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Response of cohort analysis to change in proportion of catch reported

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INTRODUCTION

This short note investigates the effect on a cohort analysis of a change in the proportion of a catch that is reported. To do this, data was generated using the catch equation, a particular set of partial recruitments, a fixed M and randomized recruitment and fishing mortality. The catches were then adjusted to simulate an under-reported catch for several years followed by a varying number of years of fully reported catch. These new figures were then analyzed and compared to the originals to determine first, how fast cohort analysis adjusts and second, what, if anything showed that a change in reporting had taken place.

Two situations were analyzed. In the first, 80% of the catch was reported and the unreported catch was assumed to have the same age distribution as the reported catch. In the second, 20% of the catch of fish of the first two ages was reported along with 100% of the catch of fish of other ages. M was set at .2 and partial recruitment at .1, .1, .2, .4, .6, .8, .9, 1, 1, ... Data was generated for 15 years and 12 ages. The F on fully recruited fish was set randomly between .1 and 1.2 and the recruitment was selected randomly between 10 thousand and 10 million.

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Case 1: 80% of catch of all ages reported

This situation is illustrated in Figs. 1-3 and Tables 1-3. Prior to the time when changes in reporting occurs, the analysis will correctly estimate the F's and the numbers will be 80% of actual values because the catch structure has not been affected, just the overall level. Whether projected recruitment is based on surveys of unrecruited fish or average recruitment, the projections will be 80% of correct figures. In other words, the whole analysis will be done on 80% of the actual population. Trends in biomass, catch and numbers will not be affected by this and as long as the situation holds it should not affect the management of the stock.

With one year of correct data, this situation changes. From the previous years analysis, partial recruitment and final F's would have been calculated correctly. If these are applied to the new data, because the original F's are correct, the numbers derived for the last year are immediately corrected. The previous ones are corrected to some degree in the usual way that cohort analyses adjust . This will cause a change in the estimation of F's. Since the last years numbers are 100% instead of 80% of actual, the numbers appear to increase forcing F's to decrease. Percent error in F is shown in Table 1. Notice that there is less error in F's of older ages because the value of F is higher than at lower ages due to partial recruitment and thus corrects more quickly. Table 2 shows partial recruitments if final F's are taken as fully recruited F's. Table 3 shows partial recruitments if fully recruited F's are estimated from the average of the F on each of the last 5 ages. This average F for the last 4 years before the change in reporting is .994, .0976, .3832 and .9. If the cohort was rerun with these figures for final F's, very little would change. The largest error in F on mature fish is for the last year of under-reported catch. Even for this year, the error is within the variation usually found in cohort analyses and probably would not be noticed. The partial recruitments in no year were changed enough to be noticed in an analysis. Since numbers for the last year are now estimated correctly if correct F's are put into the cohort run, as more years of correct data are added, these numbers will not be changed. Hence this pattern of under-estimated F's will stay in the analysis each year. Thus, also the numbers estimated for years before the change in reporting will not correct any more than after one years correct data is added. Figure 1 shows the relationship between the average F on ages 8 through 12 and the correct value for this F. If the correct mature F is well correlated with effort, the figure shows that the estimated mature F will also be correlated with effort. Thus this relationship would also not show that a change in reporting had occurred.

Before a change in reporting, all numbers of recruits are estimated at 80% there actual level. Hence if there was an indication of year class size (larval survey, juvenile survey), that was without error, there would be a perfect correlation between it and the estimated numbers as well as between it and the correct numbers. Figure 2 shows what happens when recruitment estimated after one year of correct data is entered, is plotted against the indicator of year class size. The correlation is no longer perfect but is still high (92%). The difference would never be noticed in the usual variation found in actual data. Also, the regression line is close to the correct relationship so that if the line is used to predict future recruitment, the predicted figure will be almost correct.

Often an average recruitment is used in projections. If all numbers are 80% of the correct numbers, the average used will be 80% of the correct average. With one years correct data the recruitments for several years back in the cohort table are corrected to some degree. Thus, many of the points averaged over are improved. As new data is added, however, not much changes since the partially corrected recruitment figures are not improved any further. Thus the average used corrects most after one year of correct data is added and then slowly rises towards the proper value. Figure 3 shows the percent that the estimated average is of the correct average versus the number of years of correct catch data.

This example shows that a change from reporting 80% of all catch to reporting 100% may not be noticed in a practical example but the cohort analysis shifts fairly quickly to give reasonable values and allow reasonable predictions.

Case 2: 20% of catch of 1 and 2 year olds reported

While under-reporting takes place we are in the following situation. Since all catch is reported for ages 3 and above, all F's and numbers will be properly estimated for these age groups. The usual methods for developing partial recruitments in a cohort analysis will lead to .02 being used for ages 1 and 2 instead of .1 because of the apparent small catch. Numbers of 1 and 2-year olds are somewhat underestimated. Again, projections based on these figures will estimate the future adequately if this reporting practise continues.

After one year of fully reported catch, very little can be told from the table of estimated F's. The only change is a partial recruitment of .004 on one-year olds in the second last year instead of .02. Unless the data showed little variation this change would probably go unnoticed in a normal run. The problem lies in estimated recruitment. Because of using incorrect partial recruitments for ages 1 and 2, the numbers of 1 and 2 year olds in the final year are 490% of their correct values and the number of 1-year olds in the second last year is 446% of its correct value. If these are taken as large incoming year classes and they are used in estimating an average recruitment for projections, the future stock will be vastly over-estimated (Table 4). If an index of year class strength is available that is exactly correlated with recruitment, the vaste over-estimate of the last two year classes in the cohort will ruin the correlation. Thus, there is a real problem if this sort of under-reporting is unnoticed and stops. However, a careful study of recruitment might allow us to diagnose what is going on.

The real problem with this sort of under-reporting is that with two years of correct data we are no better off unless we realize the partial recruitment figures for the reported catch have changed. The analysis with two years of good data gives almost identical numbers at age to the last analysis with one years correct data. The only thing that adjusts to the better data is the F's. In this case the partial recruitments for the first 2 ages for the second last year are .02 and .1. However, again only one is different than the values derived before the change in reporting takes place and this might again go unnoticed. All other results are the same as the previous run.

As more years of correct data are entered, more of the partial recruitments for 1 and 2 year olds will become .1 and the change should be detected. Since only small F values on early ages are affected, mature F will not change and weighted F will be changed only a little. Hence comparisons of these to effort figures will not indicate that a change has taken place.

In summary, if the catch of young fish is grossly under-reported for a number of years and then this practice ends, it will be hard to detect from catch and effort data alone. Also the effects of this sort of change on our estimated figures are much more serious than when the unreported catch comes from all age groups.

Tables 1-3 &
Figures 1-3

<u>Change from 80% reporting to 100%, all ages.</u>

Table 1. % error in F's

AGE	YEARS BEFORE CHANGE 10	9	8	7	6	5	4	3	2	1	0
1	0	-1	-2	-4	-6	-9	-13	-15	-18	-19	0
2	0	0	-1	-3	-4	-7	-10	-10	-18	-19	0
3	0	0	0	-1	-2	-4	- 8	-10	-14	-19	0
4	0	0	0	-1	-1	-3	- 6	- 8	-11	-17	0
5	0	0	0	0	-1	-2	- 4	- 7	- 9	-16	0
6	0	0	0	0	-1	-2	- 4	- 6	- 8	-14	0
7	0	0	0	0	0	-1	- 4	- 6	- 7	-14	0
8	0	0	0	0	0	0	- 3	- 5	- 7	-14	0
9	0	0	0	0	0	0	0	- 5	- 7	-14	0
10	0	0	0	0	0	0	0	0	- 7	-14	0
11	0	0	0	0	0	0	0	0	0	-14	0
12	0	0	0	0	0	0	0	0	0	0	0

Table 2. Partial recruitment, fully recruited F=F on oldest age

AGE	ACTUAL	YEARS BEFORE CHANGE IN REPORTING 5	4	3	2	1	0
1	.1	.09	.09	.08	.08	.08	.1
2	.1	.09	.09	.09	.08	.08	.1
3	.2	.19	.19	.18	.17	.16	.2
4	.4	.39	.38	.37	.36	.33	.4
5	.6	.59	.58	.56	.55	.51	.6
6	.8	.79	.77	.75	.74	.69	.8
7	.9	.89	.87	.84	.83	.78	.9
8	1	1	.97	.94	.93	.88	1
9	1	1	1	.94	.93	.88	1
10	1	1	1	1	.93	.88	1
11	1	1	1	1	1	.88	1
12	1	1	1	1	1	1	1

Table 3. Partial recruitment, fully recruited F = mean F on last 5 ages.

AGE	YEARS BEFORE CHANGE IN REPORTING 5	4	3	2	1	0
1	.09	.09	.08	.08	.09	.1
2	.09	.09	.09	.08	.09	.1
3	.19	.19	.18	.18	.18	.2
4	.39	.38	.38	.38	.37	.4
5	.59	.58	.57	.57	.56	.6
6	.79	.77	.77	.77	.76	.8
7	.89	.88	.87	.87	.87	.9
8	1	1	1	1	1	1
9	1	1	1	1	1	1
10	1	1	1	1	1	1
11	1	1	1	1	1	1
12	1	1	1	1	1	1

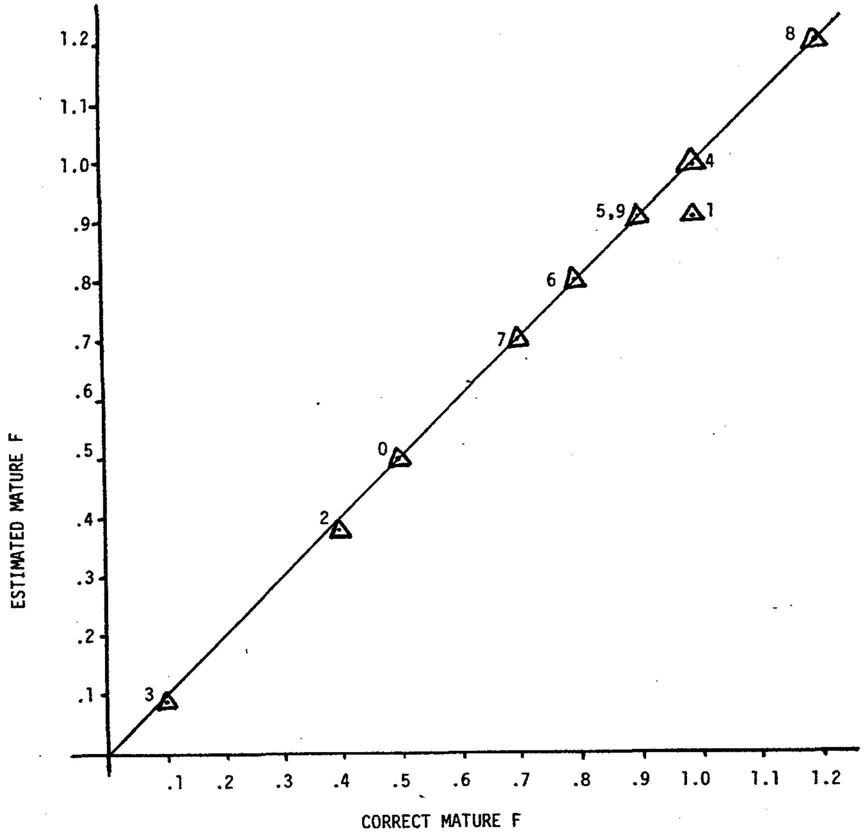

Fig. 1. Estimated mature F (average of last 5 ages) vs correct mature F (shows years before change in reporting).

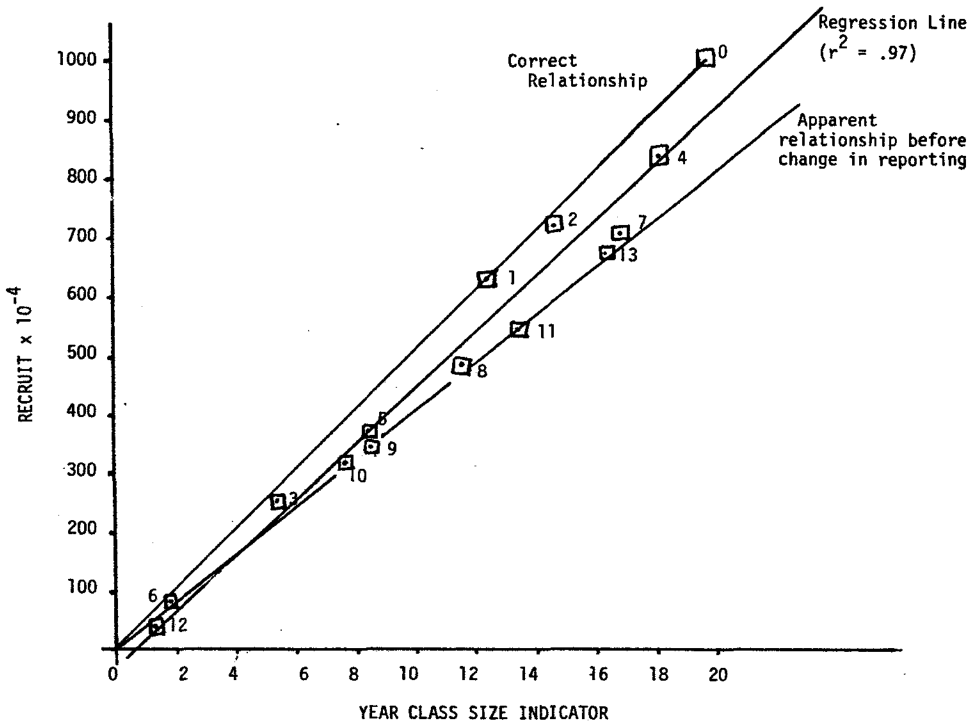

Fig. 2. Recruits vs year class size indicator (shows years before change in reporting).

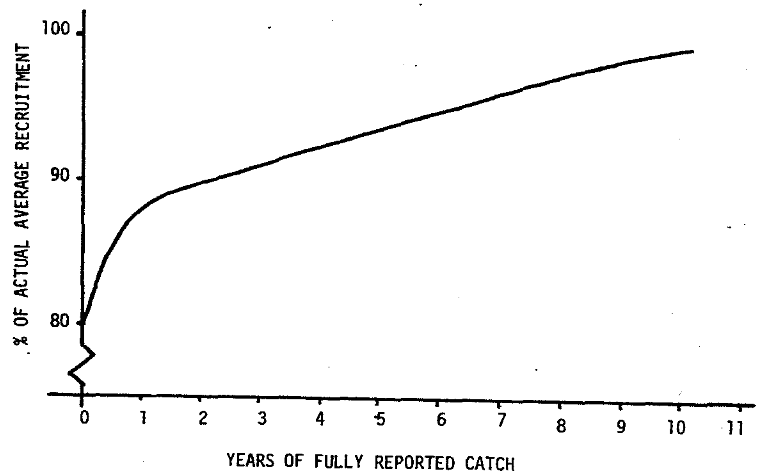

Fig. 3. Years of corrected catch data vs percent of actual average recruitment estimated from 15 year cohort run.

Table 4. Original reporting -20% of catch of 1 and 2 yr-olds. Population biomass projections.

YEAR	CORRECT PROJECTION	PROJECTION WITH ONE YEAR OF CORRECT DATA	SECOND AS PERCENT OF FIRST
1	49	110	224
2	56	157	280
3	58	191	329
4	58	187	322
5	56	162	289
6	55	140	255

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