APPENDIX 2

CATCHABILITY ANALYSIS

by

D W Armstrong

In previous North Sea Roundfish Working Groups various methods for tuning VPAs have been implemented. In particular, Lewy (1983) introduced a method in which catchability coefficients were calculated for each of a number of fleets for which effort data are available over an extended period of years. Estimates of the catchability of each fleet in the last data year were then obtained by fitting a linear regression to the time-series of catchability values and extrapolating to the last data year.

While Lewy's method was a considerable advance on previous methods, its application was limited to situations in which it appeared justified to fit straight lines to a time-series of catchability values. If this condition did not exist, Lewy's method was likely to give misleading results.

The method to be described below was presented to the Group by D. W. Armstrong and is a direct extension of Lewy's method which permits extrapolation from non-rectilinear time-series of catchability coefficients. To avoid confusion with all other 'Armstrong' or 'Armstrong-Cook' methods, the new method has been christened 'Catchability Analysis'.

Data requirements

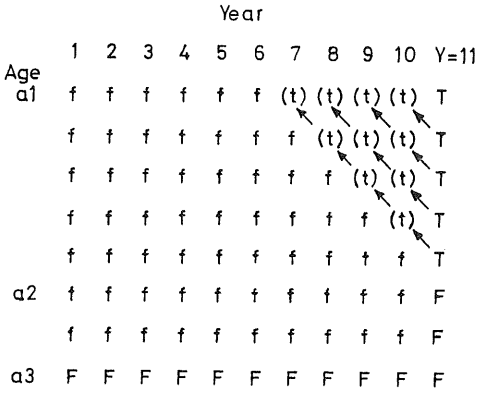
Denote age : a
year : y
fleet : f

(i) International catch at age matrix: C(a,y)

(ii) Catch at age matrix for fleets for which catchability coefficients are to be calculated: K(f,a,y)

(iii) Effort data for fleets for which catchability coefficients are to be cvalculated : E(f,y)

The outcome of these calculations is depicted diagrammatically below.



F denotes an input value of fishing mortality

f denotes a value of fishing mortality derived from an input F

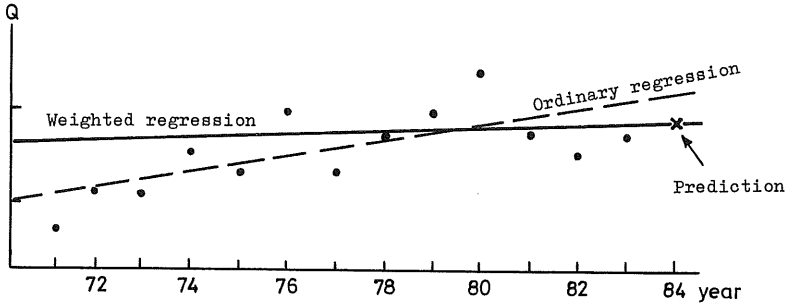
T denotes a tuned value of fishing mortality

(t) denotes a value of fishing mortality derived from a tuned value

Cleveland's method for smoothing scatterplots

The method used for extrapolating a value of Q for the last data year from a time-series of Q values is that of Cleveland (1979).

A typical situation is illustrated below where catchability has increased but is levelling off or perhaps declining in recent years. We therefore require some method of taking recent trends in Q into account while not entirely forgetting about more distant historical events.



d	13	12	11	10	9	8	7	6	5	4	3	2	1	0
weight	0	.01	.06	.16	.30	.45	.60	.73	.84	.92	.96	.99	1.0	1.0

$\left(=\left(1-\left(\frac{d}{13}\right)^3\right)^3\right)$

Number of neighbours = 13.

Computation of catchability coefficients and tuning of VPA

This section is written as a pseudo BASIC program.

Maximum age in international catch-at-age matrix is 3.
VPA is to be tuned for ages a1 to a2 (a1<=a2<a3).
Input F at highest age for all years of VPA.
Perform VPA for ages a3 to a2.

For ages a2-1 to a1

Perform VPA for ages a3 to a

For each fleet

For each year EXCEPT LAST DATA YEAR

Calculate catchability coefficient Q(f,a,y)where

$Q(f,a,y)=(F(a,y)*K(f,a,y)) \;/\; (C(a,y)*E(f,y))$

Next year

Using time-series pf Qs extrapolate a value of Q for this fleet in last data year. (Extrapolation is achieved using Cleveland's method which is explained below.)

Estimate F for fleet in the last data year as

$F(f,a,Y)=Q(f,a,Y)*E(f,Y)$: Y denotes last data year

Next fleet

Calculate total international F at this age as

$$F(a,Y) = \sum_{f} F(f,a,Y)*C(a,Y) \Big/ \sum_{f} K(f,a,Y)$$

and use this as the tuned value of F at age a in the last data year.

Next age.

To extrapolate a point for the last data year Cleveland's method assumes that it is reasonable to fit a straight line to the data points in the region close to the year being considered. This is achieved by giving to each data point a weight which decreases for data points more distant from the year being considered. The weighting function suggested by Cleveland is

$$W = \left(1 - \left(\frac{d}{\max d}\right)^3\right)^3$$

W = weight

d = distance of data point to be weighted from year for which a smoothed value of Q is to be fitted.

The number of nearest neighbours to be used in the computations can be specified by the user. Increasing the permitted number of nearest neighbours increases the smoothness of the fitted points. For this reason, all the runs carried out during this meeting specified as many neighbours as the data sets allowed. (See hypothetical example in the Figure above).

While it is necessary only to extrapolate to the last data year to carry out tuning, to illustrate the trend which is being extrapolated the program allows interpolation or smoothed historical values. Appropriate tables and graphs are printed and an example of one of these is given in App.2,Figure 1.

Reference

Cleveland, W. S. 1979. Robust locally weighted regression and smoothing scatterplots. Journ.Amer.Statistical Assoc., Vol.74 (368):829-836.

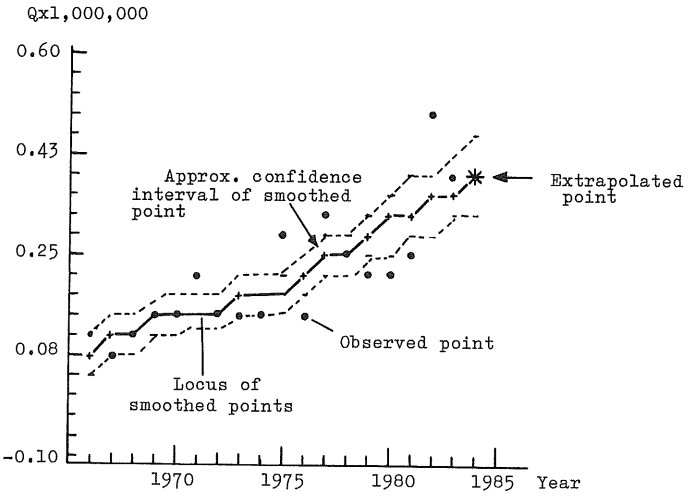
App.2. Table 1

Observed and fitted values of catchability (Q) for COD Sub-area IV. Maximum number of iterations for robustness weighting = 0.

Nation: SCO Gear: SEI Age: 4

Year	F int.	P gear	Effort	Q obs.	Q est	S.D.(Q)	Nobs
1966	0.514	0.0986	500668	0.101	0.073	0.017	16
1967	0.520	0.0474	514618	0.048	0.085	0.015	16
1968	0.707	0.0814	548642	0.105	0.098	0.014	16
1969	0.578	0.0989	491435	0.116	0.110	0.012	16
1970	0.577	0.0818	426650	0.111	0.123	0.012	16
1971	0.703	0.1088	416144	0.184	0.136	0.011	16
1972	0.669	0.0723	392432	0.123	0.149	0.011	16
1973	0.798	0.0649	414898	0.125	0.162	0.012	16
1974	0.666	0.0727	349604	0.138	0.175	0.013	15
1975	0.657	0.1324	329432	0.264	0.186	0.014	15
1976	0.799	0.0550	307165	0.143	0.204	0.015	16
1977	0.545	0.1660	313913	0.288	0.224	0.017	16
1978	0.742	0.1015	325246	0.232	0.245	0.018	16
1979	0.612	0.1068	316419	0.206	0.266	0.019	16
1980	0.721	0.0842	297227	0.204	0.286	0.022	16
1981	0.729	0.0950	289672	0.239	0.307	0.025	16
1982	0.787	0.1239	207730	0.469	0.328	0.028	16
1983	0.927	0.1307	333168	0.364	0.350	0.032	16
1984		0.1220	255696		0.372	0.037	16
1985		0.1249	246336		0.395	0.042	16
1986		0.1279	237197		0.418	0.047	16

Appendix 2,Figure 1



• Observed points
+ Fitted points
– Upper-lower 95% confidence limits on fitted points.

NB. Observed points overwrite any other point if required