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Andrew P. Matykiewicz
University of Rhode Island

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CONSERVATION MEASURES IN THE INTERIM FISHERY MANAGEMENT PLAN FOR ATLANTIC GROUNDFISH

BY

ANDREW P. MATYKIEWICZ

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ANDREW P. MATYKIEWICZ

APPROVED:

Thesis Committee

Major Professor Dennis W. Nixon

Bernard E. Skud

Conrad W. Recksiek

A. A. Michel

DEAN OF THE GRADUATE SCHOOL

UNIVERSITY OF RHODE ISLAND

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ABSTRACT

The conservation measures used in the Interim Fishery Management Plan for Atlantic Groundfish (IFMP) were analyzed. The management techniques used include a minimum mesh size, minimum fish size and haddock spawning area closure. A minimum mesh size of 5 1/8 inches during the first year of the IFMP and 5 1/2 inches thereafter should lead to reduced fishing mortality on juvenile groundfish. However the mesh regulation does not adequately address the IFMP conservation objectives. The reason is that the selection coefficient for a 5 1/2 inch mesh size is significantly below that which corresponds to the 50% retention lengths of mature cod, haddock and yellowtail flounder. The minimum size regulation will impact the resource only to a small degree since it is used exclusively to support the mesh regulation. The haddock spawning area closure, in effect since 1970, may have contributed to the substantial improvement of the haddock spawning stock since the early 1970's. However, at average spawning stock sizes the haddock spawning area closure has little relationship to enhancing future haddock recruitment. Nevertheless, because it is a closure, the haddock spawning closure prevents high fishing mortality during the time when haddock congregate and may help reduce annual fishing mortality in the short-term.

Without amendment, the IFMP cannot prevent overfishing as it is required to do by the Magnuson Fishery Conservation

and Management Act (MFCMA). The use of a non-numeric Optimum Yield (OY) for groundfish is inappropriate without a definition of overfishing and without a contingency plan to prevent overfishing. The IFMP reduces fishery regulations in an attempt to enlist the cooperation of participants in the fishery in providing accurate fishery data. While the regulatory program of the IFMP may compromise the conservation requirements of the MFCMA there is no assurance that accurate data will be obtained from the fishery.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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INTRODUCTION

Since the mid-1950's declines in abundance of various fish species in the northwest Atlantic led fishery scientists and the fishing industry to concur that a better understanding of the resource was needed. As declines became more severe, regulations restricting fishing practices were imposed in an attempt to alleviate some of the pressure on the fish stocks without unduly prejudicing fishing practices. The fishery regulations were often met with resistance from those whose actions were to be modified by the management program. Therefore, early attempts to manage oceanic fisheries off New England gained little success. Two examples are the International Commission for Northwest Atlantic Fisheries groundfish management efforts and the Fisheries Management Plan for Atlantic Groundfish.

At face value, the basis for the lack of success was the inability of the programs to accomplish their primary objectives. Principal reasons were the unacceptability of the allowances for foreign fishing under ICNAF and resistance to the regulatory scheme exhibited by the fishing industry under the groundfish FMP. What was learned from the previous management experiences was that the fishing industry's needs must be taken into account when developing a FMP. The most recent management plan, the Interim Fishery Management Plan for Atlantic Groundfish (IFMP), was implemented on March 31, 1982. The IFMP was designed to address the needs of the New England fishing industry and provide conservation for the resource.

Addressing the needs of the fishing industry in the IFMP is important to securing its acceptability. It is equally important to consider what compromises were made in negotiating with fishing interests. It is important to assess the integrity of the conservation measures specified in the IFMP with respect to the Fishery Conservation and Management Act of 1976. It is essential that the effectiveness of the IFMP be measured in broader terms than its own limited objectives. Without question, strong conservation measures are the best assurance of long-term growth in the fishing industry. The issues raised in this paragraph were the impetus for this research and objective responses to those issues are the goal of this thesis. The IFMP exhibits a departure from past Atlantic groundfish management practices. What this change will mean for future groundfish management will be interesting to follow.

HISTORY OF ATLANTIC GROUNDFISH MANAGEMENT

NACFI

The North American Council on Fisheries Investigations was the first international organization whose purposes included the management of northwest Atlantic fisheries.[1] NACFI was active from 1920 to 1938 and its membership included Canada, Newfoundland and the U.S. Unfortunately, NACFI's only significant accomplishment was the delineation of statistical areas which were adopted by ICNAF and continue to be recognized today.

ICNAF

The first international organization which took an active role in regulation of fisheries off New England was the International Commission for Northwest Atlantic Fisheries (ICNAF). ICNAF originated in 1949 with 11 member countries including the United States, Canada, Soviet Union, and several European countries. The two primary objectives of ICNAF were to obtain scientific information on northwest Atlantic fisheries and regulate the fisheries to obtain the maximum sustainable yields.[2] ICNAF was successful in promoting fisheries research. However, organizational procedures, overcapitalization of the fishing fleets and disputes over allocation prevented maintenance of fish stocks at levels capable of producing maximum yield.[3]

ICNAF groundfish management relied primarily on mesh size restrictions to regulate the fishery. During the mid-1960's to early 1970's poor recruitment and overexploitation led to stock declines for several species. ICNAF's response to the haddock decline was to establish spawning closures and catch quotas for haddock in the Gulf of Maine and on Georges Bank in 1970.[4] In 1971 minimum mesh size was increased to 114 mm (4 1/2 inches) and country quotas were established for yellowtail flounder in New England sectors east and west of 69°W longitude.[5] Minimum mesh size was increased again in 1974 to 130 mm (5 1/8 inches) and due to continued declines in the haddock stocks, proposals for closing the haddock fishery became commonplace at ICNAF meetings.[6]

In spite of ICNAF's conservation measures, abundance of cod, haddock, yellowtail flounder and other species continued to decline into the early 1970's. The U.S. fishing industry believed the primary reason for the declines to be excess fishing capacity and foreign fishing practices. In the latter case pulse fishing[7] by the Soviet fleet and alleged misreporting of catches were particularly irksome to U.S. fishermen. For these reasons the U.S. fishing industry became dissatisfied with ICNAF groundfish management and began working toward national legislation which would preclude non-U.S. vessels from fishing in (extended) U.S. waters.

MFCMA

The result of the combined effort of the fishing industry, Congress and several federal agencies was the

Fisheries Conservation and Management Act of 1976 now known as the Magnuson Fisheries Conservation and Management Act or MFCMA. Title III of the MFCMA establishes the National Fishery Management Program of which the New England Fishery Management Council is a part. Title III also outlines the responsibilities and limitations of the Regional Fishery Management Councils. These responsibilities and limitations include the development of Fishery Management Plans (FMP) in conformity with the national standards established in Title III, sec. 301 (a)(1-7) of the MFCMA.

The effective date of the MFCMA was March 1, 1977. To prepare for the assumption of management responsibility of New England fisheries, the U.S. withdrew from ICNAF on December 31, 1976. This left a two month period, plus the time it would take to develop a FMP and regulations, for unrestricted fishing to take place in the Fishery Conservation Zone (FCZ). For that reason the New England Council felt it to be imperative that a FMP was prepared and regulations in place as quickly as possible. With the help of the National Marine Fisheries Service (NMFS), the New England Council developed a groundfish FMP. A significant amount of the information used to prepare the plan was from ICNAF sources. Considering the plan was designed to give maximum protection to depleted stocks in the interim until a comprehensive plan could be developed, it is no surprise that the groundfish management system was very similar to ICNAF's.

In 1973 cod, haddock and yellowtail flounder accounted for $25 million or 47% of the value of total New England finfish landings.[8] In 1978 revenues from cod, haddock, and yellowtail at major New England ports were approximately $37 million.[9] Economic importance of these three species combined with the poor conditions of the stocks at the time the New England Council assumed responsibility for their management led management effort to be concentrated on cod, haddock and yellowtail flounder.

Atlantic Groundfish FMP

The original FMP and fishery regulations were published in the Federal Register on March 14, 1977. The regulations were promulgated under emergency rules because of the "demonstrated fishing capability of the U.S. fleet."[10] The regulatory scheme of the FMP was based upon limiting the total catch by use of quotas and trip limits. The biological rationale for a quota management system is that controlling the total catch (i.e. fishing mortality) implies a degree of control over stock size. Trip limits were used to allocate the quota and spread the catch over time.

The quota for cod was divided into recreational and commercial quotas totalling 7300 metric tons (MT) for the Gulf of Maine and 30,000 MT for Georges Bank. In June, 1977 the recreational cod quota was dropped since monitoring the recreational cod catch was extremely difficult. The haddock quota was set at 6,200 MT which was an amount that could be met entirely by incidental catches of haddock. In other words, the 6,200 MT haddock quota closed the directed fishery for haddock. The yellowtail fishery west of 69° W was also closed as a directed fishery with a quota of 4,000 MT. The yellowtail quota east of 69°W was 10,000 MT.

The cod and yellowtail flounder fisheries were subject to a mesh size restriction of 5 1/8 inches minimum cod end mesh and savings gear[11] was restricted. The mesh size restriction was applicable to vessels fishing for cod or yellowtail only, as proven by possesing greater than 10% cod or yellowtail on board. Since the haddock fishery was closed and the amount of haddock a vessel could possess was limited to less than 10%, the mesh restriction did not apply to haddock.

In addition to closing the directed fishery for haddock there was an area/seasonal closure which corresponded to the time and geographic concentrations of haddock spawning activity. Two large areas of Georges Bank were closed from March through May annually. During the rest of the year a 16 inch minimum size limit was applied to haddock landings.

Restrictions on landings were imposed for haddock and yellowtail in attempt to curtail directed effort on closed stocks and to prevent the quotas from being reached too rapidly. Originally, vessels fishing east of 69°W could land no more than 13.608 MT (30,000 pounds) of yellowtail per trip. Vessels fishing west of 69°W could land no more than 2.5 MT (5,510 pounds) of yellowtail or less than 10% of their total finfish catch per trip. The 2.5 MT or 10% trip limit also applied to haddock landings.

The annual quotas or optimum yields and the landings restrictions proved to be the most problematic of the management techniques employed in the groundfish FMP. All quotas were continuously exceeded prompting the New England Council to propose methods aimed at making it more difficult to exceed the quotas. These regulations included: 1) dividing the annual quota into quarterly quotas and vessel class quotas, 2) constant adjustment of the trip limits, 3) redefinition of vessel classes, 4) redefinition of the fishing year, 5) subtracting overages from subsequent quarterly quotas and 6) increasing the quota during the fishing year. Between March, 1977 and early 1980, there were nearly 40 changes or amendments to the original final regulations.[12] Each change increased the complexity of the regulatory scheme and increased the need to monitor the fishery.

Fishermen in New England responded to the relative plethora of regulations by throwing their hands up. Some fishermen simply ignored the regulations, others found creative loop-holes such as "piggy-backing"[13] while many under-reported or misreported their catches. In September 1979 the New England council determined that the management environment was unsatisfactory for making informed, long-term decisions.[14] The growing complexity of the regulations and subsequent deteriorating quality of fisheries data were probably the most significant factors influencing this decision.

In 1979 work had begun on a long-term, mixed trawl fishery plan, the Atlantic Demersal Finfish Plan (ADF), but the New England Council felt that moving to the ADF plan without a history of good fishery data would be courting failure. The Council decided that an interim plan of limited scope shall be put to use while the comprehensive ADF plan was allowed more time to develop.

IFMP

The Interim Fishery Management Plan for Atlantic Groundfish (IFMP) was implemented on March 31, 1982. The objectives of the IFMP are stated specifically:

> "(1) enhance spawning activity;
> (2) reduce the risk of recruitment overfishing of cod, haddock and yellowtail flounder; and
> (3) acquire reliable data, in support of the development of ADF, on normal fishing patterns of the industry and the biological attributes of stocks as indicated by fishing."[15]

The primary objective implied in the IFMP is to reduce antagonism and resistance to management authority which grew out of the previous regulatory system. In working toward greater cooperation between management and the fishery the New England Council hopes to assure the success of the IFMP and subsequent plans.

THE IFMP REGULATORY SYSTEM

In selecting the appropriate methods for managing Atlantic groundfish the New England Council reviewed four basic strategies: catch control, effort control, control over fishing practices and maintaining the status quo. These strategies were qualitatively tested against the following criteria: 1) minimizing administrative, enforcement and industry costs and 2) feasibility of implementation. Controlling the catch was rejected because it is most effective for single species fisheries, it may induce undesirable changes in fishing patterns and it wasn't working under the original FMP. Maintaining the status quo was rejected because it wasn't working either and administrative, enforcement and industry costs were high. Effort control was rejected because it would not be acceptable to the industry and legal complications to implementing effort control exist. There is also the problem of measuring and standardizing effort in a large, diverse fishery. Control over fishing practices faired somewhat better than the other strategies in the New England Council's view. It was therefore decided that control over fishing practices would be the appropriate management strategy.

The techniques chosen in pursuit of controlling fishing practices include a minimum mesh size restriction applicable in a large mesh area, minimum fish size restrictions and a season/area closure for spawning haddock.

Mesh Regulations

Mesh size restrictions have been in effect for Georges Bank haddock since 1953. Consequently basing the IFMP management strategy on mesh regulations poses no impediment to implementation. It is a management technique that many fishermen have come to understand and accept.

The IFMP requires that vessels fishing in the large mesh area for cod, haddock or yellowtail flounder with trawl gear must use meshes not less than 5 1/8 inches, stretch, in the cod ends. The 5 1/8 inch mesh restriction is to be in effect during the first year of the IFMP, afterwards the mesh restriction is to be increased to 5 1/2 inches. It is currently anticipated that the 5 1/2 inch restriction will come into effect March 31, 1983. The mesh size in the body of the net was to be no less than 4 1/2 inches. However, fishermen expressed displeasure with this regulation so the New England Council deleted body mesh size restrictions from the final regulations. Vessels using gillnets in the large mesh area must use nets with a 5 1/2 inch minimum stretch mesh.

The large mesh area defined in the IFMP was chosen on the basis of historical catches and differs from other area options by being somewhat smaller in area or excluding seasonal exemptions for small mesh fisheries. Records show that 88% of the cod, 81% of the haddock and 90% of the yellowtail catches are encompassed by the large mesh area.[16] However it must be noted that the poor quality of fishery statistics was an impetus for rejecting the original groundfish FMP. Therefore the above percentages should be viewed with caution. Their intent is to show that most of the prime groundfish grounds are covered by the large mesh area. See Figure 1. Outside of the large mesh areas there are no mesh restrictions.

The New England Council decided that a step-wise move to a 5 1/2 inch mesh size is an appropriate balance between short-term costs and long-term benefits. The costs refer to loss of revenues due to a short-term decrease in landings expected from the change in mesh size. Through June 1982, three months after implementation of the IFMP, there has been little actual change in revenues from groundfish landings compared with 1981.[17] Long-term benefits refer to the increased yield expected from increasing the mesh size.

Mesh size restrictions are designed to work in two ways. Large meshes allow smaller fish to escape the net through the meshes and be recaptured when they are older and larger. Thus after changing to a larger mesh size the average size of fish landed would be greater and total weight landed would increase at the same level of effort.[18] The other way in which mesh regulations are designed to work is by having a mesh size large enough to allow the escapement of all sexually immature fish. By not taking fish until after they have spawned at least once each mature fish contributes to the spawning stock thereby contributing to future year classes. This is the principle expectation of the mesh regulations in the IFMP.

Consider the case where the goal of using large meshes is to increase total landed weight by catching larger fish. The age the fish enter the fishery (tp') often occurs later than the age of recruitment (tr).[19] If tp' is delayed by using a larger mesh, for example, larger fish are caught and total landed weight increases for the same fishing effort. This assumes that enough fish survive the period between tr and tp' to contribute positively to total landed weight, that all fish above the selection size for the mesh used are exposed to the full fishing mortality rate and that effort does not increase. If effort does increase stock density will decrease which leads to a decrease, in weight, in catch per unit effort.[20] Subtle changes in effort alter the analysis by amounts that are difficult to determine.

A yield isopleth diagram provides a good illustration of the relationship between mesh size, yield and fishing effort. See Figure 2. While Figure 2 represents North Sea plaice, the relationship is presumably applicable to Atlantic groundfish because of similarities in their biology and in the fisheries that exploit them. Fishing effort is directly proportional to fishing mortality hence the abscissa can be viewed as either fishing mortality or fishing effort. The age of entry into the fishery is determined by mesh size. The curves represent yield contours (yield per recruit) with peak yield occurring somewhere within the 425 YPR contour. These contours represent long-term or equilibrium conditions.

Cushing states that pre-WWII fishing mortality on plaice was 0.73 (F=.73) and trawl mesh size used by English plaice fishermen was 70 mm which selected for fish age three and above.[21] If mesh sizes used at that time were increased to 180 mm long-term yield per recruit for plaice could have been doubled at the same level of effort. It is important to be conscious of the difference between yield and yield per recruit. It is not yet possible to predict the effect of changing mesh sizes on total yield because future yield depends on the strengths of future year classes which are unpredictable.[22] Obviously where long-term recruitment is average or better, yield will increase as yield per recruit increases.

Figure 2 also illustrates the fact that a mesh size increase will have little or no effect on long-term yield if it is accompanied by an increase in fishing effort. For example, if the English trawlermen had decided to increase the mesh size, they may have done so step-wise to prevent economic dislocation. Assume that the mesh size was initially increased to the size that would select for four year old fish. The immediate catches would decrease since many of the fish that would have formed part of the catch with the small mesh trawls are now able to escape through the meshes. The response of the fishermen to smaller catches in the short-term may be to go back to small mesh net or to increase effort. If effort had doubled the increase in mesh size would not have lead to increased long-term yield per recruit. Of course fishing effort would not have doubled under the conditions described for the

English plaice fishery, the point is that in a trawl fishery yield responds to fishing effort as well as mesh size.

As pointed out in APPENDIX II, fishing effort on Atlantic groundfish has been increasing since the mid-1970's. While there appears to be a plateau in the number of vessels fishing for cod, haddock and yellowtail the efficiency and productivity of individual vessels continues to increase. Even though the number of standard days has increased more slowly lately, the effort expended per standard day continues to increase. There is no doubt that increasing effort will work against any expected increase in yield per recruit.

In addressing the goals of the IFMP there is heavy reliance on mesh regulations. The primary purpose of mesh size restriction, as expressed in the IFMP, is to allow for the escapement of small, immature fish until they have spawned at least once. Their contribution to the spawning stock is expected to sustain or increase recruitment of future year classes. To be effective the specified mesh size should provide for the escape from the net of the majority of immature fish.[23]

Sexual maturity in groundfish is more a function of length than age. Furthermore, length is a function of the growth rate which is positively correlated to temperature and negatively correlated to abundance. For this reason, different stocks of the same species often have different 50% retention lengths at the same mesh size. The Gulf of Maine cod stock and the Georges Bank cod stock are an example.

Mesh size is prescribed by matching its selectivity with the age of maturity of the species under study. Sea trials provide selection factors for different species according to mesh size, cod end materials and other variables. The selection factors are used to calculate the 50% retention length for a species at a particular mesh size. The equation used is: mesh size multiplied by selection factor equals 50% retention length. The 50% retention length is the length of the fish at which 50% of those entering the net will be retained.

The selection range relates the percentages of fish retained by a specific mesh size at various fish sizes. Clearly a narrow range is more useful than a broad one if the management objective is to take no fish smaller and all fish larger than the desired size. The selection range is important for evaluating the usefulness of mesh regulations but the 50% retention length is used to compare the selectivity of different mesh sizes.

Studies suggest that most Atlantic cod reach maturity between 19.5 and 21.1 inches.[24] This size range is equivalent to a three year old Georges Bank cod or a four year old Gulf of Maine cod. The 50% retention mesh size for this size cod is 5 3/4 to 6 1/4 inches. See Table 1.

Most haddock mature at age three. Georges Bank, post spawning (April) haddock average 20.1 inches and Gulf of Maine, post spawn haddock average 18.5 inches.[25] The cod end mesh size that would give 50% retention of three year old, post spawn haddock is 5 3/4 to 6 1/4 inches.

Yellowtail flounder also mature at age three. Post spawn (May) yellowtail are appriximately 13.8 inches in length.[26] The cod end mesh size which gives 50% retention of this size yellowtail is 6 1/4 inches.

The IFMP reports the size at 50% maturity of haddock to be 16.3 inches for males and 16.9 inches for females and yellowtail to be 9.6 inches for males and 10.8 inches for females.[27] While these data are important, for the purpose of ensuring that the mesh size used will allow most recruits to spawn at least once, the post spawn sizes should be used.

The mesh size prescribed for the first year of the IFMP is 5 1/8 inches to be followed by an increase to 5 1/2 inches. Experimental results provide the retention data for groundfish in Table 1. Using a cod end mesh of 5.1 inches the 50% retention length for cod was 17.2 inches, 16.5 inches for haddock and 11.1 inches for yellowtail. These lengths are significantly below the lengths at maturity. Using this mesh size on Georges Bank 20% to 40% of age two cod and all age three cod would be retained in the net. In the Gulf of Maine 10% age two cod and 40% to 90% age three cod would be retained. The situation is similar for haddock and yellowtail. That is, the majority of the spawning stocks are subject to 100% retention.[28]

There is potential improvement in moving to a 5 1/2 inch mesh. Using a 5 1/2 inch mesh cod end 5% to 20% age two yellowtail and 60% to 90% age three yellowtail would be retained. The same mesh size would retain 0% to 20% age two

Georges Bank haddock, 70% to 90% age three Georges Bank haddock and 0% age two Gulf of Maine haddock and 30% to 80% age three Gulf of Maine haddock.[29] The largest mesh size used on cod was 5.3 inches which retained 0% two year old and 20% three year old Gulf of Maine cod and 20% and 100% two and three year old Georges Bank cod respectively.[30] Undoubtedly a 5 1/2 inch mesh will retain lesser percentage of two and three year old cod.

While the 5 1/2 inch results are a measurable improvement over the 5.1 inch results, to rely on the 5 1/2 inch mesh regulation as the foremost conservation measure is playing the percentages very closely. To conclude that going to a 5 1/2 inch mesh size will lead to increased long-term yield is unrealistic. Long-term yield may increase under specific conditions but not under current trends in fishing mortality. See APPENDIX II. Based on selection factors from the literature, a 6 inch cod end mesh will afford 50% retention lengths corresponding to the lengths of post spawning, three year old Gulf of Maine haddock and cod.[31] From the above assesment it appears that a 6 1/4 inch mesh size would provide more secure conservation for Atlantic groundfish.

The potential contribution of a cohort[32] to the spawning stock is graphically related to mesh size in Figure 3. Figure 3 represents the log of the number of individuals in a cohort throughout the lifetime of that cohort from egg onward. The age at which exploitation begins (tp') which, in trawl fisheries, is determined by mesh size is less than the age of maturity (tm) for both 5 1/8 inch and 5 1/2 inch mesh sizes. The dashed curve represents the decline of the cohort from fishing and natural mortality combined. This curve tends toward the abscissa more rapidly at higher levels of fishing mortality and decays more slowly at low levels of fishing mortality.

Under the current conditions represented in Figure 3 the number of fish from the cohort contributing to the spawning stock is approximately A. It can be argued that by delaying the age at which exploitation begins by increasing the mesh size to 5 1/2 inches (i.e. moving tp' to the right but tp' < tm), the number of individuals from the cohort that potentially will spawn will increase. However the magnitude of the increase is less than if the age at which exploitation begins equals the age of maturity (i.e. tp' = tm). That could be accomplished in the groundfish fishery by setting the mesh size at 6 1/4 inches. It is also clear that if fishing mortality decreases, the number of individuals from the cohort that will reach maturity will increase without a change in mesh size.

The increase in the number of potential spawners is inconsequential in the absence of a stock-recruitment relationship. Whether the groundfish stock-recruitment relationships are positive or negative varies with factors that have yet to be understood. Biologists currently believe that the likelihood of good year classes occurring under favorable environmental conditions is enhanced by an abundant spawning stock.[33] However, there have been large year classes from relatively small spawning stocks. Cod, haddock and yellowtail are highly fecund species whose recruitment potential has yet to be conclusively related to strength of parent stock.

The degree of potential increase to the spawning stock these mesh size changes imply is trivial relative to the entire curve in Figure 3. Mortality of eggs, larvae and juvenile fish is extremely high. As can be seen in Figure 3 the number of individuals rapidly declines prior to recruitment (tr). In a stable population a mature female cod, in its lifetime, will produce only two offspring which survive to maturity despite the fact that she may produce millions of eggs per season.[34] Therefore, spawning stocks would be most favorably enhanced by reducing mortality on the early life history stages of the fish if it were possible.

The arguments presented above show that the biological basis for depending solely on mesh size regulation for managing groundfish is tenuous. The IFMP mesh regulation, by itself, does not prevent or reduce the risk of overfishing. If effective in increasing long-term yield the mesh regulation may increase the risk of overfishing by encouraging the entry of additional vessels into the fishery. The mesh regulation selected in the IFMP does not enhance spawning activity. While mortality on juveniles will probably be slightly reduced with a 5 1/2 inch mesh size, the escapement of the majority of juveniles until they have spawned once has not been guaranteed.

There are advantages to managing fisheries with trawl net regulations. As previously stated mesh regulations are not a new or complex management technique. This technique has been used by ICNAF and under the original groundfish FMP. Its use is, more or less, accepted by New England draggermen. Therefore implementing that portion of the management plan dealing with mesh regulations should not produce extensive or unexpected criticism from fishermen.

There are two advantages for the individual fisherman using a larger mesh size in his cod end. The first is less time spent culling out small fish at sea. Total discards should decrease. This in itself would be a substantial benefit. No exact figures are available, but as an example, 1977 haddock discards are believed to be on the order of two to three times the total landed weight of haddock.[35]

The other advantage is that the price per pound of larger fish is higher than that for smaller fish depending on the size and species. In other words the value of the catch should increase. However, imperfect trawl selection combined with the fact that fish taken with smaller mesh sizes are no longer being taken means that total short-term catch will decline at the same level of effort. That is, an increase in mesh size will increase the average costs (inefficiency) of capture and the landed value of groundfish.[36] How New England groundfish fishermen respond to this has yet to be seen. This is an important point because the strength of the New England Councils argument for mesh size regulations lies in the expected increase in long-term yield. In the absence of effort control increased yield will encourage additional effort into the fishery.[37] A significant amount of new effort will bring a proportionate increase in fishing mortality which at worst will lead to overfishing and at best depress catch per effort back to the pre-IFMP levels.

One other advantage of using mesh regulations is the relative simplicity of enforcement. The quota management scheme of the original FMP required enforcement that was time consuming, complicated and therefore expensive. For the most part there wasn't much enforcement. Under ideal conditions enforcement of mesh regulations would be less difficult; a vessel in the directed groundfish fishery would only be allowed to carry cod ends with meshes that conform to the regulations.

Furthermore there would be no geographical variation in the regulations. Enforcement would be dockside and all fishermen could see what others were up to.

However the groundfish fleet harvests large quantities of smaller demersal species, from roughly the same areas, that require small meshed nets. For example, scup, whiting, redfish, butterfish and squid are directed fisheries off New England whose capture requires a substantially smaller cod end mesh size. Many vessels direct their effort on species according to price and availability which can vary greatly over relatively short time periods. This practice demands that trawls of various mesh size be carried on board for quick conversion at sea. Under this condition the enforcement advantage is lost.

The New England Council developed the Optional Settlement Program to allow the small mesh fisheries to continue without dissipating the conservation efforts of the IFMP. The Optional Settlement Program is administered by the Regional Director of NMFS. A vessel owner or master desiring to fish for small meshed species must contact NMFS and request a permit. Once permitted the vessel may fish within the large mesh area with small mesh nets provided no more than 15%, by weight, of his catch is cod, haddock or yellowtail and at least 50% of the catch is small mesh species. All small mesh species will be identified by NMFS. These requirements apply throughout the time the vessel holds the permit which will be no less than seven days and no more than six months. The frequency of switching fisheries will be reduced but this is expected to impact only a small fraction of the groundfish fleet. Therefore, from an enforcement perspective the Optional Settlement Program is better than area or other exemptions to the large mesh area restrictions.

A potential problem with the Optional Settlement Program will be its impact on groundfish discards. Minimizing discards is an important strategy behind the Optional Settlement Program.[38] The New England Council contends that fishermen in the Optional Settlement Program won't set on cod, haddock or yellowtail since they cannot market more than their 15% trip limit. However, under the original groundfish FMP it was shown that while fishermen may be aware of the regulations, those regulations do not prevent fishermen from maximizing returns. If a fisherman can increase his return to investment by setting on cod, haddock or yellowtail while in the Optional Settlement Program there is a chance that he may do it. If he does, discards may increase since the small mesh net will catch undersized groundfish.

In the effort to gain the confidence of fishermen and enlist their help in obtaining accurate fisheries data the mesh regulations probably have a very positive influence. Compared with alternatives from previous management regimes the IFMP offers the industry a good deal of freedom and is a major improvement. Therefore, generally speaking, the mesh regulations of the IFMP, i.e. increasing the mesh size to 5 1/2 inches, is better than no change at all.

Minimum Size Restrictions

A size limit used by itself can affect the yield of a fish stock. Yield from a given year class will be maximized at high rates of fishing when the minimum size limit approaches the critical size. Critical size is that fish size when a year class has maximum bulk and occurs when the instantaneous growth rate equals the instantaneous natural mortality rate.[39] At a low rate of fishing a small size limit should be used since a broader range of fish sizes must be taken to maximize yield.[40]

When the minimum size limit is within the selection range of the mesh size used, as in the IFMP, undersized fish will be taken. The minimum size limit requires the small fish to be discarded at sea. The effect on yield of capture and discard of undersized fish depends on the number of discards that survive. If discard survival is high the effect is minimal. But if discard survival is low, as it is believed to be for trawl fisheries, undersized fish in the selection range are subject to some fraction of the fishing mortality rate.[41] That is, the year class is reduced by fishing mortality before reaching marketable size.

The minimum fish size regulation used in the IFMP is a complementary management technique designed to augment the effectiveness of the mesh regulations. It is not expected to affect any long-term changes in the fishery independent of the other regulations. The purpose of the minimum size restriction in the IFMP is to create disincentives for using smaller meshed cod ends, cod end liners or covers or setting gear on concentrations of juvenile fish. For this purpose the specific minimum sizes selected should match the chosen mesh size so not to reduce the effectiveness of that regulation.

The minimum fish sizes chosen for the IFMP are 17 inches for commercially caught cod and haddock, 15 inches for recreationally caught cod and haddock and 11 inches for any yellowtail. All sizes are for total length hence, filleting or heading at sea could provide a loop-hole. The minimum sizes for commercially landed cod and haddock and all yellowtail roughly correspond with the 50% retention lengths of a 5 1/8 inch mesh size. See Table 1. Since the selective action of the trawl works over a range of fish sizes the minimum size necessitates discarding at sea. Table 1 indicates that dragging for haddock with a 5 1/8 inch mesh cod end and a 17 inch minimum size could lead to substantial haddock discards. However discarding should be reduced if the 5 1/2 inch mesh size restriction is implemented in March, 1983. Currently the Massachusetts Inshore Draggermens Association plans to request that the New England Council delay implementation of the 5 1/2 inch mesh regulation since they claim to be catching quantities of small yellowtail and fear there won't be many larger ones next April.[42]

An apparent problem in using these minimum sizes is that all are below the size at maturity for each species. This is not a major concern however, since most discarded groundfish probably do not survive and, it has been argued, should not be wasted by being thrown back. That is to say, undersized, immature groundfish will have no greater chance of spawning by being discarded than being kept. Increasing the minimum size to the size at maturity could theoretically increase the spawning stock if discard survival were higher. Increasing minimum size to 20 inches for cod, 19 inches for haddock and 13 inches for yellowtail would require a mesh size increase to 6 inches or greater. However without a commensurate increase in mesh size discards would be excessive resulting in a tremendous waste of the resource. If the mesh size is increased the minimum size need not change. This will result in a reduction of discards since fewer undersized fish will be retained in the net.

Under pressure from recreational fishermen and their associations the New England Council reasoned that recreational fishermen do not catch significant quantities of juvenile groundfish and will be allowed to take 15 inch cod and haddock. There were problems created by this distinction until the New England Council defined recreational catch as catch for any use except sale.[43] One problem that remains is that even though recreational fishermen allegedly do not catch juvenile cod, 15, 16, 17, 18 and 19 inch cod are, in most instances, juveniles. The same recreational opportunities are available whether the minimum size is 15 inches or 17 inches. Particularly since recreational fishermen do not catch significant quantities of juvenile cod. What is confusing is that if recreational fishermen do not catch many small cod, why do they need a 15 inch minimum size? Similar arguments can be used for haddock but the magnitude of the recreational haddock catch is much smaller.

In that the minimum fish size management technique is not distinct from the mesh regulations, it will support the mesh regulations since it should reduce landings of small groundfish and aid enforcement. However from a strictly conservation and management point of view the regulatory separation of commercial and recreational cod and haddock minimum sizes is questionable.

Haddock Spawning Area Closure

A haddock spawning area closure was first introduced by ICNAF in 1969 and was implemented in 1970. At that time the Georges Bank haddock stock had severely declined with no prospects of recovery until an abundant year class came along. The original ICNAF closure period spanned March and April and covered two areas: Area I east of Cape Cod and, Area II enclosing much of northeastern Georges Bank. In 1971 ICNAF extended the closure through May and in 1973 the areas were modified to exclude prime redfish grounds. When the New England Council was given the responsibility to develop a management plan in 1976, available evidence indicated that the haddock stock had remained at low levels of abundance. Hence the ICNAF haddock spawning closure was maintained in the FMP for Atlantic groundfish.

The IFMP also continues to utilize the haddock spawning closure management technique. The closure is in effect from March through May and precludes the harvest of groundfish from areas bounded by the following points:

Area I	Area II
41°50'N 69°40'W	42°20'N 67°00'W
40°53'N 68°58'W	41°15'N 67°00'W
41°35'N 68°30'W	41°15'N 65°40'W
41°50'N 68°45'W	42°00'N 65°40'W
	42°00'N 66°00'W

With regards to gear other than trawls or for species other than haddock, it should be noted that hooks having a gape[44] not less than 1.18 inches (Area I only), lobster traps and scallop dredges may be used during the closure.

Under the IFMP, Area I east of Cape Cod has been reduced in size and shifted to the southeast relative to Area I of the original FMP. According to the IFMP this shift is in response to public desire to reduce the impact of the closure on fisheries for other species and to a shift of haddock spawning activity to the southeast.[45] However the other impacted fisheries and the nature of the shift in spawning activity were not explained in the IFMP.

According to its current usage the efficacy of spawning closures depends on whether spawning grounds are well defined, whether a significant portion of the spawning stock is concentrated over these grounds and are particularly susceptible to capture and whether fishing will disrupt successfull spawning. Haddock tend to exhibit sufficient spacial and temporal constancy in spawning behavior to satisfy the above requirements, at least to a greater degree than cod or yellowtail.

In 1969 it was believed that the poor condition of the haddock stock was primarily due to overfishing and recruitment failures. It was reasoned that the haddock spawning stock had been depleted to a level below that which was required for the production of an abundant year class, i.e. the fishery was experiencing recruitment overfishing. Spawning closures tend to reduce the short-term fishing mortality on the spawning stock and theoretically enhance spawning activities. In this way the closure prevents very high fishing mortality by controlling fishing when the fish congregate and may be most susceptible to the gear. It is difficult to say if the strong haddock year classes in 1975 and 1978 are a direct result of the haddock spawning closure. Nevertheless, haddock landings have increased since 1977.

The IFMP was drafted under the assumption that a haddock spawning closure is an essential management technique.[46] However this assumption was never substantiated or explained. A spawning closure enhances future recruitment only under the assumption that by enhancing the number of spawners future recruitment will be increased. That is, that recruitment is a function of stock size and increases as stock size increases within an average range of stock sizes. This is an application of animal husbandry and is well documented for animals with relatively low reproductive potential such as mammals and certain fish species. However, stock-recruitment relationships have not been defined for Atlantic groundfish and there is little more than a tendency for recruitment to be lower and more variable at very low spawning stock sizes.[47] Moreover, there may be an upper limit to spawning stock size above which will not be advantageous for yield from the stock.[48] Beyond this upper spawning stock size density-dependent factors, such as intraspecific competition and cannibalism, play an increasingly important role in determining recruitment success.

During the development of the IFMP much consideration was given to a spawning closure for cod. Two areas, both in proximity to the haddock spawning areas, were selected based on prior studies.[49] However, Serchuk[50] argued against the proposed cod spawning closure for two reasons. His first argument was that there is little empirical evidence of well defined cod spawning grounds, of large percentages of the population concentrating on the grounds in the prescribed time period or of increased succeptability to gear during spawning. Serchuck also argued that there is no empirical evidence of a stock-recruitment relationship for Georges Bank cod. Hence the expected utility of a cod spawning closure in affecting increased future recruitment can not be predicted. One wonders if this latter argument can be made against the haddock spawning closure as well. More explicitly, in view of the improved condition of the haddock stocks and the lack of a demonstrated stock-recruitment relationship, is the haddock spawning closure biologically justifiable?

If present stock condition and stock-recruitment were the only considerations, the advantages of the haddock spawning closure could not be demonstrated. However, the closure protects the stocks by preventing very high fishing mortality during March through May when it congregates. In this way the spawning closure behaves like any other closure by limiting fishing mortality and catch in the short-term, provided there are no large changes in annual effort. This inclination combined with any possible beneficial effects the spawning closure has on future recruitment probably justifies maintenance of the closure in the IFMP.

particularly since it is an established practice which fishermen accept (more or less) and it is relatively easy to observe and enforce. The haddock spawning closure is generally acceptable to fishermen because 1) a large percentage of the fleet does not go out to Georges Bank in the late winter and 2) spawning haddock are in poor market condition. Therefore the closure has relatively little impact on most commercial fishermen.

The IFMP points out that the haddock spawning closure covers some cod and yellowtail spawning activities and therefore will have beneficial spillover effects for those fisheries.[51] However, it is difficult enough to forecast the direct effects of the management procedure without attempting to predict spillover effects.

In total, while the utility of the haddock closure in optimizing future haddock yield cannot be measured, current conditions in the haddock fishery (see APPENDIX II) dictate that having the closure may be better than not having the closure.

Optimum Yield

In the IFMP optimum yield (OY) is defined as:

> "the amount of those species harvested by the United States fishermen under the conservation and management measures specified in this [Plan]."[52]

In other words, OY is the quantity of cod, haddock and yellowtail flounder that will eventually be landed during the fishing year. The MFCMA defines OY as the amount of fish from an exploited stock:

> "(A) which will provide the greatest overall benefit to the Nation, with particular reference to food production and recreational opportunities; and
> (B) which is prescribed as such on the basis of the maximum sustainable yield from such fishery as modified by any relevant economic, social, or ecological factor."[53]

While this latter definition does not preclude the use of a descriptive OY in a FMP, there is no precedent for the IFMP definition of OY.[54] Therefore it should be closely scrutinized in terms of its ability to address the requirements of the MFCMA and the needs of the resource.

According to the MFCMA, maximum sustainable yield (MSY) is to be the basis for prescribing the OY of a managed fishery. MSY is defined as the average of the highest potential surplus that may be produced by a given fish stock over the long-term.[55] Computation of MSY is performed with the aid of various mathematical models known as logistic or surplus production models. Yield from a fish stock is often calculated using a dynamic pool model which gives yield in terms of yield per recruit. However, details of this model will not be given here since the surplus production model is intuitively easier and will suffice for this discussion of MSY.

The premise for most fish population modelling is that the population is dependent on growth and recruitment for input, and natural mortality and fishing mortality to decrease the population.[56] It is usually assumed that in the absence of fishing a stock will reach an equilibrium size, k, where natural mortality is just balanced by growth and recruitment. Once fishing has been introduced the stock will stabilize at some size less than the maximum at which point production from growth and recruitment will have increased to compensate for the additional mortality from fishing.

The surplus production model assumes, among other things, that rate of growth, rate of natural mortality and the absolute number of recruits per year are constant.[57] This model's primary function is to predict surplus production of biomass (i.e. yield) from fishing mortality at various stock sizes. Simply put, the production model states that potential yield from a stock is a function of stock size. This is usually written:

$$dB/dt = rB(1 - B/k)$$

Where B is stock biomass, r is the intrinsic rate of increase of the population, and k is the maximum stock size or carrying capacity of the environment. When surplus production is plotted against biomass a parabola similiar to the one in Figure 4 results. The height of the curve in Figure 4 represents growth and recruitment in excess of natural mortality at each level of biomass, i.e. the surplus production available for harvest. The parabola translates biomass or stock size into potential yield and shows that yield is maximized at some intermediate level of biomass. This conclusion is reasonable when the following three postulates are considered.

> "1) When food is a limiting factor, food is less efficiently converted to new biomass by a large stock since individuals may get less food and spend more energy acquiring it.
> 2) As the stock approaches maximum density, efficiency of reproduction is reduced.
> 3) An unfished stock often contains relatively more older fish than a fished stock. Older fish convert a smaller fraction of food into new biomass since mature fish divert substantial energy into production of gametes. Also, since larger fish tend to eat larger foods an extra step may be added to the food chain."[58]

When fishing effort is applied to a virgin stock, fishing mortality increases to a rate which is proportional to that effort. As fish are removed from a stock the surplus production model assumes that natural factors will cause an increase in the biomass replacement rate, that is, an increase in surplus production. As effort increases fishing mortality increases and surplus production available for harvest increases. Yield will continue to increase as effort increases until the stock is reduced to approximately half of its equilibrium size, i.e., k/2. If effort continues to increase so that the stock size is reduced to levels less than half the equilibrium size the fishery enters an overfishing phase and surplus production will be reduced. This cause and effect is not instantaneous as the model suggests. However, the model is useful for fisheries which behave according to most of the model's assumptions.

The surplus production model has been criticized for three reasons: 1) all of the assumptions can never be met since some are contradictory, 2) the model does not account for environmental variability and 3) the model does not account for species interactions.[59] While the production model, like all models, is not infallible and is often criticized for being less than dependable, this model gives a good first approximation of MSY. The models used for groundfish assessment purposes are becoming increasingly complex. However the assesment methods now in use are probably adequate for current levels of fishery management sophistication.[60]

The above analysis shows that MSY is a biological term and has a numerical value which is relatively constant, subject primarily to natural perturbations. This analysis of MSY may also lead one to conclude that the optimum method for managing the fishery would be to maintain fishing effort at a level which would produce MSY. However, the OY concept was developed on the premise that there is more to managing a fishery than the biological considerations discussed above.

Rodel defined OY as, "a deliberate melding of biologic, economic, social, and political values designed to produce the maximum benefit to society from a given stock of fish."[61] That is, OY is a modification of MSY which takes the human system into account. Defined as such, OY gives everyone interested in the fishery an opportunity to influence the specification of OY, whereas the principle inputs for determination of MSY are survey fishing data and commercial statistics.

The definition of OY in the MFCMA is clear. The intent is to preclude the regional councils from managing the fishery purely for the fish. Those who formulated the MFCMA recognized that U.S. fisheries are best managed by taking the physical and human environment into account. They also recognized the individuality of fisheries and the unacceptability of a universal methodology for specifying OY.

Optimum yield is not a means for allocating the expected yield.[62] By definition, OY is an elaboration of MSY which includes social and economic considerations. Requiring OY to allocate the resource in addition to its designed use of establishing how much is to be taken will complicate the process by making OY a more onerous issue. OY was designed specifically to address questions of, "how much fish," not questions of, "who gets the fish." Allowing those groups with the greatest collective voice the strongest influence in allocation decisions does not promote wise resource management or guarantee maximum benefit to society.

Optimum yield, as defined in the MFCMA, has been criticized for being both ambiguous and based upon MSY which was not defined in the MFCMA. The ambiguity of OY stems from the lack of a prescribed methodology for quantifying the economic, social and ecological factors that were alluded to in the definition. This lack of a prescribed methodology prevents a rigorous, quantitative approach to specification of OY. The MFCMA could have provided more guidance by legislating a formula for OY, but that may have overly constrained the regional councils. The MFCMA intentionally allows the councils to use their good judgement in establishing OY for fisheries under their jurisdiction.

It is widely accepted that without due consideration of economic and social factors most fishery management plans will fail. Therefore, despite the criticizms leveled at OY, it remains a useful objective of fisheries management. Until a more systematic approach for determining optimum level of harvest is developed, OY will continue to be used.

Probably the most constructive way of describing OY is by looking at how it is put to use and the results of its use. Optimum yield can be either a management objective or a means for accomplishing an objective. For example, in a fishery where the stock is somewhat depleted but fishing is still profitable, maintaining a harvest level at OY which is significantly lower than last year's catch may be an objective of the management scheme. In the same fishery, maintaining harvest at OY may also be a means of accomplishing the goal of rebuilding the stock since reduced fishing pressure on the stock may present an opportunity for the stock to increase its numbers.

Since OY is individually tailored to each fishery and because it is dynamic, OY has been described with significant variability in different management plans. Optimum yield has been defined as a number, a range with an annual fixed point, a multi-year number the whole of which may be taken at any instant, a percentage of another species in a mixed fishery, a description of some biological characteristic, or the result of an ecological model.[63] In all cases except where OY is a specific characteristic of the fishery, OY has an assigned numerical value. In addition, the value is specified prior to commencement of the fishing period.

The exception noted above is in the Florida stone crab fishery where there is no maximum number of crabs that may be captured but all must be returned to the water after the removal of one claw. There is a clear distinction between stone crab and the Atlantic groundfish fisheries. In the stone crab fishery total catches, in terms of total number of crabs, does not effect future yield to the same degree that total catch effects future yield in the groundfish fishery. The reason is that survival of discarded crabs is beleived to be very high and therefore fishing mortality is sufficiently low to be of almost no consequence. That is, in the stone crab fishery OY has no influence on fishing mortality. While in the Atlantic groundfish fishery, fishing mortality is very high and OY has been used to indirectly limit fishing mortality by limiting catch.

The relationship of the value of OY to the value of MSY varies according to the fishery and the economic and sociological factors influencing that fishery at that point in time. For example, OY may be zero for critical or endangered species, equal to maximum economic yield (usually below MSY), equal to MSY in fisheries where protein production is paramount, or may be occasionally above MSY when conditions demand it. The nature of OY for a recreational fishery will likely be different than OY for a commercial fishery directed at the same stock. In this case, OY for an exclusively recreational fishery may be substantially less than MSY where, provided effort is not excessive, lower total landings will mean the stock will contain more and larger fish than the same stock held at MSY.

Atlantic groundfish provide an example of how a figure for OY is reached. In the years prior to 1977 total catch for cod had been below MSY but total effort had been higher than that necessary to acheive MSY for cod. This meant that the stock size for cod was below that size which corresponds to MSY. Therefore it was recommended that total commercial catch of cod be limited to 18,200 metric tons (MT) to allow the stocks to rebuild. However, the industry asserted that they would incur large negative economic impacts if cod landings were limited to 18,200 MT. Therefore a compromise figure of 25,000 MT was eventually reached. Including the 12,300 MT expected recreational cod catch, OY for 1977 was set at 37,300 MT while MSY was 60,000 MT.[64]

Resource assesment data for yellowtail flounder indicated that the Georges Bank stock was below the level which corresponds to MSY and that the level of the Southern New England stock was declining.[65] This information suggested that harvest from both stocks should be strictly limited to allow for a build-up of the spawning population. However a potential for economic hardship as a result of the proposed strict catch limits was shown by participants in the fishery. Consequently, OY was set at 10,000 MT for Georges Bank and 4,000 MT (by-catch only) for Southern New England in 1977 while total MSY was 39,000 MT.[66]

In the years up to and including 1977, the New England haddock stocks were severely depleted. It was determined that removals should be kept to a minimum. Therefore OY was set at 6,200 MT (by-catch only) while MSY was 47,000 MT in 1977.[67]

What is conclusive from this discussion of OY is that OY as defined in the MFCMA can be both an objective and a method of fisheries management. As an objective OY must be established prior to the fishing period and OY must be rigid to be of value. As a means for accomplishing a management objective OY may be more flexible. Adjustments in OY may need to be made throughout the fishing period to enhance the probability of attaining the management goal. In either case, since OY is based upon MSY, OY must have an assigned value. Without an assigned value it becomes difficult to assess the condition of the fishery relative to anticipated continuous yield. The exception to this would be the use of a cut-off point, such as MSY, but this would run counter to the first national standard (MFCMA) which states:

> "Conservation and management measures shall prevent overfishing while achieving on a continuous basis, the optimum yield from each fishery."[68]

In the Interim Plan, OY cannot be a goal since in a quantitative sense, it is overly flexible. As a management method this definition of OY relates only to the Interim Plan objective of acquiring accurate data from the industry. It is expected that the industry will view the descriptive definition of OY as an effort by government to relax regulation and control of the fishery. It is further expected that the regulatory concessions will be viewed by fishermen as an incentive to cooperate with the New England Council by providing accurate data. However, reduction of regulation and control can be effectively accomplished without compromising the management methods.

From the preceeding analysis it is clear that OY as defined in the Interim Plan is not consistent with either the intent or the language of the MFCMA definition of OY. The primary reasons are that the Interim Plan definition lacks a specific value that is clear to all concerned and it transcends its functional use by allocating all of the expected catch to U.S. fishermen.

The New England Council's rationale for using a descriptive rather than analytical OY may provide insight into the implications this definition of OY will have. The original OY of the 1977 groundfish plan had been amended upward several times. The reasons for the changes vary but common ones were improvement of the resource and pressure from industry. Even though OY was increased, it was continually exceeded under the original groundfish plan.

Specification of OY is characteristically a long and arduous process for many fisheries. Public hearings where comments on specifications of OY are heard have occasionally been confrontational. Typically at odds are the industry who see regulations restricting their practices and perhaps affecting their profits and NMFS who supply information on relevant ecological factors. It is the Council's obligation to strike a balance between avoiding over-regulation, protecting the resource and enhancing cooperation and data collection.[69]

According to the Interim Plan there were no ecological factors which would modify MSY one way or another to produce OY.[70] The lack of industry cooperation with the management scheme represented the major input for MSY modification to OY. Faced with the prospect of continuing difficulty in achieving OY, the Council circumvented the problem by using a descriptive OY. Considering the lack of control over the fishery evinced by the New England Council the definition of OY employed in the Interim Plan was clever. It greatly simplifies the task of specifying OY and assures that OY will be continuously met.

Although it is difficult to precisely define overfishing, for convenience overfishing may be thought of as occurring when landings exceed OY. Because the Interim Plan lacks a value for OY it also lacks a precise definition of overfishing. This absence will make it difficult to stop overfishing in a timely manner since it will take time for the Council to agree that overfishing is occurring, agree on what action to take, and implement their recommendations. This is particularily relevant for the Interim Plan which lacks a built-in contingency scheme and where fishing capacity has been underestimated.

In addressing compliance to the first national standard, the Interim Plan maintains that limiting harvest to U.S. fishermen will prevent overfishing.[71] The result of allocating all of the catch to U.S. fishermen will be to simply prevent foreign participation in the fishery. Optimum yield as defined in the Interim Plan does not address overfishing unless the fleet capacity is well below that capable of harvesting MSY. As it turns out, U.S. vessels have harvested at or above MSY for the past few years.[72]

In combination with other management techniques employed in the plan (mesh size, minimum size, spawning closure), the Council expects that OY may help reduce the risk of recruitment overfishing. However reducing the risk of overfishing is not strictly coincident with the MFCMA requirement to "prevent overfishing".[73] There is no assurance that overfishing on one or more of the three species under consideration will not occur. Additionally, growth overfishing may not be adequately addressed.

There are currently two bills in Congress which propose changes to the MFCMA. The intent of the changes is to promote U.S. fisheries.[74] The changes relevant to this discussion will facilitate elimination of total allowable levels of foreign fishing (TALFF's) by equating domestic annual harvest (DAH) to OY. If this amendment is passed, the Interim Plan OY will gain a more secure legal basis. However, in practice DAH has been assigned a numerical value, usually weight in tons, that is specified prior to the fishing period. While the Interim Plan OY eliminates foreign fishing and equates DAH to OY it fails to establish a value for OY and consequently fails to meet the conservation and management requirements of the MFCMA.

It is clear that advantages and disadvantages for the use of a non-numerical descriptive OY exist. For example, the use of a descriptive OY may enhance rapport between fishermen and fish managers and thereby aid in achieving plan objectives. In addition, a descriptive OY facilitates administration of the management plan by simplifiying the annual specification of OY and eliminating foreign fishing. However, plan administration may become more complex in the event of overfishing. Because the descriptive OY of the Interim Plan does not prevent overfishing its conservation argument is weak. While the present legal basis for the use of a descriptive OY is tenuous, this situation may soon change. Finally, although the arguments for the use of a descriptive OY are valid, the OY defined in the Interim Plan is not adequate for groundfish. Unless a more satisfactory descriptive OY can be developed, strict use of OY as defined in the MFCMA should be adhered to.

DISCUSSION

The previous sections have shown that on an individual basis the management methods specified in the IFMP may not provide protection for the resources. While this is not a specific goal of the IFMP it is an obligation of the New England Council. Raising the minimum mesh size should have a positive effect on the fishery particularly if the regulations are embraced by fishermen. A larger minimum mesh size could reduce mortality on juvenile groundfish provided fishing effort does not increase significantly. However, mesh size regulations of 5 1/8 inches the first year and 5 1/2 inches thereafter are significantly below that which the size at maturity data suggest are appropriate for cod, haddock and yellowtail flounder. The expected increase in yield from the increase in spawning stock size due to the change in mesh size will be smaller than that predicted in the IFMP. Furthermore, any benefits from increased size at first capture will be diminished by increasing fishing effort over which management exercises little control.

The minimum sizes will contribute to the management scheme only if fishermen adopt mesh sizes of 5 1/8 inches or larger and avoid concentrations of small groundfish. Otherwise undersized groundfish will be caught at rates comparable to pre-IFMP rates and discarding will reduce the positive effects of the management method. The minimum size regulation does clarify the discard issue. Under the original groundfish FMP possession of large quantities of undersized haddock could lead to a fine. Later, when discards were heavy but data on the practice unavailable, discarding was restricted, placing fishermen in the situation where it was illegal to discard or land undersized fish.

The haddock spawning closure reduces fishing mortality on those groundfish in the two haddock spawning areas during the March through May spawning season. However, fishing effort is limited only by the fleet size during the other nine months of the year. As the fleet expands and technology advances, fishing mortality will increase during those nine months to compensate for the annual spawning closure hiatus. The connection between a haddock spawning closure and increased future recruitment is an elusive one at average spawning stock sizes. There is no evidence in the IFMP that the connection will be realized in the groundfish fishery. However as a means of limiting fishing mortality in the short-term, the closure is advisable.

Three scenarios are developed pertaining to the effects the IFMP will have on the resource.

First Scenario: The management methods of IFMP will positively impact the resource and increase annual yield for each stock. The IFMP maintains that long-term yield will increase as a result of the increase in mesh size. If the IFMP is correct in this anticipation the increased yield will attract additional effort to enter the fishery. The resultant increase in fishing mortality will tend to reduce any benefits to individual fishermen, in terms of catch-per-effort, to pre-IFMP levels.

Second Scenario: The management methods of the IFMP will negatively impact the resource and annual yield from each stock will decrease. There is potential for overfishing and damage to the groundfish stocks under the IFMP. The fact that the New England Council has stated that overfishing should not occur during the first three years after implementation of the IFMP,[75] leads one to expect overfishing to occur soon after the third year. The Council established a goal of reducing the risk of overfishing but not necessarily removing the risk altogether.

Under either of these two scenarios the IFMP produces a pendulum effect in fishery management needs. Under the original FMP, regulations were very restrictive and resisted by fishermen. The IFMP proposes non-restrictive management which could lead to deterioration of the resource prompting a return to stricter regulation of fishing activities in the future. The New England Council envisions the IFMP to be in effect for only a few years, perhaps three. They expect no major changes in the fishery during that period but if significant problems do occur the IFMP can be amended to respond to those changes. This would be a return to the "band-aid" approach to management used by the New England Council during the original FMP years. The "band-aid" approach would simply fuel the pendulum effect created by the IFMP.

Third Scenario: Factors affecting the fishery allow little or no change in resource levels over the next several years. The New England Council contends that previous management regimes have so distorted normal fishing patterns that the only way to gain accurate information on how the fishery is conducted is to assume a laissez-faire posture. It is implicit in the IFMP that the New England Council is hoping for this third scenario. In this scenario no major change in resource levels or fishing activity occurs and a sound fishery data base is developed. This data base will be heavily relied upon to construct a more affirmative fishery management plan, the Atlantic Demersal Finfish Plan (ADF), in the future. One could argue then that the IFMP is actually an experiment in resource management. The experimental design of the IFMP is to affect as little change as possible in the subject while extracting as much information as possible from it. In the extreme, the IFMP may be a classical naturalistic approach to fishery management.

There may be a problem created by the laissez-faire management approach. While development of management plans is left to the Councils the MFCMA implies that management is an active process.[76] Fishery management involves the manipulation of biota, habitat use and users of the resource to bring about desired effects or results. Hence, a laissez-faire management plan is inconsistant with the type of management described in the MFCMA for fisheries in need of conservation.

The IFMP is not all bad. It contains sufficient needed changes from the original FMP to be approved by the Secretary of Commerce. In addition, the management strategy pursued in the IFMP may present the best alternative. Of the four management strategies considered by the New England Council, effort control appears to be a reasonable alternative. Most will agree that there are too many vessels for the potential of the resource. Therefore, limiting the number of vessels, or limiting effort in another way, seems logical. However, in the context of the current New England fishery management environment, effort control is the least logical due to its overwhelming unacceptability.

Whereas the principal objective of the IFMP is to facilitate data collection, it also provides fishermen the opportunity to conduct their operations mostly unobstructed by regulations. The IFMP allows fishermen to fish as they see fit without becoming criminals. Under a favorable regulatory environment it is anticipated that fishermen will volunteer accurate data. There is no requirement in the IFMP to restrict fishing activities even if the data show that overfishing is imminent. While this is not an incentive to report accurate data, from the fisherman's perspective it is a vast improvement over the previous management regime.

The New England Council actively promoted the IFMP. The IFMP simplifies their task substantially. Fisheries data was allegedly so bad that the Council could not finish the ADF plan. The interim and laissez-faire nature of the

IFMP places the Council in a wait-and-see position. The Council can now get on with other business. The IFMP is in place and, short of a stock collapse, few changes will be needed during the expected interim period. Evidence of this continuity was the general compliance with the law during the past summer when the emergency provisions of the IFMP regulations expired.[77] There were no groundfish regulations between the June 28 expiration date and September 29, the date final regulations went into effect. Even so, no reports of excessive deviation from the IFMP regulations have appeared. This seems to indicate that the design of the IFMP presents a reasonable solution. Nevertheless, the conservation measures of the IFMP could be strengthened.

The predominant flaw in the IFMP argument is that while it facilitates accurate data collection it does not guarantee that an adequate data base will be developed. The IFMP does not specify a data collection program but states that the program will be based on a three-tier data collection system. The first tier is reported landings of all species for all trips by statistical area. These data will be collected from dealer weigh-out logs. The second tier is reported catch and effort by area from fishermen on a voluntary basis. Vessels in the Optional Settlement Program are required to maintain logs and make them available to NMFS. The third tier will come from sampling at sea. The three tier system shows great promise for providing very useful data to fishery managers. However there is still the problem of actually acquiring the data.

A great deal of time and money has been spent on developing a management plan and data collection system that removes the possibility of punitive consequences if incriminating data is provided by fishermen as individuals. Under the IFMP there is no longer reason for fishermen to believe that next years catches will be restricted by regulation if large catches are reported from areas where large catches could damage the stock. The incentives for misreporting are removed but, is there an incentive for fishermen to report accurate data on a voluntary basis?

The competitive advantage that a skipper has is what he carries in his head and in his personal log. The personal log could provide valuable data on the fishery but asking a fisherman to give a copy of his log away is asking him to give away his competitive advantage as a businessman. Even with assurances that the data will be classified so few can use it, most fishermen are reluctant.

Under the voluntary log book system there is the chance that the data collected may be skewed. If, for example, only the highliners provide accurate data on a voluntary basis, fishery statistics will not reflect average trends. The volunteer system is non-random and provides no means of testing for randomness.

What this means is that the IFMP sacrifices short-term conservation with the intention of developing a stronger data base. However there is no assurance that the data collected under the IFMP will be 5% better, 10% better or any better at all. The IFMP provides a relative open season for the fishery without a guarantee of receiving anything in return. A lesson from this is that apparently New England groundfish fishermen and their representatives are better negotiators than the New England Council. However, it may not be a simple matter of negotiating talent. The Council is largely composed of persons whose profession is dependent on fishing. Of the 17 voting members on the New England Council in March, 1981, eight were affiliated with commercial fishing, two with recreational fishing, six with state/federal governments and one listed no affiliation.[78]

From the council's perspective, there is an element of risk involved in the IFMP. There is reason to expect that refinements in the data collection system will be made as the quality of incoming data is found to be below expectations. Over time the data base will improve but it is doubtful that great improvement will occur before the end of the planned two to three year period of the IFMP.

CONCLUSION

From a conservation perspective the IFMP is unsound. The component fishery management methods of the IFMP do little to promote long-term stability in the fishery or in the resource. Stability is used here to mean long-term stabilizing of fishing mortality at intermediate levels of fishing mortality. This kind of stability is very desirable in the groundfish fishery.[79] Granted, the goals of the IFMP do not include long-term stability, there may be a management strategy that does not result in instability in the fishery or the resource.

It is clear that the use of a non-numeric OY in the groundfish fishery is currently inappropriate without a definition of overfishing and a contingency for preventing overfishing. The New England Council intends to develop a "braking mechanism" that would address overfishing and be implemented should overfishing become imminent. However, defining overfishing, developing an efficient method of addressing it and amending that to the IFMP would be a painfully long and potentially disruptive process even under emergency action. Hence the IFMP is not consistent with the national standard in the MFCMA which requires a FMP to "prevent overfishing." The IFMP is less a plan for managing the fishery than a response by the New England Council to the difficulties encountered in managing the fishery.

The idea of establishing limited objectives for the fishery and a relatively simple regulatory scheme is sound but the IFMP is incomplete. Adjustments in the management techniques employed in the IFMP are neccesary to provide more secure conservation for the resource. The long-term requirements of the resource may have been compromised to gain the cooperation of fishermen. Yet there is no guarantee and, perhaps, only a chance that fishermen's cooperation and the specific information sought will be gained. The potential for the IFMP's failure, as measured by its own objectives, is high. Such a negotiated outcome would not be viewed favorably if the New England Council operated in the private sector. The greatest need in the fishery, therefore, is to develop an efficient data collection system.

The IFMP opens the fishery to growth limited only by economic constraints. This in itself is not inherently bad neglecting the fact that the fleet has been harvesting at or above MSY for the three species for the past few years. The fundamental question is, if the fishery responds to the IFMP by expanding effort will the resource have the resilience to absorb increased fishing pressure? Presently, too many factors are directly involved to predict the outcome.

APPENDIX I

THE BIOLOGY OF COD, HADDOCK AND YELLOWTAIL FLOUNDER

The term groundfish collectively refers to a wide variety of bottom living species. The most common of which include various hakes, haddock, pollock, flounders and soles, redfish, cod, scup, butterfish and whiting. As pointed out previously, the three species of principle economic interest are cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and yellowtail flounder (*Limanda ferruginea*).

Cod

Bigelow and Schroeder describe cod as being heavy bodied with a large head and tapering caudal peduncle.[80] See Figure 5. Sizes of commercially harvested cod range from just under 2 pounds for a 17 inch cod to 50 pounds for a 52 inch cod. See Table 2. The largest cod on record was taken off Massachusetts in 1895 and weighed 211 1/4 pounds.[81]

Cod are widely distributed across the continental shelves of most of the North Atlantic. In northern Europe cod are noted for their migratory behavior. However cod off New England are non-migratory aside from involuntary drift by eggs and larvae and movements of concentrations of cod on spawning grounds and in search of food.[82]

Cod are demersal in habit, prefering hard bottom and range in depth from the surface to 250 fathoms. However commercial concentrations are found between 5 and 75 fathoms.[83] Off New England the most productive cod grounds are on eastern Georges Bank, the South Channel region from Cultivator shoals to Cape Cod and on the smaller banks in the western Gulf of Maine.[84]

Cod exhibit very high fecundity. For example, a 40 inch female will produce between 3 and 4 million eggs annually. The spawning season typically peaks from January through April but is not strictly defined. There is significant seasonal variability at different spawning grounds within the region. There is also variation in the time of peak spawning activity from season to season. Concentrations of ripe cod may be found on eastern Georges Bank through the winter months. See Figure 3, area V. During late autumn and early winter ripe cod are abundant on Nantucket Shoals. See Figure 6, area III. The two remaining cod spawning grounds off New England are centered on the 20 fathom line, one in Ipswich Bay and the other spanning from Cape Cod Bay to Massachusetts Bay. See Figure 6, area IV. On these latter two grounds ripe cod gather in late winter and spring. Other small and scattered grounds exsist but the majority of spawning activity and production occurs in these four areas.

Larval and post-larval cod subsist on copepods and other minute crustaceans that are abundant in the upper water column during the summer months. Adult cod are voracious feeders consuming large quantities of molluscs, of haddock spawning off New England. Haddock spawn from February to May with peak activity occurring during March and April.[87] The most productive haddock spawning grounds off North America are on Georges Bank. Haddock spawn over most of Georges Bank but high densities of eggs may be found over eastern Georges Bank and east of Cape Cod.[88] See Figure 2, areas II and I. Spawning occurs primarily between 30 and 70 fathoms and between 36.5° F and 42° F.[89]

Haddock eggs and young are pelagic and drift for the first few months of their existence. This particular adaptation is hypothesized to be a major factor explaining the high variability in haddock spawning success. Prevailing currents tend to move haddock eggs and larvae off the banks and over deep water where they presumably cannot survive. Under exceptional conditions the current patterns break down and the resultant haddock year class may be very large. It is believed that that was the case with the 1963 year class which recruited in 1965. See Table 6, 1965 total haddock landings.

The fry take to the bottom on the offshore banks and only rarely are found inshore. As adults haddock are continually on the move in search of food over the banks and throughout the Gulf of Maine, staying close to the bottom and more or less bounded by the 100 fathom contour.

Yellowtail Flounder

The yellowtail flounder is a small mouthed, right handed flounder which is almost half as broad as it is long.

See Figure 8. The right or upper side is brownish to olive and the blind side is white except for the caudal peduncle which is usually yellowish. An 11 inch yellowtail, one approximately two years old, weighs about one half pound and an 18 inch yellowtail weighs about two pounds. The maximum reported length for yellowtail is 21 3/4 inches which was probably an 11 or 12 year old fish.[90] Few yellowtail are landed that are older than 6 or 7 years.[91]

Yellowtail prefer sandy or sand-mud bottom types and depths between 5 and 60 fathoms.[92] The range of yellowtail flounder extends from Labrador to the Chesapeake Bay. The prime yellowtail grounds are the southern New England grounds from east of Nantucket shoals to Montauk Pt., southeastern Georges Bank and north and east of Cape Cod along the 50 fathom contour.[93] See Figure 9. Bigelow and Schroeder suggest that yellowtail are relatively stationary, even sluggish once they take to the bottom. However, yellowtail may move into shoaler water in the winter and deeper water in the summer to avoid high temperatures.

Yellowtail flounder are reported to spawn all along Georges Bank and southern New England between the 20 and 50 fathom contours with spawning concentrations occurring on Georges Bank, Nantucket shoals and in southern New England.[94] Spawning occurs from March to August with peak activity occurring from April to June depending on the year and location. As with many other species, ripe yellowtail can be found outside of the areas and times listed above. Egg count estimates for yellowtail range from 350,000 eggs to 4.7 million eggs for a large yellowtail.[95]

Yellowtail first take to the bottom when they are about 14 mm in length and reach about 5 inches in their first year. Yellowtail feed chiefly on small crustaceans such as amphipods and shrimp, small molluscs and annelids.[96]

APPENDIX II

THE NEW ENGLAND GROUNDFISH FISHERY

The cod fishery off New England has a long history but much of it is not recorded. Europeans began exploiting cod off New England in the early 1600's.[97] Originally, the gear used to catch cod and other groundfish was the handline. Development of steam and oil burning engines and advances in net technology rapidly changed the fishery. Today, vessels using mobile net gear, primarily otter trawls, land more cod, haddock and yellowtail flounder than all other gear types. Otter trawl vessels accounted for 80.0% of commercial cod landings, 92.7% of commercial haddock landings and 98.4% of commercial yellowtail landings in 1980.[98] See Table 4.

The existence of three major cod groups off the U.S. Atlantic coast has been known for some years. While a link exists between the Georges Bank group and the Southern New England-Middle Atlantic group, the Gulf of Maine group appears to be more isolated.[99] For this reason Atlantic cod have been managed under the MFCMA as two unit stocks: the Gulf of Maine stock (ICNAF area 5Y) and the Georges Bank and South stock (ICNAF areas 5Z and 6).

Gulf of Maine cod landings have remained relatively stable since 1969. See Table 5a. Research vessel surveys indicate that the 1977 through 1980 year classes are average to strong in abundance. Assuming that these year classes will be recruited into the Gulf of Maine fishery through 1983 effort does not increase, Serchuk et al. suggest that annual landings of 12,000 MT can be maintained for the next few years.[100] However, potential yield and total reproductive potential could be enhanced by reducing fishing mortality to Fmax[101] and delaying age at first capture.[102]

Georges Bank and South landings for 1980 were the highest reported since 1969. See Table 5b. Commercial catch per effort indices were the highest since 1965.[103] The relationship between catch per effort and abundance is unclear due to changing fishing practices, specifically an increase in directed fishing and changes resultant from regulations. The relative exploitation rate for cod on Georges Bank in 1980 is double that for 1978 prompting Serchuk et al. to warn that actual fishing mortality is comparable with the high fishing mortality level of 1964-70. High fishing mortality during 1964-70 was partially responsible for the early 1970's cod stock declines.

Research vessel surveys, while inconsistent, indicate that the 1979 and 1980 Georges Bank cod year classes are weak and average respectively, and that stock biomass is high and relatively stable.[104] The occurances of average to strong year classes through most of the late 1970's has contributed to stock stability despite the fact that fishing mortality has exceeded Fmax for several years. It is expected that the strong 1978 year class will sustain the Georges Bank cod fishery until 1983.

In the 1920's a decrease in demand for salt fish and an increase in demand for fresh fish led to greater exploitation of New England haddock. Landings averaged 52,000 MT between 1935 and 1960, increased dramatically in the mid-1960's then declined to very low levels in the early to mid-1970's. Haddock landings have been on the increase since 1976. See Table 6.

Between 1935 and 1960 fishing effort on haddock was relatively constant and catches were made primarily by U.S. vessels. There was a large influx of foreign vessels (particularly Soviet vessels) into the groundfish fishery in the early sixties. In 1965 when the large 1963 year class recruited into the fishery, landings jumped to 150,362 MT. Georges Bank haddock landings have declined from 1966 through 1976 as a result of overexploitation and poor recruitment.[105] Recruitment of the 1975 and 1978 year classes in 1977 and 1980 respectively had greatly contributed to recovery of the stock. However the 1976, 1977 and 1979 year classes were very weak and the 1980 and 1981 were average, causing the fishery to depend on the 1975 year class until 1980 and the 1978 year class until the end of 1982.[106]

The current haddock stock assesment states that stock biomass in 1981 was comparable to the stock biomass of the late sixties.[107] It was pointed out, however, that provided fishing effort remains relatively constant, increases in stock biomass can be expected for the next few years depending upon the size of future year classes and the strength of future recruitment. However recruitment of the

1980 year class is average and 1981 year class is poor indicating that continuing stock delines should be anticipated.[108] Furthermore, if fishing mortality remains at its current level, stock abundance and biomass will decline to levels comparable to the levels of the mid-1970's by the mid-1980's.[109]

Trends in the Gulf of Maine haddock fishery have been generally similar to those of the Georges Bank haddock stock. As with cod, the Gulf of Maine haddock stock is smaller and less productive than the Georges Bank stock. See Table 6. Total haddock landings for the Gulf of Maine region have averaged about 5,000 MT from 1976 through 1980. It appears that 5,000 MT is approximately equivalent to the sustainable yield from that stock.

The 1975 and 1976 year classes supported the Gulf of Maine haddock fishery into 1981. How much longer these year classes will have to support the fishery will depend on fishing effort and the strength of recruitment of the 1980 and subsequent year classes.

Clark et al. report a recent biomass decline in the Gulf of Maine haddock stock and state that the 1978 through 1980 average landings indicate fishing mortality levels in excess of Fmax.[110] This leads one to conclude that the biomass decline was partially caused by overfishing. The New England Council, through the IFMP, fails to make this caveat clear.

Yellowtail flounder were only lightly fished until winter flounder abundance declined in the 1930's.

Yellowtail are thinner in body section and usually bring less per pound, ex-vessel, than other commonly exploited flounders.

Historically, trends in yellowtail landings have fluccuated widely. Peaks in landings occured in 1942 (31,500 MT) and in 1969 (57,500 MT) and landings were at an ebb in the mid-1950's (7,600 MT) and in 1978 (11,300 MT).[111] Preliminary data indicate landings have increased to 15,900 MT in 1979 and 18,300 MT in 1980. See Table 7. Recent stock assesments show only slight improvements in abundance from the low levels of the mid-1970's. In addition, fishing mortality (a relative measure of fishing effort) has exceeded Fmax for the past several years.

For management purposes the yellowtail resources off New England are divided into two management units one east and one west of 69 W longitude. The unit east of 69 W includes the Georges Bank stock and the west unit includes the Gulf of Maine, Cape Cod and Southern New England stocks.

The Southern New England yellowtail flounder stock has experienced chronic low abundance and low biomass both of which are inversely related to fishing mortality. Available fisheries data indicate continued low abundance under the current trends of high mortality and low recruitment. If these trends continue the fishery will become increasingly dependent on incoming recruitment.[112] A similar situation is reflected in the Mid-Atlantic yellowtail fishery.[113]

There have been recent increases in abundance of the Georges Bank yellowtail stock however, absolute abundance remains relatively low.[114] Fishing mortality has substantially exceeded Fmax in recent years suggesting continued low abundance and increasing dependance on incoming recruitment for future catches.

Data from the Cape Cod yellowtail fishery indicates a degree of stability in that fishery. This is interpreted to mean that catches of approximately 2,000 to 3,000 MT, the 1960 to 1976 average, can be sustained at the present rate of exploitation.[115]

The haddock and yellowtail fisheries were primarily domestic fisheries until 1961 when many foreign vessels began fishing off New England. Recruitment of large year classes, particularly haddock, and the influx of foreign effort led to catches that could not be sustained. The maximum reported foreign cod catch was 41,144 MT in 1966, the maximum reported foreign haddock catch was 97,698 MT in 1965 and the maximum reported foreign yellowtail catch was 20.7 MT in 1969. While the validity of the catch figures reported by foreign vessels is tenuous, the numbers do give an indication of the magnitude of foreign effort at that time. Currently, Canada maintains sizable cod and haddock landings but other foreign landings of groundfish are negligable. See Table 8.

Saltwater angling surveys have provided the data used to estimate marine recreational cod and haddock landings from New England and the Mid-Atlantic. See Table 9. Yellowtail flounder are not commonly caught by marine recreational anglers.

The accuracy of the recreational landings estimates has been called into question in view of sampling difficulties and inadequacies of the surveys. It is probable that the 1979 recreational cod catch was underestimated but imprecision in earlier survey results prevents greater accuracy.

The landings are distributed among party boats, rental boats, private boats and shore fishermen and the percent of the total catch taken by each varies from one survey to the next. For this and other reasons the recreational groundfish fishery is difficult and expensive to monitor.

Three significant changes have taken place in the groundfish fishery since 1976. These changes are a large increase in the number of vessels fishing for groundfish, an upward shift in average vessel size and an increase in directed effort on cod, haddock and yellowtail.

The New England groundfish fleet declined by 56 vessels from 1960 to 1970. The total number of fixed and mobile gear vessels fishing for cod, haddock and yellowtail increased 6.7% from 1970 to 1975 and 54% from 1976 to 1979 bringing the total to 988 in 1979. See Table 10. From 1976 to 1979 the number of mobile gear vessels, mostly otter trawlers, increased 45.6% and the number of fixed gear vessels, mostly bottom gillnetters, increased 146%. The increased use of passive gear is most likely a result of high fuel costs. Technological developments such as automated longline systems may contribute to a continuing trend towards increasing use of passive groundfishing gear.

No data are available but it is believed that the rapid growth in the groundfish fleet has leveled off since 1979. The reason for this leveling off is the less than spectacular return on investment of new trawlers in the late 1970's and high interest rates. There is a presumption that the poor condition of the economy is having beneficial effects on the groundfish resources by making it very difficult for new vessels to enter the fishery thereby keeping total fishing effort down.

The average size of vessels fishing for cod, haddock and yellowtail flounder has shifted upward since the implementation of the MFCMA. From 1970 to 1975 the number of 5-60 Gross Registered Tons (GRT) class vessels decreased 0.6%, the number of 61-125 GRT class vessels increased 5.9% and the 125+ GRT class vessels increased 14.5% in number. See Table 11. From 1976 to 1979 the number of 5-60 GRT class vessels increased by 29.4%, the number of 61-125 GRT vessels increased by 31.6% and the number of 125+ GRT vessels increased by 143.2%. This dramatic increase in the number of large trawlers reflects the higher profitability of a large vessel. The larger vessels are less restrained by the weather, carry larger and more powerful gear and can therefore expend more effort per year than smaller vessels. Whether this trend to larger vessels <u>vis-a-vis</u> higher fuel costs and the capacity of New England fisheries for absorbing additional effort will continue is difficult to forcast.

Data on the number of days fished for cod, haddock and yellowtail suggests an increase in effort directed at those species. See Table 12. The percent increase in the number of days fished for cod, haddock and yellowtail from 1976 to 1979 was 44.7% for fixed and mobile gear vessels. As should be expected the greatest percent increase in the number of days fished for a vessel class between 1976 and 1979 was 95.6% for the 125+ GRT class.

Data in Table 13 show no significant changes in the number of directed trips, directed effort or directed landings for cod only. This may mean that the increase in directed effort fell primarily on either haddock or yellowtail, on both haddock and yellowtail or that directed effort is poorly defined.

Directed effort implies a conscious decision by the captain of the vessel to fish for a particular species. However, a directed effort trip for species A is one where at least 50% of the landings from that trip are species A. A directed effort trip is identified when the vessel returns from the trip not prior to the trip. Whether effort is really directed is hard to say in terms of landings alone. It is not uncommon to go out after haddock and return with cod for example. Nevertheless, while changes in directed effort are difficult to quantify, the increase in the number of vessels fishing for groundfish and the annual increase in the value of groundfish landings intuitively indicate increases in directed effort for groundfish.

The combined effect of more and larger vessels directing a greater percentage of their effort on haddock, yellowtail and perhaps cod is to increase total fishing effort and increase the dependency of the groundfish fleet on cod, haddock and yellowtail. This blend of effects is precarious and can become economically hazardous in the event of stock declines.

Table 14 gives the major New England ports and their relative importance in terms of groundfish landings. The Mid-Atlantic, primarily New York and New Jersey, has accounted for 500 MT to 1200 MT of groundfish, primarily cod and yellowtail, since 1976. See Table 15.

Domestic groundfish landings are marketed as fresh fish. New England processors and distributers of frozen groundfish rely on fish blocks imported from Canada and Iceland.[116]

Table 1

Mesh Size and Calculated 50% Retention Lengths

Mesh Size (inches)	50% Retention Lengths (inches)		
	Cod	Haddock	Yellowtail
4.00	13.5	12.9	8.7
4.50	15.2	14.5	9.8
4.75	16.1	15.3	10.4
5.00	16.9	16.2	10.9
5.125	17.3	16.6	11.2
5.25	17.7	17.0	11.4
5.50	18.6	17.8	12.0
5.75	19.4	18.6	12.5
6.00	20.3	19.4	13.1
6.25	21.1	20.2	13.6
6.50	22.0	21.0	14.2

Source: "Mesh Selectivity," NEFMC.

Selection factors used; cod 3.38, haddock 3.23, yellowtail 2.18.

Table 2

Age-Length-Weight Relationship for Atlantic Cod

Age (years)	Length[a] (inches)	Weight (pounds) female	Weight (pounds) male
1	7-8		
2	14-17		
3	19-22	2.3-4	
4	23-26	4.5-7	4-8
5	27-32	7.0-10	7-11
6	30-36	7.5-17.5	7-17
7	33-39	13-22	13-21
8	45	32-40	29-40
9	49	31-51	

Source: Estimated from Bigelow and Schroeder _Fishes of the Gulf of Maine_ pp.183 and 189.

[a] Length varies with location, cod grow more slowly in cooler waters.

Table 3

Age-Length-Weight Relationship for Northwest Atlantic Haddock

Age (years)	Length[a] (inches)	Weight (pounds)	
		female	male
2	12		
3	18		
4	20		
5	22		
6	23.5	6	5
7	25	7	6
8	25.5	7	6.5
	28-33	7-15	7-14

Source: Estimated from data in Bigelow and Schroeder *Fishes of the Gulf of Maine*, pp. 201 and 203.

[a] Length varies with location, haddock grow more slowly in cooler waters.

Table 4

1980 New England Groundfish Landings (in metric tons) by Vessel Class and Major Gear Type

		Mobile Gear		Fixed Gear	
		Total Landings	% of Total	Total Landings	% of Total
	5-60GRT	7,155.9	13.9	2,848.1	5.6
Cod	61-125GRT	11,729.5	22.8	-	-
	125+GRT	22,324.2	43.3	-	-
	Total	41,209.6	80.0	2,848.1	5.6
	5-60GRT	1,803.4	7.6	1,237.9	5.2
Haddock	61-125GRT	6,198.5	26.1	-	-
	125+GRT	13,977.5	59.0	-	-
	Total	21,979.4	92.7	1,237.9	5.2
	5-60GRT	4.848.4	29.1	15.3	0.1
Yellowtail	61-125GRT	6,568.5	34.8	-	-
	125+GRT	6,496.1	34.5	-	-
	Total	17,913.0	98.4	15.3	0.1

Source: IFMP.

Note: Undertonnage vessels landed 14.5% of total cod landings, 2.1% of total haddock landings and 1.6% of total yellowtail landings.

Table 5a

Cod Landings from the Gulf of Maine (in metric tons)

Year	USA	Foreign	Total Commerc.	USA Recreat.	Grand Total
1960	3,448	129	3,577	2,621[a]	6,198
1961	3,216	18	3,234	2,444	5,678
1962	2,989	83	3,072	2,272	5,344
1963	2,595	136	2,731	1,713	4,444
1964	3,226	25	3,251	2,129	5,380
1965	3,780	148	3,928	2,537[a]	6,465
1966	4,008	384	4,392	2,645	7,037
1967	5,676	297	5,973	3,746	9,719
1968	6,360	61	6,421	2,417	8,838
1969	8,157	327	8,484	3,100	11,384
1970	7,812	449	8,261	3,046[a]	11,307
1971	7,380	282	7,662	2,804	10,466
1972	6,776	141	6,917	2,575	9,492
1973	6,069	77	6,146	1,821	7,967
1974	7,639	125	7,764	2,313[a]	10,077
1975	8,903	112	9,015	2,671	11,686
1976	10,172	16	10,188	2,963	13,151
1977	12,426	106	12,532	-	12,532
1978	12,426	384	12,810	-	12,810
1979	11,679	379	12,058	-	12,058
1980	13,528	161	13,689	-	13,689
1981	12,534	599	13,133	-	13,133

Source: NMFS, Northeast Fisheries Center, Lab. Ref. Doc. 81-06 and 82-33.

[a] From Angler Surveys, remaining years estimated.

Table 5b

Cod Landings from Georges Bank and South
(in metric tons)

Year	USA	Foreign	Total Commerc.	USA Recreat.	Grand Total
1960	10,843	19	10,853	11,395[a]	22,248
1961	14,453	278	14,731	14,838	29,569
1962	15,637	7,849	23,486	16,146	39,632
1963	14,139	13,050	27,189	13,487	40,676
1964	12,325	12,840	25,165	11,955	37,120
1965	11,410	26,903	38,333	11,029[a]	49,362
1966	11,990	41,144	53,134	11,440	64,574
1967	13,157	23,595	36,752	12,360	49,112
1968	15,279	27,857	43,136	13,620	56,756
1969	16,782	21,157	37,939	14,884	52,823
1970	14,899	10,753	25,652	13,246[a]	38,898
1971	16,178	12,002	28,179	14,393	42,572
1972	13,406	11,653	25,059	11,957	37,016
1973	16,202	12,721	28,923	8,922	37,845
1974	18,377	8,954	27,331	10,055[a]	37,368
1975	16,017	8,991	25,008	8,534	33,542
1976	14,906	5,020	19,926	8,115	28,041
1977	21,138	6,229	27,367	-	27,367
1978	26,579	8,904	35,483	-	35,483
1979	32,645	6,011	38,656	-	38,656
1980	40,053	8,094	48,147	-	48,147
1981	33,849	8,508	42,357	-	42,357

Source: NMFS,Northeast Fisheries Center, Lab. Ref. Doc. 81-06 and 82-33.

[a] From Angler Surveys, remaining years estimated.

Table 6

Commercial Haddock Landings from New England (in metric tons)

	Georges Bank			Gulf of Maine		
Year	USA	Foreign	Total	USA	Foreign	Total
1960	40,800	77	40,877	4,541	383	4,924
1961	46,348	266	46,650	5,297	112	5,409
1962	49,409	4,595	54,004	5,003	107	5,110
1963	44,150	10,696	54,846	4,742	47	4,789
1964	46,512	17,574	64,086	5,383	70	5,453
1965	52,823	97,539	150,362	4,204	159	4,363
1966	52,919	68,356	121,274	4,579	1,125	5,704
1967	34,728	16,741	51,469	4,907	589	5,496
1968	25,469	15,454	40,923	3,437	120	3,557
1969	16,456	5,796	22,252	2,423	290	2,713
1970	8,415	2,885	11,300	1,457	105	1,562
1971	7,306	3,556	10,862	1,194	112	1,306
1972	3,869	1,864	5,733	909	27	936
1973	2,777	2,554	5,331	509	49	558
1974	2,396	1,894	4,290	622	207	829
1975	3,989	1,421	5,420	1,180	83	1,263
1976	2,904	1,365	4,324	1,865	91	1,956
1977	7,934	2,909	10,843	3,296	26	3,322
1978	12,160	10,179	22,339	4,538	641	5,179
1979	14,279	5,182	19,461	4,266	257	4,879
1980	17,470	10,101	27,571	7,270	203	7,473
1981	18,891	5,665	24,556	5,987	514	6,501

Source: NMFS, Northeast Fisheries Center, Lab. Ref. Doc. 81-05 and 82-32.

Table 7

Yellowtail Flounder Catch (in metric tons) from Southern New England, Georges Bank, Cape Cod, Mid-Atlantic and the Gulf of Maine

Year	Food Landings	Discard[a]	Indust.	Foreign	Total
1960	13,700	5,200	500	-	19,400
1961	17,600	6,800	700	-	25,100
1962	22,700	8,600	200	-	31,500
1963	36,600	12,000	300	300	49,200
1964	37,500	15,000	500	-	53,000
1965	36,200	11,900	1,000	2,200	51,300
1966	30,400	7,700	2,700	1,000	41,800
1967	26,000	14,000	4,500	4,200	48,700
1968	32,000	10,500	3,900	5,300	51,700
1969	32,600	5,300	4,200	20,700	62,800
1970	34,000	10,600	2,100	2,900	49,600
1971	28,800	7,100	400	1,800	38,000
1972	32,800	3,200	300	5,300	41,600
1973	29,800	900	300	700	31,800
1974	25,100	2,100	<100	1,100	28,300
1975	19,900	1,200	<100	100	21,200
1976	17,200	1,000	<100	<100	18,200
1977	16,500	200	<100	<100	16,900
1978	11,300	1,200	<100	<100	12,500
1979	15,900	1,700	<100	<100	17,700
1980	18,300	1,900	<100	<100	20,200

Source: NMFS, Northeast Fisheries Center, Lab. Ref. Doc. 81-10.

[a] estimated.

Table 8

Recent Foreign Harvests of Atlantic Groundfish
(in metric tons)

	Cod		Haddock		Yellowtail
Year	Canada	Other	Canada	Other	Total
1976	2,344	2,692	1,452	-	200
1977	6,279	56	2,935	-	200
1978	9,288	-	10,820	-	100
1979	6,390	-	5,439	-	100
1980	8,255	-	10,304	-	100
1981	9,107	-	6,176	3	NA

Source: NMFS, Northeast Fisheries Center, Lab. Res. Docs. 81-05 and 81-06, and IFMP.

Table 9

Marine Recreational Groundfish Catch Estimates (in metric tons)

	Cod		Haddock	
Year	Weight	% of Total Landed Weight	Weight	% of Total Landed Weight
1960	14,016	49.3	767	1.7
1965	13,565	24.3	9,702	6.3
1970	16,292	32.5	1,147	8.9
1974	12,368	26.1	NA	NA
1979	3,857	7.6	406	1.7

Source: IFMP.

Table 10

Number of Vessels (greater than 5 GRT) by Gear, Fishing for Cod, Haddock or Yellowtail Flounder

Year	Fixed Gear	Mobile Gear	Fixed and Mobile Gear[a]
1970	23	551	568
1971	27	558	577
1972	39	565	589
1973	63	576	615
1974	47	571	604
1975	56	569	606
1976	69	592	641
1977	81	619	682
1978	109	688	772
1979	170	862	988

Source: Wang and Goodreau, NEFMC Res. Doc. 81 GF 1.1.

[a] Fixed and Mobile Gear above does not double count vessels using both types of gear and is therefore less than the grand total.

Table 11

Number of Mobile Gear Vessels, by Class, Fishing for Cod, Haddock or Yellowtail Flounder

	Mobile Gear		
Year	5-60GRT	61-125GRT	125+GRT
1970	313	169	69
1971	317	168	73
1972	317	175	73
1973	329	175	72
1974	312	181	78
1975	311	179	79
1976	337	174	81
1977	332	188	99
1978	377	199	112
1979	436	229	197

Source: Wang and Goodreau, NEFMC Res. Doc. 81 GF 1.1.

Table 12

Number of Days Fished for Cod, Haddock and Yellowtail Flounder by Gear Type and Vessel Class[a]

Year	Mobile Gear	Fixed Gear	Fixed and Mobile Gear
1970	23,992.6	928.0	24,920.6
1971	23,268.7	982.5	24,251.2
1972	23,196.4	1,459.3	24,655.7
1973	21,409.0	1,799.9	23,208.9
1974	23,138.6	1,981.8	25,120.4
1975	24,534.1	2,158.3	26,692.4
1976	22,656.2	2,787.2	25,443.4
1977	23,638.6	4,220.3	27,858.9
1978	25,822.6	4,875.7	30,698.3
1979	30,578.4	5,480.0	36,058.4

	Mobile Gear Vessels		
Year	5-60GRT	61-125GRT	125+GRT
1970	8,440.7	10,806.3	4,745.6
1971	7,730.7	10,945.6	4,592.4
1972	7,888.7	11,561.9	3,745.8
1973	7,224.3	10,649.8	3,534.9
1974	7,363.4	11,398.3	4,376.9
1975	7,742.6	11,712.8	5,078.7
1976	7,276.0	10,218.4	5,161.8
1977	7,498.3	10,290.2	5,850.1
1978	8,811.1	10,118.5	6,893.0
1979	9,421.5	11,058.6	10,098.3

Source: IFMP.

[a] Does not include data on undertonnage vessels.

Table 13

Percentage, by Vessel Class, of Total Trips, Total Effort and Total Landings from the Gulf of Maine Cod Fishery Which Were Directed[a]

	5-50GRT			51-150GRT			151-500GRT		
Year	I	II	III	I	II	III	I	II	III
1965	9.2	6.8	27.9	10.1	7.7	33.1	3.3	0.7	3.0
1966	5.2	3.9	20.0	9.0	9.0	30.1	5.3	4.2	10.8
1967	10.7	8.2	36.6	18.1	21.9	51.3	1.0	0.5	1.3
1968	10.8	5.7	35.6	19.4	17.7	50.9	7.1	8.6	23.0
1969	17.5	9.8	46.8	21.8	19.5	48.1	8.1	11.3	18.9
1970	16.0	8.2	40.8	13.7	9.1	35.8	5.1	3.5	11.9
1971	14.1	9.3	35.4	15.2	8.4	31.3	3.4	5.7	25.1
1972	12.5	6.9	28.3	10.1	5.4	22.0	6.9	4.3	24.1
1973	7.6	4.6	18.8	4.4	2.3	8.2	1.4	0.3	0.7
1974	9.5	7.4	20.4	7.7	6.3	25.1	8.8	8.4	39.6
1975	12.3	7.5	33.7	15.2	12.8	40.0	5.6	3.6	21.3
1976	11.7	8.7	37.8	19.8	14.7	40.6	2.6	1.1	8.3
1977	10.5	8.9	36.4	19.5	13.7	46.8	3.4	1.0	12.8
1078	9.9	8.3	34.1	16.0	11.3	41.2	1.4	0.9	9.8
1979	9.7	6.8	29.9	18.6	11.8	38.9	2.2	0.9	9.7
1980[b]	8.9	5.3	29.1	14.6	8.3	32.8	3.0	2.6	17.9

I: % Trips Directed
II: % Effort Directed
III: % Directed Landings
Source: NMFS, Northeast Fisheries Center, Lab. Ref. Doc. 81-06.

[a] A directed trip is one where cod comprises 50% or more of the total trip landed weight.

[b] January through November.

Table 14

Percent of Total Cod, Haddock and Yellowtail Flounder Landings by Major Port Areas in 1978

Port	Cod	Haddock	Yellowtail
Eastern Maine	0.1	0.0	0.0
Rockland and County	1.0	1.8	0.1
Boothbay Area	1.3	0.6	0.9
Portland and County	3.3	6.4	0.4
York County	0.9	0.3	0.6
Gloucester and County	27.1	36.2	7.3
Boston and County	14.8	20.2	1.7
South Shore	4.3	2.8	10.3
Provincetown	7.1	2.7	15.6
South Cape Cod	1.8	0.7	1.9
New Bedford and County	31.6	25.0	44.1
Newport and County	4.0	3.2	12.1
Narragansett Bay	0.0	0.0	0.0
Pt. Judith and County	2.5	0.0	5.1
Total	100.0	100.0	100.0

Source: IFMP.

Table 15

Mid-Atlantic Landings (in metric tons) of Cod, Haddock and Yellowtail Flounder

Year	Cod	Haddock	Yellowtail
1976	412	4	271
1977	285	3	242
1978	231	0	248
1979	257	34	454
1980	233	64	906

Source: IFMP.

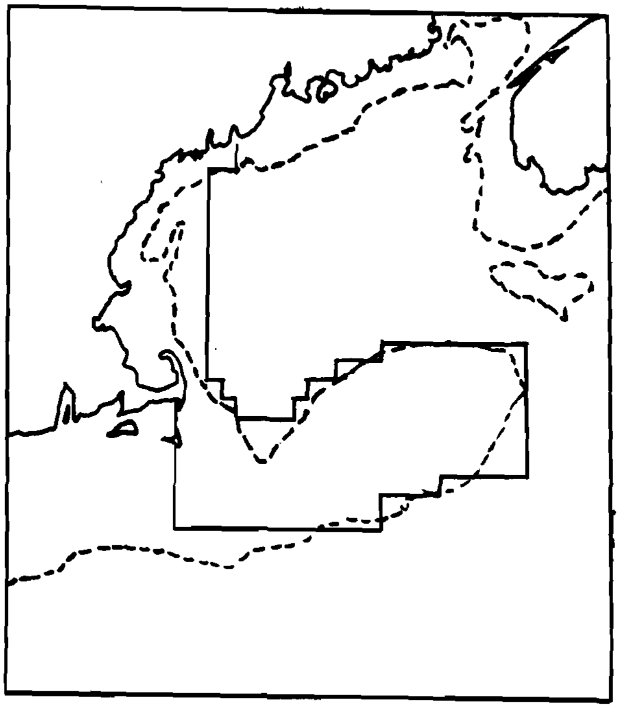

Figure 1

Large Mesh Area of IFMP

The large mesh area is defined by straight lines connecting the following points:

43°40' N	69°40' W	41°50' N	69°40' W
41°50' N	69°30' W	41°40' N	69°30' W
41°40' N	69°20' W	41°30' N	69°20' W
41°40' N	68°40' W	41°40' N	68°30' W
41°50' N	68°30' W	41°50' N	68°10' W
42°00' N	68°10' W	42°00' N	67°40' W
42°10' N	66°40' W	42°10' N	66°00' W
41°00' N	66°00' W	41°00' N	67°00' W
40°50' N	67°00' W	40°50' N	67°40' W
40°30' N	67°40' W	40°30' N	70°00' W

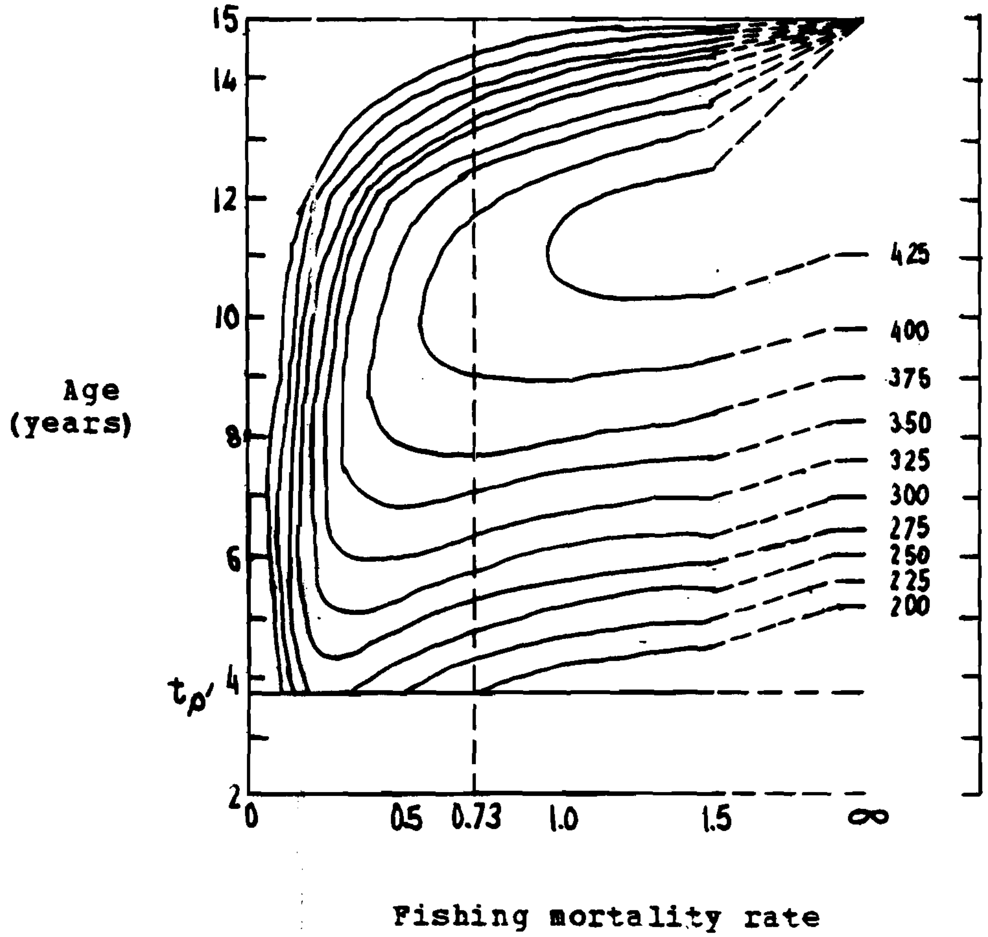

Figure 2

Yield Isopleth for North Sea Plaice

From Cushing. Fisheries Biology. p. 98.

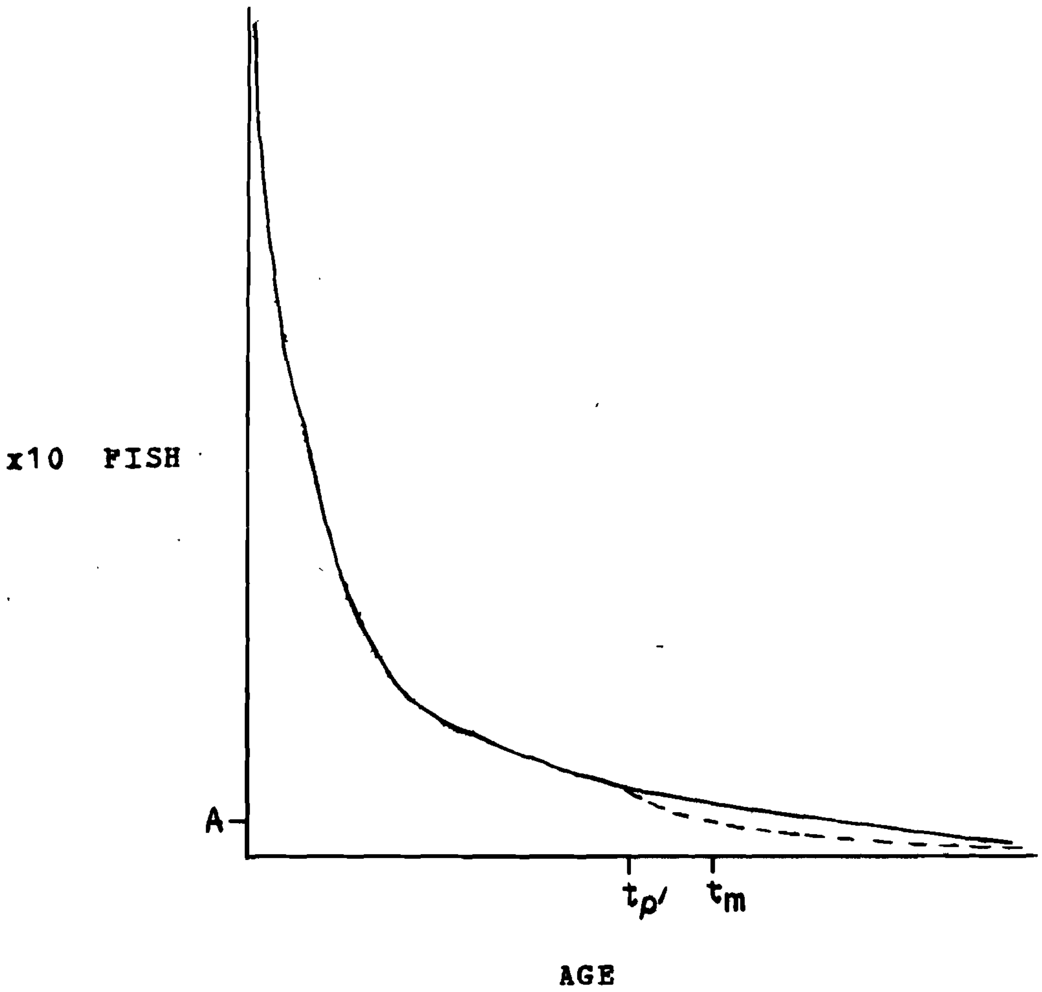

Figure 3

Changes in the Number of Individuals of a Year Class of Fish During Its Life-span.

n=number of individual fish.

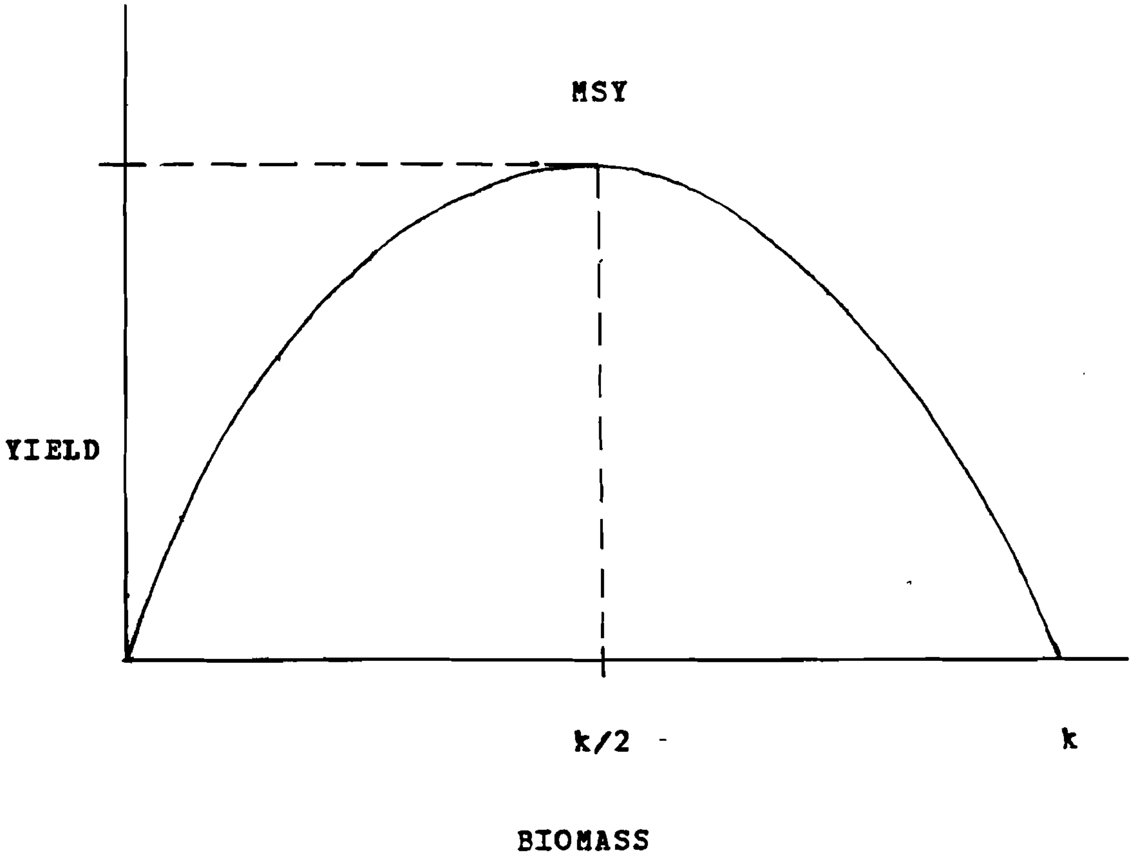

Figure 4

Yield-Biomass Relationship from the Stock Production Model

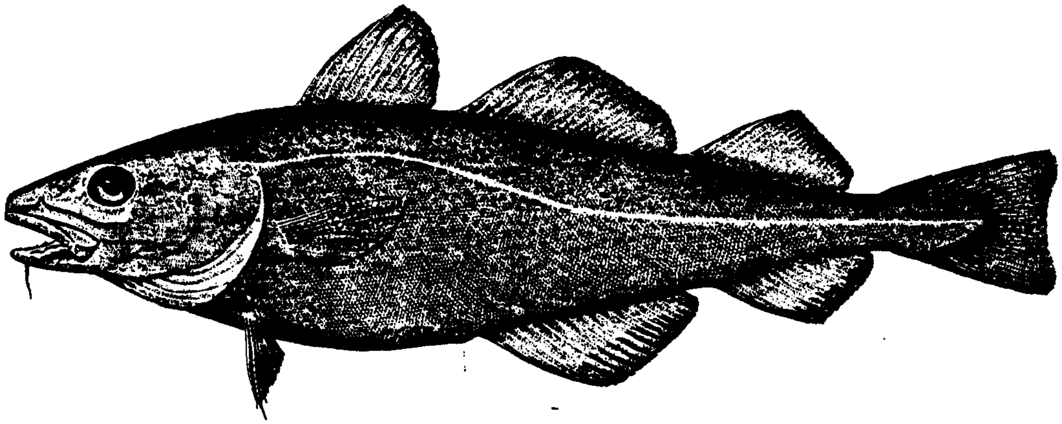

Figure 5

Atlantic Cod (<u>Gadus morhua</u>).

From Bigelow and Schroeder. <u>Fishes of the Gulf of Maine.</u> p. 182.

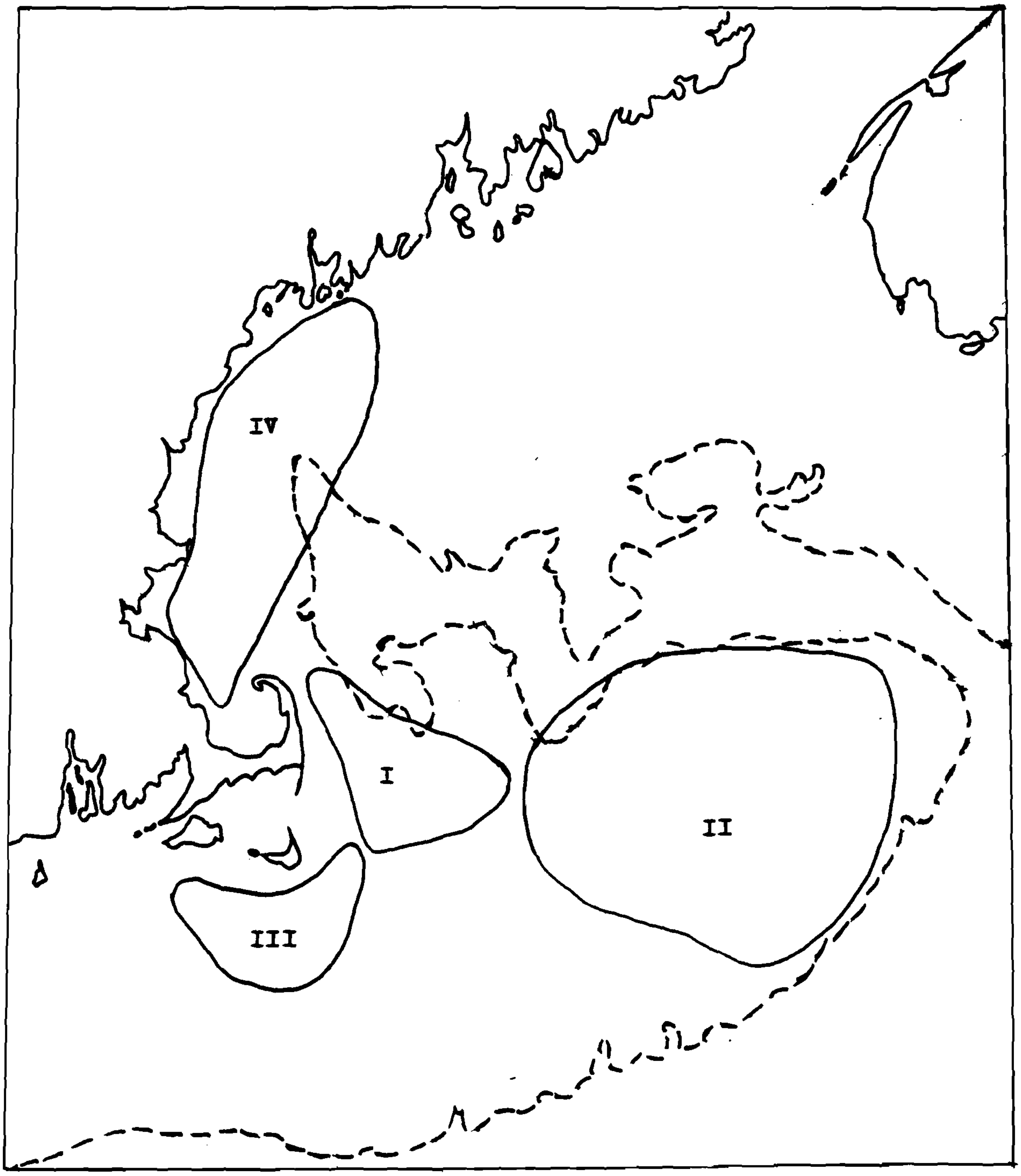

Figure 6

Spawning Areas of Cod, Haddock and Yellowtail Flounder in the Northwest Atlantic

From "Spawning Activity." (mimeographed.)

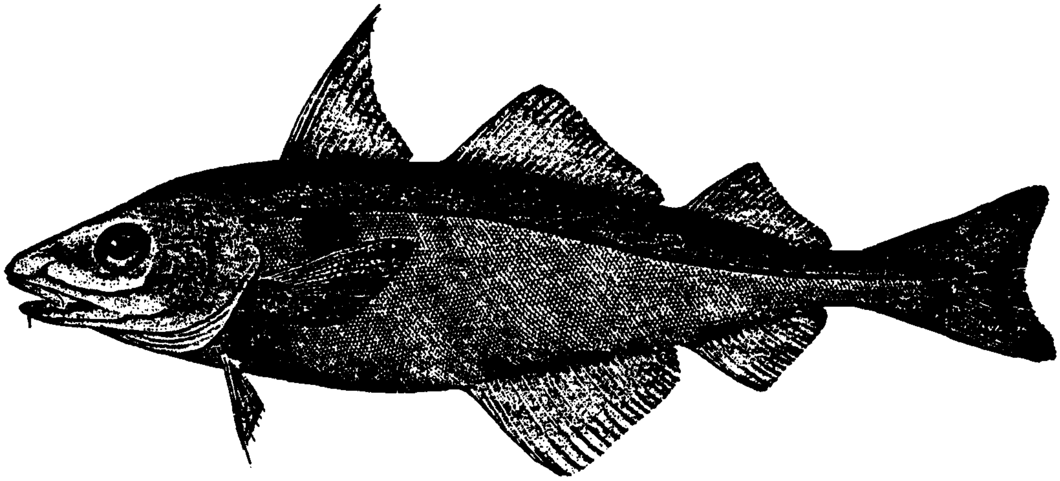

Figure 7

Haddock (*Melanogrammus aegelfinus.*)

From Bigelow and Schroeder. *Fishes of the Gulf of Maine.* p. 199.

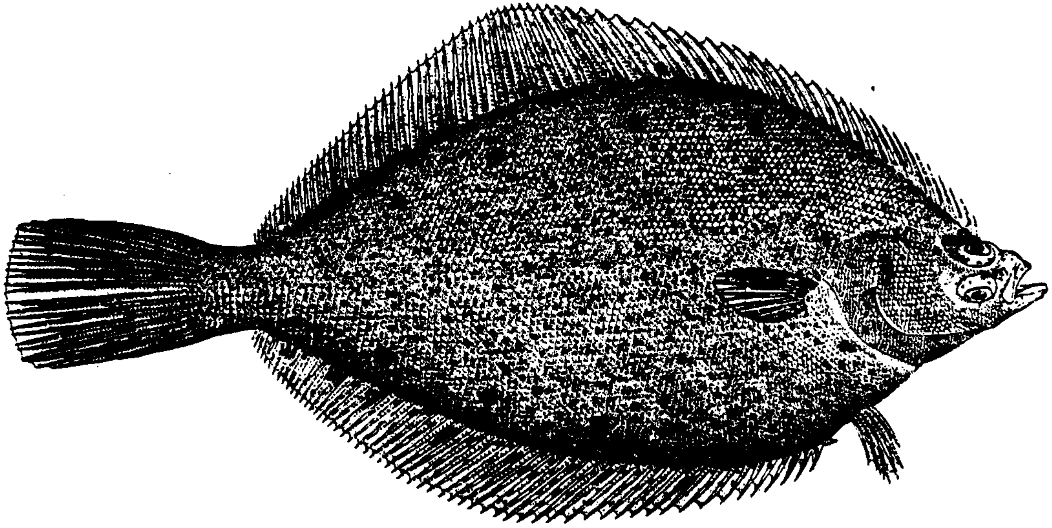

Figure 8

Yellowtail Flounder (Limanda ferruginea.)

From Bigelow and Schroeder. Fishes of the Gulf of Maine. p. 272.

Figure 9

Primary New England Fishing Grounds for Yellowtail Flounder

A: Cape Cod grounds.

B: Georges Bank grounds.

C: Southern New England grounds.

From Gates and Norton. "Benefits of Fisheries Regulation." p. 3.

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[2] *ICNAF Handbook*, (Dartmouth, N.S.: ICNAF, 1965), p. 9.

[3] A.W. Koers, *International Regulation of Marine Fisheries*, (England: Fishing News Books, 1973), p. 94.

[4] ICNAF *Annual Proceedings*, Vol. 20 (Dartmouth, N.S.: ICNAF, 1970), p. 9.

[5] ICNAF *Annual Proceedings*, Vol. 21 (Dartmouth, N.S.: ICNAF, 1971), p. 9.

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[7] Pulse fishing means expending massive fishing effort in one location until catches are diminished to uneconomical levels and then moving into another area.

[8] New England Fishery Management Council, *Fishery Management Plan/Environmental Impact Statement for Atlantic Groundfish* (Peabody: NEFMC, April, 1977), p. 145. (herein called FMP/EIS)

[9] New England Fishery Management Council, *Interim Fishery Management Plan for Atlantic Groundfish* (Saugus: NEFMC, September, 1981), p. 30. (herein called IFMP)

[10] U.S., *Federal Register* 42 FR 13998, (March 14, 1977).

[11] Savings gear includes devices by means which the mesh in any part of a trawl net is obstructed.

[12] S. Peterson and L. J. Smith, "Risk Reduction in Fisheries Management," *Ocean Management*, Vol. 8, June 1982, pp. 65-66.

[13] "Piggy-backing" means catching the trip limits from two different areas, or claiming to have done so, on the same trip.

[14] U.S., *Federal Register* 47 FR 10605, (March 15, 1982).

[15] IFMP, ibid., p. 54.

[16] IFMP, ibid., p. 71.

[17] R. Corey, "New England Groundfish Price Update," *URI Commercial Fisheries Newsletter*, July/August 1982, pp. 7-8.

[18] D.H. Cushing, *Fisheries Biology* (Madison: University of Wisconsin Press, 1968), p. 97.

[19] In this paper, tr is the age at which the fish become available for exploitation and tp' is the age at which they are actually being caught. The difference for Atlantic groundfish is probably quite small.

[20] Ibid., p. 99.

[21] Ibid., p. 98.

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[23] IFMP, ibid., p. 68.

[24] "Mesh Selectivity and its Application for Management of the New England Groundfish Fishery," (Saugus: New England Fishery Management Council), pp. 290-291. (mimeographed.)

[25] Ibid., p. 292.

[26] Ibid.

[27] IFMP, ibid., p. 66.

[28] "Mesh Selectivity," ibid., p. 293.

[29] Ibid.

[30] Ibid., p. 294.

[31] Ibid.

[32] Cohort, as used here, is synonomous with year class.

[33] B.E. Brown, M.P. Sissenwine and M.M. McBride, *Implications of Yellowtail Flounder Stock Assesment Information for Management Strategies*, Laboratory Reference No. 80-21 (Woods Hole: Northeast Fisheries Center), p. 6.

[34] J.A. Gulland, *The Management of Marine Fisheries* (Seattle: University of Washington Press, 1974), p. 134.

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[36] J.M. Gates and V.J. Norton, *The Benefits of Fisheries*

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[40] Ibid.

[41] J.A. Gulland, Manual of Methods for Fish Stock Assesment, Part 1, Fish Population Analysis FAO Fisheries Series No. 3 (Rome: FAO, 1969), pp. 88-89.

[42] "Groundfish Regulations Reinstated After Three Month Gap," Commercial Fisheries News Vol. 10, No. 3, November, 1982, p. 5.

[43] U.S., Federal Register 47 FR 43705, ibid.

[44] The gape of a fish hook is the distance between the point and the shank of the hook; gape size often determines the size of the fish that will be caught.

[45] IFMP, ibid., p. 84.

[46] New England Fishery Management Council, Spawning Activity of Cod, Haddock and Yellowtail Flounder in the Georges Bank-Gulf of Maine Area, (Saugus: NEFMC), p. 1. (mimeographed.)

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[52] Ibid., p. 90.

[53] "Magusun Fishery Conservation and Management Act of 1976," P.L. 94-265 (as ammended by P.L. 95-354 and P.L. 96-61), 94 U.S.C. (April 13, 1976) Sec. 3(18).

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[65] Ibid., p. 22.

[66] Ibid.

[67] Ibid.

[68] MFCMA, ibid., Sec. 301(a)(1).

[69] IFMP, ibid., p. 91.

[70] Ibid., p. 90.

[71] Ibid., p. 100.

[72] Ibid., p. 90.

[73] MFCMA, ibid., Sec. 301(a)(1).

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[75] U.S. Federal Register 47 FR 43705, ibid.

[76] MFCMA, ibid., Sec. 3(2)(A), Sec. 102, Sec. 301(a)(1-7), Sec. 303.

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[89] Ibid., p. 208.

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[101] Fmax is the level of fishing mortality at which the yield from a fish stock is maximized.

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[112] Ibid., p. 20.

[113] IFMP, ibid., p. 8.

[114] Clark, O'Brien and Mayo, ibid., p. 20.

[115] Ibid., p. 21.

[116] FMP/EIS, ibid., p. 46.

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