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Ecology and Fishing of Cod Stocks in Divisions 3M and 3NO

by

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INTRODUCTION

Vázquez and Larrañeta (1980) have observed that both in cod stocks Div. 3M and 3NO the points of relationship between the catch-per-unit effort and the effort may be related to two regressions, the lines meeting on the right side (high values of effort) in the abscissa axis (Fig. 1 and 2).

Afterwards, Larrañeta (in press) has studied the theoretical basis of this graphic representation, coming to the conclusion that changes in the parameters of the stock-recruitment curve can produce changes in the catch-per-unit effort against effort regressions. This approach is applied to these fisheries.

STOCK-RECRUITMENT CURVES AND CATCH-PER-UNIT EFFORT REGRESSIONS

It is assumed that the Ricker (1958) model is the most representative one for stock-recruitment curves in marine fish populations. Said model is:

$$R = ASe^{-BS} \qquad (1)$$

where S = parental stock

           R = recruitment

    A and B = parameters

The spawning stock will be $S = \sum S_i$, where S_i is the number of mature fishes at the age i. As a simplification, it is supposed that the spawning stock consists of only one age group.

Then,

$$S = Re^{-Z}$$

where Z is the total mortality between recruitment and spawning ages.

In a steady-state population the spawning stock (S') and the recruitment (R') remain constant; so, if we replace S' by R' in (1) we have:

$$R' = AR'e^{-Z}e^{-BS'}$$

or

$$lnR' = lnA + lnR' - Z - BS'$$
$$BS' = lnA - Z$$
$$S' = 1/B \, ln(Ae^{-Z}), \qquad\qquad (2)$$

In the total life span of a generation the fishing rate is F/Z, and the equilibrium catch will be

$$C' = R'(F/Z),$$

and the catch-per-unit effort

$$U' = R'/Z \qquad\qquad (3)$$

Therefore, if the Parameters A and B and the total mortality (Z) are known, it is possible to calculate the equilibrium parental stock (S') by (2), the recruitment (R') by (1), and the catch-per-unit effort (U') by (3).

Varying the Parameters A or B we can see what happens with the relationship between U' and the fishing effort (f).

Taking the example given by Larrañeta (in press), three curves are essayed, being their parameters as follows,

Curve	A	B
1	10	.05
2	7	.05
3	10	.075

These curves are shown in Fig. 3.

Using the expressions (1), (2) and (3), the corresponding catch-per-unit effort curves are drawn (Fig.4).

Taking the Curve 1 as the starting one, Curves 2 and 3 are the new ones when varing Parameter A or Parameter B, respectively. When Parameter A varies the new curve level at F = 0 changes, and the former and the new curves diverge on the right. If Parameter A decreases Curve 2 has lower position than Curve 1.

On the other hand, Curves 1 and 3 have also a different level at F = 0, but they converge on the right, having the same point at U = 0.

Therefore, on plotting U against the fishing effort
(f) if the annual points lie withing two historical series, with
regression lines diverging or converging on the right, it will
be a sign of change in factors associated to Parameter A or Pa-
rameter B of the recruitment/stock curve, respectively.

BIOLOGICAL MEANING OF PARAMETERS A AND B

In previous papers, Larrañeta (1979 and 1980) has
analyzed the biological meaning of the parameters of the so ca-
lled "generation curves". Referring to the Ricker model, the
associated factors are the following:

a) With Parameter A
   (1) Abiotic environmental factors: temperature, salinity,
                          light, etc
   (2) Ecological niche: relative importance of the principal
                          predator, competitor and prey species
   (3) Genotype: physiological and constitutional features

b) With Parameter B,
   (4) Average fecundity of the stock.
   (5) Patchiness of the food area.
   (6) Large-scale hydrographic events modifying the size and/or
       the food density of the nursery area (e.g. current changes)

Perhaps there is some confusion between factors (a-1)
and (b-6), because a change in the current patern can produce not
only a change in the abiotic environmental factors but also a
change in the food supply, and then it would affect both parameters.
The effect of factors(a-1) is assentially a physiological one (e.g.
on metabolism rates), while a change of factors(b-6) has an ecolo-
gical effect (e.g. on the available food).

In figures 1 and 2 the regression lines join them-
selves on the right side, what happens when changes in Parameter
B and associated factors take place. There will be a variation of
the parameters if there is a persistent change of the associated
factors for several years. On the contrary, all the points would
appear only scattered along one regression line, according to some
random distribution.

FISHING CONSEQUENCES

From the curves belonging to Fig. 4 can be drawn
the yield-effort curves (Fig. 5), as Y=f.U. Always comparing with
Curve 1, when Parameter A decreases (Curve 2) the MSY is lower
and is obtained also with less fishing effort. On the other hand,

when Parameter B increases (Curve 3) the MSY becomes also reduced,
but the fishing effort (f_{MSY}) to crop the MSY remains unchanged.

Fishery management consequences are evident. If a
change of factors associated to Parameter A takes place, in the
sense of a reduction in the given parameter, then it is necessary
to reduce the TAC and to take into account that the f_{MSY} is minor
than previously. But if a change of factors associated to Parameter B takes place, in the sense of an increasing in the parameter,
then it is also necessary to reduce the TAC, but the fishing effort
adjustment will have the same features than previously.

DISCUSSION AND CONCLUSIONS

According to this analysis, changes on factors
associated to Parameter B took place in the 1950's, 1960's and
1970's, apparently during periods of 5-10 year. Factors (b-6)
seem to be the most related to these periods.

This is merely a hypothesis to be tested, but a
double regression in the relationship between the catch-per-unit
effort and the effort seems to be more likely than any other
explanation given hitherto about this relationship for cod stocks
in Divisions 3M and 3NO.

Taking into account the previous analysis and the
figures 6 and 7, reported by Larrañeta and Vázquez (1980) and
Vázquez and Larrañeta (1980), for the production models of the
3M and 3NO cod stocks, respectively, it may be possible to propose the following conclussions:

(i)   In the cod stock Div. 3M there has been an overfishing during the last years, with a reduction in natural productivity.

(ii) In the cod stock Div. 3NO no sign of a real overfishing
      has been observed.

(iii) The depletion periods in the cod stock Div. 3NO must be
      attributed to variations of the stock-recruitment relationship owing to changes of the Parameter B an related ecological factors.

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curvas de generaciones. Inv.Pesq., 44(1): 85-94

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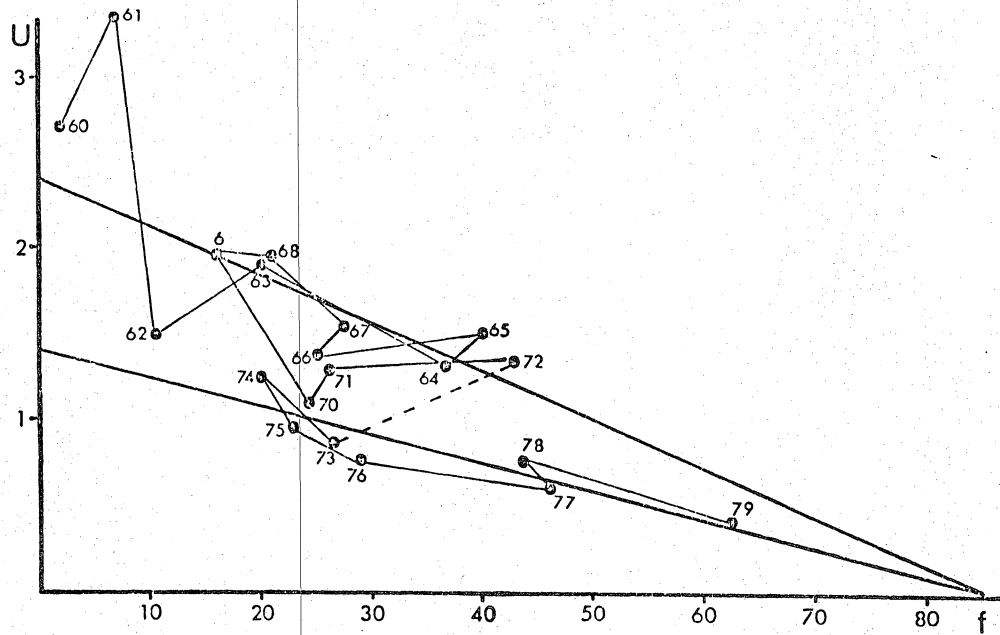
Fig. 1. Regression lines between catch-per-unit effort (U) and effort
(f) in the cod stock Div. 3M, according to Larrañeta and
Vázquez (1980)
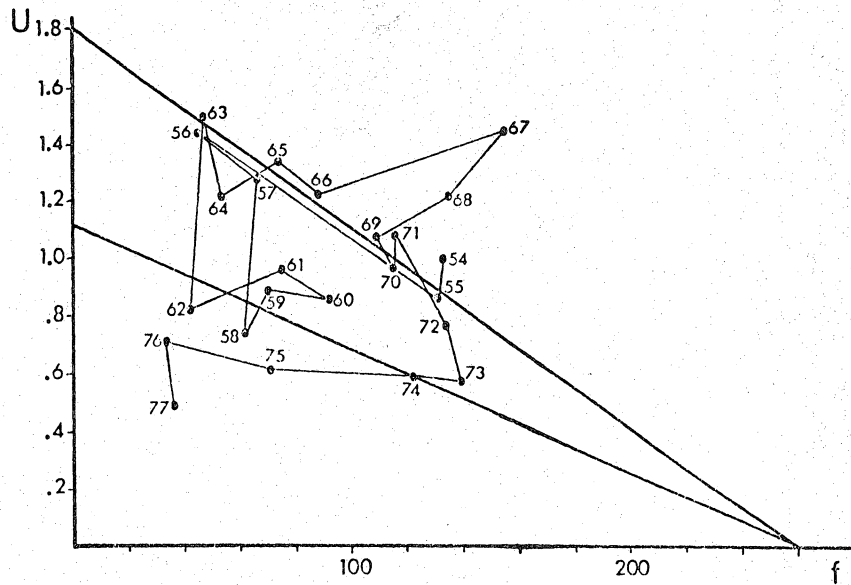
Fig. 2. Regression lines between catch-per-unit effort (U) and effort (f) in the cod stock Div. 3NO, according to Vázquez and Larrañeta (1980)
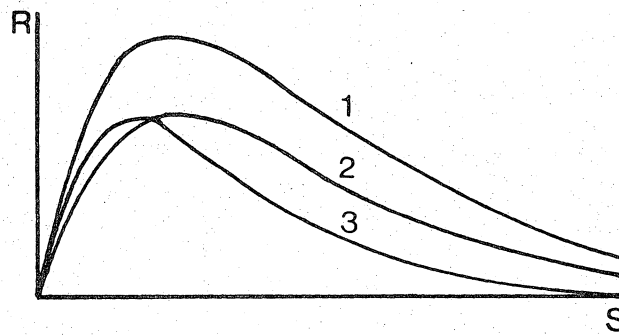

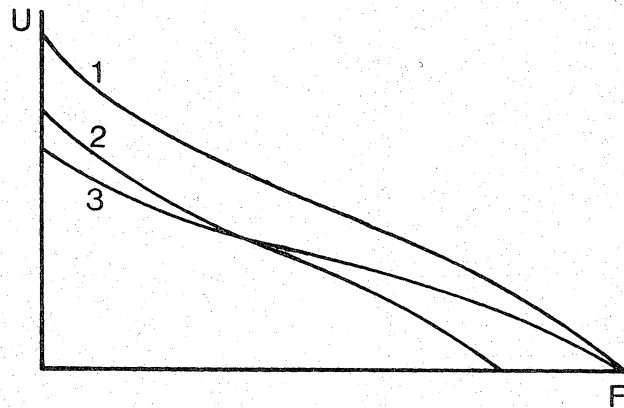Fig. 3. Three Recruitment/Stock curves with parameters given in the text.

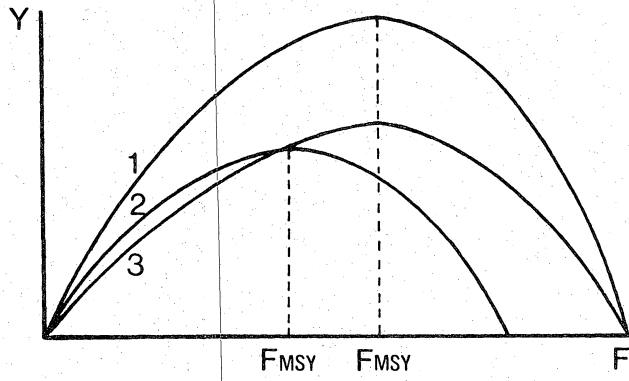Fig. 4. Catch-per-unit-effort curves derived from curves of Fig. 3.
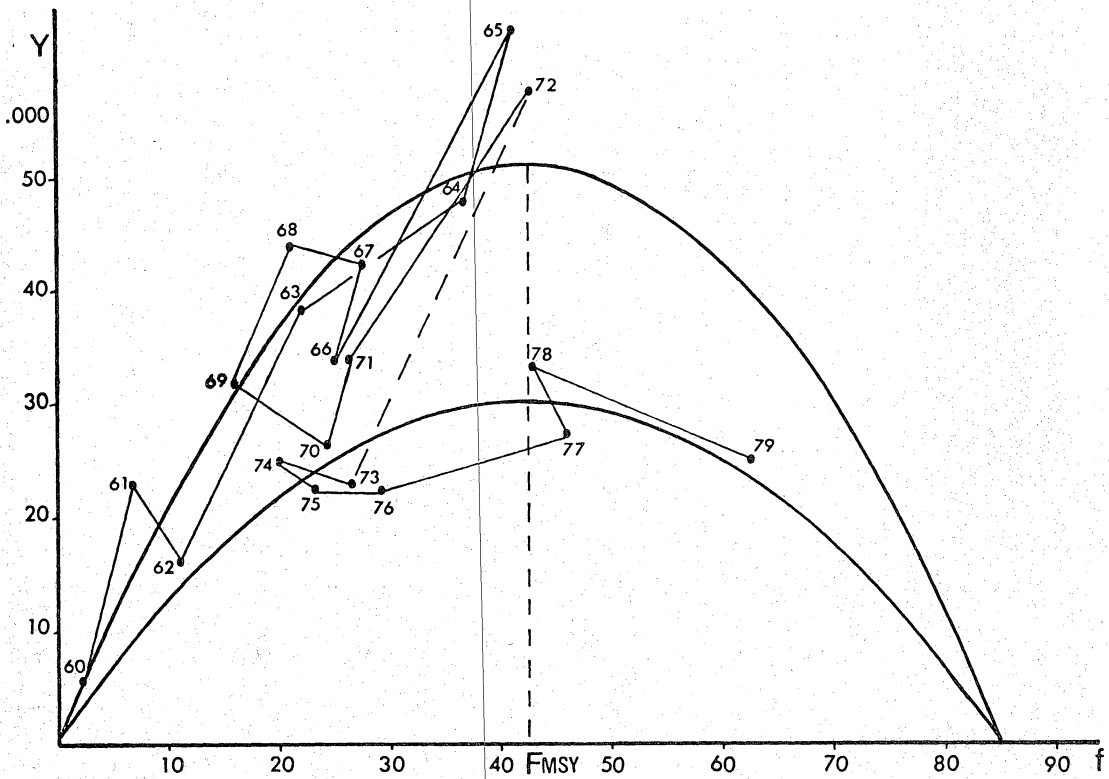
Fig. 5. Yield curves derived from curves of Fig. 4.

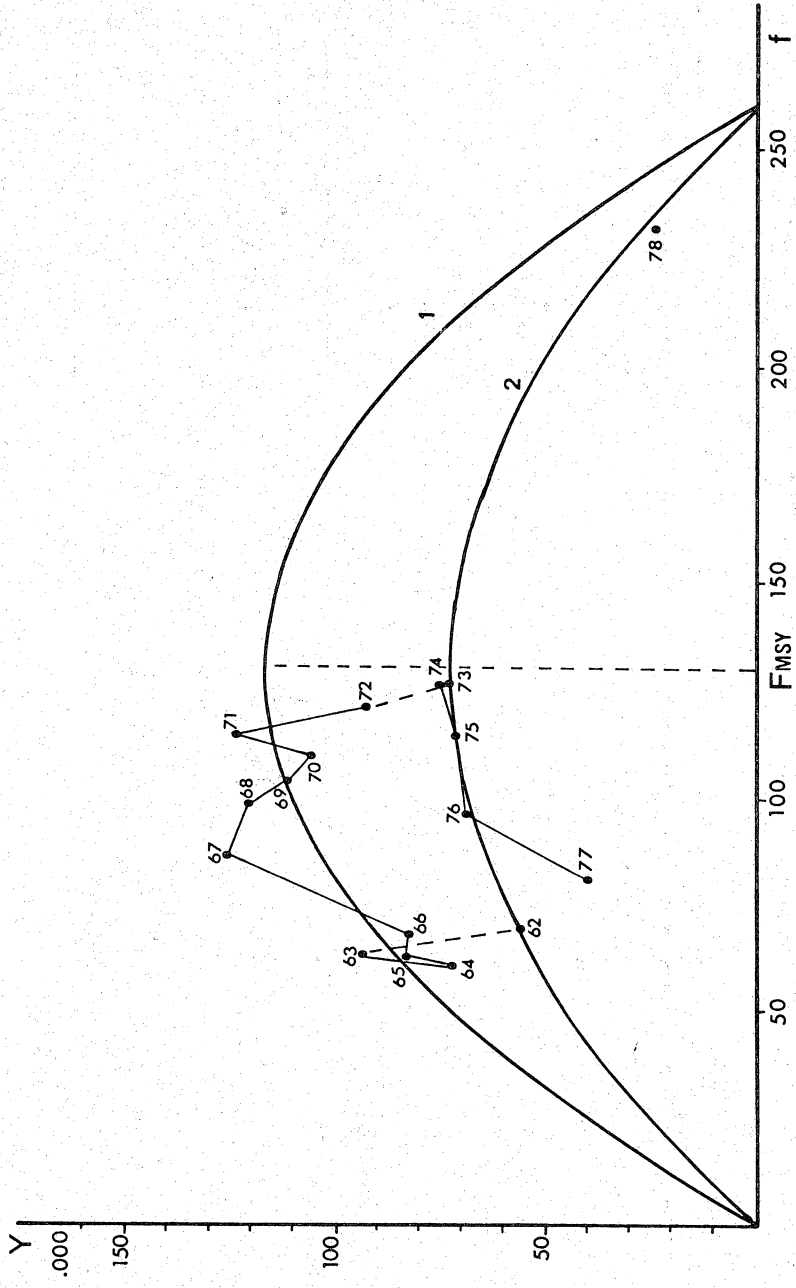Fig. 6. Yield curves of cod stock Div. 3M, according to Larrañeta and Vázquez (1980)

Fig. 7. Yield curves of cod stock Div. 3NO, according to Vázquez and Larrañeta (1980)