatures when these scallops were spawned, six growing seasons previous. Moreover, Dow (1962) found that subsequent landings were sensitive to water temperatures during the first winter-spring period following spawning. In view of the work by Dickie (1955), it may be reasonable to conclude that Dow's observations with respect to spawning and post-spawning periods with lower than optimum temperatures may have resulted from delayed larval development with larval drift to deeper waters seaward from the coastal fishery. Higher than optimum temperatures may have resulted in increased rates of natural mortality.

There is no hard evidence that bottom type directly affects the survival of adults. Adult sea scallops are found on all types of bottom from strictly mud and clay to cobbles and even large boulders. From areas where commercial fishing is most active it would appear that scallops are found most abundantly in rocks, gravel or sand, however, much of this may be accounted for by fishermen avoiding muddy bottoms, which clog their dredges. The nature and amount of suitable bottom type available for setting may be quite critical for the survival of scallops at metamorphosis. Benthic animals such as bryozoans or bivalve shells may be important as a settling medium.

Pollution, and its effect upon survival of sea scallops, has not been studied extensively. Stone (1975) conducted some experiments on the effects of experimental laboratory concentrations of Kaolin (a suspension of clay particles). His scallops displayed decreased filtering rate and weight loss when subjected to Kaolin concentrations of 0.5 - 2.0 grams per liter. The anoxic bottom water conditions that developed in the Mid-Atlantic Bight in the summer of 1976 have not been proven to be the result of pollution but Ropes, et al (1979), report that about 10 percent of the sea scallops in their samples had probably been killed by the lack of oxygen in the water.

Concern exists for the potential habitat degradation that may be associated with oil and gas exploratory drilling on Georges Bank. Chemical drilling fluids ("muds") used in exploratory operations have been tested for their toxicity to various marine organisms. The insolubility and fine particle size of drilling muds result in a high suspended solids content that may affect organisms by irritating sensitive membranes, causing suffocation, decreasing disease resistance, causing behavioral changes, introducing of toxic substances, and increasing oxygen demands. McLeod, Gilbert, Stone and Riser (1980) observed a number of these effects after exposing sea scallops for 28 or 42 days (flow-through bioassays) to separate mud components, synthetic muds and used muds. They found that attapulgite (clay) alone or when in mixed components was more stressful than bentonite (clay) and that effects were greater at higher temperatures. Mud loading on gills led to an increased filtration rate and mucous cell proliferation and production; as a result, energy stores eventually declined with an attending decline in the rates of these functions. Chromium and barium were concentrated in the kidney. In the 2 weeks following cessation of the tests, barium and chromium concentrations remained at the same level or increased, which reflects the depuration (cleansing) of other tissues by the kidney.

Liss, Knox, Wayne and Gilbert (1980) also used sea scallops to assess the uptake of trace elements contained in synthetic and used drilling fluids. Barium and chromium accumulated rapidly in the kidney during the first week of exposure. After four weeks of exposure following by a 2-week depuration period, barium and chromium concentrations had not decreased significantly.

Dredging increases the sediment load of the waters in which it occurs and would therefore have the same effect as reported in Stone (1975). The extent of the damage would, of course, depend on the amount of area covered by the dredging plume and the length of time the scallops were exposed. The effects of sea scallop dredging in the Gulf of St. Lawrence have been reported by Caddy (1973) as follows:

1. Dredging lifts fine sediments into suspension, buries gravel below the sand surface, overturns large rocks embedded in the sediment and appreciably roughens the bottom.

2. Dredging kills some scallops and causes considerable sublethal damage to scallops left in the track, the damage being greatest on rough bottom. Mortalities to scallops with a standard dredge were at least 13 to 17% per tow.

3. Predatory fish and crabs are attracted to dredge tracks and had densities 3 to 30 times greater inside than outside the tracks soon after the dredging.

The probable adverse effects of sea scallop dredging on the environment of commercial finfish populations has not been examined.

The effects of "sanding" scallops during dredging has not been examined. Some scallops, expecially small ones, become packed with sand during dredging on sand bottoms. Scallops gathered and passed over by dredges can become sand-packed. Fishermen return most small scallops to the bottom. No one knows whether the sand-packed scallops survive.

In general, there are relatively few areas within the range of the sea scallop that are, at present, subject to possible environmental degradation that might have adverse effects upon the population. Future developments may, however, change this conclusion if there are large expansions of hydrocarbon activities, sand and gravel mining, dumping of sewage sludge, or the introduction of offshore power plants. The offshore dump sites in the Mid-Atlantic Bight, having been indicated to have contributed to the anoxic conditions of 1976, could affect the future of the Hudson Canyon area sea scallop fishery. Heavy tanker traffic in the same area also raises the possibility of pollution from a major spill caused by collision or grounding.

The Great South Channel area off Cape Cod and the area off Penobscot Bay, Maine, may present the same type of hazard if there are more tanker accidents such as have occurred during the past few years.

§230 Current Abundance and Future Outlook

Sea scallops grow rapidly during their early years. They have an estimated natural life span of about 20 years, although most of the older scallops in the various resource areas have now been harvested. Vulnerability of scallops to capture by the commercial dredge begins during their third year at a shell height of about 70 mm (2 3/4 inches, or about 3 1/4 years). The youngest scallops are rarely seen in the commercial dredge catches except in years when reproduction has been extremely successful.

There is presently no estimate of the absolute abundance of the sea scallop resource. However, abundance indices (that permit comparisons among years) for sea scallops are available for the Gulf of Maine, Georges Bank/Southern New England and Mid-Atlantic Bight resource areas. These abundance indices, describing the relative condition of the sea scallop resource are derived principally from research surveys conducted by the National Marine Fisheries Service. Using standardized gear, fixed towing times and a statistically-based sampling design, research vessels collect data on numbers of animals per tow by size class. Data of this type are presented in Tables 232 and 233. Animals less than 70 mm constitute the "pre-recruit" index of abundance and those greater than or equal to 70 mm constitute the fully recruited index of abundance. These data can be compared on a year-to-year basis to give an indication of trends in population abundance, and size frequency information from the research surveys provide information on population structure.

Table 231: Current status and recruitment prospects for sea scallop resources off New England and in the Mid-Atlantic.

Resource Area	U.S. Commercial Age Class Frequency[3]	Relative Abundance Indices[1,2] Survey Year	Pre-Recruit <70 mm	Recruit ≥70 mm	Total	Recruitment Prospects
Gulf of Maine						
Offshore: 30-60 fms	1980: '75 and '74 year classes dominant	1975	1.2	1.4	2.6	Poor recruitment from the 1977 year class. Low level recruitment from the 1978 year class.
		1976	0.4	1.4	1.8	
		1977	0.4	1.5	1.9	
	1981: Mixed year classes, '76 year class and older.	1978	2.2	1.7	3.9	
		1979	0.7	3.0	3.7	
		1980	0.0	2.1	2.1	
		1981	0.5	1.2	1.7	
Offshore: 61-100 fms	1980-1981: Little, if any, commercial exploitation.	1975	0.0	0.1	0.1	Very good recruitment from the 1976 year class.
		1976	<0.1	<0.1	0.1	
		1977	1.1	0.6	1.7	
		1978	4.1	0.7	4.8	
		1979	2.1	6.2	8.3	
		1980	0.1	33.0	33.1	
		1981	5.3	92.2	97.5	
Georges Bank						
South Channel	1980: Mixed year classes, '76 year class and older.	1975	30.2	25.9	56.1	Very good recruitment from the 1977 year class. Low level recruitment from the 1978 year class.
		1977	4.0	52.5	56.5	
		1978	5.1	32.9	38.0	
		1979	4.5	56.5	61.0	
	1981: '77 year class predominant.	1980	51.2	19.3	70.5	
		1981	9.9	24.0	33.9	
Southeast Part	1980: Mixed year classes, '76 year class and older.	1975	1.8	38.2	40.0	Good recruitment from the 1977 year class. Low level recruitment from the 1978 year class.
		1977	2.8	24.3	27.1	
		1978	2.1	23.9	26.0	
		1979	6.9	19.2	26.1	
	1981: Mixed year classes '76 and older.	1980	19.4	37.4	56.8	
		1981	1.3	17.4	18.7	
Northern Edge and Peak	1980: Mixed year classes, '75 year class and '72 year class.	1975	86.9	120.2	207.1	Exceptional recruitment from the 1977 year class. Very good recruitment from the 1978 year class.
		1977	66.2	384.7	450.9	
		1978	177.5	372.6	550.1	
		1979	63.9	232.9	296.8	
	1981: '77 year class predominant.	1980	599.3	128.2	727.5	
		1981	277.0	404.9	681.9	
Mid-Atlantic						
New York Bight	1980: Mixed year classes none predominant.	1975	27.3	23.5	50.8	Low level recruitment from the 1977 and 1978 year classes.
		1977	1.1	39.4	40.5	
		1978	2.5	36.1	38.6	
	1981: Mixed year classes '76 and '74 year classes most predominant.	1979	3.9	13.7	17.6	
		1980	10.7	10.8	21.5	
		1981	13.1	13.5	26.6	
Delmarva	1980: Mixed year classes, '75 and '74 year classes most predominant.	1975	25.2	15.6	40.8	Low level recruitment from the 1977 and 1978 year classes.
		1977	3.3	24.0	27.3	
		1978	8.3	26.0	34.3	
		1979	30.8	39.3	70.1	
	1981: Mixed year classes, '77 year class and older.	1980	23.4	13.3	36.7	
		1981	2.8	5.9	8.7	
Virginia-No. Carolina	1980: '76 and '75 year classes predominant.	1975	47.7	10.9	58.6	Poor recruitment from the 1977 and 1978 year classes.
		1977	0.2	0.2	0.4	
		1978	15.4	7.1	22.5	
	1981: Mixed year classes, '76 year class and older.	1979	4.6	6.5	11.1	
		1980	0.8	4.6	5.4	
		1981	0.4	0.8	1.2	

[1] Relative abundance indices for Georges Bank and the Mid-Atlantic areas represent standardized stratified mean number per tow from sea scallop research vessel surveys. For all areas on Georges Bank, except the Northern Edge and Peak during 1978-1981, and for all areas in the Mid-Atlantic, the indices are derived from NMFS research vessel sea scallop surveys. The 1978-1981 Northern Edge and Peak indices are derived from Canadian research vessel sea scallop survey data standardized for dredge size and type, and for distance towed.

[2] Relative abundance indices for offshore Gulf of Maine represent stratified mean number per tow from NMFS spring offshore research vessel bottom trawl surveys.

[3] 1981 data derived from January-June commercial size-frequency samples only.

The following sections describe the current condition of the major sea scallop resource components. The current status and recruitment prospects for the various resource components are based on data summarized in Table 231.

§231 Gulf of Maine Populations

A fishery for sea scallops has been in existence in Maine coastal waters since the 1880's. Relatively distinct populations occur in embayments and estuaries along the entire coast of Maine, but the most extensive populations are found in the area from Penobscot Bay to Mt. Desert Island (Dow, 1962). Resource abundance in Maine waters has been found to be highly cyclical; Dow (1962) concluded that a high correlation with lagged water temperatures provides a convenient method for predicting yields from the fishery up to six years in advance. Record landing of about 900 MT occurred in 1910.

Limited historical fishery information exists with regard to sea scallop populations in the deep water portions of the Gulf of Maine. A fishery developed in the area north and east of Jeffrey's Ledge during the winter of 1979-1980 and in 1980-1981 off Machias Bay, Maine, reportedly concentrating on localized recruitment from the 1975 year class (Schick, 1981). Relative abundance indices shown in Table 231 for the Gulf of Maine were generated through bottom-trawl surveys and are not directly comparable with the standardized survey data for the other resource areas. However, the Gulf of Maine indices do indicate the contribution of the 1974 and 1975 year classes to the fishery (30-60 fathoms) in 1980, followed by a decline in abundance in 1981. In addition, the surveys indicate that resource abundance in deeper water (61-100 fathoms) has increased significantly over the last several years, apparently due to relatively good recruitment from year classes since 1974.

In view of the lack of previous significant yields from the offshore Gulf of Maine waters, similar to that which supported the winter 1979-1980 fishery, and in view of the current recruitment prospects, it is not likely that a significant offshore sea scallop fishery is sustainable in the Gulf of Maine in the foreseeable future.

§232 Georges Bank Populations

U.S. sea scallop research vessel surveys have been conducted on Georges Bank in two series. An older series between 1960 and 1968 was primarily concerned with basic life history data, but relative total abundance indices were also developed. The recent series of surveys conducted during 1975 and 1977-1981 were for the purpose of assessing relative abundance, population composition and the relative strengths of recruiting year classes (see Table 231).

Information relative to the present condition of the Georges Bank resource was obtained from the 1981 survey. The recruited stock (≥70 mm, 2 3/4 inches) in the South Channel and the Southeast Part appears to be represented by at least three year classes (1975, 1976, 1977), whereas that on the Northern Edge and Peak is dominated by the strong 1977 year class. As shown in Figure 231, the 1977 year class (indicated by the peak at about 80 mm) has recruited strongly in all areas and is followed by the 1978 year class (indicated by the peak at about 48 mm), which appears to be recruiting with above average strength on the Northern Edge and Peak and with below average strength in the South Channel and Southeast Part. The future recruitment prospects from the 1979 year class appear to be favorable in the South Channel (note the peak at about 20 mm, shell height, in Figure 231).

The relative lack of sea scallops larger than 120 mm (shell height 3.9 inches) on the Northern Edge and Peak is in contrast to the South Channel and the Southeast Part, and may be indicative of the recent heavy levels of fishing effort by both U.S. and Canadian vessels. However, survey data (Table 232) indicate that the very strong 1977 year class has contributed to a recruited population in 1981 on the Northern Edge and Peak which may be at least fifteen times as dense as that in the South Channel.

The results of recent research vessel surveys indicate that overall on Georges Bank the 1977 year class may be at least as strong as the 1972 year class, the strongest previously observed in the recent series of surveys. The results of the 1981 survey suggest that the 1978 year class may be at least half as strong as the 1977 year year class on the Northern Edge and Peak. If the 1979 year class is as strong as it currently appears in the South Channel (contributing to a somewhat broader distribution of year classes), then continuation of recent overall catches (10,800 MT, U.S. and Canadian in 1980 concentrated 25% in the South Channel and 75% on the Northern Edge and Peak) for one or two additional years may be possible without resulting in stock decline.

§233 Mid-Atlantic Populations

General patterns of recruitment to the Mid-Atlantic sea scallop fisheries in the New York Bight and Delmarva areas, as indicated from U.S. sea scallop research vessel surveys since 1975 (Table 233) show many similarities to that seen in the South Channel on Georges Bank. Over the entire region relatively poor recruitment levels have periodically been punctuated by strongly recruiting year classes typically reaching strengths about ten times former levels. In the Virginia-North Carolina area the frequency of strong year classes may be less, while the range in relative recruitment levels may be more extreme.

Overall in the Mid-Atlantic region, three important year classes have been recruited since 1976 (the 1972, 1974 and 1977 year classes). In addition, localized good recruitment appears to have occurred from the 1975 and 1976 year classes in Delmarva and Virginia-North Carolina. The 1978 year class may be important in the New York Bight area given the relatively low level of recruitment in this area since the 1975 year class. Hence, 1982 catches of sea scallops in the New York Bight may be expected to remain near current levels (3,200 MT in 1980) with continuation of current fishing mortality rates.

Weak recruitment from the 1978 year class in Delmarva implies that catch levels from that area (about 1,800 MT in 1980) may continue to decline through 1982 unless fishing mortality rates are substantially increased. The survey catch data indicate that the sea scallop resource in the Virginia-North Carolina area may be seriously depleted (catches were less than 100 MT in 1980); the very poorly recruiting 1977 and 1978 year classes imply that this condition may continue through 1982.

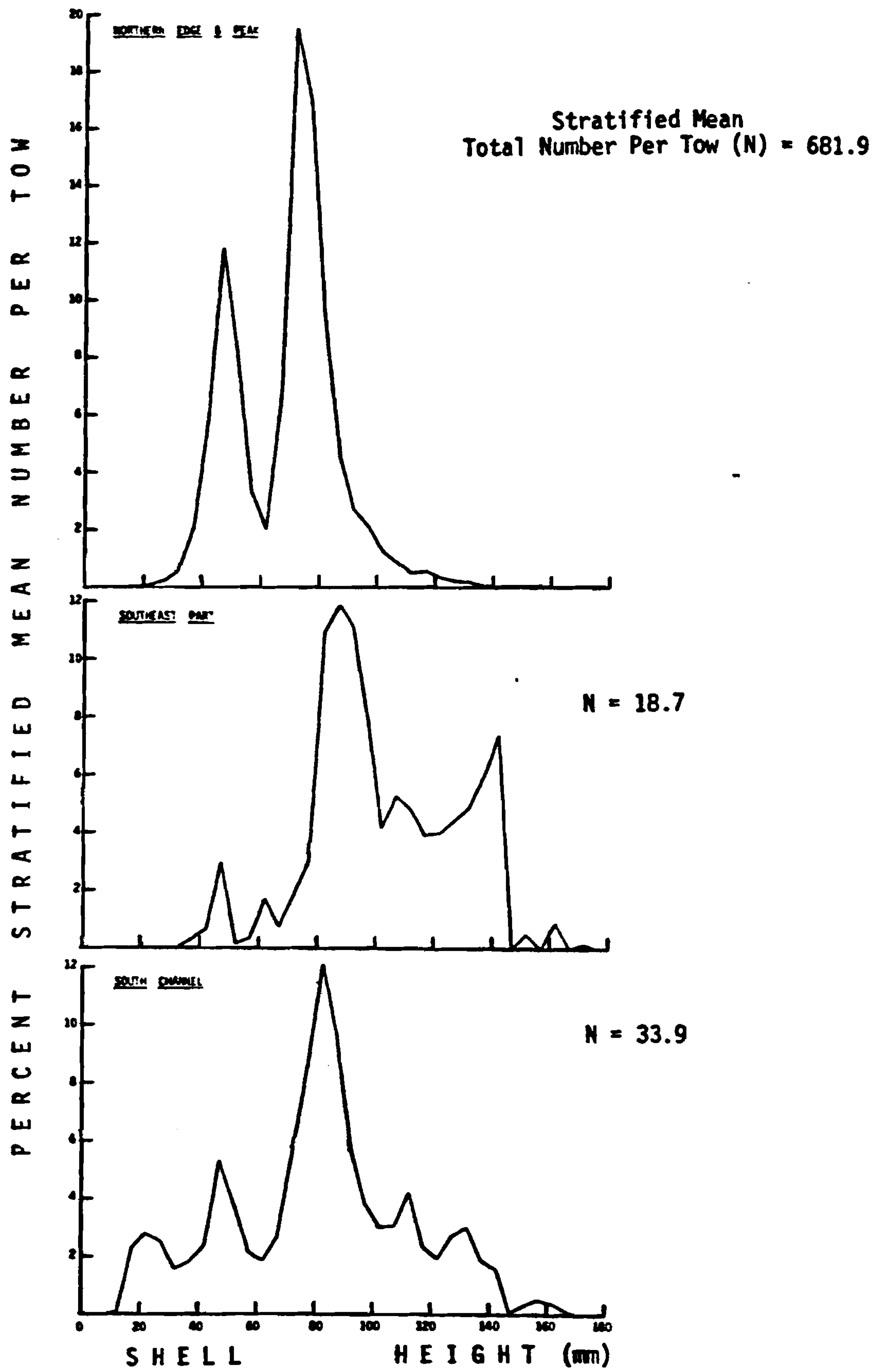


Figure 231: Results from the 1981 U.S. and Canadian sea scallop research vessel survey of major production areas of Georges Bank.

Note: 100mm = 4 inches; 75mm = 3 inches.

Table 232: U.S. sea scallop research survey relative abundance indices (standardized stratified mean number per tow) of scallops sampled from sea scallop research surveys on Georges Bank, 1975, 1977-1981. Data are presented by principal scallop regions on Georges Bank. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height) and total scallops per tow.[1]

		Standardized Stratified Mean Number Per Tow			
Area	Year	Number <70 mm Per Tow	Number ≥70 mm Per Tow	Total Number Per Tow	Average[2] Survey Meat Count
South Channel	1975	30.2	25.9	56.1	32.2
	1977	4.0	52.5	56.5	23.3
	1978	5.1	32.9	38.0	23.3
	1979	4.5	56.5	61.0	29.2
	1980	51.2	19.3	70.5	78.0
	1981	9.9	24.0	33.9	35.6
Southeast Part	1975	1.8	38.2	40.0	18.5
	1977	2.8	24.3	27.1	20.6
	1978	2.1	23.9	26.0	14.8
	1979	6.9	19.2	26.1	19.0
	1980	19.4	37.4	56.8	40.5
	1981	1.3	17.4	18.7	21.4
Northern Edge and Peak	1975	86.9	120.2	207.1	48.4
	1977	66.2	384.7	450.9	40.4
	1978	177.5	372.6	550.1	33.8
	1979	63.9	232.9	296.8	33.8
	1980	599.3	128.2	727.5	131.0
	1981	277.0	404.9	681.9	73.6
Georges Bank (All Areas)	1975	46.3	62.4	108.7	39.7
	1977	27.9	176.1	204.0	36.4
	1978	66.0	152.4	218.4	31.1
	1979	28.7	120.9	149.6	32.2
	1980	305.6	74.2	379.8	118.8
	1981	76.3	119.9	196.2	64.1

[1]Relative abundance indices from the Northern Edge and Peak, 1978-81, derived from Canadian research vessel survey data standardized to USA tow distance.

[2]Average meat count derived by dividing the calculated mean meat weight into 453.6 grams (1 pound).

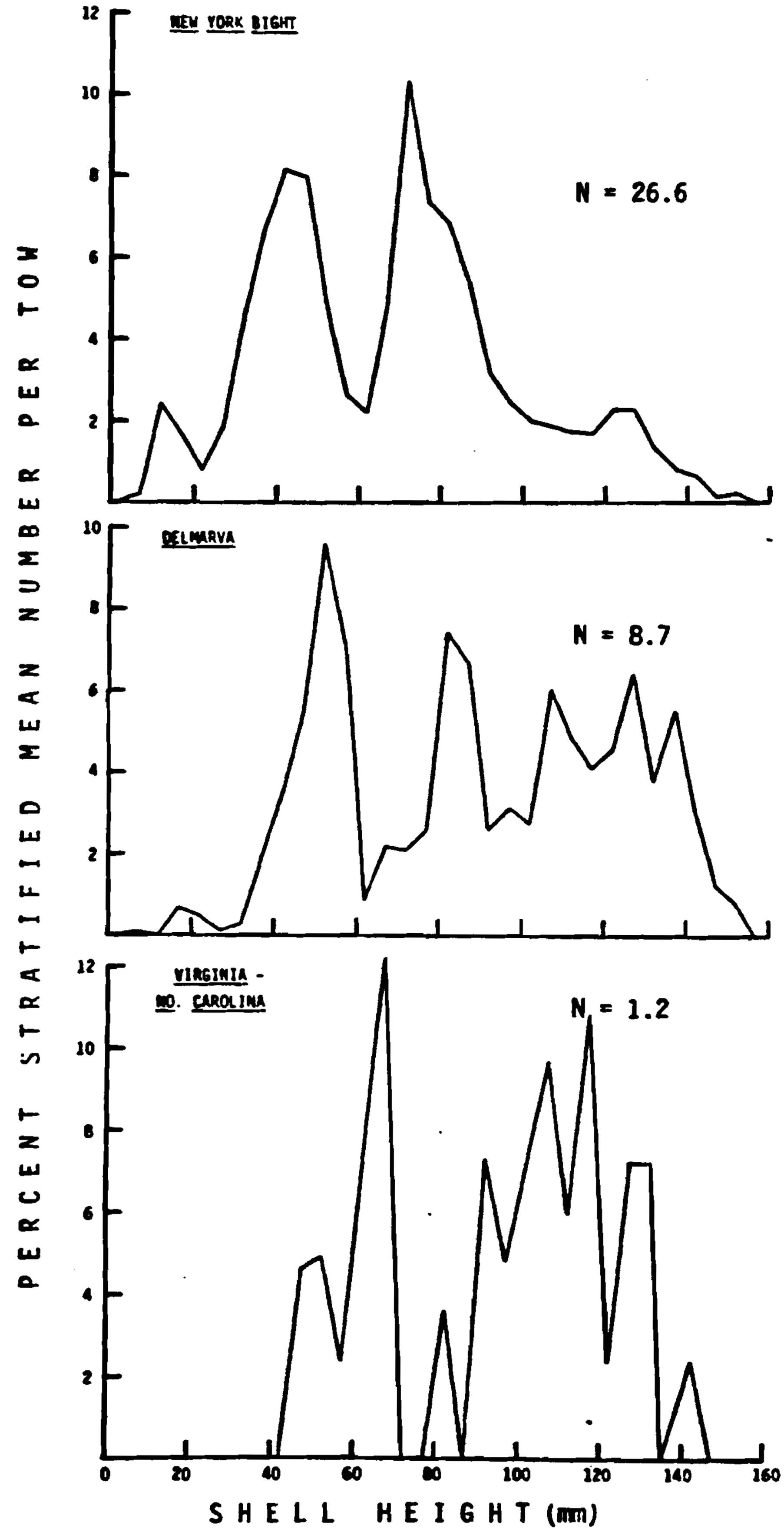


Figure 232: Results from the 1981 U.S. sea scallop research vessel survey of major production areas of the Mid-Atlantic.
Note: 100mm = 4 inches; 75mm = 3 inches.

Table 233: U.S. sea scallop research survey relative abundance indices (standardized stratified mean number per tow) of scallops sampled from sea scallop research surveys in the Mid-Atlantic, 1975, 1977-1981. Data are presented by principal scallop regions in the Mid-Atlantic. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height) and total scallops per tow.

		Standardized Stratified Mean Number Per Tow			
Area	Year	Number <70 mm Per Tow	Number ≥70 mm Per Tow	Total Number Per Tow	Average[1] Meat Count
New York Bight	1975	27.3	23.5	50.8	46.1
	1977	1.1	39.4	40.5	25.0
	1978	2.5	36.1	38.6	21.4
	1979	3.9	13.7	17.6	21.8
	1980	10.7	10.8	21.5	35.5
	1981	13.1	13.5	26.6	50.8
Delmarva	1975	25.2	15.6	40.8	56.7
	1977	3.3	24.0	27.3	19.7
	1978	8.3	26.0	34.3	23.3
	1979	30.8	39.3	70.1	47.3
	1980	23.4	13.3	36.7	52.5
	1981	2.8	5.9	8.7	24.4
Virginia - North Carolina	1975	47.7	10.9	58.6	83.1
	1977	0.2	0.2	0.4	34.4
	1978	15.4	7.1	22.5	69.7
	1979	4.6	6.5	11.1	44.4
	1980	0.8	4.6	5.4	32.6
	1981	0.4	0.8	1.2	23.8
Mid-Atlantic (All Areas)	1975	28.9	19.4	48.3	52.2
	1977	1.7	30.1	31.8	23.2
	1978	6.0	29.2	35.2	23.3
	1979	13.9	22.9	36.8	35.4
	1980	14.8	11.3	26.1	42.5
	1981	8.6	10.0	18.6	42.7

[1]Average meat count derived by dividing the calculated mean meat weight into 453.6 grams (1 pound).

§240 Biological Analysis of the Resource

§241 Introduction to Analytical Concepts

The concepts of fishing mortality, recruitment overfishing, growth overfishing, F(max), F(0.1) and MSY are often encountered in discussions on the biological basis for fisheries management. These concepts are briefly overviewed below.

Fishing mortality has importance for management because it is used as the basis for translating fishing activities into resource effects and providing feasible management options in view of the biology and condition of the resource in question. Fishing mortality (F) may be generally defined as the rate at which the number of fish in a year class will decrease as a result of fishing.

Two major aspects of fishing mortality are important for resource management. First, on an annual basis, the fishing mortality rate translates into the proportion of a year class which is caught (the exploitation factor). The higher the exploitation factor, the more rapid is the removal of year classes from the fishable stock; as a consequence, the fishery becomes increasingly dependent on recent recruitment. Further, rapid harvesting of year classes on a continuing basis is only feasible if recruitment is maintained. However, because recruitment is partially dependent upon there being a sufficient number of spawners in the stock, a high exploitation factor which allows fish to be caught before they have contributed adequately to spawning may seriously impair the stock's recruitment potential. This condition is known as "recruitment overfishing."

Second, year classes entering a fishery exhibit species-specific growth and natural mortality characteristics. Slow growing species (e.g., redfish or scallops) will produce their maximum harvestable biomass (average biomass gain due to growth in relation to average biomass loss due to natural death) at an advanced age, whereas rapid-growing or short-lived species (e.g., herring or squid) will reach their maximum harvestable biomass at an early age. These biological characteristics have important implications for the focus (age groups caught) and intensity of fishing mortality. Fishing mortality directed at too young fish may result in their being taken before they grow, thereby foregoing potential yield. This condition is known as "growth overfishing." Fishing mortality directed only at older fish may result in lost yield due to natural mortality.

Fisheries managers have at their disposal a wide range of measures (e.g., gear configuration, area closure, catch control, effort control, etc.), all of which, by design or in effect, influence fishing mortality. Some measures (i.e., gear configuration, minimum size) help to focus fishing mortality on the most productive age groups, or ensure that most fish reach sexual maturity before being caught. Other measures (i.e., catch control, effort control or area closures) assist in controlling the intensity of fishing mortality on whatever age groups are subject to capture. Fisheries managers will often find it appropriate to use a combination of measures which are tailored to the biological characteristics of the species and which make it possible to maintain adequate spawning potential while achieving a desired level of long-term average yield.

Two standard reference points for fishing mortality have been identified by fisheries scientists as having specific value for management, F(max) and F(0.1). These reference values relate specifically to the intensity of fishing on all age groups in the stock which are fully capable of being caught. F(max) refers to that level of exploitation (fishing intensity) which would theoretically result in the greatest individual yield from an average recruiting fish for as long as it is vulnerable to capture in the fishery (referred to as maximum yield per recruit).

F(max) for a population of fish is determined by the biological characteristics of growth and natural mortality, and by the age or size at which fish become subject to fishing-induced mortality (i.e., death due to catch or discard). F(max) does not relate directly to the level of annual recruitment, nor is it sensitive to the variable nature of recruitment. Rather, it serves for a guideline for deriving the greatest amount of yield from whatever recruitment happens to currently characterize the fishery. Therefore, total yield from a fishery maintained at F(max) may vary considerably from year to year.

Recognizing that fishing to achieve maximum yield per recruit [i.e, fishing at F(max)] increases the potential for fishing the stock down and negatively affecting future recruitment, fisheries scientists have formulated the fishing mortality index, F(0.1). Although F(0.1) has a technical definition, in practice it represents a level of fishing mortality below F(max) that results in only a small reduction in yield per recruit, but that is believed to meaningfully reduce the risk of recruitment overfishing. Further, fishing at the F(0.1) index level, relative to fishing at F(max), results in older year classes remaining in the fishery longer, thereby providing the fishery with a buffer to uncertain and variable recruitment, and enhancing the fishery's ability to "ride out" periods of below average recruitment.

Maximum sustainable yield (actually, maximum long-term average yield) is achieved at a fishing mortality rate [F(MSY)] that achieves a balance between long-term (stock-related) prospects for recruitment and maximum yield per recruit. F(MSY) may be equivalent to F(max) where stock abundance is not believed to affect recruitment (i.e., recruitment is influenced by environmental factors). However, it is more likely that F(MSY) is approximated by F(0.1), because the latter is better suited to maintaining an adequate spawning stock in the long run.

Biological analyses of each of the major resource areas are provided in the following sections. These analyses are presented in terms of yield-per-recruit (Paulik and Gales, 1964) and serve to illustrate the effects of management measures which control age at first capture or fishing mortality on the productivity of each of the major resource components. The information presented in §242-§243 below is integrated into an analysis of alternative management strategies in §710.

§242 Yield Per Recruit Analyses

Offshore Gulf of Maine

The following growth equation reported in Serchuk and Wood (1981) is considered herein to be representative of Gulf of Maine sea scallops in the offshore waters less than 60 fathoms:

$$L_t = 174.32\ [1 - e^{-0.2202\ (t-1.2383)}]$$

where the shell height dimension (L_t the distance from the umbo to the shell margin in millimeters) at age, t (in years), increases at a continuously decaying exponential rate as it approaches a terminal shell height of about 174.32 millimeters (6.86 inches).

The preliminary relationship for offshore sea scallops between the shell height dimension (L) and the weight (W, grams) of the edible portion, the adductor muscle, is:

$$W = 1.322 \times 10^{-6}\ L^{3.481}$$

indicating that the terminal (asymptotic) value for the weight of the adductor muscle is about 83.98 grams (2.96 ounces).

Using additional information given in Table 241, yield per recruit curves were drawn for a series of ages at first capture (expressed in terms of meat count). The curves illustrated in the top half of Figure 241 show the relationship between yield per recruit (Y/R) and the fishing mortality rate. The curves indicate that Y/R increases with increased age at first capture (decreasing meat count) and decreasing fishing mortality rate to the level of F(max).

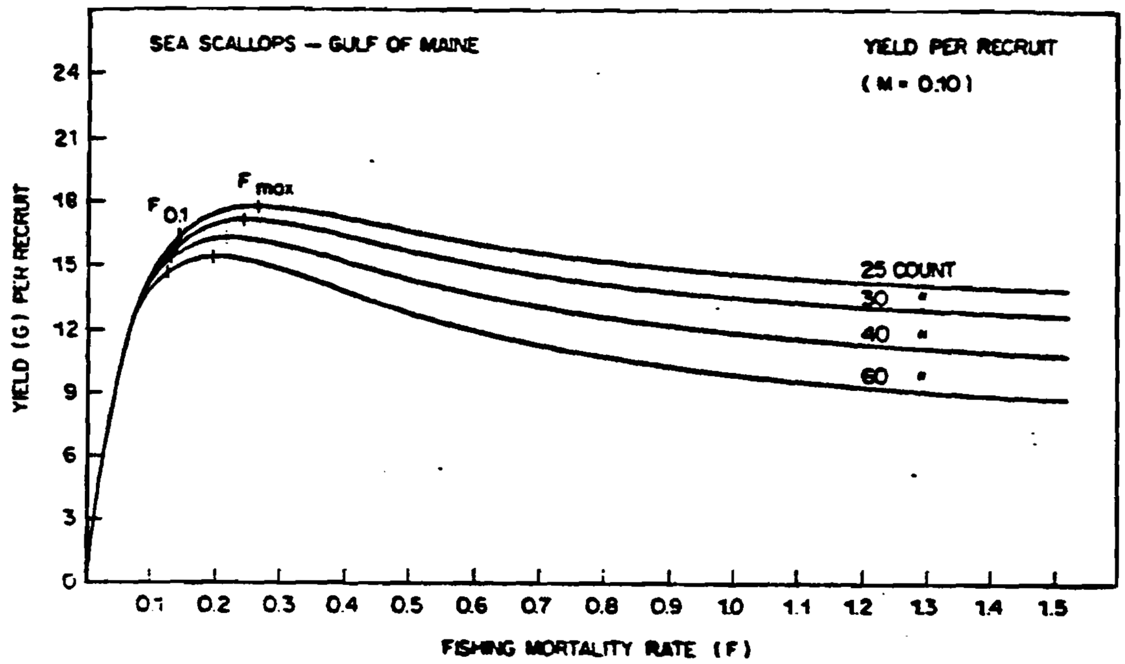
Current levels of fishing mortality in this deep-water fishery in the Gulf of Maine are unknown. However, the Y/R analysis illustrates the sensitivity of yield per recruit to the prevailing fishing mortality rate, particularly at the higher meat counts. It is noted that due to the apparent transient nature of this resource component, enhancement of long-term yield through management control on fishing mortality will accrue only if recruitment is adequate to support a continuing fishery over a number of years. Present information suggests that recruitment to these beds may be only a periodic phenomenon resulting from unpredictable environmental conditions.

Table 241: Assumed Values for all Parameters Used in the Beverton-Holt Yield Per Recruit Analysis

Parameter	Gulf of Maine	Georges Bank	Mid-Atlantic
W_∞ (asymptotic weight)	83.983 gm	61.849 gm	67.066 gm
K (catabolic growth coefficient)	0.2202	0.3374	0.2997
t_0 (hypothetical age at zero length)	1.2383 yr	1.4544 yr	1.1256 yr
t_ρ (age at recruitment)	2.0 yr	2.0 yr	2.0 yr
t_ρ' (age at first capture)			
meat count = 25/lb.	5.928 yr	4.828 yr	4.799 yr
meat count = 30/lb.	5.527 yr	4.496 yr	4.451 yr
meat count = 40/lb.	4.994 yr	4.069 yr	3.998 yr
meat count = 60/lb.	4.393 yr	3.604 yr	3.500 yr
t_λ (maximum age in the fishery)	20.0 yr	20.0 yr	20.0 yr
M (natural mortality rate)	0.1	0.1	0.1

Value of F(max) Corresponding to Alternative Sizes at First Capture (Meat Count) in the Gulf of Maine Offshore Fishery

Meat Count	Approx. Value of F(max)
25	0.27
30	0.25
40	0.22
60	0.20



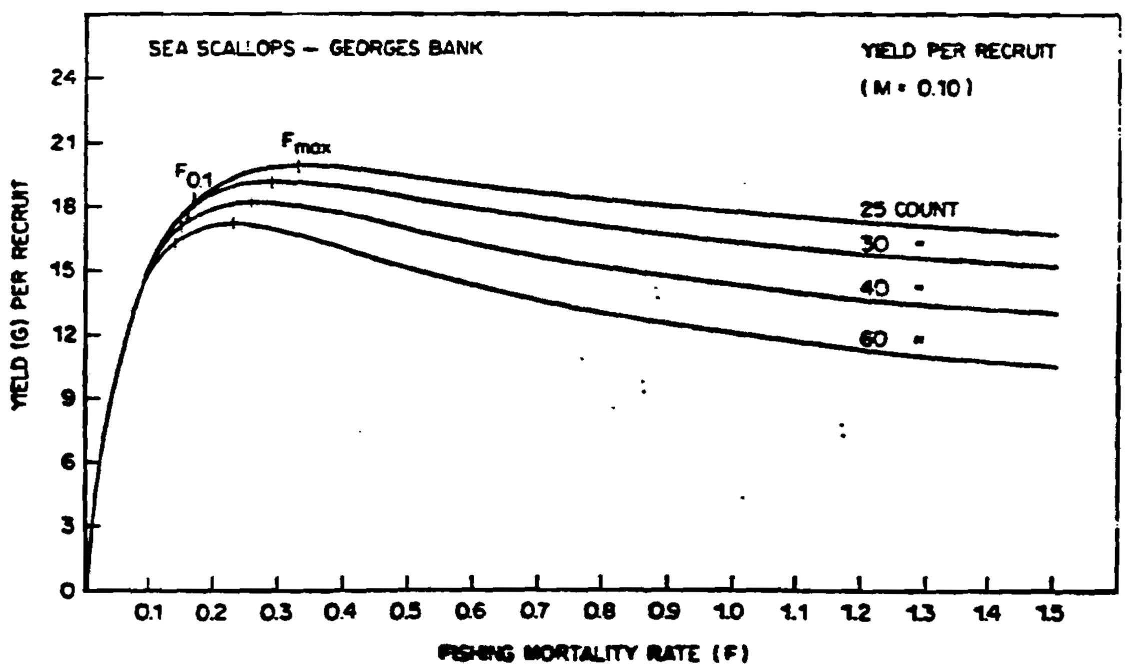


Figure 241: Yield per recruit curves for offshore Gulf of Maine and Georges Bank sea scallops at four levels of meat count (equivalent to age at first capture). Natural mortality assumed, M = 0.10.

Georges Bank

The average growth curve for Georges Bank sea scallops (from Serchuk and Wood, 1981) is:

$$L_t = 152.46\ [1 - e^{-0.3374(t-1.4544)}]$$

where the asymptotic shell height dimension is 152.46 millimeters (6.002 inches). The relationship between the shell height (L) and the weight (W, grams) of the adductor muscle is:

$$W = 7.249 \times 10^{-6}\ L^{3.175}$$

indicating that the asymptotic value for the weight of the adductor muscle is 61.85 grams (2.18 ounces).

The resulting relationship between yield per recruit and the fishing mortality rate is shown in the bottom half of Figure 241. Yield per recruit curves have been drawn for a variety of ages at first capture (expressed in terms of meat count) to illustrate its effect upon the shape of the curve. The curves indicate that the value of Y/R increases with increasing age at first capture (decreasing meat count) and decreasing fishing mortality rate to the level of F(max). It is also seen that the value of F(max) increases with decreasing meat count suggesting higher allowable rates of exploitation with increasing age at first capture (decreasing meat count).

Values of F(max) Corresponding to Alternative Sizes at First Capture (Meat Count) in the Overall Georges Bank Fishery

Meat Count	Approx. Value of F(max)
25	0.33
30	0.29
40	0.26
60	0.23

As an additional point of reference, it may be noted that the estimated value of the long-term mean fishing mortality rate for Georges Bank (see Appendix 4) is about F=0.7 implying that substantial improvement in the yield per recruit could be realized through management control on fishing mortality.

Mid-Atlantic

The mean growth curve for sea scallop populations from off North Carolina to the New York Bight (from Serchuk and Wood, 1981) is:

$$L_t = 151.84\ [1-e^{-0.2997(t-1.1256)}]$$

indicating that the absolute rate of growth for Mid-Atlantic populations is slightly slower than that for Georges Bank sea scallops and that the asymptotic shell height dimension, 151.84 millimeters (5.98 inches) is slightly smaller, although the difference is probably not significant.

The shell height dimension (L), meat weight (W) relationship is:

$$W = 5.929 \times 10^{-6} L^{3.234}$$

Thus, meat weight at a given shell dimension is somewhat higher among Mid-Atlantic scallops as compared to those from Georges Bank and the Gulf of Maine. For example, a 100 millimeter scallop (3.94 inches) from the Mid-Atlantic would yield an average meat weight of 17.38 grams (0.61 ounces) and a meat count of about 26 per pound. On Georges Bank, such a scallop would yield an average meat weight of 16.21 grams (0.57 ounces) for a meat count of about 28 per pound. Among deep water scallops in the offshore Gulf of Maine the comparable yield is 12.13 grams (0.43 ounces) and a meat count of about 37 per pound.

Utilizing the values for the yield per recruit parameters given in Table 241 the curves shown in Figure 242 illustrate the relationship between yield per recruit and fishing mortality rate for a range of ages at first capture (meat count). The value of Y/R is dependent upon age at first capture (meat count) as well as fishing mortality. Moreover, F(max) increases with increasing age at first capture (decreasing meat count).

Values of F(max) Corresponding to Alternative Sizes at First Capture (Meat Count) in the Overall Mid-Atlantic Fishery

Meat Count	Approx. Value of F(max)
25	0.31
30	0.28
40	0.25
60	0.22

The purpose of the above discussion has been to introduce the fundamental aspects of yield per recruit analysis. A more detailed elaboration of the implications of this analysis with respect to the evaluation of alternative management strategies is presented in Section 710.

§243 Fishing Mortality Rates

The historical data available from the overall commercial sea scallop fishery have not permitted quantitative estimates of absolute stock abundance. In particular, the absence of data relating specifically to catch at age has precluded the possibility of conducting virtual population analysis

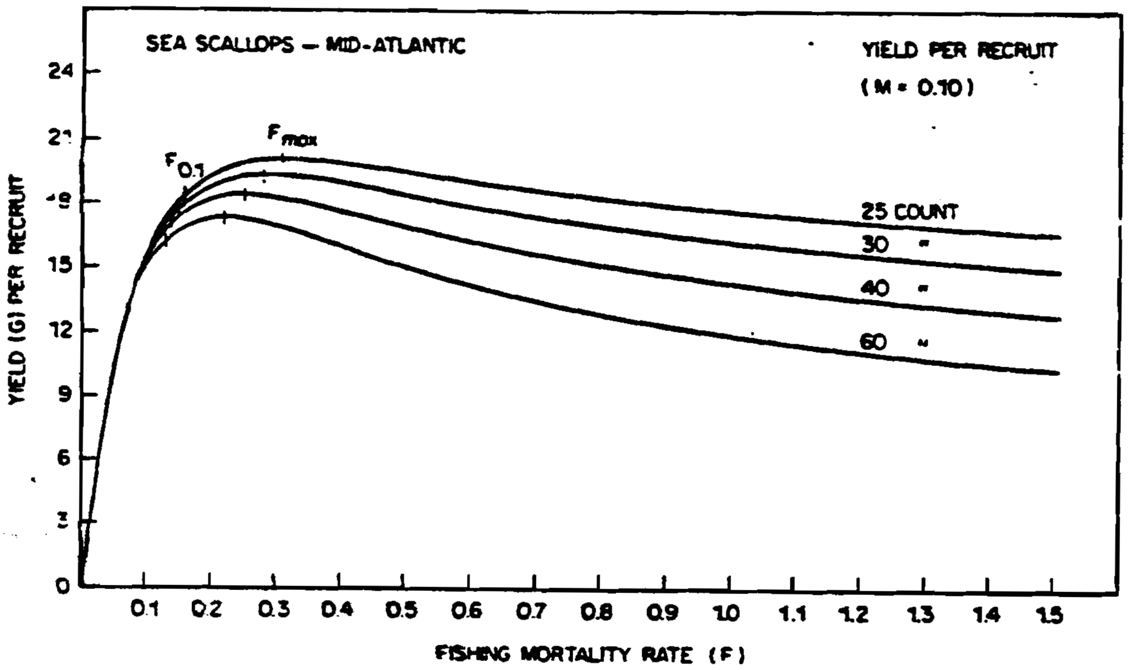


Figure 242: Yield per recruit curves for Mid-Atlantic sea scallops.

on the various resource components. Such analysis would have provided both estimates of the strength of past recruiting year classes, as well as estimates of past fishing mortality rates.

Because this information has not been available, less precise methods for estimating fishing mortality rates have been employed. Applying data from research vessel surveys, Posgay (1976) generated an estimate of mean total mortality (Z, which includes both fishing mortality, F, and natural mortality, M) for the period 1958-1963 in the Georges Bank fishery of Z=0.80. Using an earlier estimate of natural mortality, M=0.10 (Merrill and Posgay, 1964), the resultant fishing mortality over that period probably averaged F=0.70. As a consequence of record high levels of fishing effort in recent years, fishing mortality may have reached as high as F=1.0.

Therefore, while data are not available for precisely estimating recent fishing mortality levels, other methods suggest that over the past 25 years on Georges Bank fishing mortality rates may have averaged substantially higher than F(max) (i.e., F=0.3). It is noted that the above estimates of fishing mortality rates are applicable to Georges Bank as a whole. They do not reflect the fact that localized high densities of sea scallops may attract highly concentrated fishing effort and very high, localized F values. Although there are no estimates of fishing mortality rates in the Mid-Atlantic area, the rapid decline of year classes (such as the recently dominant 1972 year class in the 1976-1978 Mid-Atlantic fishery) suggests that fishing mortality rates in this area have also substantially exceeded the F(max) level.

With fishery resources such as sea scallops where target levels of catch consistent with the current status of the resource cannot be readily calculated, then the existence of a relationship between fishing effort and fishing mortality provides a potentially useful approach to achieving long-term resource productivity goals. The latter approach relies on the availability of comprehensive effort data throughout the fishery, as well as an understanding of the relationship between gear effort and fishing mortality in the various resource areas. However, through the use of various simplifying assumptions, this approach has the advantage of controling fishing mortality to desired levels while still allowing the industry to take advantage of fluctuations in resource abundance which would otherwise be difficult to respond to in a catch control program.

§244 Assessment of Maximum Sustainable Yield

The Magnuson Fishery Conservation and Management Act (MFCMA), as amended, requires an assessment of the maximum sustainable yield (MSY). The methods used for estimation of MSY require a long time series of accurate fisheries statistics. Ideally, such statistics cover a broad range of annual catches and stock sizes which, implicitly, account for the effects of an entire spectrum of environmental conditions and the total range of the strength of recruiting year classes. Any stock-recruitment relationship is also implicitly accounted for. A considerable quantity of annual catch and effort data are available from the sea scallop fisheries but attempts to fit these data to production models for the purpose of assessing MSY have not been entirely successful. Sea scallop populations are apparently subject to extremely variable recruitment which tends to mask the stock-recruitment relationship inherent to successful production modeling.

Bevan (1980) recently observed that a number of possible methods exist for estimating maximum sustainable yield (MSY) as required by the MFCMA, and these are not limited to stock production and dynamic pool analyses. Perhaps the simplest approach which Bevan suggests is to calculate average catches for historical periods which fish stocks appeared to be stable (i.e., periods when recruitment also appeared to be relatively stable). This approach was taken with sea scallops. The historical data were partitioned between periods when catches were stable at relatively low levels (implying low levels of recruitment), as distinct from periods of high catch levels supported by exceptionally strong recruitment. The weighted mean catch level resulting from such treatment of the data was taken to represent an approximation of the MSY. The derived estimate of MSY, being sensitive to the historical fishing practices which probably do not represent biological optima, may not reflect the true potential yield from the resource nor does it reflect the expected annual yield given the extreme variability in sea scallop recruitment.

Gulf of Maine

Prior to the winter of 1979-80, the major component of U.S. catches of sea scallops in the Gulf of Maine were taken along the coast of Maine. At that time, an additional fishery developed in the Jeffrey's Basin-Cashes Ledge area which is thought to be based principally upon recruitment from the 1975 year class (Schick, 1981). The maximum catch level from the coastal Maine fishery reached about 900 MT in 1910, and has averaged about 250 MT since 1962.

It is likely that MSY for the total U.S. fishery in the Gulf of Maine is not significantly different from the long-term average catch level from the coastal Maine area (i.e., about 320 MT) recognizing that phenomena such as the Jeffrey's Basin-Cashes Ledge fishery probably reflect sub-optimal exploitation conditions.

Georges Bank

The relationship between total landings (U.S. and Canada) and total fishing effort in the Georges Bank sea scallop fishery suggests that during periods when the level of recruitment was not outstanding a relatively stable equilibrium appears to have been established. Since 1946 data from all years except 1959-1964 and 1976 to the present appear to be consistent with a parabolic surplus production curve with a maximum level of about 8,000 MT. On the other hand, the average total catch over these 24 years was 6,214 MT and 8,700 MT over the entire 35 year period.

The mean of the total annual landings from Georges Bank during the above two periods of exceptional recruitment was 14,071 MT. These periods of high annual landings comprise about 31% of the total span of time since 1946. Therefore, assuming that 14,071 MT is not an unreasonable estimate of the average surplus production available during periods of exceptional recruitment, a weighted mean (taking into account the relative lengths of the periods showing "average" and "exceptional" recruitment) estimate of the maximum long-term average annual surplus production is about 9,800 MT. Therefore, MSY in Georges Bank is likely within the range of 9,000-10,000 MT.

Because there is considerable variability in the estimated value of MSY, it should not be construed as a limit, nor is it reasonable to necessarily expect such levels of harvest on an annual basis, given expected fluctuations in recruitment. The estimated MSY should be viewed as having relevance only in the context of long-range management.

Mid-Atlantic

Given the variability in annual catches from the Mid-Atlantic resource area, it appears doubtful whether a meaningful estimate of potential yield could be developed for this segment of the fishery. Typical low-level catches in the order of 1,000 MT have historically increased abruptly to about 8,000 MT for 1-4 years before declining to the mean low level again. Nevertheless, over the 20 year period 1961-1980, Mid-Atlantic catches have averaged about 3,800 MT, and this value may represent the current best estimate of MSY. It is probable that under more optimal exploitation conditions (age at entry increase and/or fishing mortality decreased), substantially higher average catch levels could be derived from the Mid-Atlantic resource.

With the improvement of data collection systems and the development of a longer time series of historical data, it may be possible in the future to make estimates of the maximum sustainable yield for the Mid-Atlantic sea scallop fishery based upon a more meaningful biological analysis.

PART 3: THE SEA SCALLOP FISHERY

§310 History of the Commercial Fisheries

The commercial harvest of Atlantic sea scallops has occurred somewhere along the continental shelf from the Gulf of St. Lawrence to Cape Hatteras since the late 1800's, but heavy exploitation of the most productive beds did not begin until after World War II. Four events in the development of the fishery have historic significance.

(1) The discovery and exploitation of scallops on Georges Bank, which began in the 1930's, opened up a major production area and provided incentive to develop offshore scallop fleets. The result has been heavy exploitation of offshore sea scallop beds throughout the northwest Atlantic. Total U.S. and Canadian landings from the offshore New England grounds have grown from a few hundred metric tons in early years to a peak production of nearly 18,000 MT of meats in 1977.

(2) Another significant event was the development of the offshore Canadian scallop fleet in the 1950's, which operated primarily on the scallop grounds of eastern Georges Bank.

(3) A third event was the periodic heavy exploitation, beginning in the early 1960's and again from 1975-79, of sea scallop beds along the Mid-Atlantic shelf. Landings of meats from this region have, over the past 20 years, fluctuated from year to year by as much as a factor of 8.

(4) Dramatic increases occurred in the ex-vessel prices of sea scallops during the late 1970's. These increases occurred despite near record levels of supply during 1978 and 1979.

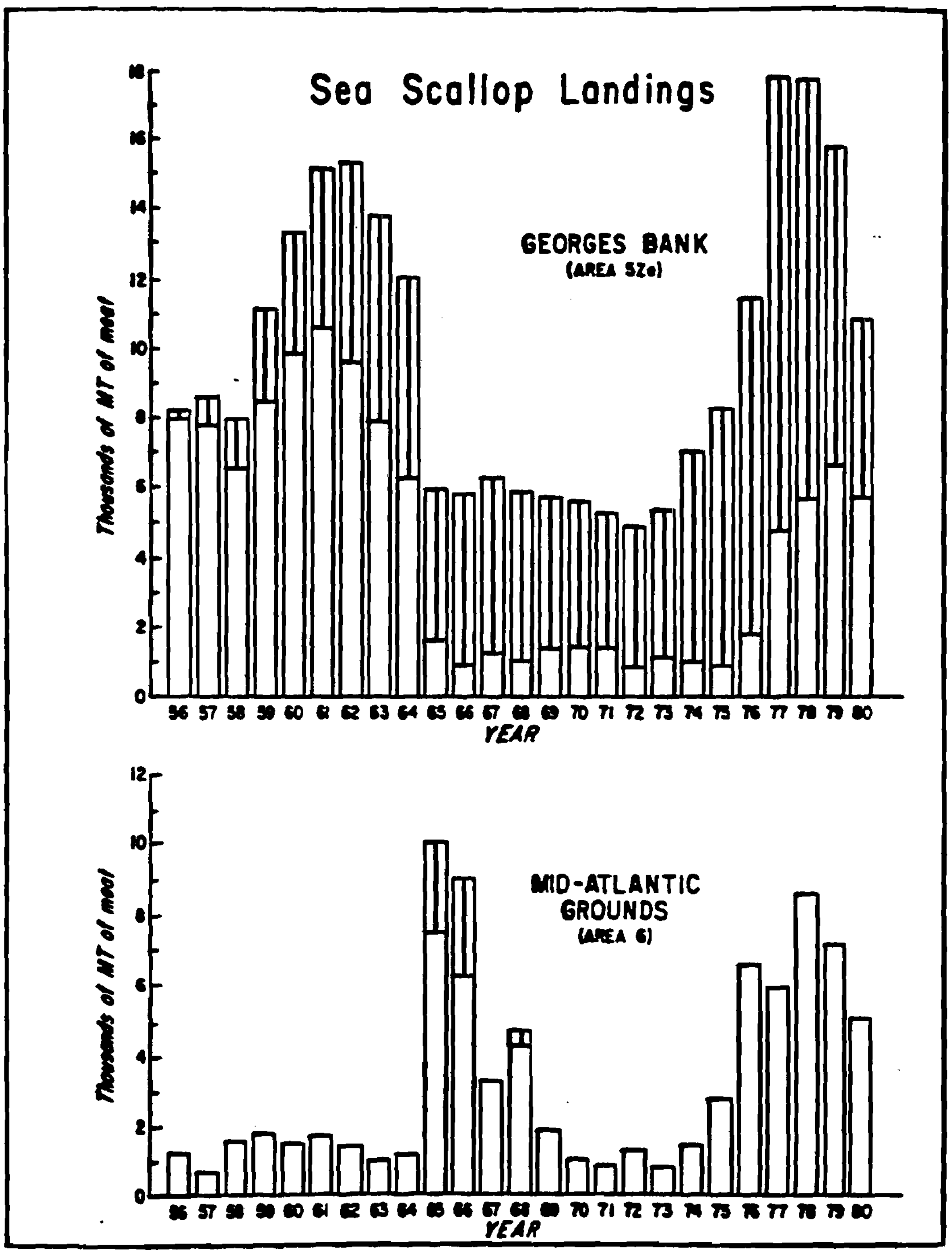
From the early 1940's up to 1959 the New England scallop fleet, primarily the New Bedford fleet, operated under industry sponsored effort restrictions. These restrictions included a per man/trip catch limitation, maximum crew size, maximum trip length, and a mandatory layover period.

By 1959, the main thrust of both the Canadian and U.S. offshore scallop fleets was on Georges Bank and a period of heavy exploitation of the scallop beds in that area occurred between 1959 and 1965 (Figure 311 and Table 311). Total annual landings from 1959-1964 averaged about 13,500 MT.

In 1965 a number of events led to a reduced U.S. effort in the eastern part of Georges Bank. The abundance of scallops had been declining, and more individual vessel effort (with accompanied higher production costs) was needed to maintain profitable catch levels. At the same time, productive scallop beds were developing in the Mid-Atlantic in areas that were accessible to the U.S. offshore fleet. Finally, the price of finfish at that time began to climb, providing an incentive for fishermen to convert from scalloping to dragging. The result was not only the virtual abandonment of the scallop beds on eastern Georges Bank by the U.S. fleet, but a reduction in the size of the

Figure 311: Annual Landings of Sea Scallop Meats 1956 - 1980

The clear portion of the bars represents U.S. landings; the shaded portion, Canadian landings.



Source: NMFS, Northeast Fisheries Center, 1981 Sea Scallop Assessment.

Table 311: U.S. and Canadian landings (MT meats), effort (days fished), and catch per unit of effort (CPUE) (MT landed of meats per days fished) from the Georges Bank sea scallop fishery, 1944 - 1980.

	Landings (MT meats)			Effort (Days Fished, Unadjusted)			Nominal CPUE (MT/days Fished)	
Year	U.S.	Canada	Total	U.S.[1]	Canada[2]	Total[3]	U.S.	Canada
1944	1,814	—	1,814	2,223	—	2,223	.816	—
1945	1,769	—	1,769	2,391	—	2,391	.740	—
1946	4,036	—	4,036	4,934	—	4,934	.818	—
1947	4,853	—	4,853	6,434	—	6,434	.754	—
1948	4,580	—	4,580	7,613	—	7,613	.602	—
1949	5,306	—	5,306	8,428	—	8,428	.630	—
1950	5,442	—	5,442	7,349	—	7,349	.741	—
1951	5,714	91	5,805	7,626	123[4]	7,749	.749	.740
1952	5,488	91	5,579	7,742	128[4]	7,870	.709	.711
1953	7,392	136	7,528	10,031	185[4]	10,216	.737	.735
1954	7,029	91	7,120	9,343	121[4]	9,464	.752	.752
1955	8,299	136	8,435	11,619	190[4]	11,809	.714	.716
1956	7,937	317	8,254	12,246	490[4]	12,736	.648	.647
1957	7,846	771	8,617	10,500	1,197	11,697	.747	.644
1958	6,531	1,470	8,001	8,775	1,598	10,373	.744	.920
1959	8,481	2,721	11,202	8,556	2,098	10,654	.991	1.297
1960	9,932	3,390	13,322	8,039	2,601	10,640	1.235	1.303
1961	10,660	4,549	15,209	8,671	3,147	11,818	1.229	1.446
1962	9,690	5,694	15,384	8,959	4,642	13,601	1.082	1.227
1963	7,910	5,877	13,787	7,718	5,905	13,623	1.025	.995
1964	6,241	5,901	12,142	6,662	6,723	13,385	.937	.878
1965	1,483	4,418	5,901	2,095	5,749	7,844	.708	.768
1966	884	4,861	5,745	1,056	5,524	6,580	.837	.880
1967	1,221	5,001	6,222	1,870	6,785	8,655	.653	.737
1968	1,025	4,805	5,830	1,854	6,972	8,826	.553	.689
1969	1,325	4,302	5,627	2,715	6,684	9,399	.488	.644
1970	1,415	4,082	5,497	2,563	7,615	10,178	.552	.536
1971	1,329	3,894	5,223	2,443	7,688	10,131	.544	.518
1972	821	4,146	4,967	1,804	8,264	10,068	.455	.502
1973	1,080	4,208	5,288	1,872	8,082	9,954	.577	.521
1974	925	6,115	7,040	1,404	8,185	9,589	.659	.747
1975	857	7,387	8,244	1,110	8,415	9,525	.772	.878
1976	1,761	9,726	11,487	1,766	7,324	9,090	.997	1.328
1977	4,805	13,044	17,849	4,514	8,601	13,115	1.064	1.517
1978	5,569	12,189	17,758	5,862	8,556	14,418	.950	1.425
1979	6,573	9,208	15,781	9,245	8,823	18,068	.711	1.044
1980	5,620	5,239	10,859	11,263	6,838	18,101	.499	.766

[1]U.S. effort for 1944-1964 taken from Caddy (1975); U.S. effort for 1965-1980 derived from NMFS Detailed Weighout files by calculating annual mean catch rates, weighted by the percentage of U.S. Georges Bank landings accounted for within each of three vessel classes (5-50 GRT; 51-150 GRT; 151-500 GRT) in relation to vessel class CPUE, and dividing the derived annual mean catch rate into the total U.S. Georges Bank sea scallop annual landings.

[2]Canadian effort for 1944-1974 taken from Caddy (1975); Canadian effort for 1975-1980 derived from effort data provided to NMFS by Canadian scientists.

[3]Not standardized for differences in fishing period between U.S. and Canadian sea scallop fleets.

[4]Estimated from U.S. catch per unit of effort.

offshore scallop fleet. In 1966, the New England fleet comprised about 42 vessels, or roughly one-half of the number of domestic vessels fishing for scallops in 1960. The remaining vessels fished mainly in areas of the Great South Channel and the Mid-Atlantic. After 1966 and until recently, the U.S. fleet did not operate extensively on eastern Georges Bank, and that area became a predominantly Canadian scallop ground.

By 1976, both the U.S. and Canadian landings began to rise; and in 1977 new record catches were made. The distribution of effort, however, remained the same, with the Canadians landing about 9725 and 13044 MT from eastern Georges Bank (Table 311) and the U.S. landing 8880 and 11167 MT from the Mid-Atlantic and western Georges resource areas (Table 331.3) in 1976 and 1977 respectively. In 1978 and 1979, the Canadians landed 12,189 MT and 9,208 MT, and the U.S. 14,456 MT and 14,145 MT respectively. At this time, the U.S. was also increasing its eastern Georges Bank catch by nearly 140% from less than 670 MT in 1977 to 1,600 MT in 1978, and again by 33% to 2140 MT in 1979 (Table 333.3). Since 1977 U.S. landings from Northeastern Georges Bank have increased from 9% (1977) to 34% (1980) of the total U.S. landings from the Georges Bank resource area.

Maine landings, primarily inshore since 1968, have not followed the general trend of other regional landings. In fact, while most landings in other states were moving from historical lows to highs during the seventies, Maine inshore landings reached high points in 1972 and 1975. Landings appear to have increased again in 1978/1979, and almost tripled in 1980. Maine landings are based on relatively distinct populations in embayments and estuaries along the entire coast of Maine, and occasional hot spots offshore (i.e., Jeffrey's Basin in 1979/80), independent of the major resource components. Maine landings have comprised 5.6% of the total domestic Atlantic Coast sea scallop landings during the seventies (Table 312).

Massachusetts has led the rest of the states in total sea scallop landings. These have been made primarily in the port of New Bedford where the long-distance scallop fleet is located. During the 1961-1973 period, there was a continuous decline in the total sea scallop landings in Massachusetts, with the 1973 catch about 15 percent of the 1960 catch. The number of vessels employed in this fishery declined by almost 50 percent between 1960 and 1973. This was a period of transition for the New Bedford fleet. Some of the older, less profitable scallop draggers converted to otter trawling for yellowtail flounder and many of the remaining vessels began fishing the Mid-Atlantic. In 1975, some 60 percent of the scallop landings at New Bedford came from waters off the Mid-Atlantic states (New York south to Virginia). By 1977-78, annual sea scallop landings in Massachusetts recovered to 78% of the 1960 catch; but have slipped to only 57% in 1980.

Table 312: Domestic Atlantic Coast Sea Scallop Landings (Principal States)
1960 - 1980 in Metric Tons (Meats)

Year	Maine Coastal	Maine Offshore	Maine Total	Mass.	New York	New Jersey	Virginia	North Carolina	Total
1960	42.9	807.6	850.5	9337.8	1265.5	256.7	80.3		11790.9
1961	63.6	1179.3	1247.9	9541.5	1369.9	157.9	54.9		12367.0
1962	69.5	914.4	983.9	8867.4	1232.7	44.0	16.8		11145.0
1963	81.6	456.4	538.0	7533.4	837.2	78.9	37.6		9061.1
1964	86.2	327.8	416.0	6174.4	927.2	63.5	35.8		7616.9
1965	87.2	100.6	187.8	5385.1	1323.2	860.0	523.0		8279.1
1966	99.3	45.9	145.2	4905.2	965.3	181.4	80.3		6277.4
1967	75.6	9.7	85.3	3093.1	622.3	96.6	65.8		3963.1
1968	99.8	---	99.8	3495.0	671.3	225.9	239.5		4731.5
1969	68.9	---	68.9	2238.5	270.8	142.9	625.2	6	3446.3
1970	81.6	---	81.6	1933.2	242.2	45.8	340.3		2643.1
1971	175.5	---	175.5	1791.3	182.3	50.8	247.7		2447.6
1972	438.6	---	438.6	1558.1	100.7	111.6	435.6		2649.6
1973	364.7	---	364.7	1417.0	69.4	188.7	350.7		2390.5
1974	201.9	---	201.9	1873.8	93.4	148.3	395.5		2713.0
1975	722.6	---	722.6	2405.0	122.0	322.1	574.3	191	4145.9
1976	285.4	---	285.4	5028.6	343.5	1304.4	1304.9	502	8266.8
1977	NA	NA	179.1	7396.5	278.5	1318.1	1637.5	298	11107.7
1978	NA	NA	411.9	7321.4	125.7	2160.5	3367.9	896	14283.4
1979	NA	NA	527.8	6402.5	242.9	2375.5	3444.2	768	13760.8
1980	NA	NA	1461.8	5293.8	295.3	1584.1	2736.4	391	11761.9

Source: 1952-75, USDC, NMFS (also USDI, BCF), Fishery Statistics of the U.S. (yearly issues), Washington, DC; 1976-80 from USDC, NMFS, State Landings for Maine, Massachusetts, New York, New Jersey, Virginia and North Carolina, (Annual Summaries and December issues), Washington, DC.

Until 1975, the price increases of finfish kept pace with the price increases of scallops, so that the ratio of draggers to scallopers did not change appreciably. In 1975, however, the price of scallops increased significantly above that of finfish and scallop beds were abundant in the Mid-Atlantic. This resulted in unprecedented returns to scallop fishermen and vessel owners. Draggers began converting to scalloping, so that by 1976 the number of New England scallop dredge vessels had risen to 86 from the previous year's 44 (Table 313). This trend continued from 1977 to 1979 as the number of vessels participating in the New England based scallop dredge fishery increased to 155 in 1977, dropped slightly to 133 in 1978, and again increased to 200 in 1979. Vessels that had never fished for sea scallops before, including some shellfish draggers from the South and standard draggers from New England, began fishing for sea scallops in the Mid-Atlantic, using trawl nets instead of dredges, and bringing scallops ashore unshucked (i.e. shellstock). This trend continued through 1978 and 1979.

In the Mid-Atlantic area, the sea scallop fishery has been a viable industry since the 1920's, with the majority of landings, until recently, recorded in New York. In recent years, Cape May, New Jersey, and Hampton, Virginia, have become significant operational ports. Through 1978, the Mid-Atlantic harvesting sector utilized only the Mid-Atlantic sea scallop resource. During the 1960 to 1975 period, there was a general decline in New York landings from about 1800 MT per year in 1959, to 240 MT in 1970, and a low plateau existed until 1975. In 1972, New Jersey landings began to exceed the New York landings, beginning a trend which still exists. In 1976, both New York and New Jersey showed marked increases in sea scallop landings, mostly because small scallops from recent successful recruitment began to be harvested. An exceptionally high ex-vessel price was a further inducement to increase effort on sea scallops. From 1976 to 1978, however, New York landings have steadily declined while New Jersey landings have continued to increase, especially during 1978. This may be partly due to vessels from North Carolina landing sea scallops in New Jersey during this time. In 1980, New York landings increased by 22%, while New Jersey landings declined 33%.

In the Chesapeake area, only Virginia has a significant sea scallop fishery which is concentrated in the Hampton-Norfolk area. In 1965, 37 scallop vessels operated out of Portsmouth-Hampton area, where in 1964 and previously, only two had operated. Since 1965, the sea scallop industry in Virginia has been significant, although it did not reach the 1300 MT level until 1976. Much of the 1976 increase in landings in both the Mid-Atlantic and Chesapeake areas are attributable to the harvest of small scallops from recent successful recruitment by vessels using otter trawls and which had previously operated in the groundfish and shrimp fisheries. For a short period in 1976 and 1977, minimum size limits on sea scallop meats and shells were imposed as a result of ICNAF regulations. In 1979, Virginia sea scallop landings rose to their highest level since 1960 and have been second only to Massachusetts since 1977. Virginia landings slipped by 20% in 1980.

In North Carolina, a significant scallop fishery developed in 1975 out of the port of Wanchese. By 1976, twenty-nine North Carolina vessels were

Table 313: Number of U.S. Vessels in the Atlantic Scallop Fishery 1970 - 1979

Year	No. of N.E. Scallop Dredges Participating	No. of N.E. Vessels Deriving Major Gross Stock from Scallop Dredging	No. of Mid-Atlantic Scallop Dredges	No. of Mid-Atlantic Otter Trawl
1970	45	38	40	-
1971	47	40	33	-
1972	44	37	38	-
1973	47	42	32	-
1974	34	31	26	3
1975	44	31	20	25
1976	86	46	24	115
1977	155	105	61	62
1978	133	97	NA	NA
1979	200	125[1]	NA	NA

Source: NEFMC master file and trip file, U.S. Fishery Statistics.

[1]Does not include vessels operating only in the Gulf of Maine.

fishing scallops, with modified calico scallop trawls, from Cape May, New Jersey to Chincoteague, Virginia and landings reached 500 MT of scallop meats. Most of the vessels concentrated on taking shellstock for shore based shucking in North Carolina. Because of the relatively small mesh of the trawls, all sizes of scallops were taken and the shore based shucking operations were able to handle all sizes profitably. Landings dropped in 1977, possibly attributable to some North Carolina vessels landing in New Jersey (of which unknown amounts may have been trucked back to North Carolina for processing) but increased significantly in 1978. North Carolina landings maintained high levels through 1979, but dropped almost 50% in 1980.

§320 Recreational Fisheries

Recreational activity for sea scallops is extremely limited, and there are little or no existing data on these activities. The cost of dredges, nets and other equipment necessary to fish conventionally for sea scallops makes recreational pursuit not practical for most recreational enthusiasts. The only method of retrieving sea scallops from the ocean bottom which may be characterized as practical recreational activity is by scuba diving, though not all scuba diving for sea scallops is recreational.*

The recreational activity which does take place for sea scallops is confined to populations found in relatively shallow waters (less than 100 feet), principally along inlets, bays and harbors of Maine and to a much lesser degree, in the coastal waters of New Hampshire and Massachusetts. Recreational activity for sea scallops in Southern New England** and the Mid-Atlantic is not probable since populations of sea scallops in these resource areas occur in offshore, deeper waters, not generally suitable for recreational diving.

The states of Maine and New Hampshire both have established seasons which allow the harvesting of sea scallops in state waters beginning on November 1 and ending on April 15. Most of the recreational diving for sea scallops along coastal Maine occurs during November with some activity continuing into December depending on the weather. Little or no recreational diving activity takes place from January until usually late in March where moderating weather conditions may permit increasing activity during the last few weeks of the season.*** Individuals from several states participate in this limited recreational diving activity in Maine waters. Scuba diving supply businesses and sport diving organizations, both in Maine and Massachusetts, often sponsor sea scallop diving activity which may involve chartering of local vessels to provide access to more productive areas. In addition, local fishing vessels occasionally provide access and a platform to recreational divers under various arrangements, including equal sharing of the days catch.

In recent years, sea scallops have not generally been found in high enough concentrations along coastal New Hampshire and Massachusetts to attract directed effort by recreational divers. The New Hampshire established winter season, as does Maine's winter season, may serve to deter recreational effort for sea scallops, especially since access to the most likely resource area (Isle of Shoals) is difficult during winter months. In Massachusetts coastal waters, sea scallops are taken incidentally by recreational divers engaged in the extensive, permitted recreational lobster fishery. There is considerable direct recreational effort and catch of bay scallops (_Argopecten irradians_) in coastal Massachusetts waters and in the coastal waters south of Massachusetts. Bay scallops are not included in the management unit of this FMP.

* Commercial diving operations for sea scallops have developed along coastal Maine and are pursued throughout the fishing season.
** South of Cape Cod.
*** Confirmed by personal communication with Daniel Schick (Maine DMR).

The Northeastern Regional Survey of Recreational Fishing in Saltwater (1973-1974) collected data which allows estimates of the recreational catch of shellfish by species group and state. Because of severe methodical problems, extreme caution is urged when using data from this survey. Based on unpublished data from this survey,* an estimated 16,000 pounds of scallops** (live weight with shell) were caught recreationally in Maine during 1974. No scallops are estimated to have been caught recreationally in New Hampshire during 1974. It is estimated that 1,042,000 pounds of scallops were caught recreationally in Massachusetts, an unknown (but probably insignificant) amount of which may have been sea scallops.

Existing state regulations affecting the commercial harvesting of sea scallops (see §420) also apply, where applicable, to recreational activity. In addition to these regulations, Maine provides a recreational catch limit of 1 gallon of shucked meats per day (2 bushels unshucked). New Hampshire does not allow a tolerance for undersized sea scallops when the method of retrieval is by diving.

Should the states enact regulations complementary to this FMP, it is anticipated that recreational activity will be further impacted only by an increase in minimum size should such a measure be adopted. Since it is possible and practical to be selective when retrieving sea scallops by diving, there is no need for a tolerance for undersized scallops when this method is pursued.

§330 Economic Analysis of the Atlantic Sea Scallop Fisheries

The following sections include the results of an analysis of the structure of the fisheries, the harvesting and processing capacity, recent trends in the near future of the fisheries, and a summary.

§331 Structure of the Fisheries

Resource Bases

The U.S. Atlantic sea scallop fishery is based on three resource components; the Gulf of Maine, Georges Bank, and the Middle Atlantic

The following estimates are provided through:

* Personal communication with David Deuel, NMFS.

** The survey did not distinguish between sea scallops/bay scallops, but it is known that bay scallops do not occur in coastal Maine waters. For general information only and recognizing that opinions may vary, it is offered that a proficient recreational scuba diver, in a reasonably productive resource area, may harvest in the vicinity of ten pounds (shucked meats) per standard dive.

populations. The Gulf of Maine resource has been relatively insignificant in its contribution to Atlantic sea scallop landings, whereas the other two populations (i.e., Georges Bank and Middle Atlantic) have played important roles in the Atlantic sea scallop fisheries. The catch from the Gulf of Maine in 1977, for example, was 258 MT, accounting for only about 2% of the total U.S. Atlantic sea scallop catches (Serchuk, et al, 1979). This trend continued during 1978-1979 (i.e., 2-3%), but Gulf of Maine landings increased to 13% in 1980, due to the increase in activity in the Jeffrey's Ledge area of the Gulf.

The Georges Bank population inhabits three areas: the Northern Edge and Northeast Peak, the Southeast part, and the South Channel. Among these areas, the South Channel area has been recently the most significant area, in terms of effort and landings, of the U.S. sea scallop fisheries. The catch from this area (4122 MT) accounted for 86% of the catch from the Georges Bank population in 1977. However, South Channel catches have declined to only 54% in 1980 of the catch from the Georges Bank population, whereas Northeast Georges catches climbed from 9% in 1977 to 34% in 1980. The Northeast and Southeast areas have been major offshore production areas in the past; the catches from these two areas in 1960 accounted for 82% of the catch from the Georges Bank population (Serchuk, et al, 1979).

It is noted that Georges Bank sea scallops had been the traditional sea scallop resource for the U.S., until the development of the offshore Canadian scallop fleet in late 1950's. As a result of Canadian competition for this resource, especially in the Northern Edge and Northeast Peak areas, and the development of productive grounds in the Middle Atlantic area, the U.S. fleet began to heavily exploit the Middle Atlantic sea scallop population.

Landings at New England ports from the Middle Atlantic resource component varied considerably from 274 MT to 3947 MT during the period 1965-1977, and have since declined to historical lows (262.8 MT) in 1980. The total U.S. catch (including landings in Mid-Atlantic ports) from this population was 6426 MT in 1976, and 5318 MT in 1980, or 72% and 42% respectively of the total U.S. sea scallop landings (Tables 2.2 and 2.1.6 in Appendix 2).

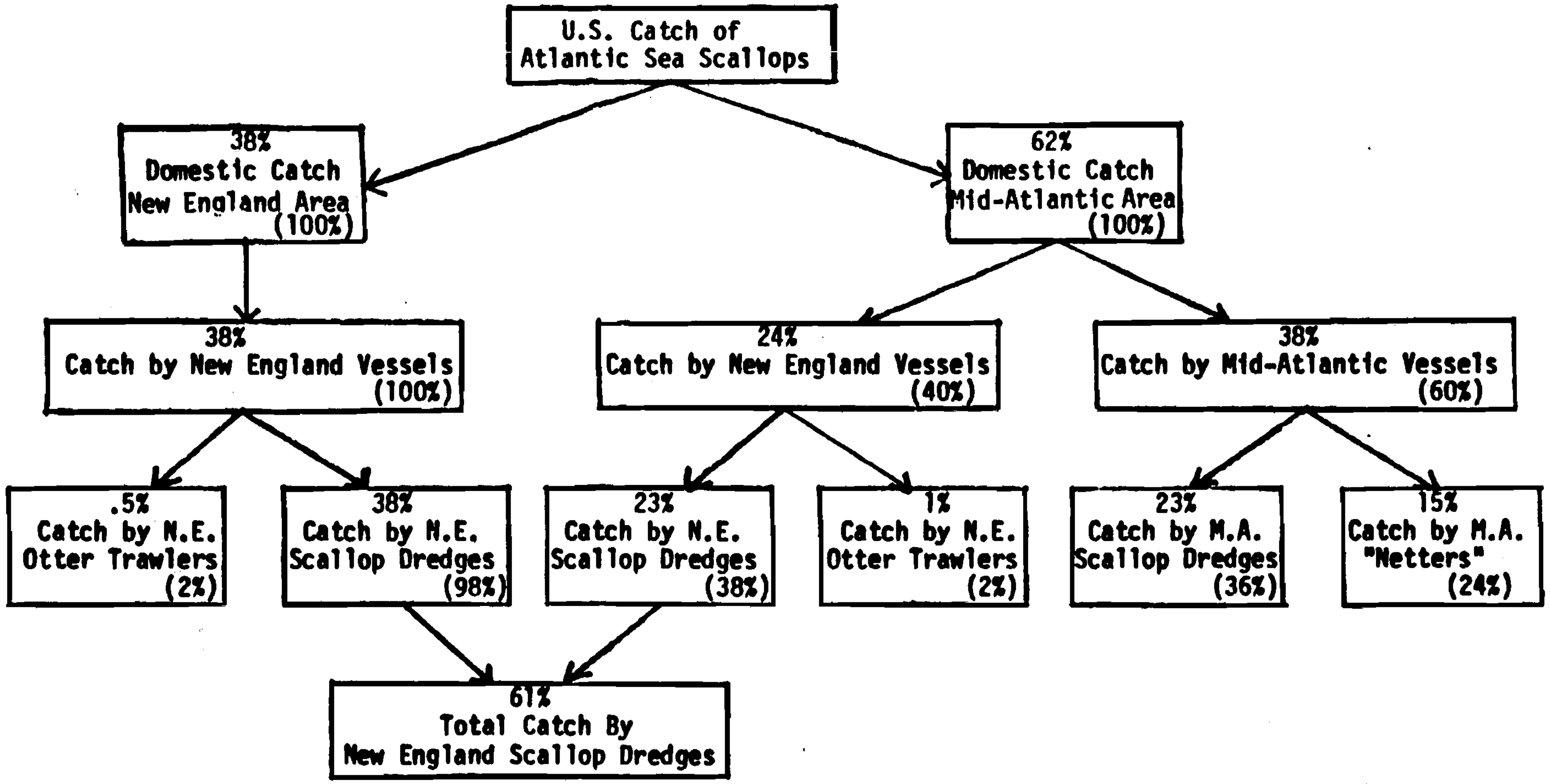
The Domestic Harvesting Sector

As illustrated in Figure 331.1, the harvest of the sea scallop resource is associated with four separate sectors. They are:

(1) The New England based scallop dredge sector utilizing the New England as well as the Mid-Atlantic scallop stocks. This fishery in recent years (1975-78) has accounted for over 60% the total domestic scallop landings.

(2) The Mid-Atlantic based scallop dredge sector utilizing exclusively the Mid-Atlantic scallop resource, until recently when some of these vessels may have landed scallops from the Georges Bank resource area. This fishery has in recent years contributed 23 percent to the total domestic landings in the region.

FIGURE 331.1 PERCENT OF DOMESTIC SCALLOP CATCHES HARVESTED BY INDIVIDUAL FLEET SECTORS (Average for Period 1975-1978).



Note: Percentages shown in parentheses refer to utilization by fleet sectors within each area.

Source: NMFS, unpublished data.

(3) The Mid-Atlantic based otter trawl sector utilizing seasonally the Mid Atlantic scallop resource and accounting for 15 percent of total domestic scallop landings in recent years.

(4) The New England based otter trawl sector harvesting scallops from the New England resource, largely incidentally while fishing for groundfish, and utilizing to a limited degree the Mid-Atlantic scallop resource. The annual landings from this fishery have in recent years averaged less than two percent of total domestic landings of scallops in the region.

In terms of the number of vessels participating, the New England scallop dredge fishery clearly dominates the Mid-Atlantic fisheries (Table 331.1.). The nature of these three fisheries, as well as the structure and performance of the fleets participating, are detailed in Sections 2.1.1. and 2.1.2. of Appendix 2.

Domestic Processing Sector

Two levels of the wholesale and processing segment of the Atlantic sea scallop industry can be defined (Altobello et al, 1977; McHugh et al, 1978). The first level is comprised of those firms which purchase the sea scallops as landed, already processed as shucked onboard the vessels. These firms act primarily as shipping agents which supply the firms of the second level with raw material which they process into finished products (Figure 331.2).

In New England, these buyers ship a good portion of their sea scallops in the same form as they are received ex-vessel - fresh and packed in bags of forty pounds each - to the large second level seafood processing firms in New York, Pennsylvania, and the Boston area. The sea scallops that are not sold fresh are washed, packed in five-pound cartons, frozen, and shipped out in that form.

In the New York-New Jersey area, some sea scallops are landed as shellstock and are immediately processed into shucked meats. These shucking plants and the buyers of fresh shucked meats then transport the scallops whole, fresh, and in 100 pound boxes to New York, Philadelphia, and local markets, where they are further processed or sold fresh.

In the Virginia-North Carolina region, sea scallops are landed both as shellstock and shucked. The shellstock is processed into shucked meats. A minimum amount of these shucked meats are shipped to plants in Massachusetts, Pennsylvania, Georgia, Florida, or Louisianna for further processing. After they are received by the second level processing firm, most sea scallops are further processed primarily by breading either cooked or uncooked.

Another major source of sea scallops for the northeastern seafood processing firms is Canadian imports, and there exists several firms which rely almost completely on this source of supply. These firms produce breaded and frozen sea scallops in addition to repacking and reselling imported fresh, chilled sea scallops. The production and employment in the Atlantic sea scallop processing sectors by product types are presented in Table 331.2.

Table 331.1 SCALLOP LANDINGS BY MAJOR USER GROUP/FISHERY 1975-1978[1/]

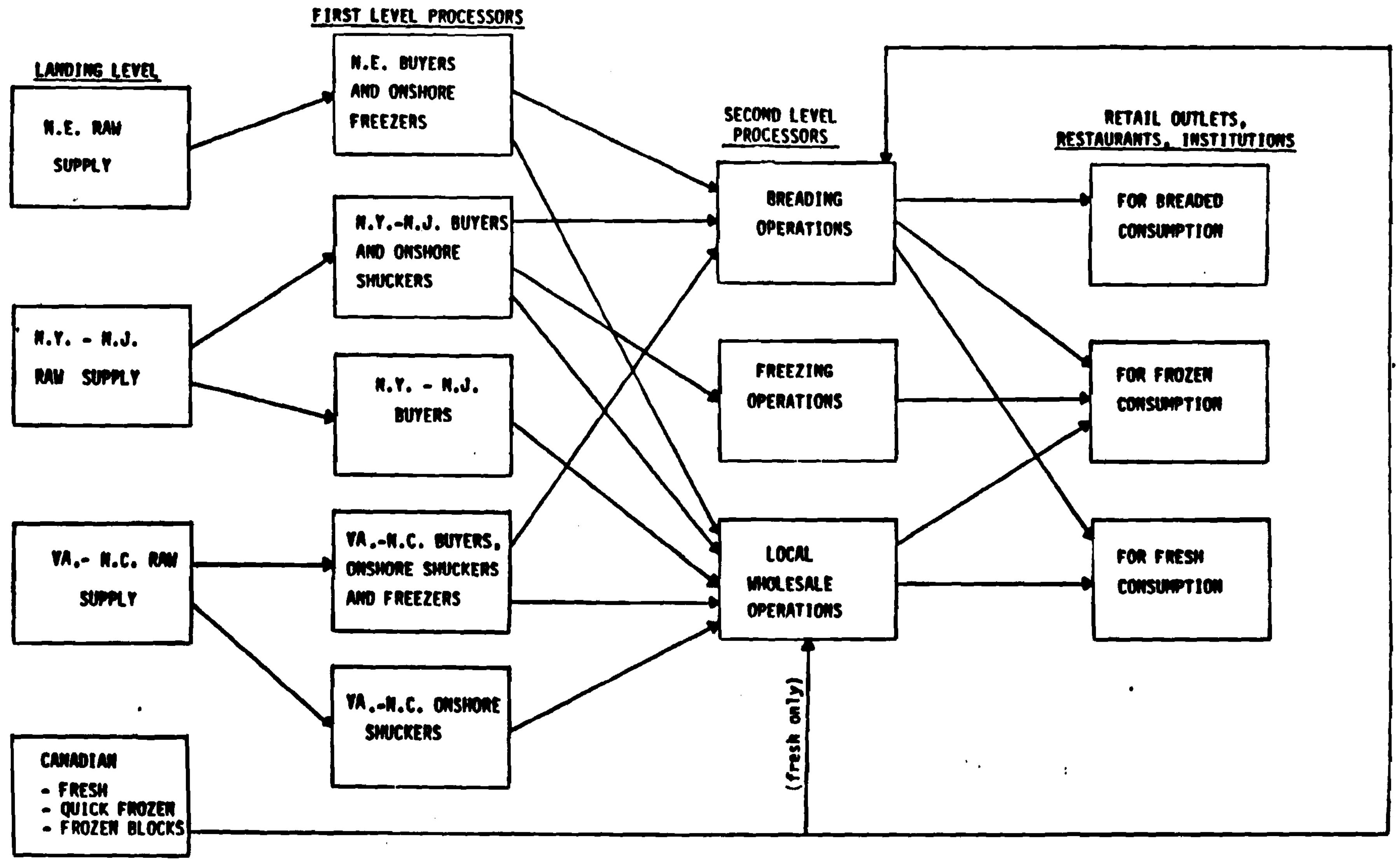
	1975			1976			1977			1978			AVERAGE 1975--1978	
	No. of Vessels	1000 lbs.	(%)	No. of Vessels	1000 lbs.	(%)	No. of Vessels	1000 lbs.	(%)	No. of Vessels	1000 lbs.	(%)	1000 lbs.	(%)
New England (based)														
Otter Trawl Fishery	81	176	(2)	127	796	(4)	103	155	(1)	108	93	(1)	305	(1)
Scallop Dredge Fishery	44	6905	(74)	86	11158	(57)	155	16588	(67)	133	17308	(54)	12989	(61)
Mid-Atlantic (based)														
Otter Trawl Fishery	8	754	(8)	118	4289	(22)	62	2095	(9)	N.A.	5819[2/]	(18)	3239	(15)
Scallop Dredge Fishery	20	1497	(16)	24	3328	(17)	61	5786	(23)	N.A.	8651[2/]	(27)	4816	(23)
TOTAL		9332	(100)		19571	(100)		24624	(100)		31871	(100)	21349	(100)

Source: NMFS unpublished data.

1/ One metric ton is equivalent to 2204.62 pounds.

2/ Adjusted from total landings by percentage landings by gear group for previous three years.

Figure 331.2 Atlantic Sea Scallop Production Flow.



SOURCE: NEFMC unpublished data.

Table 331.2: Atlantic Sea Scallop Production and Employment[1]
1970 - 1977

	Fresh Production[2]			Frozen Production			Breaded and Cooked Production		
Year	(1000 lbs)	($1000)	(man-yrs[3])	(1000 lbs)	($1000)	(man-yrs)	(1000 lbs)	($1000)	(man-yrs)
1970	4663	NA	NA	1189	1724	30.3	5352	7977	257.8
1971	4489	NA	NA	917	1526	37.0	5480	9032	264.7
1972	4812	NA	NA	1038	2357	54.4	5376	9746	259.0
1973	4733	10155	275.7	558	1167	28.3	4803	10388	173.3
1974	4994	8767	161.3	1023	1789	43.4	3595	6456	141.1
1975	7613	17237	232.3	1718	4264	55.1	4745	9252	189.6
1976	16024	31808	815.3	3551	7528	192.6	5267	10907	164.6
1977	19399	37020	755.3	5221	10510	224.0	6314	13129	180.1

1 Man years equal sum of monthly employment divided by twelve, adjusted by percent of plant's revenues from scallops.
2 Apparent fresh production.
3 Employment in the fresh sector equals reported employment adjusted by the ratio total fresh production/reported fresh production; figures unavailable before 1973, sample of less than 5 percent in 1973-74, sample of approximately 50 percent in 1975-77.

Source: NMFS unpublished data.

Domestic Marketing and Consumption

a) Marketing

Various sources of Atlantic sea scallops are marketed to the final consumers through various markets and product forms. An overview of marketing channels is presented in Figure 331.3. Most domestic sea scallops shucked and landed at the ports along the Atlantic coast are shipped in their original forms to wholesalers or processors at the wholesale market level. Upon receiving the scallops from ex-vessel markets, the wholesalers or processors may process or repack the product for shipment to retailers or institutional buyers who then market the scallops for final consumption.

At the ex-vessel market, fishermen are sellers while wholesalers' agents are buyers. Transactions may vary from port to port. In New Bedford, an auction is held 5 days a week by dock side where the auction house is located. The New Bedford market for scallops is considered as a concentrated market with few buyers. Most wholesalers are located in Boston, New Jersey, New York, and Pennsylvania. The retailing and institutional buying can be nationwide.

Canadian imports bypass the U.S. ex-vessel levels and directly compete with U.S. scallops at both the wholesale and retail markets. The marketing channel, therefore, is essentially the same as domestic landings through these markets.

Domestic landings and imports are the two major sources of Atlantic sea scallops available for U.S. supply and consumption (Table 331.3.). U.S. imports of Canadian Atlantic sea scallops make up a great majority (averaged 77%, 1973-1980) of the total scallop imports of the U.S (Table 4.3b of Appendix 2). The landings from 1955 to 1978 have fluctuated widely from 5,291 thousand pounds in 1973 to 31,870 thousand pounds in 1978, with an average of 17,740 thousand pounds, accounting for 60% of total consumption overall (1955-80). Imports from Canada increased steadily from 1955 to 1965 in response to Canadian expansion into the utilization of the Georges Bank resource. They then declined slowly in response to a decline in biological abundance, and had reached their lowest level by 1972. The average imports for the period 1955-80 was 11,858 thousand pounds, accounting for 40% of U.S. apparent consumption.

Price of Atlantic sea scallops at the ex-vessel, wholesale, and retail levels have moved closely together. These scallop prices, during 1955-1960 demonstrate a downward trend which is opposite of the general price indices of both WPI and CPI. These prices, however, have reversed that trend upwards since 1960, and the rate of increases in prices were much higher than the general price indices. The actual prices for the period 1960-1980 increased from 34 to 386, from 39 to 457, and 65 to 674 cents per pound for ex-vessel, wholesale, and retail levels respectively.

The consumer's dollar is a measurement of relative shares of consumer prices to various market elements, including the producers and middlemen.

Figure 331.3 Marketing Channels of Atlantic Sea Scallops

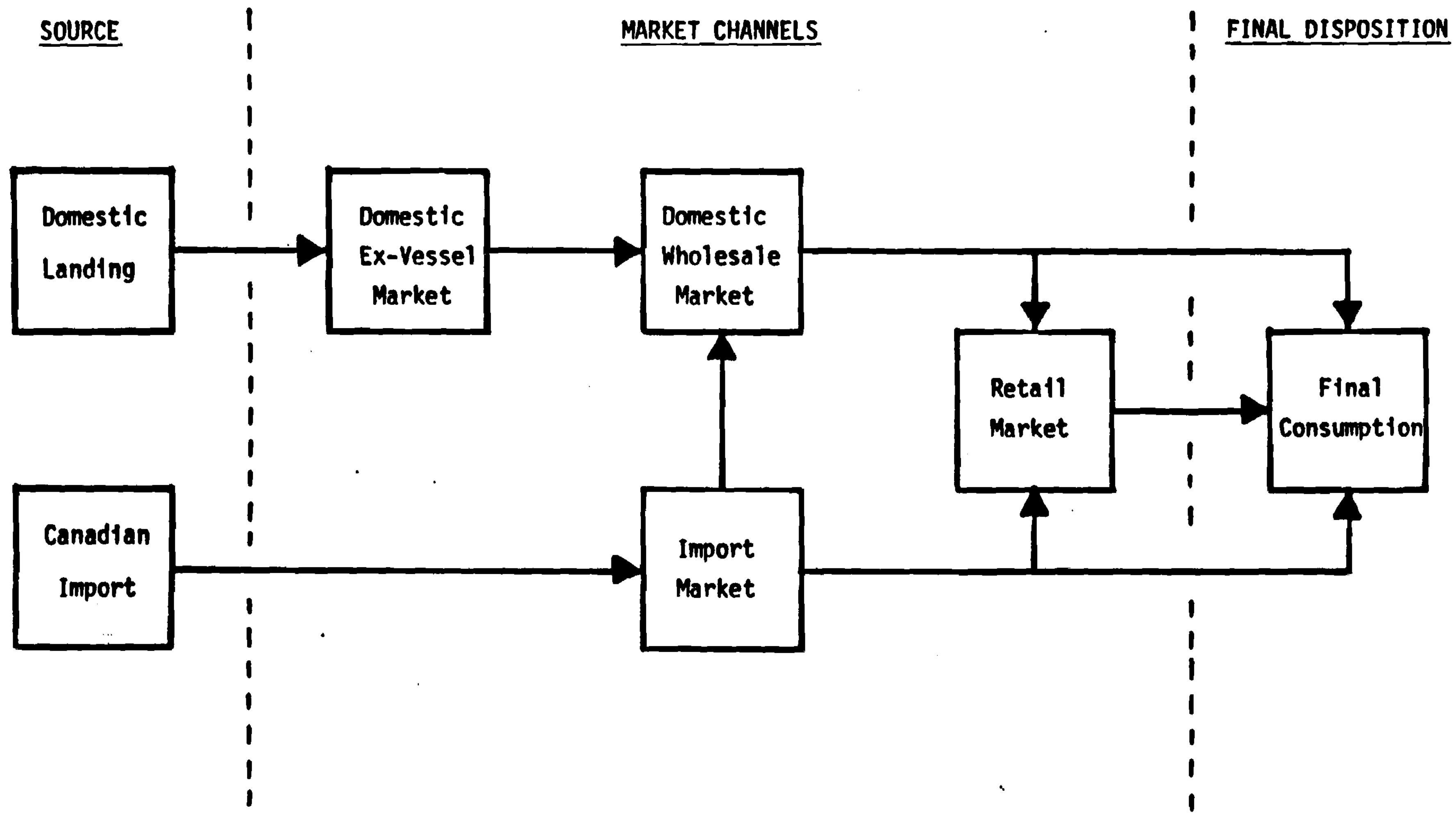


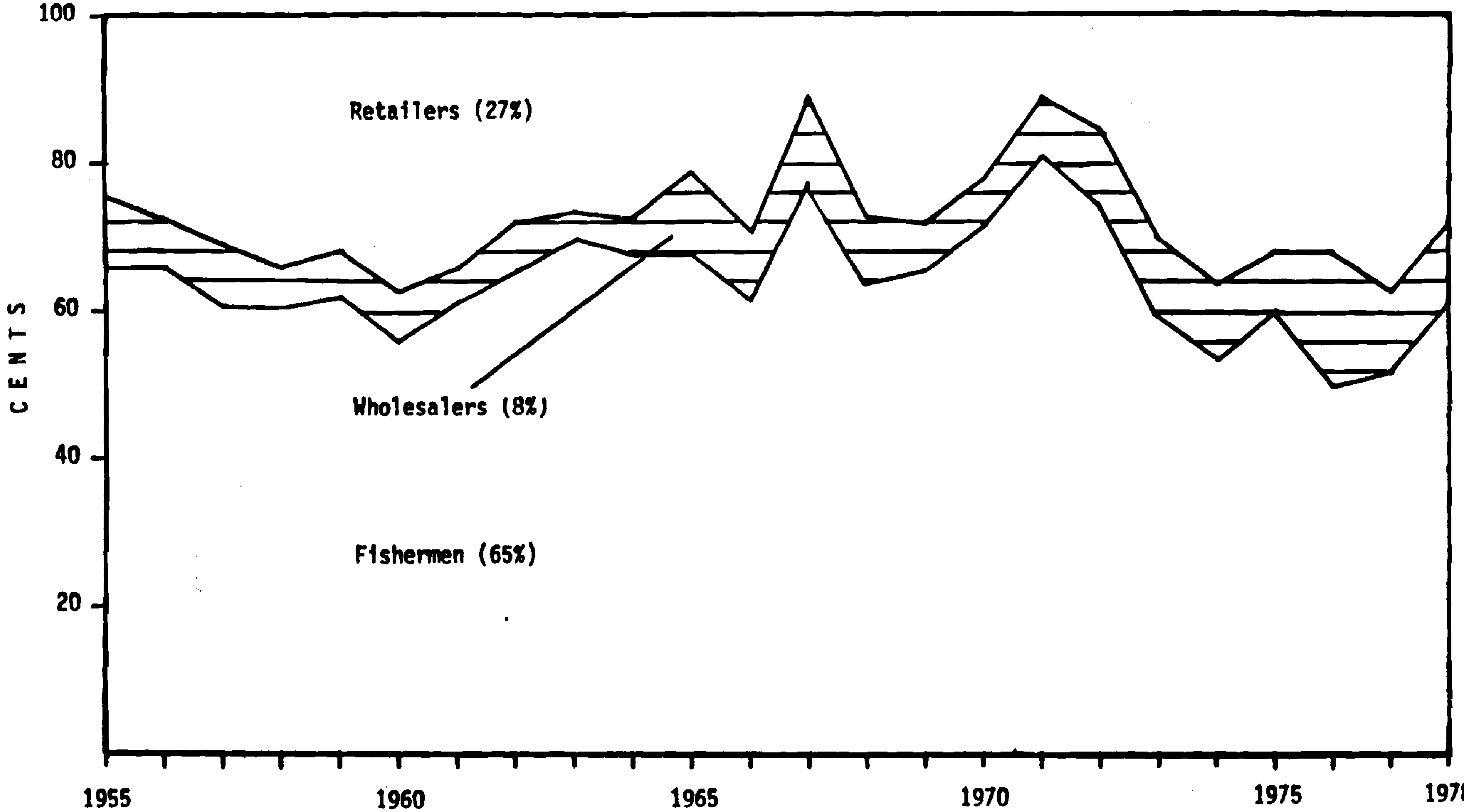
Table 331.3: Total U.S. Raw Supply (1,000 lb. Units)
of Atlantic Sea Scallops
1955 - 1980

Year	U.S. Landings	Canadian Exports to U.S.	Raw Supply
1955	22125.0	829.0	22954.0
1956	20066.0	1442.0	21508.0
1957	20994.0	2584.0	23578.0
1958	18977.0	2359.0	21336.0
1959	24644.0	2961.0	27605.0
1960	26599.0	6021.0	32620.0
1961	27461.0	7921.0	35382.0
1962	24634.0	11067.0	35701.0
1963	19939.0	12577.0	32516.0
1964	16914.0	15013.0	31927.0
1965	20700.0	14577.0	35277.0
1966	15975.0	16929.0	32904.0
1967	10242.0	13424.0	23666.0
1968	12070.0	13214.0	25284.0
1969	7410.0	12778.0	20188.0
1970	5852.0	11691.0	17543.0
1971	5406.0	10322.0	15728.0
1972	5850.0	9819.0	15669.0
1973	5291.0	10884.0	16175.0
1974	6017.0	12013.0	18030.0
1975	9331.0	14480.0	23811.0
1976	19575.0	20283.0	39858.0
1977	24620.0	25662.0	50282.0
1978	31870.0	23962.0	55832.0
1979	31184.2	19347.8	50532.0
1980	27853.7	16118.0	43971.7

Source: (1) 1955-75 from USDC, NMFS, Fishery Statistics of the U.S., Washington, DC; 1976-80 from USDC, NMFS State Landings for Maine, Massachusetts, Rhode Island, New York, New Jersey, Maryland, Virginia and North Carolina (Annual Summaries and December issues), Washington, DC.

(2) Government of Canada, Fisheries and Oceans: Annual Statistical Review of Canadian Fisheries. Vols. 9-12, 1955-1979. Canadian Exports of Fishery Products (Monthly), 1980.

Figure 331.4 Distribution of Consumer's Dollar 1955 - 1978
(Historical Average Share in Parentheses)



Source: Table 5.4 in Appendix II

Averaging over the period 1955-1980, the fishermen receive 65¢, wholesalers obtained 8¢, and retailers gained 27¢ for every dollar spent by consumers on sea scallops (Figure 331.4.).

b) Consumption

Quantity of Atlantic sea scallops available for U.S. consumption to a great extent depends on natural abundance. The annual consumption over the period 1955-1980 fluctuated from 13,518 thousand pounds to 56,619 thousand pounds, with an average of 29,531 thousand pounds. Per capita consumption fluctuated with the same trend as aggregate consumption during 1955-1980. The average per capita consumption was 0.149 pounds, with fluctuations between 0.065 and 0.260 pounds.

§332 Analytical Models for the Sea Scallop Fisheries

Four models were developed and estimated to generate quantitative economic information for policy decision-making. The first model is a sea scallop fishery model with emphasis on the analysis of markets, fishing effort, and production. The other models include processing employment, capacity, and financial analysis of harvesters. These models are summarized in Appendix 3, with some empirical results presented in §333. An assessment of the harvesting and processing capacity for sea scallops follows.

Harvesting and Processing Capacity

The harvesting and processing capacity for Atlantic sea scallops are determined using peak to peak interpolation*. Processing capacity is measured as (1) shucking capacity, and (2) marketing capacity.

Full capacity output is that level of aggregate production that would be realized if the full labor force were employed and all available capital used in the standard operations of facilities with normal stoppage for maintenance, repair, and layovers. By restricting the concept to normal operations with usual letdown time for layovers and maintenance, we introduce elements of economic and social cost into the concept. Capacity is to be understood in this presentation as an economic concept and not a purely physical measure of production. A detailed discussion of the following projections is presented in Appendix 3.

a) Harvesting and Shucking Capacity

Harvesting capacity with biological constraints may be measured utilizing the method of peak to peak interpolation on data for U.S. landings of Atlantic sea scallops contained in Table 331.3.

The primary processing activity for all Atlantic sea scallops is shucking of edible meats from the shell. This process is primarily carried out on board sea scallop dredge vessels, although unspecified amounts have been shucked at onshore facilities in the Middle and South Atlantic areas in recent

*Time Series Processor (Vers. 2.7), Harvard Institute of Economic Research, Harvard University, Cambridge, Massachusetts (1975).

years (See Appendix 2 for a complete description of the harvesting and processing sectors). Shucking capacity may be seen as an appropriate measure for initial processing capacity because all domestically landed sea scallops must be shucked in order to be processed further. This shucking constraint may be considered to be determined by (1) the harvesting capacity of vessels which process shucked meats on board, and (2) the processing capacity of onshore shucking facilities for Atlantic sea scallops. However, harvesting capacity of vessels which land shellstock may be used to approximate onshore shucking capacity. Total shucking capacity thus becomes equivalent to total harvesting capacity, when utilizing the peak to peak method.

Adjusting time to the appropriate levels (extrapolation) yields an estimated harvesting and shucking capacity for Atlantic sea scallops of 31,991,000 pounds in 1980, and 32,229,000 pounds in 1981. Using shucking capacity as an estimate for this initial processing capacity assures that such processing capacity will always match harvesting capacity, during a period of declining shellstock landings. However, this measure neglects the tremendous amounts of Atlantic sea scallops imported from Canada.

b) Processing and Marketing Capacity

An important factor in the utilization of the Atlantic sea scallop resource is the ability of the scallop industry to handle and distribute the landings quantities to consumers in an acceptable form. This same industry also handles large quantities of Canadian exports of fresh and frozen Atlantic sea scallops to the U.S., shown in Table 331.3. Thus, measuring the total final processing and marketing capacity for Atlantic sea scallops includes both U.S. landings and Canadian exports to the U.S.

It may be assumed that U.S. landed Atlantic sea scallops may be substituted for the Candian exports, and that the potential marketing capacity for domestically landed sea scallops is equivalent to this total marketing capacity. Again, the procedure for peak to peak interpolation of this series is used to estimate a time trend for marketing capacity. However, final processing capacity may be restricted by the shucking capacity if all sea scallops were domestically landed.

Adjusting time to the appropriate levels (extrapolation) yields an estimated marketing capacity for Atlantic sea scallops of 57,948,000 pounds in 1980 and 59,184,000 pounds in 1981. This means that the U.S. scallop industry would have the marketing capacity to absorb an increase in U.S. landings of Atlantic sea scallops during 1980-81.

§333 Recent Trends and Future Forecast (1980-1981)

The status of the Atlantic sea scallop fisheries will be discussed in light of the historical trends of the following variables: fishing effort, landings, prices, fishing revenue, processing employment, net return to capital and management, and net crew share. The models summarized in Appendix 3 were used to project these variables for 1980 and 1981.

Fishing Effort

Analysis indicates that levels of sea scallop fishing effort are primarily determined by resource abundance and the ex-vessel price of sea scallops. The New England dredge effort, similar to resource abundance shown in Figure 333.2., declined from 1965 to 1973. This trend held in the Mid-Atlantic resource area (Table 333.1. and Figure 333.1.). This trend in effort has been reversed since 1973, with drastic increases during 1975-1979, in response to both high abundance and unprecedented increases in ex-vessel prices. This latter trend in effort is expected to continue through 1981 in view of the projected trends in resource abundance for the immediate future, as indicated in Part 2.

Landings

Sea scallop landings, as shown in Appendix 3, are determined by fishing effort and resource abundance, between which abundance dominates this relationship. Like the trends in abundance and effort, U.S. landings generally declined during the period from 1965 to 1973, and then rose from the trough (5,291 thousand pounds in 1973) to peak at 31,870 thousand pounds in 1978 (Figure 333.3 and Table 333.2). The landings, however, dipped from the 1978 level to 31,438 thousand pounds in 1979, and approximately 28,000 thousand pounds in 1980. Landings are predicted to remain near the 1980 level in 1981. This general trend in sea scallop landings holds for both New England and Mid-Atlantic regions (Table 333.2 and Figure 333.4). Landing trends by the New England scallop dredge fleet from the three major resource areas, however, have fluctuated more than the total (Table 333.3). Recent trends and future forecasts for this fleet indicate increasing utilization of the entire Georges Bank area, with decreased New England landings from the Mid-Atlantic area.

Market Prices

The price of sea scallops at various market levels is determined by market demand and supply forces. Our price analysis indicates that landings, imports, income, inventory holdings, and the price of substitutes are major price determinants. The ex-vessel price of sea scallops, as shown in Table 333.4 and Figure 333.5, has gradually and steadily increased from $0.63 per pound in 1965 to $1.62 per pound in 1977. Since then the price shows a substantial increase to $3.28 per pound in 1979, and is expected to rise continually into 1980 and 1981. The price is projected to be $4.38 and $4.97 per pound for 1980 and 1981, respectively. The actual 1980 price is somewhat lower than projected, although it is still within the confidence limits (see Table 3.6 of Appendix 3). This price difference is apparently because the price of king crab (substitute) was lower than had been expected. It is noted that the wholesale and retail prices have shown the same trends as the ex-vessel price in the past and are expected to follow the same trend into the future as well (See figure 333.5).

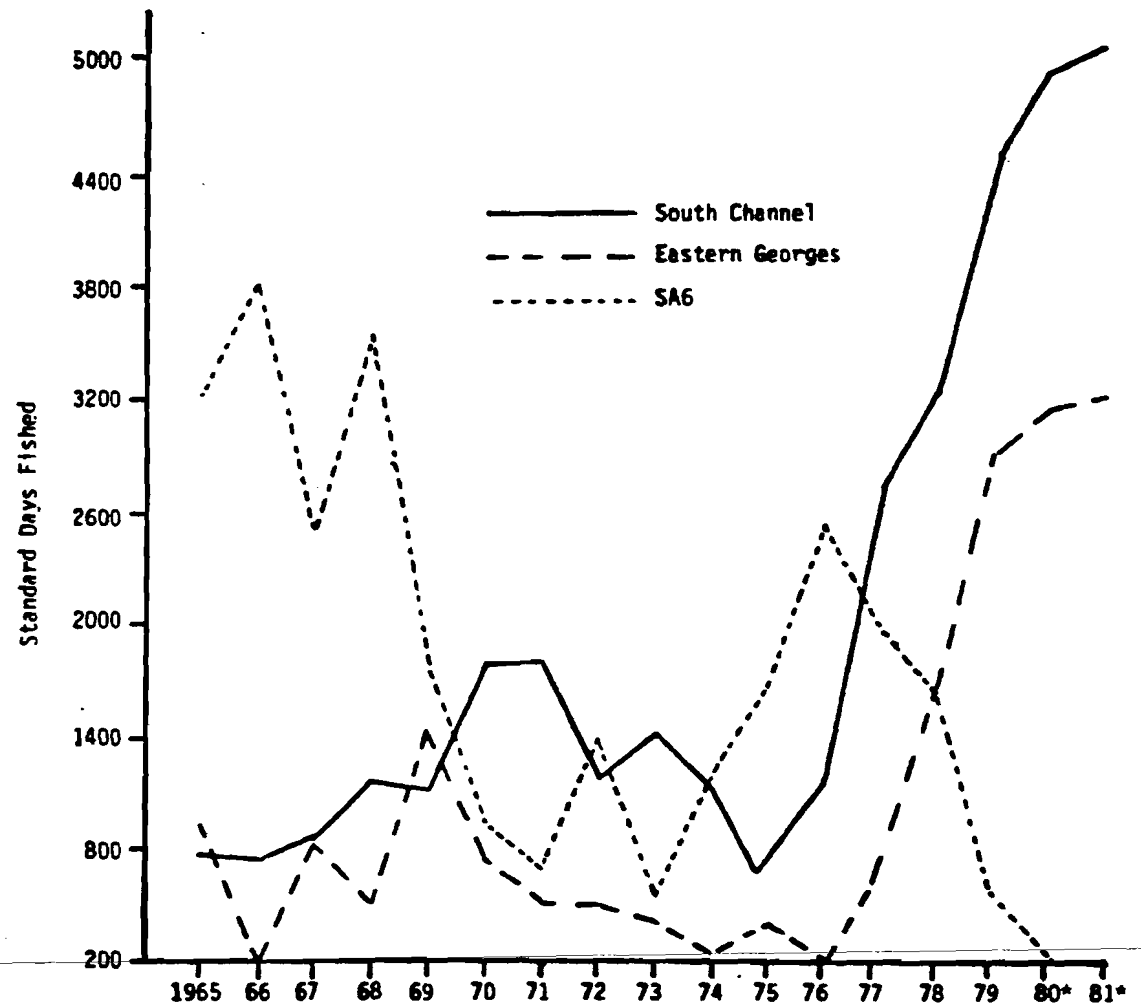
Table 333.1: Scallop Fishing Effort (Days Fished)
of New England Dredges by Area
1965 - 1981

Year	South Channel	Eastern Georges Bank	SA6	Total
1965	795	953	3248	4996
1966	763	169	3811	4743
1967	885	860	2506	4251
1968	1159	525	3548	5232
1969	1102	1467	1787	4356
1970	1797	766	972	3535
1971	1880	529	719	3128
1972	1233	520	1400	3153
1973	1399	424	551	2374
1974	1120	248	1193	2561
1975	712	405	1668	2785
1976	1163	196	2533	3892
1977	2774	590	1994	5358
1978	3269	1479	1685	6433
1979	4513	2963	637	8113
1980[1]	4960	3130	0	8090
1981[1]	5080	3199	0	8279

[1] The fishing effort for 1980-81 are estimated with abundance indices of all areas (CPUE) and ex-vessel prices of sea scallops.

Source: NEFMC unpublished information.

Figure 333.1 Scallop Fishing Effort (Days Fished)
of New England Dredges by Area 1965 - 1981



*Estimate

FIGURE 333.2 SEA SCALLOP EFFORT (STANDARD DAYS FISHED) OF NEW ENGLAND DREDGE FLEET 1965-1981

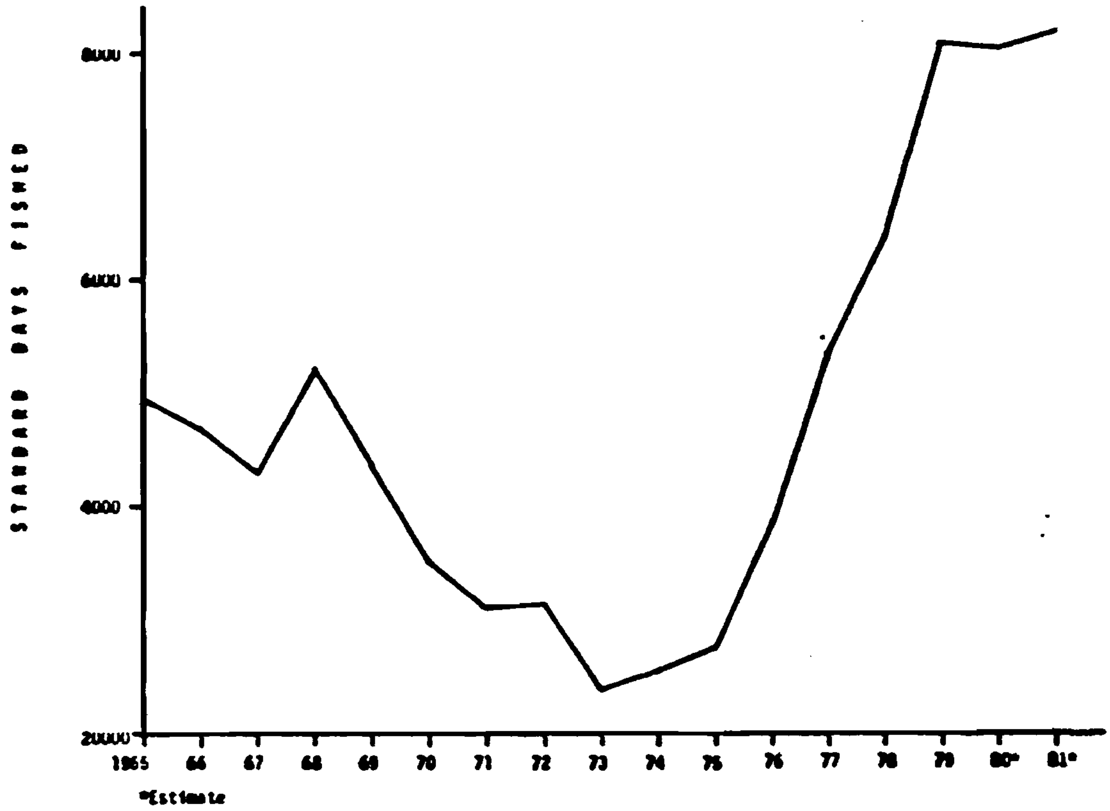


FIGURE 333.3 SCALLOP LANDINGS FROM GEORGES BANK AND SA6, 1965-1981

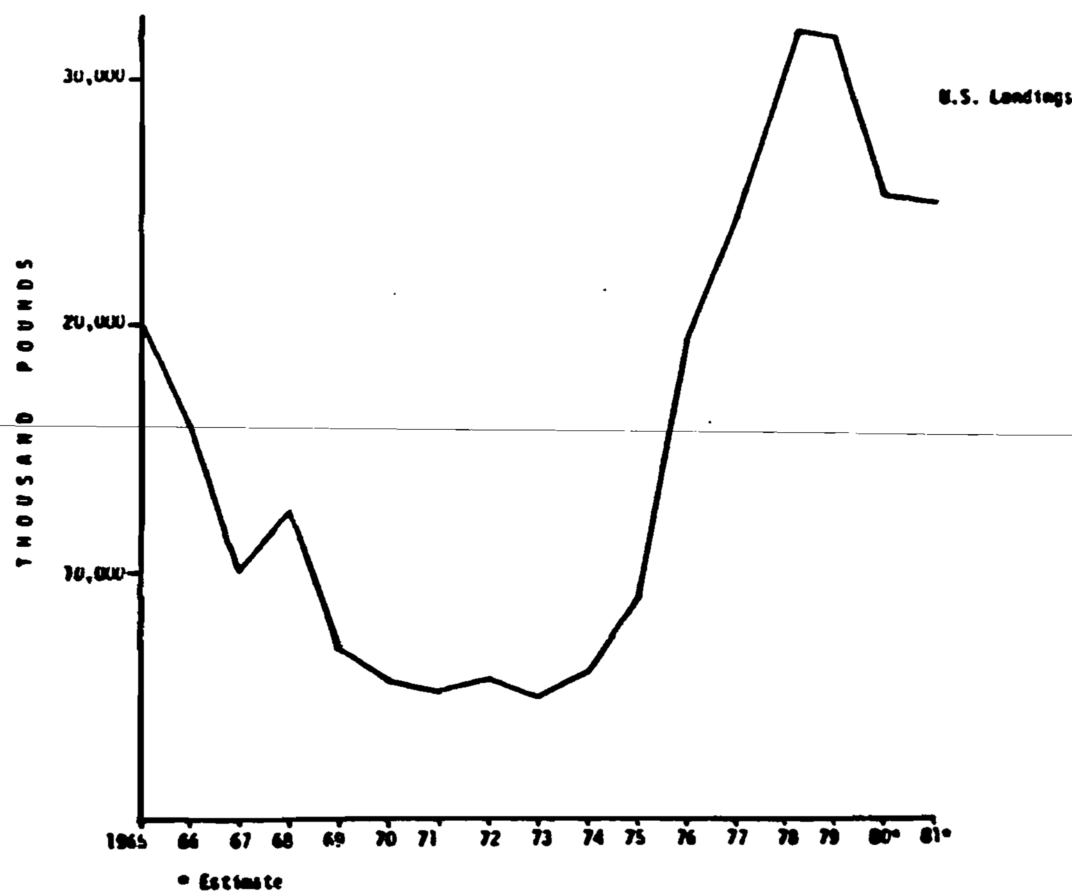


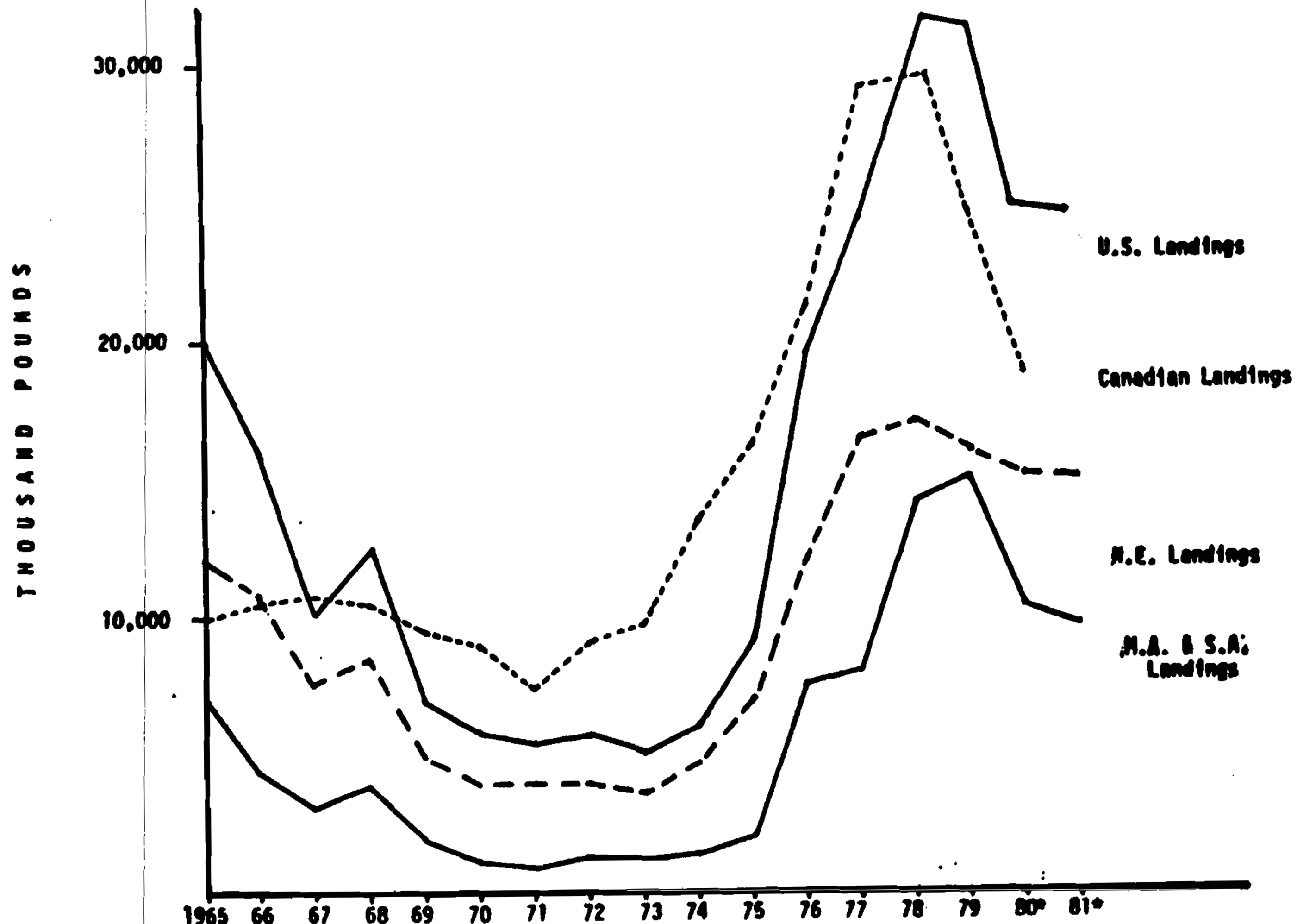
Table 333.2: Landings (Meat Weight)
From Georges Bank and SA6 Areas
1965 - 1981

Year	New England Landings	Middle & South Atlantic Landings	Total U.S. Atlantic Landings	Canadian Landings
		Thousand	Pounds	
1965	12335	7735	20070	9347
1966	11470	4505	15975	10714
1967	7025	3217	10242	10935
1968	7938	4132	12070	10538
1969	5107	2303	7410	9458
1970	4467	1385	5852	8922
1971	4346	1060	5406	7509
1972	4422	1428	5850	9140
1973	3949	1342	5291	9830
1974	4611	1406	6017	13481
1975	7080	2251	9331	16286
1976	11959	7616	19575	21442
1977	16740	7880	24620	28747
1978	17404	14470	31870	29659
1979	16043	15141	31184	24000
1980[1]	15243 (16707)	10427 (11146)	25670 (27853)	18000
1981[1]	15226	9853	25079	NA

[1] The figures for 1980 and 1981 are estimated (actual 1980 landings in parentheses). Landings are predicted from effort levels and abundance indices.

Source: See Table 331.3.

FIGURE 333.4 SCALLOP LANDINGS FROM GEORGES BANK AND SA6, 1965-1981



*Estimate

Table 333.3: Scallop Catch of New England Dredges by Area 1965 - 1981

	Thousand Pounds			
Year	South Channel	Eastern Georges Bank	SA6	Total
1965	1542.6	1770.8	8740.3	12053.7
1966	1584.2	368.9	8953.9	10907.0
1967	1414.9	1280.2	4128.2	6823.3
1968	1625.0	687.9	5372.5	7685.4
1969	1287.5	1650.3	1864.5	4802.3
1970	2359.3	760.8	1011.5	4131.6
1971	2388.3	515.0	604.7	3508.0
1972	1371.8	428.0	1439.0	3238.8
1973	1941.0	401.6	540.4	2883.0
1974	1710.0	306.3	2066.8	4083.1
1975	1323.8	628.5	3319.8	5272.1
1976	3202.4	392.4	6551.3	10146.1
1977	8270.8	1479.0	5626.7	15376.5
1978	7609.4	3547.6	4544.3	15701.3
1979	8132.4	4708.0	1030.6	13871.0
1980[1]	9350.0	4861.0	0	14211.0
1981[1]	9337.0	4886.0	0	14223.0

[1] The catches for 1980 and 1981 are projected with models which include abundance indices and fishing effort as explanatory variables.

Source: NEFMC unpublished information.

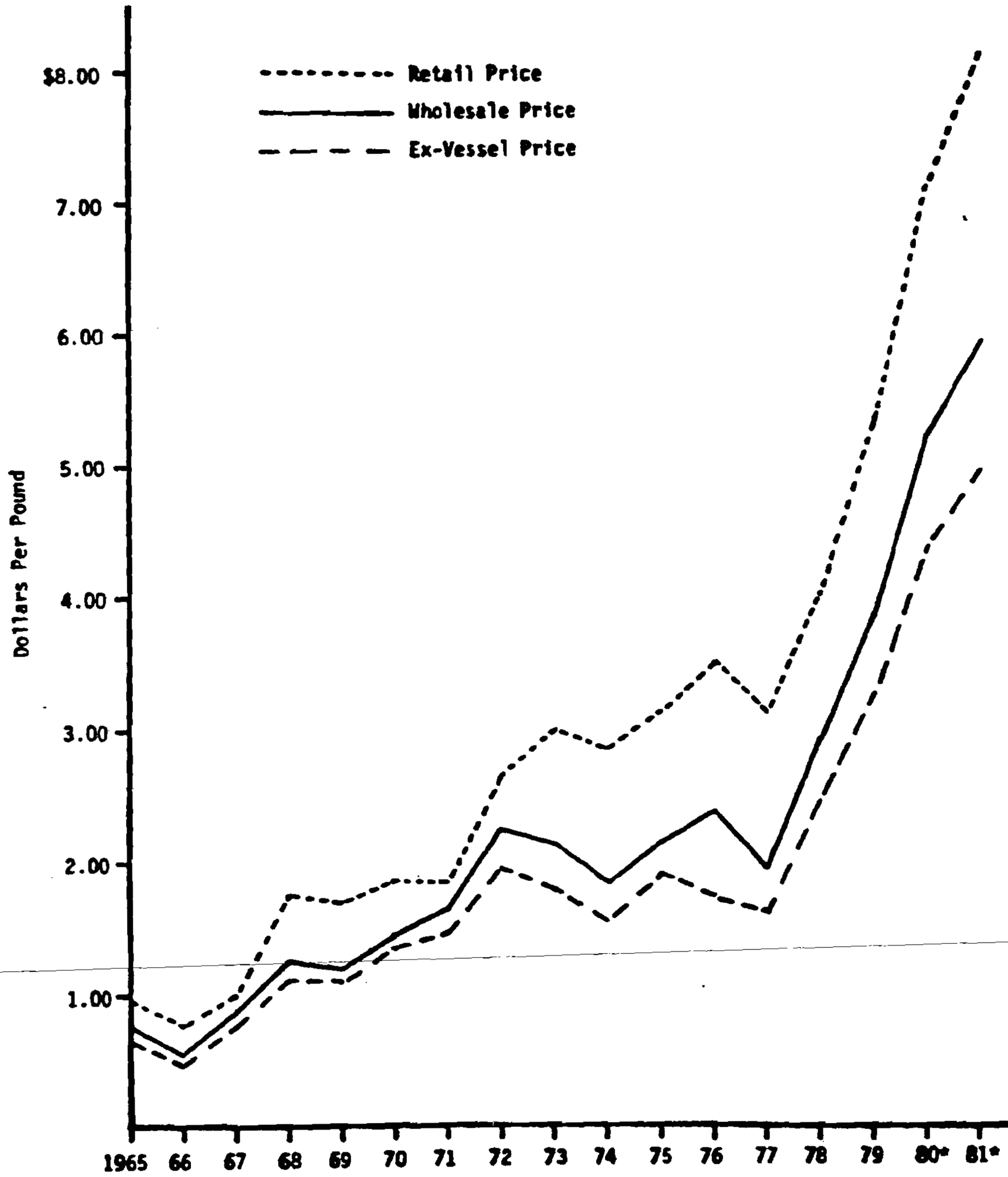
Table 333.4: Ex-Vessel, Wholesale and Retail Prices
for Sea Scallops
1965 - 1981

Year	Ex-Vessel Price ($/lb.)	Wholesale Price ($/lb.)	Retail Price ($/lb.)
1965	0.63	0.73	0.94
1966	0.47	0.54	0.77
1967	0.75	0.87	0.99
1968	1.10	1.26	1.74
1969	1.09	1.20	1.69
1970	1.34	1.46	1.88
1971	1.47	1.63	1.85
1972	1.95	2.23	2.65
1973	1.79	2.13	2.99
1974	1.54	1.85	2.87
1975	1.90	2.14	3.15
1976	1.74	2.38	3.51
1977	1.62	1.96	3.12
1978	2.47	2.92	4.02
1979	3.28	3.88	5.34
1980[1]	4.38 (4.04)	5.22 (4.57)	7.12 (6.74)
1981[1]	4.97	5.93	8.13

[1] Estimates (actual 1980 prices in parentheses). Price is projected from previous landings, imports, income, inventory and price of substitute.

Sources: Ex-vessel - same as Table 1.1 in Appendix II.
Wholesale and retail - 1955-1971, USDC, NMFS, Basic Economic Indicators, Scallops 1930-1972, Washington, DC, CFS No. 6127, June, 1973. 1972-1980, USDC, NMFS, Shellfish Market Review and Outlook, Washington, DC, Current Economic Analysis S-43, September, 1981.

Figure 333.5 Prices of Sea Scallops 1965 - 1981



*Estimate

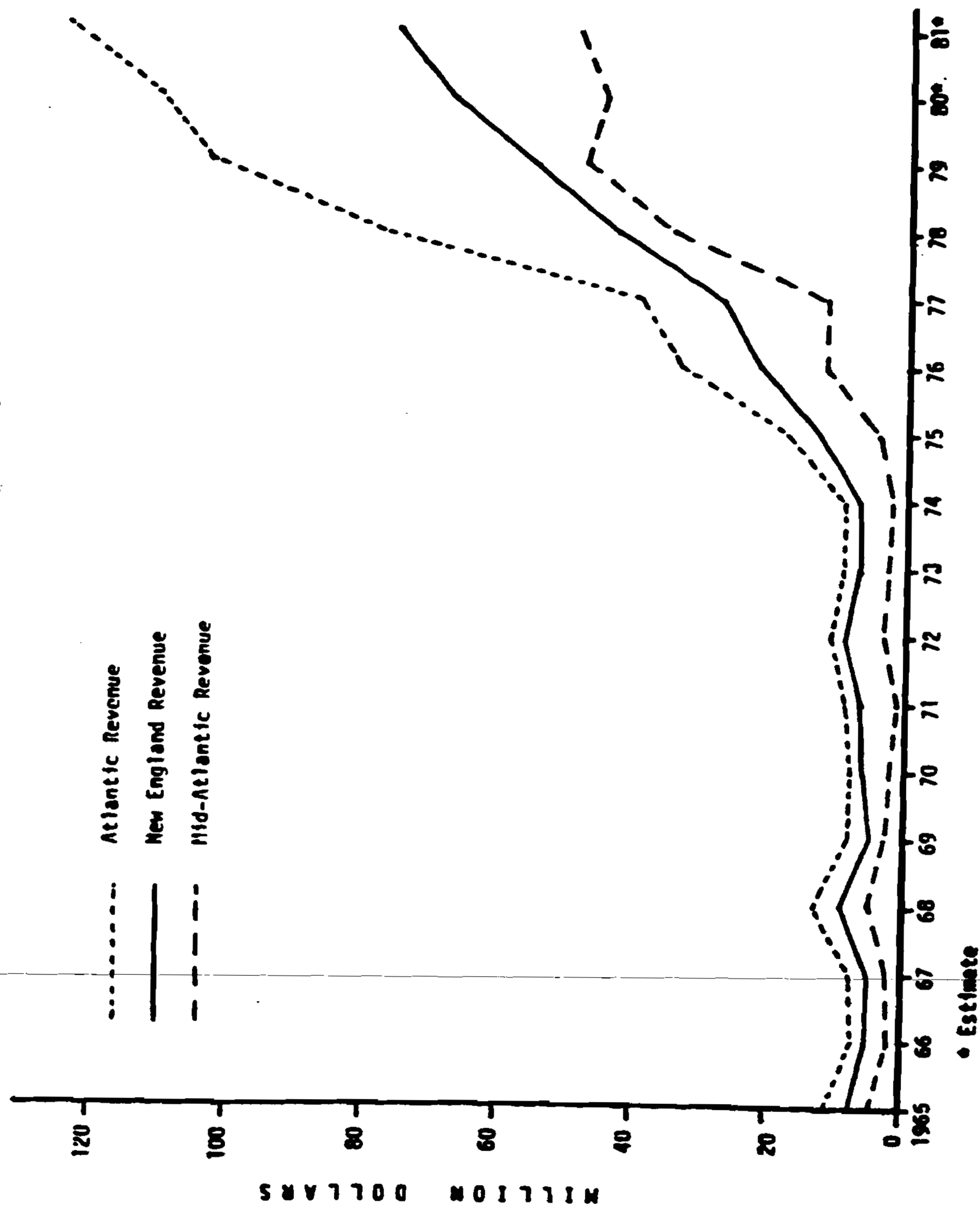
Table 333.5: Regional Revenues from Sea Scallops
1965 - 1981

Year	New England Revenues ($1000)	Mid-South Atlantic Revenues ($1000)	Total Atlantic Revenues ($1000)
1965	8,349.5	4,832.0	13,181.8
1966	5,679.9	2,105.0	7,624.8
1967	5,438.0	2,328.1	7,766.5
1968	8,850.0	4,503.8	13,354.2
1969	5,636.0	2,469.0	8,105.0
1970	6,027.7	1,830.0	7,857.4
1971	6,418.1	1,572.9	7,991.1
1972	8,627.7	2,789.0	11,416.8
1973	7,071.8	2,413.9	9,486.2
1974	7,173.7	2,092.9	9,266.7
1975	13,379.8	4,111.0	17,791.4
1976	22,230.6	12,325.0	34,244.5
1977	27,708.0	12,230.5	39,938.5
1978	43,198.0	34,664.3	77,861.5
1979	54,489.6	47,990.5	102,480.1
1980[1]	66,764.0 (64,433.7)	45,670.0 (43,030.2)	112,435.0 (107,463.9)
1981[1]	75,673.0	48,969.0	124,642.0

[1] Estimates (actual 1980 revenues in parentheses).

Source: Tables 333.2 and 333.4.

FIGURE 333.6 SEA SCALLOP REVENUE (1965-81)



Fishing Revenue (i.e. Gross Stock)

Fishing revenue from sea scallops is calculated from ex-vessel prices and landings. The sea scallop revenues at the ex-vessel level are presented, by regions, in Table 333.5 and Figure 333.6.

In the period 1965-1974, revenues were relatively stable in both the New England and Mid-Atlantic areas. Vessel scallop revenues increased moderately from 1975 through 1977. Since 1977, there has been a dramatic increase in vessel scallop revenues.

The moderate increase in revenues of 1975-77 is attributable to increased landings as prices were relatively stable during this period. The dramatic increase in revenues during 1977-1979 reflects both substantial increases in landings and constantly rising prices. Revenues were expected to continue their rise into 1980 and 1981 in response to strong consumer demand and upward pressure on product price. However, due to recessions in both 1980 and 1981 and their subsequent effects on consumer demand, these projected revenues may be viewed as high.

Employment in the Processing Sectors*

Processing employment (man years) is expected to fall to 1117 in 1980 and 1091 in 1981, down approximately 20% from 1372 in 1979, as a result of an anticipated decline in sea scallop landings (Table 333.6).

Net Return to Capital and Management**

The net returns to boat owners before depreciation and taxes is a measurement of the net return to capital and management. A group of 36 top

Table 333.6: Projected Employment in Processing Sectors (Man Years)

Sector	1978	1979	1980	1981
Fresh	1073	1071	876	856
Frozen	301	301	241	235
Total	1374	1372	1117	1091

Source: NMFS unpublished data.

*The trend in fishing employment (fishermen) is not analyzed, nor are future trends forecasted, as historical data on employment in the harvesting sector are not available.

**The estimates of net return to capital and net crew share are based on data collected from 36 New England highliners (top vessels in terms of landings) and represent the upper boundary for overall performance of the entire scallop dredge fleet.

vessels in 1978 was chosen as a sample for this analysis. The net returns are expected to increase from 1979 to 1980 for all groups, but are expected to decrease from 1980 to 1981. On average, the net returns of these top vessels in the New England region are expected to increase by 28% annually from 1979 to 1980, but decrease by 8% from 1980 to 1981 (Table 333.7).

Table 333.7: Net Return to Capital and Management (Dollars Per Vessel)

	1979	1980		1981	
	Dollars	Dollars	% Increase From 1979	Dollars	% Increase From 1980
Group 1 (12 vessels)	138,353	164,470	+19	154,050	- 6
Group 2 (11 vessels)	93,290	120,508	+29	111,144	- 8
Group 3 (13 vessels)	26,110	43,828	+68	38,406	-12
Average	85,918	109,602	+28	101,200	- 8

Source: NMFS unpublished data.

Net Crew Share**

The same top 36 vessel sample and classifications are used for the analysis of net crew shares. The same trend as net return to capital and management is prevalent for these net crew shares. The net crew share rises

Table 333.8: Net Crew Share (Dollars Per Crew Member)

	1979	1980		1981	
	Dollars	Dollars	Annual % Change From 1978	Dollars	% Change From 1980
Group 1	41,929	42,704	+2	40,200	-6
Group 2	37,466	38,465	+3	35,989	-6
Group 3	29,316	29,924	+2	27,986	-6
Average	36,234	37,031	+2	34,725	-6

Source: NMFS unpublished data.

**See footnote ** on previous page.

Table 333.9 FORECASTS FOR SEA SCALLOP FISHERY, 1980-81

		1980 4/	1981 4/	Units
1)	N.E. fishing effort in South Channel 1/	4955	5080	std. days fished
2)	N.E. fishing effort in eastern Georges Bank 1/	3130	3199	"
3)	N.E. fishing effort in Subarea 6 1/	0	0	"
4)	N.E. catch from South Channel 1/	9355	9337	1000 pounds
5)	N.E. catch from eastern Georges Bank 1/	4861	4886	"
6)	N.E. catch from Subarea 6 1/	0	0	"
7)	Mid-South Atlantic catch from Subarea 6	10427	9853	"
8)	Atlantic domestic landings (all areas & gears) 2/	25670	25079	"
9)	Total imports	33129	35155	"
10)	Market dissappearance (8 & 9)	58799	60234	"
11)	Ex-vessel price	438	497	cents per pound
12)	Wholesale price	522	593	"
13)	Retail price	712	813	"
14)	Employment in processing	1117	1091	man-years
15)	Harvesting-shucking capacity	31991	32229	1000 pounds
16)	Marketing capacity	57948	59184	"
17)	N.E. ex-vessel revenues	66764	75673	$1000
18)	Mid-South Atlantic ex-vessel revenues	45670	48969	"
19)	Total Atlantic ex-vessel revenues	112435	124642	"
20)	Net return to capital and management 3/	109602	101,200	$ per vessel
21)	Net crew share 3/	37,031	34,725	$ per man

1/ Scallop dredges only.
2/ Sum of 4, 5, 6, 7; adjusted by 1.04 to account for other N.E. landings.
3/ From top 36 vessels in N.,E. region.(average 3 groups, deflated).
4/ Confidence intervals are presented in Table 3.6 and Page A3-33, Appendix 3.

from 1979 to 1980 and falls from 1980 to 1981 (Table 333.8). The average net crew share was $36,234 per crew member in 1979, while it is expected to be $37,031 and $34,725 per crew for 1980 and 1981, respectively.

§334 Summary

Table 333.9 summarizes the projections for the sea scallop fishery discussed in this section. In general, fishing effort continues up in 1980-81, but catches drop during this same period (due to the expected decline in abundances). However, if weakness in the general economy in 1980-81, and possibly 1982, dampens the projected scallop price increases, then fishing effort may in fact decrease. Harvesting capacity estimates may be expected to directly follow such movements in fishing effort.

§340 Social and Cultural Framework

Information is currently unavailable on the social and cultural framework associated directly with the sea scallop fisheries in the New England and Mid-Atlantic regions. Some relevant information on the port of New Bedford (Massachusetts) is available; however, this information is more directly associated with the groundfishing portion of the New Bedford fleet. No cultural or social information is available for the major Mid-Atlantic sea scallop ports. Collection of relevant social and cultural data has been identified as a data need in Part 3 of this FMP supporting continuing fishery management.

PART 4: MANAGEMENT JURISDICTIONS, LAWS AND POLICIES

§410 Relationship to International Fisheries Programs

Prior to enactment of the Magnuson Act, fisheries for sea scallops were managed, along with other fisheries, under the auspices of the International Commission for the Northwest Atlantic Fisheries (ICNAF). That organization established management policies and allocated allowable harvests among member nations, but implementation and enforcement was left to the individual member nations.

Management of the sea scallop fishery never fully developed under ICNAF, because the fishery was dominated almost exclusively by the U.S. and Canada. There has never been a total allowable catch (TAC) on sea scallops, nor has there ever been any allocation of the resource between the U.S. and Canada.

In 1976, ICNAF recommended a regulation for the Georges Bank fishery designed to increase the meat yield by prohibiting the harvest of scallops less than 95 mm shell size and meats of more than 40 units per pound. Both the U.S. and Canada adopted these measures. For the U.S., the regulations went into effect on August 31, 1976 but were never implemented prior to U.S. withdrawal from ICNAF on December 31, 1976.

A significant fishery for sea scallops is pursued by Canadian fishermen under regulation by that country. Much of this fishery is conducted on the same resource being fished by United States fishermen. There is currently no bilateral fisheries agreement in effect between the United States and Canada.

The Canadian offshore sea scallop fishery, however, is managed in part based upon the ICNAF recommendation. In addition to the 40 meats/pound landing limit, a limited entry scheme allows 77 licensed vessels in the fishery. (In recent years, participating vessels have numbered fewer than 77.) Each licensed vessel's landings is limited to 30,000 pounds of meat per trip and 180,000 pounds per four month period. There is a maximum 12-day trip, dock to dock, and vessels are required to maintain logbooks. A shell size restriction was adopted at one time but is not now in effect. Total annual catches are effectively limited to about 19,000 metric tons.

§420 Relationship to Other Federal Fishery Management Plans

Fisheries in the areas covered by this Plan, which are currently under regulation by other fishery management plans include groundfish (cod, haddock, and yellowtail flounder), Atlantic herring, surf clams and ocean quahogs, squid, mackerel, and butterfish. The Council has completed drafting major portions of the plan for lobsters.

Fishermen fishing for sea scallops are subject to these other plans if their activities are likely to result in the harvest of any of these other species. Similarly, fishing for any of these other species may subject a fisherman to the provisions of this Plan if his activities are likely to result in the harvest of sea scallops.

§430 Relationship to State Fisheries Programs

Atlantic sea scallops occur within most of the New England and Mid-Atlantic States' territorial waters as well as within the FCZ. The management unit is considered to include the resource wherever it occurs; and the management policies, measures and objectives contained in this Plan are appropriate for application in State waters. Therefore, the coordination of the states' policies and regulations for sea scallops with those of this Plan is very important for the effective implementation of this regional management program. The following summarizes current state laws concerning sea scallops, and §443 of this Part describes the relationship between this Plan and State coastal zone management programs.

The State of Maine requires a license for commercial harvesting of sea scallops from its waters. License eligibility is limited to Maine residents. No quota is imposed on the commercial fishery, but only sea scallops with a shell height of 3 or more inches (7.6 cm) may be landed or possessed. Regulations specify areas where harvesting by dredge and by otter trawl is authorized, and the sea scallop season is limited to November 1 through April 15 in coastal waters. Recreational sea scallop fishing in Maine does not require a license, but individual fishermen are limited to two bushels of scallops in the shell or four quarts of shucked scallops per day. Scallops retained by recreational fishermen must meet the 3 inch minimum shell height. The state law permits a 10% tolerance under the minimum size.

Massachusetts and New Hampshire also have sea scallop landing laws setting a 3 inch minimum shell size. In mid-1980, North Carolina fisheries authorities and advisors were considering restrictions on shell size and meat count. No state regulations currently exist for sea scallops in New Jersey, New York, Rhode Island, Connecticut, Virginia, or North Carolina.

§440 Other Special Management Programs

§441 OCS Leasing

During the summer of 1981, exploratory drilling for oil and gas began on Georges Bank. Other sections of Georges Bank are currently proposed to be leased under the Outer Continental Shelf Lands Act. A discussion of the potential adverse effects of these activities on sea scallop resources and habitat is presented in section 230. The Council, through its representation on the Biological Task Force, and NMFS monitor these activities and advise the Bureau of Land Management and the United States Geological Survey concerning ways of minimizing impacts on fishery resources and interference with fishing vessel operations.

§442 Marine Mammals and Endangered Species Acts

Numerous species of marine mammals occur in the Northwest Atlantic, although the definitive species composition is unknown. The most numerous species in the area are the common (saddleback) dolphin (Delphinus delphis), harbor porpoise (Phocoena phocoena), and harbor seal (Phoca vitulina). Data on population abundance for various species are sketchy at best, and non-existent for some species, although current studies are gradually improving the information base. Marine mammal feeding behavior and food preferences are not well understood. These factors make it extremely difficult to assess, even qualitatively, the potential impact of the sea scallop management program on marine mammal populations.

Whenever fishing and marine mammals occur in the same area, there exists a potential for an incidental take of marine mammals. However, the number of animals killed is relatively small in comparison to the total population size. Incidental mortalities of harbor seals and harbor porpoises are known to take place in the Gulf of Maine fixed gear finfish fisheries; preliminary estimates place this mortality at about 100 animals per year.

Of the numerous marine mammal species which frequent the Gulf of Maine, Georges Bank, and southern New England waters, six have been classified as endangered. These are the finback whale (Balaenoptera physalus), the humpback whale (Megaptera novaeangliae), the right whale (Eubalaena glacialis), the blue whale (Balaenoptera musculus), the sei whale (Balaenoptera borealis), and the sperm whale (Physeter catodon). The finback, humpback, and right whales sometimes frequent nearshore waters. All whales inhabit the area only on a seasonal basis and "critical habitats" have not been designated in the Northwest Atlantic. Data on population abundance and occurrence is sparse, typically gathered through "sightings."

In addition to certain marine mammals, the only other threatened or endangered species occurring in the Northwest Atlantic are shortnosed sturgeon (Acipenser brevirostrum) and several species of sea turtles. There has been no documented mortality of shortnosed sturgeon as a result of fishing operations for sea scallops. Because data on occurrences of shortnose sturgeon are vital to understanding its current status, the Council urges fishermen to report any incidental catch of this species to the Sturgeon Recovery Project of the National Marine Fisheries Service.

Available data appear to indicate that several species of sea turtles are regularly found in New England waters. These turtles are the Kemp's Ridley, (Lepidochelys kempi), the leather back (Dermochelys coriacea), and the loggerhead (Caretta mydas). In addition, hawksbill turtles (Eretmochelys imbricata) occasionally stray into the area. The Kemp's Ridley turtle, while probably the most endangered reptile on earth (total population estimated at several thousand adults), is also the most frequently observed sea turtle in New England waters, especially in Cape Cod Bay.

Although Kemp's Ridley turtles have in past years been found stranded or dead along the beaches of Cape Cod Bay, there is no solid evidence to indicate that fishing operations were responsible. Based on inquiries to fishermen conducted by the National Marine Fisheries Service and the Massachusetts

Division of Marine Fisheries, the general conclusion can be drawn that the occasionally numerous deaths of Kemp's Ridley turtles in Cape Cod Bay do not occur as a result of normal commercial fishing operations. Yet, because of the extremely tenuous status of the population of the Kemp's Ridley turtle, NOAA and the New England Fishery Management Council remain concerned about the mortalities in Cape Cod Bay. The Council and NMFS believe that monitoring of turtles in New England is necessary.

No habitat areas where fishing for sea scallops is conducted have been identified as critical areas for any endangered species.

Implementation of this plan will have no effect upon populations of marine mammals and endangered species in the area. As additional understanding of the status and dynamics of marine mammals and sea turtle populations become available, the Council will integrate this information into its examination of potential impacts upon the environment as a result of fishery management programs.

§443 Coastal Zone Management

Most of the states in the areas affected by this Plan have approved Coastal Zone Management programs. These programs have been reviewed, and no major inconsistencies between them and the measures, policies, and provisions of this Plan have been found. Those states whose fishery management regulations are part of their coastal management programs may require amendments to their programs to conform with measures specified in this Plan.

The Coastal Zone Management Act requires direct federal actions affecting state coastal zones to be consistent "to the maximum extent practicable" with state programs. Section 303 (b)(5) of the Magnuson Act authorizes the incorporation of fishery conservation and management measures of the coastal states nearest to the fishery into FMPs, if these measures are consistent with the National Standards of the Act and other applicable law. The Council has determined that consistency with the National Standards and the Plan's management objectives (see Part 9) requires that the scallop resource be managed uniformly throughout its range and that measures do not discriminate against segments of the industry on the basis of residency. Therefore, incorporation of individual state sea scallop landing laws is rejected as an option for regional management. The Council determines that this Plan is consistent "to the maximum extent practicable" with the approved state programs.

PART 5: MANAGEMENT OBJECTIVES

§510 Introduction

Before committing Federal resources to the development and implementation of a fishery management program for sea scallops, the existing institutional frameworks were reviewed to determine whether the management problems (see §120) could be satisfactorily addressed by other management authorities. Thus, the first major alternative considered by the Council in the development of the FMP was the "no action" alternative. This alternative would mean not developing and implementing a federal plan to manage the sea scallop fishery in the Fishery Conservation Zone (FCZ), but rather leaving management of sea scallops to state authorities. The scope of current state management programs is described in Part 4. All other alternatives to "no action" reflect a commitment by the Council to embark on a federal management program with objectives and measures developed according to the criteria and national standards of the FCMA.

The Council determined that the management problems identified (see §120) could not be satisfactorily addressed through state regulation and industry practice alone, particularly in recognition of the fact that over 90% of the commercially exploited resource is located in waters not subject to state authority. Therefore, the Council concluded that it would exercise its authority under the FCMA to develop a management program for the sea scallop resource which may be generally found from the inshore waters of New England to the Northern Edge of Georges Bank and southward along the mid-Atlantic shelf to North Carolina.

Before the Council could identify reasonable alternative specifications of a management program for sea scallops, a fundamental management policy, leading to the adoption of management objectives, needed to be articulated. Three basic management policies were available to the Council, each implying different underlying management objectives and supporting management strategies:

1) to address the long-term productivity of the sea scallop resource,

2) to address the quality and volume of landed sea scallops, independent of long-term supply, or

3) to address the overall long-term benefits derivable from harvesting and use of the sea scallop resource.

The first policy alternative reflects a biological approach which does not take specific account of economic impacts, although economic benefits may in fact accrue in the long-run. The second alternative looks principally at the short-term economic aspects of the fishery without accounting for the future viability of the resource. The third alternative recognizes that the long-term economics of the fishery depend upon biological considerations for the long-term productivity of the resource. In view of the important bio-economic relationships that exist in the sea scallop fishery, and the long-term economic significance of the sea scallop fishery in New England and the Mid-Atlantic, the Council selected a policy based on the third alternative, which called for the design of a management program that meaningfully addresses the achievement of long-term benefits to the region from the continued prosecution of the sea scallop fishery.

§520 Statement of Management Objective

Consistent with the policy discussed in §510, the Council adopted the following overall management objective:

to maximize over time the joint social and economic benefits from the harvesting and use of the sea scallop resource.

In support of this broad objective the following factors shall be considered:

a) Restoration of the adult stocks in terms of their abundances and age distribution can be expected to reduce the year to year fluctuations in stock abundance caused by variation in recruitment.

In order to achieve the maximum long-term average harvest from the scallop resource, while minimizing fluctuations in annual catch, it is necessary to increase both the abundance of sea scallops as well as achieve a broad distribution of year classes supporting harvests. When the stock is reasonably abundant and a number of age classes are present, removals will not be solely dependent upon those scallops which are just entering the fishery. As such, the annual variability in recruiting year class strength will impact less on the relative stability of annual catches.

b) Enhancement of the yield per recruit for each stock.

Independent of the total sea scallop abundance, the average yield that may be derived from each individual within the fishable stock (yield per recruit) is generally greater as the size at first capture is increased. Where a scallop stock is heavily exploited, increasing age at entry by as little as one year may increase yield per recruit by over 20%. Moreover, increasing age at entry can be expected to increase the probability of good recruitment by allowing scallops to reach maturity and spawn before becoming subject to harvest.

c) Evaluation of the impact of the plan provisions on research, plan development, and enforcement costs.

An important consideration is unfavorable impact on the net benefits from scallop management that is associated with costs of enforcement of regulations. From another view point, it becomes necessary to evaluate the costs of additional biological research in relation to the expected benefits from improved management facilitated by such research.

d) Minimization of adverse environmental impacts on stock levels and utilization.

It is recognized that the most effective way of achieving this objective may be through management of the exploitation of competing ocean activities, i.e., ocean dumping.

PART 6: ALTERNATIVE MANAGEMENT STRATEGIES

§610 Introduction

Management strategies are defined as approaches to achieving the management objectives. Strategies are comprised of management measures which are suited to the particular management approach. Alternatives may be defined for both strategies and the measures they contain. The alternative approaches represented by the various candidate strategies in this FMP reflect considerations for technical feasibility, data availability, practical implementation, and management objectives. Alternative measures are identified with specific reference to the selected management strategy. They reflect considerations for sufficiency in achieving the objective, desirability for implementation and practical applicability. In addition, alternative specifications of the various measures are possible and are evaluated in view of their resource and industry impacts. The following section (§620) contains a description of the strategy alternatives considered in this FMP. Section 630 discusses the narrowing of management strategy alternatives for the purpose of conducting the detailed bio-economic analysis which appears in Part 7.

§620 Description of Alternative Strategies

In view of the adopted management objective, four alternative management strategies can be identified. The four strategies discussed below are primarily defined in terms of the kinds of control measures that they employ to achieve the management objective. Because the overall objective calls for a long-term bio-economic approach to management, the alternative strategies are designed to control some aspect of the harvesting or exploitation of the resource so as to enhance prospects for long-term abundance and productivity. This in turn promotes the long-term viability and economic well being of the industry. To achieve this objective, the management program should be formulated and applied on an industry-wide basis, and not on the basis of separate, sub-regional management regimes. This policy determination reflects the various bioeconomic interrelationships in the sea scallop fishery, including the interregional nature of sea scallop processing and marketing. Further, this policy is appropriate given the demonstrated ability of most fleet sectors to exploit the resource throughout the region, and given that no biological basis exists for separating the sea scallop resource into separate stocks for management purposes.

In summary, the four alternative strategies considered by the Council are as follows:

1) to <u>control total quantity</u> of sea scallops landed (through, e.g., annual or seasonal quotas),

2) to <u>control fishing practices</u> in the sea scallop fishery (through, e.g., gear restrictions, cull size, closed areas, and seasons),

3) to <u>control fishing effort</u> in the sea scallop fishery (through, e.g., limiting entry, number of vessels, or fishing time), and

4) to <u>combine two or more</u> of the above strategies.

This section describes the alternatives and presents their advantages and disadvantages in order to provide a basis for comparison.

(1) <u>To Control Total Quantity of Sea Scallops Landed</u>:

This general strategy for managing the sea scallop fishery has been adopted for several other domestically managed fishery resources where increased long-term productivity has been a consideration. The strategy most often employs annual or seasonal quotas on landings as the control measure. In managing the sea scallop fishery, quotas would have to be based upon assessments of the immediate and future prospects of the resource and be manipulated over time in such a way as to enhance long-term productivity without unduly penalizing short-term economic opportunity (which may be presented by periodic strong recruitment).

The present capability for assessing the status of the sea scallop populations subject to management does not support estimates of absolute abundance or calculations of appropriate short-term levels of catch from each resource component. This is primarily due to the lack of an extended time-series of commercial catch-at-age data, as well as the lack of a basis for estimating recent levels of fishing mortality applied to the resource. Assessment procedures do, however, provide a strong basis for monitoring relative change in population abundance and structure.

Despite the lack of an analytical basis for calculating appropriate short-term quota levels, it is possible to use historic landings data to calculate long-term average catch, and use this value as the basis for establishing fixed quotas. In the context of the sea scallop fishery resource, a quota calculated in this way has the probable advantage of assuring a sustainable level of catch in the fishery by maintaining the viability of the resource. If, however, fishing practices change in such a way as to adversely impact the productivity of the resource, (e.g., by catching scallops at a smaller size) the quota may over-estimate a sustainable level of catch. Conversely, if fishing practices change so as to enhance the productivity of the resource (e.g., by catching scallops at a larger size), the quota will likely underestimate the level of catch which is actually sustainable. These observations are due to the fact that sea scallop resource productivity is a function of both year class structure and overall abundance. In addition, a fixed quota is not sensitive to current resource conditions and therefore precludes the possibility of either restricting catch when the resource may be in jeopardy or increasing catch to take economic advantage of unusually abundant year classes entering the fishery.

Finally, in a situation where vessel entry into and exit from the sea scallop fishery is not controlled, the existence of quotas may result in a scramble to assure a share of the benefits. Unless mitigated by specific vessel limitations (i.e., trip or period limits), such behavior often results in operating inefficiencies, negative price effects (reduced revenue to the industry), and product scarcity during periods of closure. Whether quotas are implemented on an aggregated fleet-wide basis or at some level of fleet disaggregation, the administrative costs of implementing a quota can be significant.

(2) <u>To Control Fishing Practices</u>:

The general strategy of controlling fishing practices so as to reduce the exploitation of the sea scallop resource and thereby increase productivity implies the use of management measures such as gear restrictions (e.g., ring size in the dredge or number and/or size of dredges towed), cull-size, or closed areas and seasons. Of these measures, currently only cull-size control would be based on a satisfactory understanding of cause and effect so as to make the application of the measure meaningful. Measures such as dredge size or number and area/season closures attempt to effect the fishing effort applied to the fishery (exploitation). But, because they address only limited aspects of overall effort, and because little or no data exist to help quantify even this limited effect, the use of such measures is presently not meaningful.

Measures, such as ring size in the dredge or minimum cull size, attempt to control the portion of the population that is subject to fishing effort. Such a tactic is firmly grounded in what is known about the biology of sea scallops. It takes advantage of their growth characteristics and effectively allows the average scallop to reach a larger size before being captured (see §240). As a result, more production is generated by the sea scallop resource for each unit of effort applied. Unfortunately, the use of ring size control to achieve an increase in size at first capture is presently unrealistic because no useful relationship has ever been demonstrated between ring size and the size of the scallop retained. As a consequence, only the manual culling out of undersized scallops after they have been taken on board is an effective method of controlling the size of scallops harvested. Hand culling is a common practice in that sector of the fishery which shucks scallops at sea, and, therefore, the cull-size measure could be easily incorporated into normal fishing operations. However, hand culling is not a common practice in that sector of the fishery that lands scallops in the shell.

The control of minimum size in the sea scallop fishery has significant implications for the harvestable production from the resource. The yield per recruit analysis in §240 shows that significant increases in average individual scallop yield is possible by simply delaying average age at first capture by one year, which corresponds to an increase in meat weight (i.e., edible portion). Such increases in yield are, in part, dependent upon the effort being applied to the fishery. However, as an example, an increase of nearly 7% in average yield per scallop (more specifically "yield per recruit") would be associated with a change in average meat count from 30 to 25 on Georges Bank under applied effort conditions (relating to actual fishing mortality) that have occurred in the past.

A major advantage associated with cull-size control (i.e., minimum shell size or meat count) is that the effect on average individual scallop yield (yield per recruit) is direct, resulting in relatively consistent increases in yield over the range of effort that has been observed, or might be expected, in the sea scallop fishery. Absolute increases in average individual scallop yield vary with applied effort (i.e., fishing mortality rate); however, even if effort were to remain at recent high levels, increases in average individual scallop yield would still be realized.

Other biological benefits of a cull-size measure are due to increased reproductive potential. By delaying capture until an older age, scallops which are just beginning to contribute significantly to spawning remain in the population. Although a stock recruitment relationship has not been demonstrated for sea scallops, the increase in scallop fecundity with age may provide a buffer against recruitment overfishing.

Finally, the imposition of controls on fishing practices has implications for administrative costs. Depending on the measure selected, both shore-side and at-sea enforcement costs are likely to be incurred. In addition, costs that may be borne by the industry associated with gear acquisition or fishing inefficiency should be assessed in evaluating this strategy alternative.

(3) <u>To Control Fishing Effort</u>:

The general strategy of controlling fishing effort to increase the long-term productivity of the sea scallop resource implies the use of management measures such as a limit on the number of fishing days available in a given year or a limit on the number of participating vessels. In theory, such effort control measures are more efficient at limiting exploitation of the resource (to enhance productivity) than are quota measures. They provide a more direct control on the rate of fishing mortality without acting to deny the opportunity for the industry to take advantage of increased catch rates that come with natural fluctuations in resource abundance. Further, effective control on fishing mortality rate is an important consideration in evaluating the effectiveness or benefits of measures directed at age-at-first-capture (or cull size as discussed above).

In practice, however, successful implementation of effort control measures currently suffers from several important shortcomings. First, as with controls on gear configuration, direct vessel effort control represents only a portion of those factors which influence exploitation; gear/vessel efficiency and size (age)-at-first-capture must be simultaneously considered. Second, historic effort data are not available for all fishery components, and are not adjusted (where available) for changes in vessel/gear configuration and efficiency over time. Most importantly, there is currently very little basis for accurately assessing the actual fishing mortality which is being generated by the scallop fleet at any given time.

Notwithstanding these limitations, broad-based control on applied effort is likely to result in long-term benefits to the resource, and effort control is complementary to control on size-at-first-capture. However, the immediate imposition of an effort control measure is not essential to assure long-term benefits from control on age-at-first-capture, so long as some form of fishing mortality control is adopted or fishing mortality does not substantially increase.

(4) To Combine Two or More of the Above Strategies:

The discussion presented above under each of the strategy alternatives has supported the notion of combining different types of control measures to affect the long-term productivity of the resource in a more efficient or desirable way. In support of a multiple year management program, such as is envisioned for sea scallops to achieve the stated objective, two options exist for combined measure implementation:

(a) initially implement control measures which are technically feasible, analytically supportable, and acceptable, and optionally delay other measures which require further study, or

(b) postpone implementation of all control measures until all acceptable measures are technically feasible and their joint interactions are fully evaluated.

The management program could include immediate implementation of administrative and data gathering measures, regardless of which option was selected.

Various combinations of quota control, gear control, cull size, and vessel effort control measures can be considered as candidate options for implementation under (a) or (b). However, limitations on our knowledge and understanding of benefits to the resource, impacts on the industry, mode of implementation, or technical feasibility will effect both the desirability of individual combinations and the timing of their implementation.

§630 Selection of Strategy Alternative for Detailed Analysis

The selection of a strategy alternative(s) for detailed analysis in the Sea Scallop FMP is based upon an evaluation of the four general strategies discussed in §620. The evaluation presented in Table 631 was conducted only for the first three alternative strategies (the fourth being a combination of the others) with reference to the following four criteria:

1) compatibility with the overall objective;

2) feasibility for implementation;

3) minimization of costs to the industry; and

4) minimization of administrative and enforcement costs.

Table 631: Evaluation of Strategy Alternatives

Generalized Strategy	Criteria	Rating[1]	Comment
1. Control on Total Quantity: (e.g., catch control)	Compatability with Objective	G	- Control on Quantity landed is generally efficient and relevant to the objective, but must be tied closely to current stock assessments in order to avoid sub-optimal harvests or overexploitation.
	Feasibility for Implementation	P	- Technical knowledge of resource does not support establishment of a responsive catch control system; only fixed catch control is possible.
	Minimum of Costs to Industry	P	- Fixed catch limitations likely to deny short-term benefit from fluctuations in abundance and result in short-term loss of revenue. - Catch limitations encourage "scramble" behavior, result in economically inefficient use of the resource.
	Min. of Admin./Enforcement Costs	F	- Administration and monitoring of catch limitations impose reasonable costs.
2. Control on Fishing Practices: (e.g., age at entry controls such as gear configuration, minimum size or meat count)	Compatability with Objective	F	- Controls affect some aspect of overall resource exploitation to enhance resource productivity, but less effective than either catch or effort control.
	Feasibility for Implementation	F-G	- No basis for implementing control on gear configuration. - Measures controlling minimum size or meat count are feasible for implementation and closely related to considerations for increased yield per recruit and stock structure. - Benefit for achievement of objective is, in part, a function of prevailing fishing mortality (effort).
	Minimum of Costs to Industry	F	- Feasible control on minimum size or meat count constitute accepted practice in the industry, but may result in short-term harvesting inefficiency.
	Min. of Admin./Enforcement Costs	F	- Administration and monitoring of controls on fishing practices impose reasonable costs.
3. Control on Fishing Effort: (e.g., control on total days fished or participating vessels)	Compatability with Objective	G	- Effort control is generally efficient and relevant to the objective, but dependent upon ability to relate fleet effort to fishing mortality.
	Feasibility for Implementation	P	- Effort data characterizing the overall harvesting sectors is unavailable, but where data are available for certain sectors or resource areas, they are not standardized. - Data describing allocation of effort among resource components is incomplete. - Data relating fishing effort to fishing mortality is preliminary and incomplete. - Insufficient basis for a complete examination of effort based management options at this time.
	Minimum of Costs to Industry	-	- Candidate options not available for evaluation.
	Min. of Admin./Enforcement Costs	-	- Candidate options not available for evaluation.

[1]G = Good, F = Fair, P = Poor; These ratings are relevant only to the management of the sea scallop resources off the Northeast coast of the United States.

The alternative strategies are rated qualitatively [i.e., good (G), fair (F) and poor (P)] against each of the above criteria.

An examination of the information summarized in Table 631 indicates that control on fishing effort is not feasible at this time, and control on quantity landed is not sufficiently supported by our current ability to assess resource abundance to warrant its adoption as an overall management strategy. As a consequence, control on fishing practices, and more specifically control on minimum size or meat count, is adopted as the principal management strategy. It is recognized, however, that in light of the biological analysis presented in §240 and the discussion in §620, minimum size or meat count control may not be sufficient to achieve the overall objective in the long run. That is, the achievement of the overall management objective is partially related to the level of fishing mortality witnessed by the resource over the duration of the management program.

It is not currently possible to devise direct effort control measures that will affect fishing mortality in a manner that is complementary to the effect of minimum size or meat count control. However, the detailed, long-run analysis of alternative specifications of the management measures (see Part 7) must be undertaken in the context of various assumed levels of long-term fishing mortality so that relative benefits may be properly evaluated. On the other hand, the detailed, short-run analysis (examining the first two years of program implementation) will be conducted without explicit reference to any level of fishing mortality other than that currently estimated for each fishery resource area.

Therefore, the following 12 strategy specifications are defined for long-term analysis purposes in Part 7 of this FMP, where four meat count options are simultaneously evaluated with three (conveniently defined) effort levels:

Age-at-Entry Meat Count Measure Specification	Effort Specification		
	Historical Avg. Level	Intermediate Level	Biologically Optimal Level [F(max)]
Meats/lb. (#1)	SS1	SS2	SS3
Meats/lb. (#2)	SS4	SS5	SS6
Meats/lb. (#3)	SS7	SS8	SS9
Meats/lb. (#4)	SS10	SS11	SS12

For the purposes of the short-term (2 year) analysis in Part 7, three strategy specifications are defined. These specifications consider meat count only, but allow for a change in specification following the first year of implementation. Further details of this analysis are presented in Part 7.

PART 7: DETAILED ANALYSIS OF ALTERNATIVE STRATEGY SPECIFICATIONS

§710 Resource Analysis

The principal component in the analysis of resource impacts is the long-term implications of the alternative management strategies discussed in §620. The principle analytic technique used is yield per recruit analysis. Its application allows evaluation of the relative impacts upon expected total average yield which may result from feasible combinations of all strategies which have been considered. The yield per recruit analysis, however, views fishery dynamics from the perspective of an equilibrium, which is appropriate for a long-term analysis, but which is unable to describe the short-term effects of new management action.

Anticipating that this FMP will first take effect during calendar year 1982, a short-term biological analysis for the 2-year period (1982-1983) following Plan implementation focuses upon the implications of controls on the age at entry of sea scallops to the fishery. A fishery simulation approach has been taken using the best available information describing the current sea scallop resource. A major component of the economic impact analysis (§720) is grounded in the results from the short-term biological analysis.

§711 The Long-Term Resource Analysis

This segment of the resource impact analysis expands the yield per recruit analyses introduced in §242, elaborating upon the relationships within resource components between age at entry and fishing mortality rate. The analysis focuses upon three resource components, offshore Gulf of Maine, Georges Bank and the Mid-Atlantic.

Offshore Gulf of Maine

Relatively little information exists describing the offshore Gulf of Maine fishery. Although catches of a few hundred metric tons have been taken annually in the long existant coastal Maine fishery, the offshore fishery has attracted little historic interest outside of the local fishing communities. Moreover, it is difficult to ascribe historic catches as having come from one area or the other.

In the winter of 1979-1980, a sharp increase in fishing effort occurred in the area of Jeffrey's Basin and eastward to Cashes Ledge, probably because of exceptional localized recruitment from the 1975 year class (Schick, 1981). Nearly all of the catches in this extraordinary fishery were made by shell-stocking vessels with shucking conducted in shore-side facilities. Inasmuch as the State of Maine was compelled to issue a number of citations for violations of its regulations specifying a minimum shell height of 3 inches, it is probable that the effective cull size may have been somewhat less. A realistic estimate of that cull size is probably not possible. However, in consideration of the shell height - meat weight relationship (see §242), it is probable that the age at entry was at least equivalent to 60

Table 711.1: Percent changes in yield per recruit (Y/R) for offshore Gulf of Maine sea scallops associated with alternative ages at first capture (in terms of meat count) and changes in fishing mortality (F) relative to assumed historical average age at first capture (equivalent to a 60 meat count) and assumed historical average F=0.7. Values of F are shown in brackets.

Percent Change in F		25	30	40	60
+114.29	(1.5)	+21.24	+10.62	- 4.42	-23.01
+100.00	(1.4)	+23.01	+12.39	- 3.54	-21.24
+ 85.71	(1.3)	+24.78	+13.27	- 1.77	-19.47
+ 71.43	(1.2)	+25.66	+15.93	+ 0.88	-17.70
+ 57.14	(1.1)	+28.32	+17.70	+ 2.65	-15.04
+ 42.86	(1.0)	+30.09	+20.35	+ 5.31	-12.39
+ 28.57	(0.9)	+32.74	+23.01	+ 7.96	- 8.85
+ 14.29	(0.8)	+35.40	+25.66	+12.39	- 5.31
0.00	(0.7)	+38.94	+29.20	+15.93	0.00
- 14.29	(0.6)	+42.48	+33.63	+21.24	+ 5.31
- 28.57	(0.5)	+46.90	+38.94	+27.43	+12.39
- 42.86	(0.4)	+52.21	+44.25	+34.51	+20.35
- 57.14	(0.3)	+55.75	+49.56	+40.71	+29.20
- 64.29	(0.25)	+56.19 1/	+50.33 1/	+42.48	+32.74
- 71.43	(0.2)	+53.10	+49.56	+43.36 1/	+35.40 1/
- 85.71	(0.1)	+25.66	+23.89	+22.12	+19.47

1/ Percent change in Y/R associated with F(max).

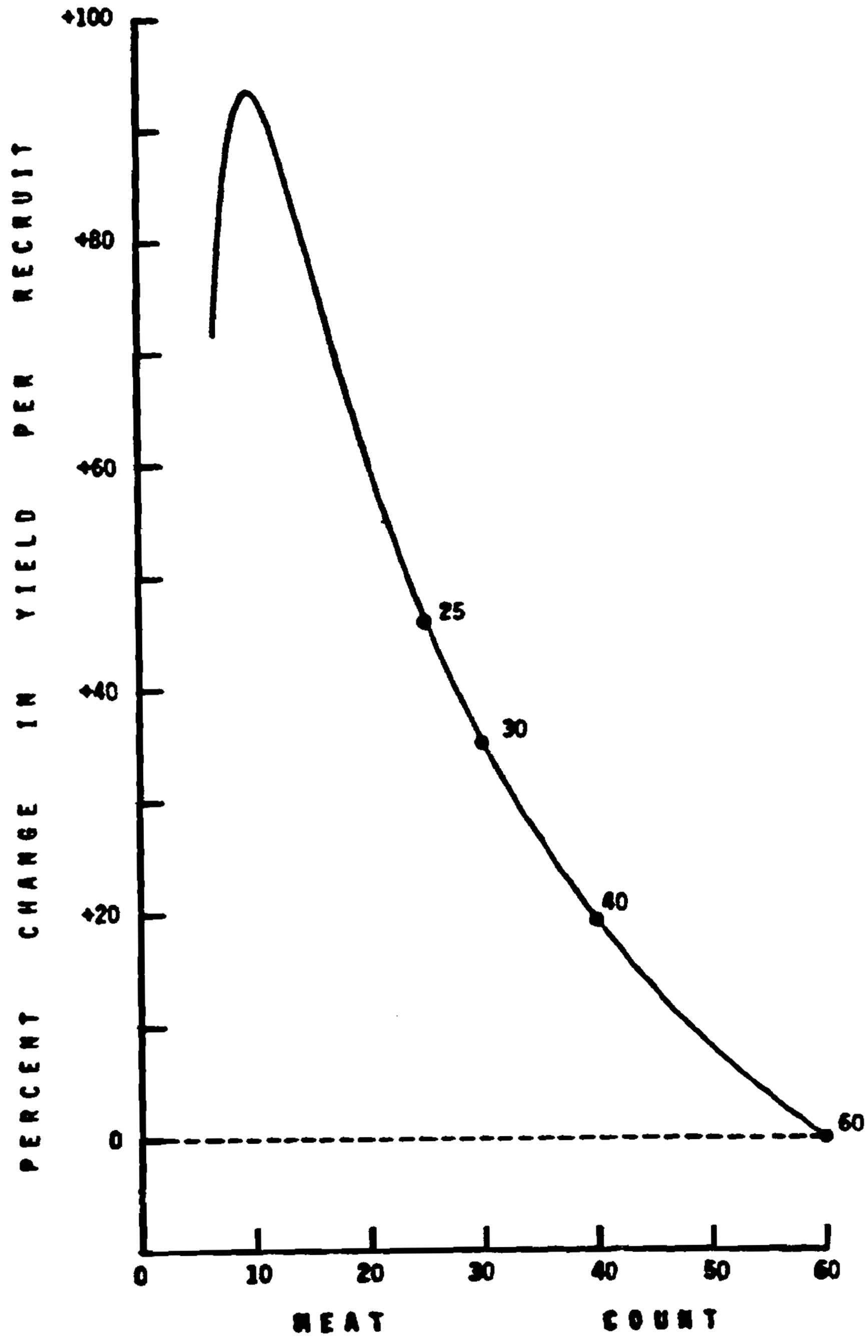


Figure 711.1: Percent change in offshore Gulf of Maine sea scallop yield per recruit relative to assumed historical average conditions (age at entry equivalent to 60 meat count) associated with a range of alternative ages at entry (meat counts) with no adjustment of the average fishing mortality rate.

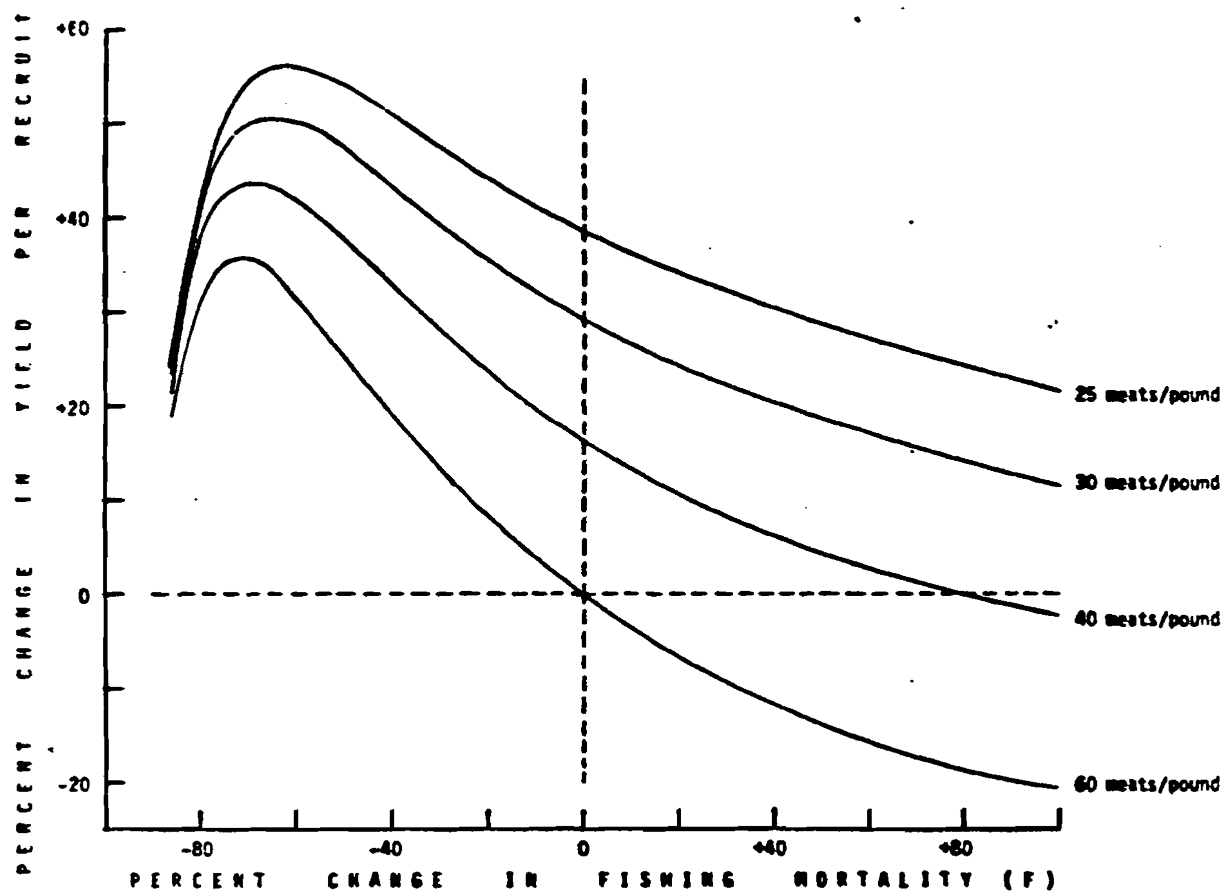


Figure 711.2: Percent change in offshore Gulf of Maine sea scallop yield per recruit associated with adjustment of the fishing mortality rate and alternative ages at entry (meat count) relative to assumed historical average levels (F=0.7, age at entry equivalent to 60 meat count).

meats per pound (and may have been significantly higher). Conversely, if it is assumed that a dredge fishery with on-board shucking, as typified by the Georges Bank fishery, may be more characteristic for the offshore Gulf of Maine, then the average cull sizes used on Georges Bank (i.e., 3 3/8 - 3 1/2 inches, see below) may be expected to result in an age at entry equivalent to a 60 meat count in the offshore Gulf of Maine.

A reasonable level of fishing mortality rate for the offshore Gulf of Maine fishery is probably not realistically obtainable. It is known that rapid resource depletion occurred in the area described above during the spring of 1980 such that most fishing effort was diverted to the Northern Edge and Peak during the summer months. This suggests very high levels of F. Conversely, with average scallop abundance being substantially less than was seen in 1979-1980, the long-term average level of fishing effort which could be expected to occur (i.e., the average fishing mortality) would be lower. An arbitrary value of fishing mortality, F=0.7, corresponding to the value applied in the Georges Bank analysis (see below), was assumed without implying that it necessarily represents an assessed value.

The results of the analysis (given in Table 711.1 and illustrated in Figure 711.1 and 711.2) have been expressed in terms of the percentage gain (or loss) associated with various combinations of age at entry (in terms of meat count) and fishing mortality as compared to the assumed historical average values for each (i.e., age at entry equivalent to a 60 meat count, F=0.7). It is apparent that the maximum possible gains in Y/R over the range of parameters considered is associated with increasing the age at entry to a meat count equivalent of 25 per pound and reducing F to F(max). This combination of actions would increase Y/R over 50%. However, about 2/3 of these potential gains could be achieved by addressing only the age at entry and avoiding the costs associated with reducing F some 64%. Conversely, about the same potential gains (i.e., 35-40%) may be achieved through reductions of F while maintaining the age at entry.

As indicated in Figure 711.1, the single, most effective measure for obtaining potential gains in Y/R is adjustment of the age at entry. Without addressing the fishing mortality, Y/R may be increased in excess of 90% but at the cost of increasing the age at entry to about 9.5 years (associated with a meat count of 10 per pound) for an average cull size of about 5 3/4 inches.

Georges Bank

In the recent historic commercial fishery (since 1976) on Georges Bank (including the Canadian fishery), typical at-sea culling practices may be expected to result in average selected scallop shell heights ranging from at least 3 inches to about 3 3/4 inches and averaging about 3 3/8 - 3 1/2 inches. A group of such scallops, all between 3 3/8 and 3 1/2 inches, shell height, may be expected to yield a meat count of about 40 meats per pound. The actual culling practice by fishermen shucking at sea may vary from year to

Table 711.2: Percent changes in yield per recruit (Y/R) for Georges Bank sea scallops associated with alternative ages at first capture (in terms of meat count) and changes in fishing mortality (F) relative to assumed historical average age at first capture (equivalent to a 40 meat count) and assumed historical average F=0.7. Values of F are shown in brackets.

		Percent Change in Y/R Meat Count			
Percent Change in F		25	30	40	50
+114.29	(1.5)	+ 5.73	- 3.82	-17.83	-33.76
+100.00	(1.4)	+ 6.37	- 2.55	-16.56	-31.85
+ 85.71	(1.3)	+ 7.64	- 1.27	-14.65	-30.57
+ 71.43	(1.2)	+ 8.92	0.00	-13.38	-28.66
+ 57.14	(1.1)	+10.83	+ 1.91	-11.46	-26.11
+ 42.86	(1.0)	+12.10	+ 3.83	- 8.92	-23.57
+ 28.57	(0.9)	+14.01	+ 5.73	- 6.37	-21.02
+ 14.29	(0.8)	+15.92	+ 8.28	- 3.82	-17.20
0.00	(0.7)	+17.83	+10.83	0.00	-13.38
- 14.29	(0.6)	+20.38	+13.38	+ 3.18	- 8.92
- 28.57	(0.5)	+22.93	+16.56	+ 7.64	- 3.82
- 42.86	(0.4)	+24.84	+19.75	+12.10	+ 1.91
- 50.00	(0.35)	+25.61 1/	+20.70	+14.01	+ 4.46
- 57.14	(0.3)	+25.48	+21.66	+15.29	+ 7.01
- 64.29	(0.25)	+22.93	+19.75	+15.92 1/	+ 9.24
- 71.43	(0.2)	+20.38	+17.83	+14.01	+ 8.92
- 85.71	(0.1)	- 3.82	- 4.46	- 5.73	- 7.64

1/ Percent change in Y/R associated with F(max).

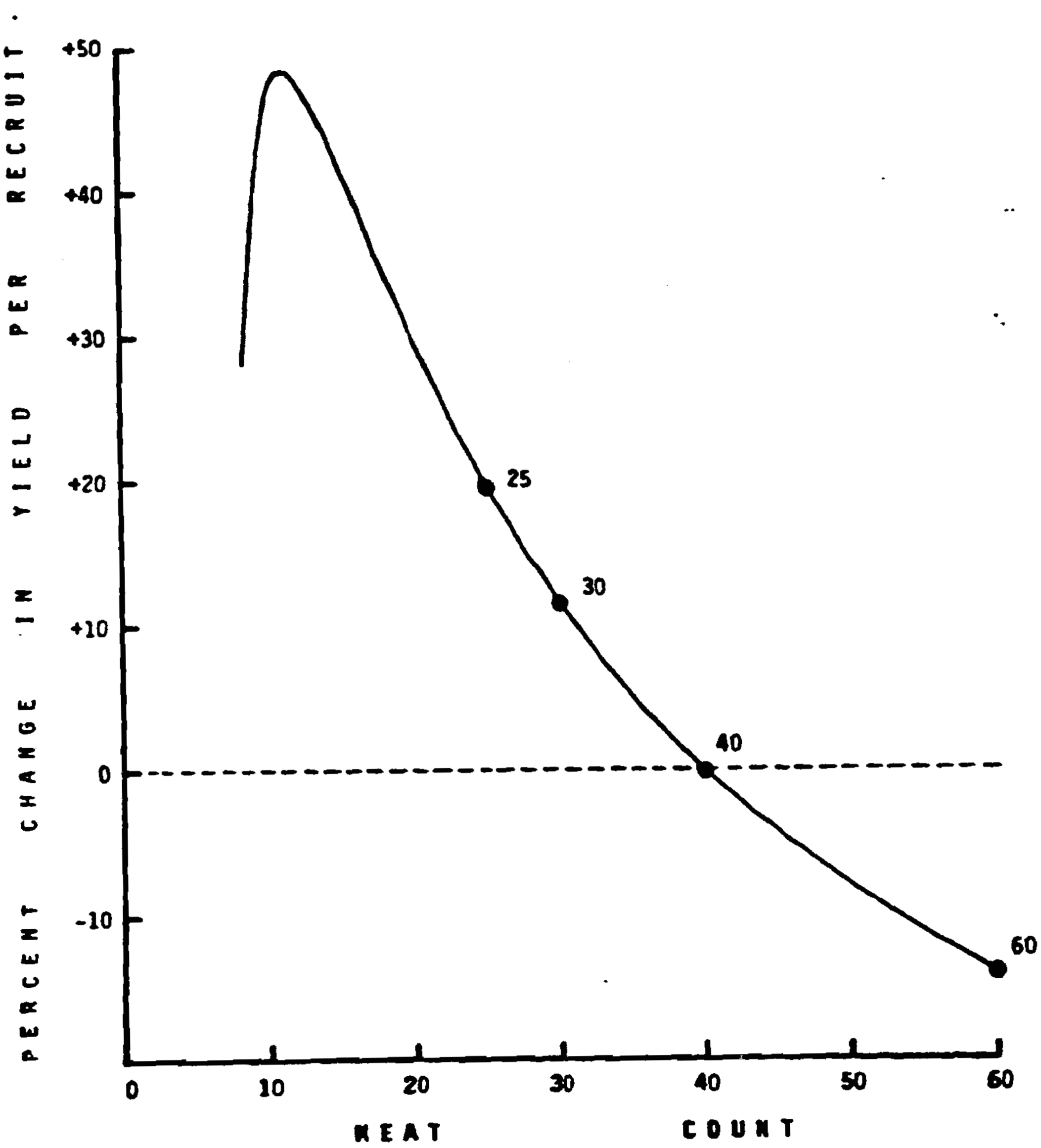


Figure 711.3: Percent change in Georges Bank sea scallop yield per recruit relative to that under historical average conditions (age at entry equivalent to 40 meat count) associated with a range of alternative ages at entry (meat counts) with no adjustment of the average fishing mortality rate.

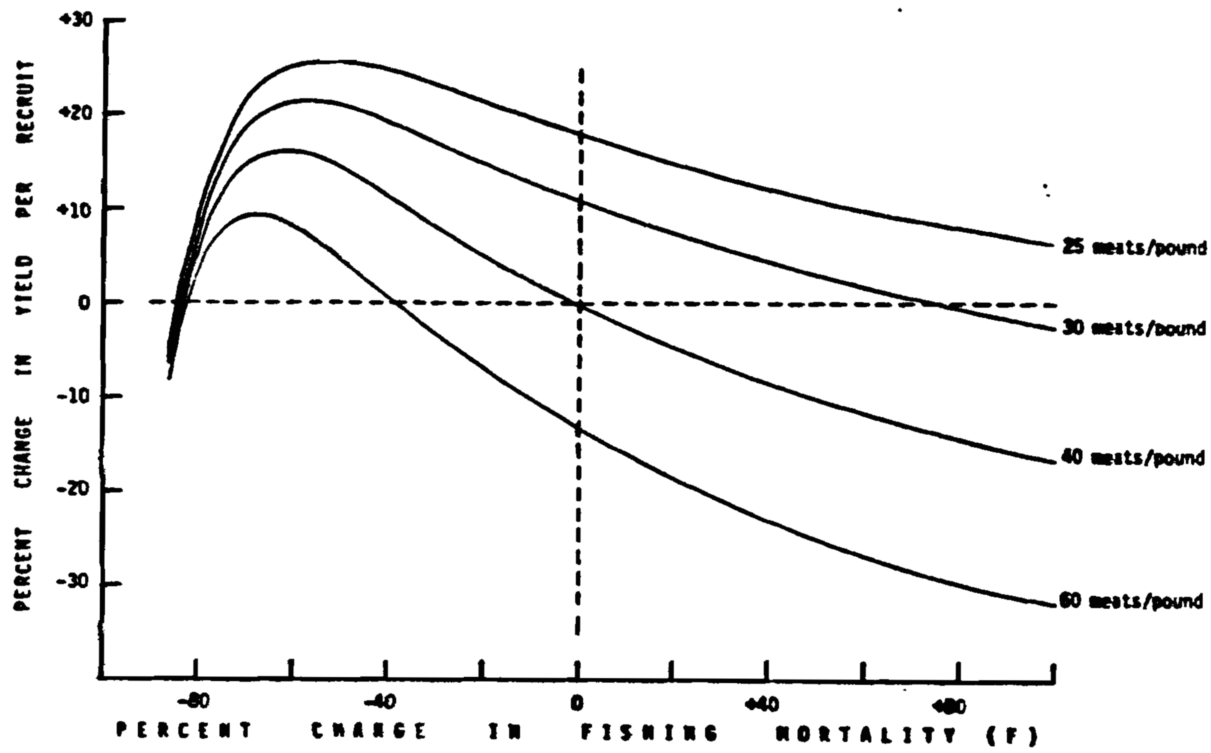


Figure 711.4: Percent change in Georges Bank sea scallop yield per recruit associated with adjustment of the fishing mortality rate and at alternative ages at entry (meat count) relative to assumed historical average levels (F=0.7, age at entry equivalent to 40 meat count).

year (or trip to trip) depending upon the size distribution and availability of sea scallops. But as a reasonable approximation of current fishing practices in the Georges Bank fishery, it was assumed that the current age at entry of scallops to that fishery is equivalent to that size which would yield about 40 meats per pound. The long-term (20 years) average fishing mortality (F) in the Georges Bank sea scallop fishery was assumed to be about F=0.7. All calculated values for yield per recruit (Y/R) associated with alternative management action have been expressed in terms of the percentage gains (or losses) relative to the Y/R associated with the current assumed F and age at entry to aid in their interpretation and comparison between different resource areas.

The estimated percentage gains (or losses) in Y/R for Georges Bank are given in Table 711.2 and illustrated in Figures 711.3 and 711.4. It is seen that if fishing mortality were maintained at its assumed historical average level (F=0.7), then Y/R would be expected to increase 17.8% with an age at entry equivalent to a 25 meat count, but would be reduced some 13.4% with an age at entry equivalent to a 60 meat count. If the current age at entry (i.e., cull size) is maintained (equivalent to a 40 meat count) while controls were placed upon the fishing mortality (F), the greatest gains (+15.9%) could be achieved with reduction of F some 64% to the level of F(max).

As was demonstrated for the offshore Gulf of Maine resource component, age at entry is the single, most effective measure for achieving potential gains in Y/R. The curve shown in Figure 711.3 shows that a nearly 50% increase in the long-term average yield could be expected with an age at entry equivalent to a meat count of about 11 per pound (equivalent to an average cull size of about 5 1/4 inches). Over the range of considered ages at entry (i.e., meat counts of 25-60), the maximum yield per recruit would result from an age at entry equivalent to a 25 meat count (about 4 inch average cull size) and a 50% reduction of fishing mortality to the level of F(max). Such a combination of management measures would increase Y/R some 25.6%. This illustrates the point that the maximum gains in Y/R will result from simultaneous adjustments of both fishing mortality and age at entry, although the latter is potentially the single most effective management tool.

Mid-Atlantic

The historic pattern of sea scallop exploitation in the Mid-Atlantic region has largely reflected the characteristic variability in recruitment to this resource component. Significant quantities of scallops able to support the development of a strong commercial fishery in this area have typically occurred only briefly about once every decade over the past 25 years. Consequently, one of the characteristic modes of exploitation has been the use of mobile finfish trawl gear in shell-stocking operations. A more recent trend has been towards the use of dredgers employing on-board shuckers, but, especially during periods of exceptional recruitment, "netters" remain as one of the important segments of the harvesting sector. One of the consequences of the latter mode of operation is that the age at first capture of sea scallops in the fishery is somewhat reduced as compared to a pure dredge fishery with on-board shucking in which smaller scallops are culled out to be returned alive to the sea. As a generalization, this statement needs to be qualified to reflect the availability of the various size classes of scallops. But, during periods of exceptional recruitment in the Mid-Atlantic region, harvesting begins when scallops reach about 70 mm (2.76 inches) in shell height during the third year of life. The meat weight from such a scallop is equivalent to a meat count of about 83 per pound. With an average size at first capture of 3 inches, shell height, the corresponding meat count of scallops at that size is 63 per pound. Hence, it has been assumed that the historic fishing practices in the unregulated Mid-Atlantic fishery is characterized by an age at entry equivalent to a meat count of 60 per pound.

Assessment of the historic levels of fishing mortality (F) in the Mid-Atlantic sea scallop fishery represents a much more difficult problem; the more traditional methods for its estimation are not applicable because of the lack of required data. However, a simulation approach used to study the typical pattern of periodic exceptional recruitment (Marchesseault and Russell, 1979) suggests that average levels of fishing mortality during the mid 1960s and early 1970s was about F=0.6.

The expected percentage changes in yield per recruit (Y/R) associated with adjustment of the fishing mortality rate (from F = 0.6) and alternative ages at entry (expressed in terms of meat count) are shown in Table 711.3. In view of the fact that some uncertainty may exist regarding the level of natural mortality (M), two values, M= 0.10 and M=0.20, have been included in the calculations. It appears likely that periodic intrusions of anoxic bottom water in the New York Bight (such as occurred in 1976) may increase the average rate of natural mortality beyond the normally expected rate of about M = 0.10. As may be seen, the maximum potential gains in Y/R achievable through adjustment of fishing mortality alone are about 22%. But, if M is as high as 0.20, then the potential gains in Y/R through reduction of F while maintaining the age at entry are insignificant (less than 5%). Given the most liberal assumption with regard to the level of natural mortality (i.e., M=0.10), significant gains in Y/R (≥10%) would require reductions in the level of F of at least 30% (i.e., F=0.4).

Very substantial gains in Y/R could be expected to result if age at entry is increased, even without adjustment of the fishing mortality rate and despite the possibility that natural mortality may be as high as M=0.20. As shown in Table 711.3 and illustrated in Figure 711.5, gains in Y/R on the order of +30% are within the range of feasible options.

It is through combinations of adjustments of both age at entry and fishing mortality that maximum gains in yield per recruit may be achieved (Figure 711.6). Thus, for example, a 17% reduction in fishing mortality, when combined with an age at entry equivalent to a 30-meat count, could be expected to increase Y/R more than 30%; nearly 20% if natural mortality is as high as M = 0.20. If a similar reduction in fishing mortality were combined with an age at entry equivalent to a 40-meat count, then significant gains in Y/R of at least 10% may be expected.

Table 711.3: Percent changes in yield per recruit (Y/R) for Mid-Atlantic sea scallops associated with alternative ages at first capture (expressed in terms of meat count) and changes in fishing mortality (F) relative to assumed historical average age at first capture (equivalent to a 60 meat count) and assumed historical average F=0.6. Two levels of natural mortality (M) have been assumed, values of F are in brackets.

		25		30		40		60	
% Change in F		M=0.10	M=0.20	M=0.10	M=0.20	M=0.10	M=0.20	M=0.10	M=0.20
+150.00	(1.5)	+17.02	+17.56	+ 6.38	+9.87	- 9.22	- 1.14	-27.66	-18.08
+133.33	(1.4)	+18.44	+18.41	+ 7.80	+10.92	- 7.80	- 0.03	-25.53	-16.44
+116.67	(1.3)	+19.86	+19.12	+ 9.22	+11.78	- 5.67	+ 1.02	-24.11	-15.27
+100.00	(1.2)	+21.28	+19.74	+10.64	+12.47	- 4.26	+ 1.86	-21.99	-13.62
+ 83.33	(1.1)	+22.70	+20.20	+12.77	+13.78	- 2.13	+ 2.24	-19.15	-11.59
+ 66.67	(1.0)	+24.82	+21.11	+14.89	+14.84	+ 0.71	+ 3.25	-16.31	- 9.58
+ 50.00	(0.9)	+26.95	+21.76	+17.02	+15.63	+ 3.55	+ 5.97	-13.48	- 7.64
+ 33.33	(0.8)	+29.08	+22.13	+19.86	+16.76	+ 6.38	+ 7.31	- 9.93	- 5.36
+ 16.67	(0.7)	+31.91	+22.63 1/	+22.70	+17.44	+ 9.93	+ 8.94	- 4.96	- 2.52
0.00	(0.6)	+34.75	+22.52	+26.24	+18.12	+14.89	+11.05	0.00	0.00
- 16.67	(0.5)	+37.59	+21.60	+30.50	+18.39 1/	+19.15	+11.79	+ 5.67	+ 2.33
- 33.33	(0.4)	+40.43	+19.38	+34.04	+16.91	+24.82	+12.10 1/	+12.17	+ 4.22
- 41.67	(0.35)	+41.75	+17.21	+35.46	+15.25	+26.95	+11.16	+15.96	+ 4.36 1/
- 50.00	(0.3)	+41.84 1/	+14.15	+36.88 1/	+12.81	+29.08	+ 9.47	+19.15	+ 3.76
- 58.33	(0.25)	+39.72	+ 9.11	+35.93	+ 8.45	+29.43 1/	+ 6.11	+20.57	+ 1.71
- 66.67	(0.2)	+36.88	+ 2.05	+34.04	+ 19.5	+29.08	+ 0.61	+21.99 1/	- 2.41
- 83.33	(0.1)	+ 9.93	-25.12	+ 9.22	-24.42	+ 7.80	-23.64	+ 5.67	-22.26

1/ Percent change in Y/R associated with F(max).

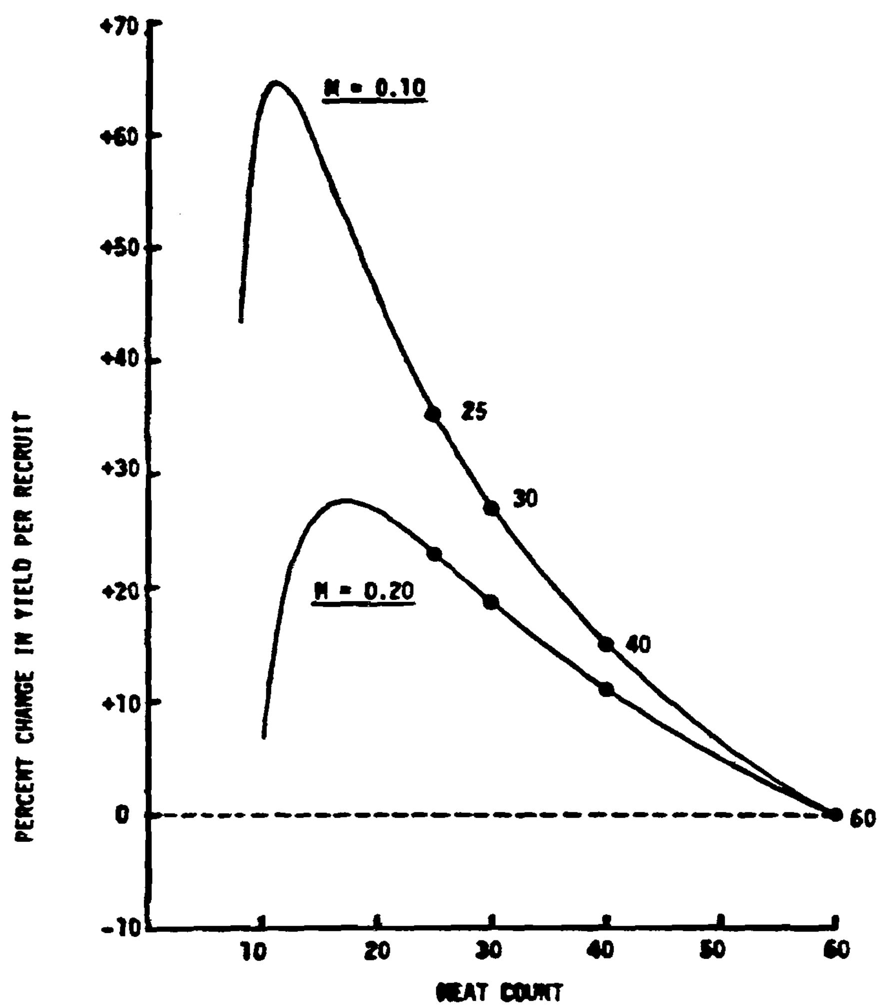


Figure 711.5: Percent change in yield per recruit for Mid-Atlantic sea scallops relative to assumed historical average conditions (age at entry equivalent to 60-meat count) associated with a range of alternative ages at entry (meat counts) with no adjustment of the average fishing mortality rate and at two assumed levels of natural mortality (M).

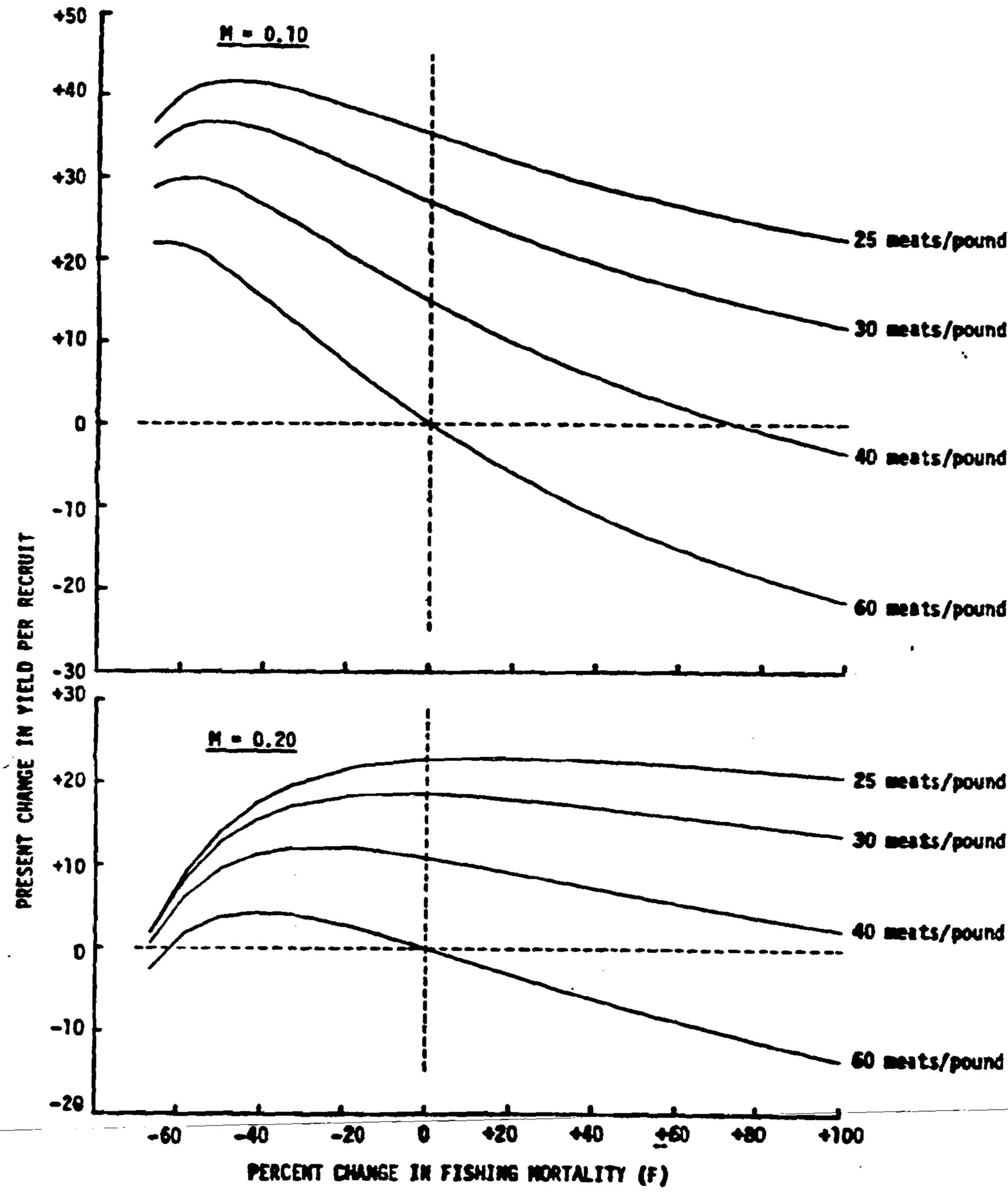


Figure 711.6: Percentage changes in Mid-Atlantic sea scallop yield per recruit associated percentage adjustment of the fishing mortality rate and at alternative ages at entry (meat count) at two assumed levels of natural mortality (M), all relative to assumed historical average conditions (F=0.6, age at entry equivalent to 60 meat count).

It should be observed that other considerations not explicitly addressed in a yield per recruit analysis are relevant in all resource areas when interpreting the results presented above. For example, reductions in fishing mortality will result in not only increased long-term average yields, but will also tend to create a population comprised of greater representation in the older age groups. Such a population would aid the industry to "ride-out" periods of unusually poor recruitment. Moreover, a relatively larger number of scallops in the older age groups may enhance the probability of greater spawning success with the potential of more stable and enhanced recruitment. Thus, reductions in the level of fishing mortality may result in greater gains in the long-term average total yield than the yield per recruit analysis would otherwise suggest.

Long-Term Equilibrium Catch Streams

The detailed yield per recruit analyses which have been presented in this section represent an assessment of the expected relative long-term average biological implications associated with implementation of a range of management measures for controlling the age at entry of sea scallops to the component fisheries or the fishing mortality rates or a combination of both. These results are appropriate from a biological perspective, but are inadequate for assessment of expected economic impacts. Available modeling techniques for estimation of effects upon economic parameters such as employment and revenue require estimates of annual catch levels plus a knowledge of factors affecting prices. Ideally, such estimates should encompass the entire span of time required for the complete manifestation of biological and economic perturbations caused by management actions. In practice, the uncertainties with respect to expected levels of annual recruitment to fishery resources prevent the complete specification of the expected stream of annual catches. It is only in the short term, where knowledge of the strength of recruiting year classes is available, that plausible estimates of annual catches may be forecasted (see §712).

In the longer time frame, some insight into expected bio-economic impacts may be derived if the results of the yield per recruit analysis may be cast in absolute terms through reasonable assumptions regarding the long-term pattern of recruitment. Given such assumptions regarding recruitment and in consideration of the fact that fishing mortality rates in the sea scallop fisheries are quite high in all resource components, the resulting total annual catch levels (based upon the yield per recruit data) should not differ materially from comparable levels which might be generated using a fishery simulation. It is important to realize, however, that the approach is still essentially a simulation of what might transpire and should never be construed as purporting to be an assessment of future stock conditions. Nevertheless, the exercise has intrinsic value since management decisions which are based upon the derived relative long-term bio-economic impacts will remain valid regardless of the absolute accuracy of the forecasted catch levels. The criterion for such long-term decisions is the relative ordering of projected impacts which will remain independent of the absolute accuracy of prediction.

As judged from past events in the fishery, sea scallop populations in all resource areas, with the possible exception of the Northern Edge on Georges Bank, are subject to periodic exceptionally strong recruiting year classes which result in significant, temporary increases in resource abundance. Recruitment to the fishery on the Northern Edge has typically been more uniformly good (less variable) than in other areas. The general pattern of historical catches plus the available survey abundance indices of recruiting year classes suggest that the sea scallop resource is subject to long-term cycles in overall abundance. Dow (1962) describes such long-term cycles in the abundance of scallops along the Maine coast. There are, of course, subtle variations among individual populations of sea scallops but the overall pattern of recruitment appears to be a cyclical phenomenon. Perhaps much of the motive force for creation of these cyclical patterns in recruitment are environmental conditions such as long-term trends in sea water temperature, strength and persistence of the clockwise current gyre over Georges Bank and many others. If these factors are relevant then it may be reasonable to assume that cyclical patterns in recruitment seen in the past will tend to continue in the future.

Not being able to predict the amplitude and period of oscillations in the cyclical pattern of future recruitment, the approach taken in this section is to assume that such patterns may be described by that which was seen in the past. Because a great deal more is known about the overall Georges Bank component of the resource than in the Mid-Atlantic region or in the offshore Gulf of Maine, the focus of the analysis has been Georges Bank. Nevertheless, the approach is sufficiently broad in its concept that conclusions may have general application for all areas. More specifically, the catch per unit effort data given in Table 311 shows peaks in Georges Bank scallop abundance in 1961 and 1977 and suggests the possibility of a 16 year cycle. Given the nature of the long-term analysis (relative long-term productivity), the exact period of the cycle is of less importance to the conclusions then is the assumption of repeatable resource patterns, leading to equilibrium conditions. Nevertheless, the 16 year cycle chosen is considered to be sufficiently representative of intrinsic population variation so as to provide an acceptable and "realistic" basis for comparing long-term management strategies.

The analysis was cast within the framework of two boundary conditions. These are represented by:

1. Simulation of the historical fishery.
   An attempt was made to simulate the historic levels of total catch, total effort, and catch per unit of effort observed in the total Georges Bank fishery over the period 1961-1977 with the proviso that the long-term cycles in each of these parameters have their exact replication in succeeding cycles. This simulation may also be considered the zero effort-control scenario.

2. Simulation of constant fishing effort equivalent to F(max).
   This scenario asks the question, what if, in the historic fishery, the level of applied fishing effort had been held constant such that a fishing mortality equivalent to F(max) had been achieved. It represents the optimal level of control on fishing effort relative to yield per recruit considerations.

Between these two boundary conditions an unlimited number of possible effort control scenarios could be constructed. The approach taken was to elaborate a number of alternative constant effort scenarios, acknowledging that constant effort management probably does not constitute a practical solution for application to the fishery, but recognizing the futility of attempting to specify annual effort levels in the face of uncertainty regarding future conditions. In conjunction with alternative effort control scenarios, a range of feasible options with regard to meat count were incorporated as the second control variable.

To conduct the analysis it was necessary to develop estimates of the levels of recruitment which may have been characteristic of the historic fishery on Georges Bank and to develop a preliminary evaluation of the relationship between fishing mortality rate and the level of applied fishing effort. A detailed account of the methodology used appears in Appendix 4. Briefly, the relationship between fishing mortality (F) and fishing effort (f), expressed as a constant of proportionality, the catchability coefficient (q), was estimated from a detailed examination of data from the recent series of scallop research vessel dredge surveys conducted during the period 1975-1977 together with estimates of the overall F on Georges Bank during 1958-1963 by Posgay (1976).

Annual mean catches per unit of effort generated by the commercial fishery over the period 1961-1977 may be closely approximated by a linear function over time during each half-cycle with the minimum value occurring in 1972. Making use of the Beverton-Holt yield per recruit model, maximum levels of recruitment during the cycle were empirically estimated on the basis of the understanding of the fishing mortality rates in the early 1960s and the corresponding mean level of effort, but constrained by-catch per unit of effort specified from the linear function with time. Thus, equilibrium yields and the corresponding equilibrium recruitment levels required were generated consistent with a required catch per unit of effort. The minimum level of recruitment, coincident with the minimum catch per unit of effort, was constrained by an F of about 0.7 and a total yield approximating that observed in 1972. It is clear that the resulting series of recruitment values does not represent a unique solution to the problem nor should they be viewed as estimates of the true, historic levels of recruitment. They are intended only as indices of stock size in an equilibrium context. In such a context, the annual yield from a population comprised of many year classes is equivalent to the total yield from a single year class over the total number of years that it remains in the fishery.

Finally, with regard to those simulations which examine various levels of effort control, it may be expected that stock sizes would be increased relative to the historic simulation since survivorship would be increased with lower Fs. The procedure was to compare annual survival in the historic simulation to the same year's survival rates in each of the other simulations. The additional survivors were then added to the following year's recruitment. It is acknowledged that the procedure was not entirely rigorous given the assumptions of the BevertonHolt model -- total yield was calculated from estimated recruitment levels given yield per recruit but survivors were treated as additional recruits -- but it probably illustrates the expected effect. Moreover, it may be argued that under equilibrium conditions, the number of recruits may be treated as a surrogate for stock size.

Table 711.4: Simulations of the historic Georges Bank sea scallop fishery under four alternative assumptions of age at entry (meat count). It has been assumed that an age at entry equivalent to a 40 meat count most closely approximates the historic fishing practices.

	MEAT COUNT = 25				MEAT COUNT = 30				MEAT COUNT = 40				MEAT COUNT = 60			
Year	N	F	Y	f	N	F	Y	f	N	F	Y	f	N	F	Y	f
0	970	.871	16400	13257	970	.817	15225	13257	970	.817	13490	13257	970	.817	11390	13257
1	970	.859	16305	13936	970	.859	15104	13936	970	.859	13336	13936	970	.859	11202	13936
2	935	.880	15672	14269	935	.880	14504	14269	935	.880	12783	14269	935	.880	10711	14269
3	829	.841	13969	13643	829	.841	12951	13643	829	.841	11453	13643	829	.841	9641	13643
4	735	.796	12260	12918	735	.796	11395	12918	735	.796	10115	12918	735	.796	8562	12918
5	623	.750	10635	12160	623	.750	9909	12160	623	.750	8833	12160	623	.750	7523	12160
6	535	.708	9190	11481	535	.708	8584	11481	535	.708	7683	11481	535	.708	6582	11481
7	465	.680	8021	11029	465	.680	7506	11029	465	.680	6736	11029	465	.680	5795	11029
8	405	.660	7007	10705	405	.660	6565	10705	405	.660	5905	10705	405	.660	5094	10705
9	357	.654	6182	10610	357	.654	5794	10610	357	.654	5215	10610	357	.654	4504	10610
10	317	.661	5483	10727	317	.661	5137	10727	317	.661	4620	10727	317	.661	5986	10727
11	285	.681	4915	11044	285	.681	4599	11044	285	.681	4127	11044	285	.681	3550	11044
12	372	.654	6442	10601	372	.654	6039	10601	372	.654	5434	10601	372	.654	4693	10601
13	490	.683	8448	11085	490	.683	7902	11085	490	.683	7092	11085	490	.683	6098	11085
14	652	.747	11135	12117	652	.747	10376	12117	652	.747	9253	12117	652	.747	7884	12117
15	868	.837	14634	13576	868	.837	13570	13576	868	.837	12004	13576	868	.837	10110	13576
$\bar{X}$		.744	10419	12072		.744	9698	12072		.744	8630	12072		.744	7333	12072

N = Stock size index given the historically simulated fishing mortality rates.
F = Fishing mortality rate.
Y = Equilibrium Yield in metric tons.
f = Fishing effort in standard USA days fished.

Simulations of the historic fishery were run under four alternative assumptions of age at entry (equivalent to meat counts of 25, 30, 40, and 60 meats per pound, see Table 711.4). The resulting catch streams over a resource cycle illustrate what may be expected if historic patterns of fishing effort are repeated while only age at entry is adjusted. It has been assumed that an age at entry equivalent to a 40-meat count reflects the actual fishing practice in the historic fishery, despite some information suggesting that lower ages at entry (higher meat counts) occurred over part of the cycle.

Noting that the average level of effort in the historic simulation was about 12,000 days fished, three additional levels of constant effort [9,500, 7,500 and 5,676 days fished, the latter corresponding to a fishing mortality of $F = 0.35$, the approximate level of F(max)] were simulated, all with the above four options of age at entry. The simulated equilibrium catch streams over a resource cycle associated with 25, 30, 40 and 60 meat count control specifications are given in Tables 711.5, 711.6, 711.7 and 711.8. Information from these tables was used in the economic impact analysis in Section 720.

The calculated long-term mean equilibrium yields for all combinations of constant effort control and age at entry (meat count) which were examined appear in Table 711.9 for the reader's convenience. It seems clear that, given the assumptions of the analysis, substantial gains in total yield may be achieved through appropriate controls on age at entry and fishing effort. To better illustrate the relationship which the long-term average equilibrium yield has with alternative levels of constant fishing effort and age at entry, the data in Table 711.9 were contoured to reveal the shape of the yield isopleths (Figure 711.7). Thus, other possible scenarios, within the broad range covered, may be examined.

Table 711.5: Simulated catch and effort streams under equilibrium conditions for various effort control scenarios. Age at entry equivalent to 25 meat count.

CONSTANT EFFORT SCENARIOS

	12,072 days fished			9,500 days fished			7,500 days fished			Approx. F_{max} (F=0.35, f=5676 df)		
Year	F	Y	f	F	Y	f	F	Y	f	F	Y	f
0	.744	16572	12072	.586	18847	9500	.463	20010	7500	.350	21178	5676
1	.744	16572	12072	.586	18921	9500	.463	20189	7500	.350	21490	5676
2	.744	15974	12072	.586	18616	9500	.463	19850	7500	.350	21148	5676
3	.744	14163	12072	.586	16825	9500	.463	17982	7500	.350	19256	5676
4	.744	12352	12072	.586	14468	9500	.463	15509	7500	.350	16609	5676
5	.744	10644	12072	.586	12234	9500	.463	13160	7500	.350	14118	5676
6	.744	9140	12072	.586	10278	9500	.463	11094	7500	.350	11919	5676
7	.744	7944	12072	.586	8735	9500	.463	9453	7500	.350	10160	5676
8	.744	6919	12072	.586	7493	9500	.463	8126	7500	.350	8739	5676
9	.744	6099	12072	.586	6527	9500	.463	7087	7500	.350	7620	5676
10	.744	5416	12072	.586	5775	9500	.463	6270	7500	.350	6741	5676
11	.744	4869	12072	.586	5210	9500	.463	5648	7500	.350	6067	5676
12	.744	6355	12072	.586	6760	9500	.463	7185	7500	.350	7574	5676
13	.744	8371	12072	.586	8812	9500	.463	9874	7500	.350	9822	5676
14	.744	11139	12072	.586	11849	9500	.463	12581	7500	.350	13252	5676
15	.744	14829	12072	.586	16130	9500	.463	17076	7500	.350	17971	5676
$\bar{X}$	.744	10460	12072	.586	11718	9500	.463	12537	7500	.350	13356	5676

F = Fishing mortality rate.
Y = Equilibrium yield in metric tons.
f = Fishing effort in standard USA days fished.

Table 711.6: Simulated catch and effort streams under equilibrium conditions for various effort control scenarios. Age at entry equivalent to 30 meat count.

	CONSTANT EFFORT SCENARIOS											
	12,072 days fished			9,500 days fished			7,500 days fished			Approx. F_{max} (F=0.35, f=5676 df)		
Year	F	Y	f	F	Y	f	F	Y	f	F	Y	f
0	.744	15466	12072	.586	17750	9500	.463	19033	7500	.350	20370	5676
1	.744	15466	12072	.586	17819	9500	.463	19204	7500	.350	20669	5676
2	.744	14889	12072	.586	17532	9500	.463	18881	7500	.350	20341	5676
3	.744	13201	12072	.586	15845	9500	.463	17104	7500	.350	18492	5676
4	.744	11513	12072	.586	13626	9500	.463	14753	7500	.350	15975	5676
5	.744	9921	12072	.586	11522	9500	.463	12517	7500	.350	13579	5676
6	.744	8519	12072	.586	9680	9500	.463	10553	7500	.350	11464	5676
7	.744	7405	12072	.586	8226	9500	.463	8991	7500	.350	9772	5676
8	.744	6449	12072	.586	7057	9500	.463	7729	7500	.350	8405	5676
9	.744	5685	12072	.586	6147	9500	.463	6741	7500	.350	7329	5676
10	.744	5048	12072	.586	5439	9500	.463	5964	7500	.350	6484	5676
11	.744	4538	12072	.586	4907	9500	.463	5372	7500	.350	5835	5676
12	.744	5924	12072	.586	6366	9500	.463	6834	7500	.350	7285	5676
13	.744	7803	12072	.586	8299	9500	.463	8917	7500	.350	9505	5676
14	.744	10382	12072	.586	11159	9500	.463	11968	7500	.350	12746	5676
15	.744	13822	12072	.586	15191	9500	.463	16243	7500	.350	17285	5676
$\bar{X}$	.744	9749	12072	.586	11035	9500	.463	11925	7500	.350	12846	5676

F = Fishing mortality rate.
Y = Equilibrium yield in metric tons.
f = Fishing effort in standard USA days fished.

Table 711.7: Simulated catch and effort streams under equilibrium conditions for various effort control scenarios. Age at entry equivalent to 40 meat count.

CONSTANT EFFORT SCENARIOS

Year	12,072 days fished			9,500 days fished			7,500 days fished			Approx. F_{max} (F=0.35, f=5676 df)		
	F	Y	f	F	Y	f	F	Y	f	F	Y	f
0	.744	13776	12072	.586	16097	9500	.463	17536	7500	.350	19096	5676
1	.744	13776	12072	.586	16160	9500	.463	17694	7500	.350	19377	5676
2	.744	13279	12072	.586	15900	9500	.463	17396	7500	.350	19069	5676
3	.744	11774	12072	.586	14370	9500	.463	15759	7500	.350	17336	5676
4	.744	10268	12072	.586	12357	9500	.463	13592	7500	.350	14977	5676
5	.744	8848	12072	.586	10449	9500	.463	11533	7500	.350	12730	5676
6	.744	7598	12072	.586	8778	9500	.463	9723	7500	.350	10747	5676
7	.744	6604	12072	.586	7461	9500	.463	8284	7500	.350	9161	5676
8	.744	6449	12072	.586	6400	9500	.463	7121	7500	.350	7880	5676
9	.744	5070	12072	.586	5575	9500	.463	6211	7500	.350	6871	5676
10	.744	4502	12072	.586	4932	9500	.463	5495	7500	.350	6079	5676
11	.744	4048	12072	.586	4450	9500	.463	4950	7500	.350	5470	5676
12	.744	5283	12072	.586	5774	9500	.463	6296	7500	.350	6829	5676
13	.744	6959	12072	.586	7526	9500	.463	8215	7500	.350	8911	5676
14	.744	9260	12072	.586	10120	9500	.463	11026	7500	.350	11949	5676
15	.744	12327	12072	.586	13777	9500	.463	14965	7500	.350	16205	5676
$\bar{X}$	.744	8695	12072	.586	10008	9500	.463	10987	7500	.350	12043	5676

F = Fishing mortality rate.
Y = Equilibrium yield in metric tons.
f = Fishing effort in standard USA days fished.

Table 711.8: Simulated catch and effort streams under equilibrium conditions for various effort control scenarios. Age at entry equivalent to 60 meat count.

	CONSTANT EFFORT SCENARIOS											
	12,072 days fished			9,500 days fished			7,500 days fished			Approx. F_{max} (F=0.35, f=5676 df)		
Year	F	Y	f	F	Y	f	F	Y	f	F	Y	f
0	.744	11743	12072	.586	14052	9500	.463	15652	7500	.350	17452	5676
1	.744	11743	12072	.586	14107	9500	.463	15792	7500	.350	17708	5676
2	.744	11319	12072	.586	13880	9500	.463	15527	7500	.350	17427	5676
3	.744	10036	12072	.586	12544	9500	.463	14066	7500	.350	15843	5676
4	.744	8752	12072	.586	10787	9500	.463	12132	7500	.350	13687	5676
5	.744	7542	12072	.586	9122	9500	.463	10294	7500	.350	11634	5676
6	.744	6477	12072	.586	7663	9500	.463	8678	7500	.350	9822	5676
7	.744	5629	12072	.586	6513	9500	.463	7394	7500	.350	8372	5676
8	.744	4903	12072	.586	5587	9500	.463	6356	7500	.350	7201	5676
9	.744	4322	12072	.586	4867	9500	.463	5543	7500	.350	6279	5676
10	.744	3838	12072	.586	4306	9500	.463	4905	7500	.350	5555	5676
11	.744	3450	12072	.586	3885	9500	.463	4418	7500	.350	4999	5676
12	.744	4503	12072	.586	5040	9500	.463	5620	7500	.350	6241	5676
13	.744	5932	12072	.586	6570	9500	.463	7333	7500	.350	8143	5676
14	.744	7893	12072	.586	8835	9500	.463	9841	7500	.350	10920	5776
15	.744	10508	12072	.586	12027	9500	.463	13357	7500	.350	14809	5676
$\bar{X}$	.744	7412	12072	.586	8736	9500	.463	9807	7500	.350	11006	5676

F = Fishing mortality rate.
Y = Equilibrium yield in metric tons.
f = Fishing effort in standard USA days fished.

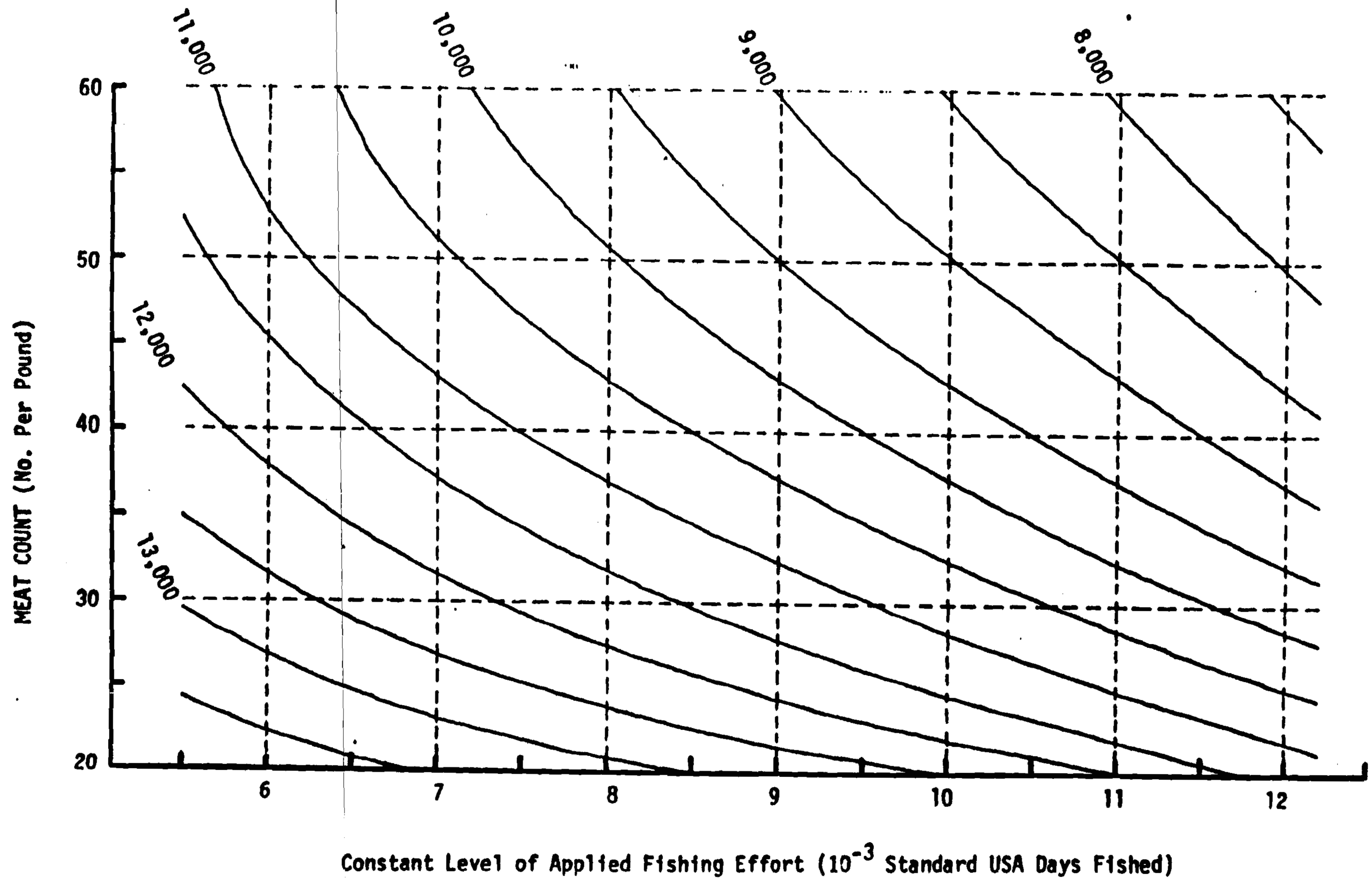


Figure 711.7: Long-term mean equilibrium yield isopleths (mt) for the Georges Bank sea scallop fishery associated with a range of ages at entry (meat counts) and a range of constant levels of applied fishing effort.

Table 711.9: Mean total annual equilibrium yields (metric tons) over a resource cycle at four levels of constant fishing mortality (and effort) and four levels of age at entry (meat count).

Mortality Rate (Effort) 1/	MEAT COUNT 25	30	40	60
.350 (5,676)	13,356	12,846	12,043	11,006
.463 (7,500)	12,537	11,925	10,987	9,807
.586 (9,500)	11,718	11,035	10,008	8,736
.744 (12,072)	10,460	9,749	8,695	7,412

1/Fishing effort is expressed in standard USA days fished.

§712 The Short-Term Biological Analysis

In a single species fishery, such as that for sea scallops, the ideal biological basis for management decisions is probably an accurate stock assessment. To generate such an assessment based upon established dynamic pool models, however, requires a prodigious amount of accurate information about the fishery. In the case of the sea scallop fishery, collection of that information may be a task having insurmountable obstacles given existing sampling technology. Nevertheless, while absolute estimates of stock size and year class composition are lacking, the NMFS research vessel sea scallop survey catch per tow data provide relative estimates of these quantities. As a caveat, it should be understood that the sampling efficiency of the research sea scallop dredge is not necessarily equal for all sized scallops. It is known that small scallops are capable of sensing the pressure wave in front of a towed dredge and are able to take evasive maneuvers to avoid capture, whereas large sea scallops generally do not exercise that same capability. Hence, the youngest year classes recruiting to the fishery may be poorly sampled.

Recognizing the limitations of survey catch data for the youngest age groups, the catch per tow data were assumed to represent the best available indices of relative density on the fishing grounds of sea scallops across the spectrum of size ranges available to the fishery.

As such, these data could be adapted for use in making short-term catch projections, testing the effects of various management measure specifications. Accurate catch projections, however, require a knowledge of the past history of fishing mortality (F) exerted in the fishery. Hence, the analysis using survey catch data required certain assumptions regarding F.

1. Size at first capture.

   Examination of commercial shell height frequency data from shell samples (see Figure 712.3 for the South Channel as an example) suggests that recruitment commences after the 70-74 mm shell height size group and that recruitment is essentially complete for the 85-89 mm size grouping. This pattern of recruitment is assumed to be consistent with a 3 inch (76.2 mm) minimum cull size.

2. Fishing mortality rate.

   For the purposes of the analysis, 1982 and 1983 catch projections were made assuming a constant fishing mortality rate (F=0.6) for 1981-1983 on Georges Bank and F=0.7 in the Mid-Atlantic. Whether or not such an assumption is realistic, this approach allows isolation of the effects of various meat count/minimum size specifications. Moreover, the relative ordering of such effects should not change, in spite of the fact that fishing mortality rates may vary over the three-year period.

With these assumptions regarding the sea scallop selection curve and fishing mortalities, the 1981 research vessel sea scallop catch per tow data (assumed to have been taken synoptically in June 1981) were first segregated by age class through a probit-type analysis and then discounted by one-half of the projected 1981 catch (to provide a multiplier to convert stratified mean number per tow to estimated stock in millions), arriving at an estimated stock size by age class for January 1982. From tables for the ordinates of the normal probability density function, size distributions at age were constructed for June 1981 and for January 1982 and 1983.

As an example of the form taken by the population size structure as a result of the analysis, Figure 712.1 illustrates the projected sea scallop populations in the South Channel. The heavy line in the uppermost curve of Figure 712.1, the curve of summation, is a representation of the catch per tow data after the latter were broken down by year class. As seen here, the 1977 year class dominates the population and is projected to remain as a significant component through January 1983. The 1979 year class, by virtue of its performance in the 1981 survey, which probably underestimated its relative strength, was assumed to be equal to the size of the 1978 year class (indicated by the dotted line). This assumption was used in constructing the projected population for January 1982. Finally, it should be noted that assumptions regarding the size of the 1979 year class are irrelevant to projected 1982 catches in any resource area, but may be a source of significant error in projected catches for 1983.

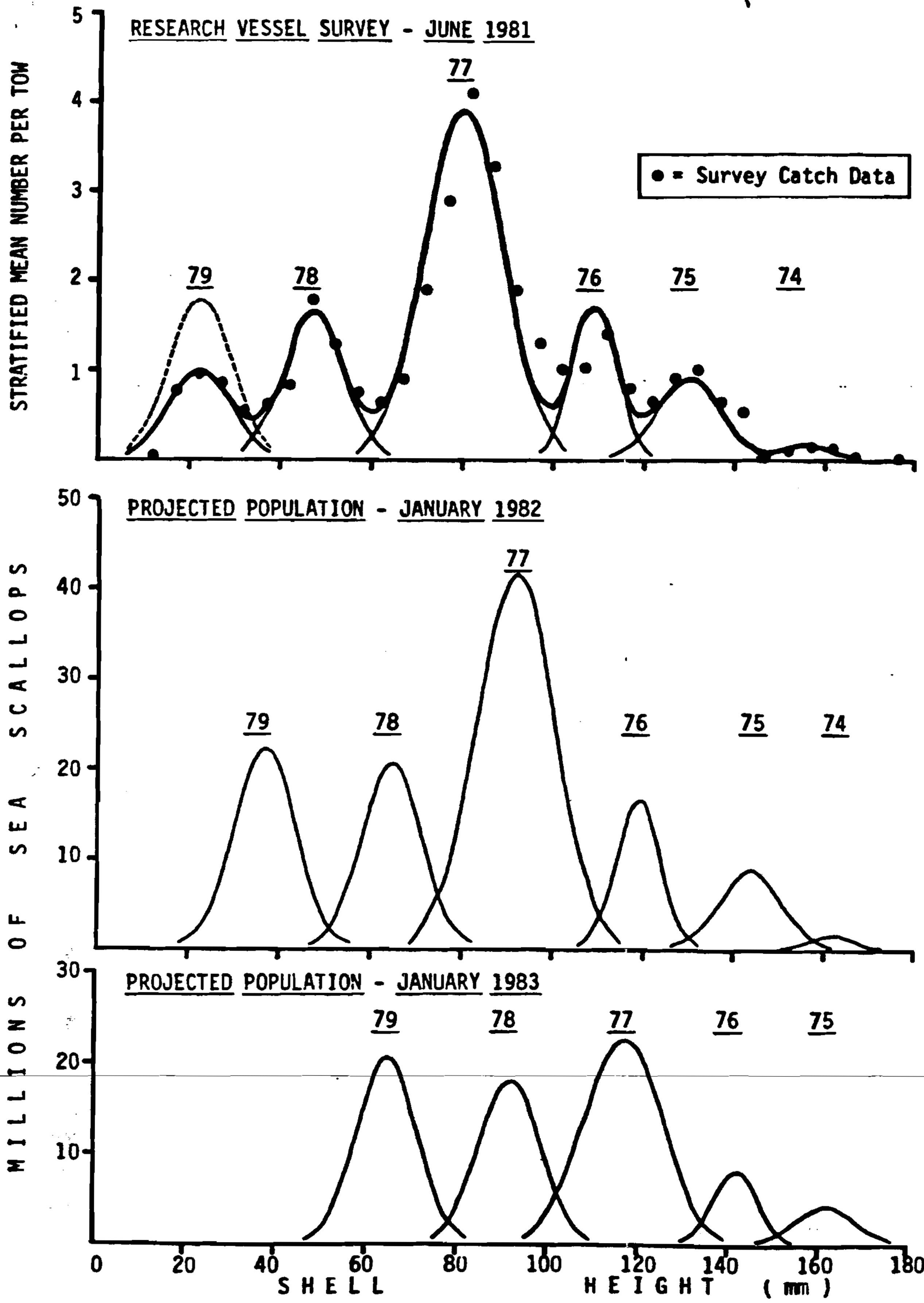


Figure 712.1: Estimated sea scallop populations (by year class) in the South Channel projected to January 1982 and 1983 where year classes assume normal random height - frequency distributions and are subject to a fishing mortality, F = 0.6. The 1979 year class (dotted) assumed equal to the 1978 year class.

The projected size distribution of commercial catches in 1982 and 1983 from the South Channel are shown in Figure 712.2 as an example of the analyses that were performed given a continuation of the assumed current 3 inch minimum cull size and a constant fishing mortality rate, F=0.6. It is seen that the 1982 catch may be expected to be dominated by the 1977 year class; a somewhat smoother size-distribution envelope with a somewhat larger average size (relative to 1982) is expected for 1983. A previous example of the effects on the catch when a large year class recruits to the fishery is provided from the commercial shell sample data (Figure 712.3). The very strong 1972 year class, which began recruiting to the commercial fishery in 1976 and was fully recruited in 1977, substantially increased the average size of sea scallops in the catch in 1978 analogous to the pattern which has been projected for 1983.

From the projected catch at size data, as exemplified by Figure 712.2, and the corresponding projected catch in weight data, weighted average meat counts by resource area were calculated for 1982 and 1983. As noted above, these calculations were performed assuming no change is made in the current assumed minimum cull size (3.0 inches, shell height). The estimated weighted average meat counts, which may be expected in 1982 and 1983, appear in Table 712.1. The highest meat counts (i.e., smallest average scallop size) are expected to occur in 1982 on the Northern Edge and Peak (22.1 meats per pound) as a result of recruitment from the relatively strong 1978 year class. These results indicate that fishery regulations governing allowable meat counts over the range considered, even including a 25 meat count option, should not impact sea scallop harvesters who shuck scallops at sea. Of course, the calculated estimates reflect the expected average catch; depending upon the harvesting strategy pursued by individual fishermen, substantially higher meat counts could result with concentration of effort on beds of newly recruiting scallops.

The specification of a minimum shell height as an alternative (to a meat count specification) method for controlling the age at entry to the fishery may entail significant short term impacts upon the harvesters. Table 712.2 shows projected total catches by resource area for 1982 and 1983 under various minimum shell height specifications with the percentage loss relative to the current assumed 3 inch minimum cull size (taken as the base case).

Overall, the expected impacts for 1982 and 1983 associated with going to a 3.25 minimum shell height (equivalent to a 40 meat count) amount to 3% or less with the greatest impacts expected to occur on the Northern Edge and Peak. A 3.50 inch minimum size (equivalent to 30 meat count) may generally be expected to result in moderate impacts within resource areas of 11% or less in 1982, dropping to less than 5% in 1983 except on the Northern Edge and Peak where losses amounting to about one-third of the potential catches may be expected. Moderate to substantial losses in potential catch may be expected in all areas over both years with implementation of a 3.75 inch minimum shell height (associated with a 25 meat count). Nevertheless, it should be noted that even with these projected losses in potential catch, only the 3.75 minimum shell height option in 1982 would result in a total Georges Bank catch of less than the 15-year (1966-1980) average (8894 mt); and all options in 1983 may be expected to result in total Georges Bank catches exceeded only by those during 1977-1979.

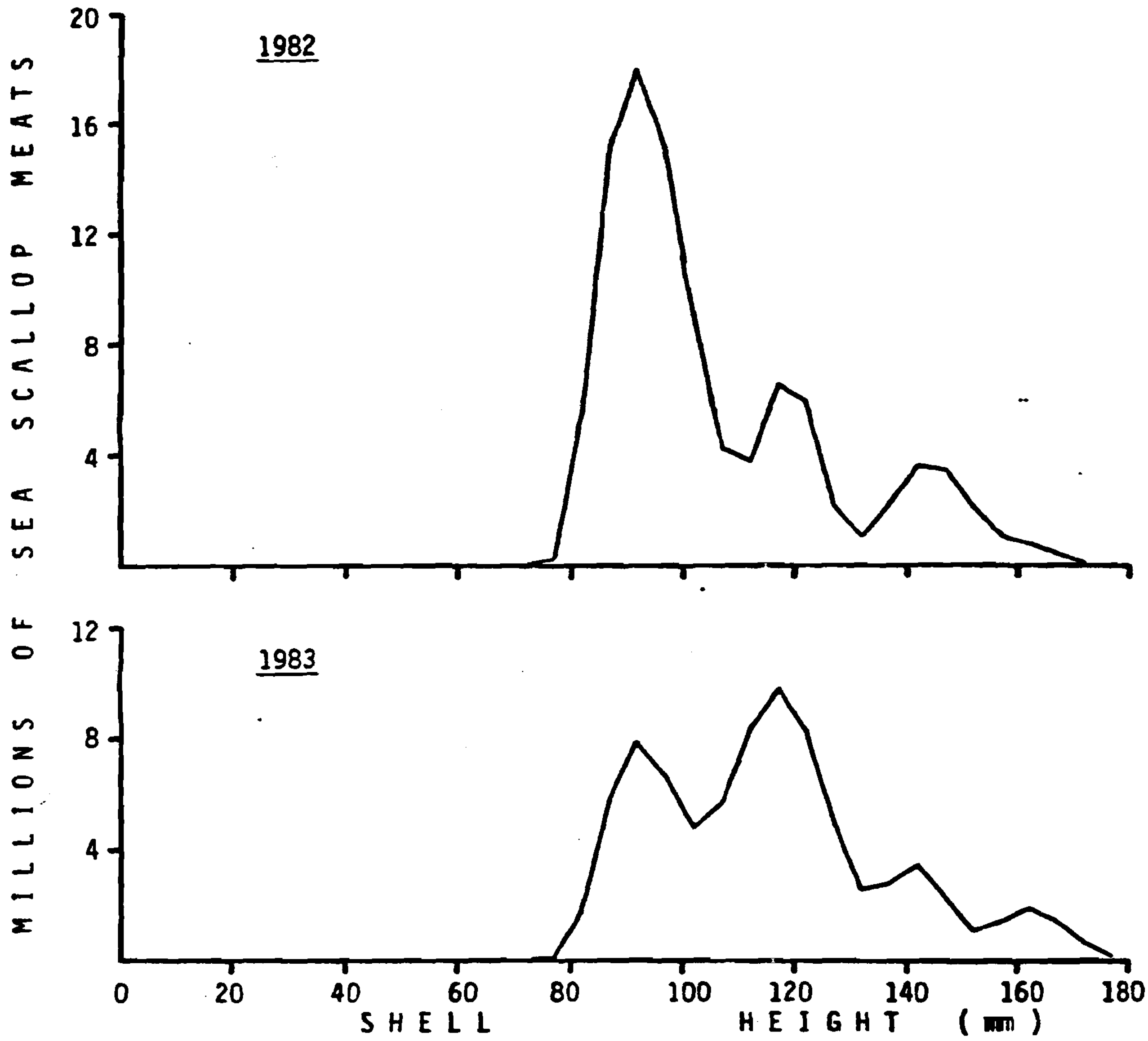


Figure 712.2: Projected USA commercial sea scallop shell height frequency distributions from the South Channel in 1982 and 1983 assuming the populations shown in Figure 712.1 with a fishing mortality, F = 0.6, and a cull size of 3.0 inches.

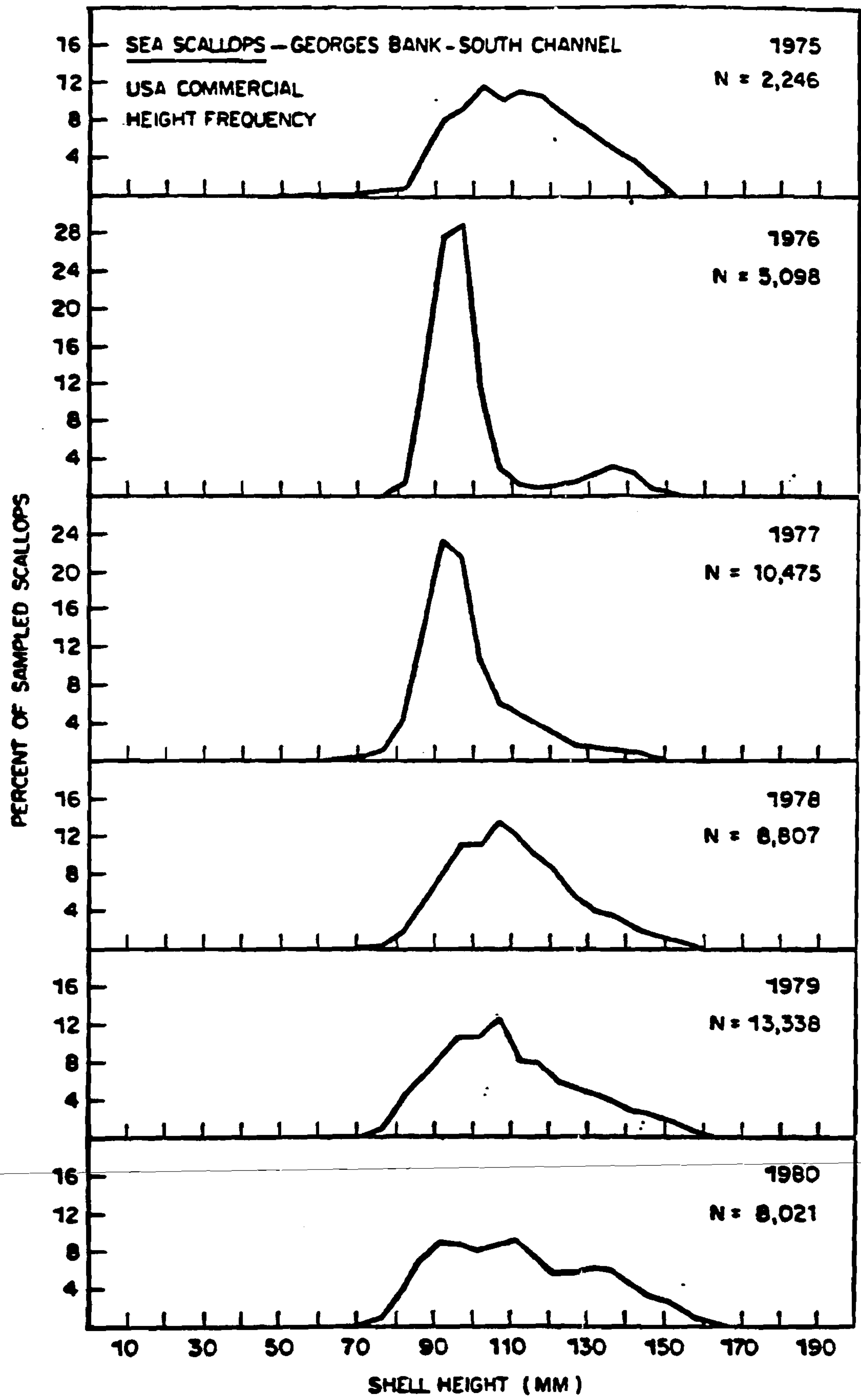


Figure 712.3: Sea scallop shell height frequencies in the commercial catch from the South Channel as determined from shell samples.

Principally, by virtue of expected recruitment from the 1978 year class in the New York Bight area, combined with growth of older scallops in the population, total Mid-Atlantic catches are expected to increase in 1983 to levels exceeded only in 1978 and 1979 over the past decade. Projected moderate impacts (less than 7%) in 1982 and 1983 associated with instituting a minimum shell height up to 3.50 inches may, nevertheless, be expected to result in a 1983 catch level exceeding the 1976-1980 average. More substantial impacts (12-17%) may be expected to result from a 3.75 inch minimum shell height.

Table 712.1: Projected weighted average sea scallop meat counts by resource area for 1982 and 1983 under assumed minimum cull size of 3.0 inches (shell height) if entire projected catches were shucked at sea.

	1982	1983
South Channel	15.1	12.0
Southeast Part	12.1	8.7
Northern Edge & Peak	22.1	16.1
Mid-Atlantic (Combined)	15.5	14.3

Finally, it is noted that where age-at-entry is implemented on the basis of both meat count and minimum shell size (pragmatically associated with shuckers and shell stockers, respectively), then the impacts given in Table 712.2 will have to be discounted accordingly. Such a procedure is used in the short-term economic analysis presented in §723.

Table 712.2: Projected total sea scallop catch (metric tons) levels by resource area (U.S. & Canada) with implementation of industry-wide alternative minimum shell heights in 1982 and 1983. Percent Change relative to catch under current assumed minimum cull size (3.0 inches) is given in brackets.

Resource Area	Minimum Shell Height	1982	1983
South Channel	3.00"	3008	3088
	3.25"	2967 (- 1.4%)	3075 (- 0.4%)
	3.50"	2684 (-10.8%)	2967 (- 3.9%)
	3.75"	2344 (-22.1%)	2819 (- 8.7%)
Southeast Part	3.00"	517	440
	3.25"	515 (- 0.5%)	440 (nil)
	3.50"	486 (- 6.1%)	436 (- 0.8%)
	3.75"	441 (-14.6%)	420 (- 4.5%)
Northern Edge & Peak	3.00"	9683	13756
	3.25"	9217 (- 4.8%)	13602 (- 1.1%)
	3.50"	6398 (-33.9%)	12437 (- 9.6%)
	3.75"	4287 (-55.7%)	11646 (-15.3%)
Mid-Atlantic (Combined)	3.00"	5962	7081
	3.25"	5899 (- 1.0%)	7049 (- 0.4%)
	3.50"	5551 (- 6.9%)	6776 (- 4.3%)
	3.75"	4979 (-16.5%)	6254 (-11.7%)
All Areas	3.00"	19170	24365
	3.25"	18598 (- 3.0%)	23770 (- 2.4%)
	3.50"	15119 (-21.1%)	22616 (- 7.2%)
	3.75"	12051 (-37.1%)	21139 (-13.2%)

Current cull size assumed to be 3.0 inches.
3.25 inch minimum shell height equivalent to 40 meat count.
3.50 inch minimum shell height equivalent to 30 meat count.
3.75 inch minimum shell height equivalent to 25 meat count.

§713 Relative Sea Scallop Fecundity

One of the biological benefits which may be associated with implementation of the considered sea scallop management measures is an enhanced reproductive potential for the spawning stock. Thus, either an increase in the age at

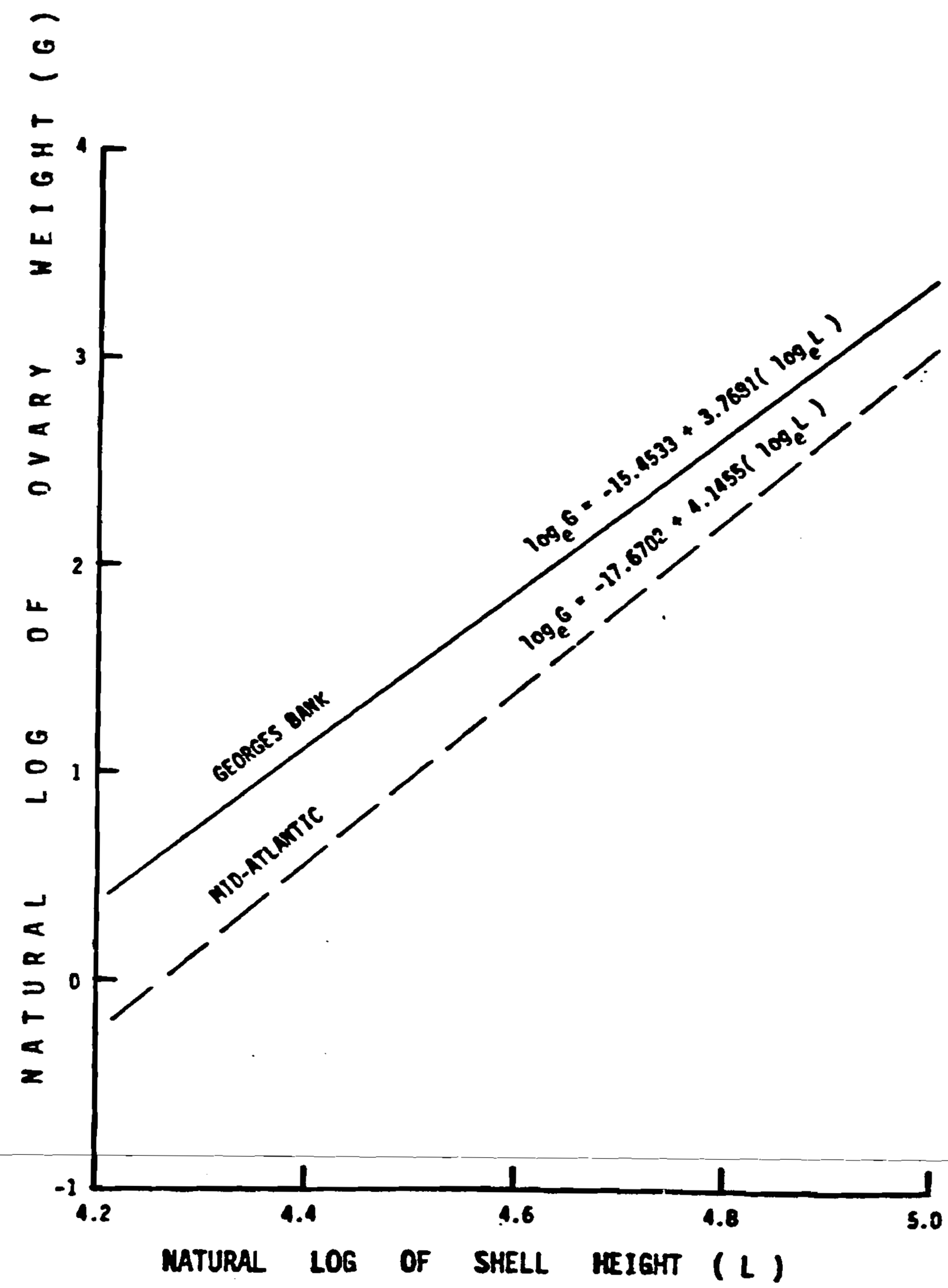


Figure 713.1: Derived relationships between sea scallop ovary weight and shell height for Georges Bank and Mid-Atlantic sea scallops based upon results from the 1981 sea scallop research vessel survey. (Source: Serchuk, 1981)

entry to the fishery or a reduction in the fishing mortality rate (relative to the historic values of each) or, most particularly, a combination of both, may result in substantial increases in the total egg production by the population. It is thought that greater egg production may enhance subsequent recruitment or, at least, should act to buffer the extreme variability in recruitment so characteristic of the historic sea scallop fishery.

Few data are available giving egg production in numbers (i.e., fecundity) by female sea scallops. However, the total weight of the ovary (proportional to the volume which in turn is related to the number of eggs produced) should provide a workable index of fecundity. Based upon information obtained in the 1981 USA sea scallop research vessel survey, a significant relationship was developed between the weight of the ovary and the shell height. That relationship is illustrated in Figure 713.1. Survey data for developing the ovary weight/shell height relationship were obtained from sea scallop populations on Georges Bank and in the Mid-Atlantic. Although no data have yet been collected from offshore Gulf of Maine sea scallops, it is likely that those populations exhibit a relationship similar to Georges Bank sea scallops.

In a preliminary evaluation of the expected impacts upon total population fecundity which may be expected from implementation of the contemplated meat count management measure, simulations were run examining the implications of adjustments to the age at entry (i.e., minimum size or comparable meat count). In §711 the discussion served to support the assumption that the present average cull sizes are about 3 3/8 - 3 1/2 inches on Georges Bank and about 3 inches in the Mid-Atlantic. The specifications relating to age at entry which have been considered in this FMP, in terms of the minimum shell height and the corresponding maximum meat count, include:

Minimum Shell Height (inches)	Maximum Meat Count
3	60
3 1/4	40
3 1/2	30
3 3/4	25

If the fishing mortality rate remains constant at the assumed current levels (see §712), the estimated effects upon total fecundity associated with alternative specifications of age at entry are given in Table 713.1. The slight gain in expected total fecundity on Georges Bank (7.7%) associated with a 3 1/4 inch minimum shell height (40 meats per pound) reflects an understanding that the current cull size, if expressed in terms of meat count is slightly higher than 40 per pound. The current assumed cull size in the Mid-Atlantic, however, corresponds almost exactly to a 60 meat count. Hence, specification of a 3 inch minimum shell height (i.e., 60 meats per pound) would have no effect upon total fecundity in Mid-Atlantic sea scallop populations.

This analysis indicates that potentially very substantial gains in total fecundity could result from increases in the age at entry (reduced meat counts). Although the gains associated with implementing an age at entry

Table 713.1: Estimated percentage gains (and losses) in total fecundity by resource area associated with alternative specifications of age at entry (expressed in terms of meat count) with fishing mortality remaining at the assumed current levels.

	MEAT COUNT			
	25	30	40	60
Georges Bank	+50.5	+34.0	+ 7.7	-25.0
Mid-Atlantic	+80.1	+64.1	+27.6	0.0

equivalent to a 40 meat count may not be significant on Georges Bank, total fecundity in the Mid-Atlantic may be increased some 28%. An age at entry specification which is equivalent to a 30 meat count may increase total fecundity at least 1/3; the gain to the total resource should be at least 40%.

It is important to note, however, that all of the estimated potential gains in total fecundity which may result from increasing the age at entry may be easily wiped out with a concomittant increase in the fishing mortality rate. Indeed, if the catch per unit of effort is significantly reduced as a result of implementation of an increased age at entry, fishermen may respond by increasing their fishing effort (hence, an increase in the fishing mortality rate).

This analysis concentrated on the effects of age at entry as an attempt to define the possible magnitude of the anticipated gains in total fecundity. It is likely that even greater gains could be achieved if fishing mortality rates were simultaneously reduced.

§720 Economic Analysis

The economic impact analysis of alternative strategy specifications for sea scallop management will include two parts, a long-term analysis and a short-term analysis.

§721 Economic Criteria

The economic variables used to evaluate alternative strategies for the sea scallop plan include: prices, employment, producer revenues, impact on regional income, and consumer surplus. These variables are used in evaluating the long-term impacts; whereas, the first three are used for short-term impacts, with full recognition that a trade-off between long-term and short-term must be made. The economic rationale for each variable is elaborated in Appendix 3 pages A3-50 to A3-51.

§722 Long-Term Economic Analysis of Strategy Specifications

This long-term economic analysis will focus on a comparison of the economic implications of the 12 management strategy specifications that were introduced in §630 and elaborated in §710. The analysis is specifically focused on the Georges Bank resource area; the only area where candidate effort levels may be feasibly calculated. Despite the Georges Bank resource focus, the conclusions that may be drawn are applicable to the industry as a whole, because the economic parameters have been calculated on the basis of the overall industry. The 12 strategy specifications represent combinations of 4 meat count levels (60, 40, 30 and 25 meats per pound) and 3 effort level equivalents for fishing mortality [7001 std. days, F=0.7; 4350 std. days; and 3292 std days, F=F(max)]. The first effort level, 7001 std. days, represents the unadjusted historic average on Georges Bank; and the last effort level, 3292 std. days, represents approximately the F(max) level of fishing mortality. The latter is unadjusted for increases in efficiency that may have occurred in recent years; and therefore, 3292 std. days may exceed F(max).

The analysis is based on the long-term equilibrium resource conditions which were simulated in §710 for each combination of meat count and fishing mortality (represented by effort) control. The long-term economic implications of the 12 strategy specifications may differ from those of an actual management program where short-term resource and industry variability can be accounted for. The analysis contained herein concentrates on the fishery after it has achieved the simulated equilibrium condition which is defined by a particular combination of meat count and fishing mortality control. But because equilibrium is unlikely to be achieved immediately, evaluation under more realistic circumstances would consider both the equilibrium condition and the transition phase which preceded it. Unfortunately, the transition phase (up to several years in duration) cannot be characterized quantitatively, either in terms of the length of the period or the changes in resource or economic conditions that may occur during that period. As a result, it is not possible to accommodate this transition phase as part of the long-term economic analysis in any other way than to assume that its effect is constant across all strategy specifications, and, therefore, does not significantly effect the long-term evaluation. This assumption is probably valid where equilibrium conditions may be assumed to commence at the same time for all strategy specifications, and where the transition phase is short relative to the period of the analysis. Nevertheless, the economic analysis is acknowledged to be a partial evaluation of the long-term implications of the various strategy specifications.

The long-term economic analysis makes use of the stream of catch values that is believed to most realistically represent the equilibrium conditions associated with each strategy specification. Catch can either be assumed to be constant over time or to vary in response to environmental conditions or intrinsic biological feed-back. Because environmental cycles that influence sea scallop recruitment, abundance and catch are known to exist, an illustrative 16-year cycle was selected for Georges Bank (see §710) to best represent the <u>changes</u> in annual catch that might be expected over time under equilibrium conditions. Therefore, to provide a more realistic long-term economic evaluation, cycle-based catch data for Georges Bank was used as a common element in the comparative analysis of all strategy specifications. For the purposes of this comparative analysis, the economic criteria presented in §721 are generated, as either average values or present values, at the beginning of each representative equilibrium period.

(A) Methodology for the Long-Term Analysis

The economic evaluation presented in Table 722.3 through 722.10 is always expressed in terms of the differences (or changes) in the values of each economic criterion between a given strategy specificaton and strategy specification #1 (a common point of reference). For example, in Table 722.3 the long-term impact of strategy specification #4 on ex-vessel price is given as the difference in price between that strategy (SS4) and SS1, or -3.31 cents per pound. This manner of presentation provides the basis for a relative comparison among specifications without reference to the absolute value of the criterion, which may be considered to be of secondary importance. The information provided in Tables 722.3 through 722.10 is based upon the equilibrium catch stream generated for each strategy specification. Individual annual differences in catch among specifications are considered in calculating comparative values for the various criteria. These catch streams are presented in Table 722.1 and summarized in Table 722.2. The methodology for the long-term analysis is more fully explained in Appendix 3, pages A3-52 through A3-59.

(B) Summary of Long-Term Analysis

In this analysis, strategy specification one, which is a combination of 60 meat count and management control on fishing effort at the approximate historic average level (F=0.7), is chosen as a common base for comparison with other strategy specifications. Effort control at the historic average level is assumed to adequately represent no effort control for analyses purposes and is referred to as such in this section. This analysis is based on domestic catch stream simulations for the Georges Bank resource area (see Section 710), and is assumed to be representative of all resource areas for evaluation purposes. These catch streams, presented in Table 722.1, have been adjusted to U.S. catches by a factor of 0.57 based on the overall U.S. and Canadian Georges Bank catches. Associated with each meat count and effort control specification, changes in prices, employment, harvesting revenues, regional income, and consumer surplus, in relation to the base specification (SS1), are given in Tables 722.3 through 722.10 for long-term equilibrium conditions.

Table 722.1: Expected Domestic Sea Scallop Catch Streams (1000 Pounds) from Georges Bank Under Twelve Strategy Specifications 1/ 2/

Year	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10	SS11	SS12
1	14757	19845	22252	17311	22235	24350	19410	24132	25973	20825	25370	27005
2	14224	19512	21899	16687	21860	23963	18710	23726	25561	20073	24944	26575
3	12612	17676	19909	14796	19803	21785	16589	21493	23238	17798	22597	24198
4	10998	15245	17200	12903	17080	18821	14468	18539	20075	15522	19489	20871
5	9478	12936	14620	11119	14493	15997	12467	15729	17064	13376	16537	17741
6	8139	10905	12343	9548	12218	13505	10705	13261	14406	11486	13941	14978
7	7074	9292	10521	8299	10410	11512	9305	11298	12280	9983	11879	12767
8	6161	7987	9049	7228	8948	9902	8104	9713	10562	8695	10211	10982
9	5431	6966	7890	6371	7805	8634	7144	8471	9210	7664	8906	9576
10	4823	6164	6981	5657	6905	7639	6343	7495	8148	6806	7879	8471
11	4335	5552	6282	5087	6220	6874	5703	6751	7332	6119	7097	7624
12	5659	7062	7843	6639	7912	8582	7444	8588	9155	7986	9029	9518
13	7454	9215	10233	8745	10323	11198	9806	11205	11944	10519	11780	12418
14	9919	12367	13722	11636	13856	15016	13046	15039	16017	13998	15810	16653
15	13205	16785	18609	15491	18806	20364	17369	20411	21721	18635	21458	22583
16	14757	19669	21931	17311	22036	23997	19410	23918	25598	20825	25145	26613
Avg.	9314	12323	13830	10927	13807	15134	12251	14986	16143	13144	15755	16786

1/ SS1 = 60 meat count; 7001 USA std. D.F. SS7 = 30 meat count; 7001 USA std. D.F.
SS2 = 60 meat count; 4350 USA std. D.F. SS8 = 30 meat count; 4350 USA std. D.F.
SS3 = 60 meat count; 3292 USA std. D.F. SS9 = 30 meat count; 3292 USA std. D.F.
SS4 = 40 meat count; 7001 USA std. D.F. SS10= 25 meat count; 7001 USA std. D.F.
SS5 = 40 meat count; 4350 USA std. D.F. SS11= 25 meat count; 4350 USA std. D.F.
SS6 = 40 meat count; 3292 USA std. D.F. SS12= 25 meat count; 3292 USA std. D.F.

2/ Long-term equilibrium catch streams from Section 710 have been adjusted by a factor of 0.58, which is based on 1944-77 historical shares of catch from the resource between the U.S. and Canada.

Table 722.2: Average Annual Sea Scallop Catch (Range in Parentheses)
At Long-Term Biological Equilibrium (Thousand Pounds)

	Effort Control Specification		
	Control* at 7001 USA Std. D. F.** F = 0.7	Control at 4350 USA Std. D. F.**	Control at 3292 USA Std. D. F.** F = F(max)
	SS1:	SS2:	SS3:
60 Meats	9314	12323	13830
	(4335-14757)	(5552-19845)	(6282-22252)
	SS4:	SS5:	SS6:
40 Meats	10927	13807	15134
	(5087-17311)	(6220-22235)	(6874-24350)
	SS7:	SS8:	SS9:
30 Meats	12251	14986	16143
	(5703-19410)	(6751-24132)	(7332-25973)
	SS10:	SS11:	SS12:
25 Meats	13144	15755	16786
	(6119-20825)	(7097-25370)	(7624-27005)

*This level of effort control, which approximates the historic average on Georges Bank, is taken to represent no effective management control.

**Based on 1944-1977 historical shares of U.S. and Canadian effort to the resource, under which the U.S. accounts for 58% of total effort.

Prices

Prices, including ex-vessel, wholesale, and retail prices of sea scallops, would decline along with meat count and/or effort level reductions in the long run (Tables 722.3 - 722.5). For example, under no management control on effort, the ex-vessel price is expected to drop relative to the 60 meat count level by 3.31 cents, 6.02 cents, and 7.85 cents per pound for the 40 count, 30 count, and 25 count strategy specifications, respectively.

To compare the drops in prices, it is noted that retail prices would drop at a faster rate than wholesale and ex-vessel prices. For example, average price under SS12 relative to SS1 is expected to drop by 23.24 cents, 16.06 cents, and 15.32 cents per pound for retail, wholesale, and ex-vessel prices, respectively. These indicate that more effort control and/or a greater reduction in the meat count would exert less inflationary pressure under long-term equilibrium conditions.

Processing Employment

Long-term processing employment tends to be higher in association with lower levels of effort and meat count (Table 722.6). For example, under the 60 meat count strategy, an increase in processing employment of 133 and 198 man-years is expected for increased effort control at the 4350 and 3292 standard days fished levels. Similar results are obtained when comparing decreasing meat counts within any given effort control level. This indicates that under long-term equilibrium conditions, the economy would be benefited from fuller employment if greater reductions in both effort and meat count are prescribed.

Gross Revenue to the Fishing Sector

Average changes in the gross revenue to sea scallop harvesters, relative to SS1, are presented in Table 722.7. Within a resource cycle, increases in gross stock relative to SS1 are observed and are higher as reductions in effort and/or meat count become larger. This implies that under long-term equilibrium conditions, average revenues within a cycle are higher for a greater reduction in effort and/or meat count. It is also noted that the same conclusion holds true for the present values measured at the first year of the resource cycle (Table 722.8).

Regional Income

Impact on the present value of New England regional income at the first year of the resource cycle is presented in Table 722.9 for various strategy specifications relative to SS1. The increase in regional income from sea scallop fishing activities is greater as effort and/or meat count decreases, indicating that tighter control on both effort and meat count would result in a greater positive impact from fishing for sea scallops on regional income, under long-term equilibrium conditions. The multiplier used in the calculation of regional income is from Rorholm et al, 1965.

Table 722.3: Average Change in Annual Ex-Vessel Prices of Sea Scallops Relative to Strategy Specification 1 (SS1) at Long-Term Biological Equilibrium (Cents Per Pound)

	Effort Control Specification		
	Control* at 7001 USA Std. D. F.** F = 0.7	Control at 4350 USA Std. D. F.**	Control at 3292 USA Std. D. F.** F = F(max)
	SS1:	SS2:	SS3:
60 Meats	0	-6.17	-9.26
	SS4:	SS5:	SS6:
40 Meats	-3.31	-9.21	-11.93
	SS7:	SS8:	SS9:
30 Meats	-6.02	-11.63	-14.00
	SS10:	SS11:	SS12:
25 Meats	-7.85	-13.20	-15.32

*This level of effort control, which approximates the historic average on Georges Bank, is taken to represent no effective management control.

**Based on 1944-1977 historical shares of U.S. and Canadian effort to the resource, under which the U.S. accounts for 58% of total effort.

Table 722.4: Average Change in Annual Wholesale Prices of Sea Scallops Relative to Strategy Specification 1 (SS1) at Long-Term Biological Equilibrium (Cents Per Pound)

	Effort Control Specification		
	Control* at 7001 USA Std. D. F.** F = 0.7	Control at 4350 USA Std. D. F.**	Control at 3292 USA Std. D. F.** F = F(max)
	SS1:	SS2:	SS3:
60 Meats	0	-6.47	-9.71
	SS4:	SS5:	SS6:
40 Meats	-3.47	-9.66	-12.51
	SS7:	SS8:	SS9:
30 Meats	-6.32	-12.19	-14.68
	SS10:	SS11:	SS12:
25 Meats	-8.23	-13.85	-16.06

*This level of effort control, which approximates the historic average on Georges Bank, is taken to represent no effective management control.

**Based on 1944-1977 historical shares of U.S. and Canadian effort to the resource, under which the U.S. accounts for 58% of total effort.

Table 722.5: Average Change in Annual Retail Prices of Sea Scallops Relative to Strategy Specification 1 (SS1) at Long-Term Biological Equilibrium (Cents Per Pound)

	Effort Control Specification		
	Control* at 7001 USA Std. D. F.** F = 0.7	Control at 4350 USA Std. D. F.**	Control at 3292 USA Std. D. F.** F = F(max)
	SS1:	SS2:	SS3:
60 Meats	0	-9.36	-14.05
	SS4:	SS5:	SS6:
40 Meats	-5.02	-13.97	-18.10
	SS7:	SS8:	SS9:
30 Meats	-9.14	-17.64	-21.24
	SS10:	SS11:	SS12:
25 Meats	-11.91	-20.03	-23.24

*This level of effort control, which approximates the historic average on Georges Bank, is taken to represent no effective management control.

**Based on 1944-1977 historical shares of U.S. and Canadian effort to the resource, under which the U.S. accounts for 58% of total effort.

Table 722.6: Average Change in Sea Scallop Processing Employment (Fresh and Frozen) Relative to Strategy Specification 1 (SS1) at Long-Term Biological Equilibrium (Man-Years)

	Effort Control Specification		
	Control* at 7001 USA Std. D. F.** F = 0.7	Control at 4350 USA Std. D. F.**	Control at 3292 USA Std. D. F.** F = F(max)
60 Meats	SS1: 0	SS2: +133	SS3: +198
40 Meats	SS4: +71	SS5: +197	SS6: +256
30 Meats	SS7: +129	SS8: +249	SS9: +300
25 Meats	SS10: +168	SS11: +283	SS12: +329

*This level of effort control, which approximates the historic average on Georges Bank, is taken to represent no effective management control.

**Based on 1944-1977 historical shares of U.S. and Canadian effort to the resource, under which the U.S. accounts for 58% of total effort.

Table 722.7: Average Change in Annual Gross Stock to Sea Scallop Harvesters Relative to Strategy Specification 1 (SS1) at Long-Term Biological Equilibrium (Thousand Dollars)

	Effort Control Specification		
	Control* at 7001 USA Std. D. F.** F = 0.7	Control at 4350 USA Std. D. F.**	Control at 3292 USA Std. D. F.** F = F(max)
	SS1:	SS2:	SS3:
60 Meats	0	+48,022	+72,410
	SS4:	SS5:	SS6:
40 Meats	+27,834	+72,952	+94,139
	SS7:	SS8:	SS9:
30 Meats	+50,606	+92,690	+110,908
	SS10:	SS11:	SS12:
25 Meats	+75,906	+105,527	+121,542

*This level of effort control, which approximates the historic average on Georges Bank, is taken to represent no effective management control.

**Based on 1944-1977 historical shares of U.S. and Canadian effort to the resource, under which the U.S. accounts for 58% of total effort.

Table 722.8: Change in Present Value of Harvesters' Gross Stock At Three Discount Rates Relative to Strategy Specification 1 (SS1) At Long-Term Biological Equilibrium (Thousand Dollars)

		Effort Control Specification		
	Int. Rate	Control* at 7001 USA Std. D. F.** F = 0.7	Control at 4350 USA Std. D. F.**	Control at 3292 USA Std. D. F.** F = F(max)
		SS1:	SS2:	SS3:
60 Meats	7 1/8%	0	+371,957	+559,378
	10%	0	+291,363	+437,373
	12%	0	+249,627	+374,171
		SS4:	SS5:	SS6:
40 Meats	7 1/8%	+209,160	+560,019	+723,363
	10%	+161,470	+436,824	+564,214
	12%	+136,897	+373,123	+481,855
		SS7:	SS8:	SS9:
30 Meats	7 1/8%	+380,047	+708,692	+849,759
	10%	+293,303	+551,738	+661,923
	12%	+248,612	+470,635	+564,770
		SS10:	SS11:	SS12:
25 Meats	7 1/8%	+494,738	+805,295	+929,921
	10%	+381,738	+626,372	+723,894
	12%	+323,523	+533,945	+617,361

*This level of effort control, which approximates the historic average on Georges Bank, is taken to represent no effective management control.

**Based on 1944-1977 historical shares of U.S. and Canadian effort to the resource, under which the U.S. accounts for 58% of total effort.

Table 722.9: Change in Present Value of New England Regional Income From Sea Scallops at Three Discount Rates Relative to Strategy Specification 1 (SS1) at Long-Term Biological Equilibrium (Thousand Dollars)

		Effort Control Specification		
	Int. Rate	Control* at 7001 USA Std. D. F.** F = 0.7	Control at 4350 USA Std. D. F.**	Control at 3292 USA Std. D. F.** F = F(max)
		SS1:	SS2:	SS3:
60 Meats	7 1/8%	0	+1,100,993	+1,655,757
	10%	0	+862,436	+1,294,623
	12%	0	+738,897	+1,107,547
		SS4:	SS5:	SS6:
40 Meats	7 1/8%	+619,115	+1,657,654	+2,141,151
	10%	+477,951	+1,292,997	+1,670,072
	12%	+405,215	+1,104,443	+1,426,291
		SS7:	SS8:	SS9:
30 Meats	7 1/8%	+1,124,939	+2,097,727	+2,515,281
	10%	+868,177	+1,633,143	+1,959,288
	12%	+735,892	+1,393,078	+1,671,718
		SS10:	SS11:	SS12:
25 Meats	7 1/8%	+1,464,424	+2,383,671	+2,752,564
	10%	+1,129,945	+1,854,057	+2,142,724
	12%	+957,630	+1,580,476	+1,827,384

*This level of effort control, which approximates the historic average on Georges Bank, is taken to represent no effective management control.

**Based on 1944-1977 historical shares of U.S. and Canadian effort to the resource, under which the U.S. accounts for 58% of total effort.

Consumer Surplus

Changes in present value of consumer surplus for each strategy specification relative to SS1 are presented in Table 722.10. It is shown that consumer surplus increases as meat count and effort are reduced. For example, the present value of consumer surplus at a 7 1/8% discount rate, under no management control on effort, would increase relative to the 60 meat count specification by 5888, 11426, and 15516 thousand dollars for the 40 count, 30 count, and 25 count specifications, respectively. These results indicate that consumers would be better off with reductions in effort and/or meat count, under the assumed long-term equilibrium conditions.

(C) Economic Implications of Long-Term Equilibrium

It is noted that the above summary discussion of the relative benefits associated with each strategy specification is valid for comparison at the long-run equilibria only. In relation to strategy selection, economic conditions during the transition period are not considered, and consequently, the economic gains or losses during these transition periods are not incorporated into the evaluation. Therefore, the above discussion represents only a partial comparison of benefits among strategy specifications. It illustrates that relative benefits may be gained after the long-term equilibrium is reached. It does not address the economic trade-offs which may be associated with the time it takes to reach the equilibrium conditions, nor the magnitude of any economic disturbances that may be caused during the transition period by a particular strategy specification.

In this partial comparison, it is shown that (1) controlled reductions in effort and/or meat count would accrue positive benefits to the sea scallop industries and consumers, and (2) the higher the reduction in effort and/or meat count, the larger the benefits to the industries and consumers, under long-term equilibrium conditions.

The analysis also illustrates the role of economic criteria in the strategy selection process. For example, one might consider SS2 (60 meat count; effort control at 4350 U.S. standard days fished), with an average annual catch of 12,323,000 pounds, to be roughly equivalent to SS7 (30 meat count; no effort control), with a catch at 12,251,000 pounds (see Table 722.2). In fact, if one compares the expected changes in prices, employment, and consumer surplus, then SS2 is slightly more beneficial; whereas, comparing expected values of gross stock and regional income, SS7 is slightly more beneficial (see Tables 722.3 - 722.10). Thus, the ultimate selection of a particular strategy specification must involve a policy decision based on factors other than the economic criteria presented here (see Part 6).

Table 722.10: Change in Present Value of Consumer Surplus from Sea Scallops At Three Discount Rates Relative to Strategy Specification 1 (SS1) At Long-Term Biological Equilibrium (Thousand Dollars)

	Int. Rate	Effort Control Specification Control* at 7001 USA Std. D. F.** F = 0.7	Control at 4350 USA Std. D. F.**	Control at 3292 USA Std. D. F.** F = F(max)
		SS1:	SS2:	SS3:
60 Meats	7 1/8%	0	+12,668	+20,062
	10%	0	+11,140	+17,617
	12%	0	+10,289	+16,256
		SS4:	SS5:	SS6:
40 Meats	7 1/8%	+5,888	+19,896	+27,109
	10%	+5,110	+17,450	+23,774
	12%	+4,683	+16,092	+21,920
		SS7:	SS8:	SS9:
30 Meats	7 1/8%	+11,426	+26,223	+33,002
	10%	+9,916	+22,974	+26,291
	12%	+9,087	+21,172	+26,656
		SS10:	SS11:	SS12:
25 Meats	7 1/8%	+15,516	+30,630	+36,963
	10%	+13,465	+26,821	+32,384
	12%	+12,340	+24,710	+29,842

*This level of effort control, which approximates the historic average on Georges Bank, is taken to represent no effective management control.

**Based on 1944-1977 historical shares of U.S. and Canadian effort to the resource, under which the U.S. accounts for 58% of total effort.

§723 Short-Term Economic Impacts

Methodology

The short-term economic impact analysis is limited to a period from 1982 to 1983, the period during which the desired meat count level for the sea scallop fishery will be reached. This economic analysis is conducted as a comparison of three meat count specifications with effort assumed to remain at currently estimated levels. The catch forecasts for 1982 and 1983, (i.e., sea scallop landings of 29.1 and 34.0 million pounds respectively), under conditions of no explicit meat count control (see Section 710), are adopted as the points of reference in this analysis. In each of these two years it is assumed that there is the potential for management control at either 40 or 30 meats per pound. Thus, three illustrative strategies are defined including 40-40, 40-30 and 30-30 meat count in 1982 and 1983, respectively. The analysis focuses on an economic comparison, (using prices, employment and revenues as economic criteria) of the effects of no meat count control in 1982-83 versus the three meat count strategies noted. Finally, because it was shown in §710 that vessels that shuck scallops at sea and vessels that retain scallops in the shell are likely to be effected differently by meat count (minimum size) control, it is assumed that the percentage distribution of catch among "shuckers" and "shell stockers" that occurred in the 1980 fishery will be continued through 1983. The summary comparison is presented in Table 723.1.*

Prices

Prices of sea scallops at all market levels for 1982 and 1983 are expected to rise under all meat count strategies, as compared with no meat count control. For example, 1982 prices are expected to rise by 1.51, 1.58 and 2.29 cents per pound at the ex-vessel, wholesale and retail levels, respectively, under a 30 meat count. In general, the lower the level of meat count, the higher the level of price in all three categories.

Processing Employment

Processing employment is expected to drop (relative to no meat count control) by only 1 to 24 man-years under either 40 or 30 meat count control in 1982 and 1983. The higher the meat count specification, the lower the expected drop in employment.

Gross Revenues

Gross revenues for 1982 and 1983 under all meat count control cases are expected to drop, but by only 0.03 to 2.22% from the no meat count control case. For instance, gross revenues in 1982 are expected to drop by 2.6, 3.2 and 3.8 million dollars (2.17, 2.22 and 0.92%) at the ex-vessel, wholesale and retail (consumption expenditures) levels, respectively with a 30 meat count.

*This Section constitutes the analysis necessary for the Regulatory Impact Review (RIR).

Table 723.1: Economic Short-Term Impacts of Sea Scallop Meat Count Controls
1982 - 1983

	No Meat Count Control	40 Meat Count Total	40 Meat Count Change	40 Meat Count % Change	30 Meat Count Total	30 Meat Count Change	30 Meat Count % Change
1 9 8 2							
Landings (1000 Lbs.)	29061.34	28956.20	-105.14	-0.36	28325.30	-736.04	-2.53
P r i c e s (Cents Per Pound)							
Retail	700.99	701.32	0.33	0.05	703.28	2.29	0.33
Wholesale	491.13	491.36	0.23	0.05	492.71	1.58	0.32
Ex-Vessel	405.81	405.81	0.22	0.05	407.10	1.51	0.37
P r o c e s s i n g E m p l o y m e n t (Man-Years)							
Fresh	990	987	3	-0.36	966	24	-2.50
Frozen	276	275	1	-0.39	268	8	-2.73
G r o s s R e v e n u e ($1,000)							
Consumption Expenditures	414715.08	414172.94	-542.14	-0.13	410893.45	-3821.63	-0.92
Wholesale	142728.96	142279.18	-449.77	-0.32	139561.59	-3167.37	-2.22
Ex-Vessel	117869.89	117507.16	-362.73	-0.31	115312.30	-2557.59	-2.17
1 9 8 3							
Landings (1,000 Lbs.)	33984.26	33955.91	-28.35	-0.08	33729.58	-254.68	-0.75
P r i c e s (Cents Per Pound)							
Retail	795.20	795.29	0.09	0.01	795.99	0.79	0.10
Wholesale	555.81	555.87	0.06	0.01	556.36	0.55	0.10
Ex-Vessel	457.13	457.19	0.06	0.01	457.65	0.52	0.11
P r o c e s s i n g E m p l o y m e n t (Man-Years)							
Fresh	1156	1155	1	-0.08	1148	8	-0.74
Frozen	327	326	1	-0.31	324	3	-0.80
G r o s s R e v e n u e ($1,000)							
Consumption Expenditures	509598.04	509430.25	-167.79	-0.03	508077.07	-1520.16	-0.30
Wholesale	188887.92	188750.72	-137.20	-0.07	187657.89	-1230.02	-0.65
Ex-Vessel	155352.25	155243.02	-109.22	-0.07	154363.42	-988.82	-0.64

Capacity

Harvesting and shucking capacity are estimated at 32.5 and 32.7 million pounds of sea scallops in 1982 and 1983, respectively. The corresponding values for processing and marketing capacity have been estimated at 60.4 million pounds and 61.7 million pounds for 1982 and 1983 (see §332).

Conclusions

This short-term analysis has shown that the meat count controls would be expected, at a minimum, to exert the above adverse economic impacts on the 1982 and 1983 U.S. sea scallop fisheries. The potential impacts on fishing costs in the affected harvesting sectors (i.e., shell stockers) cannot be measured at this time and are therefore expected to remain constant. It is unknown whether current prospects for resource abundance, with particular reference to increased abundance in the Mid-Atlantic area, would encourage increased effort in this sector, or whether excessive discards (of undersized scallops) might encourage conversion to shucking or exit from the sea scallop fishery entirely. Finally, the impact on administrative costs to industry (data recording) and government (NMFS port agents and enforcement agents, Coast Guard surveillance) would be zero. Industry currently records most data that would be required (weigh-out and interview system); NMFS and Coast Guard, although required to enforce meat count controls, must operate under fixed personnel/budget levels.

§730 Conclusions for Strategy Selection

§731 Introduction

The analyses presented in §710 and §720 provide the basis for a bio-economic evaluation of alternative specifications of the principal management strategy (see Part 6).* Specifically, the analyses are focused on both the long-term and short-term implications of various specifications of a meat count (minimum size) control measure, and in addition examine the effects of fishing effort (related to fishing mortality) in the context of long-term benefits to the resource/industry and achievement of the management objective. The key assumptions and major conclusions of the long and short-term analyses are given below.

§732 Long-Term Analysis

Assumptions

The long-term phase of the analysis is focused on equilibrium resource conditions; that is, this phase describes the resource (i.e., productivity) and examines impacts on the industry after the fishery has had time to fully respond to a particular strategy specification, and the resource is once again synchronized with natural environmental patterns. This phase does not consider a transition period between program implementation and equilibrium, because resource trends and economic conditions are not currently predictable over that period.

Conclusions for the Resource

From a resource perspective, the demonstrated long-term benefits of increased yield per recruit and productivity can be assumed to be independent of annual variations in recruitment, abundance and catch. The relative biological benefits among the various meat count (minimum size) specifications examined are maintained over a range of fishing mortality values (effort), but absolute benefits are maximized at some optimal level of effort (fishing mortality) within the range. Importantly, long-term resource prospects are dependent upon fishing mortality in the fishery not jeopardizing long-term recruitment prospects. This argues for the adoption of some form of explicit limitation on fishing mortality (most efficiently achieved through effort control) in the future to, at a minimum, reduce the risk of recruitment overfishing and, more significantly, meet the overall objective.

More specific conclusions of a long-term resource nature are as follows:

1. In the analysis presented in §710, the Gulf of Maine, Georges Bank and Mid-Atlantic resource components are treated independently for yield-per-recruit purposes. Although values of the biological parameters for these resource components differ (e.g., growth rate, mortality rate), the analysis does demonstrate a consistent increase in individual average sea scallop production (yield per recruit) associated with <u>increases</u> in the size at which the average sea scallop is retained by the fishery (approximated for management through minimum size or meat count provisions), and <u>reductions</u> in fishing mortality to the F(max) level [note that recent levels of fishing mortality have been estimated to be in excess of F(max)].

2. The analysis shows that if fishing mortality were currently at the F(max) level, between 4.5% and 5.5% (applicable to the Gulf of Maine, Georges Bank and Mid-Atlantic resource components) more long-term individual average scallop yield would be possible with meat count specified at 30 than would be possible with meat count specified at 40 (previously recommended under ICNAF). The relative benefit would increase to between 8.5% and 9.5% for 25 meat count relative to 40 meat count. Where fishing mortality rates have been averaging in excess of F(max) (assumed to be the case for all resource components), the <u>relative benefits</u> in productivity between 40 count and 30 or 25 count scallops increase significantly. For example, at the fishing mortality rate which is believed to reasonably characterize the overall Georges Bank fishery in recent years (F=0.7), the yield per recruit benefit between 40 and 30 or 40 and 25 count scallops is nearly 11% or 18% respectively. Of course, on an <u>absolute</u> basis, the yield per recruit benefits associated with maintaining a level of fishing mortality near F(max) will always exceed those associated with higher levels of fishing mortality for a wide range of meat counts.

Therefore, under prevailing exploitation conditions in the sea scallop fishery, an industry average meat count of 30 or 25 relative to 40 will result in significantly greater harvestable yield from all resource components, no matter what the prospects for recruitment happen to be. Further, as is illustrated in Figures 241 and 242 of Part 2, as meat count in all resource areas in reduced, the yield-per-recruit curves flatten, and the productivity benefit associated with meat count becomes less sensitive to increasing fishing mortality (i.e., the resource is naturally buffered to wide-ranging fluctuations in fishing effort). As a result, control on meat count (or size at first capture) appears to be the most practical and efficient control measure for addressing the yield per recruit aspect of the overall management objective in the current resource and management context.

3. The analysis presented in §713 shows that for sea scallops reproductive tissue mass increases markedly as the size (or meat count) of the animal increases, particularly during the early years. For example, the reproductive tissue (gonad) in a Georges Bank scallop that averages 30 meat count is about 40% greater (by weight) than a scallop averaging 40 meat count. Similarly, the reproductive tissue in a 25 count scallop (average) is nearly 80% greater than in a 40 count scallop. This general relationship holds for all sea scallop resource components. Assuming egg production is proportional to gonad weight, then management action to increase meat count may significantly increase the reproductive potential of newly recruited scallops over their life in the fishery. For example, §713 shows that scallops entering the fishery at 30 meat count will over their lifetime contribute about 34% more to the reproductive potential of the resource than if they entered the fishery at the current cull size. Of course, if exploitation should increase on the stock as a specific consequence of the meat count control, then benefits for the overall reproductive potential of the resource may be dissipated.

Conclusions for the Industry

From an industry perspective, the calculation of long-term economic benefits requires the generation of a stream of expected catch data, and is therefore subject to long-term recruitment prospects. As a consequence, the long-term economic analysis is based upon the catch streams that were generated in §711 as an approximation of fishing under equilibrium resource conditions. These catch streams are believed to reasonably illustrate the cyclical nature of sea scallop recruitment and abundance, and principally serve to demonstrate the variable nature of annual catch under long-term management conditions. Because no direct relationship between the magnitude and variability of annual recruitment and the specification of the meat count control measure was assumed in generating the catch streams (§711), the conclusions of the long-term economic analysis are the same as if constant recruitment were assumed; and, therefore, the conclusions are not dependent upon either the length of resource cycle (16 years was selected in the analysis) or the specific pattern of recruitment.

Specific conclusions of a long-term industry nature are as follows:

1. The lower the level at which the meat count measure is specified (larger scallops), the lower are the expected long-term prices (ex-vessel, wholesale, retail) and the higher are the expected levels of catch, employment, gross revenue, regional income and consumer surplus, which imply a more favorable economic climate for the industry. Similar effects are associated with long-term reductions in fishing mortality. Certain combinations of meat count and fishing mortality control (associated with the various strategy specifications) may lead to the same level of benefits (as illustrated in Tables 722.2 - 722.10).

2. All of the gross benefits measured reach their maximum value at the biologically optimal level of fishing mortality, F(max). Were the analysis to consider fishing mortality levels below F(max), then relative total benefits (based on catch) would be expected to decline just as with increases in fishing mortality above F(max). However, net benefits may continue to increase with fishing mortality below F(max), if costs decline at a faster rate than do the total benefits.

3. In the absence of some long-term constraint on fishing mortality, the benefits among alternative specifications of the meat count control measure will be dissipated in absolute terms, but maintained in relative terms so long as the specification itself does not induce differential effects on fleet effort (and thus fishing mortality), which could otherwise possibly re-order the relative long-term benefits among meat count specifications.

§733 Short-Term Analysis

Assumptions

The short-term phase of the analysis (see §712 and §723) is focused on the current and immediate future resource conditions. The analysis deals only with the first two years of Plan implementation, 1982 and 1983, because the most recent NMFS research survey and assessment information (1981) does not permit reasonable estimates of stock composition and abundance beyond 1983. The short-term phase of the analysis anticipates the timing and mode of Plan implementation, and in so doing serves primarily to refine the specification of the primary management measure (meat count) based upon impacts evaluated in the current resource and industry context.

The short-term analysis considers the two identifiable fleet sectors in the sea scallop fishery, shuckers and shell stockers, in evaluating overall impacts on the industry. The expected behavior of these two sectors relative to the resource in 1982 and 1983 is evaluated in §712, and the resultant combined effect on the industry is analyzed in §723.

Conclusions

1. Given the expected sea scallop resource composition and abundance in 1982 and 1983, vessels that shuck scallops at sea ("shuckers") and are permitted to average together small and large scallops to meet a meat count specification will not be measurably impacted by either a 40, 30 or 25 meat count specification in 1982 or 1983.

2. Vessels that retain and land scallops in the shell ("shell stockers"), and are subject to a minimum size requirement, will likely be impacted by either a 40 (3.25 inch), 30 (3.5 inch) or 25 (3.75 inch) meat count (minimum size) specification in 1982 or 1983, but the impact (foregone catch) will be greater as meat count decreases from 40 (see Table 712.2).

3. Assuming that sea scallop catch attributable to "shell-stocking" will remain at the 1980 level relative to total sea scallop catch (i.e., 16.3%), then impacts on the industry in 1982 and 1983 are summarized in Table 723.1 relative to price, employment and gross revenue. In general it is seen that employment and gross revenues decline and prices increase as the meat count specification decreases in either 1982 or 1983.

4. The most significant impact on either price, employment or gross revenue, shown in Table 723.1, is associated with establishing a 30 meat count (3 1/2 inch minimum size) or smaller in 1982, the first year of implementation. The gross revenue impact at the consumption level of establishing a 30 meat count in 1983 is 60% lower than if 30 count were established in 1982. Establishing a 40 meat count in either 1982 or 1983 would be expected to result in only minimal overall impacts, with gross revenue impacts averaging less than -.3% in 1982 and less than -.1% in 1983.

5. All of the impacts on gross revenues, employment and price are associated with foregone catch in the shell-stocking sector of the industry. At 1980 shell-stocking activity (i.e., catch) levels (16.3%), establishing a 30 meat count (3 1/2 inch minimum size) in the first year of Plan implementation would result in less than a $5 million impact on the total cost of goods and services to the national economy (criteria for a significant regulatory action under E.O. 12291). However, if shell-stocking activity should increase in response to the somewhat improved resource conditions in the Mid-Atlantic area (discussed in §230), then only a 30% increase in shell-stocking activity could result in a significant regulatory action. Conversely, shell-stocking activity would have to increase nine fold before the establishment of a 40 meat count (3 1/4 inch minimum size) regulation in 1982 would constitute a significant impact. Similarly, establishment of a 30 meat count in 1983 (delayed one year) would not be significant unless shell-stocking activity increased three fold over 1980. Finally, in evaluating this

short-term impact information, it is important to note that shell-stocking in 1981 appears to have dropped relative to 1980 due to considerations for product quality, the location of productive beds and increasing fuel costs.

PART 8: SPECIFICATION OF THE MANAGEMENT PROGRAM

§810 Preferred Alternative and Optimum Yield

Preferred Alternative

In view of the evaluation of alternative management strategies presented in §620, and the detailed analysis of various strategy specifications presented in Part 7, the Council selects an overall management strategy that combines immediate implementation of controls on fishing practices (through minimum shell size and meat count restrictions) with delayed implementation of complementary measures which effectively limit fishing mortality [strategy alternative 4(a), §620]. This selection is based upon the judgement that primary control on meat count (minimum size) is an effective strategy for meeting the objective, is appropriate in view of the limitations of other strategies, is compatible with prevailing fishing practices, and poses an acceptable level of administrative and enforcement costs. Specification of the meat count (minimum size) control measure is discussed in §820.

Implementation of measures aimed at limiting fishing mortality is desirable in view of the fact that the degree to which the management objective is achievable is, in the long term, directly related to the level of fishing mortality. However, measures which limit fishing mortality are not essential in the short term because fluctuations in fishing effort over the next few years will not negate the long or short-term benefits of the meat count (minimum size) control measure. The appropriate basis and means for limiting fishing mortality will be developed as part of the continuing management process (see §850), and move forward as data become available on the factors which directly affect fishing mortality (e.g., gear efficiency and the degree and nature of participation in all sectors of the fishery). In deferring action on the issue of fishing mortality, any discussion of potential measures that may have implications for product quality (e.g., trip length or number of tows on board) is also deferred because such measures are likely to have direct implications for effort. The adoption of quality control measures by the industry independent of this FMP is encouraged.

The management unit to which the above measures shall apply includes those sea scallop populations described in §130 and encompasses all commercial and recreational fishing activity affecting those populations.

Optimum Yield

Because of the decision not to adopt control on quantity landed as a strategy in the sea scallop management program, the actual catch in the sea scallop fishery will be a consequence of the structure and economics of the industry in relation to the abundance and condition of the resource. Control on minimum size and meat count is expected to have an effect on landings; although, that effect will likely be minimal in the short term (see §720, §730). Notwithstanding such catch effects, the purpose for imposition of the meat count (minimum size) measure is the expected effect on the productivity of the sea scallop resource, that will result in long-term benefits to the industry.

Optimum Yield in the Sea Scallop FMP is therefore defined as that amount of annual, domestic sea scallop catch that results from implementation of the sea scallop fishery management program. The provisions of the management program are designed to: (1) generate increased long-term benefits from the harvesting and use of the sea scallop resources, and (2) provide the Council with necessary information for future improvements and modifications to the management program as deemed appropriate.

Maximum sustainable yield (MSY) values for the various sea scallop resource components are discussed in §244. Optimum yield is related to MSY in the following way. Increased long-term benefits to be derived from the harvesting and utilization of the resource must be based upon considerations for the long-term productivity and harvestable yield from the resource. MSY is best understood as the maximum long-term average yield derivable from the fishery. Under optimum conditions of exploitation, year-to-year catches can be expected to vary about the MSY value as a result of natural fluctuation in resource abundance. In the Sea Scallop FMP, optimum yield accommodates annual fluctuations in yield that are due to natural resource variability, and seeks to achieve an increased long-term average level of yield from the fishery approaching MSY through the initial and future adoption of various conservation and management measures.

§820 Conservation and Management Measures

The following sections define the specific measures that are adopted for implementation. Each element of the management program is described, followed by the rationale for its inclusion.

§821 Meat Count and Minimum Shell Size

Specification

The meat count measure is initially specified at 40 meats per pound (40 count), which represents a maximum average value for the trip, and is applicable to sea scallops shucked at sea. The corresponding minimum shell size measure is initially specified at 3 1/4 inches and is applicable to sea scallops in the shell that are either caught recreationally or harvested by the shell-stocking sector of the fishery. The minimum shell size measure is subject to a tolerance of 10% by number less than the specified value. The meat count specification decreases to 30 meats per pound, and the minimum shell size specification increases to 3 1/2 inches effective automatically one year from the date of implementation of this FMP.

The Regional Director shall thereafter have authority to change the meat count and minimum shell size designations upon a finding of fact relevant to the criteria detailed in Part II(C) of Appendix A, and after consultation with the New England, Mid-Atlantic and South Atlantic Fishery Management Councils. A fact-finding process by the Regional Director may be originated either at his initiative or upon a request from the Council. Such changes shall be made only within a range of 25 to 40 meats per pound, with the corresponding shell sizes, and shall not be made in increments greater than five meats per pound.

Rationale

The Council believes that the long-term biological and economic analyses of alternative specifications of age-at-first-capture (represented as meat count) presented in Part 7 indicate that the 30 meats per pound measure, as a maximum average value (and its corresponding shell size), provides significant long-term benefits in terms of yield per recruit and the long-term, overall productivity of the sea scallop resource. Further, this 30 meat count value, relative to others considered, is judged to be most appropriate to the achievement of the adopted management objective. However, immediate imposition of a 30 meat count control measure would cause some fleet sectors to suffer short-term economic losses (see §730) that would not necessarily be outweighed by biological benefits to the resource, given its current condition. These sectors are primarily represented by those vessels in the regional shell-stocking fisheries. Therefore, to mitigate such impacts, the Council initially adopts a meat count of 40 meats per pound and a corresponding minimum shell size of 3 1/4 inches to be in effect for the first year following Plan implementation. This action will in addition provide an opportunity for State management authorities to adjust their regulatory measures to the target values of 30 meats per pound for shucked sea scallops and 3 1/2 inches for sea scallops in the shell (see §420 and §430).

The Council recognizes that the initial specifications of a 3 1/4 inch minimum size in 1982 and a 3 1/2 inch minimum size in 1983 for shell-stocking vessels operating in offshore Gulf of Maine waters will likely correspond to a meat count substantially in excess of 40 and 30 meats per pound, respectively (see §242). However, the Council believes that with the relatively low level of expected catch from that area, and in the interest of consistent and enforceable management policy, this discrepancy will not diminish the effectiveness of the management program. Vessels which land shucked scallops from the offshore Gulf of Maine will be subject to the 40 and 30 meat count specifications, but will probably have to concentrate on larger scallops than in other areas in order to comply with the measure.

Whereas meat counts (and corresponding minimum shell sizes) less than 30 meats per pound (e.g., 25 meats per pound) are not specified for implementation at this time, the Plan does, however, contain a mechanism for adjusting the management measure specifications in the regulations if the Regional Director and the Council deem it appropriate to do so based upon available biological and socioeconomic information. The fact-finding process that is specified would allow changes to be made in the specification of the measures without requiring the formal and time-consuming plan amendment process. Appendix A to this FMP contains details of the procedures for within plan adjustments in the meat count and minimum size control measures.

§822 Compliance Monitoring and Enforcement

The meat count and minimum shell size restrictions are applicable to the direct and indirect harvesting of sea scallops from all areas under United States jurisdiction and by every sector of the commercial and recreational fisheries. The meat count is a minimum average measure for each trip catch and it is the Council's intent that enforcement of this measure shall occur primarily at the dock and at the end of a vessel's trip. The Council recognizes, however, that at-sea enforcement may be necessary under certain circumstances such as, for example, when regulatory measures applicable to territorial waters are not yet complementary to the federal regulations, and inspection of catches is desired before a vessel leaves the FCZ. The minimum shell size measure applies to all shell-stocking vessels and to recreational fishing activities. In the latter case, a 10% (by number) tolerance is allowed for sea scallops in possession that are smaller than the specified value. Specific sampling techniques for monitoring compliance with both the meat count and minimum shell size measures are to be developed by the NMFS Enforcement Division.

Enforcement of the management measures shall be accomplished through a prohibition against the possession of non-conforming sea scallops up to and including the point of first transaction in the United States. The Council's intent in adopting the possession measure is to distribute the responsibility for compliance with the measures among all who participate in those first-point-of-sale commercial sea scallop transactions, as well as those involved in the actual harvesting, and to thereby expand the time frame in which enforcement can be accomplished.

§823 Licensing and Reporting

The Council specifies that any vessel taking and landing sea scallops must obtain a permit from the Regional Director of the National Marine Fisheries Service. Any U.S. vessel is eligible for a sea scallop permit, which is to be issued without charge. The primary purposes of the permit are to collect fishery statistics (see §860), to identify participants, and to foster communications in the management program. Information obtained is necessary to provide a continuous review of conditions in the fishery and to meet the Council's objectives for continuing management (see §850). For example, data acquired under these measures will allow the Council to analyze various approaches to achieve control on fishing mortality and develop appropriate measures as required.

§830 Other Management Parameters

This section defines the management parameters, other than optimum yield and maximum sustainable yield which have been defined in §810, that are required to be specified in fishery management plans by section 303 of the Magnuson Act. These parameters - Domestic Annual Harvest (DAH), Total Allowable Level of Foreign Fishing (TALFF), Domestic Annual Processing (DAP) and Joint Venture Processing (JVP) are required by the Act to allow determinations of whether participation by foreign fishing or foreign processing vessels in the fishery under management may be appropriate.

§831 Domestic Annual Harvest (DAH)

In view of the sea scallop management program selected by the Council for implementation and the analysis described in §330, the DAH for sea scallops from all areas equals the optimum yield. In 1982 and 1983 it is anticipated that DAH will be as follows:

1982	32,500,000 pounds	(14,730 metric tons)
1983	32,700,000 pounds	(14,835 metric tons)

Alternatively, using the short-term analysis of the sea scallop fishery described in §712, it is expected that DAH will be as follows:

1982	29,061,000 pounds	(13,182 metric tons)
1983	33,984,000 pounds	(15,415 metric tons)

§832 Total Allowable Level of Foreign Fishing (TALFF)

The Council determines that there is no surplus in the sea scallop fishery that may be made available for allocation to foreign fisheries. This determination is based upon the Council's specification of optimum yield (§810) and its assessment of the domestic industry's capacity to harvest the sea scallop resource.

The determination that the total allowable level of foreign fishing shall equal zero does not affect any allocations of the Georges Bank scallop resource to U.S. and Canadian fisheries that may be made pursuant to any negotiations between the U.S. and Canadian governments.

§833 Domestic Annual Processing (DAP)

Domestic annual processing capacity for Atlantic sea scallops is estimated to be 60,448,000 pounds (27,420 mt) for 1982 and 61,685,000 pounds (27,980 mt) for 1983. These estimates of processing capacity are significantly greater than the domestic harvesting capacity estimates specified in §831 for 1982 and 1983. This difference arises from the fact that domestic firms have historically handled and processed large amounts of imported Canadian fresh, chilled and frozen sea scallops, which on the average have exceeded domestic sea scallop landings during the past 20 years.

§834 Joint Venture Processing (JVP)

On the basis of the above estimates of the harvesting and processing capacity of the U.S. sea scallop industry, the Council determines that there should be no opportunity for joint ventures between U.S. sea scallop fishermen and foreign processing operations in the foreseeable future. Domestic processing capacity is expected to easily absorb any future increase in domestic harvests of sea scallops. Therefore, joint venture processing (JVP) is set at zero.

§840 Continuing Fishery Management

It is the Council's intention that the Sea Scallop FMP constitute a program of continuing fishery management. This program recognizes the need to establish initial management measures aimed at resource conservation and the achievement of management objectives. Importantly, the program also recognizes the need to study and to adopt additional measures, at the Council's option, in response to an improved understanding of various aspects of the fishery and directed at more efficient management and enhanced achievement of management goals. The Council believes that the continuing management program represents a rational approach to the management of a fishery where economic importance and intense exploitation justify immediate management action, but where the present understanding of the relationships between theoretical controls and operationally meaningful control measures is incomplete.

Parts 2, 3 and 7 of this FMP provide analytical support for a broad range of management decision making. The analyses contained in these parts provide the scientific basis for the Council's decision to adopt immediate control measures on age-at-entry in the sea scallop fishery. Additionally, however, these analyses provide a firm analytical foundation for future Council action to further consider and possibly propose respecification of the initial control measure and/or the imposition of other complementary control measures. In effect, the FMP is designed to provide a framework and support for a program of continuing sea scallop fishery management, responsive to the Council's evolving understanding of the resource and the fishery it supports. Various aspects of the continuing fishery management program as discussed below.

§841 Reassessment and Respecification of Management Parameters

Periodically the Council will review the current specifications of domestic annual harvest (DAH), domestic annual processing (DAP), and joint venture processing (JVP), and advise the Secretary of any appropriate changes to the FMP. Given the Council's present approach to managing the sea scallop fishery, changes in optimum yield (OY) are not likely to occur because of the manner in which it is defined; and as a consequence, no formal action to amend the FMP would be required by a Council determination of the need to respecify DAH or DAP.

§842 Regulatory Adjustments in Management Measures

The Council anticipates the need to make periodic adjustments in the management measures specified in the program. Such adjustments are possible in the specification of the meat count and minimum shell size measures, (§821) and specification of the types of statistical data to be required of vessels participating in the fishery (§823). The Council intends that, following the NMFS Regional Director's recommendation (made pursuant to procedures and criteria outlined in §821 and Appendix A), adjustments in the management measures will be handled by means other than formal amendment of the FMP. Changes in the recordkeeping and reporting requirements will also require only informal rulemaking procedures.

§850 Data Requirements

The Council identifies the following data requirements pursuant to section 303 (a)(5) of the Magnuson Act.

In order to undertake the economic impact analysis required for further management measure evaluation and selection as part of the continuing sea scallop fishery management program, the Council's continued access to data sources used in the formulation of this Plan is required, and an expansion in the range of data previously collected is necessary.

Data which must remain accessible to the Council include:

(1) that which is contained in the NMFS weigh-out/interview data base on sea scallop fishing; and

(2) that which is contained in the existing, voluntary NMFS data base on sea scallop processing.

Additional necessary data include:

(1) expanded NMFS weigh-out/interview data collection for all New England, Mid-Atlantic and South Atlantic coastal states;

(2) vessel employment data on a trip-by-trip basis to be included in the weigh-out/interview data base; and

(3) expanded, voluntary NMFS processing data collection which should be compiled on a monthly basis and which should additionally include annual capital inventory and physical production capacity on an individual plant basis.

The Council supports implementation of the NMFS Three-Tier Data Collection System as the vehicle by which the additional data needs can be accomodated. However, the Council requires that all data collected relevant to the sea scallop fishery shall be retained indefinitely for management analysis purposes.

Biological data required for the analysis of the sea scallop resources and analysis of the impacts associated with the management program include:

(1) data routinely collected as part of the NMFS Three-Tier Data System, to include more exact information (through the second and third tiers) on applied effort and catch location. Additionally, the system must encompass all geographical areas where sea scallops are landed;

(2) NMFS port sampling must be strengthened through broader coverage of ports and the requirement that all participating vessels provide NMFS, on request, with shell samples and relevant data on discards (below cull size); and

(3) information relating to the operating characteristics and efficiency of gear used to fish for scallops should be provided voluntarily to NMFS port agents as part of the Three-Tier Data Collection System.

Currently little data exist regarding the social and cultural context of the regional sea scallop fisheries (§340). As part of its continuing management program, the Council will compile pertinent data as they become available either through existing or planned research programs, or through Council-initiated research, where appropriate. Although these data will be assembled for future inclusion in the FMP, their acquisition is not presently considered essential for effective implementation of the sea scallop management program.

PART 9: CONSISTENCY WITH OBJECTIVES AND NATIONAL STANDARDS

§910 Consistency with Management Objectives

As described in §520, the Council adopted one overall management objective for the sea scallop management program, supported by four considerations. The overall objective is to maximize over time the joint social and economic benefits from the harvesting and use of the sea scallop resource. The four considerations include stock restoration in terms of abundance and age distribution, enhancement of yield per recruit, evaluation of plan-related costs and minimization of adverse environmental impacts.

The management strategy adopted in this Plan, as part of a continuing management program, directly addresses stock restoration and increased yield-per-recruit through control on age-at-entry into the exploitable part of the fishery. The biological benefits associated with adoption of a minimum meat count and shell size measure are discussed in sections 240 and 710. Average productivity per individual in the sea scallop population is shown to increase as controls on meat count and minimum size effectively require the industry to consistently cull scallops that are larger than that which would be retained under traditional industry practice. As a consequence of the increased age-at-entry, the distribution of year classes in the population improves, thereby contributing to stock restoration. The possible future adoption of additional measures, in the continuing management process, to control fishing mortality (supported by data gathered under the licensing and reporting system) will substantially enhance the Council's ability to address these considerations in meeting its overall management objective.

Other biological benefits of a cull-size measure are due to increased reproductive potential. By delaying capture until an older age, scallops which are just beginning to contribute significantly to spawning remain in the population. Although sea scallops begin to mature at age 3, they do not produce many eggs in the first year. At age 4, a female scallop will release about 2 million eggs during spawning. Historically on Georges Bank, sea scallops typically become subject to retention between 3 and 4 years of age. Because significant spawning does not take place until late summer or fall of their fourth year, many scallops are caught before they can contribute to the reproductive potential of the resource. Therefore, the Plan's action to institute a 30 meat count means that fewer immature scallops will be removed from the resource, particularly when recent recruitment dominates the population structure. Therefore, the action will substantially benefit the long-term viability of the overall resource.

As noted in §520, the consideration for minimization of adverse environmental impacts cannot be directly addressed by measures adopted in this Plan. However, measures directed at overall stock restoration will tend to make the fishery resource less susceptible to localized environmental perturbations. A more robust, restored population will also tend to be buffered against uncertain recruitment.

Finally, the management strategy proposed in this Plan is expected to result in minimum implementation, enforcement and research costs. Enforcement will rely on compliance monitoring by NMFS agents, and may result in additional personnel requirements. However, no new system of enforcement within NMFS would be required. Data gathering is expected to rely heavily upon participating, permitted vessels, in addition to ongoing research and survey programs by NMFS. As a result, costs associated with gathering any additional data required by the Council's continuing fishery management programs are expected to be minimal.

§920 Consistency with the National Standards

Section 301 of the Magnuson Act establishes seven National Standards for fishery conservation and management with which all fishery management plans must be consistent. The measures and provisions of the Sea Scallop Plan are consistent with these National Standards in the following manner:

National Standard No. 1:

> Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery.

This Plan defines optimum yield to be the amount of scallops that are harvested by the domestic fishing industry while complying with the specified maximum average meat count and minimum shell size limitations. These measures were selected because of their contribution to the long-term productivity of the scallop resource, as demonstrated by the biological analyses in sections 240 and 710. The Council believes that optimum yield will be achieved for the sea scallop fishery because the industry will accept the specified management measures and comply with them.

The meat count and shell size measures were specifically designed to prevent recruitment overfishing by minimizing the harvest of scallops that are not old and fecund enough to have contributed to the spawning stock.

National Standard No. 2:

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

The Council used the best and most recent scientific information available in developing the sea scallop management program and analyzing its impacts. The 1981 sea scallop stock assessment, prepared by the National Marine Fisheries Service, as well as the most recent statistical information available in the sea scallop industry, served as the basis for much of the descriptive and analytical materials in Parts 2, 3 and 7. Also, a significant amount of biological and life history information was incorporated into the Plan's provisions.

National Standard No. 3:

> 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.

The entire Atlantic sea scallop resource under U.S. jurisdiction is managed uniformly throughout the New England and Mid-Atlantic regions by the Plan. The Council finds that there are no significant, observed biological differences that would support the separation of regional sea scallop population within the management unit (see §212). Further, there is no biological basis to suggest that separate management of sea scallop populations outside U.S. jurisdiction will have any negative effect on the U.S. sea scallop resource.

National Standard No. 4:

> 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 (a) fair and equitable to all such fishermen; (b) reasonably calculated to promote conservation; and (c) carried out in such a manner that no particular individual, corporation or other entity acquires an excessive share of such privileges.

This Plan does not discriminate nor make any distinctions between fishermen from the various states. The Council determined that in order to achieve the management objective it is necessary to formulate the management program on an industry-wide basis, and not on the basis of separate, subregional management regimes. The various bioeconomic interrelationships in the sea scallop fishery and the interregional nature of scallop processing and marketing makes this determination necessary. Further, uniform regulation is appropriate in view of the demonstrated ability of most fleet sectors to exploit the resource throughout its range and the lack of any biological basis for creating subregional management areas.

National Standard No. 5:

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

This Plan does not make any allocations, either directly or indirectly, of the sea scallop resource to sectors of the industry.

Compliance with the meat count and shell size measures and the licensing and reporting requirements will not induce inefficiency in the fishery because culling and sorting are already part of sea scallop fishing operations. The resource is efficiently utilized under this management program because long-term yield is increased for every unit of fishing effort applied. The Plan allows all scallops above the specified sizes to be harvested as they become available, without restrictions imposed on areas or times fished.

National Standard No. 6:

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

The Plan addresses the problems created for the industry by recruitment-induced fluctuations in the resource through measures that are designed to increase overall stock abundance. Nevertheless, fluctuations in year class strength and, therefore, in sizes of scallops available for harvesting will occur. The Council adopted the flexibility mechanism described in Section 821 and Appendix A to allow adjustments in the meat count and shell size measures reflecting changes in resource and fishery conditions.

National Standard No. 7:

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

The measures specified in the sea scallop management program do not impose additional costs on the industry because compliance can be achieved with only slight modifications to traditional harvesting practices. The administrative costs of the program are not expected to be substantial.

APPENDIX A

Procedure for In-Season Adjustments in the Sea Scallop Meat Count and Management Measures Minimum Size

I. Introduction

The use of flexibility within a management program must be constrained so that changes do not exceed the range of actions that have been presented to the public and analyzed in the management plan. Changes in the management measures can only respond to circumstances which affect the attainment of the management objective. They must enhance the probability that the management objective will be achieved in the short or the long term.

The magnitude and frequency of changes in the management measure specification are critical. Frequent modifications of fishing gear or practice are costly for fishermen, making it difficult for them to plan and execute their fishing strategies. Such changes would discourage stability in the resource, the fishery and industry. Changes of great magnitude could significantly alter the ability of fishermen to operate and could alter supplies and markets. The program must ensure that the frequency and magnitude of changes are controlled within bounds which will allow fishermen the opportunity to plan and adjust to changes without incurring significant hardship. Significant changes in management philosophy or application must be addressed through amendment of the fishery management plan rather than through use of discretion within the plan.

Any program which allows for flexibility must ensure that the exercise of that flexibility occurs only after the public has had an opportunity for review and comment. The program must be responsive, but the response must be thoroughly considered, thoroughly discussed and clearly presented.

II. Procedure

The flexibility provision here proposed is sensitive to the constraints discussed above. Use of the provision is limited within bounds and to address conditions which are clearly defined. The procedure is efficient and responsive while allowing for careful consideration and full public review.

A. Frequency and Magnitude of Adjustments

The management measure specification is the meat count, or corresponding shell size, which may be harvested. The specification can range from 40 meat count, or the corresponding 3 1/4 inch shell size, to 25 meat count, or the corresponding 3 3/4 inch shell size. The specification may not be altered by more than 5 meat count, or the equivalent shell size differential, in any adjustment cycle.

B. Information Considered

Any decision to alter the management measure specification must reflect careful consideration of all available resource survey and assessment information, with special emphasis given to the most recently completed survey and assessment. Reports and records maintained by fishermen and made available as a part of the fishery statistics program must also be considered. Other fishery statistics, and any other information which increases understanding of current conditions of the stock, the fishery and the industry should also be used as available.

C. Judgement Criteria

The decision to alter the management measure specification rests on a determination that the objective of the fishery management plan would be achieved more readily, or would be better served through an adjustment to the current meat count or minimum size. The specification may not be altered unless at least one of the following conditions exists in the resource, fishery or industry, subject to the condition that in no case would such an alteration result in a reduction in expected catch over the following year by more than 5% from that which would have been expected under the existing management measure specification.

1. International inconsistencies exist in the management measures applied to sea scallop stocks in areas harvested by both domestic and foreign fishermen, and such inconsistencies provide foreign fishermen with an advantage over domestic fishermen that can be demonstrated to adversely affect the domestic fishermen.

2. Analysis of the size distribution of sea scallops shows that more than 50% of the harvestable sea scallop biomass is at sizes smaller than those consistent with the prevailing management measure specification and that a temporary relaxation of the specification would not jeopardize future recruitment to the fishery.

D. Operation of Procedure

The Regional Director will review the status of the resource, the fishery and the industry on a continuing basis. If, upon reviewing any of the information specified in (B) above, the Regional Director determines that any of the criteria in (C) above have been met, he may prepare a recommendation for action. The Regional Director shall, in any event, prepare an annual report describing the status of the fishery and offering prudent projections of any possible changes in the resource, fishery or industry which might require adjustment or amendment of the management program. The Council may, at any time, by majority vote, request a review and recommendation from the Regional Director.

The Regional Director will advise the Council of his completion of a report and recommendation. The Council may, at its option, request an opportunity to review and comment on the report or recommendation prior to any notice of a public hearing.

A public hearing on the recommendation will be held in conjunction with the Council Meeting at which it will be discussed. The Regional Director will asure that adequate notice of the public hearing is given to all interested parties. The Regional Director may modify his recommendation as a result of the public hearing.

The Secretary will publish notice in the Federal Register of any finding by the Regional Director to alter the minimum size limit, along with a date for implementation.

The Regional Director will provide notice of the adjustment by mail to every holder of a sea scallop permit.

APPENDIX B

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APPENDIX C

Glossary of Terms

abundance index	- A standard measure of resource abundance relative to other years.
Act	- Magnuson Fishery Conservation and Management Act.
age at entry	- age or size when a scallop is first retained in the fishery.
Council	- New England Fishery Management Council.
DAH	- Domestic Annual Harvest; a term in the Act.
DAP	- Domestic Annual Processing; a term in the Act.
dredge	- Metal framed apparatus with a metal ring bag that is towed behind a vessel on the sea bottom to collect scallops.
ex-vessel price	- Price of fish (product) to the fisherman (boat) at first transaction.
fathoms (fm)	- Measure of water depth, 1 fathom = 6 feet = 1.83 meters.
FCZ	- Fishery Conservation Zone; the area covering and extending 197 nautical miles from the seaward limit of the States' territorial waters subject to U.S. jurisdiction.
fishing mortality	- Loss from the fish population due to fishing; may take the form of catch or discard.
F	- The instantaneous rate of fishing mortality.
F(max)	- The fishing mortality rate associated with maximum yield per recruit.
F(0.1)	- The fishing mortality rate, less than F(max), that is believed to result in the greatest long-term average yield from the fishery.
ICNAF	- International Convention for the Northwest Atlantic Fisheries.
JVP	- Joint Venture Processing; a term in the Act.
kilometer (km)	- 1,000 meters = .62 mile.
Lay System	- A method of dividing the gross revenues and expenses of a fishing vessel among the owner(s) and crew.
meat count	- The number of scallop meats making up one pound of product.

metric ton (MT)	- 2204.6 pounds.
MFCMA	- Magnuson Fishery Conservation and Management Act.
MSY	- Maximum Sustainable Yield; the greatest long-term average yield which may be derived from a fishery resource.
National Standards	- Fishery conservation and management criteria for the preparation of Fishery Management Plans in the MFCMA.
NEFC	- Northeast Fishery Center.
NMFS	- National Marine Fisheries Service.
NOAA	- National Oceanic & Atmospheric Administration.
OY	- Optimum Yield.
recruitment	- The group of fish (often a year class) that reaches the size or age during a given year when it will first be subject to being caught.
Regional Director	- NMFS Regional Director.
Secretary	- Secretary of Commerce.
shell stocker	- Vessel engaging in scallop fishing that does not remove scallop meats from the shell before landing.
shucker	- Vessel engaging in scallop fishing that removes meat from the shell before landing.
TALFF	- Total allowable level of foreign fishing; a term in the Act.
territorial sea	- The area extending 3 nautical miles seaward from the shoreline of the coastal states and under the management authority of the individual states.
year class	- The group of fish that were spawned in a given year; e.g., the 1978 year class was spawned in 1978.