flexible boundaries. Other area rotation alternatives were considered, but the committee recommended rejecting them before public hearings due to the perceived superiority of the adaptive, flexible boundary approach.

The Council received the committee recommendations and remanded the issue back to committee, with a charge to develop a broader range of management alternatives, addressing a broader range of issues, including measures to minimize impacts on habitat (see EFH discussion below). Essentially restarting the Amendment 10 process, the Council adopted a set of goals and objectives in January 2001 for Amendment 10, charging the Scallop Plan Development Team (PDT) with developing management alternatives for consideration. The PDT developed a 60-page document with a broad range of alternatives (including measures to minimize bycatch and habitat impacts) and area rotation strategies in July 2001, which were later approved by the Oversight Committee and Council for analysis in the Amendment 10 DSEIS.

NMFS published a Notice of Intent (NOI) to prepare a supplemental EIS for the EFH components of the Northeast Multispecies and Atlantic Sea Scallop Fishery Management Plans on February 1, 2001 (66 FR 8568). The public comment period was open until April 4, 2001. NMFS (and/or the Council) solicited public comment to identify a range of alternatives for identifying and describing EFH and HAPCs and requested information on adverse effects of fishing activities on EFH and HAPCs. NMFS (and/or the Council) solicited public comment on appropriate management measures and alternatives to minimize, to the extent practicable, any adverse effects of fishing on EFH. NMFS (and/or the Council) held one public scoping meeting. The meeting occurred in Gloucester, MA on February 22, 2001. A summary of the public comments and primary issues raised during the meetings is in the Scoping Report (Appendix 2).

While developing a broader range of alternatives and following the EFH scoping hearings, it became apparent that more work was needed on the alternatives to minimize habitat impacts. This issue was remanded back to the PDT for more work, in coordination with other PDTs and technical teams, leading to a joint meeting of the Scallop PDT, the Groundfish PDT, and the Habitat Technical Team (HTT) in January 2002. Further communication between the Council's technical teams lead to an approach that the Council adopted in March 2002 and further developed during the rest of 2002. Working with the Council's Habitat Technical Team, several alternatives were developed, including an objective model-based approach whose concept the Council approved for analysis in March 2002. Both model-based and ad hoc closure alternatives were recommended for inclusion and analysis in the DSEIS, which the Council approved in September 2002.

3.4 Definition of Overfishing

Following a two-meeting review by the Council's Scientific and Statistical Committee of the proposed overfishing definition and the status quo overfishing definition, the Committee reached the following conclusions:

1. Under the current overfishing definition policy, while the current closed areas are likely protecting the stock from recruitment overfishing, the stock will not be protected from growth overfishing, that is loss of yield due to excessive fishing mortality rates will occur in the open areas. In particular, closed areas do not justify excessive fishing mortality rates in the open areas. What matters (from a yield per recruit perspective) are the fishing mortality rates in the open areas, not the average fishing mortality (averaged over the open and closed areas).

2. Under the overfishing definition guidelines, we need to define targets and thresholds. The biomass reference points should provide primary protection against recruitment overfishing. The fishing mortality rate reference points should protect against overfishing the stock as well as loss of yield per recruiting scallop (growth overfishing).

3. Permanently closed areas clearly offer a way to help keep the total biomass above minimum biomass thresholds but potentially restrict fishing opportunities. A system of temporarily closed areas (i.e., a system of rotating closures) is likely to enhance fishing opportunities.

4. The proposed overfishing definition developed by the PDT provides an appropriate scheme for addressing area rotation and protects against the loss of yield due to excessive fishing in the open areas. It allows management flexibility both in terms of which areas are opened and the time frame over which the stock is utilized. The committee felt that substantial benefits could be gained from the use of area rotation.

5. The technical details of the overfishing definition and control rule need to be continually evaluated as new information becomes available and new analyses are done concerning issues such as the form of the stock-recruitment relationship and the relationship between yield per recruit based reference points and B_{MSY}.

6. There are some reasonable arguments for moving toward a real time monitoring scheme on an area-by-area basis, but a lot more work needs to be done to take advantage of such a scheme. To do this, real time management is needed in addition to real time assessments.

The DSEIS presented two potential overfishing definitions and evaluated them in a way that provided the Council with a basis to consider a new overfishing definition. The presentation was intended to identify to the Council that its decision to use an area rotation scheme might benefit from the selection of a new overfishing definition designed specifically for area rotation. However, it was not intended to force the Council to select the proposed overfishing definition if management measures selected by the Council, combined with the status quo overfishing definition, could continue to achieve the FMP's objectives and comply with the requirements of the Magnuson-Stevens Act and other applicable laws. Section 3.4 remains unchanged from the DSEIS so that the original choices in front of the Council are not lost. Section 5.1.1 explains the Council's rationale for recommending that the current overfishing definition remains in effect and Section 6.1.1 explains how the management measures proposed in Amendment 10, along with the status quo overfishing definition, would continue to comply with National Standards of the Magnuson-Stevens Act.

3.4.1 Proposed Overfishing Definition

3.4.1.1 Biological reference points and control rule

The biological reference points associated with the overfishing definition control rule are based on F_{max}, the fishing mortality rate that produces maximum yield per recruit, and B_{max}, the average stock biomass that results when fishing is held constant at F_{max}. Current estimates of F_{max} remain unchanged and the fishing mortality target is 80% of F_{max}. Estimates of B_{max} have been updated to include the recruitment (40 – 72 mm observed in the survey from 1982 to 2001.

3.4.1.2 Status determination – overfishing and overfished conditions

For each of the three stocks currently recognized (Gulf of Maine, Georges Bank, Mid-Atlantic Bight) the proposed definition of overfishing will comprise two parts: a biomass criterion that applies to the whole stock as described below, and separate fishing mortality criteria for the complex of areas under area rotation and for the areas under the ordinary management system [excluding long term area closures that are unlikely to contribute to future yield].

1. **The target biomass for the scallop resource is Bmax (the biomass of scallops that would result from fishing at Fmax, a proxy for Fmsy).** The target biomass for an entire stock remains, as before, at B_{msy} proxy and is defined to be the conventional B_{max} per recruit multiplied by the average number of recruits per tow over the entire stock area surveyed by NMFS. (Scallops in the shallow water unsurveyed areas are not included). There is no specific target biomass for the areas under rotation management (either singly or in aggregate). This is because the purpose of biomass targets and thresholds are to insure that reproductive capacity is not seriously reduced and, given the widespread dispersal of larval scallops, this only makes sense when biomass is considered on an appropriately large scale.

2. **The scallop stocks are overfished when the biomass is below 50% of B_{max}, when a formal rebuilding program would be needed to initiate recovery to B_{max}.** Although the control rule below would define overfishing at values below F_{max} when the stock is less than 75% of Bmax, the stock would be defined as being overfished (i.e. the FMP would be out of compliance) in a manner consistent with the National Standard 1 guidelines.

3. **Control rule: Fishing mortality thresholds and targets decrease linearly between zero and Fmax when the biomass is between 25% and 75%** of B_{max}. The control rule modifies the fishing mortality threshold for the stock that defines overfishing as well as the operational limits for rotation management areas. The biomass limit is 25% of B_{target} (i.e., 25% of B_{MSY} proxy). Thus, fishing mortality in an entire stock area should be as close to zero as possible if the biomass falls below 25% of B_{max}.

   Provided that biomass exceeds 75% of B_{target}, the fishing mortality limit for each area under area rotation, is 0 if the area is closed, and for open areas it is that fishing mortality which, when averaged over the fishing mortalities that have occurred in the area since area rotation was declared (or over the past 10 years, whichever is a shorter period of time), will result in an average equal to F_{max} where F_{max} is computed according to the existing method. When biomass for a stock is between 25% Btarget and 75% Btarget, the limit for each area under area rotation is $F = (2B/Btarget - 0.5) F_{limit}$ where F is the limit fishing mortality for the area, B is the stock biomass, and F_{limit} is the fishing mortality that would be the limit fishing mortality if the stock were above 0.75 Btarget. This simply ramps the fishing mortality down linearly as the stock biomass declines. Reducing fishing mortality when the stock is below 75% of B_{max} can be achieved by reducing the area-specific fishing mortality limits (see below) across the board or by temporarily closing more areas than specified by the area rotation rules.

4. Overfishing occurs if the number-weighted fishing mortality averaged over the rotation areas exceeds the threshold fishing mortality. For determining compliance with the overfishing definition, the threshold fishing mortality for the entire complex of areas under area rotation (within a stock) is the average of the fishing mortality limits in the rotation areas computed as a numbers-weighted average. Overfishing does not occur if the fishing mortality in an area under rotation management exceeds the limit fishing mortality for that area provided the average

mortality over all areas under rotation management does not exceed the area-wide threshold.

5. **Area management implementation**: The target fishing mortality in any area under area rotation can be any value not exceeding the area's limit fishing mortality, subject to the restriction that the numbers-weighted average of the target fishing mortalities does not exceed 90% of the threshold fishing mortality.. (However, if the mortality in an area under area rotation exceeds that area's limit, the limit for the next year would be included in the time-averaged mortality limit for the following year.)For the areas not under rotation management, the limit and target fishing mortalities remain as before, i.e., are calculated as if the areas under rotation management were a separate stock

3.4.1.3 Options considered

The PDT reviewed the present overfishing definition and determined that it is clear that the definition is inconsistent with area based management, whether or not it includes area rotation. The present overfishing definition allows for excessive localized overfishing in open fishing areas. This localized overfishing prevents the plan from meeting its maximum yield objectives, whether the closed areas are permanent (i.e. HAPC) or temporary (area rotation). In addition, area rotation introduces variations in fishing effort that need to be taken into account to maximize yield when closed areas re-open to fishing. The three options considered by the Scallop PDT take different approaches on this point. In all cases, the annual day-at-sea allocations would depend on the combined product of the number of open fishing areas, the annual fishing mortality threshold within each area, the expected average catch per day-at-sea (constrained by crew limits), the number of active fishing vessels, and either the general category TAC or the expected landings by vessels fishing under general category rules.

Although the application of the current overfishing definition has problems (i.e. including unexploitable biomass in permanently closed areas to allow overfishing in open areas; the inflexibility to allow fishing mortality to temporarily exceed F_{max} after rotational closures), none of the options for revising the overfishing definition suggest that F_{max} and B_{max}, the current proxies for F_{msy} and B_{msy} respectively, are inappropriate. In addition, the current estimate of F_{max} (F=0.24) and a target F (F=0.2) are also deemed acceptable. The options for redefining overfishing do not suggest that the current B_{max} as a target and proxy for B_{msy} are inappropriate for the scallop stocks as currently defined.

The PDT reviewed all three options presented to it and agreed to recommend proposal one as the most appropriate approach to defining overfishing in a way that is consistent with area based management.

During the discussion, the PDT agreed to use the following six principles to judge the suitability for any overfishing definition developed to be compatible with area based management or rotation:

1. Overfishing definitions **must** be based on **current** fishing mortality, not past events (i.e. mistakes).

2. Area specific TACs can take into account past mortality history (i.e. closures).

3. The reference points and TACs cannot take 'credit' for future, planned management that may not be guaranteed.

4. Zero fishing mortality in permanent closures cannot be considered in spatial averaging for overfishing or status determinations.

5. Long-term average mortality should not exceed F_{max}.

6. Overfishing should be determined for the **stock**, not area by area, on an annual basis.

Considering the above principles, three proposals were developed and presented to the PDT, taking three different approaches to correct the inconsistency with area based management and the proposed area rotation alternatives. They are:

1. Time-averaged fishing morality

A method to determine area-specific fishing mortality thresholds based on past fishing mortality rates and area rotation policies

Fishing mortality in re-opened areas depends on the number of years when an area is closed to fishing and the number of years managed as a re-built, re-opened area. Thus, the time-averaged fishing mortality should not exceed the fishing mortality target (F=0.2), regardless of the fishing mortality and biomass in other areas. Overfishing in this proposal is defined as a time-averaged mortality rate that exceeds F_{max}. Since the fishing mortality threshold for an area would depend on the past fishing mortality history for a defined area, it would be very difficult, but not impossible to calculate thresholds for areas with adaptive boundaries. Since scallops are relatively immobile and recruitment appears to be not at risk at target biomass levels, this approach is applicable and maximizes yield. If biomass is below the target for the stock, the individual area annual fishing mortality targets would follow the same controls that exist in the present overfishing definition.

If the majority of areas open to fishing are in a re-opened status, the resource-wide fishing mortality rate could temporarily exceed the fishing mortality target (F=0.2). The variation in annual resource-wide fishing mortality will be constrained by ceilings on the amount of the resource that could be closed in any single year. One variant on this theme, which appears to reduce variation in annual landings, is to ramp annual fishing mortality during the re-opened management period. The following tables provide two examples of how this might work. The actual closure duration may be set for all areas in Amendment 10 or could vary for each area according to resource conditions.

Table 4. Example of time-averaged fishing mortality overfishing definition with a three-year closure, followed by a three-year period of re-opened management status.

Year	Year N	1	2	3	4	5	6	7 - N	1	All
Status	**Open**	**Closed**	**Closed**	**Closed**	**Re-opened**	**Re-opened**	**Re-opened**	**Open**	**Closed**	**Average**
No rotation	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Simple rotation	0.20	0.00	0.00	0.00	0.40	0.40	0.4	0.20	0.0	0.20
Ramped rotation	0.20	0.00	0.00	0.00	0.32	0.40	0.48	0.20	0.0	0.20

Table 5. Example of time-averaged fishing mortality overfishing definition with a two-year closure, followed by a three-year period of re-opened management status.

Year	Year N	1	2	3	4	5	6	7 - N	1	All
Status	**Open**	**Closed**	**Closed**	**Closed**	**Re-opened**	**Re-opened**	**Re-opened**	**Open**	**Closed**	**Average**
No rotation	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Simple rotation	0.20	0.00	0.00	0.30	0.30	0.30	0.30	0.20	0.0	0.20
Ramped rotation	0.20	0.00	0.00	0.21	0.27	0.33	0.39	0.20	0.0	0.20

2. **Size mitigated fishing mortality targets**
   A method to determine area-specific fishing mortality thresholds based on current scallop size frequencies

Like the time-averaged mortality threshold in Proposal 1, this method allows for area-specific fishing mortality targets that are higher than the stock-wide target. On the other hand, the annual mortality target for an area would depend on the size of scallops, compared to the average size of scallops when fished constantly at F_{max}. Larger scallops in a re-opened fishing area would mean that the annual mortality target for that area would be greater than F_{max} and vice versa. The annual target would be determined from the ratio of the average size of exploitable scallops in an area to the average size of exploitable scallops when fished constantly at F_{max}. Overfishing in this case would be determined from a biomass-weighted average of open fishing areas.

Thus, the mortality target in an area would depend not on the length of time in which the area was closed or the actual past fishing mortality history, but on the size of scallops occurring there when re-opened and in each year the area remains open. If high recruitment occurs in an area during its closure, this method would reduce mortality and protect the smaller scallop, even though the area might have been closed for a long period. Conversely, an area that closes late (i.e. the scallops are intermediate size, rather than small when the closure occurs) and recruitment is low, this method would allow a higher annual fishing mortality target even if the closure duration is short.

3. **Synthetic F_{max}**
   A method to determine resource-wide fishing mortality thresholds through projections of future fishing mortality and area rotation policy

A third alternative would modify the F_{max} threshold based on the amount of closed areas and the size of scallops in the resource. Thus, the synthetic F_{max} (the fishing mortality threshold) would vary from year to year and the fishing mortality target would be a fraction (80%?) of the synthetic F_{max} value.

In some ways, this is similar to Proposal 2 above, but the change in F_{max} is calculated by a dynamic yield per recruit model or simulation, rather than a ratio of size method. On the other hand, it is conceptually a little different from Proposal 2 in that the long-term threshold F is undefined and allows for specification of an annual synthetic F_{max} for the entire resource instead of an area-specific fishing mortality threshold as proposed under proposals 1 and 2.

It also requires a iterative simulation to determine the synthetic F_{max} value that maximizes future yield based on the current size structure, assumed recruitment, size selectivity of the current and future fishery, and future fishing mortality and area management policy. The projected synthetic F_{max} could be a single value through time (which may vary in the future) or a time-stream of fishing mortality rates that vary through time to maximize yield. Although not part of the original proposal, this could be taken one step further by calculating net benefits and discounting for time, or F_{npv}.

3.4.2 Status quo

The present overfishing definition is also based on reference points (B_{max} and F_{max}) that maximize yield per recruit, an acceptable proxy for MSY when there is no stock recruitment relationship (Applegate et al. 1998). These reference points depend on the average amount of recruitment and size selection by the fishery.

B_{max} has been approved as the target biomass in the overfishing definition. It is calculated as the product of the average meat weight at age and the number of scallops that would survive age-specific fishing mortality and a constant natural mortality, such that the fishing mortality maximizes yield. Higher and lower fishing mortality produce less yield either because scallops would be harvested before they reach optimum size or harvested too slow so that natural mortality reduces the total biomass more than growth adds to it. This parameter is known as F_{max} (Hilborn and Walters 1992). Bmax is the expected biomass per recruit that survives when fished at the F_{max} rate.

The present overfishing definition reads:

"If stock biomass is equal or greater than B_{max} as measured by the resource survey weight per tow index (currently estimated at 8.16 kg/tow for the Georges Bank resource and 3.90 kg/tow for the Mid-Atlantic resource area), overfishing occurs when fishing mortality exceeds F_{max}, currently estimated as 0.24. If stock biomass is below B_{max}, overfishing occurs when fishing mortality exceeds the level that has a 50 percent probability to rebuild stock biomass to B_{max} in 10 years. The stock is in an overfished condition when stock biomass is below ¼B_{max} and overfishing occurs when fishing mortality is above zero. These reference points are thresholds and form the basis for the control rule."

In the present overfishing definition, the minimum biomass threshold is 25 percent of B_{max} and the stock is deemed overfished when biomass is less than this value. The value of B_{max} differs for Georges Bank and Mid-Atlantic scallops because the average recruitment level is different. Differences in size selection and mortality in the two regions are believed to be negligible, but growth differences have been accounted for when estimating the biological reference points (NEFSC 2001b). The reference points are also valid for Gulf of Maine scallops, but surveys have been insufficient to be able to estimate biological reference points for the Gulf of Maine.

Overfishing occurs when fishing mortality exceeds the fishing mortality threshold. The threshold is F_{max} when biomass is above B_{max} and declines to zero as the stock approaches the minimum biomass threshold, 25 percent of B_{max} (Figure 4). Between ¼B_{max} and B_{max}, the fishing mortality threshold was determined from the calculated rate of logistic biomass growth, assuming that the intrinsic rate of population growth is two times the value of F_{max} and F_{max} is a valid proxy for F_{MSY}. When biomass is between ½B_{max} and B_{max}, the threshold is based on a ten-year rebuilding calculation. A more risk-adverse strategy is employed in the current overfishing definition when biomass is lower, between ¼B_{max} and ½B_{max} a more aggressive five-year rebuilding calculation is employed. The target fishing mortality rate is 80% of the threshold value.

Both B_{max} and F_{max} apply to all stock areas, regardless of their status (i.e. open or closed). Thus, it is possible to increase biomass or reduce mortality by closing more of the scallop resource area, as has occurred since 1994. Greater survival in the closed areas will increase biomass as scallops there grow and reduce mortality, if fishing mortality does not increase an equal amount in the remaining open areas.

In the extreme case, the stock-wide biomass target could be achieved without overfishing the resource if 80 percent or more of the exploitable scallop abundance occurs in closed areas. Even if fishing mortality in the open areas is unlimited (thousands of boats fishing 365 days per year, for example), it could meet the overfishing definition criteria through closures, although there might be no scallops available to the fishery!

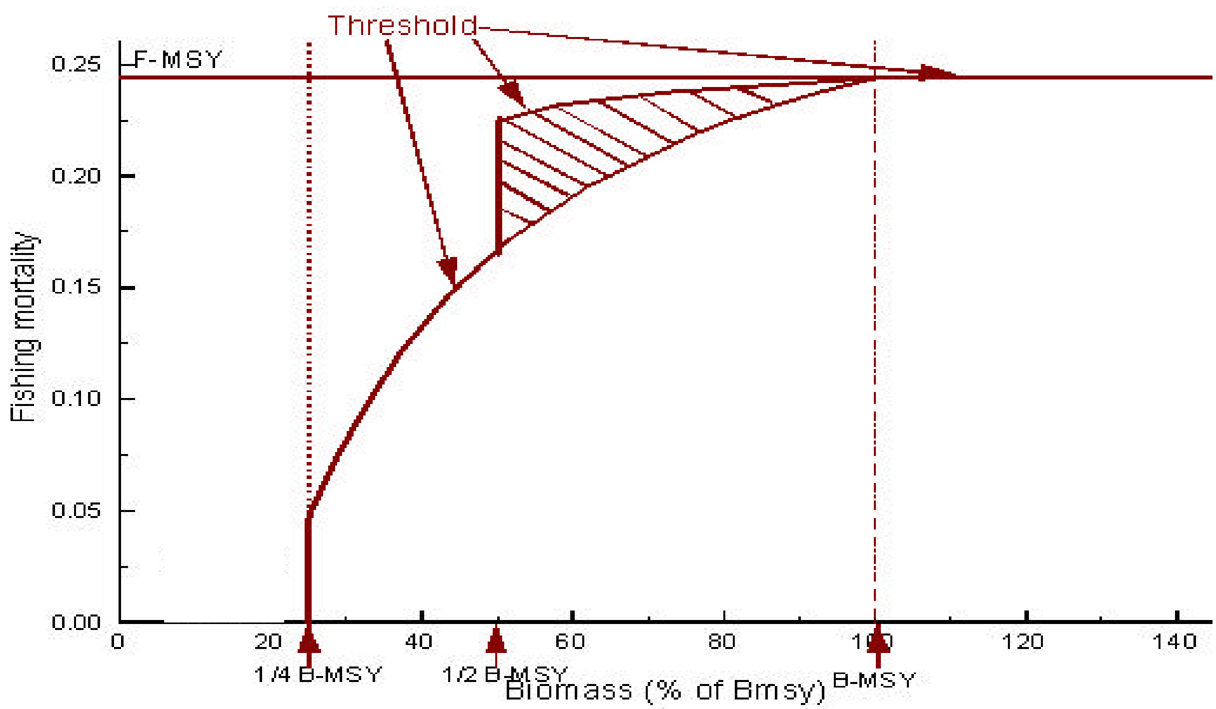

Figure 3. Existing overfishing definition control rule for sea scallops. Calculated threshold fishing mortality rates assume that the intrinsic rate of population growth is two times the value of F_{max}, then estimated to be F=0.24.

While the above outcome might seem absurd, about 80 percent of the exploitable biomass of Georges Bank scallops are presently in long-term closed areas and it totals about 50 percent of the resource in both regions. At the same time, fishing mortality in the open areas of the Mid-Atlantic is about 0.7, or almost three times higher than F_{max}. As such, the application of F_{max} and B_{max} as acceptable proxies for F_{MSY} and B_{MSY} is debatable.

The maximum fishing mortality threshold and target are also inflexible, i.e. they apply in all stock areas regardless of the age structure of the stock and its recent management history. Even if the majority of the resource had been subject to several years of closure and scallops were larger than optimum (i.e. natural mortality was removing more biomass than growth was adding), the fishing mortality target could not exceed F_{max}, even temporarily when it would improve long-term yield. Even with spatial averaging, inherent in the present overfishing definition, it would be difficult to accommodate a control rule that would maximize yield from the fishery after a period of greater than average closures to postpone mortality on strong year classes. With area rotation and the current overfishing definition, it would also be questionable whether F_{max} and B_{max} would be acceptable proxies for F_{MSY} and B_{MSY}, respectively, without modifying the overfishing definition to account for long term closures and area rotation.

Lastly, the basis for the control rule (Figure 4) presumes that F_{max} is a valid proxy for Fmsy and rebuilding would occur according to a logistic growth curve whose rate is maximized when biomass is some fraction of the carrying capacity (Pella and Tomlison 1969). In many cases, it is assumed that this maximum population growth rate occurs at 50 percent of carrying capacity. With a heterogeneous resource caused by long-term closures, its probable that the population growth is not maximized when the spatial average of the two types of areas (closed and open) are near ½ of the carrying capacity when averaged together. In this case, the scallops in long-term closures have slow growth rates and density dependent factors may adversely affect productivity. In open areas with high exploitation rates (as permitted with the present overfishing definition), the young scallops contribute less than optimum amount of spawning.

3.5 Optimum Yield

Optimum yield (OY) is a long term average, defined as the amount of biomass that can be landed when the stock biomass is at B_{max} by using regulated fishing gear in resource areas that are not managed as long term closures, at a rate equivalent to the open area fishing mortality target. The stock-wide fishing mortality target is 80% of Fmax, accounting for the risk that the numerical estimate exceeds the true value of F_{max}. The open area fishing mortality target increases linearly from 80% of F_{max} in proportion to the amount of exploitable biomass in long-term closed areas, but cannot exceed F_{max}.

Table 6. Open area target fishing mortality for determining optimum yield.

Percent of scallop productivity in long-term closed areas	Stock wide target fishing mortality	Open area target fishing mortality for defining OY
0	80% of F_{max}	80% of F_{max}
5	80% of F_{max}	85% of F_{max}
10	80% of F_{max}	90% of F_{max}
20	80% of F_{max}	F_{max}
> 20	80% of F_{max}	F_{max}

Long term closures are excluded from the calculation of OY, because other than an insignificant movement of large scallops, long term area closures contribute to total scallop productivity only through the amount of spawning activity that produces settlement elsewhere. The recruitment from spawning activity is a component of Bmax, which may change due to differences in long-term average recruitment.

Annual yield targets may differ from the long-term average optimum due to variations in exploitable stock biomass and age structure of the scallop stocks. When stock biomass is less than B_{max} or when the abundance of older scallops is low, the annual yield target that achieves this long-term average optimum is less than optimum yield. This may be determined from the control rule (see above) that defines overfishing when stock biomass is less than B_{max}. When stock biomass is greater than B_{max}