Wikiprint Book

Title: EwEugDensityDependentChangesInCatchability

Subject: Ecopath Developer Site - EwEugDensityDependentChangesInCatchability

Version: 4

Date: 2024-04-16 12:35:11

Table of Contents

3.19 Density-dependent changes in catchability

In fisheries modelling we usually represent the fishing mortality rate F as a product of catchability q times fishing effort f:

$F = qf$

Here the catchability q represents the mortality rate caused by a unit of fishing effort, or in intuitive terms the proportion of the stock harvested by a unit of fishing effort. A useful way to think about q is in terms of the spatial or Effort response power ganization of fishing: if each unit of effort 'sweeps' an area *'a'* while the stock is distributed over a total area A, and if effort is randomly distributed within A, then $q=a/A$. There are two problems with this formulation:

i. A is generally seen by both fish and fishers as a much smaller area than the map area over which you might display a stock's range (neither fish nor fishing are randomly distributed, so A is generally much smaller than the map range area for a stock), so we usually cannot predict q from simple analysis of gear swept area and total range area; and
ii. almost always, the actual area A occupied by fish and fishers decreases with decreasing fish abundance, (i.e., the occupied range 'collapses' as stock size decreases) due to fish behaviours like shoaling and also cumulative effects of localized stock depletion events. The second problem is particularly important for fisheries analysis, since it implies that q increases, sometimes grossly, as A decreases ($q = a / A$ increases when A decreases) whether or not there is a change in fishing technology as represented in the area swept per unit effort.

On entry to Ecosim, Ecopath has provided a base fishing rate F_o = Catch / (Ecopath biomass)'. You can specify time scenarios for F (F_t, $t > 0$) relative to this F_o by using either the fishing rate 'sketch pad' interface (Ecosim Run Ecosim form) or time reference data files (see Time series). The Ecosim default is to treat your time series values as relative or absolute fishing rates without reference to changes in q. But you can also treat the time input values as relative fishing efforts f_t where $f_o = F_o$ (efforts scaled so base $q_o = 1$). Then to create density-dependent catchability effects, set a value greater than 1.0 for the q_{max} / q_o ratio(s) in the Ecosim Group info form.

For example, setting a value of 5 represents assuming that q can be as much as 5 times higher than the q that led to the Ecopath base F_o, if stock size is very low. That is, suppose you set $q_{max} / q_o = 5$, then run a scenario where you shape the relative fishing rate over time (now treated as relative effort) so as to cause a gross stock depletion followed by a return to $f_t = f_o$. In this scenario, the 'realized' fishing rate F_t can be as much as 5 times F_o even for $f_t = f_o$, due to density-dependent decrease in the effective area A occupied by the depleted stock.

Internally, Ecosim represents the density-dependent effect by calculating time dependent fishing rate F_t using the equation $F_t = f_t\, QR_o / [1 + (QR_o - 1)\, B_t / B_o]$, where

$QRo = q_{max} / q_o$

is your specified catchability increase ratio, B_t is stock biomass, and B_o is Ecopath base biomass.

Note that this dependence is applied to the individual group fishing rates rather than the relative efforts by fishing fleets, to represent the idea that decreases in area occupied by a stock (A) when biomass B_t is less than the Ecopath base biomass Bo are likely to result in concentration of efforts by fishers in general. If you need to represent a differential change in availability of fish to some particular fleet(s) but not others, you will need to develop an Ecospace model that explicitly represents spatial distinctions in where particular gears can operate. Note further that the QR parameter is not used in Ecospace: we assume random distribution of effort within each Ecospace cell, recognizing that Ecospace can already represent larger-scale range changes and associated changes in the spatial concentration of fishing effort.

In Ecosim scenarios where you do choose to treat the time input fishing information as relative fishing efforts f_t rather than absolute fishing rates F_t, you should be quite careful to recognize that catchability often increases quite dramatically for low values of B_t/B_o. QR values (q_{max}/q_o) of 5 to 10 are not uncommon in the fishery literature, especially for shoaling fishes like herring, sardine, and spawning cod. Further, modern fishing technologies like side-scan sonar and GPS are making fishers ever better at concentrating their swept areas *'a'* within the actual areas A where fish are concentrated (probability of a sweep of area *'a'* not being within the occupied area A has decreased dramatically). Even where there are not such technological changes, fishers are generally capable of making very good assessments of A just by combining their own search information with observation of where other fishers are doing well.

Note that you generally do not want to set $QR > 1$ for 'reconstruction' scenarios where you have provided historical F_t estimates based on single-species assessment methods such as virtual population analysis (VPA) or stock synthesis. Presumably these methods have already accounted for density dependent effects on q, by calculating F_t=(historical catch)/(estimated stock biomass) without regard to whether the historical catch was high relative to biomass because of catchability changes or changes in total fishing effort. But you should check the single species assessment method carefully, to insure that the method did not make an inappropriate assumption about stability of q in its reconstruction of historical biomass, (e.g., was fitted to the data using historical effort data under a constant q assumption, or was 'tuned' to historical catch per effort data uncorrected for temporal/stock dependent changes in q).