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RECOMMENDED OVERFISHING DEFINITIONS AND CONTROL RULES FOR THE WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL'S CRUSTACEAN FISHERY MANAGEMENT PLAN

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REVIEW OF OVERFISHING DEFINITIONS AND CONTROL RULES

The goal of the Magnuson-Stevens Fisheries Conservation and Management Act (MSFCMA) is to ensure the long-term sustainability of fish catches by halting or preventing overfishing and by rebuilding any overfished stocks. Overfishing is defined to occur when fishing mortality (F) is higher than the level at which fishing produces the maximum sustainable yield (MSY). The MSY is the maximum long term average yield that can be produced by a stock on a continuing basis. A stock is overfished when stock biomass (B) has fallen to a level below that which can produce MSY. So there are two aspects that managers must monitor to determine the status of a fishery: the level of F in relation to F at MSY (F_{MSY}), and the level of B in relation to B at MSY (B_{MSY}).

The National Standard Guidelines (NSG) of the MSFCMA requires that ″control rules″ be developed which identify ″good″ versus ″bad″ stock conditions, and which describe management action that will influence a control variable (e.g., F) as a function of some stock size variable (e.g., B), to achieve good stock conditions. Each control rule must define reference points (or thresholds) called ″status determination criteria″: one for F that identifies when overfishing is occurring, and one for B that indicates when the stock is overfished. The status determination criteria for F is the maximum fishing mortality threshold (MFMT) and the status determination criteria for B is the minimum stock size threshold (MSST). When F exceeds the MFMT overfishing is occurring, and when B falls below MSST the stock is overfished. When either of these two conditions occurs NMFS must notify Congress that the stock is overfished, and fishery managers must take action to halt overfishing, or rebuild the stock.

A special case of control rule is the MSY control rule, and this rule is recommended when implementing the NSGs. A reasonable MSY control rule template for NWHI lobsters may be derived from the default MSY control rule suggested by Restrepo et al. (1998) and illustrated in Figure 1. The y-axis labeled F illustrates the variable over which managers must exert some control over the fishery as a function of B on the x-axis. The default MFMT recommended by the Technical Guidelines (Restrepo et al., 1998) is an upper limit set at F_{MSY}, shown as a horizontal line at MFMT. In applying the MSY control rule, when B > MSST, F must not be allowed to exceed the MFMT. When F exceeds MFMT, remedial action is required to reduce fishing mortality. When B falls below MSST, however, the stock is considered to be overfished and F must be reduced below the MFMT by an amount that depends on the severity of the stock depletion, the stock's capacity to rebuild, and the desired recovery time for the stock. This allows for some natural fluctuation around B_{MSY} under an MSY harvest policy. A minimum biomass flag or warning level, B_{FLAG}, could also be defined so that if B drops below it managers are prompted to implement remedial action before biomass is reduced to the MSST or below. Incorporating a warning level into the MSY control rule provides a safety margin to ensure that the realized B does not fall below the MSST.

The NSGs call for the use of precautionary approaches when developing control rules and recommend an ″optimal yield″ (OY) control rule. OY is MSY as reduced by relevant socioeconomic factors, ecological considerations, and fishery biological constraints to provide the greatest long-term benefits to the Nation. Compared to the MSY control rule, it is more precautionary to follow an OY control rule as illustrated in Figure 1. At biomass levels above B_{MSY}, F is controlled so it does not exceed F_{OY}. A target optimum biomass level (B_{OY}) somewhat greater than B_{MSY} is achieved by keeping F at F_{OY}. Under the suggested OY control rule (adapted from the Restrepo et al., 1998 default guidelines), when B is below B_{MSY} F is reduced as a linear function of B.

Rebuilding plans are required when stock biomass falls below MSST and must be designed to achieve the desired result within a specified time period. A rebuilding plan is a strategy of selecting fishing mortality rates or equivalent catches that are expected to increase the stock size to the MSY level within a specified period of time.

OVERFISHING DEFINITIONS AND CONTROL RULES FOR THE NWHI LOBSTER FISHERY

Background

Crustacean fisheries within the U.S. Exclusive Economic Zone (EEZ) in the Western Pacific (Hawaii, American Samoa, and Guam) are managed under the Fishery Management Plan for the Crustaceans of the Western Pacific Region (Crustaceans FMP). The Western Pacific Regional Fisheries Management Council (WPRFMC) is responsible for the development of the Crustaceans FMP; NMFS is responsible for stewardship of the resources and review and implementation of the proposed management actions. Most crustacean landings come from the Northwestern Hawaiian Islands (NWHI) commercial lobster trap fishery which commenced in 1977 and which primarily harvests two species: spiny lobster and slipper lobster. Three other species of lobster--green spiny lobster, ridgeback slipper lobster, and Chinese slipper lobster--are caught in low abundance. The fishery currently operates under a seasonal harvest guideline (catch quota) system which opens the fishery yearly on July 1. The harvest guideline specifies the total allowable catch of lobsters (in numbers of lobster) in the NWHI with no reference to lobster species.

In previous amendments to the Crustaceans FMP, the WPRFMC has defined overfishing as a level of fishing mortality exceeding $F_{20\%}$, the level of F associated with a 20% spawning potential ratio (SPR). The WPRFMC also determined that $F_{50\%}$ would serve as a warning level for overfishing; if fishing mortality exceeded $F_{50\%}$ the WPRFMC would consider taking steps to reduce it. In FMP Amendment 9, the WPRFMC adopted a constant harvest rate policy. Under this policy, the harvest guideline is computed as 13% of the predicted July 1 exploitable stock size. The WPRFMC established this guideline with a view to limiting the risk of overfishing (as defined above). Simulation studies estimated that a 13% harvest rate would entail roughly a 10% chance that F would exceed $F_{20\%}$ (DiNardo and Wetherall, 1999). The 10% level of overfishing risk was chosen by the WPRFMC.

In the NWHI lobster fishery, historical logbook data and catch and effort are available to allow estimation of stock size (in numbers of lobster) using a discrete population model. The model estimates average recruitment level (R, assumed constant since 1989), catchability, and abundance of exploitable-sized lobster, conditional on an estimate of the natural mortality rate (annual M = 0.456). The logbooks also provide estimates of total nominal effort. Data on size composition and reproductive state of lobsters in the catch are also available, particularly in recent years, through at-sea catch sampling by NMFS observers. Gear selectivity curves are also available. Both fishery performance and biological data are available through a cooperative lobster tagging program which commenced in 1998. With all the data it is possible to monitor spawning stock biomass (B) and fishing mortality (F) to determine status of stocks relative to status determination criteria.

Status Determination Criteria

An age-based, sex-structured simulation model of lobster population dynamics was used to compute MSY, $F_{MSY,}$ and B_{MSY} under equilibrium conditions, given a set of assumptions about growth, natural mortality, maturation, recruitment, and fishing mortality. All model parameters and assumptions were identical to those in the 1995 Amendment 9 analysis in that a retain-all fishery was assumed. Except for the stock-recruitment relationship, all model processes were density independent. Annual lobster recruitment was modeled using a power function:

$$R/R_{MAX} = (B/B_{MAX})^{\beta}, \qquad (1)$$

where R is recruitment, R_{MAX} is maximum equilibrium recruitment in the absence of fishing, B is spawning biomass, B_{MAX} is the spawning biomass corresponding to $R_{MAX,}$ and β is a parameter controlling the strength of the dependence between recruitment and spawning biomass. If $\beta = 0$, recruitment is independent of spawning biomass. As β increases, the dependence of recruitment on spawning biomass also increases (Fig. 2). Because the relationship between B and R is unknown, MSY, F_{MSY}, and B_{MSY} have been estimated under a range of assumptions about the stock-recruitment relationship.

Under moderately conservative assumptions about the stock-recruitment relationship (see Fig. 2 with $\beta = 0.10$), the current estimates of these parameters are: MSY = 222 mt; $F_{MSY} = 0.72$ (applied over a 6-month fishing season); $B_{MSY} = 131$ t. Status determination criteria for the lobster fishery are as follows:

<u>Maximum Fishing Mortality Threshold</u> - Under the NSG default the maximum fishing mortality threshold, MFMT, is defined as:

$$MFMT \leq F_{MSY,} \qquad (2)$$

where $F_{MSY} = 0.72$ (applied over a 6-month fishing season).

<u>Minimum Stock Size Threshold</u> - The minimum stock size threshold, MSST, is defined using the NSG default formula; i.e.,

$$MSST = (1 - M) \times B_{MSY} = 0.54 \times B_{MSY} = 71 \text{ mt.} \qquad (3)$$

Given estimates of MSST and MFMT, control rules (MSY and OY) can be developed.

MSY Control Rule

The suggested MSY control rule for the NWHI lobster fishery is shown in Figure 3. The rule limits fishing mortality to F_{MSY} at levels of NWHI lobster spawning biomass above B_{MSY}, the warning level, and calls for a linear reduction in fishing mortality at lower levels of spawning biomass. When spawning biomass falls below MSST the stock is considered overfished and action to rebuild the stock would commence (i.e., implementing a stock rebuilding plan). The suggested MSY control rule is conservative compared with the default MSY control rule of the NSG, which suggests that the reduction of the fishing mortality begin at MSST, which is lower than B_{MSY} (See Fig. 1).

The MSY control rule is specific to assumptions made about the stock recruitment relationship. The suggested control rule assumes a relatively weak dependence of recruitment on spawning stock ($\beta = 0.10$ curve in Fig. 2). A stronger dependence of recruitment on spawning biomass (higher β values in Equation 1) would mean MFMT would be lower and both B_{MSY} and MSST higher; thus, current conditions would be closer to overfishing limits defined by the control rule.

OY Control Rule

The Council's constant harvest rate, risk averse harvest policy implicitly defines the target fishing mortality as F = 0.14. This annual fishing mortality coefficient (as applied to the exploitable stock during July-December) is equivalent to the 13% harvest rate. Because of the risk-averse nature of Amendment 9 the target fishing mortality may be considered to be the optimum fishing mortality, $F_{OY.}$ An OY control rule consistent with the Council's harvest policy is shown in Figure 3, and calls for applying a constant $F_{OY} = 0.14$ (i.e., 13% harvest rate) when spawning biomass is above B_{MSY}, and reducing F in a linear fashion as levels of spawning biomass fall below B_{MSY} (the harvest rate would also be reduced accordingly). When spawning biomass falls below MSST the stock is considered overfished, the fishery closed, and action to rebuild the stock would commence (i.e., implementing a stock rebuilding plan). This control rule is conservative compared with the NSG default OY control rule which sets a higher, less risk-averse F_{OY} (Fig. 3).

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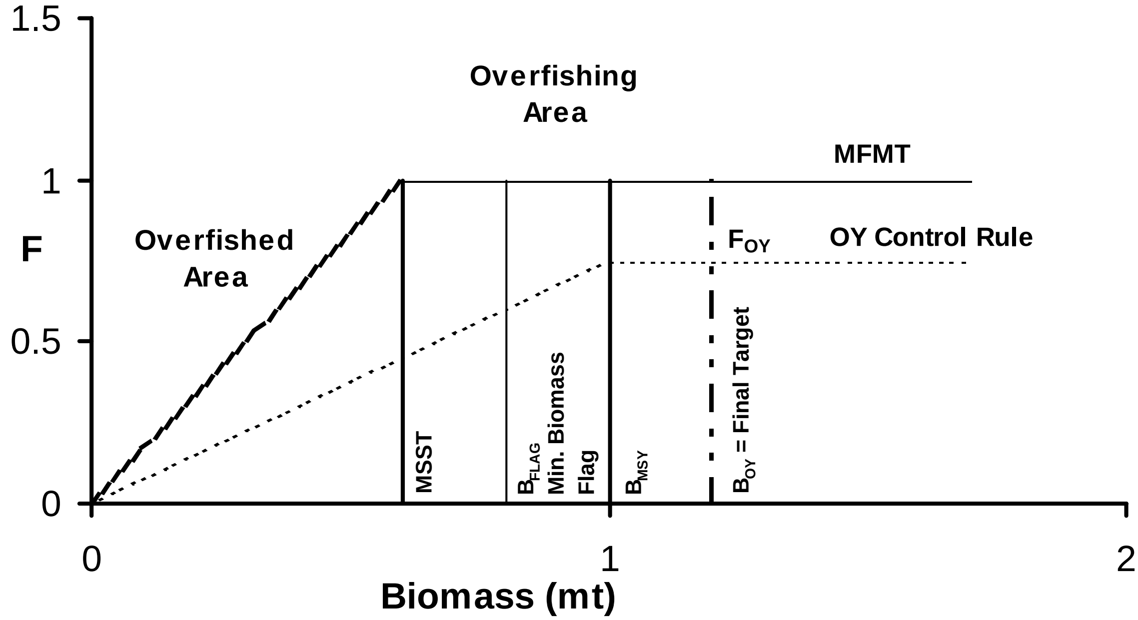

Figure 1.--Example MSY control rule and reference points.

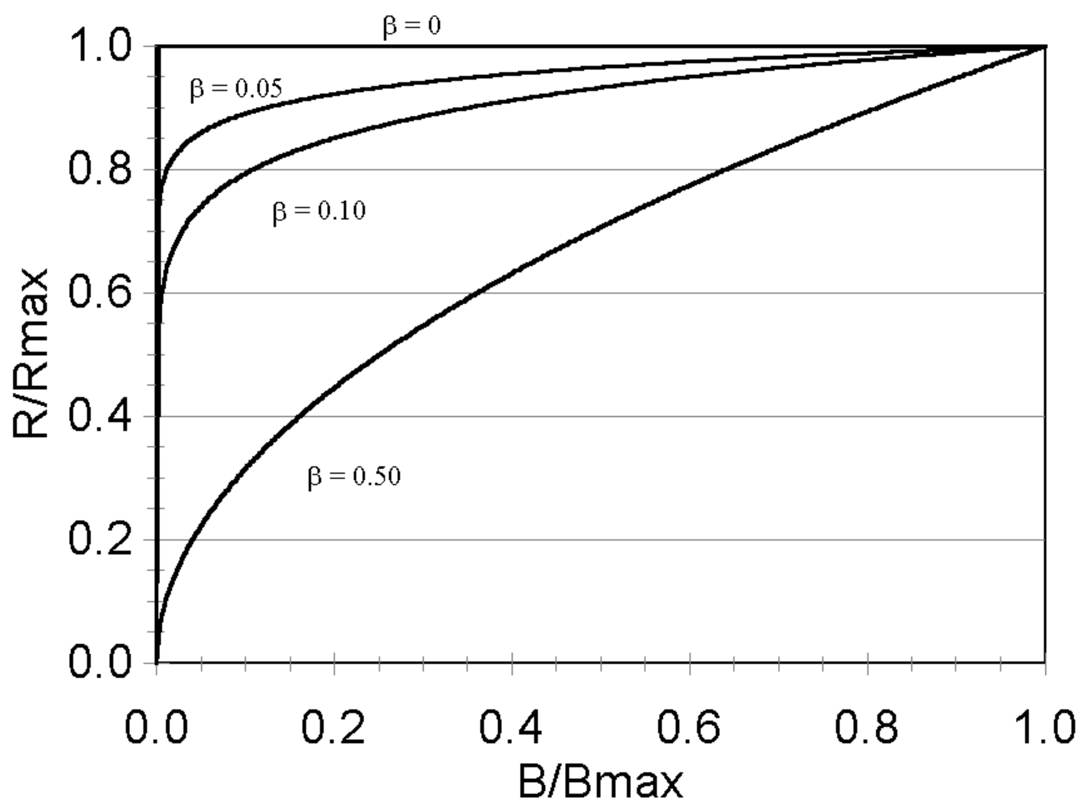

Figure 2.--Recruitment-spawning biomass relationships.

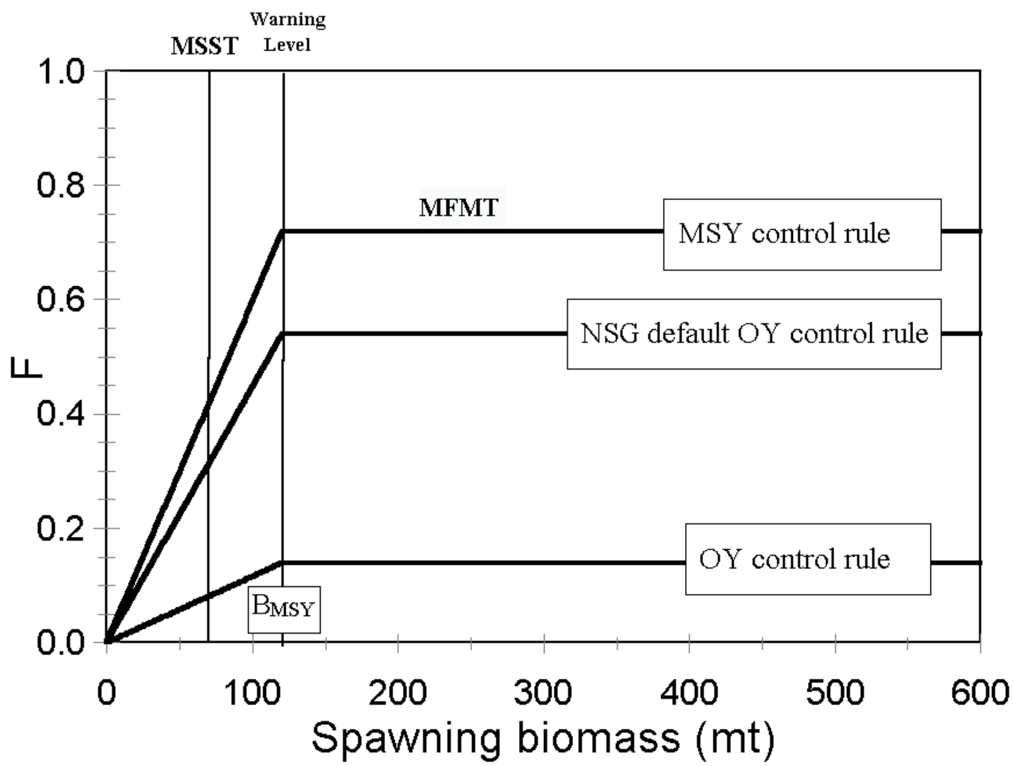

Figure 3.--Control rules for NWHI lobster fishery assuming weak dependence of recruitment on spawning biomass.