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**SCAA MSY Evaluation Methodology for Greenland Halibut**

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**MSY and related quantities**

The equilibrium catch for a fully selected fishing mortality  $F$  is calculated as:

$$C(F) = \sum_{a=0}^m w_a^{mid} N_a(F) S_a F^* (1 - e^{-(M_a + S_a F)}) / (M_a + S_a F) \quad (1)$$

where

$S_a$  is the commercial selectivity specified for the projections (equal to the selectivity in the last selectivity period for OM0),

$w_a^{mid}$  is the mid-year weight-at-age specified for the projections (taken as the average of the last 10 years (2006-2015) for OM0),

and

$$N_a(F) = \begin{cases} R_0(F) & \text{for } a = 0 \\ N_{a-1} e^{-(M_{a-1} + S_{a-1} F)} & \text{for } 0 < a < m \\ N_{m-1} e^{-(M_{m-1} + S_{m-1} F)} / (M_m + S_m F) & \text{for } a = m \end{cases} \quad (2)$$

where

$$R_0(F) = \frac{\alpha SPR(F) - \beta}{SPR(F)} \quad (3)$$

for a Beverton-Holt stock–recruitment relationship, and

$$SPR(F) = \sum_{a=1}^m f_a w_a^{strt} e^{-\sum_{a'=1}^m (FS_{a'} + M_{a'})} + f_m w_m^{strt} \frac{e^{-\sum_{a'=1}^m (FS_{a'} + M_{a'})}}{1 - e^{-(FS_m + M_m)}} \quad (4)$$

For a given value of  $F$ , equations (2) – (4) can be used to provide the inputs needed to evaluate  $C(F)$  using equation (1). The maximum likelihood estimates for the parameters of the stock-recruitment relationship and for selectivities are used for this evaluation.



The maximum of  $C(F)$  (which is  $MSY$ ) is then found by searching<sup>1</sup> over  $F$  to give  $F_{MSY}$ , with the associated spawning biomass given by:

$$B^{sp}(F_{MSY}) = \sum_{a=1}^m f_a w_a^{strt} N_a(F_{MSY}) \quad (5)$$

with

$w_a^{strt}$  is the begin-year weight-at-age specified for the projections (taken as the average of the last 10 years (2006-2015) for OM0).

A similar equation provides  $B_{MSY}$  for the exploitable biomass.

CVs for  $MSY$  and  $B_{MSY}$  may then be found from the Hessian associated with the assessment; note that they are conditional on the value of  $F_{MSY}$  calculated as above..

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<sup>1</sup> This is done by numerically approximating the derivative of  $C(F)$  with respect to  $F$  and iterating until this becomes zero.