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LARGE SCALE CHANGES IN FISHERIES AND THEIR EFFECT ON STOCK ASSESSMENTS

by

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INTRODUCTION.

Most of the major stocks in the North Eastern Atlantic are at present assessed by various ICES Working Groups. The procedures in the different Working Groups have attained a certain uniformity, rather independent of the quality of the data base. One of the main features is the overwhelming confidence in the Virtual Population Analysis,VPA.

In earlier years for a large number of stocks, the fisheries were rather similar from year to year, but with the new regime of the seas, large scale changes have taken place in many areas, especially in the composition of the fleets fishing the stocks.

In theory most large scale changes should be no more difficult to handle, than stable situtions, when data are adequate. But in real life most Working Groups have to cope with inadequate data in some respect, and in this situation the chances to make inaccurate or wrong stock assessments are drastically increased with large scale changes in the fisheries.

In some cases, especially mixed fisheries, even in theory the problem is diffcult to handle.

This paper tries to illustrate some of the problems one might run into, and what kind of data are necessary to overcome them.

DESCRIPTION OF A LARGE SCALE CHANGE.

As an example of an area, where large scale changes have taken place, the Faroe Plateau, (ICES subdivision Vb1) from 1973 to 1979 has been chosen.

Quoting from the Report of the Working Group on Fish Stocks at the Faroes, (Anon. 1980)"....There have been two changes in legal mesh size during the period..... A closed area system has been imposed during the period..."

The major change might, however, be the change in the fishing fleets fishing at the Faroes. This is an effect of the change in fishery limits, which has decreased foreign fishery and increased Faroese fishery.

Table 1 gives an illustration of the change together with fig. 1A and 1B. The Faroese data are from the Faroese Fiskhag databank (Coop. Res. Rep.91) Total catch of all species and effort has been estimated for 12 fleet categories.Data on British fleets have been taken from the Report of the Working Group on Fish Stocks at the Faroes.

These 14 fleet categories are the main componets of the fishery on the Faroe Plateau proper, and cover almost all effort on the cod and haddock stocks.

The table shows, that the non- trawl gears have fluctuated, with tops in 1976 and 1977, when the cod and haddock stocks were at a high level. The British effort has decreased dramatically, and there has been a large increase in Faroese trawl effort in all groups of larger trawlers.

ICES WORKING GROUP PROCEDURES.

Most ICES Working Groups seem to have adopted a procedure, which involves the following steps.

1. The Group establishes a database with data for several years.At each meeting of the group, the data for the last year with catch data are added, and the data for the year before are brought to a final form. The data usually include: Yield by country,catch in numbers by age and country, and in some cases catch/effort data.
2. The data on catch by age by countries are aggregated to a combined estimate of total catch by age and year, and this is put into a VPA, which only differs from last years in that one year has been added.
3. Trial VPA runs are made by changing the terminal fishing mortality coefficients. At this stage other information on effort or of less quanti-

fiable nature might be used to try to determine the fishing mortality in the last year. At some stage one of the trial runs is pickedout by the Group, and agreed upon as the final one.
4. Fishing mortality level for the last year and exploitation pattern are taken from the VPA, and this together with the catch data gives the stock estimate for the last year.
5. Using this forecasts are made assuming different fishing mortalities for the subsequent years.
6. One of these options is later used as the basis for a TAC recommendation by ACFM.

In situations, where changes are moderate in effort by the different fleet categories, there may in the group be some non quantifiable knowledge about the fisheries, helping to determine the fishing mortality for the last year. Very few groups have really detailed catch/ effort data.

A SIMULATION STUDY OF THE PROBLEM OF LARGE SCALE CHANGES

In order to get an impression of what kind of problems one might run into, a simulation study has been undertaken.

The model described by Hoydal, Rörvik and Sparre (1980) has been used to simulate a fish stock fished by three different fleets.

The model is described in details in the paper mentioned above. In order to simulate a more realistic situation the model in this paper has been used with variable recruitment each year simulated.

The input parameters for stock and fleets in the simulation are given in table 2. It might be noted that these are similar to the data for the haddock on the Faroe Plateau.

The simulation was run for 8 years. For the first 7 years it has been assumed that effort level has been stable in all three fleets. For the 8 year one simulation has the same assumptions, but further 6 different changes have been simulated. The details of the input for simulation of the changes are given in table 3. The changes are.

Change 1. The overall effort level is increased by 100 %
-"- 2. The overall effort level is decreased by 50 %
-"- 3. Fleet 3 effort is reduced drastically, the two other fleets unchanged.
-"- 4. Fleet 3 effort is reduced drastically, the two other fleets increase their effort.
-"- 5. The exploitation pattern of fleet 1 and 3 is changed, so the mortality on younger age groups is reduced.
-"- 6. The mortality on younger age groups from fleet 1 and 3 is further reduced.

From the simulations precise estimates of stock and catch parameters are available. In table 4 some of the figures are summarized for the 7 simulations in year 8.

We now assume we are in the same situtation as a Working Group, which has only the catch data to work on. The catch at age data from the simulations are put into a VPA and fishing mortalities and stock numbers and weight are estimated back to year 1.

The Working Group has no additional knowledge about changes in the fishery, and assumes that no change has been in effort level and exploitation pattern for the three fleets.

In the first simulation this is true, and the VPA reproduces almost excactly the figuresfrom the simulation. The only difference arises from rounding errors. The VPA uses 2 significant digits in the fishing mortality coefficient, where in the simulation six digits are used.

In the 6 cases where changes have been assumed, by assuming no change the

In the 6 cases where changes have been simulated, by assuming no change, the VPA gives very different estimates of fishing mortalities and stock.

The outcome of these VPA runs are compared to the values from the simulation year by year. The simulation values are the "true" values.

In figure 2 A to F the VPA and the simulated estimates are compared. The curves show the percentage deviation in the VPA estimate from the true simulation estimate. It is shown for:
1. Fishing mortality age 1 to 10, weighted by stock in numbers.
2. Stock in numbers age 1 to 10.
3. Stock in weight age 1 to 10.

RESULTS.

The results of change 1 and 2 (fig. 2A and 2B) demonstrate the well known effect of using a VPA with no independent data to determine the terminal fishing mortality coefficients to go into the VPA. The stock can be increased or decreased freely by decreasing or increasing the fishing mortality coefficients.

In changes 3 and 4 (fig.2C and 2D) the effect of excluding one fleet from the fishery is illustrated. In change 3 with no change in other fleets in change 4 the other fleets take over and bring the effort level up to the one before one fleet was excluded.
This situations might be one of the most common, since the new fishery limits entered into force.
It is not quite simple to predict how this affects the assessments. This will depend on the specific exploitation patterns of the fleets involved. In the present cases, where the fleet which is excluded exploits younger age groups than the two other ones, the fishing mortality is overestimated and correspondingly the stocks underestimated.
If ones looks at the results by age groups (not given in this paper) it is seen that estimates of the different agegroups are very differently affected.

In changes 5 and 6 (fig. 2E and 2F) the gear parameters for fleet 1 and 3 have been changed, simulating two increases in mesh size. The effect is very much like the one from changes 3 and 4, although the reasons are different.
It should perhaps be stressed, that changes 5 and 6 could not only be the effect of changes in gear parameters. The same effect might be seen, when restriction are enforced on a fleet. The size dsitribution in the catches in the restricted area might be quite different from the size dsitribution in the area previously free to fishery.

THE PROBLEM OF FORECASTING WITH LARGE SCALE CHANGES

The simulation shows that the chances of making quite inaccurate stock estimates are likely, when large scale changes take place, and adequate data are not at hand. This of course also makes any forecast inaccurate.
But even if the Working Group was able to come up with a correct estimate of stock and fishing mortality, there can be problems with the forecasts.

The usual procedure is to agree on certain levels of fishing mortality, which should be aimed at in the regulation of the stock (ex. F_{max}, $F_{0.1}$)

This fishing mortality is translated into a certain yield in weight, and this is the TAC recommended.

But with large scale changes there is the obivous possibility that a certain yield in weight in one year corresponding to a certain level of fishing mortality, does not correspond to the same level in fishing mortality in the year the TAC was set for.

DISCUSSION.

The examples in the simulation perhaps are rather extreme for illustrative purposes. Most Working Groups would be able to do a better job with the given data.
But it should stress the need for very detailed data on effort and catch. Without these it will be very diffcult to detect or model the changes.

In a great many cases there is no much hope at present, that fishery independent data will render stock estimates to check the fishery dependent calculations.

So the only realistic way seems to be to refine the effort data, and make the sampling of catches more extensive.
Most Working Group seem to have paid very little attention to this in the later years. In many stocks effort data have definitely deteriorated. Both because the sampling has broken down and because long time series of effort data have been terminated due to restriction on fisheries for different fleets.
Judging from the simulation data, the demand on data to detect fleet changes have to be on a detailed basis by small fleet categories and time units.

Perhaps a short description of the Faroese Fiskhag system for sampling catch and effort will provide an illustration to how detailed one should try to get the database.(a full description is given in Coop.Res.91)
For the larger vessels in the Faroese fleet it is possible to sort effort and catch by hour,day. statistical rectangle for each vessel. For the smaller vessels this is possible on a day/trip basis.

The vessels can be aggregated to fleet categories and the data can be aggregated on combinations of time and geographical scale down to hours and statistical rectangles (1/2 degree latitude x 1 degree longitude).

The total effort estimate by years in ICES subdiv. Vb1 in table 1 is one such example of aggregation from the basic file.

The large amounts of detailed data makes computerization indispensable. The Working Groups should have acces to computerfiles for each fleet category fishing on the stocks to be assessed.

The log book systems, which have been introduced in the last years in many countries, should, suitably computerized, be a valuable source of this kind of data.

In these sampling systems the yield is given as a weight caught. From biological sampling of at least the major species, it should be possible to estimate the corresponding catches as numbers by age.

This makes catch by age data on a fleet category basis necessary.
As an example the biological sampling system for catches from the Faroe Area can be taken,table (Administrative Report of the Demersal Committee CM 1980). Sampling in most countries is on a vessel basis, so it should be to difficult to bring the data on a fleet category basis to the Working Group meetings.

However, even with access to advanced data on effort and catch on a detailed basis, there still are problems in correlating effort data to fishing mortality on a specific species.

Some of these problems are well known from the literature (see f.e. Rotschild 1977)
But there is especially one problem that demands a rapid solution, and that is the problem of mixed fisheries. What fishing mortality is produced on single species by fleets fishing for several species.
Another problem is the problem how to interpret effort data, when there

are regulations, regulating by boat/day quotas by species.

THE RESPONSIBILITY OF ICES OF THE QUALITY OF ASSESSMENTS

There is at the moment a lot of discussion going on about the responsibility of the different stages in the managemental process.
It should at least be indisputable that the basic stock assessment , on which all sound management has to be based, is the responsibility of ICES in the the North Eastern Atlantic Region.
To the authors mind the large scale changes in the fisheries in this region have (together with other factors as well) brought the assessment work on a more shaky basis, than it was before.
It could be said, that in a situation with large scale changes, bad or inadequate data are punished more severely , than in times with stable situations.Punished in this sense meaning the risk of Assessment Working Groups coming out with quite wrong stocks assessments.

Only one or two such cases will suffice to destroy much of the image painfully conquered by ICES, as an organisation able of giving reliable advice to managing bodies.

Last year ICES reacted to a criticism of not taking into account the interaction between species in the single species assessments, by recommending an Ad Hoc Group to look at this problem.

I think an Ad Hoc Group skould be recommended to have a look of what data are necessary to be able to detect changes and correlate effort by different fleets with fishing mortality.

The terms of reference of such a group might tentatively be grouped under the following headings:

1. Sampling systems and processing of effort data useful in assessment work.
2. Effort in mixed fisheries correlated to fishing mortality on single species.
3. The effect of quota systems and other regulating systems on effort data.

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References:

Administrative Report. Demersal Fish Committee. CM 198o/ G:1

Anon. 1980: Report of the Working Group on the Fish Stocks at Faroe. CM 1980 / G:6

Coop.Res.Rep.91: Description of National Fisheries Statistics Systems in ICES Member Countries .

Hoydal,Rörvik & Sparre, 1980: A Method for Estimating the Effective Mesh Sizes and the Effects of Changes in Gear Parameters. CM 1980 / G: 28

Rotschild,B.J,1977 Fishing Effort. In Fish Population Dynamics edited by John Gulland. John Wiley & Sons 1977

TABLE 1

Detailed effort statistisc for the Faroe Plateau 1973-1979 (ICES subdiv.Vb1)

Y = Total Yield, All Species, tonnes
E = Total Effort, 'ooo units.

	1973		1974		1975		1976		1977		1978		1979		
	Y	E	Y	E	Y	E	Y	E	Y	E	Y	E	Y	E	
1	-	-	-	-	87	-	1552	2	2229	4	1081	1	841		Open boats, longline
2	-	-	-	-	261	-	3578	-	3518	2	906	1	1117		- - , handline
3	7912	96	6575	6	11253	57	16994	49	22388	78	16913	68	13189		Wooden boats, longline
4	4530	29	4406	31	6543	37	6030	29	5102	37	5470	40	5040		- - , trawl
5	2749	3	5790	5	4993	5	2536	3	2961	12	1527	3	2449		Larger vessels, handline
6	892	7	2440	34	2981	81	3302	103	4253	69	3502	51	3562		Gill netters
7	377	2	876	4	3382	17	5159	31	5799	31	4072	19	5023		Steel vessels, longline
8	167	-	850	4	2326	11	3554	16	4290	26	8375	37	983		- - , 400-700 HP
9	90	1	-	-	163	-	2	-	128	-	3256	13	5334		- - , 700-1000 HP
10	-	-	28	-	83	-	176	1	595	2	5736	17	9744		- - ,>1000 HP Faroe
11	-	-	62	-	810	1	1005	4	1919	7	3081	7	5206		- - ,>1000 HP Iceland
12	-	-	-	-	-	-	-	-	-	-	2611	5	3332		- - ,>1000 HP Dist.Wat.
1	9272	51	12992	81	12635	73	12015	70	6545	51	1784	15	684	5	Scottish trawlers
2	5232	35	4005	25	4045	25	3733	25	1518	13	365	7	298	3	English trawlers

Effort units:
Long line 1ooo hooks
Trawl hours trawled
Handline number of handlines x days
Gill nets number of gill nets x days

TABLE 2

INPUT PARAMETERS USED TO SIMULATE 7 YEARS OF STABLE FISHERY SITUATION.

For description of model
see Hoydal, Rörvik & Sparre. (1980)

BERTALANFFY PARAMETERS

L8 : 82.7 cm K · o.1⁴⁹ TO -1.55

LENGTH WEIGHT CORRELATION $W = L^3\ 9.5^{-6}$

PROPORTION OF TOTAL FISHING MORTALITY ON EACH FLEET

FLEET 1	0.15
- 2	0.30
- 3	.55

TOTAL F (INPUT) 0.5 (describes level of total effort)

RECRUITMENT AND SELECTION CURVES

	ASCENDING LIMB		DESCENDING LIMB	
	50% cm	75% cm	75% cm	50% cm
FLEET 1	33.1	35.1	50.0	47.0
- 2	30.0	31.0	-	-
- 3	22.0	23.0	52.0	49.0
RECRUITMENT CURVE	20.0	22.0	-	-

TABLE 3

INPUT PARAMETERS USED TO SIMULATE CHANGES IN THE 8th YEAR.

BERTALANFFY PARAMETERS, LENGTH-WEIGHT RELATIONSHIP AND RECRUITMENT CURVE UNCHANGED FROM STABLE SITUATION.

	TOTAL F	PROPORTION OF F			FLEET SELECTION CURVE FLEET %				FLEET 2 UNCHANGED			
		FLEET 1	FLEET 2	FLEET 3	FLEET 3							
					ASCENDING		DESCENDING		ASCENDING		DESCENDING	
					50 %	75 %	50 %	75 %	50 %	75 %	50 %	75 %
STABLE SITUATION	0.5	0.15	0.30	0.55	33.1	35.1	50.0	47.0	22.0	23.0	52.0	49.0
CHANGE 1	1.0	-	-	-	-	-	-	-	-	-	-	-
2	0.25	-	-	-	-	-	-	-	-	-	-	-
3	0.5	-	-	-	-	-	-	-	-	-	-	-
4	0.5	-	0.64	-	-	-	-	-	-	-	-	-
5	0.5	0.15	0.30	0.55	37.2	39.2	52.0	49.0	37.2	39.2	54.0	51.0
6	0.5	-	-	-	42.1	44.1	55.0	52.0	42.1	44.1	59.0	56.0

- means no change

TABLE 4 SIMULATING THE EIGHT YEAR UNDER 7 DIFFERENT ASSUMPTIONS. For details on changes see table 3 and text.

		NO CHANGE	CHANGE 1	2	3	4	5	6
Catch	1	1592	2572	891	1802	3368	1051	492
	2	5252	8727	2898	5847	11420	5714	5865
	3	12995	22423	7036	1304	1234	4017	2087
Total		19839	33721	10825	8954	16022	10781	8444
Yield	1	874	1399	492	989	1829	697	455
	2	4478	7728	2424	4795	9313	4657	4713
	3	4952	8211	2737	504	463	2779	2185
Total		10303	17338	5652	6288	11605	8133	7353
Aw. Weight in catch	1	.549	.544	.552	.549	.543	.663	.925
	2	.853	.886	.836	.834	.815	.815	.804
	3	.381	.366	.389	.387	.375	.692	1.047
	Total	.519	.514	.522	.702	.724	.754	.871
F x)	1	.042	.069	.023	.048	.089	.032	.016
	2	.132	.232	.070	.145	.301	.140	.145
	3	.194	.346	.103	.018	.017	.126	.069
Total		.278	.505	.146	.125	.223	.146	.124
CPUE	1	.206	.204	.212	.208	.205	.221	.292
	2	.338	.332	.344	.330	.310	.330	.326
	3	.255	.237	.267	.278	.279	.220	.319
Total		.279	.268	.288	.298	.286	.273	.321

x) Fishing mortality coefficients weighted by stock in numbers.

TABLE 5

ADMINISTRATIVE REPORT***FAROE ISLANDS** 1979

TOSKUR/cod #### ICES Vb1 ##### SAMPLED CATEGORIES 1979

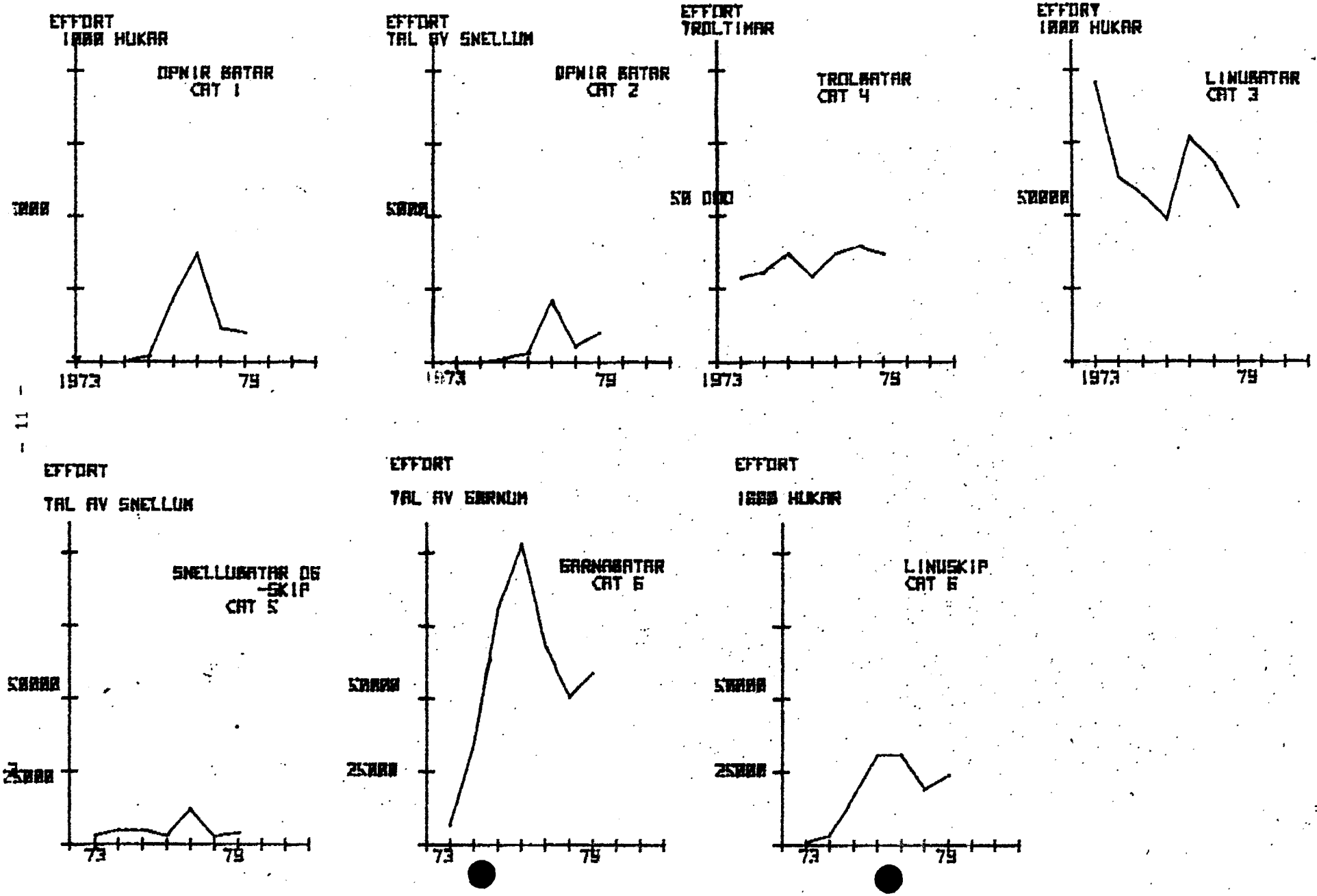
VESSEL CAT	QUART.	NUMBER OF SAMPLES	WEIGHT SAMP.KG	MEASUR. NO.	AGED NO.	YIELD TONS	CATCH NO.	YIELD/ SAMP.WEIGH	CATCH/ MEASUR	AVERAG WEIGHT
1	2	2	1171	284	•	1554	453	1327	1595	4.12
1	4	3	2287	434	•	434	96	190	221	5.27
2	1	3	2212	643	•	1228	319	555	496	3.44
2	2	5	5657	1992	•	2195	946	388	475	2.84
2	3	1	645	160	•	984	244	1526	1525	4.03
4	2	4	1215	744	•	551	307	453	413	1.63
4	3	2	618	249	•	609	284	985	1141	2.48
5	1	5	2830	725	•	1921	440	679	607	3.90
5	2	2	2610	717	•	376	94	144	131	3.64
6	1	6	4905	2478	•	1999	991	408	400	1.98
6	2	4	1217	524	•	478	181	393	345	2.32
6	3	1	233	193	•	104	86	446	446	1.21
6	4	5	20346	10878	•	2136	1196	105	110	1.87
7	1	3	1515	527	•	449	167	296	317	2.87
7	2	2	2849	1080	•	976	355	343	329	2.04
7	3	1	690	406	•	1117	657	1619	1618	1.70
7	4	4	2480	793	•	142	36	57	45	3.13
8	1	2	1108	585	•	604	264	545	451	1.89
8	2	2	1165	700	•	232	134	199	191	1.66
8	4	1	128	31	•	36	9	281	290	4.13
9	1	2	828	264	•	532	132	643	500	3.14
9	4	5	7623	2126	•	800	206	105	97	3.59
TOTAL /AVERAGE		65	64332	26533	3011	19457	7597	302	286	2.56

***** VESSEL CATEGORIES *****

CAT.	TYPE	CAT.	TYPE
1	TRAWLERS > 1000 HP	2	TRAWLERS 400-1000 HP
3	TRAWLERS < 400 HP	4	OPEN BOATS HANDLINE
5	GILL NETTERS	6	SMALL VESSELS LONGLINE
7	SMALL VESSELS TRAWL	8	LARGER VESSELS HANDLINE
9	LARGER VESSELS LONGLINE		

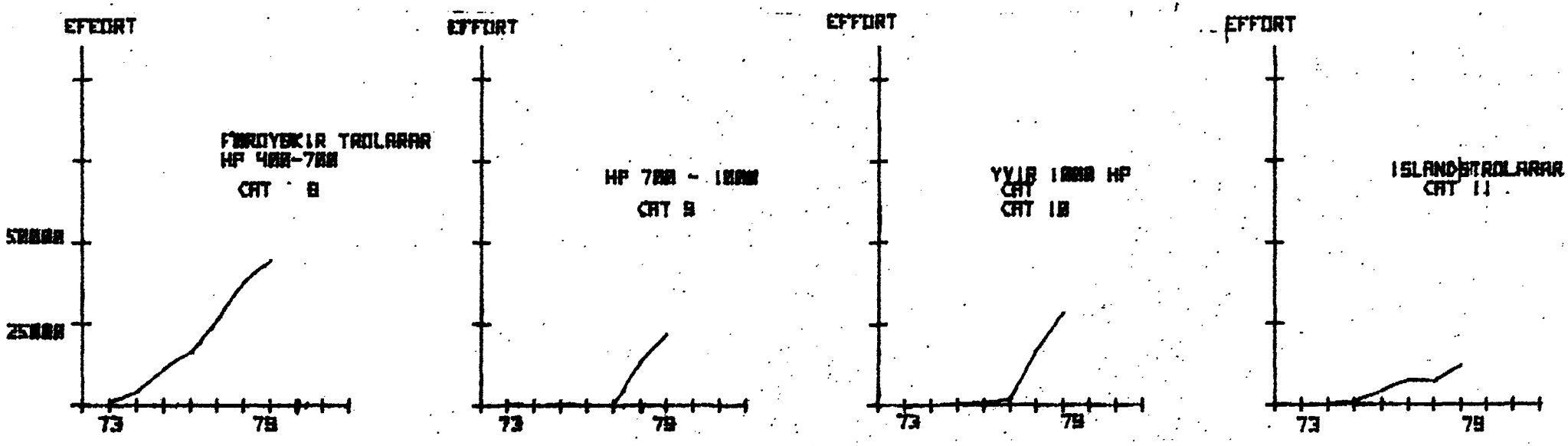
EFFORT ON FLEET CATEGORIES IN ICES SUBDIV VBI 1973-79
FOR DETAILS SEE TABLE 1/ EFFORT MEASURED IN GEARSPECIFIC UNITS

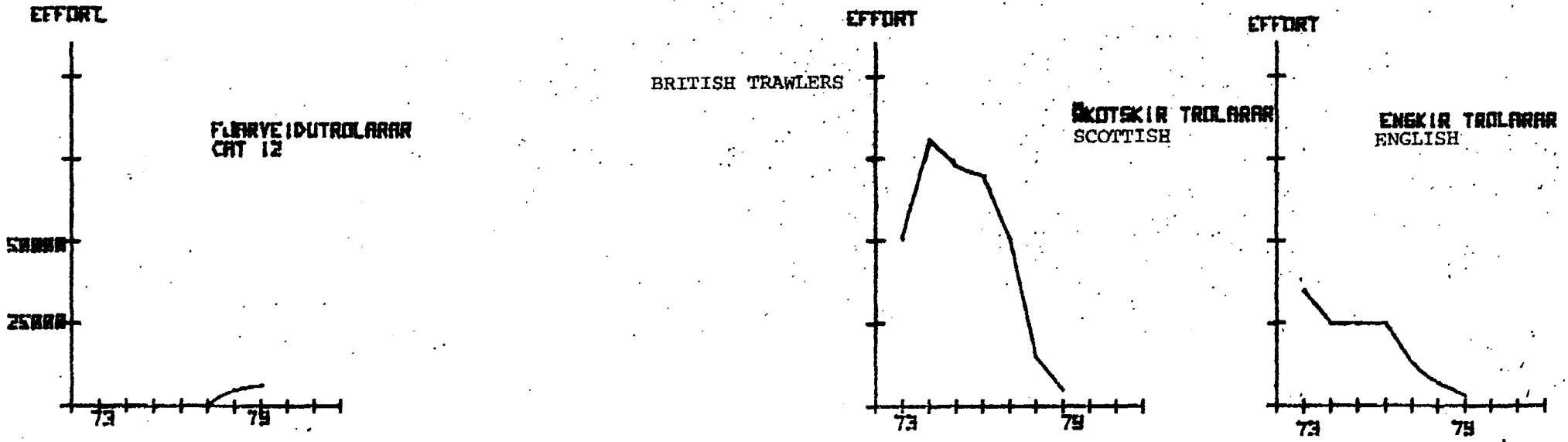
FIG. 1 A



EFFORT ON FLEET CATEGORIES IN ICES SUBDIV VBI 1973-79
FOR DETAILS SEE TABLE 1, EFFORT MEASURED IN GEARSPECIFIC UNITS

FIG 1 B



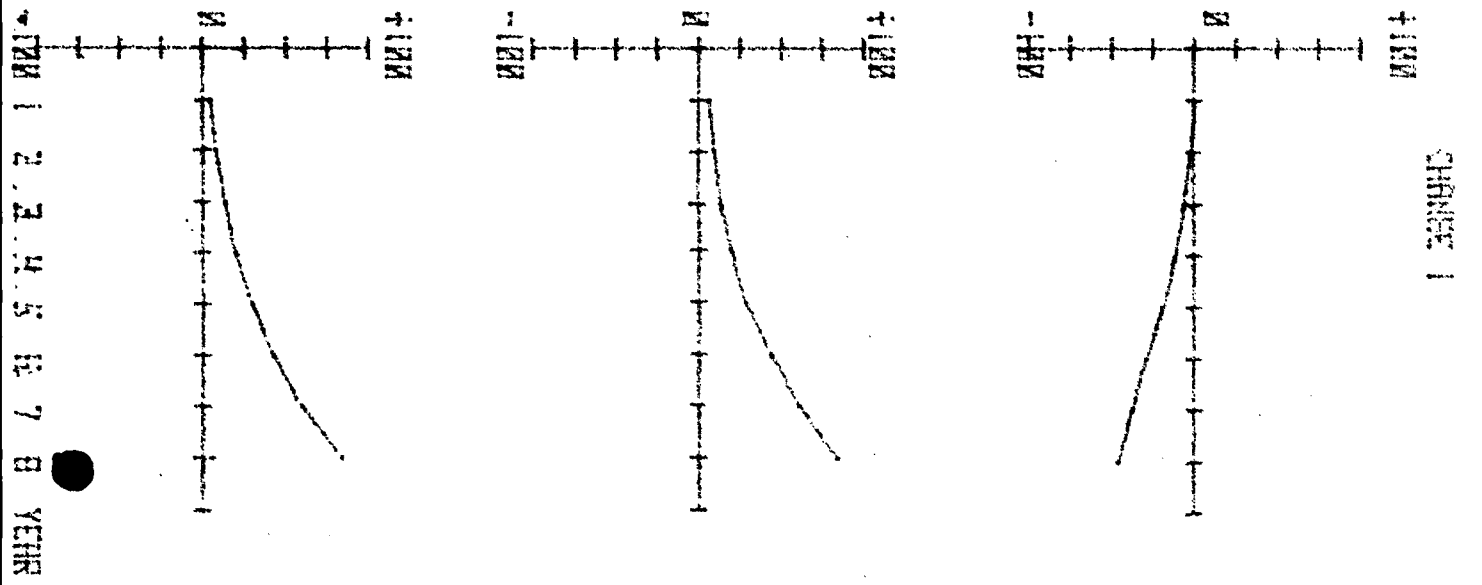


PERCENTAGE DEVIATION OF VPA ESTIMATE FROM "TRUE" VALUE
(FOR EXPLANATION SEE TEXT)

STOCK IN WEIGHT

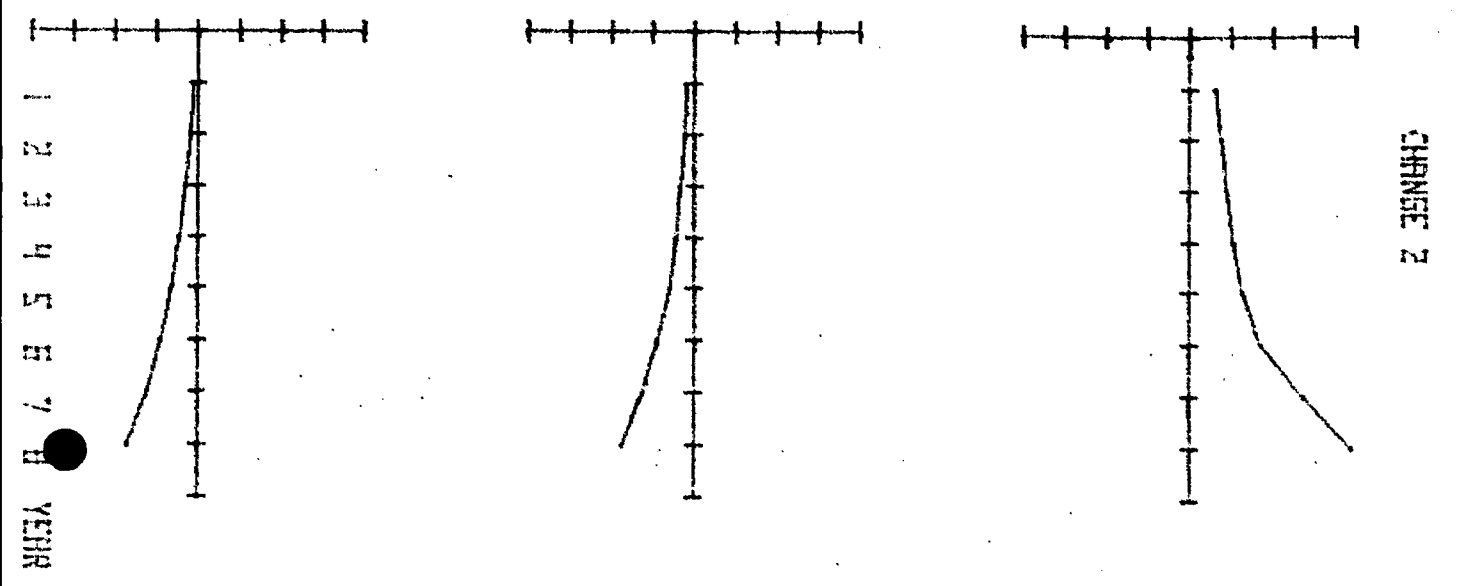
STOCK IN NUMBERS

F/ AGE 1 TO 10



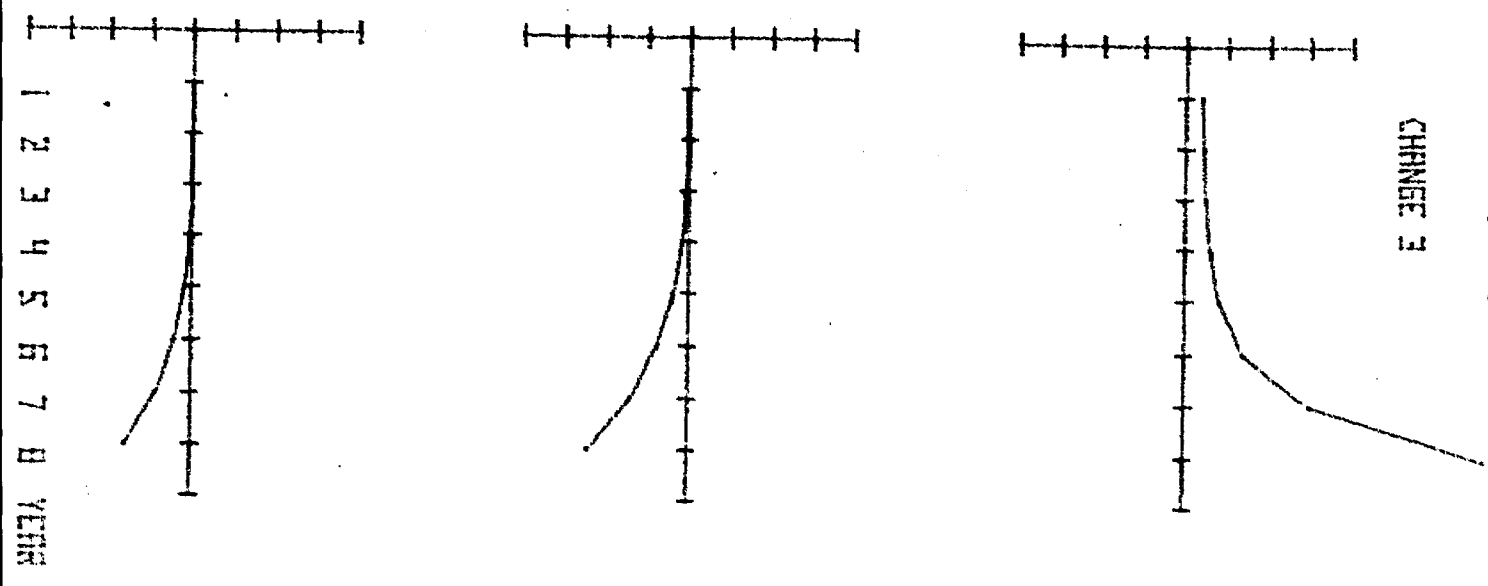
CHANGE 1

FIG 2 A



CHANGE 2

FIG 2 B



CHANGE 3

FIG 2 C

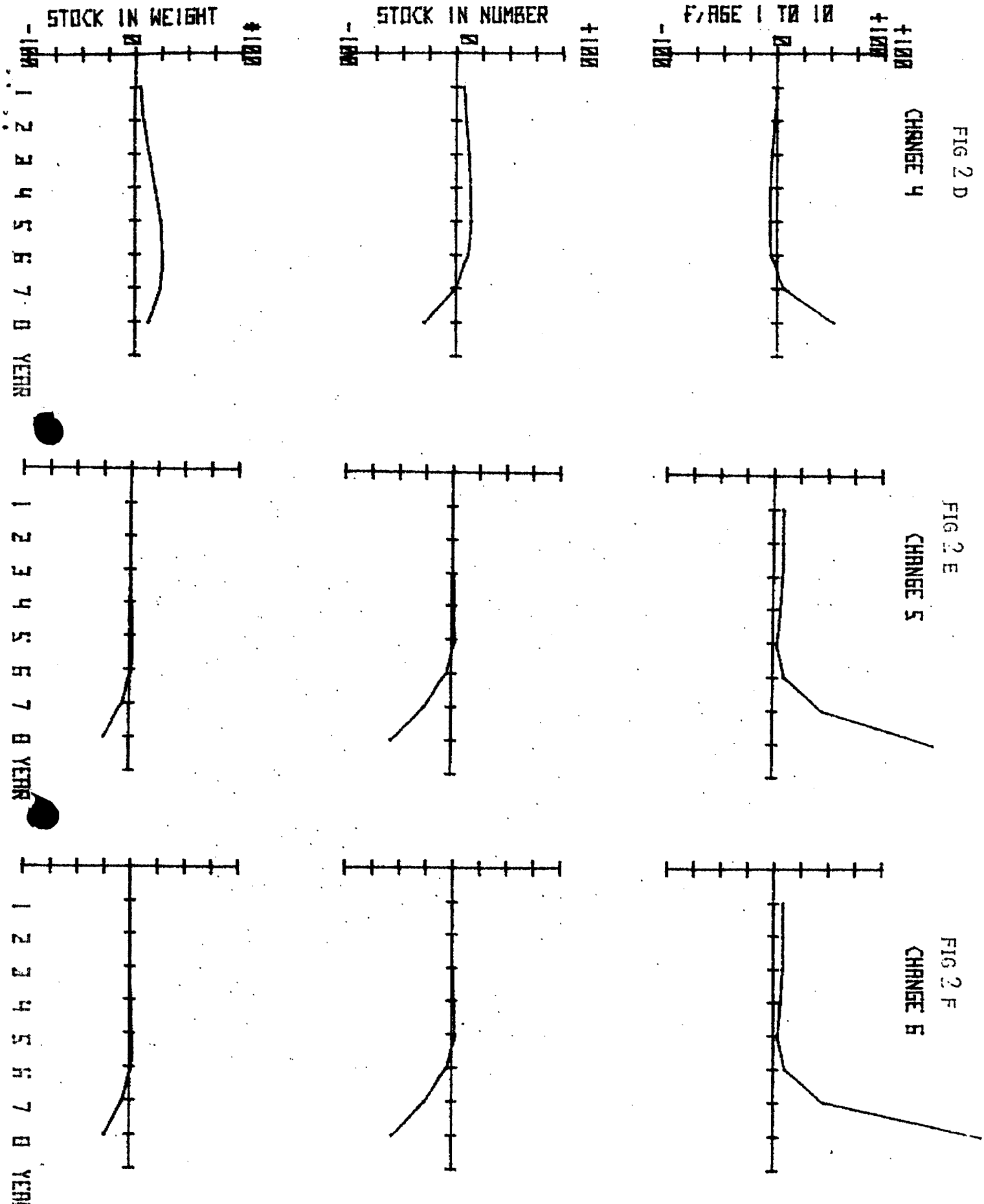


FIG 2 D

FIG 2 E

FIG 2 F